CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

SECOND SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering,Madurai-625015

Department of Mechanical Engineering

Scheduling of Courses

Semester	**Theory Courses**						**Practical/Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					G88 Project 0:12	
7th (22)	G71 Management Theory & Practice 3:0	G72 Automobile Engineering 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G76 Modeling & Simulation Lab - II 0:1	G77 Mini Project 0:6	
6th (22)	G61 Accounting & Finance 3:0	G62 Mechanical Vibrations 2:1	G63 Quality Engineering 3:0	G64 Metrology 3:0	Elective 1 3:0	Elective 2 3:0	G67 Modeling & Simulation Lab - I 0:1	G68 Metrology Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Design of Machine Elements 3:1	G53 Advanced Measurement & Control 3:0	G54 Heat & Mass Transfer 3:0	G55 Manufacturing Technology/Sys. 3:0	G56 Industrial Engg. & Operations Research 4:0	G57 CAD/CAM Lab 0:1	G58 Heat & Mass Transfer Lab 0:1	G59 Mech. Meas. & Control Sys. Lab 0:1
4th (23)	G41 Numerical Methods 4:0	G42 Kinematics & Dynamics of Machinery 3:1	G43 CAD & Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Manufacturing Processes- III Machining 3:0	G46 Mechatronics 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (24)	G31 Engineering Mathematics-III 4:0	G32 Free Body Mechanics- II 4:0	G33 Applied Material & Metallurgy 3:0	G34 Fluid Mechanics 3:1	G35 Manufacturing Processes - I Casting & Forging 3:0	G36 Manufacturing Processes -II Forming, Joining & Finishing 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics & CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Environment and Ecology 2:0	G26 Computers & Programming 3:0	G27 Strength of Materials & Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
G 21	Engineering Mathematics - II	BS	3	1	-	4
G22	Free Body Mechanics	DC	3	1	-	4
G 23	Material Science	ES	3	-	-	3
G 24	Thermodynamics	DC	3	1	-	4
G 25	Environment and Ecology	HSS	2	-	-	2
G 26	Computers and Programming	ES	3	-	-	3
PRACTICAL						
G27	Strength of Materials and Composite Materials Lab.	DC	-	-	3	1
G28	Computer Programming Lab.	DC	-	-	3	1
G29	Workshop	DC	-	-	3	1
	Total		**17**	**3**	**9**	**23**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

SECOND SEMESTER

S.No.	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G 21	Engineering Mathematics - II	3	50	50	100	25	50
2	G22	Free Body Mechanics	3	50	50	100	25	50
3	G 23	Material Science	3	50	50	100	25	50
4	G 24	Thermodynamics	3	50	50	100	25	50
5	G 25	Environment and Ecology	3	50	50	100	25	50
6	G 26	Computers and Programming	3	50	50	100	25	50
PRACTICAL								
7	G27	Strength of Materials and Composite Materials Lab.	3	50	50	100	25	50
8	G28	Computer Programming Lab.	3	50	50	100	25	50
9	G29	Workshop	3	100	-	100	-	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
G 21	3	1	-	4

G21 Engineering Mathematics II 3:1

(Common to all branches of Engineering B21, C21, D21, E21, G21, T21)

Preamble: An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this the course aims at giving adequate exposure in the theory and applications of Functions of Several Variables, Multiple Integrals, Analytical Functions and Differentiation, Integrations for a complex variable.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

b. An ability to identify, formulate and solve engineering problems

c. An ability to engage in life-long learning

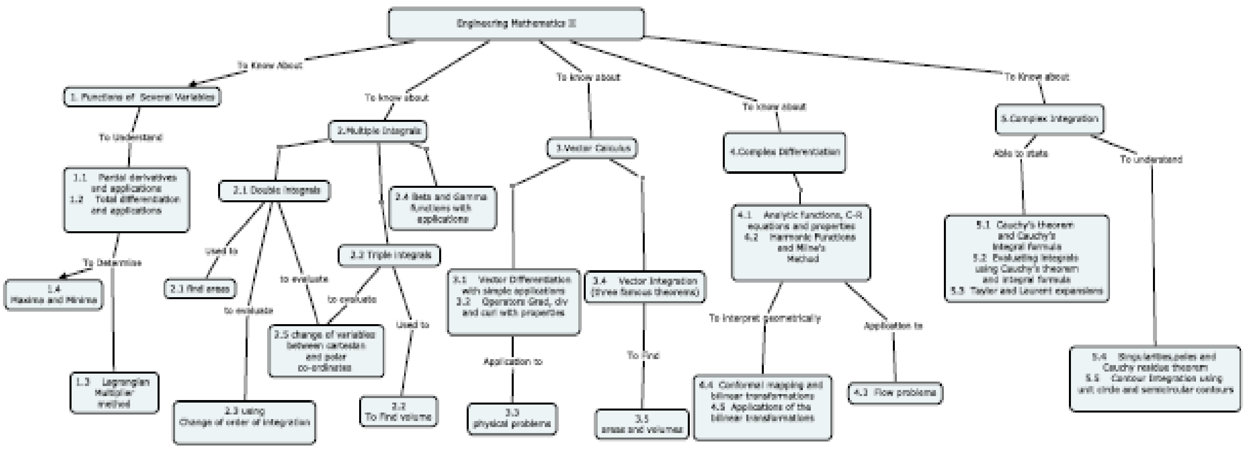
Competencies: At the end of the course the students should be able to

1. Formulate Partial Differentiation and Total Differentiation in and Solve Engineering field especially to mechanics of Materials, Thermodynamics, Heat Transfer, Mechanical Vibrations etc.
2. Determine quantities like areas and volumes using double and triple integral.
3. Perform vector differentiation and will determine areas and volumes of a vector valued function using Green's, Gauss and Stoke's theorem.
4. Solve physical problems resulting in Mathematical functions that involve complex differentiation and Geometrical interpretation of conformal mapping and bilinear transformations.
5. Solve physical problems resulting in Mathematical functions that involve complex integration and determine contour integration of unit circle using residue

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Concept Map



Course level learning objectives:

Remember

1. Define total differentiation
2. Describe change of order of integration
3. Identify the value of λ, so that $\bar{F}$= (2x-5y)$\bar{i}$+(x+λy)$\bar{j}$+(3x-z)$\bar{k}$ is solenoidal
4. If C is a simple closed curve and $\bar{r}$=x$\bar{i}$+y$\bar{j}$+z$\bar{k}$ show that $\int_{c} c.dr = 0$
5. Define "harmonic" and "conjugate harmonic" functions.
6. Show by an example that there exist harmonic functions u(x,y) and v(x,y), such that u+iv is not analytic.
7. State Cauchy's integral theorem or Cauchy's fundamental theorem.
8. State the extension of Cauchy's integral theorem.
9. State Cauchy's Integral formula.
10. State Cauchy's integral formula for the derivatives of an analytic function.

Understand

1. Elevation of land above sea level H, depends on two map coordinates x, y in the following way H(x,y) $= e^{-0.01(x^2+y^2)}$. A car travels through this terrain, so it's coordinates depend on time in the following way x(t) = -7 + 10 cos(10t), y(t) = 4 + 10 sin(10 t). Find the speed with which the altitude of the car is increasing or decreasing at t = 0.
2. Prove that the rectangular solid of maximum volume which can be inscribed in a sphere is a cube.
3. Interpret the integral $\iint xy(x+y)dxdy$ over the area between $y = x^2$ and y=x.
4. Change the order of integration and hence predict $\int_0^{\frac{a}{\sqrt{2}}} \int_0^{\sqrt{x^2-y^2}} \log(x^2+y^2)dxdy$ (a>0)
5. Change the order of integration and hence predict $\int_0^a \int_{\sqrt{ax}}^a \frac{y^2}{\sqrt{y^4-a^2x^2}} dydx$
6. If $\vec{f} = 3x^2\,\vec{i} + 5xy^2\,\vec{j} + xyz^3\,\vec{k}$ the estimate the value Of $\nabla \bullet f; \nabla(\nabla \bullet f); \nabla \times f; \nabla \bullet (\nabla \times f)$ and $\nabla \times (\nabla \times f)$ at the point (1,2,3)
7. Predict the value of a and b, so that the surface $ax^3-by^2z=(a+3)x^2$ and $4x^2y-$
    a. $z^3=11$ may cut orthogonally at the point (2,-1,-3)
8. Estimate the integral $\iint_c \vec{f} \times dr$ along the curve x=cost ,y=2sint and z=cost from t=0 to t=$\frac{\pi}{2}$ given that $\vec{f} = 2x\,\vec{i} + y\,\vec{j} + z\,\vec{k}$
9. Predict the value of the integral ∫ $(z+4)/(z^2+2z+5)$ dz , over the circle |z+1-i|=2.
10. Find the Taylor's series expansion of f(z)=z/(z+1)(z-3) about z=0.

Apply

1. Show the volume of the region of the space bounded by the coordinate planes and surface $\sqrt{\frac{x}{a}} + \sqrt{\frac{y}{b}} + \sqrt{\frac{z}{c}} = 1$ is abc/90
2. Show that the rectangular solid of maximum volume which can be inscribed in a sphere is a cube.
3. Apply Green's theorem in a plane to evaluate $\int_c \{x^2(1+y)dx + (x^3+y^3)dy\}$;where c is the square formed by $x = \pm 1, y = \pm 1.$
4. If z=f(x,y) where $u = x^2 - y^2$ and v=xy show that $(\frac{\partial z}{\partial x})^2 + (\frac{\partial z}{\partial y})^2 = 4(x^2+y^2)\{(\frac{\partial z}{\partial u})^2 + (\frac{\partial z}{\partial v})^2\}$
5. Examine the maximum and minimum distance from the origin to the curve $5x^2 + 6xy + 5y^2 - 8 = 0$

6. Examine the functional dependence of the functions $u = \frac{x+y}{x-y}$ and $v = \frac{xy}{(x-y)^2}$: If they are dependent , find the relation between them
7. Verify stokes theorem for $\overline{F}$ = xy$\bar{i}$ -2yz$\bar{j}$ -zx$\bar{k}$ where S is the surface of the rectangular parallelopiped formed by the planes x = 0 , x = 1, y=0, y=2, and z = 3 above the xy-plane
8. Apply reen's theorem in a plane to evaluate $\int_c \{x^2(1+y)dx + (x^3+y^3)dy\}$;where c is the square formed by $x = \pm 1; y = \pm 1$

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Functions of Several Variables**	
1.1	Partial derivatives and Jacobians	2
1.2	Total differentiation and applications	2
1.3	Lagrangian Multiplier method	2
1.4	Applications to Maxima and Minima	2
2.	**Multiple Integrals**	
2.1	Double integrals and areas	2
2.2	Triple integrals and volumes	2
2.3	Change of order of integration	1
2.4	Beta and Gamma functions with applications	1
2.5	Change of variables between Cartesian and polar with applications	2
3	**Vector calculus**	
3.1	Vector Differentiation with simple applications	1
3.2	Operators Grad, div and curl with properties	2
3.3	Applications to Physics	1
3.4	Vector Integration(three famous theorems)	2
3.5	Applications to areas and volumes	2

No.	Topic	No. of Lectures
4	**Complex Differentiation:**	
4.1	Analytic functions, C-R equations and properties	2
4.2	Harmonic Functions and Milne-Thompson Method	2
4.3	Applications to flow problems	1
4.4	Conformal maps and bilinear transformations	2
4.5	Applications of the bilinear transformations	1
5.	**Complex Integration**	
5.1	Cauchy’s theorem and consequences	1
5.2	Evaluating integrals using Cauchy’s integral formula	2
5.3	Taylor and Laurent expansions	1
5.4	Singularities, poles and Cauchy residue theorem	2
5.5	Contour integration using unit circle and semicircular contours	2
	Total	**40**

Syllabus

Functions of Several Variables: Partial derivatives and Jacobians, Total differentiation and applications, Lagrangian Multiplier method, Applications to Maxima and Minima **Multiple Integrals:** Double integrals and areas, Triple integrals and volumes, Change of order of integration, Beta and Gamma functions with applications, Change of variables between Cartesian and polar with applications **Vector calculus:** Vector Differentiation with simple applications, Operators Grad, div and curl with properties, Applications to Physics, Vector Integration(three famous theorems), Applications to areas and volumes **Complex Differentiation:** Analytic functions, C-R equations and properties, Harmonic Functions and Milne-Thompson Method, Applications to flow problems, Conformal maps and bilinear transformations, Applications of the bilinear transformations **Complex Integration:** Cauchy’s theorem and consequences, Evaluating integrals using Cauchy’s integral formula, Taylor and Laurent expansions, Singularities, poles and Cauchy residue theorem, Contour integration using unit circle and semicircular contours

Text Book

Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edn. John Wiley & Sons,2009

References

1. Veerarajan T., Engineering Mathematics, 3rd Edn., Tata McGraw Hill, New Delhi, 2004
2. Venkataraman M.K., Multiple Integrals and Gamma, Beta functions, National Publishing Czigo., 2004
3. B.S. Grewal: Higher Engineering Mathematics, 39th Edn., Khanna Publishers, New Delhi,2006
4. Thomas Phinny, Calculus,13th Edition Pearson Education, New Delhi,2005

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Sub Code	Lectures	Tutorial	Practical	Credit
G 22	3	1	-	4

G22 Free Body Mechanics 3:1

Preamble: Mechanics is the branch of physics concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effect of the bodies on their environment. The discipline has its roots in several ancient civilizations. Scientists such as Galileo, Kepler and especially Newton, during the early modern period, laid the foundation for what is now known as classical mechanics. The major division of the mechanics discipline separates classical mechanics from quantum mechanics. Both are commonly held to constitute the most certain knowledge that exists about physical nature. Quantum mechanics is of a wider scope, as it encompasses classical mechanics as a sub-discipline which applies under certain restricted circumstances. There is no contradiction or conflict between the two subjects, each simply pertains to specific situations. Quantum mechanics has superseded classical mechanics at foundational level and is indispensable for the explanation and prediction of processes at molecular and (sub) atomic level. However, for macroscopical processes classical mechanics is able to solve problems which are unmanageably difficult in quantum mechanics and hence remains useful and well used.

The often-used term 'body' in the field of mechanics stands for a wide assortment of objects, including particles, projectiles, spacecraft, stars, parts of machinery, parts of solid, parts of fluids (gases and liquids) etc. Distinctions between the various sub-disciplines of mechanics, concern the nature of the bodies being described. Sub-disciplines of mechanics include Newtonian mechanics (dynamics, theory of motion and forces), Lagrangian mechanics (a theoretical formalism based on the principle of conservation of energy), Hamiltonian mechanics (another theoretical formalism based on the principle of the least action), Celestial mechanics (the motion of heavenly bodies: planets, comets, stars, galaxies, etc.), Astrodynamics (spacecraft navigation etc.), Solid mechanics (properties of rigid bodies), Elasticity (properties of semi-rigid bodies), Acoustics (density variation propagation in solids, fluids and gases), Statics (semi-rigid bodies in (mechanical equilibrium), Fluid mechanics (the motion of fluids), Soil mechanics (mechanical behavior of soils), Continuum mechanics (mechanics of continua - both solid and fluid), Hydraulics (mechanical properties of liquids), Fluid statics (liquids in equilibrium)

Program outcomes addressed

a. An ability to apply knowledge of engineering, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

d. An ability to identify, formulate and solve engineering problems

Competencies: At the end of the course the student should be able to

1. Solve problems in engineering systems using the concept of static equilibrium
2. Determine the centroid of a line, areas, and volumes, center of mass of body and moment of inertia of composite areas.
3. Understand the phenomena of friction and solve problems involving frictional phenomena in machines
4. Understand the concept and principle of virtual work
5. Solve problems involving kinematics and kinetics of particles in two- and three-dimensions
6. Solve problems involving kinematics and kinetics of rigid bodies in plane motion.
7. Solve problems involving three-dimensional dynamics of rigid bodies using angular momentum and energy equation

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	10	0
2	Understand	20	20	20
3	Apply	60	70	80
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Remember

1. What is equilibrium of mechanical system?
2. Define centroid of gravity
3. Locate the centroid of a semicircle
4. State parallel – axis theorem
5. Define couple and its characteristics
6. What are the conditions of equilibrium of rigid body in three dimensions?
7. Define variable acceleration give example
8. Define the term relative velocity

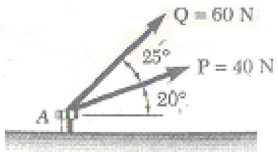
9. Describe the dynamic equilibrium of a rigid boy in plane motion
10. State the Newton's law of motion

Understand

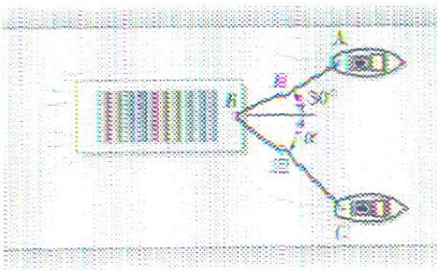
1. How do you resolve a force system into rectangular components?
2. What is meant by resultant force?
3. Distinguish between static friction and dynamic friction.
4. Write down the equation of polar moment of inertia of a circular section?
5. Differentiate between fixed beam and overhanging beam.
6. What do you meant by virtual work?
7. Distinguish between rectilinear motion and curvilinear motion.
8. Why dynamic equilibrium is necessary for a mechanical system?
9. What is meant by uniformly accelerated motion?
10. State impulse momentum principle.

Apply

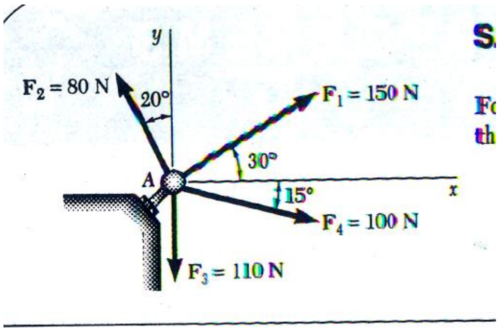
1. Determine the resultant of two force P and Q act on a bolt A



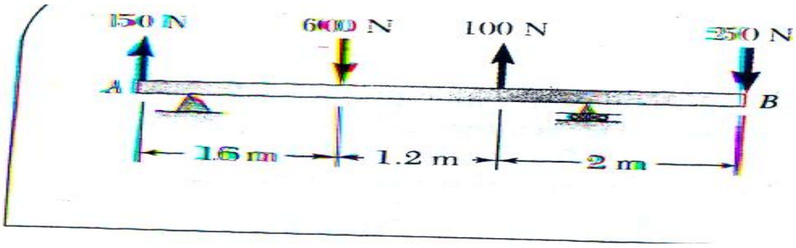
2. A barge is pulled by two tugboats. If the resultant of the forces exerted by the tugboats is a 5000 N force directed along the axis if the barge, determine the a) the tension in each of the ropes knowing that ɑ = 45° b) the value of ɑ for which the tension in rope 2 is minimum.



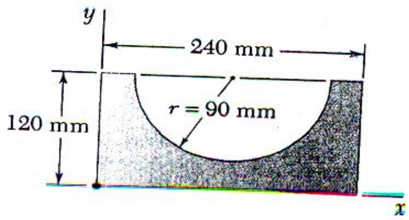
3. Four forces act on bolt A shown, Determine the resultant of the forces on the bolt,



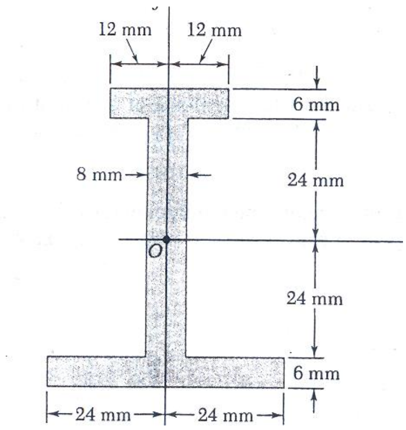
4. A 4.8 m long beam is subjected to the force shown. Reduce the given system of forces to a) an equivalent force couple system at a b) an equivalent force couple system at B, c) a single force of resultant.
Note: since the reaction at the supports are not included in the given system of forces



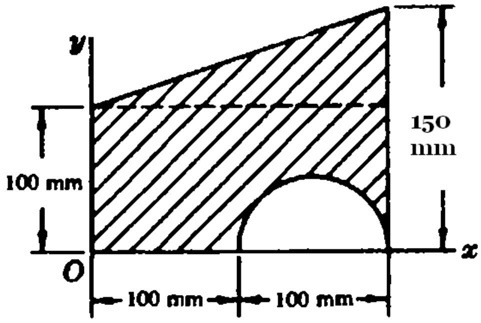
5. Determine the moment of inertia of the shaded are with respect to the x axis



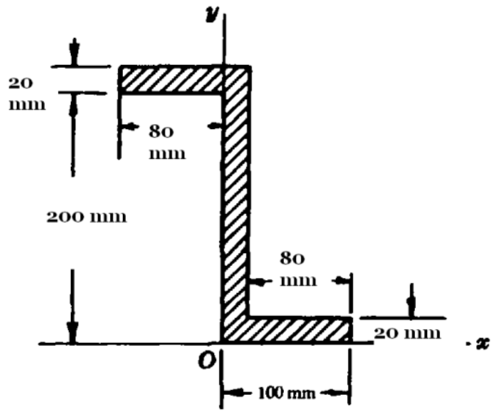
6. Determine the moment of inertia and radius of gyration of the shaded are with respect to the x axis



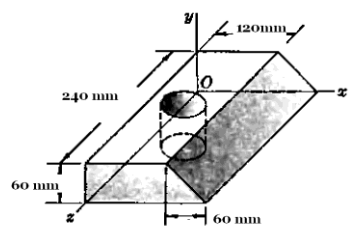
7. A semicircular area is removed from the trapezoid as shown in Fig. Determine the centroid of the remaining area.



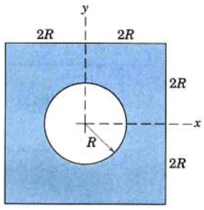
8. Locate the centroid of the given figure with respect to the axes



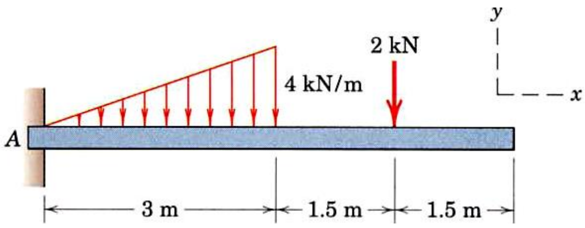
9. Locate the centre of gravity along x-direction of the composite volume shown in Figure . The 40-mm hole is drilled in the centre of the top face and is normal to that face.



10. A semicircular area is removed from the trapezoid as shown in Figure 6. Determine the centroid of the remaining area.



11. Determine the reactions at A for the beam subjected to the following load distribution (figure 1)

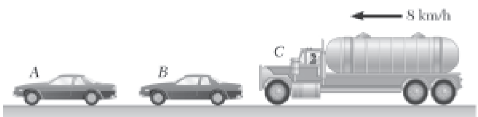


12. A Stone is thrown vertically upwards with a velocity of 40 m/sec. Find its position after 5 seconds.

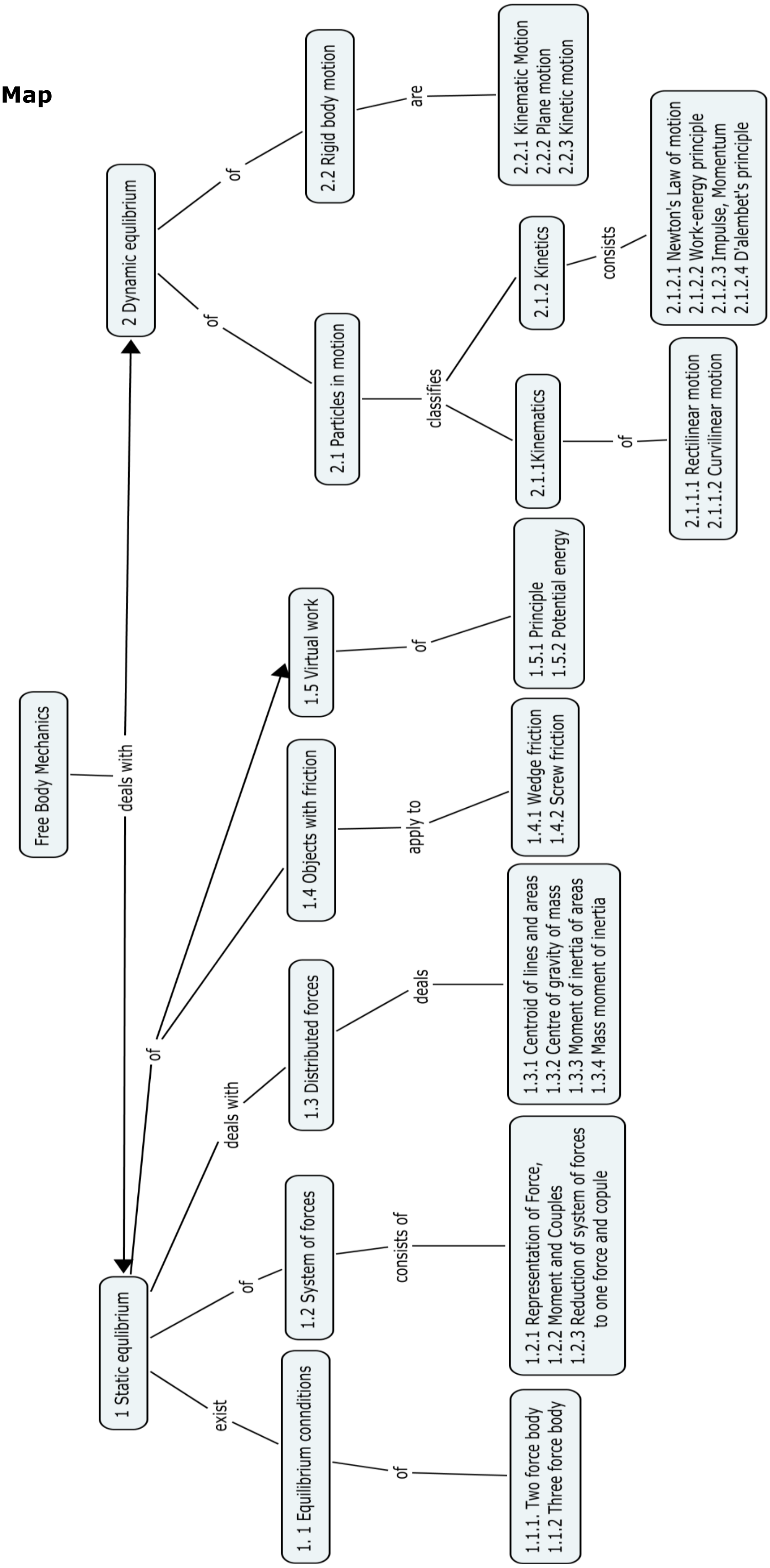
13. A body of mass 4 kg lying on a rough horizontal plane is attached to one end of a string. The string passes over a smooth pulley and carries at its other end, a body of mass 10 kg which hangs freely vertically down. If the system starts from rest and attains an acceleration of 6 m/s^2 m, find the coefficient of friction.

14. A flywheel executes 1800 revolutions while it coasts to rest from speed of 6000 rpm. Assuming uniformly accelerated motion, determine (*a*) the time required for the flywheel to coast to rest, (*b*) the time required for the flywheel to execute the first 900 revolutions.

15. Two identical 1350-kg automobiles *A* and *B* are at rest with their brakes released when *B* is struck by a 5400-kg truck *C* which is moving to the left at 8 km/h. A second collision then occurs when *B* strikes *A*.Assuming the first collision is perfectly plastic and the second collision is perfectly elastic, determine the velocities of the three vehicles just after the second collision.



Concept Map


Free Body Mechanics
deals with
1 Static equlibrium
2 Dynamic equlibrium
exist
1. 1 Equilibrium conditions
of
1.1.1. Two force body
1.1.2 Three force body
of
1.2 System of forces
consists of
1.2.1 Representation of Force,
1.2.2 Moment and Couples
1.2.3 Reduction of system of forces to one force and copule
deals with
1.3 Distributed forces
deals
1.3.1 Centroid of lines and areas
1.3.2 Centre of gravity of mass
1.3.3 Moment of inertia of areas
1.3.4 Mass moment of inertia
of
1.4 Objects with friction
apply to
1.4.1 Wedge friction
1.4.2 Screw friction
1.5 Virtual work
of
1.5.1 Principle
1.5.2 Potential energy
of
2.1 Particles in motion
classifies
2.1.1Kinematics
of
2.1.1.1 Rectilinear motion
2.1.1.2 Curvilinear motion
2.1.2 Kinetics
consists
2.1.2.1 Newton's Law of motion
2.1.2.2 Work-energy principle
2.1.2.3 Impulse, Momentum
2.1.2.4 D'alembet's principle
of
2.2 Rigid body motion
are
2.2.1 Kinematic Motion
2.2.2 Plane motion
2.2.3 Kinetic motion

Syllabus

Static Equilibrium of Mechanical Systems: Equilibrium conditions-Two force body-Three force body. **System of forces**: Representation of Force, Moment and Couples-Reduction of system of forces to one force and couple. **Distributed forces:** Centroid of lines and areas-Centre of gravity of mass-Moment of inertia of areas-Mass moment of inertia. **Objects with friction**: Wedge friction-Screw friction-Virtual work-Principle of virtual work-Potential energy. **Dynamic equilibrium:** Particles in motion-Kinematics of particles-Rectilinear motion-Curvilinear motion-Kinetics of particles-Newton's Law of motion-Work-energy principle-Impulse-Momentum principle, D'Alembert's principle. **Rigid body motion:** Kinematic Motion-Plane motion-Kinetic motion.

Textbooks

1. Beer F.P. and Johnston Jr. E.R., **Vector Mechanics for Engineers: Statics and Dynamics**, Eighth Edition, Tata McGraw Hill, 2008.
2. Meriam J.L and Kraig L.G, 'Engineering **Mechanics-Statics and Dynamics**, John Wiley & sons, Newyork, 2008.

Reference Books

1. Boresi A.P. and Schmidt R.J**.: Engineering Mechanics and Dynamics**, Thomson Asia Press, Singapore, 2004
2. Shames, I.H**.: Engineering Mechanics – Statics and Dynamics**, Pearson Education, Asia,2006
3. Palanichamy and Nagan S. **Engineering Mechanics – Statics and Dynamics**, Tata McGraw Hill, 2005
4. Lakshmana Rao**: Engineering Mechanics– Statics and Dynamics**, Prentice Hall of India, New Delhi, 2003
5. Timoshenko, S, Young, D, Rao, J, **Engineering Mechanics**, Fourth Edition, Tata McGraw Hill, 2006

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Static Equilibrium of Mechanical Systems**	
1.1	Equilibrium conditions	1
1.1.1	Two force body	
1.1.2	Three force body	1
1.2	**System of forces**	
1.2.1	Representation of Force,	2
1.2.2	Moment and Couples	2
1.2.3	Reduction of system of forces to one force and couple	1

1.3	**Distributed forces**	
1.3.1	Centroid of lines and areas	2
1.3.2	Centre of gravity of mass	2
1.3.3	Moment of inertia of areas	2
1.3.4	Mass moment of inertia	2
1.4	**Objects with friction**	
1.4.1	Wedge friction	2
1.4.2	Screw friction	2
1.5	**Virtual work**	
1.5.1	Principle of virtual work	1
1.5.2	Potential energy	2
2	**Dynamic equilibrium**	
2.1	**Particles in motion**	
2.1.1	Kinematics of particles	1
2.1.1.1	Rectilinear motion	1
2.1.1.2	Curvilinear motion	1
2.1.2	Kinetics of particles	2
2.1.2.1	Newton's Law of motion	2
2.1.2.2	Work-energy principle	2
2.1.2.3	Impulse, Momentum	2
2.1.2.4	D'Alembert's principle	1
2.2	**Rigid body motion**	
2.2.1	Kinematic Motion	2
2.2.2	Plane motion	2
2.2.3	Kinetic motion	2
	Total	**40**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 23	3	-	-	3

G23 Materials Science 3:0

Preamble

Materials science is an interdisciplinary field involving the properties of matter and its applications to various areas of science and engineering. This scientific field investigates the relationship between the structure of materials at atomic or molecular scales and their macroscopic properties. It incorporates elements of applied physics and chemistry. Materials science also deals with fundamental properties and characteristics of materials. This course work aims at imparting the fundamental knowledge on Fundamentals and Classification of Materials, Properties of Bulk Materials, Strengthening Mechanism in Metals, Phase Diagram and Characterization.

Program Outcomes Addressed

a. An ability to apply knowledge of engineering, mathematics and science with respect to Materials Science

Competencies:

1. Explain the various types of materials and its applications.
2. Explain the various crystal systems, crystal structures and slip systems.
3. Explain the physics of properties of materials.
4. Explain the various strengthening mechanisms involved in materials.
5. Explain the role of binary phase diagram in material selection.
6. Select the characterization tools for materials.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	20
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define ceramic and give two examples of ceramic.
2. What are nanomaterials.

3. Define magnetic susceptibility, permeability and magnetic moment.
4. Define coefficient of thermal expansion.
5. What are dielectric constant, dielectric loss and dielectric breakdown?
6. What you mean by hardness, ductility, brittleness, fatigue strength, creep resistance?
7. Define vacancy. Give an example for vacancy
8. Define recrystallisation.
9. What is Hume Rothery Rule of solid solutions?
10. What is the principle of scanning electron microscope?

Understand

1. Differentiate between metals, polymers and ceramics on the basis of thermal conductivity.
2. Derive the packing fraction of an FCC crystal and give examples for FCC.
3. Explain the hysteresis curve for ferromagnetic materials.
4. With a neat diagram explain the tensile testing of materials. What are the mechanical properties obtained from a tensile test?
5. Explain the various stages involved in a creep curve and what are the factors affecting creep.
6. With a neat diagram explain edge dislocation and screw dislocation.
7. Explain the various types of point defects involved in metals.
8. With a neat diagram explain the X-ray diffraction and how will you detect the crystal structure from XRD pattern.
9. Explain the construction and working of Scanning Electron microscope.

Apply

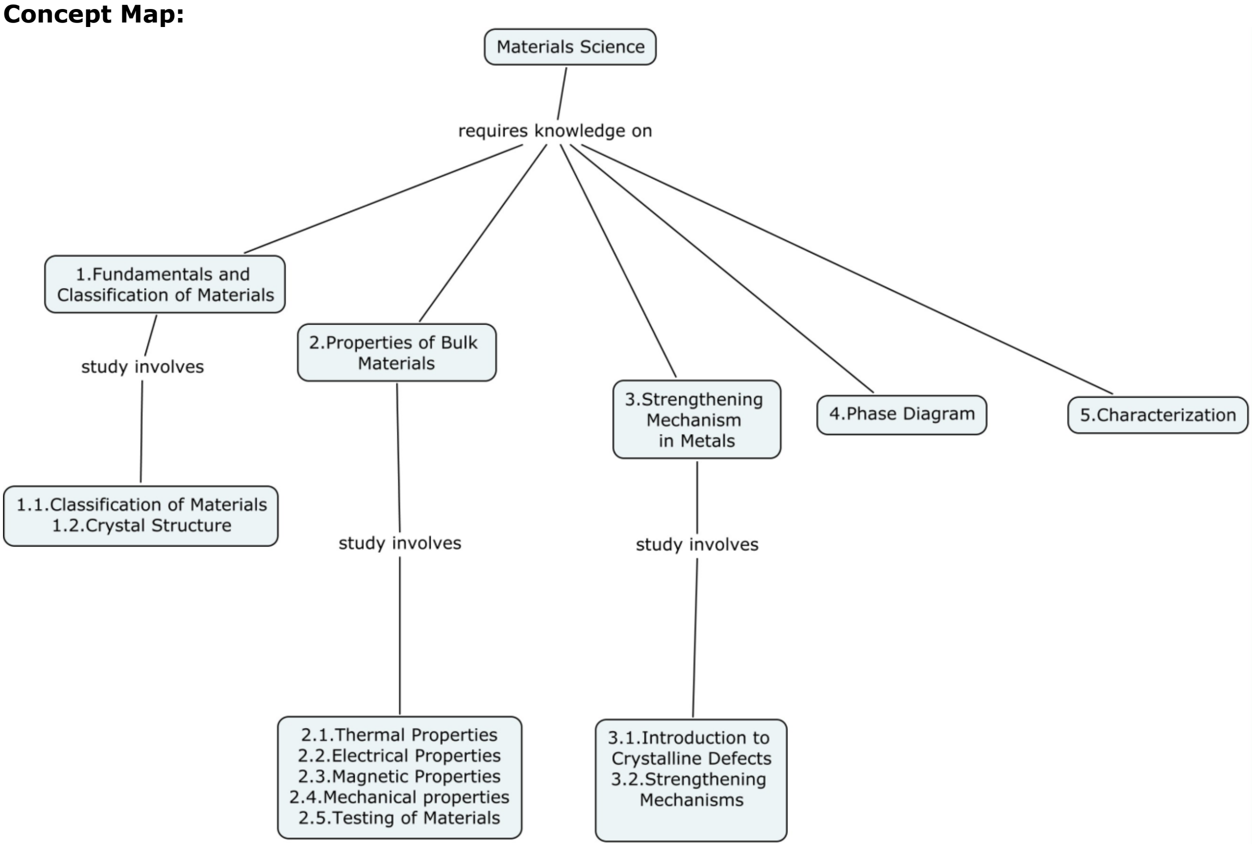
1. The lattice parameter of Cu is 1.28A. Calculate the atomic radius, volume of unit cell, packing fraction of Cu.
2. For aluminium, the heat capacity at constant volume C_v at 30 K is 0.81 J/mol-K and the Debye temperature is 375 K. Estimate the specific heat a) at 50 K and b) at 425 K.
3. The magnetization within a bar of some metal alloy is $1.2X10^6$ A/m at an H field of 200 A/m. Compute a) the magnetic susceptibility, b) the permeability and c) the magnetic flux density within this material. What type of magnetism would you suggest as being displayed by this material? Why?

4. What is the wavelength of an electron if it is accelerated by a potential difference of 100 KV ?

Analyze

1. Estimate the thermal conductivity of copper at 40° C from its electrical conductivity?
2. What are the interpretations of a Cu-Ni binary phase diagram?
3. Differentiate between ductile and brittle fracture with respect to fracture surface. How will you estimate a ductile or brittle fracture from a stress-strain curve?
4. How will you determine the nature of magnetic material from the hysterisis loop?.Suggest few applications based on hysterisis loop.
5. What are the parameters you can estimate from an XRD pattern.

Concept Map:



Syllabus

Fundamentals and Classification of Materials. Classification of Materials: Metals and alloys, Polymers, Ceramics and Composites. Crystal structure: Unit cell, Single and Polycrystalline Materials, Miller Indices, Bravias lattice, crystal systems, SC, BCC, FCC and HCP, Structure of diamond Polymorphism and Allotropy and nano materials.

Properties of Bulk Materials. Thermal Properties: Expansion, Heat Capacity and Conductivity. Electrical Properties: Conductivity, Dielectric Constant, Dielectric Strength, Dielectric Loss and Dielectric Breakdown. Magnetic Properties: Permeability, Hysteresis, Susceptibility and Magnetic Intensity. Mechanical Properties: Concept of Stress and Strain, Elastic and Plastic Deformation, Hardness, Tensile Strength, Fatigue, Creep, Toughness and Wear. Testing of Materials: Brinell, Vickers and Rockwell Hardness test, Tension test, Creep test, Fracture toughness test and RB Fatigue test.

Strengthening Mechanism: Introduction to crystalline defects: Point, Line, Surface and Volume Defect, Dislocation and Plastic Deformation, Basic Concept and characteristics of Dislocation, Slip systems, Slip in single Crystals, Plastic Deformation of Polycrystalline Materials, Deformation by Twinning. Strengthening mechanisms: Solid solution strengthening, Strengthening by Grain Size Reduction - Recovery, Recrystallization and Grain Growth, Strain Hardening and Precipitation Hardening.

Phase Diagram

Vegards law, Hume Rothery rule, Solid Solutions and Intermetalic Compounds. Solubility Limit, Phases, Micro Structure, Phase Equilibrium, One component Phase Diagram, Gibbs phase rule, Lever Rule, Introduction to Binary Phase Diagram (Cu-Ni), Interpretations of Phase Diagram.

Characterization

Optical Microscopy. X-Ray Diffraction. Electron Microscopy.

Text Book:

1. Callister W. D., Materials Science and Engineering, John Wiley & Sons, 2007

Reference books:

2. Van Vlack L.H., Elements of Materials Science and Engineering, 6th Edition, Addison-Wesley, 1989
3. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata McGraw Hill Private Limited, 4th Edition, 2008.
4. George T. Austin, Shreve's Chemical Process Industries, McGraw Hill International, 5th Edition, 1984.

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Fundamentals and Classification Of Materials**	
1.1	Classification of Materials: Metals and alloys, Polymers, Ceramics and Composites	3
1.2	Crystal structure: Unit cell, Single and Polycrystalline Materials, Miller Indices, Bravias lattice, crystal systems, SC, BCC, FCC and HCP, Structure of diamond, Polymorphism and Allotropy and nano materials	6
2	**Properties of Bulk Materials**	
2.1	Thermal Properties: Expansion, Heat Capacity and Conductivity	2
2.2	Electrical Properties: Conductivity, Dielectric Constant, Dielectric Strength, Dielectric Loss and Dielectric Breakdown	2
2.3	Magnetic Properties: Permeability, Hysteresis, Susceptibility and Magnetic Intensity	2
2.4	Mechanical Properties: Concept of Stress and Strain, Elastic and Plastic Deformation, Hardness, Tensile Strength, Fatigue, Creep, Toughness and Wear	5
2.5	Testing of Materials: Brinell, Vickers and Rockwell Hardness test, Tension test, Creep test, Fracture toughness test and RB Fatigue test.	4
3	**Strengthening Mechanism**	
3.1	Introduction to crystalline defects: Point, Line, Surface and Volume Defect, Dislocation and Plastic Deformation, Basic Concept and characteristics of Dislocation, Slip systems, Slip in single Crystals, Plastic Deformation of Polycrystalline Materials, Deformation by Twinning	4
3.2	Strengthening mechanisms: Solid solution strengthening, Strengthening by Grain Size Reduction - Recovery, Recrystallization and Grain Growth, Strain Hardening and Precipitation Hardening	4
4	**Phase Diagram**	
4.1	Vegards law, Hume Rothery rule, Solid Solutions and Intermetalic Compounds	4
4.2	Solubility Limit, Phases, Micro Structure, Phase Equilibrium, One component Phase Diagram, Gibbs phase rule, Lever Rule, Introduction to Binary Phase Diagram (Cu-Ni), Interpretations of Phase Diagram	4
5	**Characterization**	

No.	Topic	No. of Lectures
1	**Fundamentals and Classification Of Materials**	
1.1	Classification of Materials: Metals and alloys, Polymers, Ceramics and Composites	3
1.2	Crystal structure: Unit cell, Single and Polycrystalline Materials, Miller Indices, Bravias lattice, crystal systems, SC, BCC, FCC and HCP, Structure of diamond, Polymorphism and Allotropy and nano materials	6
5.1	Optical Microscopy	2
5.2	X-Ray Diffraction	2
5.3	Electron Microscopy	2
	Total	46

Course Designers:

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4. Dr.T.Sornakumar tskmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
G 24	3	1	-	4

G24 Thermodynamics 3:1

Preamble:

Thermodynamics is a branch of science that deals with energy and its transfer. All activities in nature involve some interaction between energy and matter; thus it is hard to imagine an area that does not relate to thermodynamics in some manner. On a large scale, thermodynamics plays a major part in the design and analysis of automotive engines, rockets, jet engines, refrigeration and air-conditioning systems, and power plants. Therefore, developing a good understanding of the basic principles of thermodynamics is essential for mechanical engineers. This course deals with the basic principles and concepts of thermodynamics, laws of thermodynamics, entropy, steam, and air-water mixtures.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

Competencies

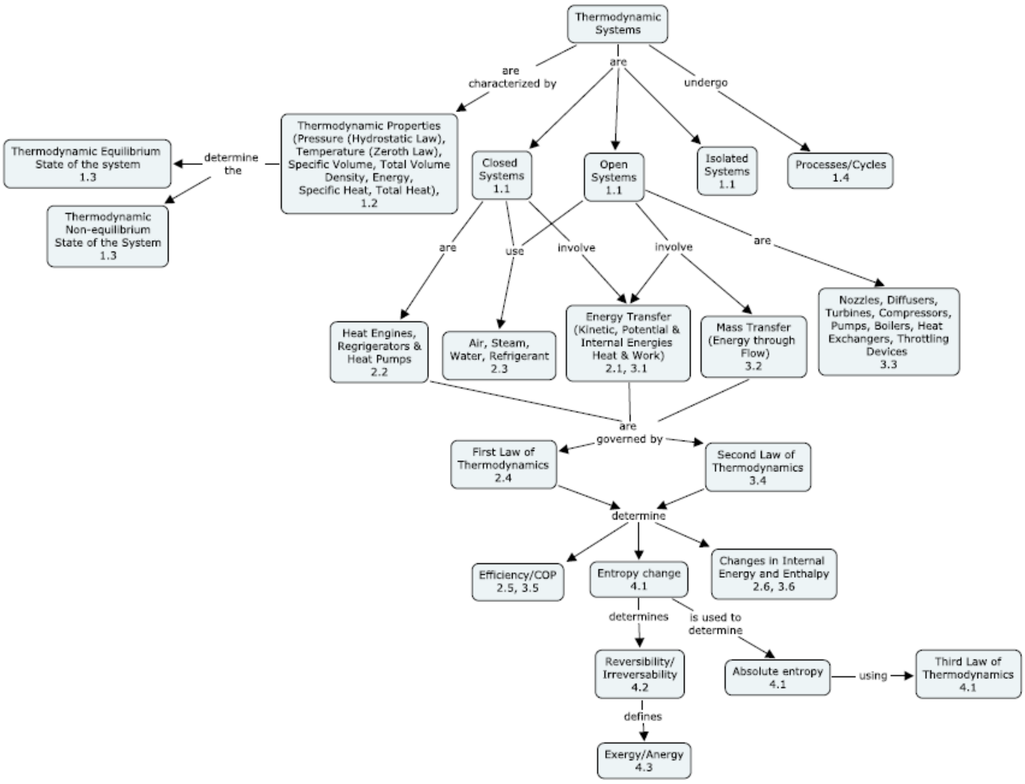
Comprehend the role of laws of thermodynamics.

1. Determine the energy transfer (work transfer and heat transfer), and change in properties of working fluids in thermodynamically closed systems like piston-cylinder arrangement, and thermometer
2. Determine the energy transfer (work transfer and heat transfer) and change in properties of working fluids in thermodynamically open systems like nozzles, diffusers, turbines, compressors, pumps, heat engines, heat exchangers, boilers, refrigerators, heat pumps and air-conditioners.
3. Determine the efficiency and entropy change in reversible and irreversible processes and cycles.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	10
2	Understand	30	30	30
3	Apply	30	30	40
4	Analyze	20	20	20
5	Evaluation	0	0	0
6	Create	0	0	0

Concept Map



Syllabus

Thermodynamic Systems: Open, Closed and Isolated Systems, Thermodynamic Properties (Hydrostatic Law and Zeroth Law), Equilibrium and Non-equilibrium States of Systems, Cyclic and non cyclic Thermodynamic Processes **Thermodynamically Closed Systems:** Energy Transfer, Heat and Work in Thermodynamically closed Systems, Heat Engines, Refrigerators and Heat Pumps, Properties of gases and steam - Ideal gas and real gas, definition and ideal gas law, Water/steam-sensible heat and later heat and Refrigerants – Physical and Chemical Properties First law of Thermodynamics, Changes in Internal Energy **Thermodynamically Open Systems:** Energy Transfer, Heat and Work in Thermodynamically Open Systems, Mass Transfer in Thermodynamically Open Systems; First law - Nozzles, Diffusers, Turbines, Compressors, Pumps, Boilers, Heat Exchangers and Throttling Devices, Changes in Internal Energy and Enthalpy **Second Law of Thermodynamics:** Second Law of Thermodynamics Carnot Cycle, Efficiency and COP **Entropy:** Entropy and Third Law of Thermodynamics, Reversibility/Irreversibility, Exergy/Anergy, Entropy of Gases and Steam.

TEXT BOOKS

1. Yunus A. Cengel and Michael A. Boles, "Thermodynamics: An Engineering Approach", Second edition, McGraw Hill, 2001.

REFERENCES

1. Richard E. Sonntag, Claus Borgnakke, Gordon J. Vanwylen, "Fundamental of Thermodynamics", Wiley, 2002.
2. Rayner Joel, "Basic Engineering Thermodynamics in SI units" ELBS, 1998.
3. Nag, P.K., 'Engineering Thermodynamics", Tata McGraw Hill, 1997.
4. Venkatesh, A. "Basic Engineering Thermodynamics", University Press, 2007.
5. Valan Arasu, A. "Engineering Thermodynamics", Vijay Nicole Imprints Pvt. Ltd., Chennai, 2006.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Thermodynamic Systems**	
1.1	Open, Closed and Isolated Systems	2
1.2	Thermodynamic Properties (Hydrostatic Law and Zeroth Law)	2
1.3	Equilibrium and Non-equilibrium States of Systems	1
1.4	Cyclic and non cyclic Thermodynamic Processes	2
2.	**Thermodynamically Closed Systems**	
2.1	Energy Transfer, Heat and Work in Thermodynamically Closed Systems	3
2.2	Heat Engines, Refrigerators and Heat Pumps	2
2.3	Properties of gases and steam	
2.3.1	Ideal gas and real gas-definition and ideal gas law	1
2.3.2	Water/steam-sensible heat and later heat	1
2.3.3	Refrigerants – Physical and Chemical Properties	1
2.4	First law of Thermodynamics	1
2.5	Changes in Internal Energy	1

No.	Topic	No. of Lectures
3.	**Thermodynamically Open Systems**	
3.1	Energy Transfer, Heat and Work in Thermodynamically Open Systems	2
3.2	Mass Transfer in Thermodynamically Open Systems, First law of thermodynamics	1
3.3	First law – Nozzles, Diffusers, Turbines, Compressors, Pumps, Boilers, Heat Exchangers and Throttling Devices	3
3.4	Changes in Internal Energy and Enthalpy	2
4.	**Second Law of Thermodynamics**	
4.1	Second Law of Thermodynamics, Carnot Cycle	3
4.2	Efficiency and COP	1
5.	**Entropy**	
5.1	Entropy, Third Law of Thermodynamics, and Entropy of steam	
5.1.1	Entropy	2
5.1.2	Third Law of Thermodynamics	1
5.1.3	Entropy of Gases and Steam	4
5.2	Reversibility/Irreversibility	2
5.3	Exergy/Anergy	2
	Total	**40**

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 25	2	-	-	2

G25 Environment and Ecology 2.0

Preamble

Ecology and Environment is a subject carries too much of importance in the modern world. The basic knowledge on environment is an absolute necessity for all citizens. This course work aims at imparting the fundamental knowledge on Environmental science which includes natural resources and their exploitation, Ecosystem, Biodiversity and its conservation and Environmental pollution.

Programme outcomes addressed

(a) Graduates will demonstrate knowledge of science and engineering

(i) ability to consider social, environmental, economic and ethical impact of engineering activities in a given context

Competencies

At the end of the course the student should be able to

1. realize that who is also one of the components of the ecosystem like any other species.
2. explain the significance of conservation of natural resources.
3. appreciate the values of biodiversity and the necessity of its conservation.
4. find out the various sources, effects and control measures of environmental pollution.
5. deliver the best individually towards environment sustainability.

Assessment Pattern

S.No	**Bloom's Category**	**Test- I**	**Test - II**	**Test – III End semester Exam**
1	Remember	20	20	20
2	Understand	60	80	60
3	Apply	20	-	20
4	Analyze	-	-	-
5	Evaluate	-	-	-
6	Create	-	-	-

Course level learning objectives

Remember

1. What is water logging?
2. What are the uses of forest resource?
3. List renewable and non renewable energy sources.
4. What is soil erosion?
5. Define land degradation.
6. What are the components of an ecosystem?
7. What is an ecological pyramid?
8. Define Food chain and Food web.
9. Define genetic diversity and species diversity.
10. Define ethical value of biodiversity.
11. What are hot spots of biodiversity?
12. Define endangered species.

Understand

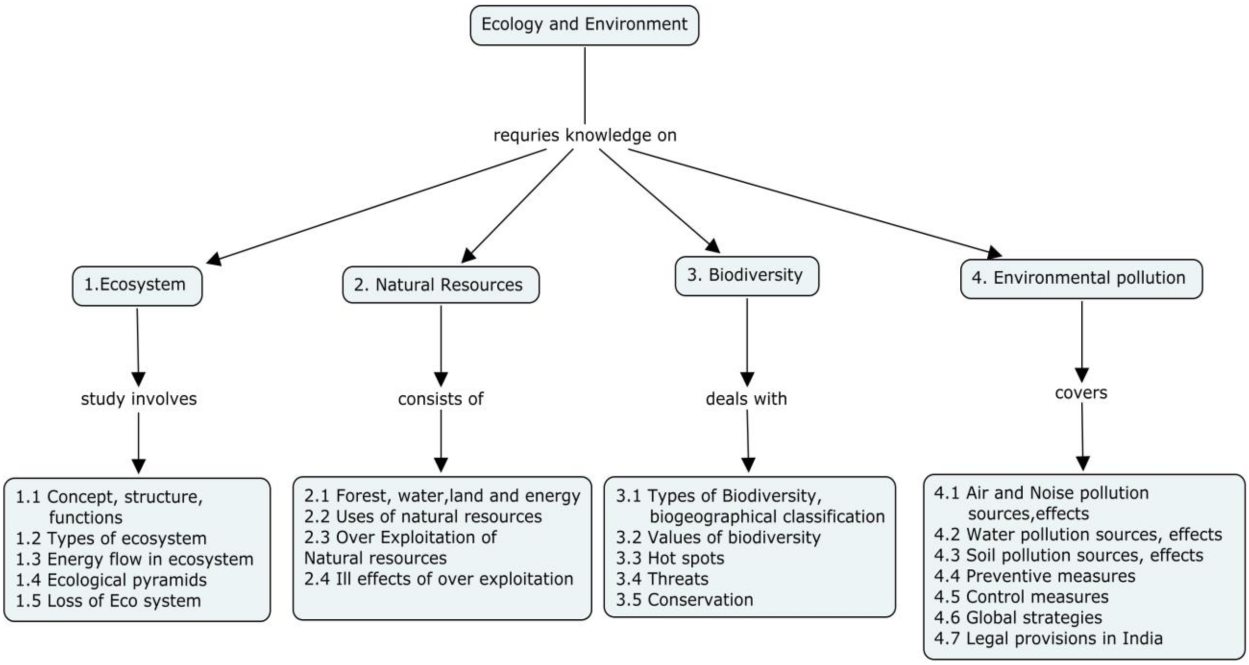
1. How do Floods and droughts are caused?
2. How do modern agricultural practices bring environmental problems?
3. How salinity is caused on a land?
4. What are the factors influencing soil erosion?
5. How desertification is caused?
6. What are the roles of decomposers in an ecosystem?
7. What are the different stages of ecological succession?
8. What are the needs for biodiversity conservation?
9. What are the ill effects of air pollution?
10. What are the sources of water pollution?
11. How pollutants in water affect its beneficial uses?
12. Why do we need a good solid waste management for a city?

Apply

1. How do over exploitation of natural resources affects survival of future generation?
2. How energy flow is taking place in an ecosystem? Explain.
3. Complex food webs in an ecosystem is most desirable – Explain.
4. Rich biodiversity in an eco system is so beneficial – How?
5. How could man – animal conflict be avoided?
6. How air pollution could be controlled using equipments?
7. Why rain water harvesting is to be given importance?

8. As an individual, how could you contribute to reduce environmental degradation?

Concept Map



Course content and Lecture schedule

S.No	Topics	Periods
1	**Ecosystem**	
1.1	Ecosystem-concept, structure, functions	1
1.2	Types of ecosystem-Forest, grass land, aquatic, desert	1
1.3	Food chain, Food webs, energy flow in ecosystem – biogeochemical cycles	1
1.4	Human intervention in ecological balance	1
1.5	Ecological pyramids, Loss of Eco system	1
2	**Natural resources**	
2.1	Types of natural resources -Forest-Water-Energy-Land	1
2.2	Uses of forest - uses of water-utilization of energy-exploitation of land	1
2.3	Over Exploitation of Natural resources - Deforestation, Water Scarcity, Water logging, land Salinity, Land degradation and energy crisis	2

2.4	Methods of conservation of natural resources - Afforestation, Rain water harvesting, Water conservation, alternate and renewable energy sources	1
3	**Biodiversity and its conservation**	
3.1	Biodiversity-types, biogeographical classification in India	1
3.2	Direct and Indirect values of biodiversity	1
3.3	Hot spots of biodiversity, global and Indian scenario	1
3.4	Loss of biodiversity-loss of habitat, poaching, man-wild life conflicts	1
3.5	Endangered species, vulnerable, rare and extinct species	1
3.6	In - situ and Ex - situ ways of conserving Biodiversity	1
4	**Environmental pollution**	
4.1	Environmental pollution, types	1
4.2	Air pollution - types of air pollutants – sources of air pollutants	1
4.3	Effects of air pollution – indoor air pollution – Noise pollution – sources and effects	1
4.4	Water pollution – Water pollutants – sources of water pollutants – effects of water pollution	1
4.5	Soil pollution – sources and effects	1
4.6	Global environmental problems – global warming – green house gases – ozone layer depletion	1
4.7	Preventive measures - Green technologies-green building concepts.	1
4.8	Use of alternate materials, cleaner production, Reduce, Recycle and Reuse concepts. Public awareness, mass transport system, reduced consumerism	1
4.9	Air pollution control-use of equipments, dilution, zoning. Noise control-noise reduction by design, isolation and noise absorption	1
4.10	Water pollution control-treatment of sewage and industrial effluent	1

4.11	Soil pollution control -solid waste management, organic farming	1
4.12	International strategies to control pollution – Rio conference, Kyoto protocol, WSSD, Copenhagen summit	1
4.13	Legal provisions in India - Air pollution control act, water act, Hazardous wastes rules, municipal solid waste rules,	1
4.14	Environment protection act, wild life protection act, forest conservation act, biological diversity act	1
	Total	**30**

Syllabus

Ecosystem-concept, structure, functions. Types of ecosystem-Forest, grass land, aquatic, desert. Food chain, Food webs, energy flow in ecosystem – biogeochemical cycles, ecological pyramids. Human intervention in ecological balance. Loss of Eco system.

Natural resources, types of natural resources -Forest-Water-Energy-Land. Uses of forest - uses of water-utilization of energy-exploitation of land. Over Exploitation of Natural resources - Deforestation, Water Scarcity, Water logging, land Salinity, Land degradation and energy crisis. Methods of conservation of natural resources - Afforestation, Rain water harvesting, Water conservation, alternate and renewable energy sources.

Biodiversity-types, biogeographical classification in India. Direct and Indirect values of biodiversity. Hot spots of biodiversity, global and Indian scenario. Loss of biodiversity-loss of habitat, poaching, man-wild life conflicts. Endangered species, vulnerable, rare and extinct species. In - situ and Ex - situ ways of conserving Biodiversity.

Environmental pollution, types - Air pollution – types of air pollutants – sources of air pollutants – effects of air pollution – indoor air pollution – Noise pollution – sources and effects.Water pollution – Water pollutants – sources of water pollutants – effects of water pollution. Soil pollution – sources and effects. Global environmental problems – global warming – green house gases – ozone layer depletion

Preventive measures - Green technologies-green building concepts, use of alternate materials, cleaner production, Reduce, Recycle and Reuse concepts. Public awareness, mass transport system, reduced consumerism. Air pollution control-use of equipments, dilution, zoning. Noise control-noise reduction by design, isolation and noise absorption. Water pollution control-treatment of sewage and industrial effluent. Soil pollution control -solid waste management, organic farming.

International strategies to control pollution – Rio conference, Kyoto protocol, WSSD, Copenhagen summit. Legal provisions in India - Air pollution control act, water act, Hazardous wastes rules, municipal solid waste rules, environment protection act, wild life protection act, forest conservation act, biological diversity act.

Text book

1. Kaushik and Kaushik, Environmental Science and Engineering, 2nd edition, New age International publishers, New Delhi, 2006.

Reference Books

1. Wright and Nebel, Environmental science towards a sustainable future, Prentice Hall of India Ltd, 2000.
2. S.K. Garg and Garg, Ecological and Environmental studies, khanna publishers, Delhi, 2006.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 26	3	-	-	3

G26 Computers and Programming 3:0

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics, and science

c. An ability to design a system or component, or process to meet stated specifications

Competencies

By the end of the course, the students will:

1. Explain the basics of information technology
2. Analyze the complexity of given requirements & represent the process in a suitable flowchart/DFD
3. Explain the basics of computer programming & apply this knowledge to solve engineering problems.
4. Identify & understand the capabilities of other technologies/tools for analyzing engineering data

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	10
2	Understand	50	20	30
3	Apply	30	60	45
4	Analyze	0	0	15
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:
Remember

1. What is a Computer?
2. Name the different I/O devices used with a computer?
3. What is the difference between system software and application software?
4. List five programming languages commonly used?
5. What is the role of operating system in a computer?
6. What is structured programming?

Understand

1. Describe the history of computers?
2. Differentiate translators with Compilers?
3. Compare while loop with do – while Loop?

4. What are the advantages of using Macro?
5. Explain how recursive functions affect the run time efficiency?
6. Differentiate between Structure and Union in C.

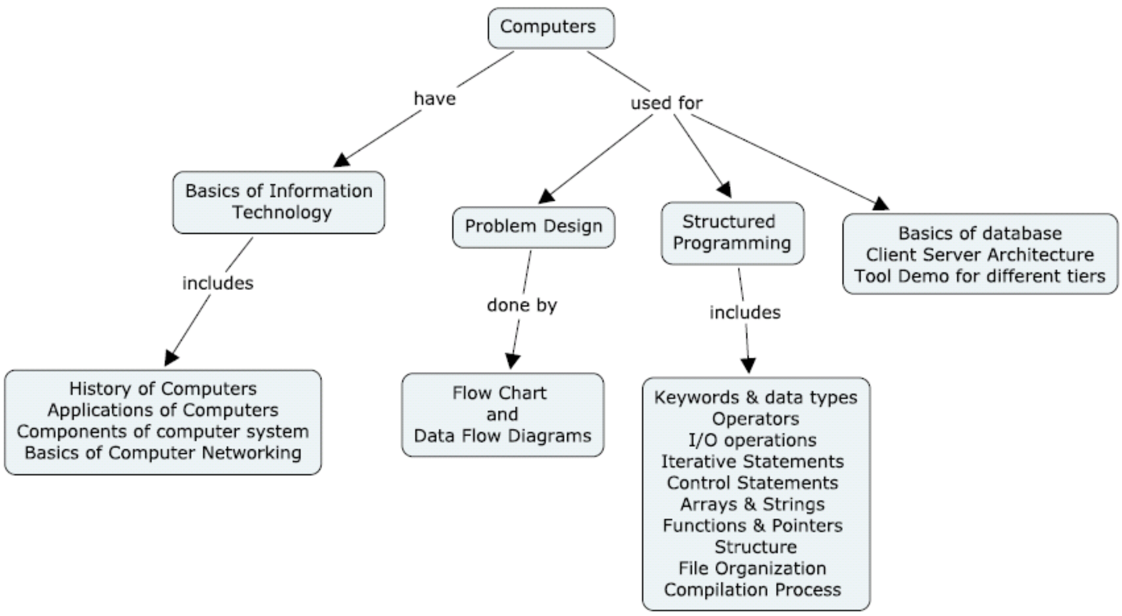
Apply

1. Write a Macro to find the Armstrong number between 1 and 1000?
2. Write a recursive function to calculate the Combinatory of a nCr?
3. Write a program to perform stack operation using pointers?
4. Write a program to perform linked list operation using pointers?
5. Write a program to generate the pay slip of an employee using dangling if – else statement?
6. Write a program to compute Matrix Multiplication using Pointers?

Analyze

1. Explain the difference between the following:
   (i) Program testing and debugging.
   (ii) Top down and bottom up approaches.
   (iii) Interpreted and compiled languages
2. Why are pointers so powerful? Analyze their efficiency giving an example?
3. Are the following statements valid? Justify your answer
   (i) k = (char*)& m
   (ii) m= (float*)& p
4. Is there any advantage of using recursion over looping control structures? Give a suitable example?
5. Differentiate the keywords BREAK and CONTINUE?

Concept Map:



Course contents and Lecture Schedule:

No	Topic	No. of Lectures
1	**Basics of Information Technology**	
1.1	History of Computers	1
1.2	Applications of Computers	1
1.3	Components of computer system	2
1.4	Basics of Computer Networking	4
2	**Problem Design**	
2.1	Flow Chart Symbols	1
2.2	Flow Chart Tutorial	2
2.3	Elements of DFD and various levels	1
2.4	DFD Tutorial	2
3	**Structured Programming Language**	
3.1	Keywords & data types	1
3.2	Operators	1
3.3	I/O operations	1
3.4	Iterative Statements	3
3.5	Control Statements	3
3.6	Arrays	3
3.7	Strings	2
3.8	Functions	4
3.9	Pointers	3
3.10	Structure	3
3.11	File Organization	3
3.12	Compilation Process	1
4	**Advanced Computing Techniques**	
4.1	Basics of database	2
4.2	Client-Server Architecture	1
4.3	Tool Demo for different Tiers	2
	Total No of Hours	47

Syllabus:

Basics of Information Technology: History of Computers-Applications of Computers in Engineering-Components of computer system- Basics of Computer Networking- Basics - Internet, Distributed Computing - Basics of MIS.

Problem Design: Symbols in Flow Chart - Practice flowchart for simple process - Elements of DFD and various levels - Practice & Tutorial on DFD for complex process.

Structured Programming Language: Keywords, Identifiers, constants, variables, various data type, Storage classes - Various operators and operator precedence - Input and Output operations - Iterative statements - Practice on iterative statements - Conditional control statements - Practice on decision controls and case control statements - Array declaration, initialization, array dimensions - Use of arrays in different dimensional problems - String declaration, Initialization, Operations on Strings(Built-in functions) - Function Declaration, Definition, Function call - Function using Call by Value, Scope of the variables in function – Recursion - Pointer Concepts Pointer operators, pointer expressions, Pointer in function call - Structure Concepts Structure definition, initialization of structures, arrays of structures, arrays within Structures, nested structures - Organization of files, file operations - Practice on various I/O operations on sequential and random files - Simple flow of compilation and execution with Assembler, Compiler.

Advanced Computing Techniques:

Need for Data base- Basics of Data Models- Client-Server Architecture and listing of tools available for all tiers - Front-end tools, Middle Tier Tools, Back-end tools, Mobile Computing Tools.

References:

a. Yashavant Kanetkar, **"ANSI C Programming**", Business Promotion Bureau Delhi, 2009.
b. Yashavant Kanetkar, "**Let us C**", 8th Edition, BPB Publications, 2007.
c. E. Balagurusamy, "**Computing Fundamentals & C programming**", Tata McGraw-Hill Publishing Company Ltd., 2008.
d. David Budgen, "**Software Design**", Pearson Education Ltd, 2008.
e. Raj. K. Jain, "**Insight into Flowcharting**", S. Chand & Co., 2000.
f. http://codex.cs.yale.edu/avi/db-book/db4

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G27	-	-	3	1

G27 Strength of Materials and Composite Materials Lab 0:1

Objective: To enable the students to test different materials subjected to different load conditions, and to prepare and test composite materials under different load conditions

List of Experiments

Part A: Strength of Materials (Any six experiments to be conducted)

1. Tension test
2. Ductility test
3. Torsion Test (Both circular and non-circular)
4. Verification of Maxell's Law
5. Bending test
6. Deflection test
7. Spring Test
8. Impact Test
9. Shear and Compression Test

Part B: Composite Materials (Any six experiments to be conducted)

1. Hand lay up method for preparing composites
2. Tensile test on composites
3. Compressive test on composites
4. Three point bending test on composites
5. In plane shear test on composites
6. Determination of fracture toughness
7. Determination of fibre volume fraction
8. Impact Test on composites
9. Fatigue test on composites

Final Examination

Duration: 3 hours

Maximum Marks: 100

Part A: Strength of Materials **–** 1 Hr 30 Mins. duration for 50 marks

Part B: Composite Materials **–** 1 Hr 30 Mins. duration for 50 marks

Course Designers:

1. M.C. Sundarraja

2. M. Kathiresan

Sub Code	Lectures	Tutorial	Practical	Credit
G 28	-	-	3	1

G28 Computer Programming Lab 0:1

Competency:

Student will develop programs to solve given requirements meeting stated specifications (simple mathematical & related mechanical problems)

List of Experiments

Cycle 1: General Problems

(Choose any 6 from the following)

1. Simple Programs
   a. Fibonacci Series
   b. Sum of set of numbers
   c. Generation of prime numbers
2. Matrix Addition, Subtraction and Multiplication
3. Sorting of Names & Numbers
4. String Manipulation
5. Bitwise Operation
6. Using Structures – Student Data Manipulation
7. File Manipulations
   a. Read the file and display the contents of the file
   b. Read the lines from the keyboard and write it into a specified file

Cycle 2: Problems from Free Body Mechanics.

(Choose any 6 from the following)

1. Determine the resultant of a given force system.
2. Determine the location of a centroid of 'L' section.
3. Determine the location of a centroid of 'T' section.
4. Determine the moment of inertia of 'T' section.
5. Determine the reaction force at the support end of a simply supported beam.
6. Determine the reaction force at the support end of a Cantilever beam.
7. Determine the velocity and acceleration of a particle at a given time.
8. Determine the kinetic energy of a moving particle.

Sub Code	Lectures	Tutorial	Practical	Credit
G 29	-	-	2	1

G29 Work Shop 0:1

Objective: The students of all branches of engineering would get exposure to basic practices in a mechanical workshop. The students get trained to acquire skills at basic level in card board modeling, fitting, sheet metal and carpentry.

List of Exercises

I Card Board Exercises (6 periods)

1. Construction of Hexagonal/Pentagonal Prisms
2. Construction of Hexagonal/Pentagonal Pyramids

II Fitting (9 periods)

1. Fitting tools and practice
2. Preparation of Gauge joint/ 'V' joint

III Sheet Metal Exercises (9 periods)

1. Sheet Metal tools and practice
2. Preparation of Liter Cone

IV Carpentry (9 periods)

1. Carpentry tools and practice
2. Preparation of Photo-frame using any two types of joints

V Demo on House wiring and Plumbing (6 periods)

Assessment Pattern:

All the exercises are evaluated on continuous assessment basis based on the fit/finish of the component, measurement and record. Students are given with additional attempt on each trade for their better performance (within the specified time of each trade). The distribution of marks in each trade is as follows:

Trade	Fit/Finish	Record	Total (Marks)
Card Board Exercises	15	5	20
Fitting	15	5	20
Sheet Metal	25	5	30
Carpentry	25	5	30

Students are evaluated based on continuous assessment only and No terminal examination for this course.

Course Designers:

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S.Saravana Perumaal - sspmech@tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

B.E. DEGREE (Mechanical Engineering) PROGRAM

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering,Madurai-625015

Department of Mechanical Engineering

Scheduling of Courses

Semester	**Theory Courses**						**Practical/Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					G88 Project 0:12	
7th (22)	G71 Management Theory & Practice 3:0	G72 Automobile Engineering 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G76 Modeling & Simulation Lab - II 0:1	G77 Mini Project 0:6	
6th (22)	G61 Accounting & Finance 3:0	G62 Design of Transmission 2:1	G63 Quality Engineering 3:0	G64 Metrology 3:0	Elective 1 3:0	Elective 2 3:0	G67 Modeling & Simulation Lab - I 0:1	G68 Metrology Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Kinematics & Dynamics of Machinery 3:1	G53 Advanced Measurement & Control 3:0	G54 Heat and Mass Transfer 3:0	G55 Manufacturing Technology/Sys. 3:0	G56 Industrial Engg. & Operations Research 4:0	G57 CAD/CAM Lab 0:1	G58 Heat and Mass Transfer Lab 0:1	G59 Mech. Meas. & Control Sys. Lab 0:1
4th (24)	G41 Numerical Methods 4:0	G42 Design of Machine Elements 3:1	G43 CAD & Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Mechatronics 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (23)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 3:1	G33 Applied Material & Metallurgy 3:0	G34 Fluid Mechanics 4:0	G35 Metal Casting & Plastic Forming processes 2:0	G36 Metal Forming & Joining Processes 2:0	G37 Manufacturing Processes and Metallurgy Lab 0:1	G38 Fluid Mechanics & CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Environment and Ecology 2:0	G26 Computers & Programming 3:0	G27 Strength of Materials & Composite Materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics – 1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2008-2009 onwards)

SEVENTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
G31	Engineering Mathematics III	DC	4	-	-	4
G32	Mechanics of Materials	DC	3	1	-	4
G33	Applied Materials and Metallurgy	DC	3	-	-	3
G34	Fluid mechanics	DC	4	-	-	4
G35	Metal Casting & Plastic Forming processes	DC	2	-	-	2
G36	Metal Forming & Joining Processes	DC	2	-	-	2
PRACTICAL						
G37	Manufacturing Processes and Metallurgy Lab	DC	-	-	2	1
G38	Fluid Mechanics and CFD lab	DC	-	-	2	1
G39	Machine Drawing	DC	-	-	5	2
Total			**18**	**1**	**9**	**23**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2008-2009 onwards)

THIRD SEMESTER

S.No.	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G31	Engineering Mathematics III	3	50	50	100	25	50
2	G32	Mechanics of Materials	3	50	50	100	25	50
3	G33	Applied Materials and Metallurgy	3	50	50	100	25	50
4	G34	Fluid mechanics	3	50	50	100	25	50
5	G35	Metal Casting & Plastic Forming processes	3	50	50	100	25	50
6	G36	Metal Forming & Joining Processes	3	50	50	100	25	50
PRACTICAL								
7	G37	Manufacturing Processes and Metallurgy Lab	3	50	50	100	25	50
8	G38	Fluid Mechanics and CFD lab	3	50	50	100	25	50
9	G39	Machine Drawing	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

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Sub Code	Lectures	Tutorial	Practical	Credit
G 31	4	0	-	4

G31 Engineering Mathematics III 4:0

(Common to all branches of Engineering, B31,C31,D31,E31,G31,T31)

Preamble:

An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this the course aims at giving adequate exposure in the theory and applications of Fourier series, Fourier Transforms, PDE's and BVP

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

j. Graduate will develop confidence for self education and ability for life-long learning.

Competencies

At the end of the course the student should be able to

1. Express the periodic functions arising in the study of engineering problems as Fourier series of Sines and Cosines.
2. Find the Fourier series for the typical waveforms.
3. Find the Fourier series for discrete data using Harmonic Analysis.
4. To study some of the well-known integral transforms (like Fourier, Fourier Sine and Cosine) and properties.
5. Formulate simple Engineering problems as Partial Differential Equations and state the boundary conditions.
6. Solve Partial Differential Equations, linear, nonlinear, homogeneous and non-homogeneous, by various methods.
7. Solve the standard Partial Differential Equations arising in engineering problems like Wave equation, Heat flow equation (one dimensional and two dimensional, Cartesian and polar coordinates) by Fourier series.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/End-semester examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define Periodic function.
2. Show that f(x)= x^3 is an odd function.
3. State the Fourier Series for the function f(x) in the interval (1, 3).
4. Identify the Kernel for Fourier Cosine and Sine Transforms.
5. State Parseval's Identity.
6. State Convolution Theorem.

Understand

1. Distinguish between Odd and Even functions.
2. Use the Fourier series expansion of $x^2 = \frac{\pi^2}{3} + 4\sum_{1}^{\infty}(-1)^n \frac{\cos nx}{n^2}$, $-\pi < x < \pi$ to predict the value of $\sum \frac{1}{n^2}$.
3. Discuss harmonic analysis.
4. Discuss Fourier Series in Complex form.
5. Interpret the result $F\left[f(ax)\right] = \frac{1}{a}F\left(\frac{s}{a}\right)$.
6. Interpret the usage of Parseval's theorem.
7. Discuss the two methods of forming partial differential equations.
8. Discuss the solution of $\frac{\partial^2 z}{\partial x \partial y} = x^2 y$ by direct integration.
9. Discuss the working rule of solving the Lagrange's linear equation.
10. Discuss the working rule of solving f(p,q)=0.

11. Discuss the working rule of solving f(z,p,q)=0.

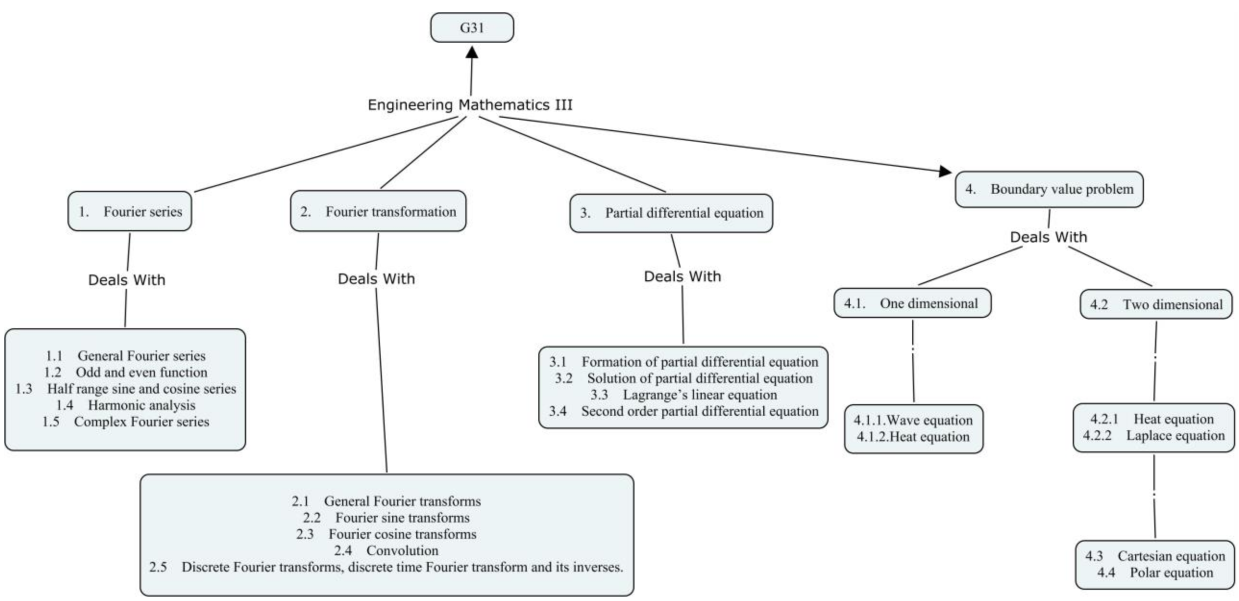
Apply

1. Find the Fourier transform of $e^{-a^2x^2}$. Hence prove that $e^{-\frac{x^2}{2}}$ is self reciprocal with respect to Fourier transforms and (i) Find the Fourier Cosine transform of e^{-x^2}.
2. Solve the equation $z^2(p^2+q^2+1)=c^2$ where c is a constant.
3. Obtain the first three harmonics in the Fourier series expansion in (0,12) for the function y=f(x) defined by the table given below:

X:	0	1	2	3	4	5	6	7	8	9	10	11
Y:	1.8	1.1	0.3	0.1	0.5	1.5	2.16	1.88	1.25	1.30	1.76	2

4. Find the Fourier transform of f(x), if $f(x)=\{1-|x|, for|x|<1 and 0, for|x|>1\}$.

Concept Map



Syllabus

Fourier Series: Dirichlet's conditions, General Fourier Series, Half range Sine and Cosine series, Parseval's Identity, Harmonic Analysis, Complex form of Fourier Series. **Fourier Transformation:** Fourier Integral Theorem, Fourier Transform, Fourier Sine and Cosine Transforms, Convolution Theorem, properties, Parseval's Identity, Discrete Fourier Transform, Discrete Time Fourier Transform, Demonstration of Fourier transforms and its properties using MATLAB (Tutorial).**Partial Differential Equations**: Formation, Solution of standard types of first order equations, Lagrange's linear equation, Linear partial differential equations of second and higher order with constant coefficient. **Boundary Value Problem**: Classification of Second Order linear partial differential equations, One-dimensional Wave equation, One dimensional heat equation, Solution by Fourier Series, Steady State Solution of two dimensional heat equation in Cartesian Co-ordinates, Laplace equation in Polar Co-ordinates, Solution by Fourier Series method.

Text Book

B.S. Grewal, "Higher Engineering Mathematics", 39th Edn. , Khanna Publishers, New Delhi, 2007.

References

1. Veerarajan .T, "Engineering Mathematics", 3rd Edition. , Tata McGraw Hill, New Delhi, 2004
2. Kreyszig,E., "Advanced Engineering Mathematics", John wiley and sons,(Asia)Pte Ltd., Singapore.2006.
3. Kandasamy.P, Thilagavathy.K, Gunavathy.K , "Engineering Mathematics Vol. III",S.Chand & Company Ltd, New Delhi, 2008

Course contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	**Fourier Series**	
1.1	Dirichlet's conditions, General Fourier Series	3

1.2	Half range Sine and Cosine series	2
1.3	Parseval's Identity	1
1.4	Harmonic Analysis	2
1.5	Complex form of Fourier Series	2
2.	**Fourier Transformation**	
2.1	Fourier Integral Theorem, Fourier Transform	2
2.2	Fourier Sine and Cosine Transforms	2
2.3	Convolution Theorem	2
2.4	Properties, Parseval's Identity	2
2.5	Discrete Fourier Transform, Discrete time Fourier Transform	2
3	**Partial Differential Equations**	
3.1	Formation	2
3.2	Solution of standard types of first order equations	3
3.3	Lagrange's linear equation	2
3.4	Linear partial differential equations of second and higher order with constant coefficient	3
4	**Boundary Value Problems**	
4.1	Classification of Second Order linear partial differential equations	1
4.2	One-dimensional Wave equation, Solution by Fourier Series	4
4.3	One dimensional heat equation, Solution by Fourier Series	5
4.4	Steady State Solution of two dimensional heat equation in Cartesian Co-ordinates, Solution by Fourier Series	5
4.5	Laplace equation in Polar Co-ordinates, Solution by Fourier Series	5

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 32	3	1		4

G 32 Mechanics of Materials 0:4

Preamble:

Mechanics of materials is the study of mechanical properties of engineering materials and the behaviour of structures made thereof. It deals with analysis of structure to find the forces and stress at various points. Mechanics of material is essential for many branches of engineering, and has an inter-disciplinary character and is essential to be studied by undergraduate mechanical engineering students. It covers relationships between various types of stresses and strain, deformations of various mechanical members such as beams, shafts, cylinders, etc. It is a decision-making process, in which the mechanical properties of materials, various theories of failure, type of stress developed due to a particular type of load are applied to select suitable material in order to meet a stated objective. This course is concerned with one aspect of engineering design pertaining to the failure/stability of mechanical components under different static loading conditions.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

Competencies

At the end of semester students will be able to

1. Determine the stress, strain, stress-strain relationship and strain energy & Explain the failure theories
2. Determine the bending moment , shear force, bending stress , slope and deflection of cantilever , simply supported , and fixed beams

3. Determine the diameter of solid and hallow shaft subjected to torsion, bending , and torsion and bending based on strength and rigidity.
4. Determine the diameter thick and thin cylinder based on circumferential and hooks stresses
5. Determine the columns and struts sizes subjected to bending and axial stresses based on Euler and Rankine formula

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember:

1. Define principal planes
2. What is known as principal stresses
3. Write the expression for Normal stress
4. Write the expression for finding the maximum shear stress
5. Name the different types of beams
6. Sketch the shear stress distribution in a circular shaft
7. What do you mean by the terms column and strut
8. Write the significance of Mohr's circle and its uses.

Understand:

1. Discuss about the various load acting on the beam and its effect
2. Estimate the number of contraflexure points for a simple supported beam
3. Classify the beams based on the supports
4. What do you understand by the term, point of contraflexuture ?
5. Distinguish between circumferential stress and longitudinal stress in a cylindrical shell when subjected to an internal pressure
6. Distinguish clearly between columns and short columns.
7. Explain the effect of change of temperature in a composite bar.

Apply :

1. A copper rod, 25 mm in diameter is encased in steel tube 30mm internal diameter and 35mm external diameter. The ends are rigidity attached. The composite bar is 500mm long and is

subjected to an axial pull of 30kN. Find the stress induced in the rod and the tube. Take E for steel = 2*10^5 N/mm^2 and E for copper = 1*10^5 N/mm^2.

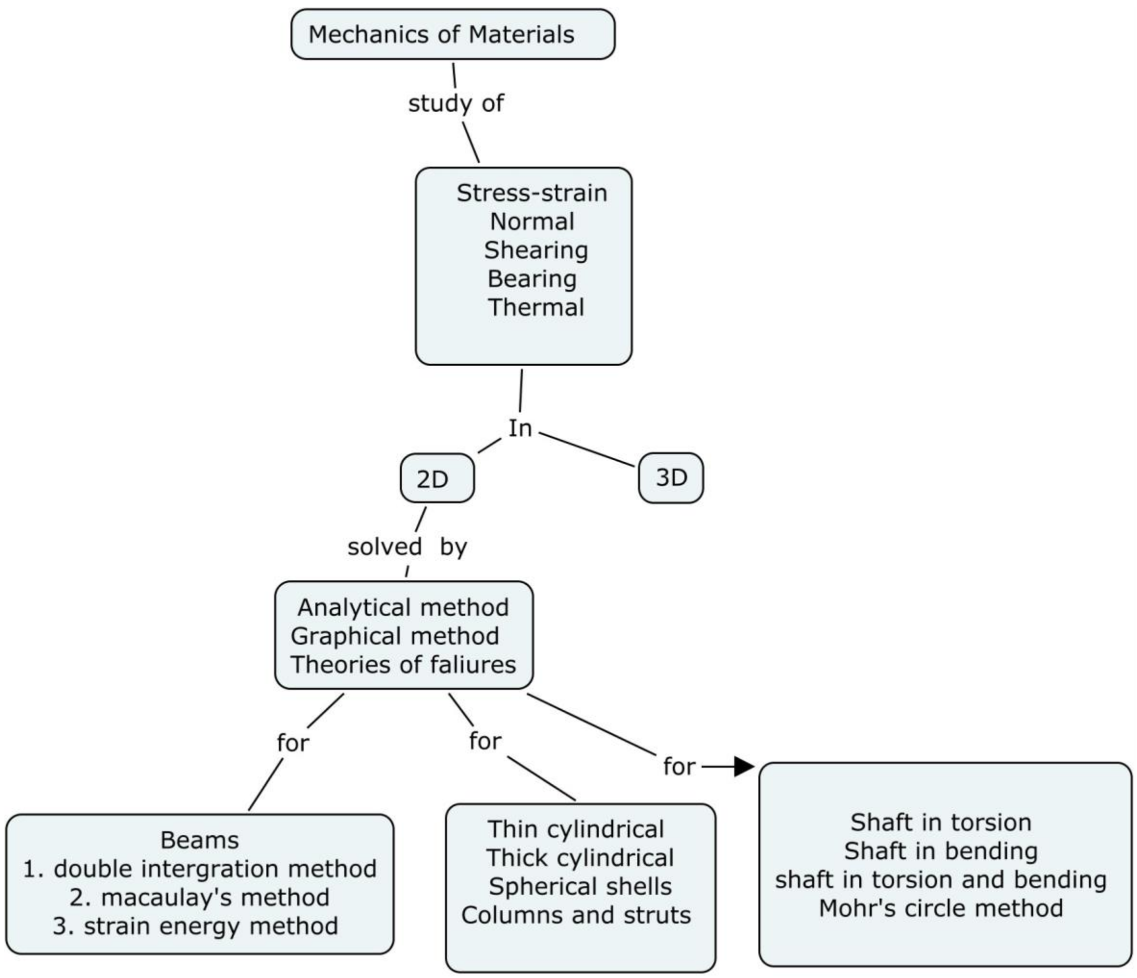
2. A 30cm*16 cm rolled steel joint of I-section has flanges 11mm thick and web 8mm thick. Find the safe uniformly distributed load that this section will carry over a span of 5m if the permissible skin stress is limited to 120 N/mm^2.
15. Derive the expression for the deflection of a simply supported beam when subjected to a central point load by double integration method.

3. Compare the crippling loads given by Euler's and Rankine's formula for a tubular steel strut 2.3 m long having outer and inner diameter 38mm and 33mm respectively, loaded through pin joints at each end. Take the yield stress as 335N/mm^2. The Rankine's constant = 1/7500 and E=0.205*10^6 N/mm^2. For what length of strut of this cross-section does the Euler formula cease to apply?

4. At a point in an elastic material under strain, there are normal stresses of 50 N/mm^2 and 30 N/mm^2, respectively at right angles to each other with a shearing stress of 25 N/mm^2. Find the principal stresses and the position of principal planes if
a) 50 N/mm^2 is tensile and 30 N/mm^2 is also tensile
b) 50 N/mm^2 is tensile and 30 N/mm^2 is compressive.
Find also the maximum shear stress and its plane in both the cases

5. A C.I. pipe has 20cm internal diameter and 50mm metal thickness, and carries water under a pressure of 5N/mm^2. Calculate the maximum and minimum intensities of circumferential stress and sketch the distribution of circumferential stress intensity and the intensity of radial pressure across the section
6. A horizontal beam, 30m long, carries a uniformly distributed load of 10kn/m over the whole length and a concentrated load of 30kN at the right end. If the beam is freely support at the left end, find the position of the second support so that the bending moment on the beam should be small as possible. Draw the diagrams of shearing force and bending moment and insert the principal-values

Concept Map



Syllabus:

Concept of Stress - normal stress, shearing stress, bearing stress, stress on an oblique plane under axial loading, component of stresses, ultimate and allowable stress, factor of safety- concept of strain, stress-strain diagram, Hook’s law, Poisson’s relation –elastic constants and their relationship- Axial loading in composite bars- Thermal stresses - Impact load – Resilience – stress concentration.

Principal Stresses – Maximum Shearing Stress, Mohr’s Circle for Plane Stress, Mohr’s Circle to the one, two and three dimensional analysis of Stresses - Theories of failure - Maximum principle stress theory, Maximum shear stress theory, Maximum strain energy theory, Maximum shear strain energy theory and Maximum principle strain energy theory

Bending Stresses in simple and composite beams Bending moment diagram- Shear stress in beams shear force diagram - Rectangular, Circular and I – sections - Torsion of Solid and hollow circular shafts - strain energy in torsion - stress concentration in torsion - shafts subjected to combined bending and twisting - Rigidity of shafts.

Slope and deflection of cantilever, simply supported and propped beams by double integration method , Macaulay's method for different types of loading and with applied moments - strain energy method – Slope and deflection of propped cantilever and fixed beams.

Thin cylindrical and spherical shells – thick cylinders under internal pressure - shrink fit - compound cylinders.
Columns and struts – Combined bending and axial stresses – Euler's formula for long column. Rankine's formula for columns.

Text Book

1. Ferdinard P. Beer and E. Russell Johnston. JR., Dewolf, John, T.,– **"Mechanics of Materials",** McGraw Hill Book Company, 2004.

Reference Books

1. J.M. Gere, Stephen P. Timoshenko, **"Mechanics of materials",** Nelson Thoranes, 2002.
2. Egor P. Popov, "**Engineering Mechanics of Solids**" , Second Edition - Pearson Education Ltd, New Delhi, 2001.
3. Bansal. R.K, "**A Text Book of Strength of Materials**" Lakshmi Publications, 2004.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	Concept of Stress - normal stress, shearing stress, bearing stress	1
2.	stress on an oblique plane under axial loading, component of stresses, ultimate and	
3.	allowable stress, factor of safety- concept of strain, stress-strain diagram	2
4.	Hook's law, Poisson's relation	1
5.	elastic constants and their relationship	2
6.	Axial loading in composite bars	2
7.	Thermal stresses - Impact load	1
8.	Resilience– stress concentration	1

No.	Topic	No. of Lectures
9.	Principal Stresses – Maximum Shearing Stress, of Stresses -, and	2
10.	Mohr's Circle for Plane Stress, Mohr's Circle to the one, two dimensional analysis	2
11.	Theories of failure - Maximum principle stress theory,	2
12.	Maximum shear stress theory, Maximum strain energy theory	2
13.	Maximum shear strain energy theory	2
14.	Maximum principle strain energy theory	2
15.	Bending Stresses in simple and composite beams –Bending moment diagram	
16.	Rectangular, Circular and I – sections	2
17.	Shear stress in beams- shear force diagram,	2
18.	Torsion of Solid and hollow circular shafts	
19.	Strain energy in torsion - stress concentration in torsion	**2**
20.	shafts subjected to combined bending and twisting -	2
21.	Rigidity of shafts	1
22.	Slope and deflection of cantilever, -	2
23.	simply supported and propped beams by double integration method	**2**
24.	Macaulay's method for different types of loading and with applied moments	2
25.	Strain energy method – Slope and deflection of propped cantilever and fixed beams	2
26.	Thin cylindrical and spherical shells	1
27.	thick cylinders under internal pressure	2
28.	shrink fit - compound cylinders.	2
29.	Columns and struts -Combined bending and axial stresses	2

No.	Topic	No. of Lectures
30.	Euler's formula for long column	2
31.	Rankine's formula for columns	2
		50

Course designers :

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Sub Code	Lectures	Tutorial	Practical	Credit
G 33	3	-	-	3

G 33 Applied Materials and Metallurgy 3:0

Preamble:

Applied Materials and Metallurgy deals with Solidification of Metals, Ferrous alloys, Nonferrous alloys, Composite materials, Powder Metallurgy and Failure analysis of metals.

Program Outcomes Addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate who can participate and succeed in competitive examinations.

Competencies

1. Explain the Solidification of Metals.
2. Explain the ferrous alloys and its heat treatment.
3. Explain the non-ferrous alloys.
4. Explain composite materials.
5. Explain powder metallurgy.
6. Explain Failure analysis of metals.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives under each Bloom's Category
Remember

1. What is homogeneous nucleation?
2. What is ferrite?
3. List the case hardening processes.
4. What are the applications of grey cast irons?
5. What is a metal matrix composite?
6. Define fracture toughness.

Understand

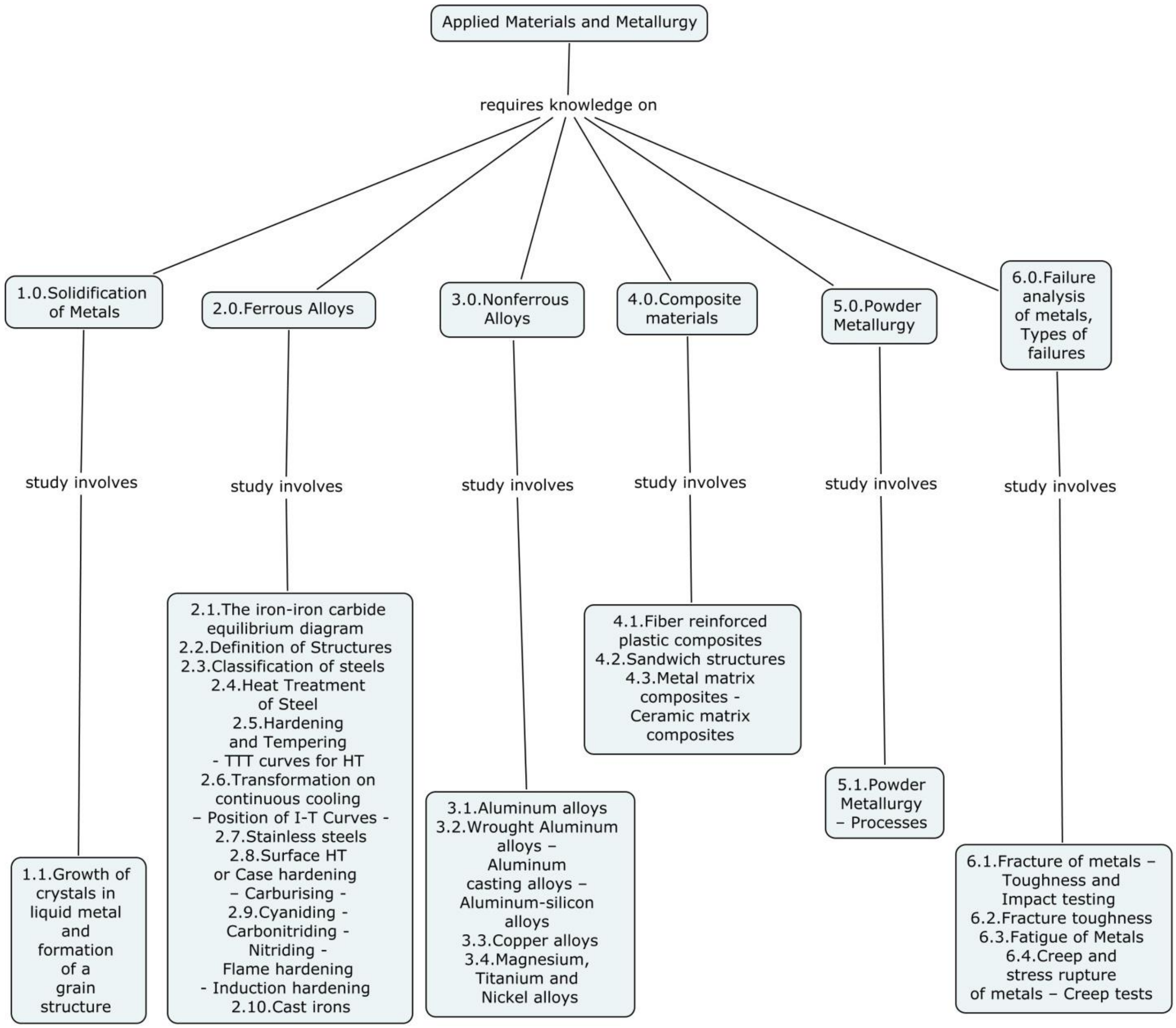
1. What are the effects of alloying elements on the properties of steels?
2. Describe the full annealing process of plain carbon steel
3. Explain the CCT diagram of steel.
4. Explain the white cast iron with the help of an iron - iron carbide diagram.
5. Explain the sandwich structures.
6. Describe the solid carburising process for steel.

Apply

1. Sketch the iron-iron carbide equilibrium diagram and explain the different phases?
2. Draw and explain the TTT diagram of a plain carbon steel.
3. Explain the Al-Si alloy equilibrium diagram with a neat sketch.
4. Explain Annealing, spheroidising and normalizing of plain carbon steels with the steel portion of iron-iron carbide equilibrium diagram.

5. Discuss the liquid carbursing for hardening the case of a steel gear.
6. Explain the creep rupture test.

Concept Map



Syllabus

Solidification of Metals: Solidification of Metals – The formation of stable nuclei in liquid metals – Growth of crystals in liquid metal and formation of a grain structure – Grain structure in Industrial castings. **Ferrous Alloys:** The iron-iron carbide equilibrium diagram - Eutectic, eutectoid and peritectic reactions - Definition of Structures - Carbon solubility in iron - Classification of steels – Effect of alloying elements – Applications - Heat Treatment of Steel - Full Annealing, spheroidising - Stress relief annealing, process annealing, normalizing - Hardening and Tempering - TTT curves for heat treatment of steels - Transformation on continuous cooling – Position of I-T Curves - Stainless steels- Ferritic, Martensitic and Austenitic Stainless steels – Applications. Surface Heat treatment or Case hardening of steel – Carburising - Cyaniding - Carbonitriding - Nitriding - Flame hardening - Induction hardening - Cast Irons- White cast iron - Grey cast Iron - Ductile Cast Iron - Malleable cast iron - Applications. **Nonferrous Alloys:** Aluminum alloys - Applications - Wrought Aluminum alloys – Aluminum casting alloys – Aluminum-silicon alloys – Applications - Copper alloys – Applications - Magnesium, Titanium and Nickel alloys - Applications. **Composite materials:** Fiber reinforced plastic composites - Applications. Sandwich structures - Applications. Metal matrix composites - Applications. Ceramic matrix composites - Applications. **Powder Metallurgy:** Powder Metallurgy – Processes - Applications. **Failure analysis of metals, Types of failures:** Fracture of metals –Ductile fracture – Brittle fracture- Toughness and Impact testing – Ductile to Brittle transition temperature - Fracture toughness - Fatigue of Metals – Cyclic stresses – Basic structural changes that occur in a ductile metal in the fatigue process – Major factors that affect the fatigue strength of a metal - Fatigue crack propagation rate - Creep and stress rupture of metals – Creep of metals – Creep test – Creep rupture test.

Text Books

1. Sidney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, New Delhi, 1997.
2. William F Smith, Javad Hashemi, Ravi Prakash, Materials Science and Engineering, Tata McGraw Hill, New Delhi, 2008.

Reference Books

1. Vijayendra Singh, "Physical Metallurgy", Standard Publishers distributors, Delhi, 2005.
2. Rajan.T.V., Sharma C.P., Ashok Sharma., "Heat Treatment Principles And Techniques", Prentice-Hall Of India Pvt. Ltd., New Delhi, 2002.
3. Higgins R A: "Engineering Metallurgy Part 1 & 2", Viva Books Pvt Ltd, Delhi, 1998.
4. Donald S. Clark & Wolbur R. Varney: "Physical Metallurgy for Engineers", CBS Publishers, Delhi, 1987.
5. Burton. M.S., "Applied Metallurgy for Engineers", McGraw Hill, NewYork, 1979.
6. George E. Dieter, "Mechanical Metallurgy", McGraw Hill, NewYork, 1988.

Course Contents and Lecture schedule

S.No	**Topics**	**No. of Lect-ures**
1.0	**Solidification of Metals**	
1.1	Solidification of Metals – The formation of stable nuclei in liquid metals – Growth of crystals in liquid metal and formation of a grain structure – Grain structure in Industrial castings	2
2.0	**Ferrous Alloys**	
2.1	The iron-iron carbide equilibrium diagram - Eutectic, eutectoid and peritectic reactions	3
2.2	Definition of Structures - Carbon solubility in iron	1
2.3	Classification of steels – Effect of alloying elements - Applications	1
2.4	Heat Treatment of Steel - Full Annealing, spheroidising - Stress relief annealing, process annealing, normalising	2
2.5	Hardening and Tempering - TTT curves for heat treatment of steels	3
2.6	Transformation on continuous cooling – Position of I-T Curves	1
2.7	Stainless steels- Ferritic, Martensitic and Austenitic Stainless steels - Applications	1
2.8	Surface Heat treatment or Case hardening of steel - Carburising	2
2.9	Cyaniding - Carbonitriding - Nitriding - Flame hardening - Induction hardening	2
2.10	Cast Irons - White cast iron - Grey cast Iron - Ductile Cast Iron - Malleable cast iron -Applications.	3
3.0	**Nonferrous Alloys**	
3.1	Aluminum alloys - Applications	1
3.2	Wrought Aluminum alloys – Aluminum casting alloys – Aluminum-silicon alloys - Applications	2
3.3	Copper alloys - Applications	2
3.4	Magnesium, Titanium and Nickel alloys - Applications.	2
4.0	**Composite materials**	
4.1	Fiber reinforced plastic composites - Applications	3
4.2	Sandwich structures - Applications	1

S.No	**Topics**	**No. of Lect-ures**
4.3	Metal matrix composites - Ceramic matrix composites - Applications	2
5.0	**Powder Metallurgy**	
5.1	Powder Metallurgy – Processes – Applications	3
6.0	**Failure analysis of metals, Types of failures**	
6.1	Fracture of metals –Ductile fracture – Brittle fracture- Toughness and Impact testing – Ductile to Brittle transition temperature	2
6.2	Fracture toughness	2
6.3	Fatigue of Metals – Cyclic stresses – Basic structural changes that occur in a ductile metal in the fatigue process – Major factors that affect the fatigue strength of a metal - Fatigue crack propagation rate	2
6.4	Creep and stress rupture of metals – Creep of metals – Creep test – Creep rupture test	2
	Total	45

Course Designers name with E-Mail ID:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 34	4	0	-	4

G34Fluid Mechanics 4:0

Preamble:

Fluid mechanics is defined as the science that deals with the behavior of fluids at rest (fluid statics) or in motion (fluid dynamics) and the interaction of fluids with solids or other fluids at the boundaries. Fluid mechanics itself is also divided in to several categories. The study of the motion of fluids that are practically incompressible (such as liquids, especially water and gases at low speeds) is usually referred to as hydrodynamics. Gas dynamics deals with the flow of fluids that undergo significant density changes such as the flow of gases through the nozzle at high speeds. The occurrence of normal shocks and constant area flow with friction (Fanno flow) and constant area flow with heat transfer (Rayleigh flow) are the branches of gas dynamics used to acquire knowledge in compressible flow.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
b. Graduates will demonstrate an ability to identify, formulate and solve Engineering problems.
c. Graduates will demonstrate skills to use modern Engineering tools, softwares and equipments to analyze problems.

Competencies:

At the end of the course the student should be able to

1. Understand the basic properties of fluids.
2. Understand Lagrangian and Eulerian descriptions of fluid flow.
3. Apply Bernoulli's equation to solve fluid flow problems.
4. Understand laminar and turbulent flow in pipes.
5. Analyze the losses associated with pipe flow.
6. Understand the different techniques for measurement of velocity and volume flow rate of laminar flow in pipes.
7. Understand the basic properties of compressible fluids.
8. Understand the flow of compressible fluids, with and without shocks, through nozzles and diffusers.

9. Understand the effects of friction (Fanno flow) and heat transfer (Rayleigh flow) on flow of compressible fluids in constant area duct.
10. Determine the properties of flow of fluids in pipes and duct

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	20
2	Understand	30	30	30
3	Apply	50	50	40
4	Analyze	0	0	10
5	Evaluate	0	0	0
6	Create	0	0	0

Remember

1. Define the term fluid.
2. Write Newton's law of viscosity.
3. What is non-Newtonian fluid?
4. Write down the3-D continuity equation.
5. In a capillary tube some liquids rise above the liquid surface and some other liquids fall below the liquid surface. Why?
6. Some insects could freely walk on the free surface of water. How?
7. What is Langrangain h and Eulerian approaches of fluid flow?
8. Define the term Mach number.
9. Define stream and potential functions.
10. Define the stagnation state.
11. What is kinetic temperature?
12. What is Fanno flow?
13. What is Rayleigh flow?
14. Define the term normal shock.

Understand

1. Derive an expression for capillary rise or fall of a liquid
2. Derive an expression for 3D continuity equation.
3. Derive the basic equation for pressure field and obtain the hydrostatic equation from the same.
4. Derive 3D Euler equation and obtain the Bernoulli equation from it.
5. Derive an expression for flow rate through a venturimeter.
6. Derive an expression relating change in area with change in velocity and Mach number.

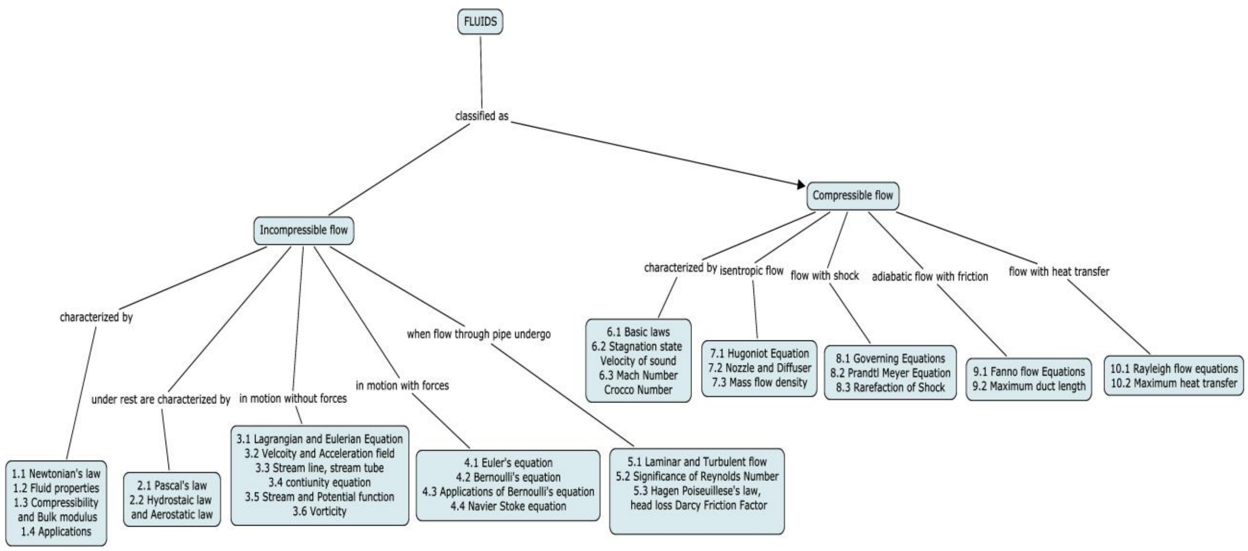
Apply

1. Determine the density, specific gravity and mass of the air in a room whose dimensions are 4 m x 5 m x 6 m at 100 kPa and 15^0C
2. A 0.6 mm diameter glass tube is inserted into water at 20^0C in a cup. Determine the capillary rise of water in the tube.
3. A manometer is used to measure the pressure of a gas in a tank. The fluid used has a specific gravity of 0.85, and the manometer column height is 55 cm. If the atmospheric pressure is 96 kPa, determine the absolute pressure within the tank.
4. Water is flowing from a garden hose. A child places his thumb to cover most of the hose outlet, causing a thin jet og high sped water emerge. The pressure in the hose just upstream of his thumb is 400 kPa. If the hose is help upward, what is the maximum height that the jet could achieve?
5. Co_2 flows steadily through a varying cross sectional area duct such as a nozzle at a mass rate of 3.00 kg/s. The co_2 enters the duct at a pressure of 1400 kPa and 200^0C with a low velocity, and it expands in the nozzle to a pressure of 200 kPa. The duct is designed so that the flow can be approximated as isentropic. Determine the density, velocity, flow area and Mach number at each location along the duct that corresponds to a pressure drop of a 200 kPa.

Analyze

1. Contrary to what you might expect, a solid steel ball can float on water due to the surface tension effect. Determine the maximum diameter of the steel ball that would float on water at 20^0C. What would your answer be for an aluminium ball? Take the densities of steel and aluminium balls to be 7800 kg/m^3 and 270 kg/m^3, respectively.
2. A Boeing 777 flies at Mach 0.82 at an altitude of 10 km in a standard atmosphere. Determine the stagnation pressure on the leading edge of its wing if the flow in incompressible; and if the flow is compressible isentropic.
3. Consider the fully developed flow of glycerin at 40^0C through a 70-m long, 4-cm diameter, horizontal, circular pipe. If the flow velocity at the center line is measured to be 6 m/s, determine the velocity profile and the pressure difference across this 70-m-long section of the pipe, and the useful power required to maintain this flow. For the same useful pumping power input, determine the percent decrease if it is inclined 15^0 downward and the percent decrease if it is inclined 15^0 upward. The pump is located outside the pipe section.
4. Consider subsonic Rayleigh flow of air with a mach number of 0.92. Heat is now transferred to the fluid and the Mach number increases to 0.95. Does the temperature T of the fluid increase, decrease, or remain constant directing this process? How about the stagnation temperature T_0.
5. Consider subsonic Fanno flow accelerated to sonic velocity at the duct exit as a result of frictional effects. If the duct length is increased further, will the flow at the duct exit be supersonic, subsonic, or remain sonic? Will the mass flow rate of the fluid increase, decrease, or remain constant as a result of increasing the duct length?

Concept Map



Syllabus:

Basic Concepts : Introduction - Liquids and Gases - Dimensions and Units- Properties of Fluids-Pressure, Density, Specific Gravity, Viscosity, Surface Tension, Capillarity, Compressibility and Bulk Modulus- applications of fluid properties. **Fluid Statics**: Pressure at a Point (Pascal's Law) – Hydrostatic law and aerostatic law. Hydrostatic forces **Fluid Kinematics:** Lagrangian and Eulerian Descriptions –
Velocity and Acceleration of a fluid particle-Stream line, stream tubes and path line-Continuity Equation in Cartesian Co-ordinates – Velocity Potential and Stream Function - Vorticity **Fluid Dynamics:** Bernoulli's Equation - Euler's Equation for Motion - Applications of Bernoulli's Equation, venturimeter and orifice meter – Navier Stokes Equation – flow over flat plate, flow across cylinders. **Pipe Flow:** Laminar and turbulent flow - Reynolds Experiment - Significance of Reynolds Number - Laminar Flow in Pipes, Hagen Poiseuille's flow, head loss and Darcy friction factor. **Gas Dynamics :**Definition - Basic laws and Governing equations - Stagnation state and properties- Velocity of sound - Mach number – critical Mach number – Crocco number. **Isentropic Flow with**

variable area: Hugoniot equation – Nozzle and Diffuser -relation between area and mach number-mass flow density **Normal Shocks in one dimensional flow:** Governing equations- Property ratios in terms of Mach numbers across the shock- Prandtl relation – impossibility of rarefaction shock. **Fanno Flow:** Fanno curve - Fanno flow equations - Maximum duct length. **Rayleigh Flow:** Rayleigh curve - Rayleigh flow equations - Maximum heat transfer.

Text Books:

1. Bruce R. Munson, Donald F. Young, Theodore H. Okiishi, **"Fundamental of Fluid Mechanics**", Wiley, 2001.
2. Yahya .S.M, **"Fundamentals of Compressible Flow"**, New Age International (P) Ltd, 1995.
3. Ascher H. Shapiro, "**Dynamics and Thermodynamics of Compressible Fluid Flow (Volume 1)"**, Wiley, 1953.

Reference Books

1. S. K. Som, G. Biswas , **"Introduction to Fluid Mechanics and Fluid Machines"**, Tata McGraw - Hill Publishing Company Limited - New Delhi – 2009.
2. Yunus Cengel, John Cimbala, Fluid Mechanics with Student Resources DVD McGraw-Hill Science,2009**.**
3. Frank White, **" Fluid Mechanics with student resources CD Rom"**, McGraw Hill, 2006.
4. Robert D. Zucker, Oscar Biblarz, **"Fundamental of Gas Dynamics"**, Wiley, 2002.
5. R.K. Bansal , **"A Text Book of Fluid Mechanics and Hydraulic Machines"**, Laxmi Publications (P) Ltd., 2004.
6. R.J. Garde, A.G. Mirajgaoker, "**Engineering Fluid Mechanics**", Scitech Publication (India) Ltd, 2003.
7. E. Rathakrishnan, "**Gas Dynamics**", Prentice-Hall of India Private Ltd, 1995.
8. E. Rathakrishnan, "**Fluid Mechanics**", Prentice-Hall of India Private Ltd, 2009.
9. R.K. Rajput, "**Fluid Mechanics and Hydraulic machines**", S.Chand & Company Ltd, 2005.
10. Yahya .S.M, **"Gas tables for Compressible Flow"**, New Age International (P) Ltd, 2004.

Course contents and Lecture schedule

No	Topic	No. of Lectures
1.	**Basic Concepts**	
1.1	Introduction - Liquids and Gases, Ideal and real fluids, Newtonian and Non-Newtonian fluids	2

1.2	Properties of Fluids, Pressure, Density, Specific Gravity, Viscosity, Surface Tension and Capillarity	2
1.3	Compressibility and Bulk Modulus	1
1.4	Applications of fluid properties	2
2	**Fluid Statics**	
2.1	Pressure at a Point (Pascal's Law) and hydrostatic law	1
2.2	Hydrostatic forces	2
3.	**Fluid Kinematics**	
3.1	Lagrangian and Eulerian Descriptions	1
3.2	Velocity and Acceleration of a fluid particle	2
3.3	Stream line, stream tubes and path line	1
3.4	Continuity Equation in Cartesian Co-ordinates	2
3.5	Velocity Potential and Stream Function	3
3.6	Vorticity	1
4.	**Fluid Dynamics**	
4.1	Euler's equation of motion	1
4.2	Bernoulli's equation	1
4.3	Applications of Bernoulli's Equation, venturimeter and orifice meter	3
4.4	Navier Srokes Equation, Flow over flat plate and across cylinders	2
5.	**Pipe Flow**	
5.1	Laminar and turbulent flow, Reynolds Experiment	1
5.2	Significance of Reynolds Number	1

5.3	Laminar Flow in Pipes, Hagen Poiseuille's flow, head loss and Darcy friction factor	2

6.	**Gas Dynamics**	
6.1	Definition - Basic laws and Governing equations	1
6.2	Stagnation state and properties - Velocity of sound	2

6.3	Mach number – critical Mach number – Crocco number	2
7.	**Isentropic Flow with variable area**	
7.1	Hugoniot equation	1
7.2	Nozzle and Diffuser -Relation between area and Mach number	2
7.3	Mass flow density	1
8.	**Normal Shocks in One dimensional flow**	
8.1	Governing equations- Property ratios in terms of Mach numbers across the shock	2
8.2	Prandtl relation	1
8.3	Impossibility of rarefaction shock	1
9.	**Fanno Flow**	
9.1	Fanno curve - Fanno flow equations	2
9.2	Maximum duct length	1
10.	**Rayleigh Flow**	
10.1	Rayleigh curve - Rayleigh flow equations	2
10.2	Maximum heat transfer	1
	Total hours	**50**

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3. Mr. Sreenivasulu TVS motors Hosur

Sub Code	Lectures	Tutorial	Practical	Credit
G 35	2	-	-	2

G35 Metal Casting and Plastic Forming Processes 2:0

Preamble

Metal casting is a low cost, mass production method and widely used method. Products may be discrete products like nails, piston, engine blocks or continuous products like rod, tube and pipes of metal or plastics. Plastics are commonly used in almost all products. This course delineates applications of metal casting and plastic forming processes.

Programme Outcomes addressed

d. Apply scientific principles and concepts relating to development of products and processes.
e. Design and develop products and processes, that deliver requirements of target group.
f. Demonstrate working level understanding and appreciation of inter disciplinary domains that are required for design of products and processes.
g. Check the design of products and processes for DFX-assembly, manufacture, cost, quality and reliability, serviceability, recyclability, environment, ergonomics
h. Understand industrial and business environment in which the enterprise operates.

Competencies

At the end of the course, students will able to

1. Explain the principles of various metal casting processes and plastic moulding processes.
2. Explain the process parameters and design aspects of sand casting.
3. Identify defects
4. Select the suitable process for a given casting /plastic product.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluation	0	0	0

6	Create	0	0	0

Course Level Objectives

Remember type Questions

1. State the Bernoulli's theorem
2. Define Reynolds number.
3. What is fluidity index?
4. What is stress cracking?
5. What are core prints?
6. Give the classification patterns with sketches.

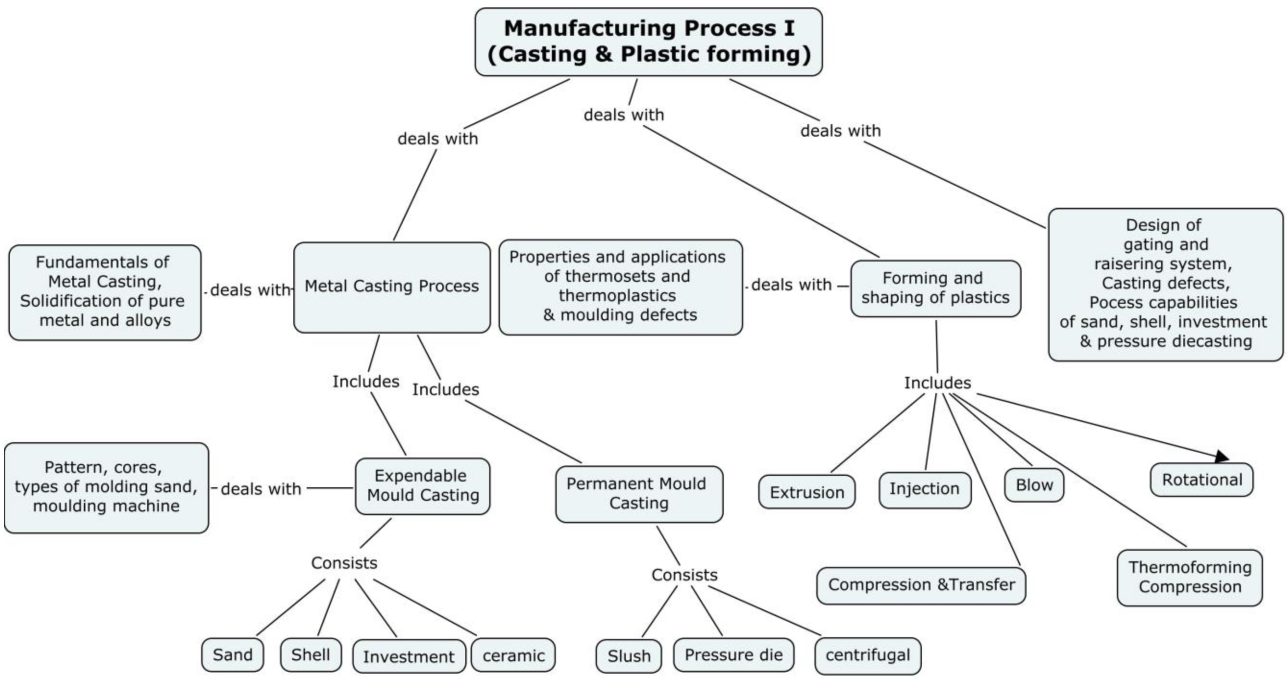
Understand Type Questions

1. Explain the temperature distribution at the interface of the mould wall and the liquid metal during solidification of metals in casting.
2. Illustrate the steps in Investment mould casting process with neat sketches.
3. Describe the true centrifugal casting process with neat sketches.
4. Describe the various types of moulding machines.
5. Explain the cold chamber die casting process with neat sketches.
6. Compare the solidification of pure metals and alloys with aid of solidification curve.

Apply Type Questions

1. List the products of investment casting.
2. Select a suitable pressure die casting process for low melting point materials.
3. Zinc components are to be produced in large volume (say 10000 units). Select the suitable process.
4. Which moulding process is used for making pet bottles? Explain.
5. Name and explain the process to produce plastic sheets.
6. Select and explain the suitable casting process for the given product details. (ADD SKETCHES, Production quantity , and material)

Concept Map



Syllabus

Metal casting:

Fluid flow, Bernoulli's theorem, continuity law, flow characteristics, fluidity of molten metal, heat transfer.

Solidification of pure metals and alloys: solidification of metals - pure metal and alloys, solidification time

Expendable mould Casting Processes:

Pattern- Materials, Types, and Allowances. Cores, Core prints, core making and core applications.

Types of Moulding sand- natural and synthetic sand, Types of sand moulds - green sand, cold box and no-bake moulds. Steps involved in making a green sand mould.

Moulding machines - Squeeze type, Jolt type, and Sand slinger.

Procedural steps and applications of Shell mould casting, Investment mould casting and Ceramic mould casting.

Permanent mould casting processes:

Procedural steps and applications of Permanent mould casting processes such as Slush casting, Centrifugal casting- True, Semi and Centrifuging, Pressure die casting – hot chamber and cold chamber.

Process capabilities of sand, shell, ceramic, investment casting and pressure die casting

Plastics: General properties and applications of thermo plastics and thermosets.

Forming/shaping and applications of plastics: Extrusion, Injection Molding, Blow Molding, Rotational Molding, Thermoforming, Compression Molding, Transfer molding, Casting, and Cold forming processes.

Casting Design:

Design of gating and risering system: Design principles, factors involved in gating design, pressurised and unpressurised gating system. Risering system – Types - shape size and location of riser - Simple problems.

Introduction to Non- destructive inspection of castings: Liquid penetration method and X-Ray Radiography.

Defects in castings - Shrinkage, metallic projections, cavities, discontinuities, defective surface, incomplete casting and inclusions.

Defects in injection moulding: Sink mark, warp, weak weld lines, inconsistent critical lines, degradation, ejection difficulty, stress cracking, inconsistent filling, Silver streaks

Reference Books:

1. Serope Kalpakjian and Steven R.Schmid, “Manufacturing Engineering and Technology”, Addition Wesley Longman Pvt.Ltd., First Indian reprint, 2000.
2. S.K.HajraChoudhury and A.K. HajraChoudhury, “Elements of Work shop Technology”, Vol – I Manufacturing Processes, Media Promoters and Publishers Pvt. Ltd, 1986.
3. Prabodh C. Bolur, “A Guide to Injection Moulding of Plastics”, Third edition, Sri Prema Sai Printers & Publishers, Mangalore, 2007.
4. R.G.W. Pye, Injection Mould Design: An Introduction and Design Manual for the Thermoplastics Industry, Fourth Edition, Affiliated East-West Press Pvt Ltd., New Delhi, 2000.
5. P.L.Jain, “Principles Of Foundry Technology”, Tata McGraw Hill, V Edision, 2009.
6. E.Paul Degarmo, J.T.Black, and Ronald A. Konser, “Materials and Processes in Manufacturing”, 5th Edition, Prentice Hall India Ltd., 1997.
7. P.C. Sharma, “A Text Book of Production Technology (Manufacturing Processes)”, S. Chand & Company Ltd., New Delhi, 2004.
8. Philip F. Oswald, and Jairo Munoz, “Manufacturing Process and systems”, John Wiley and Sons, 1992.

9. P.N.Rao, " Manufacturing Technology", Tata McGraw Hill, New Delhi, 1998.

Course Contents

S.No	**Topics**	**No. of Lectures**
1	Fluid flow, Bernoulli's theorem, continuity law, flow characteristics, fluidity of molten metal, heat transfer.	1
2	Pattern- Materials, Types, and Allowances.	1
3	Cores, Core prints and core making and core applications	0.5
4	Types of moulding sand – natural and synthetic,Types of sand moulds - green sand, cold box and no-bake moulds. Steps involved in making a green sand mould.	2
5	Moulding machines - Squeeze type, Jolt type, and Sand slinger.	1
6	Procedural steps of Shell mould casting, Investment mould casting and Ceramic mould casting.	2.5
7	Applications of Shell mould casting, Investment mould casting and Ceramic mould casting	1
8	Procedural steps of Permanent mould casting processes such as Slush casting, Centrifugal casting- True, Semi and Centrifuging,	2
9	Pressure die casting – hot chamber and cold chamber.	1
10	Applications of Permanent mould casting processes	1
11	solidification of metals - pure metal and alloys, solidification time	1
12	General properties and applications of thermo plastics and thermosets.	1
13	Principle and applications of Extrusion, Injection Molding	2
14	Principle and applications of Blow Molding, Rotational Molding Thermoforming	1
15	Principle and applications of Compression Molding, Transfer molding	1

16	Principle and applications of Casting, and Cold forming processes.	1
17	Process capabilities of sand, shell, ceramic, investment casting and pressure die casting	1
18	Design of gating and risering system: Design principles, factors involved in gating design, pressurised and unpressurised gating system.	2
19	Risering system – Types -shape size and location of riser - Simple problems.	1
20	Introduction to Non-destructive testing – Liquid Penetration and X-Ray Radiography.	1
21	Defects in castings - Shrinkage, metallic projections, cavities, discontinuities, defective surface, incomplete casting and inclusions	1
22	Defects in injection moulding: Sinkmark, warp, weak weld lines, inconsistent critical lines, degradation, ejection difficulty, stress cracking, inconsistent filling, Silverstreaks	1

Course Designers:

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4. **S.Srinivasan, TVS Motors Ltd**
5. **AR.Mani, Karun Tooling Enterprise (ktemani@yahoo.com)**

Sub Code	Lectures	Tutorial	Practical	Credit
G 36	2	-	-	2

G36 Metal Forming and Joining Processes 2:0

Preamble

Many products are manufactured using sheet metal. The rolling is the primary process to produce billets, slabs and sheets, which are subsequently used to produce parts such as tubes, panels, car doors, PC panels, computer casing, utensils, and so on. Metal joining is an inevitable process in the fabrication of parts. The first and second parts of this course aim to provide knowledge on the working, advantages, limitations and applications of various metal forming and metal joining processes.

Programme Outcomes addressed

1. Graduates will explain the principles of metal forming and joining processes.
2. Graduates will explain the working principles of machines/equipments used for metal forming and metal joining processes
3. Graduates will explain the process parameters involved in metal forming and joining processes.
4. Graduates will inspect and identify the various defects in metal forming and joining processes and suggest the suitable remedial measures.
5. Graduates will suggest the suitable forming methods for sheet metal components.
6. Graduates will suggest the suitable joining methods for fabrication/ assembly of products.

Competencies

5. Explain the principle of metal forming and joining processes.
6. Describe the processing steps of metal forming and joining processes.
7. Determine the parameters of metal forming and joining processes.
8. Select appropriate forming process for sheet metal components
9. Select appropriate joining method for fabrication.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	-	-	-
5	Evaluate	-	-	-
6	Create	-	-	-

Course Level Learning Objectives under each Bloom's Category
Remember

1. What is impact extrusion?
2. Define the term Forgeability.
3. Define the term Weldability.
4. What is Edge preparation in welding?
5. What are the defects in roll plates and sheets?
6. Name the metals commonly used in sheet metal work.
7. What are the principles governing design of good welding jigs and fixtures?

Understand

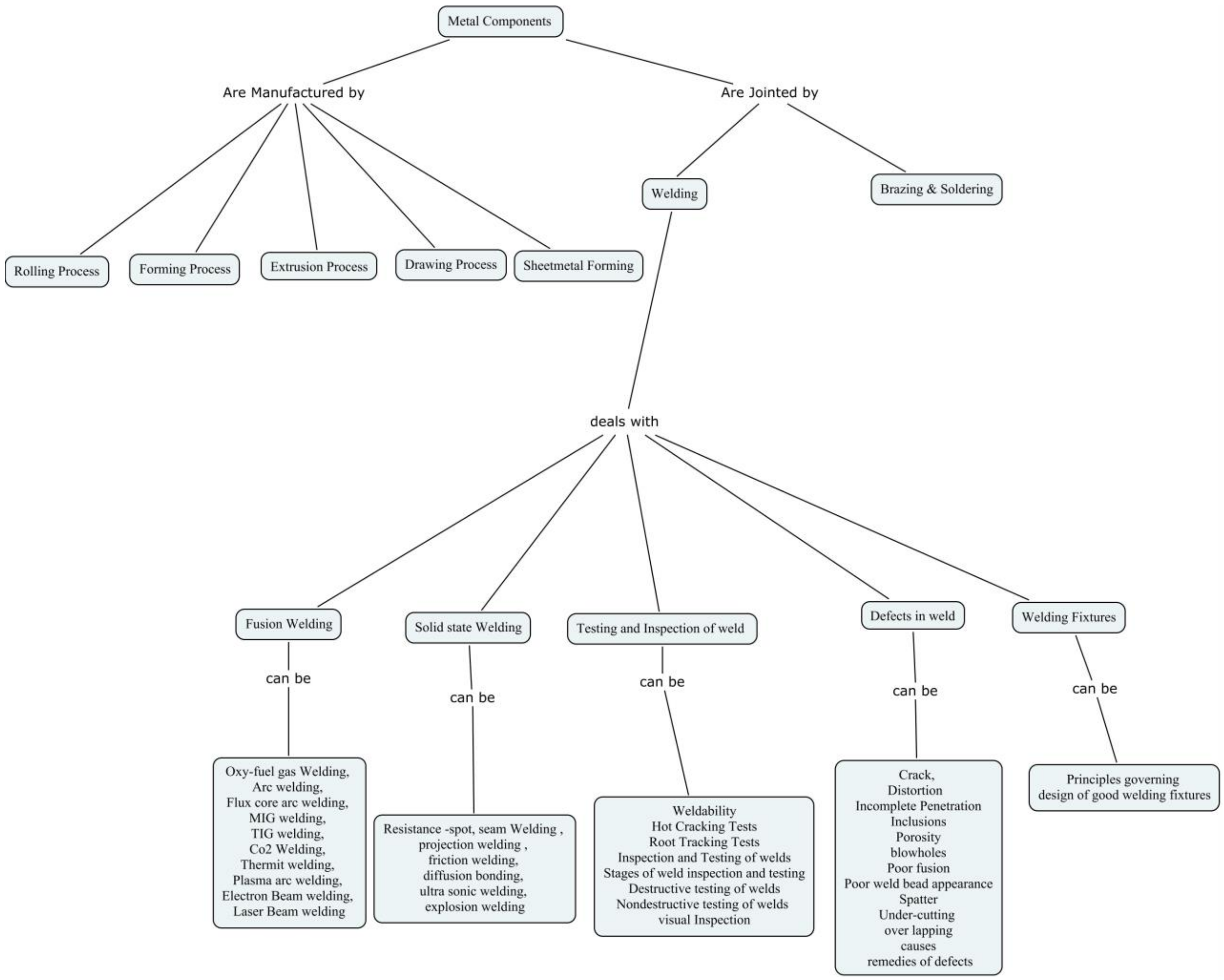
1. Distinguish between Hot rolling and Cold rolling processes.
2. Show by sketch the various roll arrangements used in rolling mills.
3. Describe the following processes with their specific uses and limitations: (a) Cold drawing, (b) Hot Extrusion, (c) Cold Extrusion, (d) Hot rolling.

4. Explain with neat sketches the following forging operations: (a) upsetting, (b) drawing down, (c) bending, (d) drifting, (e) punching, (f) fullering, (g) heading and (i) piercing
5. What are the different types of power hammer and explain with a neat sketch.
6. Explain the principle and operations of MIG welding and give their advantages, limitations and specific applications.
7. Describe and explain (1) Brazing and (2) Soldering. State the principal difference between them. Also state their specific applications.

Apply

1. How are collapsible tubes produced?
2. How is seamless tubing pierced?
3. How the weld joint is tested and inspected?
4. An annealed copper strip 228 mm wide and 25 mm thick, is rolled to a thickness of 20 mm. The roll radius is 300 mm and rotates at 100 rpm. Calculate the roll force and the power in this operation.
5. A solid cylindrical work piece made of 304 stainless steel is 150 mm in diameter and 100 mm high. It is forged by open die forging at room temperature with flat dies to a 50 % reduction in height. Assuming that the coefficient of friction is 0.2, calculate the forging force at the end of the stroke.
6. A round billet made of 70-30 brass is extruded at a temperature of 675° C. The billet diameter is 125 mm and the diameter of the extrusion is 50 mm. Calculate the extrusion force required.
7. Estimate the force required in punching a 25 mm diameter hole through a 3.2 mm thick annealed titanium alloy Ti-6Al-4V sheet at room temperature.

Concept Map



Syllabus

Metal forming Processes:

Fundamental of Metal forming, Elastic and plastic deformation. Concept of strain hardening. Hot and cold working processes.

Rolling Process: Hot and cold rolling process , process parameters involved, Type of rolling mills, Flat rolling practice, Shape rolling operations, Production of seamless pipe and tubing, Defects in roll plates and sheets.

Forging: Outline of forging and related operations, process parameters involved, Various Forging Processes such as open die, closed die, Forging Operations such as Heading, Piercing, coining, Forging presses and dies and defects in forging.

Drawing Process: Wire and tube drawing, process parameters involved, Wire Drawing equipments and dies and defects in drawing.

Extrusion Process: hot, cold, impact and hydro static extrusion, process parameter involved, Extrusion Machines-Horizontal, Vertical hydraulic presses and dies and defects in extrusion.

Sheet metal forming Process: Formability of Sheet metal, Shearing mechanism, Drawabilty, process parameter involved, Shearing operations- Blanking, Piercing, fine Blanking, Slitting, trimming, lancing, cut off, coining, Nibbling, bending, shaving, Forming, Beading, bulging Flanging, Dimpling, Hemming, Tube bending, Stretch Forming, Deep Drawing, Metal spinning Mechanical and hydraulic presses and dies and defects in sheet metal process.

Metal joining Process:

Solidification of the weld metal, base metal, heat affected zone, weld metal, shielding gases, filler metal, fluxes.

Fusion welding: Oxy-fuel gas Welding, Arc welding, Flux core arc welding, MIG welding, TIG welding, Co_2 Welding, Thermit welding, Plasma arc welding, Electron Beam welding, Laser Beam welding, **Solid State welding:** Resistance Welding-spot, seam , projection welding , friction welding, diffusion bonding, ultra sonic welding, explosion welding.

Defects in welding: Crack, Distortion (Distortion and residual stresses, Concept of distortion, Types of distortion, Control of welding distortion), Incomplete Penetration, Inclusions, Porosity and blowholes, Poor fusion, Poor weld bead appearance, Spatter, Under-cutting and over lapping, causes and remedies of defects.

Testing and Inspection of welding : Weldability, Hot Cracking Tests, Root Tracking Tests, Inspection and Testing of welds, Stages of weld inspection and testing, Destructive testing of welds, Nondestructive testing of welds and visual Inspection.

Welding fixtures: Principles governing design of good welding fixtures

Brazing and soldering: Principle of Operation, advantages, Limitations and application.

Text Books:

1. Serope Kalpakjian and Steven R.Schmid, "Manufacturing Engineering and Technology", Addition Wesley Longman Pvt.Ltd., First Indian reprint, 2000.
2. S.K.HajraChoudhury and A.K. HajraChoudhury, "Elements of Work shop Technology", Vol – I Manufacturing Processes, Media Promoters and Publishers Pvt. Ltd, 1986.

Reference Books:

1. O. P Khanna "A Textbook of Welding Technology", Dhanpat Rai & Sons, Twenteenth Reprint, 2011.
2. George E. Dieter "Mechanical Metallurgy", Mc Graw-Hill Book Company, 1998.
3. E.Paul Degarmo, J.T.Black, and Ronald A. Konser, "Materials and Processes in Manufacturing", 5th Edition, Prentice Hall India Ltd., 1997.
4. P.C. Sharma, "A Text Book of Production Technology (Manufacturing Processes)", S. Chand & Company Ltd., New Delhi, 2004.
5. Philip F. Oswald, and Jairo Munoz, "Manufacturing Process and systems", John Wiley and Sons, 1992.
6. John E. Neeley and Richard R.Kibbe, "Modern Materials and Manufacturing Processes", John Wiley and Sons, 1992.
7. P.N.Rao, "Manufacturing Technology", Tata McGraw Hill, New Delhi, 1998.

Course content

S.No	Topics	No. of Lectures
1.	**Metal Forming Process**	
1.1	Rolling	3
1.2	Forging	3
1.3	Extrusion	2
1.4	Drawing	2
1.5	Sheet metal forming	3
2.	Metal Joining Process	
2.1	Fusion welding	3
2.2	Solid state welding	3
2.3	Testing and Inspection of welding	2
2.4	Defects in welding	2
2.5	Welding fixtures	2
2.6	Brazing and soldering	2

Total **27 Periods**

Course Designer:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 37	-	-	2	1

G 37 MANUFACTURING PROCESSES AND METALLURGY LAB 0:1

Objective:

To impart hands on practice of the fundamental manufacturing processes of metal casting, injection moulding, metal joining, metal forging, metal forming and Inspection through material study and NDT. This would supplement the understanding of the theory course on Manufacturing Process Engineering.

List of Exercises

I. Foundry Practices (15 hrs)

1. Manufacture of casting for the given the material and the component drawing (Anvil, Bend pipe, Flange and Tumbles) along with the surface finish through
    a. designing of pattern and core box
    b. preparation of the mould
    c. melting, pouring and finishing **(9 hrs)**
2. Inspection of Casting
    a. Hardness using hardness testing
    b. Grain Structure using microscope
    c. Material Composition using spectrometry and
    d. Defect detection by NDT Method **(6 hrs)**

II Plastic Injection Moulding (3 hrs)

1. Study of Tools and Practice
2. Demonstration of Plastic Injection Moulding (Horizontal Machine)

III Welding Practices (15hrs)

1. Exercises in Arc / MIG Welding with use of appropriate fixtures for welding.
2. Exercises in Spot Welding different thickness by selecting appropriate current settings
3. Measurement of shear strength of various spot welded joints using UTM.
4. Brazing and Soldering in the sheet metal parts like- Dust Bin, Dust Pan , Taper Tray)
5. Inspection of Welding by NDT Method

IV Smithy Practices (3 hr)

1. Demonstration of Square / Hexagonal Head Bolt
2. Preparation of tool for shaping machine / Chisel. (Same tool to be ground and used for machining exercise)

NOTE: The Combined project is combining of all practices into one project work which will be considered for continuous assessment.
Any two practices will be given for the final practical examination

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Sub Code	Lectures	Tutorial	Practical	Credit
G38	0	0	2	1

G38 Fluid Mechanics and CFD lab

Objective

To impart practical knowledge on concepts of fluid mechanics by conducting experiments in flow through pipes/pumps and turbine, over/between parallel plates and simulation using modeling and simulation software. This would supplement the understanding of the theory course on Fluid Mechanics.

The following are the list of experiments. Minimum of 12 experiments are to be given. (At least six experiments in each Lab.)

Fluid Mechanics Lab.

1. Conduct an experiment to determine the rate of flow through a uniorm diameter pipe using orificemeter
2. Conduct an experiment to determine the rate of flow through a uniorm diameter pipe using venturimeter
3. Conduct an experiment to verify Bernoulli's theorem
4. Conduct an experiment to determine the losses in pipe section
5. Conduct Reynolds experiment to determine the type of flow in pipe
6. Conduct performance test on Pelton wheel/Francis turbine
7. Conduct performance test on centrifugal pump / reciprocating pump

CFD Lab.

1. Determine pressure, velocity distribution and losses in flow between parallel plates using numerical modeling and simulation software
2. Determine pressure, velocity distribution and losses in flow through circular pipe using numerical modeling and simulation software
3. Determine pressure, velocity distribution and losses in incompressible flow through venturimeter using numerical modeling and simulation software
4. Determine pressure, velocity distribution and losses in compressible flow through venturimeter using numerical modeling and simulation software
5. Determine the behaviour of fluid flowing over a flat plate using numerical modeling and simulation software
6. Determine the behaviour of fluid flowing over cylinder / air foil blade using numerical modeling and simulation software
7. Determine the flow distribution in a pipe circuit using numerical modeling and simulation software

Terminal Examination: Students would be tested in both labs each 1 ½ hours duration.

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Sub Code	Lectures	Tutorial	Practical	Credit
G 39	0	0	5	2

G39 Machine Drawing 0:2

Preamble:

Machine Drawing is the indispensable communicating medium employed in industries, to furnish all the information required for the manufacture and assembly of the components of a machine. It deals with the preparation of orthographic projections of various machine parts and assemblies as per Indian Standards on drawing practices and standard components.

Program Outcomes addressed:

a. Graduates will be able to communicate effectively in both verbal and written form.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate an ability to visualize and draft various machine components.

d. Graduates who can participate and succeed in competitive examinations.

Competencies:

1. Choose relevant I.S Code for drawing.
2. Understand drawing and develop ability to represent any matter or object with the help of picture.
3. Develop primary knowledge of working drawing.
4. Able to produce orthographic drawing of machine and power transmission elements.
5. Able to draw the suitable views of machine elements and power transmission elements using CAD modeling software.

Assessment Pattern:

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	0	0	0
2	Understand	20	20	20
3	Apply	80	80	80

4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Learning Objectives:

Understand:

1. Sketch the following types of line: (a) centre line, (b)cutting plane line and (c) long break
2. Sketch the conventional representation of the following materials: (a) bronze, (b) cast iron, (c) concrete, (d) wood
3. With a sketch explain revolved and removed sections.
4. How do you conventionally represent the following: (a) External threads,(b) Internal threads,(c) spur gear, (d) square on shaft
5. Show by means of sketches the method of showing location, symbol, size and depth of the following forms of weld: (a) single –V butt weld, (b) single-bevel butt weld, (c) double-J butt weld.
6. Sketch neatly, any three types of profiles of triangular threads. State the angle of the thread in each case and dimension the depth, assuming a pitch of 10 mm.
7. Show by means of neat, dimensioned sketches the shapes of the following rivets: (a) cup head, (b) pan head, (c) conical head, (d) counter sunk head.
8. Give neat sketches of a set-screw and a cap- screw.
9. Sketch the symbols for the following characteristics used for form tolerances

   (a) Symmetry (c) Perpendicularity (e) Coaxiality

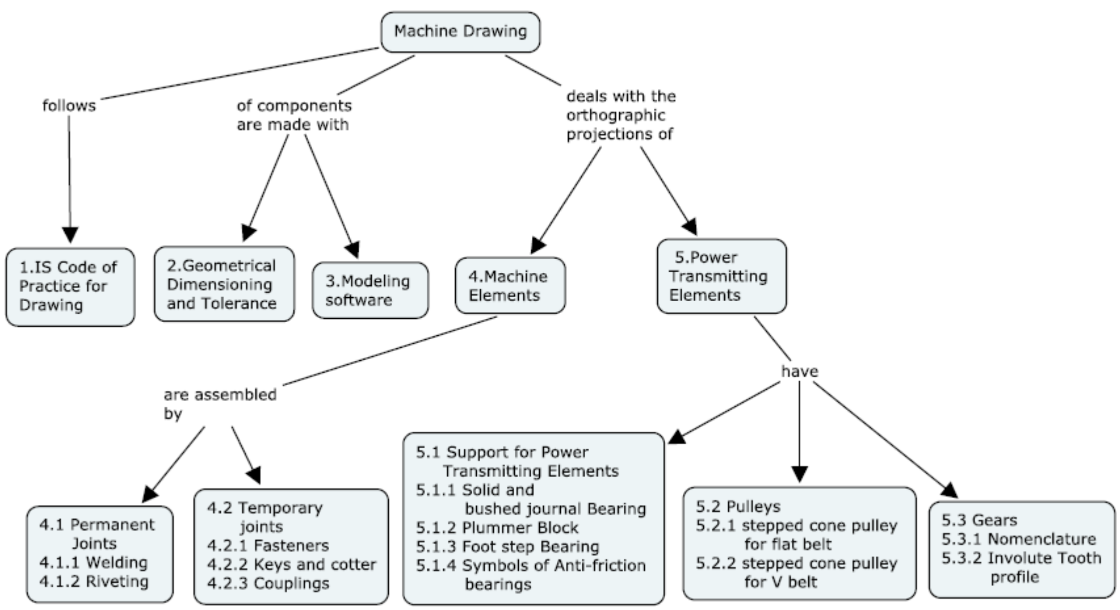
   (b) Straightness (d) Circularity (f) Parallelism

Application:

1. Draw the sectional front view and top view of a double riveted lap joint using rivets in chain arrangement of a boiler shell. Thickness of the plates = 10 mm. Show all the dimensions on the drawing.
2. Sketch neatly, two views of a double riveted butt joint using rivets in chain arrangement. Thickness of plates = 10 mm and diameter of rivets = 20 mm. Show one of the appropriate views in sections. Indicate all the dimensions.
3. Illustrate with neat assembled sketches of a feather key locked in the boss keyed to shaft of 40 mm diameter. The view which shows the length of the key should be shown in section.

4. Draw the assembled views of a cotter joint with sleeve, for the shaft diameter 30mm.
5. Draw the following views of a flanged coupling-unprotected type to 1:1 scale assuming d = 25 mm. (a) Front view with top half in section, (b) A view looking from the nut end.
6. Draw three views of a square headed bolt with a hexagonal nut. Show the bolt head and nut across corners in the front view. The nut is screwed on the bolt. The bolt is 20 mm diameter, 120 mm long with a thread length of 50mm.
7. Two square rods of side 50 mm each are connected by a cotter joint with a gib (fig 3). Sketch the following views of the assembly: (a) half sectional view from the front, (b) view from the side.
8. Draw two views of a flat saddle key fastening a boss to a shaft of 40mm diameter. The noncircular view of the assembly should be shown in half section. Indicate the empirical proportions along with the actual dimensions.
9. Draw a feather key locked to a shaft of 40mm diameter fastened to a boss. Show the noncircular view of the assembly in half section, Fully dimension the drawing.

Concept Map:



Syllabus

Introduction: I.S Code of practice for Machine Drawing- Use of scales, types of lines, hatching of sections - full section, half section, revolved and removed section, Representation of Materials. **Introduction to CAD modeling software:** Sketch plane, sketch entities, solid modeling and demo. **Geometrical Dimensioning and Tolerance**-

Symbols, tolerance frame, datum Surface Roughness- Methods and symbols, surface lay, Roughness values produced by common production process. **Machine Elements:** Permanent Joints- Welding- Types, symbol of welding- Riveting- Types of Rivet heads, Lap joint- single riveted, double riveted, straight and Zig zag, Butt Joint- single riveted, double riveted, straight and Zig zag- Temporary joints – Fasteners- forms of threads and types-Screws- cap screws, set screws, Grub screws, studs – Nuts- cap, castle, locknuts - Locking by set screw, grooved nut, plate and spring washer - hexagonal and square headed bolt- Keys and Cotter- Types of keys- hollow, saddle, sunk, parallel sunk, feather, wood ruff, round, key with gib head- Sleeve and cotter- Gib and cotter-Knuckle Joint- Couplings- Rigid and Flexible coupling- **Power Transmitting Elements:** Support for power transmitting elements- Solid and bushed journal Bearing , Plummer block, foot step bearing with radial and thrust ball bearing - symbols of antifriction bearings- Pulleys- step cone pulley for flat belt, Pulley for V-belt, fast and loose pulley- Gears- Nomenclature,Involute tooth profile.

TEXT BOOKS

1. K.R. Gopalakrishna, **"Machine Drawing"**, Subhas publications, Bangalore, Eighteenth Edition, 2004

REFERENCES

1. Warren Hammer **"Blueprint Reading Basics**, III Edition, Industrial Press Inc, New York, 2003
2. K.L.Narayana, P.Kannaiah and K.Venkata Reddy, **"Machine Drawing"**, 3rd reprint, New Age International Ltd., New Delhi, 2003.
3. P.S. Gill, "**A Text Book of Machine Drawing**" Seventh Edition Reprint, S. K. Kataria & Sons. New Delhi. 2004
4. Narayana, P.Kannaiah and K.Venkata Reddy, **"Production Drawing"**, First edition, New Age International Ltd., New Delhi, 1997
5. BIS Code 919.

Course Contents and Lecture Schedule:

No.	Topic	No. of Practice hours
	Machine Drawing	
1.	**Introduction** :I.S Code of practice for Drawing	

No.	Topic	No. of Practice hours
1.1	Use of Scales	1
1.2	Types of lines	
1.3	Hatching of sections - Full section, Half section	
1.4	Revolved and Removed section	1
1.5	Representation of Materials	
2.	**Introduction to CAD Modeling software**	
2.1	Sketch plane, Sketch entities	2
2.2	Solid modeling and demo	
3.	**Geometrical Dimensioning and Tolerance**	
3.1	Symbols, tolerance frame, datum	1
3.2	Surface Roughness	2
3.3	Methods and symbols, surface lay, roughness values produced by common production process	
4.	**Machine Elements**	
4.1	Permanent Joints	
4.1.1	Welding	1
4.1.1.1	Types	
4.1.1.2	Symbols of welding	
4.1.2	Riveting	
4.1.2.1	Types of Rivet heads	2
4.1.2.2	Lap joint- single riveted, double riveted, straight and Zig zag	2
4.1.2.3	Butt Joint- single riveted, double riveted, straight and Zig zag	3
4.2	Temporary joints	

No.	Topic	No. of Practice hours
4.2.1	Fasteners	
4.2.1.1	Forms of threads and types	2
4.2.1.2	Screws	2
4.2.1.3	Nuts	2
4.2.1.4	Hexagonal and Square headed bolt	2
4.2.2	Keys and Cotter	
4.2.2.1	Types of keys	3
4.2.2.2	Sleeve and cotter	2
4.2.2.3	Gib and cotter	2
4.2.2.4	Knuckle Joint	2
4.2.3	Couplings	
4.2.3.1	Rigid	2
4.2.3.2	Flexible	2
5	**Power Transmitting Elements**	
5.1	Support for Power Transmitting Elements *	
5.1.1	Solid and bushed journal Bearing	2
5.1.2	Plummer block	2
5.1.3	Foot step bearing	2
5.1.4	Symbol of anti friction bearings	1
5.2	Pulleys*	
5.2.1	Stepped cone pulley for flat belt	2
5.2.2	Stepped cone pulley for V belt	2
5.3	Gears	
5.3.1	Nomenclature	1
5.3.2	Involute tooth profile	2

No.	Topic	No. of Practice hours
	Total	**50**

***Note**: (i) The submission of Assignment sheets of Bridge course on Engineering Graphics is mandatory record for appearing in the terminal examination.*

(ii) * Modeling using CAD software should be done and submission of the record is mandatory.

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

FOURTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering,Madurai-625015
Department of Mechanical Engineering
Scheduling of Courses

Semester	**Theory Courses**						**Practical/Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					G88 Project 0:12	
7th (22)	G71 Management Theory & Practice 3:0	G72 Automobile Engineering 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G76 Manufacturing Systems Simulation Lab - II 0:1	G77 Mini Project 0:6	
6th (22)	G61 Accounting & Finance 3:0	G62 Design of Transmission System 2:1	G63 Quality & Reliability Engineering 3:0	G64 Mechatronics 3:0	Elective 1 3:0	Elective 2 3:0	G67 CAE Lab-I 0:1	G68 Mechatronics Lab 0:1	G69 Production Drawing 0:2
5th (23)	G51 Applied Statistical Techniques 4:0	G52 Kinematics & Dynamics of Machinery 3:1	G53 Metrology and Mechanical Measurements 3:0	G54 Heat & Mass Transfer 3:0	G55 Manufacturing Systems Engineering 3:0	G56 Industrial Engg. 3:0	G57 CAD/CAM Lab 0:1	G58 Heat Transfer Lab 0:1	G59 Mech. Measurement & Metrology Lab 0:1
4th (24)	G41 Numerical Methods 3:1	G42 Design of Machine Elements 3:1	G43 Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Control Systems 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (24)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 4:0	G33 Applied Material & Metallurgy 3:0	G34 Fluid Mechanics 3:1	G35 Metal Casting & Plastic forming processes 3:0	G36 Metal Forming & Joining Processes 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics & CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Ecology and Environment 2:0	G26 Computer Programming 3:0	G27 Strength of Materials & Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
G 41	Numerical Methods	BS	3	1	-	4
G42	Design of Machine Elements	DC	3	1	-	4
G 43	Geometric Modeling	DC	3	0	-	3
G 44	Thermal Engineering	DC	3	0	-	3
G 45	Machining Processes	DC	3	0	-	3
G 46	Control Systems	ES	3	0	-	3
PRACTICAL						
G47	Machining Practice Lab.	DC	-	-	3	1
G48	Thermal Engineering Lab.	DC	-	-	3	1
G49	Professional Communications	HSS	1	-	1	2
Total			**19**	**2**	**7**	**24**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

FOURTH SEMESTER

S.No.	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G 41	Numerical Methods	3	50	50	100	25	50
2	G42	Design of Machine Elements	3	50	50	100	25	50
3	G 43	Geometric Modeling	3	50	50	100	25	50
4	G 44	Thermal Engineering	3	50	50	100	25	50
5	G 45	Machining Processes	3	50	50	100	25	50
6	G 46	Control Systems	3	50	50	100	25	50
PRACTICAL								
7	G47	Machining Practice Lab.	3	50	50	100	25	50
8	G48	Thermal Engineering Lab.	3	50	50	100	25	50
9	G49	Professional Communications	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
G 41	3	1	-	4

G41 Numerical Methods 3:1

Preamble: An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving adequate exposure in the numerical solutions in the field of algebraic and transcendental equations, System simultaneous equations, Interpolation, Differentiation and Integration, Ordinary and Partial differential equations, for numerical solutions.

Program Outcomes addressed

a. An ability to apply knowledge of Engineering and Information Technology in Mathematics and Science.

b. An ability to identify, formulate and solve Engineering problems.

c. An ability to engage in life-long learning.

Competencies

At the end of the course the student should be able to

1. Differentiate between the analytical and numerical / approximate solutions for the problems in engineering and technology.
2. Apply the concept of numerical solutions of algebraic and transcendental equations in engineering problems by formulating such equations.
3. Apply the different techniques for getting the numerical solution of a system of simultaneous equations using direct and iterative methods.
4. Identify the importance of Eigen values for a matrix and calculate those using different numerical techniques.
5. Interpolate and extrapolate the given data using different numerical methods of interpolation with the help of various operators.
6. Apply the process of Numerical Integration to related problems of engineering and technology for getting approximate values of the given integral.
7. Formulate and give Numerical solutions using various techniques for ODEs modeled in engineering and technology.
8. Formulate and give Numerical solutions using various techniques for PDEs modeled in engineering and technology.

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Predict where the roots of the equation $x^6 + 3x^5 + 5x - 1 = 0$ lie?
2. Estimate the equation whose roots are 1 less than that of $x^4 - 4x^3 - 7x^2 + 22x + 24 = 0$.
3. Predict the solution by Gauss Elimination Method $x + y = 3; 2x + y = 5$
4. Discuss the process to find the inverse of Non Singular Matrix using Crout's Method?
5. Estimate the first order forward differences of

X	1	2	3	4	5	6
Y	4	15	40	85	156	259

6. Estimate the value of x when y =19 from the following

x	0	1	2
y	0	1	20

7. Associate an example for an Initial value problem.
8. Estimate the predicted value of $y(0.4)$ using Adam's method given $y' = \frac{1}{2}(1 + x^2)y^2$; $y(0) = 1$; $y(0.1) = 1.06$; $y(0.2) = 1.12$; $y(0.3) = 1.21$
9. Discuss the nature of the PDE $\frac{\partial^2 u}{\partial x^2} + 2\frac{\partial^2 u}{\partial x \partial y} + \frac{\partial^2 u}{\partial y^2} = 0$
10. Discuss the Leibmann's iterative scheme in solving elliptic equations.
11. List the various techniques for the approximate solution of Algebraic and transcendental equations.

Understand

1. Distinguish between the exact solution and approximate solution of equations
2. Mention out the various methods for obtaining the approximate solution of system of simultaneous equations.
3. Discuss the various methods to interpolate as well as extrapolate the given data using various methods of interpolation.

4. Interpret the importance and significance of the process of numerical integration.

5. Predict the nature of the roots of the equation $x^6 + 3x^5 + 5x - 1 = 0$.

Apply

1. Solve the following system of equations by Gauss Jacobi method
$8x + y + z = 8$; $2x + 4y + z = 4$; $x + 3y + 3z = 5$.

2. Using Newton's method find the root of $x^3 - 4x^2 + x + 6 = 0$; $x_0 = 5$ correct to 4 decimal places

3. Using Lagrange's formula for interpolation find $y(9.5)$ given:

x	:	7	8	9	10
y	:	3	1	1	9

4. The following data gives the velocity of the particle for 2 seconds at an interval of 5 seconds. Find the acceleration at 5 seconds

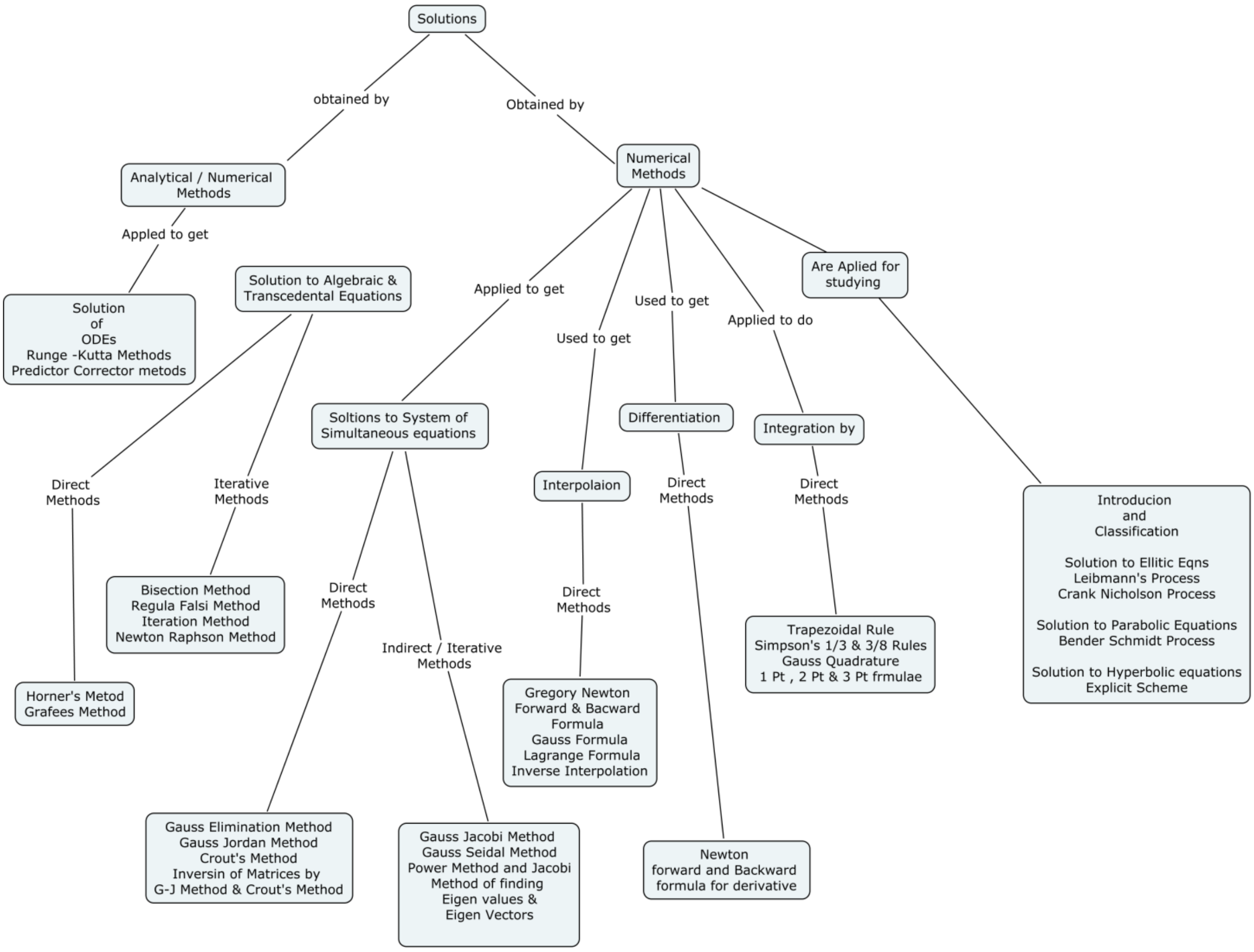
Time	:	0	5	10	15	20
Velocity	:	0	3	14	69	228

5. Compute $\int_0^6 \frac{dx}{1+x}$, using Simpson's $\frac{1}{3}$ *and* $\frac{3}{8}$ rule.

6. Find the value of $y(0.2)$ *and* $y(0.4)$ using Runge-Kutta method of fourth order with h=0.2 given that $\frac{dy}{dx} = \frac{y^2 - x^2}{y^2 + x^2}$; $y(0) = 1$.

7. Solve : $u_t = u_{xx}$ given $u(0,t) = 0$; $u(x,0) = x(1-x)$; $u(1,t) = 0$; assume h=0.1 and choose suitable k so that u(i,j) is found out for i=0,0.1…1 and j=k,2k,3k.

Concept Map



Syllabus

Solution of Transcendental and Polynomial Equations: Bisection, Regula falsi, Newton-Raphson, Iterative Methods, Horner's Method, Giraeffes Root Squaring Method.

Solution to System of Equations: Gauss Elimination, Gauss Jordan, Crou's, Gauss Seidel, Gauss Jacobi, Inversion by Gauss Jordan and Crout's Method.

Eigen Values: Power method, Jacobi Method.

Interpolation and Differentiation: Newton's forward difference interpolation and differentiation formula and backward difference interpolation and differentiation formula, Gauss's Forward difference interpolation and differentiation formula and backward difference interpolation formula, Lagrange's Interpolation formula.Newton's formulae for derivatives.

Integration:

Trapezoidal, Simpson's $\frac{1}{3}^{rd}, \frac{3}{8}^{th}$ rules, Gauss quadrature 1point, 2point, 3point formula

Ordinary Differential Equations:
Initial value Problem - Runge-Kutta Method, Predictor-Corrector Methods -Milne's, Adams -Boundary Value Problem - Finite difference Method- Numerov method

Partial Differential Equations:

Classification: Parabolic (Schmidt)-Hyperbolic- Elliptic- Implicit and Explicit methods, Crank Nicholson method.

Text Book:

1. Jain. M.K. Jain R.K., "**Numerical Methods for Scientific and Engineering Computation**", Fifth edition, New Age International Publishers, New Delhi,2009.

Reference Books:

1. Rober.J Schilling ,Sandra L.Harris, "**Applied Numerical Methods for Engineers using Mat lab and C**", Thomson Books/cole,1999.

2. Sastry S.S, "I**ntroductory Methods of Numerical Analysis**" Prentice Hall of India, 2001.

3. P.Kandasamy, K.Thilagavathy, K.Gunavathy, "**Numerical Methods**", S.Chand & Co. New Delhi, 1999.

Course contents and lecture schedule

No	Topic	No. of Lectures
1	**Solution of transcendental and polynomial equations**	
1.1	Bisection , Regulafalsi , Newton- Raphson method	3
1.2	Iterative method	2
1.3	Horner's method	3
1.4	Graffe's root squaring method	2
2	**Solution to system of equations**	
2.1	Gauss elimination and Gauss Jordan methods	2
2.2	Crout's method	2
2.3	Gauss Jacobi and Gauss siedal methods.	2
2.4	Inversion by Gauss Jordan and Crout's methods.	2
2.5	Power method and Jacobi method for finding eigen values	2
3	**Interpolation , Differentiation and integration**	
3.1	Newton Gregory's forward and backward difference interpolation formulae	2
3.2	Gauss's and Lagrange's interpolation formulae	2
3.3	Newton's forward formulae for derivatives	2
3.4	Trapezoidal, Simpson's 1/3 & 3/8 Rules	2
3.5	Gauss quadrature ,1 point , 2 point , 3 point formulae	2

4	**Ordinary Differential equations**	
4.1	Introduction – Initial value problems	2
4.2	Runge- Kutta Methods	2
4.3	Predictor corrector methods	2
4.4	Finite difference methods.	2
4.5	Hermitian / Numerov method	2
5	**Partial Differential equations**	
5.1	Introduction, Classification of PDEs.	2
5.2	Solution of parabolic equations-Bender Schmidt , Crank Nicholson Mds	3
5.3	Solution of hyperbolic equations by explicit scheme.	3
5.4	Solution of elliptic equations - Leibmann's process	2

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Sub Code	Lectures	Tutorial	Practical	Credit
G 42	3	1	-	4

G42 Design of Machine Elements 3:1

Preamble

Engineering Design is the process of deriving a system, component or process to meet desired needs. It is a decision-making process, in which the basic sciences and mathematics and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment or objectives and criterion, synthesis, analysis, construction, testing and evaluation. This course is concerned with one aspect of engineering design pertaining to Machine Elements Design. Machine Elements Design deals with the creation of machine element that goes into the making of a machine as a product.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate skills to use modern engineering tools, software's and equipment to analyze problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies

1. Identify the working conditions and its effects on the given machine elements like joints, power transmission, energy absorbing elements like clutches and brakes.
2. Select the material of the component operating in specified working environment
3. Specify the requirements of elements of different machines
4. Design machine elements as per specifications.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	10	10	10
2	Understand	10	10	10
3	Apply	80	80	80
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

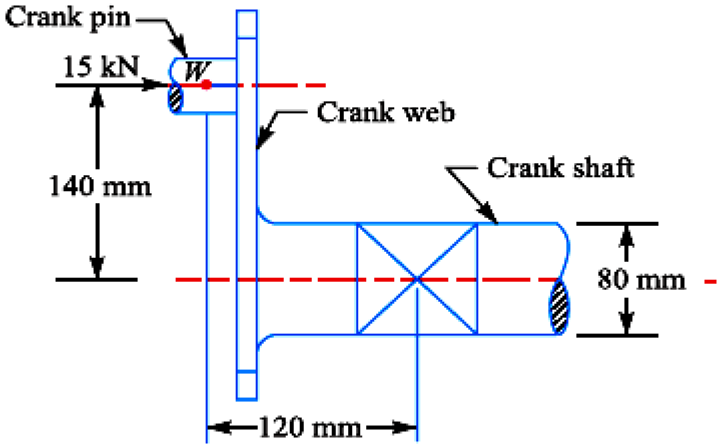
1. What is meant by endurance strength of a material?
2. What is meant by `stress concentration'?
3. Write Soderberg's equation
4. What is the material used for rivets?
5. Explain the following heat treatment processes:1. Normalizing; 2. Hardening;
6. What are the various permanent and detachable fastenings?
7. What are the methods and materials used in the manufacture of crankshafts?
8. Define the following properties of a material: Toughness and Hardness
9. What do you understand by preferred numbers?
10. What is the function of flywheel?

Understand

1. Distinguish between direct stress and bending stress.
2. Illustrate how the stress concentration in a component can be reduced.
3. Select suitable material for the following cases, indicating the reason;
   1. Spring used in a spring loaded safety valve;
   2. Nut of a heavy duty screw jack;
4. Classify springs according to their shapes.
5. Explain the various types of crankshafts.
6. Give the application of the following wire ropes:
   (a)6 × 7 rope (*b*) 6 × 19 rope
7. At what angle of the crank, the twisting moment is maximum in the crankshaft?
8. Why I section is preferred from connecting rod?
9. What types of stresses are induced in the flywheel?

Apply

1. An overhang crank with pin and shaft is shown in Fig.. A tangential load of 15 kN acts on the crank pin. Determine the maximum principal stress and the maximum shear stress at the centre of the crankshaft bearing.



2. Determine the diameter of a circular rod made of ductile material with a fatiguestrength (complete stress reversal), σe = 265 MPa and a tensile yield strength of 350 MPa. The member is subjected to a varying axial load from Wmin = – 300 × 10^3 N to Wmax = 700 × 10^3 N and has a stress concentration factor = 1.8. Use factor of safety as 2.0.

3. A triple riveted butt joint with equal double cover plates (zig-zag riveting) is used for the longitudinal joint of a Lancashire boiler of 2.5 m internal diameter. The working steam pressure is 1.12 N/mm^2 and the efficiency of the joint is 85 per cent. Calculate the plate thickness for mild steel of 460 MPa ultimate tensile strength. Assume ratio of tensile to shear stresses as 7/6 and factor of safety 4. The resistance of the rivets in double shear is to be taken as 1.875 times that of single shear. Design a suitable circumferential joint also.

4. A 125 × 95 × 10 mm angle is joined to a frame by two parallel fillet welds along the edges of 150 mm leg. The angle is subjected to a tensile load of 180 kN. Find the lengths of weld if the permissible static load per mm weld length is 430 N.

5. The pull in the tie rod of an iron roof truss is 50 kN. Design a suitable adjustable screwed joint. The permissible stresses are 75 MPa in tension, 37.5 MPa in shear and 90 MPa in crushing.

6. Design a knuckle joint to connect two mild steel bars under a tensile load of 25 kN. The allowable stresses are 65 MPa in tension, 50 MPa in shear and 83 MPa in crushing.

7. A solid circular shaft is subjected to a bending moment of 3000 N-m and a torque of 10 000 N-m. The shaft is made of 45 C 8 steel having ultimate tensile stress of 700 MPa and a ultimate shear stress of 500 MPa. Assuming a factor of safety as 6, determine the diameter of the shaft.

8. A hollow shaft is subjected to a maximum torque of 1.5 kN-m and a maximum bending moment of 3 kN-m. It is subjected, at the same time, to an axial load of 10 kN. Assume that the load is applied gradually and the ratio of the inner diameter to the outer diameter is 0.5. If the outer diameter of the shaft is 80 mm, find the shear stress induced in the shaft.

9. Design a bushed-pin type flexible coupling for connecting a motor shaft to a pump shaft for the following service conditions :
   Power to be transmitted = 40 kW ; speed of the motor shaft = 1000 r.p.m. ; diameter of the motor shaft = 50 mm ; diameter of the pump shaft = 45 mm.
   The bearing pressure in the rubber bush and allowable stress in the pins are to be limited to 0.45 N/mm^2 and 25 MPa respectively.

10. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity,G = 84 kN/mm^2.Neglect the effect of stress concentration.

11. A truck spring has 12 number of leaves, two of which are full length leaves. The spring supports are 1.05 m apart and the central band is 85 mm wide. The central load is to be 5.4 kN with a permissible stress of 280 MPa. Determine the thickness and width of the steel spring leaves. The ratio of the total depth to the width of the spring is 3. Also determine the deflection of the spring.

12. A shaft made of mild steel is required to transmit 100 kW at 300 r.p.m. The supported length of the shaft is 3 metres. It carries two pulleys each weighing 1500 N supported at a distance of 1 metre from the ends respectively. Assuming the safe value of stress, determine the diameter of the shaft.

13. A multi-cylinder engine is to run at a speed of 500 r.p.m. On drawing the crank effort diagram to scale 1 mm = 2500 N-m and 1 mm = 3º, the areas above and below the mean torque line are in sq mm as below:
+ 160, – 172, + 168, – 191, + 197, – 162.The speed is to be kept within ± 1% of the mean speed of the engine. Design a suitable rim type C.I. flywheel for the above engine. Assume rim width as twice the thickness and the overhang of the flywheel from the centre of the nearest bearing as 1.2 metres. The permissible stresses for the rim in tension are 6 MPa and those for shaft and key in shear are 42 MPa. The allowable stress for the arm is 14 MPa.

14. A semi-elliptical laminated spring 900 mm long and 55 mm wide is held together at the centre by a band 50 mm wide. If the thickness of each leaf is 5 mm, find the number of leaves required to carry a load of 4500 N. Assume a maximum working stress of 490 MPa. If the two of these leaves extend the full length of the spring, find the deflection of the spring. The Young's modulus for the spring material may be taken as 210 kN/mm^2.

15. Determine the dimensions of an *I*-section connecting rod for a petrol engine from the following data: Diameter of the piston = 110 mm; Mass of the reciprocating parts = 2 kg; Length of the connecting rod from centre to centre = 325 mm; Stroke length = 150 mm; R.P.M. = 1500 with possible over speed of 2500; Compression ratio = 4 : 1; Maximum explosion pressure = 2.5 N/mm^2.

16. Design a side crankshaft for a 500 mm × 600 mm gas engine. The weight of the flywheel is 80 kN and the explosion pressure is 2.5 N/mm^2. The gas pressure at maximum torque is 0.9 N/mm^2 when the crank angle is 30º. The connecting rod is 4.5 times the crank radius.

17. Design a Connecting Rod for a Steam Engine to the following specifications

Steam Pressure:	0.6N/mm^2
Bore of the Cylinder:	300 mm
Stroke of the Piston:	600 mm
Length of Connecting Rod	1500 mm
Speed of the Engine:	450 rpm

Select suitable Material

18. Design a Centre Crankshaft for an IC Engine to the following specifications

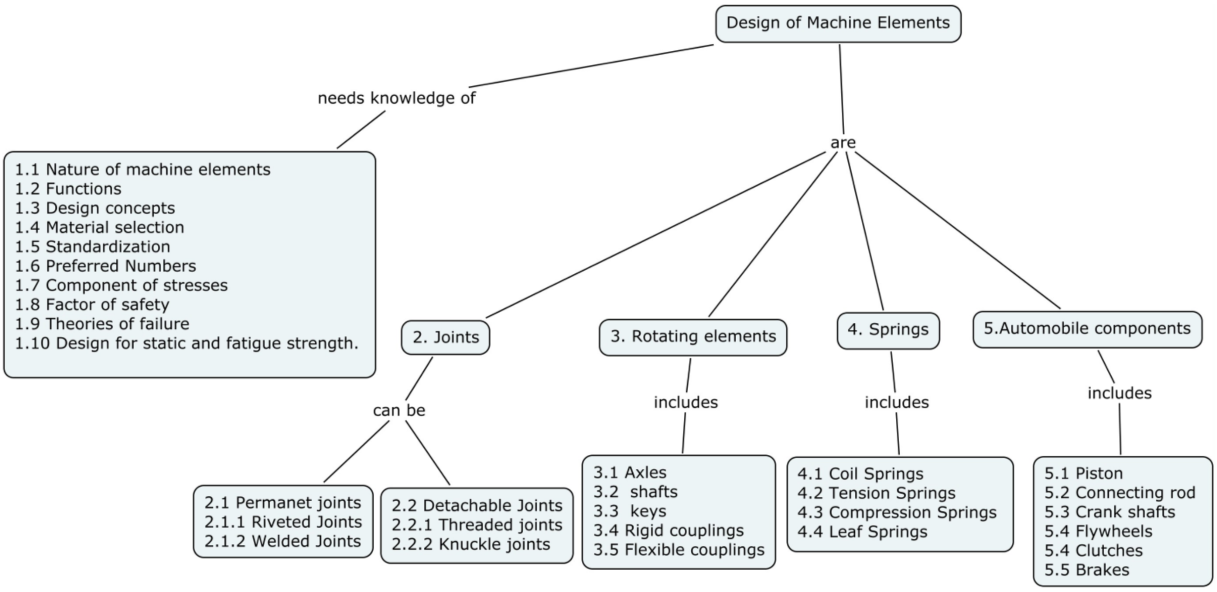
Bore	:150 mm
Stroke Length	:190 mm
Length of Connecting Rod	:380 mm
Maximum Pressure	:3.2N/mm^2
Speed	:600 rpm
Distance between Bearings	: 400mm

Select suitable Material

19. A multiple cylinder engine is to run at a speed of 600 rpm. The turning moment crank angle diagram drawn to a scale of 1mm =250 Nm. and 1mm= 30.The areas in sq.mm above and below the mean torque line are as follows: + 160,- 172,+ 168,- 191,+ 197,-162 sq.mm. The speed is to be kept within +- 1.5% of the mean speed of the Engine. Calculate necessary moment of inertia of the flywheel. Determine suitable dimensions of the cast iron flywheel with a rim whose breadth is twice its radial thickness.

20. A multi-disc clutch has three discs on the driving shaft and two on the driven shaft. The inside diameter of the contact surface is 120 mm. The maximum pressure between the surface is limited to 0.1 N/mm2. Design the clutch for transmitting 25 kW at 1575 r.p.m. Assume uniform wear condition and coefficient of friction as 0.3

Concept Map



Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Engineering design concepts**	
1.1	Nature of machine elements	1
1.2	Functions of machine elements	1
1.3	Design concepts	1
1.4	Selection of materials	1
1.5	Standardization – Preferred Numbers ,Components of stresses- Ultimate and allowable stress- Factor of safety	2
1.6	Principal Stresses	1
1.7	Theories of failure	2
1.8	Design for static strength	1
1.9	Design for fatigue strength	2
	Tutorial	1

2.	**Joints**	
2.1	Design of riveted joints	1
2.1.1	Leak proof Joints- Pressure Vessels and Structural applications	1
2.2	Design of welded Joints	1
2.2.1	Lap and Butt Joints – Design of Welded Joints with all types of loading	1
2.3	Design of threaded Joints - Foundation Bolts	1
2.4	Design of knuckle joint	1
	Tutorial	1
3	**Rotating Elements and Couplings**	
3.1	Design of Axles	1
3.2	Design of Shafts	1
3.2.1	Shafts subjected to Twisting moment and Combined Bending and Twisting moment	1
3.2.2	Shafts subjected to Combined Bending and Twisting moment with axial loads	1
3.3	Design of Keys for shafts	1
3.4	Design of rigid couplings	1
3.5	Design of flexible couplings	1
	Tutorial	1
4	**Springs**	
4.1	Tension Springs	1
4.2	Compression Springs	1
4.3	Leaf Springs	1
	Tutorial	1
5.	**Automobile Components**	
5.1	Design of Piston	1
5.2	Design of Connecting Rod - I section and Circular section -	2
5.3	Design of Crank shafts- Side crank -Centre crank-	2

5.4	Design of flywheels	2
5.5	Design of clutches - Single and Multi plate Clutches	2
5.6	Design of Brakes	3
	Tutorial	1
	Total hours	**45**

Syllabus

Engineering design concepts: Nature of Machine Elements- Design concepts- Factors influencing Design -Selection of materials - Standardization – Preferred Numbers - Component of stresses, ultimate and allowable stress, Factor of safety Theories of failure - Design for static and fatigue strength. **Joints:** Design of Permanent joints - Riveted joints- Leak proof Joints- Pressure Vessels and Structural applications - Welded Joints – Lap and Butt Joints – Design of Welded Joints with all types loading – Design of Detachable joints : Threaded Joints and Knuckle joint - **Rotating Elements and Couplings:** Axles subjected to Bending moment – Shafts subjected to Twisting moment, Combined Bending and Twisting moment with axial loads - Design of Keys for shafts - Design of couplings – Rigid couplings and Flexible couplings- **Springs:** Coil Springs :Tension Springs - Compression Springs –Leaf Springs **Automobile Components**: Piston - Connecting rod with I section and Circular section - Crank shafts : Side crank and Centre crank – Flywheels. **Clutches:** Function of clutch, classification of clutches, principle of working of single plate clutch and cone clutch with simple line diagram, multi plate clutch, calculation of frictional torque for uniform pressure and uniform wear, power transmitted. **Brakes:** Function and types of brakes, Energy equations, internal expanding brakes, disc brake system design brake liner materials

Text Books

1. Joseph Edward Shigley and Charles R. Misucke, “**Mechanical Engineering Design**”, Sixth Edition, Tata McGraw Hill, 2003.
2. Robert L. Norton, “**Machine Design: An Integrated Approach**”, Third Edition”, Prentice Hall, 2005.
3. V.B. Bhandari, **“Design of machine elements”, Third Edition,** Tata McGraw Hill, 2010

Reference Books

1. Sundarajamoorthy T.V. and Shanmugam. N, “**Machine Design**”, Anuradha Agencies, 2000.
2. K. Ganesh Babu, K. Srithar, “**Design of Machine Elements”**, Mc Graw Hill Education, 2009.
3. Hall, Holowenko and Laughin, “**Theory and Problems of Machine Design**”, Tata McGraw Hill Company, 2002.
4. Sharma P. C, and Agarwal D.K, “**Machine design**”, S.K. Kataria and Sons, New Delhi, 2000.
5. M. F. Spotts, T. E. Shoup, “**Design of Machine Elements”**, Seventh Edition” Pearson Education Asia, 2003.
6. PSG, “**Design Data Book**”, 2007.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G43	3	0	-	3

G43 Geometric Modeling 3:0

Preamble

The concept of geometric modeling is evolved rapidly due the development of computer graphics and computer aided design and manufacturing technologies. Geometric modeling is the base for the computer aided design (CAD) and it embraces computational geometry and extends to the field of solid modeling, creating an elegant synthesis of geometry and the computer. The construction of an entity is usually a computer aided operation, with the model stored in and analyzed by a computer. Computer graphics, Computer aided design and computer aided manufacturing have been the driving forces behind the rapid development of geometric modeling schemes. Robotics, computer vision and artificial intelligence are also making increasing demands on geometric modeling capabilities.

Program outcomes addressed

a. An ability to apply knowledge of engineering, mathematics and science.

b. An ability to use CAD Systems for designing a system or component or process to meet stated specification.

c. An ability to identify, formulate and solve engineering problem using Computers.

Competencies:- At the end of the course, student will be able to:

1. Define the coordinate system for the development of models based on input and geometry.
2. Develop and manipulate the curves and surfaces using parametric equations.
3. Develop and manipulate the solid models using modeling techniques.
4. Implement the transformation and projection over the geometric model.
5. Implement the neutral file formats over 2D wireframe models.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3 / End Semester Examination
1.	Remember	30	20	20
2.	Understand	40	40	40
3.	Apply	30	40	40
4.	Analyze	0	0	0
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course level learning objectives under each bloom's category

Remember

1. What is local coordinate system?
2. List the desirable properties of curve modeling.
3. What do you mean by spatial addressability?
4. List out the major area of computer graphics.
5. Give transformation matrix for perspective projection.
6. What is graphics standard?

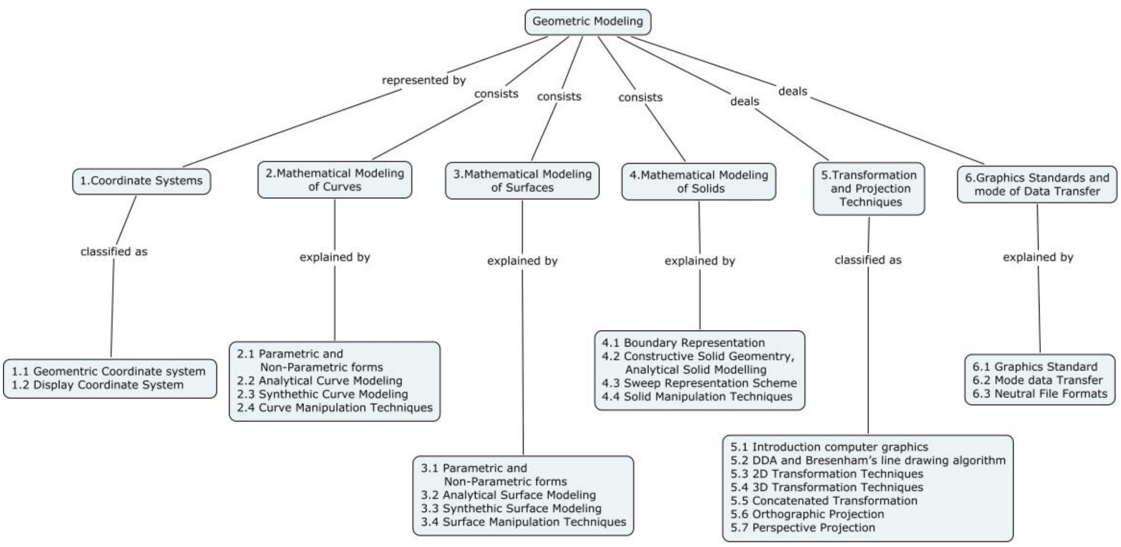
Understand

1. Differentiate between analytical curves and synthetic curves.
2. Explain the advantages of parametric representation in CAD applications.
3. Describe with a suitable example about the solid model building operations with CSG and sweep representation methods.
4. Describe the rotational transformation with a suitable example.
5. Derive the transformation matrix for elevation view with suitable example.
6. Explain the structure of IGES format.

Apply

1. Generate a segment of Bezier curve using (0, 0), (15, 0), (10, 10) and (5, 10) using polynomial equation.
2. Obtain the IGES format for circle of diameter 30 mm located at (0, 0) and line segment of (10, 5) and (20, 0).
3. How can you combine the various surface entities provided by CAD systems to design A/C ducts?
4. Develop a solid model of hollow cylinder of 20 mm thickness with ASM and sweep schemes.
5. Obtain the rotation of 30^{O} CW direction about Y axis transformation of square of side 20 mm located at WCS.
6. Use concatenated transformation principle, obtain the transformation position of a point (10, 10) with respect to (5, 5).

Concept map



Syllabus

Coordinate systems: Geometric co-ordinate systems - Cartesian, Cylindrical and Spherical coordinate systems. Display co-ordinate systems - Global, Local, View and Screen coordinate systems. **Mathematical modeling of Curves:** Define - Parametric and non-parametric forms of analytical and synthetic curves. Analytical Curve modeling - Line Segment, Circle, Ellipse. Synthetic Curve modeling - Hermite Cubic Spline, Bezier, B-spline and Rational Curves. Manipulation - Analytical and Synthetic Curve manipulation techniques. **Mathematical modeling of Surfaces:** Define - Parametric and non-parametric forms of analytical and synthetic surfaces. Analytical surface modeling - Parametric form of plane, loft, Cylindrical, Surface of revolution. Synthetic Surface modeling - Hermite Bicubic Spline, Bezier, B-spline, Coon's, triangular, blending Surfaces. Manipulation - Analytical and Synthetic Surface Manipulation techniques. **Mathematical modeling of Solids:** Boundary representation, Constructive Solid Geometry, Analytical Solid Modeling, Sweep representation schemes. Manipulation - Solid Manipulation Techniques. **Transformation and Projection techniques:** Introduction computer graphics – Non-interactive interactive Vs computer graphics, applications, graphics system configuration, DDA and Bresenham’s line drawing algorithm. 2D and 3D transformation techniques - Translation, Rotation, Scaling and Reflection. Principle of concatenated transformation. Orthographic and Perspective Projections of Geometric Models. **Graphic Standards and mode of data transfer:** Define graphics standard, geometrical data, direct and indirect data transfer. Neutral file formats – Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES).

Text books

1. Ibrahim Zeid, “Mastering CAD/CAM”, Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2008.

Reference books

1. Amarendra N Sinha and Arun D Udai, “Computer Graphics”, Tata McGraw Hill Education (P) Ltd., Second reprint, 2009.
2. Michael E. Mortenson, “Geometric modeling”, Industrial Press, Third edition, 2006.
3. Rogers, “Mathematical Elements for computer Graphics”, Tata Mcgraw Hill Education Private Limited, 2009.

Course contents and Lecture schedule

S.No	Topics	No. of Lectures
1	**Coordinate systems**	
1.1	Geometric co-ordinate systems – Cartesian, Cylindrical and Spherical coordinate systems	1
1.2	Display co-ordinate systems – Global, Local, View and Screen coordinate systems	1
2	**Mathematical modeling of Curves**	
2.1	Parametric and non-parametric forms of analytical and synthetic curves	2
2.2	Analytical Curve modeling – Line Segment, Circle, Ellipse.	2
2.3	Synthetic Curve modeling – Hermite cubic spline, Bezier curve	2
	Synthetic Curve modeling – B-spline and Rational Curves	2
2.4	Manipulation – Analytical and synthetic curve manipulation techniques	1
3	**Mathematical modeling of Surfaces**	
3.1	Parametric and non-parametric forms of analytical and synthetic surfaces	1
3.2	Analytical surface modeling – Parametric form of plane, loft surface	1
	Analytical surface modeling – Cylindrical, Surface of revolution	1
3.3	Synthetic Surface modeling – Hermite bicubic spline, Bezier surface	2
	Synthetic Surface modeling – B-spline, Coon's, Triangular, Blending Surfaces	2
	Synthetic Surface modeling – triangular, blending Surfaces	1
3.4	Manipulation – Analytical and synthetic surface manipulation techniques	1
4	**Mathematical modeling of Solids**	
4.1	Boundary representation scheme	2
4.2	Constructive Solid Geometry, Analytical Solid Modeling	2
4.3	Sweep representation scheme	1

4.4	Manipulation – Solid Manipulation Techniques	1
5	**Transformation and Projection techniques**	
5.1	Introduction computer graphics – Non-interactive Vs Interactive computer graphics, applications, graphics system configuration	2
5.2	DDA and Bresenham's line drawing algorithm	2
5.3	2D transformation techniques – Translation, Rotation	2
	2D transformation techniques – Scaling and Reflection	1
5.4	3D transformation techniques – Translation, Rotation	2
	3D transformation techniques – Scaling and Reflection	1
5.5	Principle of concatenated transformation	1
5.6	Orthographic Projections of Geometric Models	1
5.7	Perspective Projections of Geometric Models	1
6	**Graphic Standards and mode of data transfer**	
6.1	Graphics standard	1
	Geometrical data	1
6.2	Mode of data transfer - Direct and indirect data transfer	1
6.3	Neutral file formats - Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES)	2
	Total	**44**

Course designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 44	3	0	-	3

G44 Thermal Engineering 3:0

Preamble

Thermal Engineering deals with the application of thermodynamics in various Thermal systems. This course covers the study of working and performance analysis of power cycles and refrigeration systems, psychrometric process, air-conditioning systems, steam nozzels, reciprocating air compressors and internal combustion engines.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.

d. Graduates can participate and succeed in competitive examinations.

Competencies

1. Explain working principles of power cycles and refrigeration systems.
2. Compute the performance of power and refrigeration cycles.
3. Define the properties of atmospheric air.
4. Compute the heat and moisture transfer with the help of psychrometric chart for various psychrometric processes.
5. Explain the working of summer and winter air conditioning systems.
6. Compute the performance of steam nozzles and reciprocating air compressors.
7. Explain the working of engine and its accessories.
8. Determine the performance parameters of I.C. engines.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	20
2	Understand	30	30	30
3	Apply	50	50	50
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives:

Remember:

1. Define vapour power cycles
2. List the different types of vapour power cycles
3. Define reheat cycle
4. Define regenerative cycle
5. Define steam nozzles
6. Define air compressor
7. List the different types of air compressors
8. Define steam nozzle
9. What is a carburetor?
10. Define brake thermal efficiency and specific fuel consumption.

Understand:

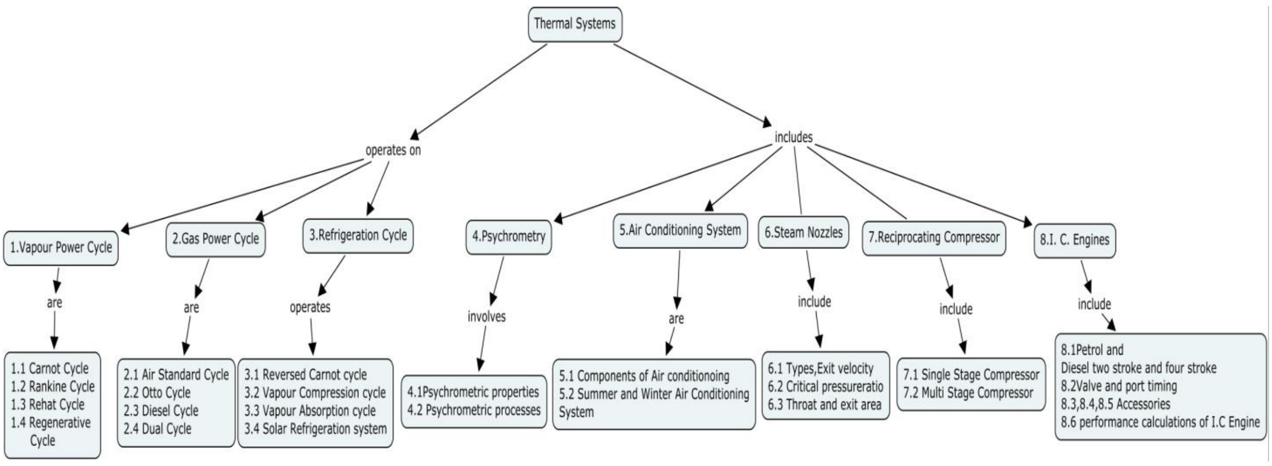
1. Distinguish between Carnot cycle and Rankine cycle
2. Explain how to improve the efficiency of simple Rankine cycle.
3. How do you determine the thermal efficiency of Rankine cycle
4. Compare the efficiency of Otto cycle and diesel cycle for the same compression ratio with the help of p-v diagram.
5. Explain the cooling and dehumidification process with the help of psychrometric chart.
6. Describe the working of summer air conditioning system with a neat sketch.
7. Explain what you understand by critical pressure ratio of a steam nozzle.
8. What is the purpose of an intercooler in a multi stage compressor?
9. Bring out the differences between a petrol engine and diesel engine.
10. Explain the working of fuel pump.
11. Derive the equation to find the work done of carnot cycle
12. Derive an expression to find the air standard efficiency of an OTTO cycle, with p-v diagram.

Apply

1. An engine works between the temperature limits of 1775 K and 375 K. What can be maximum thermal efficiency of the engine?

2. Steam at 10 bar and 300°c is expanded in a steam nozzle to 1 bar. Determine (1) Throat velocity of steam. (2) Exit velocity of steam and (3) Throat area and Exit area of the nozzle if the mass flow rate of steam is 5kg/s. Ten percent of enthalpy drop in the nozzle is lost in friction, both in the convergent and divergent part.
3. In a single stage,single acting reciprocating air compressor air at 1 bar and 27°c is polytropically compressed to 5.5 bar, according to the law pV 1.3 = C. Calculate the indicated power required to drive the compressor and the temperature of the air delivered.
4. Air at 103 kPa and 27°c is drawn in L.P cylinder of a two-stage air compressor and is isentropicallly compressed to 700kPa. The air is then cooled at constant pressure to 37°c in an inter-cooler and is then again compressed isentropically to 4 MPa in the Determine the power required to run the compressor if it has to deliver 30m^3 of air per hour measured at inlet conditions.
5. An ideal diesel engine has a diameter 150 mm and stroke 200mm.The clearance volume is 10 % of the swept volume. Determine the compression ratio and the air standard efficiency of the engine if the cutoff takes place at 6 % of the stroke . Take γ = 1.4.

Concept Map



Syllabus

Vapour cycles: Carnot cycle - impracticability, Rankine cycle – ideal and actual, Reheat cycle and working of Regeneration cycle. **Gas cycles:** Air standard cycles - Otto cycle, Diesel cycle and Dual cycle – efficiency. **Refrigeration cycles:** Reversed carnot cycle-COP Vapour compression cycle- simple, superheating and subcooling, Working of Vapour absorption cycle and solar refrigeration system **Psychrometry:** Psychrometric properties and processes. **Air conditioning systems:** Components of air conditioning systems working – summer and winter. **Steam Nozzles:** types, exit velocity, critical pressure ratio, effect of friction, throat and exit area calculations. **Reciprocating Air compressors:** single stage compressor- work done, volumetric efficiency, multi stage compressor- minimum power requirement**,** performance calculation. **Internal combustion engines:** Classification-Petrol and Diesel engines, 2 stroke and 4 stroke, valve timing and port timing diagrams, Accessories- Fuel supply and ignition system, Cooling system, Lubrication system, Performance calculation of IC engines.

Course contents and Lecture schedule

No	Topic	No. of Lectures
1.	**Vapour cycles**	
1.1	Introduction, Carnot cycle – Impracticability	1
1.2	Rankine cycle – Actual and ideal, Energy terms and cycle efficiency calculation	2
1.3	Reheat cycle- Energy terms and cycle efficiency calculation	2
1.4	working of Regeneration cycle	1
2	**Gas cycles**	
2.1	Air standard cycles – Assumptions	1
2.2	Otto cycle - working, p-v and T-s diagrams, efficiency calculation	2
2.3	Diesel cycle working, p-v and T-s diagrams, efficiency calculation	2
2.4	Dual cycle working, p-v and T-s diagrams, efficiency calculation	2
3.	**Refrigeration cycles**	
3.1	Reversed Carnot cycle – COP	1
3.2	Vapour compression cycle – working, P-h diagram, COP calculation	1
3.2.1	Superheating and subcooling, COP calculation	2

3.3	Vapour absorption cycle – working	1
3.4	Working of Solar refrigeration system, Comparison between compression and absorption refrigeration systems	1
4	**Psychrometry**	
4.1	Psychrometric properties, Psychrometric chart	2
4.2	Psychrometric processes - Sensible heating and cooling, cooling and dehumidification, heating and humdification, adiabatic mixing, evaporative cooling - psychrometric chart and heat and moisture transfer calculation	3
5	**Air conditioning systems**	
5.1	Components of air conditioning systems	1
5.2	Summer and winter air conditioning systems - working	1
6	**Steam Nozzles**	
6.1	Types, Exit velocity	1
6.2	Critical pressure ratio, Effect of friction	2
6.3	Throat and exit area calculations	2
7	**Reciprocating Air compressors**	
7.1	Single stage compressor- Work of compression, clearance ratio, volumetric efficiency, Performance parameters calculation.	2
7.2	Multi stage compressor- work done with and without perfect intercooling, performance calculation	2
8	**Internal combustion engines:**	
8.1	Classification, working of four stroke and two stroke petrol and diesel engines	1
8.2	Valve and port timing diagrams	1
8.3	Simple carburettor, spark plug, battery coil and magneto coil ignition systems, fuel pump, fuel injector - working	2
8.4	Cooling systems –water and air systems - working	1
8.5	Lubrication systems – petroil, wet and dry sump	1
8.6	Performance calculation of IC engines.	3
	Total hours	**44**

TEXT BOOKS

1. Yunus A.Cengel and Michael A.Boles, "Thermodynamics: An Engineering Approach", Fifth edition, McGraw-Hill, 2005.
2. Valan Arasu. A, "Thermal Engineering", Vijay Nicole Publishers Pvt Limited, Chennai, 2009.

TABLES

1. Khurmi,R.S, "Steam Tables with Mollier Diagrams", S.Chand and Co.Limited, 2005.
2. Maskara,P.N and Satish Chand, "Tables and charts on Refrigerant and Psychrometric properties" Technical publishers of India, 1988.

REFERENCES

1. Rajput.R.K, "Thermal Engineering", Laxmi Publications, Seventh Edition, 2009.
2. G.F.C Rogers and Yon Mayhew "Engineering Thermodynamics"Pearson Education 4th edition, 1996.
3. Nag.P.K, "Basic and Applied Thermodynamics", Tata Mc Graw-Hill, New Delhi, 1st edition, 2002.
4. Ganesan.V, "I.C.Engines", Tata McGraw-Hill, New Delhi, 3rd edition, 2008.
5. Onkar Singh, "Applied Thermodynamics" , New Age International Publishers, 2003.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 45	3	0	-	3

G45 Machining Processes 3:0

Preamble: Machining is one among the manufacturing processes for converting raw materials into end products. The end product is obtained by machining the unwanted material from a metal block / stock in the form of chips. Machine tools are power driven machine for making products of a given shape, size and accuracy by removing metal from the metal block. Most of the products get their final shape and size by metal removal. Products may be piston, engine blocks, cams, gear, shafts, hubs, flange etc.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduate can participate and succeed in competitive examinations.

Competencies

At the end of the course the student will

1. Explain the fundamentals of Metal cutting & Cutting tools.
2. Explain working principle of machine tools, work holding devices & process parameters for machining.
3. Determine the parameters of turning, drilling, boring, shaping, planning, milling and broaching.
4. Select a suitable process for machining of a given part & prepare a process sheet.
5. Prepare a process sheet for machining a given part.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	30	30	20
2	Understand	40	40	40
3	Apply	30	30	40
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define chip thickness ratio.
2. What is a thread chaser?
3. Name the operations which may be performed on a lathe.
4. What is counter boring?
5. List the functions of apron in shaper tool head.
6. What is up milling?
7. Name any four work holding devices used in planning machine.
8. Name the various milling cutters.

Understand

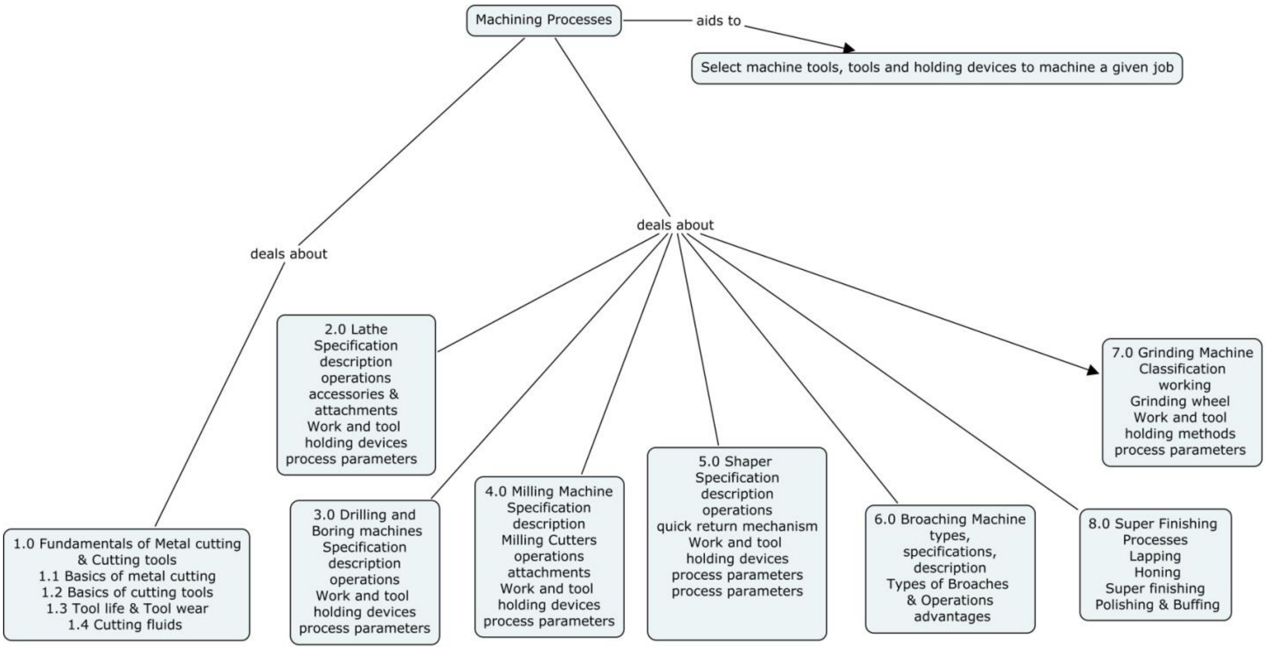
1. What is the function of the back gear?
2. Why are chucks used in a lathe?
3. Why are grinding wheels balanced?
4. How quick return is obtained in shaper?
5. Describe the drill nomenclature with neat sketches.
6. Why balancing is needed for the grinding wheel.
7. Why is milling a versatile process?
8. How centreless grinding is different from cylindrical grinding?

Apply

1. Find the angle at which the compound rest should be set up to turn taper on the work piece having a length of 200mm, larger diameter 45mm and the smaller diameter 35mm.
2. In an orthogonal cutting on a M.S tube of size 150mm diameter and 2.1mm thickness, conducted at 90 m/min and 0.21mm/rev feed, the following data are recorded: Cutting force = 1250N. Feed force = 300N, Chip thickness =0.3mm, contact length = 0.75mm and power = 2 KW, rake angle 10°. Compute shear strain, shear energy per unit volume.
3. How to calculate the machining time for the turning operation in a lathe.
4. A steel workpiece is to be milled. Metal removal rate is 30 cm^3/ min. Depth of cut is 5mm and width of cut is 100mmm. Find the table feed.
5. How is machining time calculated in planer and shaper?
6. Find the correct number of strokes per minute to use on a shaper cutting a mild steel piece of 250mm long and 150mm wide. The cutting speed is 20m/min for HSS tool. If a feed of 1mm is used then how much time will be taken for machining one surface of job.
7. Find and describe type of milling operation used for machining slender and intricate parts.

8. How do you select a grinding wheel for a given task?
9. Sketch and describe the details of a broach used to machine an internal hole.

Concept Map



Course Contents and Lecture schedule

S.No	Topics	No. of Lectures
1	**Fundamentals of Metal cutting & Cutting tools**	
1.1	Basics of metal cutting: Mechanism of chip formation (orthogonal cutting model) , Chip thickness ratio, Velocity ratio	2
1.1.1	Merchant circle diagram, Cutting forces , measurement of cutting forces	2
1.1.2	Types of chips - continuous, discontinuous & continuous with built up edge, Chip breakers.	1
1.2	Basics of cutting tools: Characteristics, Cutting tool materials, properties and applications.	2
1.3	Tool life & Tool wear- Taylor's equation, Variables affecting tool life, Machinability-Definition.	2
1.4	Cutting fluids - Function, and types	1
2.0	**Lathe**	
2.1	Centre lathe, specifications, description	1
2.2	Nomenclature of single point cutting tool, Operations performed on lathe.	2
2.3	Lathe accessories & attachments.	1

2.4	Work and tool holding methods / devices	1
2.5	Definition of process parameters – cutting speed, feed, DOC & machining time	1
3.0	**Drilling and Boring machines**	
3.1	Introduction, Radial drilling machine and Horizontal boring machine, specifications, description,	2
3.2	Nomenclature of drill, Operations performed on drilling machine.	2
3.3	Work and tool holding methods / devices	1
3.4	Definition of process parameters – cutting speed, feed, DOC & machining time	1
4.0	**Milling Machine**	
4.1	Introduction, Column and Knee type milling machine, specifications	1
4.2	Description, attachments	1
4.3	Milling cutters, Nomenclature of plain milling cutter & operations performed	2
4.4	Work and tool holding methods / devices	1
4.5	Definition of process parameters – cutting speed, feed, DOC & machining time	1
5.0	**Shaper**	
5.1	Introduction, specifications, description	1
5.2	Quick return mechanism & operations performed	1
5.3	Work and tool holding methods / devices	1
5.4	Definition of process parameters - cutting speed, feed, DOC & machining time	2
6.0	**Broaching Machine**	
6.1	Introduction, types, specifications, description	1
6.2	Types of Broaches & Operations, advantages	1
7.0	**Grinding Machine**	
7.1	Introduction, Classification, working of grinding machines.	1
7.2	Grinding wheel (Abrasives & Bond), Selection of Grinding wheel, mounting, glazing & loading, dressing, balancing.	2
7.3	Work and tool holding methods / devices	1
7.3	Definition of process parameters – cutting speed, feed, DOC & machining time	1
8.0	**Super Finishing Processes**	
8.1	Lapping, Honing	1
8.2	Super finishing, Polishing & Buffing	1
	Total	**42**

Syllabus

Fundamentals of Metal cutting & Cutting tools:

Basics of metal cutting: Mechanism of chip formation (orthogonal cutting model) , Chip thickness ratio, Velocity ratio, Merchant circle diagram, Cutting forces , measurement of cutting forces, Types of chips - continuous, discontinuous & continuous with built up edge, Chip breakers.

Basics of cutting tools: Characteristics, Cutting tool materials, properties and applications.

Tool life & Tool wear: Taylor's equation, Variables affecting tool life, Machinability-Definition. Cutting fluids: Function, and types.

Lathe: Centre lathe, specifications, description, Nomenclature of single point cutting tool, operations performed on lathe, lathe accessories & attachments, Work & tool holding methods/devices, Process parameters **-** Definition of process parameters - cutting speed, feed, DOC & machining time.

Drilling and Boring machines: Introduction Radial drilling machine and Horizontal boring machine, specifications, description, Nomenclature of drill, operations performed on drilling machine, Work & tool holding methods/devices, Process parameters **-** Definition of process parameters - cutting speed, feed, DOC & machining time.

Milling Machine: Introduction, Column and Knee type milling machine, specifications, description, attachments, milling cutters, Nomenclature of plain milling cutter & operations performed, Work & tool holding methods/devices, Process parameters **-** Definition of process parameters - cutting speed, feed, DOC & machining time.

Shaper: Introduction, types, specifications, description, quick return mechanism & operations performed Work & tool holding methods/devices, Process parameters **-** Definition of process parameters - cutting speed, feed, DOC & machining time.

Broaching Machine: Introduction, types, specifications, description, Types of Broaches & Operations, advantages.

Grinding Machines: Introduction, Classification, working of grinding machines, Grinding wheel (Abrasives & Bond), Selection of Grinding wheel, mounting, glazing & loading, dressing, balancing, Work & tool holding methods/devices, Process parameters **-** Definition of process parameters - cutting speed, feed, DOC & machining time.

Super finishing processes: Lapping, Honing, Super finishing, Polishing & Buffing.

Text Book

1. S.K. Hajra Choudhury and A.K. Hajra Choudhury, "Elements of Work shop Technology", Vol. – II Machine Tools, Media Promoters and Publishers Pvt. Ltd, Eleventh Edition, 2002.
2. Serope Kalpakjian and Steven R. Schmid, "Manufacturing Engineering and Technology", Addition Wesley Longman Pvt. Ltd., First Indian reprint, 2000.

Reference Books

1. E. Paul Degarmo, J.T. Black, and Ronald A. Konser, "Materials and Processes in Manufacturing", 5th Edition, Prentice Hall India Ltd., 1997.
2. P.C. Sharma, "A Text Book of Production Technology (Manufacturing Processes)", S. Chand & Company Ltd., New Delhi, 2004.
3. Philip F. Oswald, and Jairo Munoz, "Manufacturing Process and systems", John Wiley and Sons, 1992.
4. Hasle hurst, "Manufacturing Technology", Viva Books Pvt. Ltd., 3rd Edition, 1998
5. P.N. Rao, "Manufacturing Technology", Tata McGraw Hill, New Delhi, 1998.

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Sub Code	Lectures	Tutorial	Practical	Credit
G 46	3	0	-	0

G46 Control Systems 3:0

Preamble

Control Systems is an exciting and a challenging field. By its very nature, control Engineering is a multidisciplinary subject. A Control system is an interconnection of components forming a system configuration that will provide a desired system response. Since more than 90% controllers used in industry are PID controllers, it is considered as the topic of study for controller design. The present course is structured in such a way that it enables a mechanical engineer to model a system, Analyze the system for performance & stability.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduate who can participate and succeed in competitive examinations.

Competencies

1. Model a given simple Mechanical, electrical, electromechanical system using transfer function approach.
2. Analyze the system stability and performance using time domain techniques.
3. Analyze the system stability and performance using frequency domain techniques.
4. Model a given simple mechanical, electrical, electromechanical system using state space approach.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	End-semester examination
1	Remember	10	10	20
2	Understand	20	20	20
3	Apply	10	20	40
4	Analyze	10	0	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course level Learning Objectives

Remember

1. Define transfer function?
2. Write the equations for settling time and peak over shoot of a unit step response.
3. Define phase margin and gain margin of a system.
4. Define gain cross over frequency of a system.
5. Define Phase cross over frequency f a system.
6. State any two properties of state transition matrix.
7. Define transient response of a system.
8. List the time domain specifications.
9. List the frequency domain specifications.
10. State principle of homogeneity and superposition theorem.
11. Define Controllability.
12. Define obsevability.

Understand

1. What is meant by dynamic system?
2. What is meant by servo operation?
3. Distinguish between servo and regulator operation.
4. What is meant by steady state error?
5. Distinguish between closed loop system and open loop system.
6. Distinguish relative stability from absolute stability.
7. The unit step response of a system is $c(t) = 1 + 0.2e^{-60t} - 1.2e^{-10t}$.Find the closed loop poles.
8. The unity feedback system is characterized by an open loop transfer function $G(S) = \frac{K}{S(S+10)}$.Determine the gain K When damping ratio is 0.5.
9. What is the significance of the state transition matrix?
10. What happens when damping ratio of a system is increased?
11. What is the effect increasing steady state gain (K) in a critically damped system?
12. What are the ways to improve the stability of a LTI system?
13. How can you justify pole –zero cancellation? Explain with suitable example.
14. If a pole is moved with constant imaginary part, what will the response have in common?
15. If a pole is moved along a radial line extending from origin, what will the response have in common?

16. How the roots of the characteristic equation are related to stability?

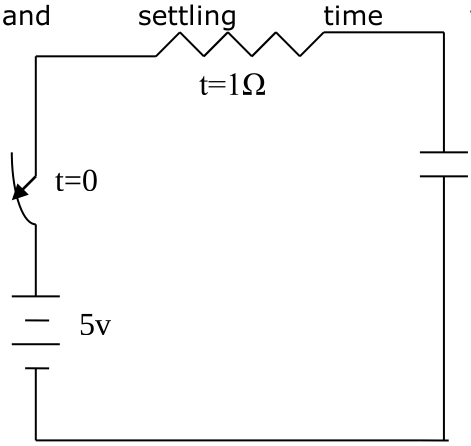
17. How can you analyze whether a system is marginally stable?

APPLY

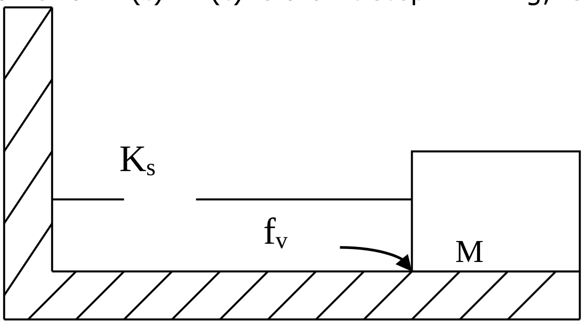
1. Sketch the bode plots for $G(S) = \frac{1}{S}$.

4. Sketch Magnitude versus phase curve for the system $G(S) = \frac{1}{(S+a)}$.

5. Find the capacitor voltage in the network shown in figure, if the switch closes at t=0.Assume zero initial conditions .Also find the time constant, rise time, and settling time for the capacitor Voltage.



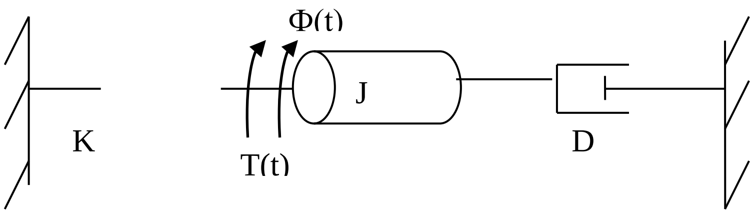
10. Solve for x (t) if f(t) is a unit step .M=1Kg,Ks=5n/m,fv=1N-s/m,f(t)=u(t) N



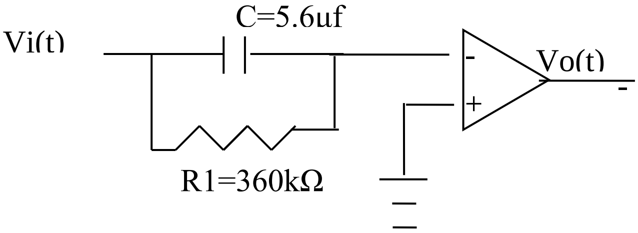
11. Draw the root locus for the given system $G(S) = \frac{10}{S(S+2)}$

12. Draw the bode plot for the given system $G(S) = \frac{100}{s(.5S+1)(.1S+1)}$

13. Draw the nyquist plot for the given system $G(S) = \frac{10}{S(S+10)}$



14. For a rotational mechanical system given. Find the J and D to yield 20% overshoot and settling time of 2 seconds for a step input of torque T (t).K=5NM/rad.
15. Derive the transfer function of the given system. $\frac{Vo}{Vi}$



Analyze

1. Find the analytical expressions for the magnitude and phase responses of $G(S) = \dfrac{1}{(S+2)(S+4)}$.
2. Consider the differential equation $\dddot{Y} + 6\ddot{Y} + 11\dot{Y} + 6Y = \dddot{u} + 8\ddot{u} + 17\dot{u} + 8u$. convert into Jordan canonical form.
3. Check the stability of the system with Routh criterion. $s^4 + 8s^3 + 18s^2 + 16s + 5 = 0$
4. Test whether the system is controllable or not?

A= $\begin{bmatrix} 0 & 1 & 0 \\ 64 & 0 & -16 \\ 0 & 0 & -100 \end{bmatrix}$ B= $\begin{bmatrix} 0 \\ 0 \\ 100 \end{bmatrix}$

5. Test whether the system is observable or not?

A= $\begin{bmatrix} 0 & 1 \\ -1 & -3 \end{bmatrix}$ B= $\begin{bmatrix} 1 \\ 2 \end{bmatrix}$ c= $\begin{bmatrix} 1 & 1 \end{bmatrix}$

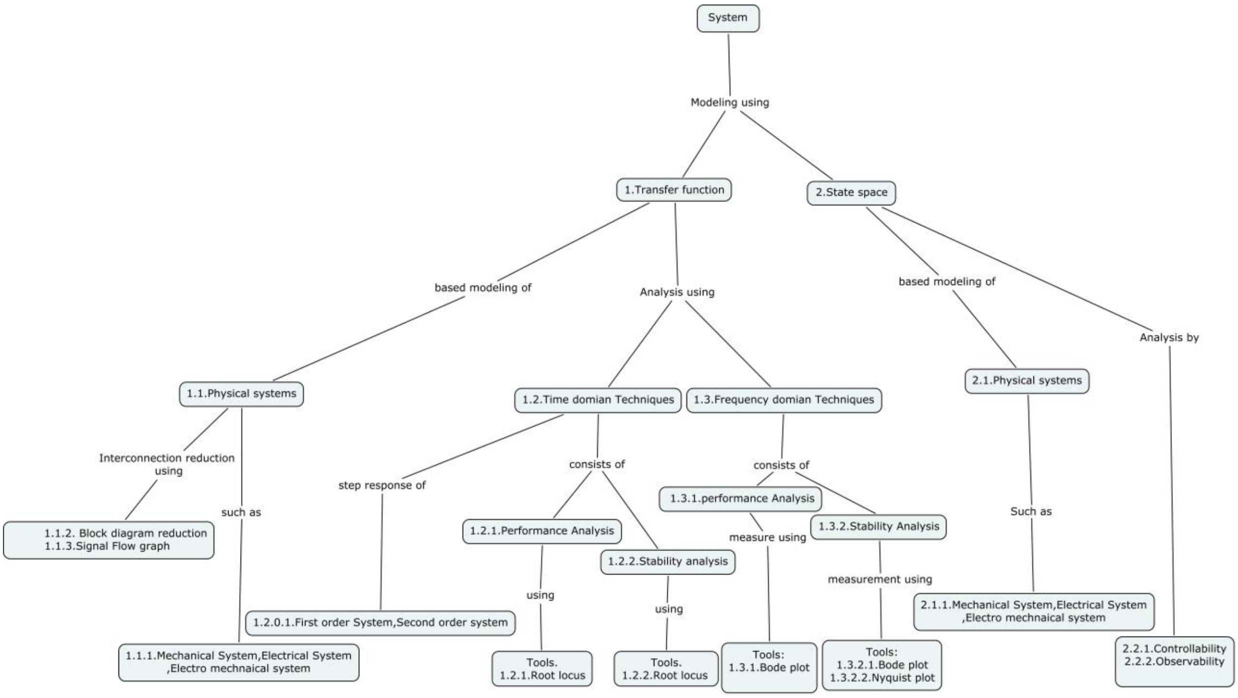
6. A matrix linear system is given by the state equation A= $\begin{bmatrix} -1 & 0 \\ 0 & -2 \end{bmatrix}$

Find the state transition matrix.

7. For the transfer function given with unity feedback system $G(s) = \dfrac{10}{s(0.1s+1)}$.find the steady state error of the system subjected to unit step input.

8. Derive the step response of first order system.
9. Derive the step response of second order system.

Concept Map



SYLLABUS

Mathematical modeling (Classical –Transfer function)

Introduction, History of control, Types of control, Application in various fields, Future Evolution. Control system Terminologies, Advantage of feedback, Transfer function, Modeling of Mechanical system, Electro Mechanical system, Block diagram Reduction, Signal flow graph.

Time domain Analysis

Test signals, Pole-Zero mapping and analysis, Response of First order, Second order system, performance specifications, Root locus techniques for stability and performance analysis.

Frequency domain Analysis

Frequency domain specifications, Bode plot, Nyquist plot.

Mathematical modeling (Modern –State space) and Analysis

Canonical forms, modeling of physical systems, conversion in to transfer function, solution of state space equation, state and output controllability, state observability.

TEXT BOOKS

1. Richard C. Dorf and Robert H. Bishop, "**Modern Control Systems**" 12th Edition, Addison Wesley,2010.
2. Jacqueline wilkie, Michael Johnson and reza katebi, " **Control Engineering**" Palgrave,2003.

REFERENCES

1. Katsuhiko Ogata, "**Modern control Engineering**" Prentice hall of India, 3rd Edition,1996.

Lecture Plan

No.	Topic	No. of Lectures
1.1	**Mathematical modeling (Classical –Transfer function)**	
1.1.0	Introduction, History of control, Types of control, Application in various fields, Future Evolution.	2
1.1.0	Control system Terminologies, Advantage of feedback, Transfer function.	1
1.1.1	Modeling of Mechanical system and Electro Mechanical system.	3
1.1.2	Block diagram Reduction.	2
1.1.3	Signal flow graph.	2
1.2	**Time domain Analysis**	
1.2.0.0	Test signals, Pole-Zero mapping and Analysis.	2
1.2.0.1	Response of First order, Second order system.	3
1.2.0.1	Time domain performance specifications.	2
1.2.1	Root locus techniques for stability and performance analysis.	6
1.3	**Frequency domain Analysis**	
1.3.0	Frequency domain specifications.	1
1.3.2.1	Bode plot for stability analysis.	4
1.3.2.2	Nyquist plot for stability analysis.	4
2.	**Mathematical modeling (Modern –State space) and Analysis**	
2.1.0	Canonical forms.	2
2.1.1	Modeling of physical systems.	2
2.1.2	Conversion in to transfer function, solution of state space equation.	1

2.2.1	State and output controllability.	2
2.2.2	State observability.	1
	Total Number of hours	**40**

Course Designers

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2. K. Dhanalakshmi kdleee@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
G 47	0	0	2	1

G47 MACHINING PRACTICE LAB. 0:1

Objective: To impart knowledge and skill in the field of machine tools used in the industries. To increase the level of confidence of students by working individually in various machine tools. This would supplement the understanding of the theory course on Machining Processes.

List of Exercises

A work/tool holding device shown in figure 1 is made by a set of 12 machining operations. The operation schedule is tabulated as follows:

OPERATION SCHEDULE

_Sl No:	I CYCLE		No. of Student	No. of Periods
	Machine	**Operation**		
1.	Lathe	Plain, Taper and Step Turning	8	3
2	Lathe	Taper Turning	8	3
3.	Horizontal Milling	Spur Gear Cutting	8	3
4.	Vertical Milling	Key Way Milling	8	3
5.	Grinding	Plain Grinding	8	3
6.	Drilling	Drilling and Counter Bore	8	3
Sl No:	**II CYCLE**		**No. of Student**	**No. of Periods**
	Machine	**Operation**		
1.	Lathe	Grooving (UCD)and Thread (Left)	8	3
2	Lathe	Grooving (UCD) and Thread (Right)	8	3
3.	Horizontal Milling	Helical Gear Cutting	8	3
4.	Vertical Milling	Flat Milling	8	3
5.	Grinding	Morse Taper Grinding	8	3
6.	Drilling	Drilling and Tapping	8	3

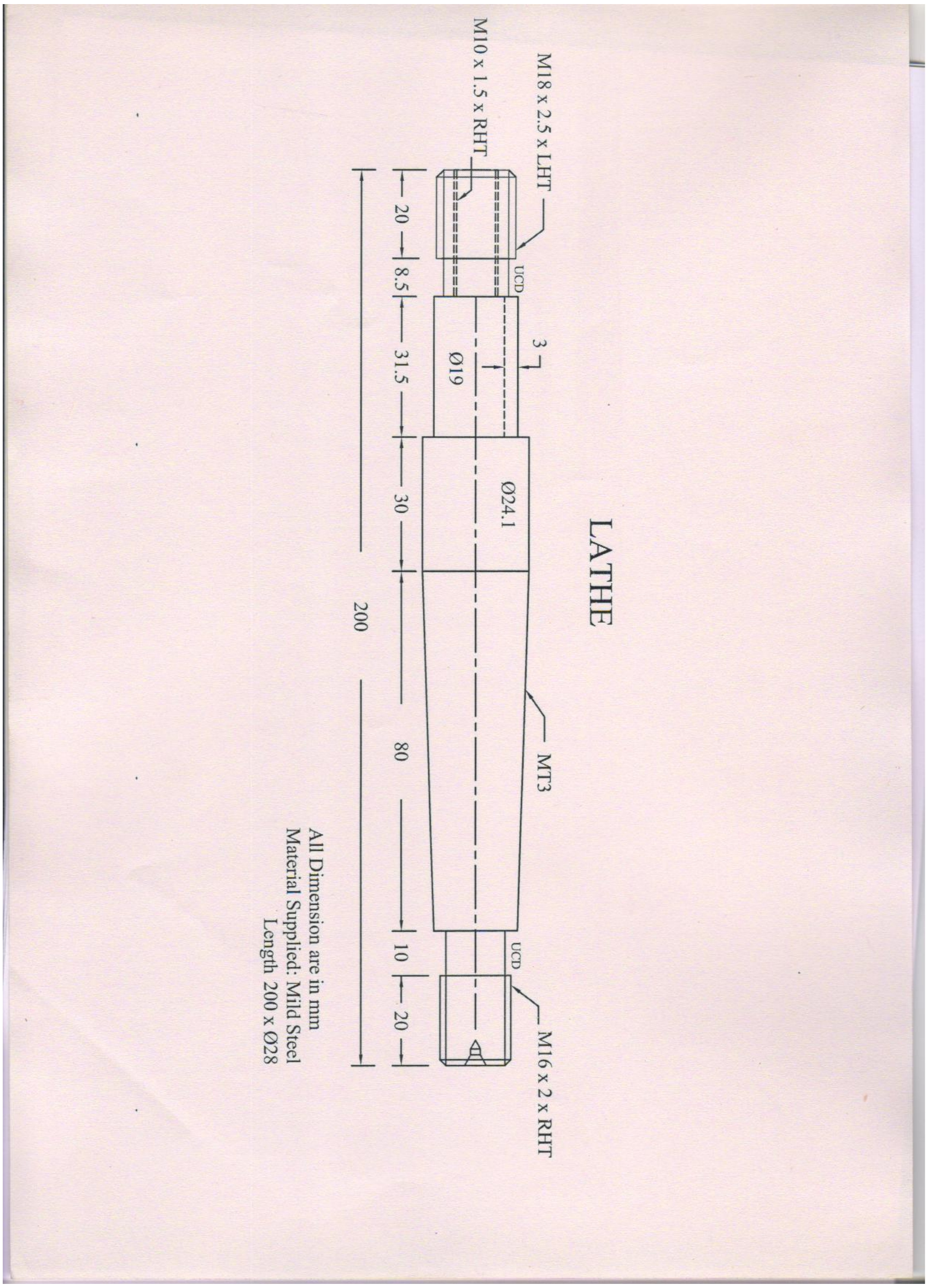

Figure 1.

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 48	0	0	2	1

G48 Thermal Engineering Lab 0:1

Objective: To enable the students to understand and apply the theoretical knowledge to determine and verify the performance of thermal engineering systems.

List of Experiments

(Any twelve experiments to be conducted)

1. Performance test on single cylinder 4-stroke Diesel Engine at constant speed
2. Performance test on variable speed 2-stroke petrol engine under part load condition
3. Performance test on variable speed 2-stroke petrol engine under full load condition
4. Performance test on variable speed 4-stroke petrol engine under part load condition
5. Performance test on variable speed 4-stroke petrol engine under full load condition
6. Determination of friction power of diesel engine using retardation test
7. Determination of friction power of 4-stroke constant speed diesel engine using Willan's line method.
8. Determination of volumetric efficiency test on a 4-stroke diesel engine.
9. Performance test on vapour compression refrigeration test rig.
10. Determination of Valve timing diagram on a 4-stroke model engine
11. Determination of port timing diagram on a 2-stroke model engine
12. Emission analysis on Petrol engine exhaust and Diesel engine exhaust
13. Energy balance test on diesel engine using airflow measurement method
14. Energy balance test on diesel engine using Exhaust gas Calorimeter measurement method
15. Performance test on a two stage reciprocating air compressor
16. Performance study on a two wheeler using chassis dynamometer
17. Determination of the efficiency of steam generator

Terminal Examination

Duration: 3 hours

Maximum Marks: 100

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 49	1	0	1	2

G49 Professional Communication 1:1

(Common to ALL branches of B.E & B.Tech.)

Subject codes: B49, C49, D49, E49, G49, IT49

Preamble: Professional communication aims to develop Listening, Speaking, Reading and Writing skills in Engineering students' professional development contexts such as projects, competitive exams, organizational communication and soft skills.

Competencies: At the end of the course the students should be able to

Listening:

1. Listen and understand the project presentations, competitive exam exercises, organizational communication activities
2. Listen to the lectures on soft skills for practice.

Speaking:

1. Present project reports, self introduction
2. Participate in GD and interview in work context.

Reading:

1. Read and collect information for project report writing.
2. Read and understand the comprehension passages given in competitive examinations.
3. Read and understand the company profile

Writing:

1. Write a project report adhering to proper format
2. Create a paragraph and essay using their own ideas
3. Write circulars, minutes of the meetings, and curriculum vitae

Assessment Pattern:

	Internal (50)	**External (100)**
1. Recall	10	10
2. Understanding	10	20
3. Application	10	20
4. Analysis	10	30
5. Evaluation	5	10
6. Creation	5	10

Course Content

1. Listening

1.1 Attention, understanding and responding

1.2 Project report writing, competitive exam exercises, organizational communication and soft skills practice

2. Speaking

2.1 Planning, preparation and presentation

2.2 Project report, self introduction, GD and interview

3. Reading

3.1 Rapid reading and reference skills

3.2 Project reports, competitive exam exercises and company profiles

4. Writing

4.1. Structure

4. 1.1 Sentence structure

4.1.2 Abstract writing

4.1.3. CV writing

4.1.4. Project report writing

4.2 Organizational Communication

4.2.1 Circulars

4.2.2 Minutes of the meeting

Syllabus

Listening: Listening to Project presentation: Asking Questions, Listening test as conducted in TOEFL and BEC, Listening in the context of Organizational communication and Soft skill practice.

Speaking: Project presentation skill, Speaking in the context of Group Discussion, Interview, TOEFL and BEC Exam Spoken Test, Speaking in the work Contexts : Self introduction, Mini Presentation

Reading: Reference Skills for Project Report Writing: Topic selection, Data Collection. Rapid Reading, Reading comprehension tests conducted in CAT, TOEFL, GRE and BEC, Reading skills in work situation: Company Profile

Writing: Project Report Writing: Format, Abstract, Bibliography, Structure : Sentence structure, CV Writing, Writing in Work context : Circulars, Minutes of the meeting

References

1. Tony Lynch: Study Listening. Cambridge, Cambridge University Press, 2007
2. Sangeeta Sharma and Binod Mishra: Communication Skills for Engineers and Scientists. New Delhi, PHI Learning Pvt. Ltd. 2009.
3. Hari Mohan Prasad and Uma Rani Sinha: Objective English for Competitive Examination. New Delhi, Tata McGraw – Hill, 2005
4. Bob Dignen, Steeve Flinders et. al.: Work and Life: English 365. Students Book 1,2 & 3. New Delhi, Cambridge, 2004.

List of Lecture sessions

Listening:

1. Effective listening skills
2. Nature of listening tests in competitive examinations
3. Introduction of soft skills

Speaking:

1. Introduction of Presentation skills
2. Suggestions for speaking tests in competitive exams
3. How to participate in GD
4. Interview techniques

Reading:

1. Rapid reading techniques
2. Reference skills
3. Suggestions for reading tests in competitive exams

Writing:

1. Format of project report
2. Abstract of the project
3. Sentence structure
4. Organizational communication like sending circulars, writing minutes of the meetings
5. CV writing

List of Practice Sessions:

Listening:

1 Messages, descriptions, conversations and lectures

Speaking:

1. Self Introduction
2. Mini Presentation
3. GD
4. Interview

Reading:

1. Rapid reading practices
2. Comprehension exercises
3. Topic selection and data collection for project report

Writing:

1. Sentence structure
2. Abstract writing
3. Project Report Writing
4. Circulars
5. Minutes of the meeting
6. Model test

Course Designers

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2. A Tamil Selvi tamilselvi@tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

FIFTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Board of studies meeting on 31.03.12 Approved in 44th Academic Council meeting on 09.06.12

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Mechanical Engineering
Scheduling of Courses

Semester	**Theory Courses**						**Practical/Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					G88 Project 0:12	
7th (22)	G71 Management Theory & Practice 3:0	G72 Operation Research 3:0	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G76 Manufacturing Systems Simulation Lab - II 0:1	G77 Mini Project 0:6	
6th (22)	G61 Accounting & Finance 3:0	G62 Design of Transmission System 2:1	G63 Quality & Reliability Engineering 3:0	G64 Mechatronics 3:0	Elective 1 3:0	Elective 2 3:0	G67 CAE Lab-I 0:1	G68 Mechatronics Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Kinematics & Dynamics of Machinery 3:1	G53 Metrology and Mechanical Measurements 3:0	G54 Heat & Mass Transfer 3:1	G55 Manufacturing Processes and Automation 3:0	G56 Industrial Engg. 3:0	G57 CAD/CAM Lab 0:1	G58 Heat Transfer Lab 0:1	G59 Mech. Measurement & Metrology Lab 0:1
4th (23)	G41 Numerical Methods 4:0	G42 Design of Machine Elements 2:1	G43 CAD & Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Control System Engineering 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (24)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 4:0	G33 Applied Material & Metallurgy 3:0	G34 Fluid Mechanics 3:1	G35 Metal Casting & Plastic forming processes 3:0	G36 Metal Forming & Joining Processes 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics & CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Ecology and Environment 2:0	G26 Computer Programming 3:0	G27 Strength of Materials & Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

FIFTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
G51	Applied Statistical Techniques	BS	4	0	-	4
G52	Kinematics & Dynamics of Machinery	DC	3	1	-	4
G53	Metrology and Mechanical Measurements	DC	3	0	-	3
G54	Heat and Mass Transfer	DC	3	1	-	4
G55	Manufacturing Processes and Automation	DC	3	0	-	3
G56	Industrial Engineering	DC	3	0	-	3
PRACTICAL						
G57	CAD/CAM Lab.	DC	-	-	3	1
G58	Heat Transfer Lab.	DC	-	-	3	1
G59	Mechanical Measurements and Metrology Lab.	DC	-	-	3	1
	Total		**19**	**2**	**9**	**24**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

FIFTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G51	Applied Statistical Techniques	3	50	50	100	25	50
2	G52	Kinematics & Dynamics of Machinery	3	50	50	100	25	50
3	G53	Metrology and Mechanical Measurements	3	50	50	100	25	50
4	G54	Heat and Mass Transfer	3	50	50	100	25	50
5	G55	Manufacturing Processes and Automation	3	50	50	100	25	50
6	G56	Industrial Engineering	3	50	50	100	25	50
PRACTICAL								
7	G57	CAD/CAM Lab	3	50	50	100	25	50
8	G58	Heat Transfer Lab	3	50	50	100	25	50
9	G59	Mechanical Measurements and Metrology Lab.	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks

Sub Code	Lectures	Tutorial	Practical	Credit
G 51	4	0	-	4

G51 Applied Statistical Techniques 4:0

Preamble: An engineering student needs to have some basic mathematical tools and techniques. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this the course aims at giving adequate exposure in the theory and applications of Statistics, Probability, Sampling and Estimation.

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will develop confidence for self education and ability for life-long learning.

Competencies:

At the end of the course the student should be able to

1. Express the probability distributions arising in the study of Engineering problems and their applications.
2. Determine correlations among variables (linear, non-linear) for regression lines.
3. Design experiments to test various attributes of an engineering problem.
4. Construct tests for testing of samples of different chosen attributes.
5. Determine estimation and error estimation for a set of sample observations.

Assessment Pattern

	Bloom's category	**Test 1**	**Test 2**	**Test 3 / End Semester Examinations**
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. State the properties of probability distribution function.
2. Define Discrete and Continuous Random Variables.
3. Define multiple correlation and Non linear regression.
4. Define test of Hypotheses.
5. Describe the basic designs of experiments.
6. Define point and interval estimation.

Understand

1. Discuss the properties of a Normal probability distribution
2. Differentiate between linear and non-linear regression
3. Discuss the uses of t – distribution.
4. Discuss the procedure for testing of hypothesis.
5. Interpret the level of significance and degrees of freedom for a chi square variant.
6. Differentiate the property of consistency from unbiasedness

Apply

1. A continuous random variable that can assume values between x = 2 and x = 5 has a density function given by f(x) = 2(1+x)/27. Calculate P(3<x<4).

2. Determine the correlation coefficient for the following data and also find the line of regression by the method of least squares.

X:	5	7	9	24	15	16	29
Y:	20	12	4	15	9	10	8

3. A coin is tossed 900 times and heads appeared 490 times. Would you conclude that the coin is a biased one?

4. Two random samples gave the following $n_1 = 10; \sum(x_i - \bar{x})^2 = 90$; $n_2 = 12$; $\sum(y_i - \bar{y})^2 = 108$. Test whether the samples came from the same population.

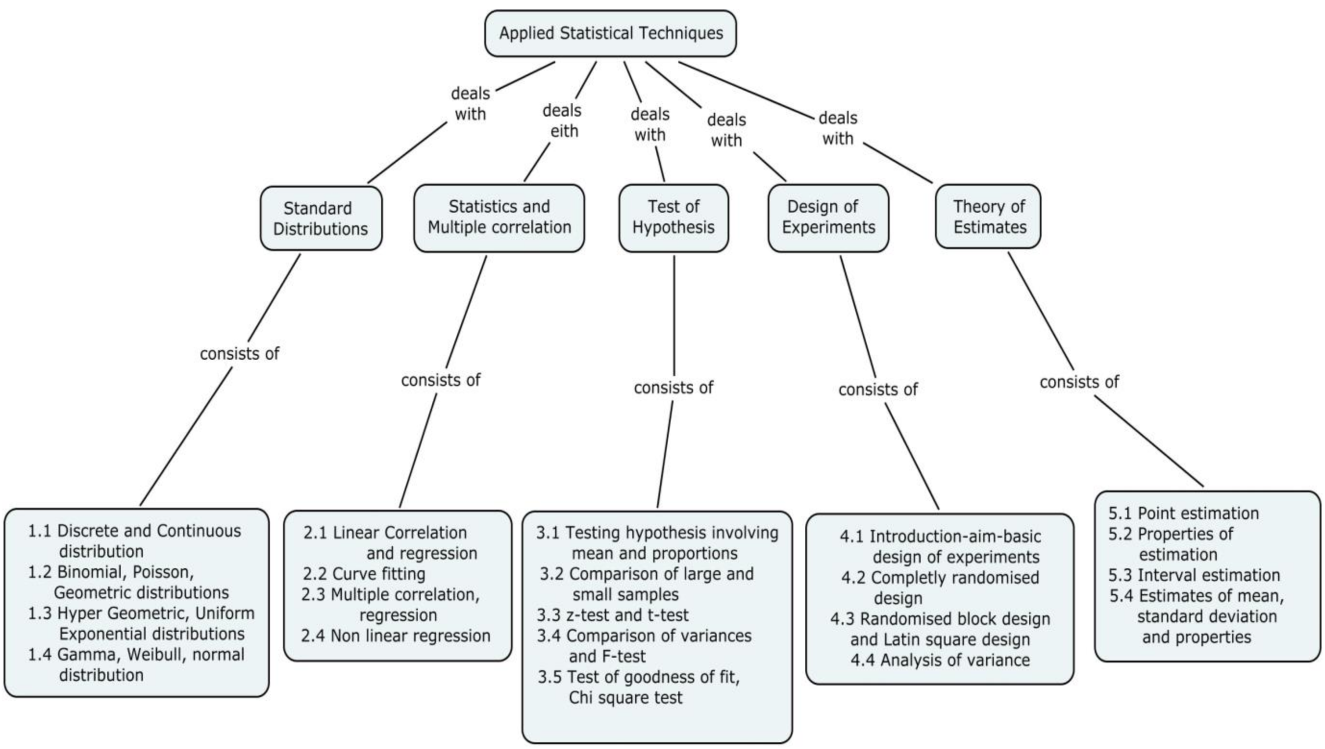
5. Given the observations

	Blocks				
Treatment1	14	6	11	0	9
Treatment2	14	10	16	9	16
Treatment3	12	7	10	9	12
Treatment4	12	9	11	6	7

Construct the analysis of variance table and test for difference among the Treatments using 5% level of significance.

6. Estimate the maximum likelihood estimator for λ when $f(x;\lambda)$ is the Poisson distribution.

Concept Map



Syllabus

Standard distributions: Discrete and Continuous distributions- Binomial, Poisson, Geometric and Hyper Geometric distributions, Uniform, Exponential, Gamma, Weibull and Normal distributions.**Statistics and multiple correlations:** Linear correlation and regression, Curve fitting – Method of least squares, Multiple correlation, Multiple Regression, Non linear regression.**Test of Hypothesis:** Testing hypothesis involving means and proportions, Comparison of large samples and small samples, z-test and t-test, Comparison of variances, F test, Test of goodness of fit, Chi square test.

Design of Experiments: Introduction – aim – Basic designs of experiments, Completely randomized design, Randomized Block Design, Analysis of variance.

Theory of Estimation: Point estimation, properties of estimation, interval estimation, estimates of mean, standard deviation and properties.

Text Books

1. S.C Gupta and V.K.Kapoor, "**Fundamentals of mathematical statistics**", Sultan Chand & Co, 2002.

2. Veerarajan .T, "**Probability, Statistics and Random Processes**" Tata Mc Graw-Hill, 2006.

References

1. Miller and Freund's, "**Probability and Statistics for Engineers**", Pearson Education, 2000.

2. Jay L. Devore, "**Probability and Statistics for Engineering and the Sciences**", Thomson Asia Pvt. Ltd., Singapore, 2002.

Course content and lecture schedule

No	Topic	No.of Lectures
1	**Standard distributions**	
1.1	Discrete and Continuous distributions	4
1.2	Binomial, Poisson, Geometric distributions	3
1.3	Hyper Geometric, Uniform, Exponential distributions	3
1.4	Gamma, Weibull, Normal Distributions	4
2	**Statistics and multiple correlation**	
2.1	Linear correlation and regression	2
2.2	Curve fitting – Method of least squares	2
2.3	Multiple Correlation,Regression	3
2.4	Non linear Regression	3
3	**Test of Hypothesis**	
3.1	Testing hypothesis involving means and proportions	2
3.2	Comparison of large samples and small samples	2
3.3	z-test and t-test	3

No	Topic	No.of Lectures
3.4	Comparison of variances, F test	3
3.5	Test of goodness of fit, Chi square test	1
4	**Design of Experiments**	
4.1	Introduction – aim – Basic designs of experiments	3
4.2	Completely Randomized design	2
4.3	Randomized Block Design and Latin Square design	3
4.4	Analysis of variance	2
5	**Theory of Estimation**	
5.1	Point estimation	1
5.2	Properties of estimation	1
5.3	Interval estimation	1
5.4	Estimates of mean, Standard deviation and properties	2
	Total	**50**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 52	3	1	-	4

G52 Kinematics and Dynamics of Machinery 3:1

Preamble:

Kinematics is a subject which deals with relative motion between the various parts of the moving elements in a machinery. Machines are used to transform the available form of energy into other form, which transmits both force and motion to produce the specific operation. Kinematics of machines deals with the theoretical aspect such as the relative motion of the various parts of the machine. Dynamics of machines deals with the inertia forces and its effect on the machines

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies:

At the end of semester students will be able to

1. Differentiate the different mechanisms.
2. Construct the simple mechanisms.
3. Find the velocities and accelerations of simple mechanisms.
4. Construct a cam profile for the different followers.
5. Differentiate the various gear trains.
6. Balance the mechanical system.

Assessment Pattern

Sl. No	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	10	10	10
2	Understand	10	10	10

3	Apply	80	40	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	40	20

Course Level Learning Objectives

Remember

1. Define Kinematic Link. Give examples for Kinematic links.
2. Define kinematic pair
3. Define Kinematic chain.
4. Name any four inversions of Single slider Crank Chain Mechanism.
5. Name any three inversions of double slider Crank Chain Mechanism.
6. Define coefficient of friction.

Understand

1. Differentiate between machine and Mechanism with suitable applications.
2. Suggest suitable mechanism to convert rotary motion to reciprocating motion.
3. Draw the different shapes of followers used in radial cams.
4. If a point B on a rigid link AB moves with respect to A with angular velocity ω rad /sec, then write an expression for the angular acceleration of the link AB .
5. Why roller follower is preferred in radial cams over knife edged followers?
6. How compound gear train is converted to Reverted epicyclic gear train.

Apply

1. An epicyclic gear train, an arm carries two gears A and B having teeth 36 and 45 teeth respectively. If the arm rotates at 150 rpm in the clockwise direction about the centre of the gear A which is fixed, determine the speed of gear B. If the gear A instead of being fixed makes 300 rpm in the clockwise direction, what will be the speed of gear B?
2. The lengths of the crank and connecting rod of a reciprocating engine are 300 mm and 1.5m respectively. The crank is rotating clockwise at a speed of 120 r.p.m. The mass of connecting rod is 250kg and the distance of centre of gravity of the rod from the crank pin centre is 475 mm. The radius of gyration of the rod about centre of gravity is 625 mm. When the crank position is 40° from the inner dead centre then find by graphical method and analytical method (i) Magnitude, position and direction of inertia force due to the mass of the connecting rod (ii) Torque exerted on the crank-shaft in magnitude and direction. Take the mass of reciprocating parts = 290kg.
3. The crank of a slider crank mechanism rotates clockwise at a constant speed of 300 r.pm. The crank is 15 cm and the connecting rod is 600 mm long. Determine (a) linear velocity and acceleration of the midpoint of the connecting rod and (b) angular velocity

and angular acceleration of the connecting rod at crank angle of 45 from the inner dead centre position.

4. PQRS is a four bar chain with link PS is fixed. The lengths of the link are PQ = 63mm; QR= 175mm; RS = 113mm; PS = 200 mm. The crank PQ rotates at 10 rad/ sec clockwise. Draw the velocity and acceleration diagram when angles QPS = 60° and Q and R lie on the same side of PS. Find the angular velocity and angular acceleration of links QR and RS.
5. A,B,C and D are four masses carried by a rotating shaft at radii 100. 125, 200 and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5kg, and 4kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance.
6. A single plate clutch both sides effective s required to transmit 33.75kW at 200rpm, the pressure being applied axially by means of springs and limited to $150 N/Cm^2$. If the outer diameter of the plate is to be 300 mm, find the required inner diameter of the clutch ring and the total force exerted by the springs. Assume the wear to be uniform and a co-efficient of friction of 0.3.

Create

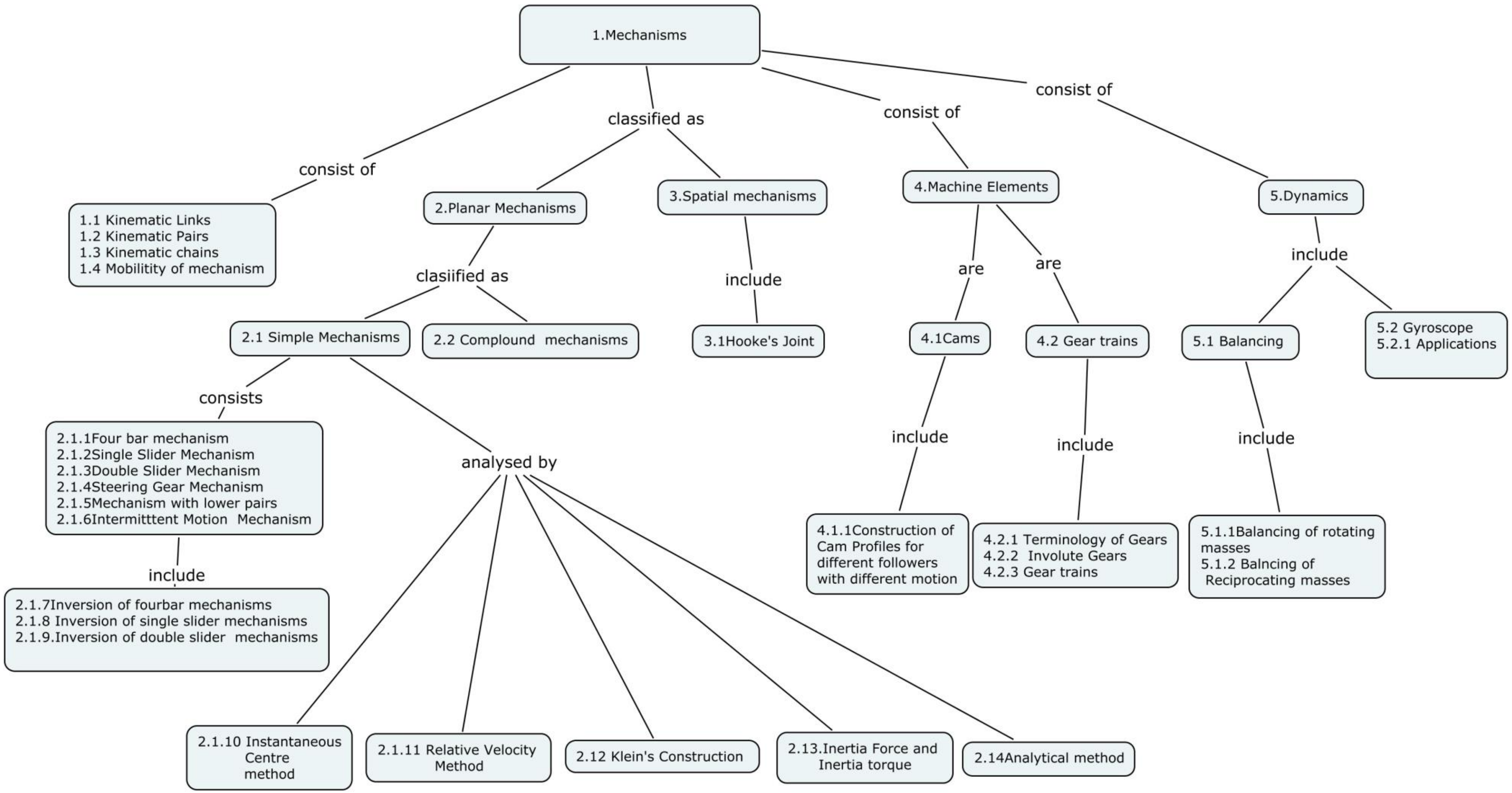
1. A cam is used in a IC engine to operate the valves, is required to give a roller follower the motion defined below:
   a. Follower to move outwards through 40 mm during 120° of cam rotation
   b. Follower to move dwell for next 60 ° of cam rotation
   c. Follower to return to its starting position during next 90° of cam rotation
   d. Follower to dwell for the rest of the cam rotation.

   The minimum radius of the cam is 50 mm and the diameter of the roller is 10mm. The line of the stroke of the follower is off-set by 20 mm from the axis of the cam shaft. The displacement of the follower takes place with uniform velocity. Create the cam profile for the given configurations. Also determine the maximum acceleration and velocity during ascent and decent when the cam rotates at 1000 r.p.m.

2. A cam is rotating clockwise at a uniform speed is required to give a roller follower the motion defined below:
   a. Follower to move outwards through 30 mm during 120° of cam rotation ,
   b. Follower to move dwell for next 60 ° of cam rotation ,
   c. Follower to return to its starting position during next 90 ° of cam rotation
   d. Follower to dwell for the rest of the cam rotation.

   The minimum radius of the cam is 45 mm and the diameter of the roller is 20mm. The line of the stroke of the follower is off-set by 10 mm from the axis of the cam shaft. If the displacement of the follower is to take place with simple harmonic motion on both the outward and return stroke. Create the cam profile for the given configurations. Also determine the maximum acceleration and velocity during ascent and decent when the cam rotates at 1500 r.p.m.

Concept Map


1.Mechanisms
consist of
classified as
consist of
consist of
1.1 Kinematic Links
1.2 Kinematic Pairs
1.3 Kinematic chains
1.4 Mobility of mechanism
2.Planar Mechanisms
3.Spatial mechanisms
4.Machine Elements
5.Dynamics
clasiified as
include
are
are
include
2.1 Simple Mechanisms
2.2 Complound mechanisms
3.1Hooke's Joint
4.1Cams
4.2 Gear trains
5.1 Balancing
5.2 Gyroscope
5.2.1 Applications
consists
2.1.1Four bar mechanism
2.1.2Single Slider Mechanism
2.1.3Double Slider Mechanism
2.1.4Steering Gear Mechanism
2.1.5Mechanism with lower pairs
2.1.6Intermitttent Motion Mechanism
analysed by
include
include
include
4.1.1Construction of Cam Profiles for different followers with different motion
4.2.1 Terminology of Gears
4.2.2 Involute Gears
4.2.3 Gear trains
5.1.1Balancing of rotating masses
5.1.2 Balncing of Reciprocating masses
include
2.1.7Inversion of fourbar mechanisms
2.1.8 Inversion of single slider mechanisms
2.1.9.Inversion of double slider mechanisms
2.1.10 Instantaneous Centre method
2.1.11 Relative Velocity Method
2.12 Klein's Construction
2.13.Inertia Force and Inertia torque
2.14Analytical method

Syllabus

Introduction to Kinematics, Mechanisms and machines **–Mechanisms:** Kinematic link, Kinematic pairs, Kinematic chains – Mechanism –Mobility of mechanism. **Planar Mechanisms: Simple mechanisms -** Four bar, Single slider crank chain and Double slider crank chain mechanism and their inversions ,Steering gear mechanism, Mechanism with lower pairs -Intermittent Motion Mechanisms. **Analysis of Simple mechanisms:** Instantaneous centre method - Velocity calculation of four bar and Single slider crank chain Mechanisms. **Relative velocity method:** Velocity and acceleration of four bar and Single slider crank chain Mechanisms -Coriolis component of acceleration in Quick return motion mechanisms. **Klein's construction:** Velocity and acceleration of Single slider crank chain Mechanisms. Inertia force and Inertia torque calculations in single slider mechanisms – Graphical method and Analytical method. **Analytical Method:** Angular velocity and angular acceleration of connecting rod in Single slider crank chain Mechanisms. Complex Mechanisms. **Spatial Mechanisms:** Hooke's Joint. **Cams:** Types of cams and followers - Cam Nomenclature-Displacement, velocity and acceleration curves for various types of motions of follower -Construction of cam profiles for radial cams with reciprocating followers-Knife edge followers - Roller follower - flat faced follower -Uniform Velocity Motion- Cycloidal Motion- Uniform Acceleration and Retardation Motion- Oscillating Roller follower. **Gear trains**: General profiles of gears- Theory of involute gearing - Contact ratio - Gear trains: Simple, Compound, Reverted and Epicyclic gear trains. **Balancing-** need of balancing, concept of static and dynamic balancing, Balancing of rotating mass by another mass in the same plane, Forces due to revolving masses. Concept of reference plane, balancing of several rotating masses in same plane and different planes. Balancing of reciprocating masses. **Gyroscope** – Introduction – gyroscope couple – applications – airplane, ship, two wheelers.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Mechanisms - Introduction**	
1.1	Kinematic link	1
1.2	Kinematic pairs	
1.3	Kinematic chains – Mechanism	1
1.4	Mobility of mechanism	1
2	**Planar Mechanisms**	
2.1	Simple Mechanisms	

No.	Topic	No. of Lectures
2.1.1	Four bar Mechanisms	1
2.1.2	Single slider crank chain Mechanism	
2.1.3	Double slider crank chain mechanisms	
2.1.4	Steering gear mechanism	
2.1.4.1	Ackermann's steering gear mechanism	1
2.1.4.2	Davis steering gear mechanism	1
2.1.5.	Mechanism with lower pairs	
2.1.5.1	Pantograph	2
2.1.5.2	Straight Line Motion Mechanisms	
2.1.6	Intermittent Motion Mechanisms	2
2.1.7	Inversions of Four bar chain	
2.1.8	Inversions of Single slider crank chain mechanisms	1
2.1.9	Inversions of double slider crank chain mechanisms	1
	Analysis of Simple mechanisms	
2.1.10	Instantaneous centre method	
2.1.10.1	Properties of Instantaneous Centre and Arnold-Kennedy's theorem	1
2.1.10.2	Velocity calculation of four bar mechanisms and Single slider crank chain Mechanisms	1
2.1.11	Relative velocity method	
2.1.11.1	Velocity and acceleration of four bar mechanisms and Single slider crank chain Mechanisms	3
2.1.11.2	Coriolis component of acceleration in Quick return motion mechanisms.	2
2.1.12	Klein's construction	
2.1.12.1	Velocity and acceleration of Single slider crank chain Mechanisms	1
2.1.13.	Inertia force and Inertia torque	
2.1.13.1	Inertia force and Inertia torque calculations in single slider mechanisms – Graphical method	1
2.1.13.2	Inertia force and Inertia torque calculations in single slider mechanisms – Analytical method	1
2.1.14.	Analytical Method- Angular velocity and angular acceleration of connecting rod in Single slider crank chain	1

No.	Topic	No. of Lectures
	Mechanisms	
2.2	Complex Mechanisms – examples	1
3.1	**Spatial Mechanisms - Hooke's Joint**	
4.1	**Cams**	
4.1.1	Construction of cam profiles for radial cams with reciprocating followers	1
4.1.2	Types of cams and followers - Cam Nomenclature- Displacement, velocity and acceleration curves for various types of motions of follower	1
4.1.3	Construction of cam profiles- Knife edge followers - Roller follower - flat faced follower -Uniform Velocity Motion- Cycloidal Motion- Uniform Acceleration And Retardation Motion- Oscillating Roller follower	3
4.2	**Gear trains**	
4.2.1	General profiles of gears-Terminology of gears and types	1
4.2.2	Theory involute gearing	1
4.2.2.1	Construction of Involute profile and its Characteristics	1
4.2.3	Gear trains	1
4.2.3.1	Simple, Compound and Reverted gear trains	2
4.2.3.2	Epicyclic gear trains	2
5	**Dynamics**	
5.1	**Balancing**	
5.1.1	Need of balancing, concept of static and dynamic balancing	1
5.1.2	Balancing of rotating mass by another mass in the same plane	1
5.1.3	Forces due to revolving masses. Concept of reference plane	1
5.1.4	balancing of several rotating masses in same plane and different planes	1
5.1.5	Balancing of reciprocating masses.	1
5.2	**Gyroscope**	
5.2.1	Introduction –gyroscope couple	2
5.2.2	Applications airplane, ship, two wheelers	2
	Total	**46**

Text Books:

1 John Joseph Uicker, Gordon Pennock, Joselph E.Shigley, “**Theory of Machines and Mechanisms**”, Third Edition, Oxford University Press, 2010.
2. Rao and Dukkipati, R.V, **“Mechanism and Machine Theory”,** New Age International (P) Ltd., 2010.

Reference Books:

1. Thomas Bevan, **“Theory of Machines”,** CBS – Third Edition, 2010.
2. Singh, V.P., **“Theory of Machines”,** Dhanpat Rai & Co., (P) Ltd., New Delhi, 2011.
3. Sadhu Singh, “**Theory of Machines**” . Pearson Education, New Delhi, 2009.
4. Ashok G.Ambekar ,” **Mechanism and Machine theory** ”,Prentice Hall of India , New Delhi,2011.
5. Ballaney, P.L., **“Theory of Machines”,** Khanna Publishers, New Delhi, 2002.
6. http:// nptel.iitm.ac.in- video lectures

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Sub Code	Lectures	Tutorial	Practical	Credit
G53	3	0	-	3

G53 Metrology and Mechanical Measurements 3:0

Preamble: In science and engineering, objects of interest have to be characterized by measurement and testing. Measurement is an essential activity in every branch of technology and science and it is the process of experimentally obtaining quantity values that can reasonably be attributed to a property of a body or substance. Metrology is the science of measurement. The ability to measure and to compare measurements between laboratories is one of the cornerstones of the scientific method. Globalization of research, development and manufacture has produced greatly increased attention to international standards of measurement. It is no longer sufficient to achieve internal consistency in measurements within a local laboratory or manufacturing facility; measurements must now be able to be reproduced accurately anywhere in the world. In a time of constant and rapid technological development, it would be quite ambitious to develop and present a course that claimed to cover each and every industrial measuring type of equipment.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

i. Graduates will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

k. Graduate can participate and succeed in competitive examinations.

Competencies:

At the end of the course, students should be able to

1. Explain about various stages in a measurement system
2. Explain the static and dynamic characteristics of measuring instruments.
3. Explain the concepts of linear, angular, surface finish measuring Instruments gauges and measuring machines.
4. Describe the method of usage of instruments and inspection gauges
5. Read component drawing and select appropriate instruments/gauges to measure/inspect its specifications.
6. Explain the basic working principle of various transducers for the measurement of motion, strain, force, torque, temperature, pressure, flow and level.

7. Choose appropriate instruments for the measurement of the specified applications

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End Semester examination
1	Remember	20	20	20
2	Understand	50	40	40
3	Apply	30	40	40
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What is a comparator?
2. What are the factors involved in selection of measuring instruments?
3. What are the elements of generalized measurement system?
4. Define 'precision and 'accuracy'
5. Define Resolution
6. Define international standard for length.

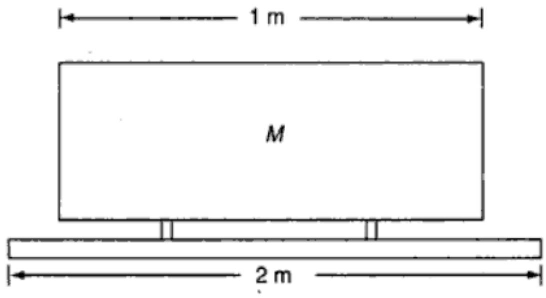
Understand

1. Explain the basic principles of interferometry.
2. Explain how a pneumatic comparator works and briefly enumerate the merits of differential pneumatic comparator.
3. Describe with a sketch the principle of working of an auto-collimator.
4. Explain the working principle of pneumatic comparator with a neat sketch.
5. How are the major and minor diameters of thread measured?
6. Explain construction, working, merits and demerits of ultrasonic type flow meters.

Apply

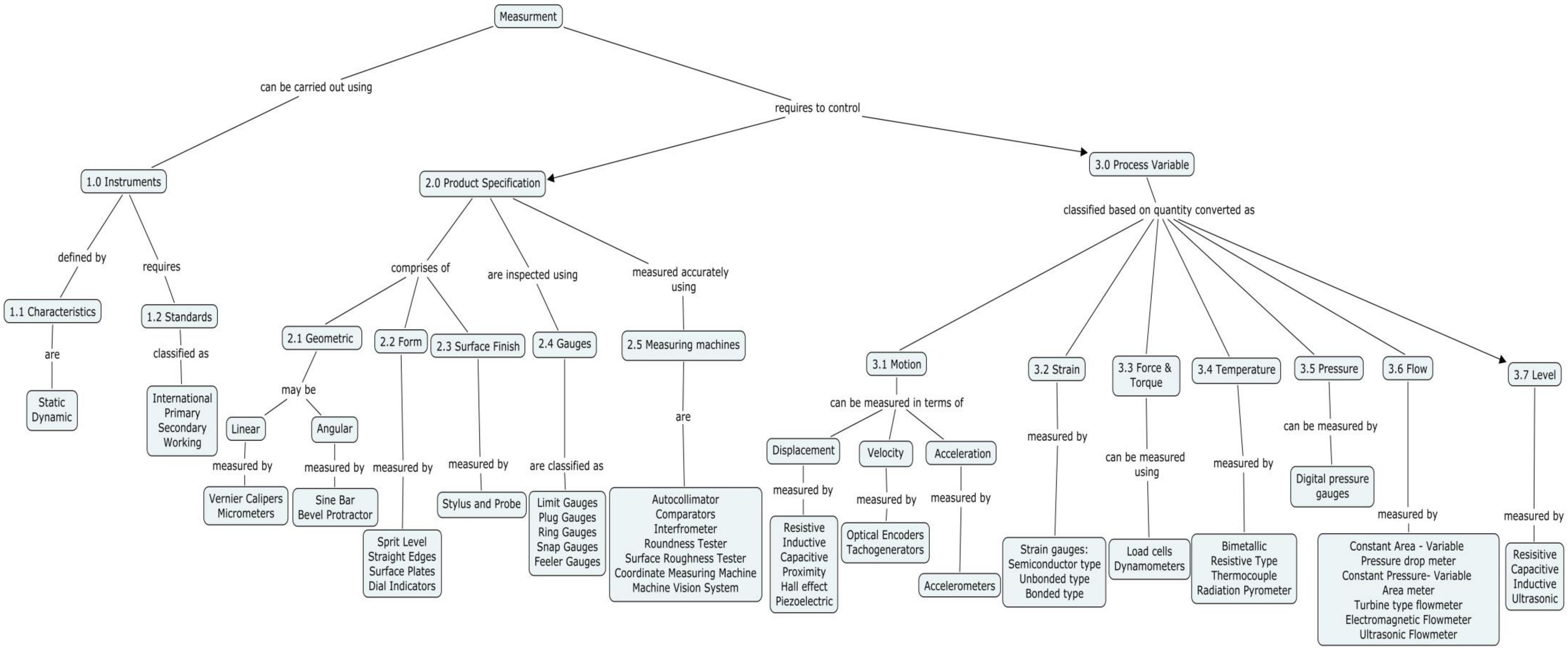
1. Prepare a stack of slip – gauges for Height 34.468 mm by using a normal Set of M 45.
2. Select suitable instruments for measuring a) diameter of a hole upto 50 mm and b) diameter of hole less than 5 mm.

3. Using a linear reading adjustable sprit level, suggest the suitable method of determining the parallelism of two rectangular bearing surfaces as shown in the following figure:



4. Design and sketch a working gauge with a GO and NO-GO ends for spindle $\frac{80.009}{80.000}$ mm and a hole of $\frac{79.866}{79.786}$ mm.
5. A Rota meter has an effective height of 200mm, effective base diameter of 10 mm and top diameter 20mm.it has a float of diameter 10 mm, thickness 3 mm and density 2500kgm^{-3}.its discharge coefficient is .95, if water is flowing through it and the float is at 1000.00 mm height what is the rate of flow?
6. A thermometer is initially at room temperature of 23 deg C. it is immersed in an oil bath at 151° C. After 3 seconds it shows a reading of 95 deg c. find its time constant. After what time from the start will be thermometer read 150° C.

Concept Map


Measurment
can be carried out using
requires to control
1.0 Instruments
2.0 Product Specification
3.0 Process Variable
defined by
requires
1.1 Characteristics
1.2 Standards
are
classified as
Static
Dynamic
International
Primary
Secondary
Working
comprises of
are inspected using
measured accurately using
2.1 Geometric
2.2 Form
2.3 Surface Finish
2.4 Gauges
2.5 Measuring machines
may be
Linear
Angular
measured by
Vernier Calipers
Micrometers
measured by
Sine Bar
Bevel Protractor
measured by
Sprit Level
Straight Edges
Surface Plates
Dial Indicators
measured by
Stylus and Probe
are classified as
Limit Gauges
Plug Gauges
Ring Gauges
Snap Gauges
Feeler Gauges
are
Autocollimator
Comparators
Interfrometer
Roundness Tester
Surface Roughness Tester
Coordinate Measuring Machine
Machine Vision System
classified based on quantity converted as
3.1 Motion
3.2 Strain
3.3 Force & Torque
3.4 Temperature
3.5 Pressure
3.6 Flow
3.7 Level
can be measured in terms of
Displacement
Velocity
Acceleration
measured by
Resistive
Inductive
Capacitive
Proximity
Hall effect
Piezoelectric
measured by
Optical Encoders
Tachogenerators
measured by
Accelerometers
measured by
Strain gauges:
Semiconductor type
Unbonded type
Bonded type
can be measured using
Load cells
Dynamometers
measured by
Bimetallic
Resistive Type
Thermocouple
Radiation Pyrometer
can be measured by
Digital pressure gauges
measured by
Constant Area - Variable
Pressure drop meter
Constant Pressure- Variable
Area meter
Turbine type flowmeter
Electromagnetic Flowmeter
Ultrasonic Flowmeter
measured by
Resisitive
Capacitive
Inductive
Ultrasonic

Syllabus

Measurement Fundamentals: The process of measurement- significance, generalized measuring system, Characteristics of measuring instruments: Static characteristics -Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity, Stability, interchangeability, Errors- Systematic and Random, Uncertainty of Measurement, Calibration, Traceability, Confidence level, Standards - National, Reference, Secondary, and Working Standards. *Linear Measurement:* Usage, Internal/ External calipers, Vernier caliper, Vernier Height gauge, Depth gauge, Gear tooth vernier, plunger dials, Slip gauges, Inside / Outside Micrometer. *Angular Measurement:* Sine Bar, Bevel protractor. *Form Measurement:* Sprit level, Straight edges, Surface plate, Dial indicators for squareness, V-Blocks, Measurement of major diameter, minor diameter, flank angle, pitch and effective diameter of screw thread. *Surface finish Measurement:* Surface Roughness, Symbols, sample length, cut off cutoff length, Roughness comparison as per specimen, R_a, R_z, R_q, R_t, R_p, R_v - Principle and operation of stylus probe instruments. *Inspection using gauges:* Types- limit gauges, Indicative snap gauge, Plain plug gauge, ring gauges, Radius gauges, Feeler gauges - Gauge design. *Measuring Machines:* Auto collimator, Comparator - Mechanical comparator, Electronic comparator, Optical comparators, Pneumatic Air gauge, Electronic Air gauge, laser interferometer, roundness tester, Co-ordinating measuring machine (CMM), Surface Roughness tester (Stylus and Skid). *Measurement of motion :* Resistive, inductive-LVDT, capacitive, piezo electric, hall effect sensor, Speed measurement using optical encoders, tacho generators. Accelerometers. *Measurement of strain:* Types of strain gauges - Gauge factor - Signal conditioning circuits for strain gauges. *Measurement of Force and Torque:* Load cells, Dynamometers. *Measurement of Temperature:* Thermal Expansion; Bimetallic, Thermo Electric Methods: RTD, Thermistor, Thermo couples, Optical Pyrometers. *Measurement of Pressure:* Digital pressure gauges. *Measurement of Flow:* Constant area variable pressure drop meters, Constant pressure drop variable area meters, Turbine meters, Electromagnetic flow meters, ultra sonic flow meters. *Measurement of Level:* Resistive, capacitive, inductive and ultra sonic type.

Text Book:

1. Anand K Bewoor and Vinay A Kulkarni "**Metrology and Measurement**" Tata McGraw Hill Edition, 2009.

Reference Books:

1. Ernest O Doeblin "**Measurement Systems Application and Design**" Tata McGraw Hill Edition, 2004.
2. Sabrie Solomon, "**Sensors and control systems in manufacturing**", McGraw Hill international Editions, 1994.
3. Galyer.J.F.W. Shotbolt, C.R., "**Metrology for Engineers**", ELBS with Casell Ltd., UK, Fifth Edition, 1990.
4. Jain, R.K, "**Engineering Metrology**", Khanna publishers, 2009.
5. R.K.Rajput, "**Engineering Metrology and Instrumentation**", Kataris & sons Publishers, 2001.
6. Singh S.K., "**Industrial Instrumentation and Control**", Tata McGraw Hill Edition, 2003.
7. I.C.Gupta., "**A Text Book of Engineering Metrology**", 3rd Edition, Dhanpatrai Sons Publishers, 1996.

Course contents and Lecture schedule

No	Topic	No. of Lectures
0	Fundamentals of Measurement: The process of measurement-significance, generalized measuring system	1
1.0	**Measuring instruments**	
1.1	Static characteristics –Precision, Accuracy, Sensitivity, Repeatability, Reproducibility, Linearity, Stability, Bias, interchangeability	2
1.1.1	Errors- Systematic and Random, Uncertainty of Measurement	1
1.1.2	Calibration, Traceability, Confidence level	2
1.2	Standards – National, Reference, Secondary, and Working Standards.	1
2.0	**Measurement of Product Specifications**	
2.1	Geometric Specification – classification	1
2.1.1	Linear Measurements: Usage, Internal/ External calipers, Vernier caliper, Vernier Height gauge, Depth gauge, Gear tooth vernier, plunger dials, Slip gauges, Inside/Outside Micrometer	2

No	Topic	No. of Lectures
2.1.2	Angular Measurement: Sine Bar, Bevel protractor.	2
2.2	Form Measurement: Sprit level, Straight edges, Surface plate, Dial indicators for squareness, V-Blocks,	2
2.2.1	Measurement of major diameter, minor diameter, flank angle, pitch and effective diameter of screw thread.	2
2.3	Surface finish Measurement: Surface Roughness, Symbols, sample length, cut off cutoff length,	1
2.3.1	Roughness comparison as per specimen, R_a, R_z, R_q, R_t, R_p, R_v	2
2.3.2	Principle and operation of stylus probe instruments	1
2.4	Inspection using gauges: Types- limit gauges	1
2.4.1	Snap gauge, Plain plug gauge, ring gauges, Radius gauges, Feeler gauges - Gauge design.	2
2.5	Measuring Machines	
2.5.1	Auto collimator, Comparator – Mechanical, Electronic and Optical comparators,	2
2.5.2	Pneumatic Air gauge, Electronic Air gauge, laser interferometer, roundness tester	2
2.5.3	Co-ordinating measuring machine (CMM), Surface Roughness tester (Stylus and Skid)	2
3.0	**Measurement of Process Variables**	
3.1	Measurement of motion	
3.1.1	Displacement Measurement: Resistive, inductive-LVDT, capacitive, piezo electric, hall effect sensor	2
3.1.2	Speed measurement using optical encoders, tacho generators.	2
3.1.3	Acceleration measurement using accelerometers	1
3.2	Measurement of strain: Types of strain gauges - Gauge factor - Signal conditioning circuits for strain gauges	2
3.3	Measurement of Force and Torque: Load cells, Dynamometers	2
3.4	Measurement of Temperature: Thermal Expansion; Bimetallic, Thermo Electric Methods: RTD	1
3.4.1	Thermistor, Thermo couples, Optical Pyrometers.	2
3.5	Measurement of Pressure: Digital pressure gauges	1
3.6	Measurement of Flow: Constant area variable pressure drop meters, Constant pressure drop variable area meters,	2
3.6.1	Turbine meters, Electromagnetic flow meters, ultra sonic flow	1

No	Topic	No. of Lectures
	meters	
3.7	Measurement of Level: Resistive, capacitive, inductive and ultra sonic type	2
	TOTAL	**47**

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Sub Code	Lectures	Tutorial	Practical	Credit
G 54	3	1	-	4

G54 Heat and Mass Transfer 3:1

Preamble: Heat and mass transfer is a basic science that deals with the rate of transfer of thermal energy. Heat transfer is that science which seeks to predict the energy transfer which may take place between material bodies as a result of a temperature difference. The mass transfer is due to concentration difference. Thermodynamics teaches that this energy transfer is defined as heat. The science of heat transfer seeks not merely to explain how heat energy may be transferred, but also to predict the rate at which the exchange will take place under certain specified conditions. Finding heat transfer rate is the desired objective of heat transfer studies.

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.

d. Graduates can participate and succeed in competitive examinations.

Competencies:

At the end of the course, the student should able to

1. Understand the principles of heat and mass transfer
2. Model three modes of heat transfer including conduction, convection and radiation
3. Model and solve heat transfer problems as they occur in IC engines, electronic packages, electrical transformers, steam boilers, condensers, and thermal barriers.
4. Model diffusion and convective mass transfer problems
5. Model and solve mass transfer problems as they occur in evaporation of lakes and mixing of liquids

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	20	20	10
2	Understand	30	30	20
3	Apply	30	30	50
4	Analyze	20	20	20
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. A person who sits in front of a fire place feels warm. Name the mode of heat transfer through which he receives heat.
2. A pipe is insulated to reduce the heat loss from it. However, measurements indicate that the rate of heat loss has increased instead of having decreased. Can the measurement be right?
3. Define Biot number.
4. Give the physical significance of Prandtl number.
5. Determine the shape factor / view factor, when two parallel discs of same radii, 5 cm placed at a distant of 10 cm apart.
6. State Stefen's law of mass diffusion.

Understand

1. Starting with energy balance equation derive the three dimensional, steady state heat conduction equation with heat generation.
2. Obtain an expression for the temperature distribution of a short fin exposed with ambient with end insulated.
3. Show that, the heat exchange between two parallel non black bodies is given by,

$$Q_{1-2} = \frac{E_{b,1} - E_{b,2}}{\frac{1-\varepsilon_1}{A_1\varepsilon_1} + \frac{1}{A_1 F_{12}} + \frac{1-\varepsilon_2}{A_2\varepsilon_2}}$$

4. Derive effectiveness, ε, for a parallel flow heat exchanger by assuming cold fluid is minimum.
5. Obtain an expression for LMTD of a parallel flow heat exchanger.
6. Show that the critical radius of insulation for a cylindrical body to be, $r_{cri} = \frac{k}{h}$.

Apply

1. A laboratory furnace wall is constructed of 0.2 m thick fire clay bricks (k= 1 W/m K). The wall is covered on the outer surface with a thick layer of insulating material (k = 0.07 W/m K). The furnace inner brick surface is at 1250 K and the outer surface of the insulating material is at 32^0C. If the maximum allowable heat transfer rate through the wall of the furnace is 900 W/m^2, how thick must the insulating layer be?
2. A long cylinder of radius 150 mm and at an initial uniform temperature of 530^0 C is suddenly exposed to an environment at 30^0 C. The convection heat transfer coefficient between the surface of the cylinder and the environment is 380 W/m^2 K. The thermal conductivity and thermal diffusivity of the cylinder material are 200 W/ m K and 8.5 x 10^{-5} m^2/s respectively. Determine the temperature at a radius of 120 mm after the time duration of 265 seconds.
3. One end of long rod of diameter 10 mm is inserted into a furnace. The temperatures measured at two points **A** and **B**, 40 mm apart gave 265^0 C and 150^0 C respectively. If the convection coefficient is 35 W/m^2 K, when exposed to air at 25^0 C, determine the conductivity of the material.
4. Two parallel black plates 0.5 by 1 m are spaced 0.5 m apart. One plate is maintained at T_1 = 1000^0 C and the other at T_2 = 500^0 C. What is net radiant heat exchange between the two plates? Rework the problem by considering the plates are gray surfaces with ε_1 = 0.5 and ε_2 = 0.6.
5. Two parallel plates 0.5 by 1 m spared 1 m apart. One plate is maintained at 1000^0 C and the other at 600^0 C. The emissivities of the plates are 0.2 and 0.5 respectively. The plates are located in a very large room, the walls of which are maintained at 30^0 C. The plates exchange heat with each other and with the room, but only the plate surface facing each other are to be considered in the analysis. Find the net transfer to each plate and to the room.
6. Thermal energy is generated at a constant rate of 2 x 10^8 W/ m^3 in a copper rod of radius r =5 mm and thermal conductivity k = 400 W/ m K. The rod is cooled by convection from its cylindrical surface into an ambient at 25^0 C with a heat transfer coefficient h = 1000 W/m^2 K. Determine the surface temperature of the rod.

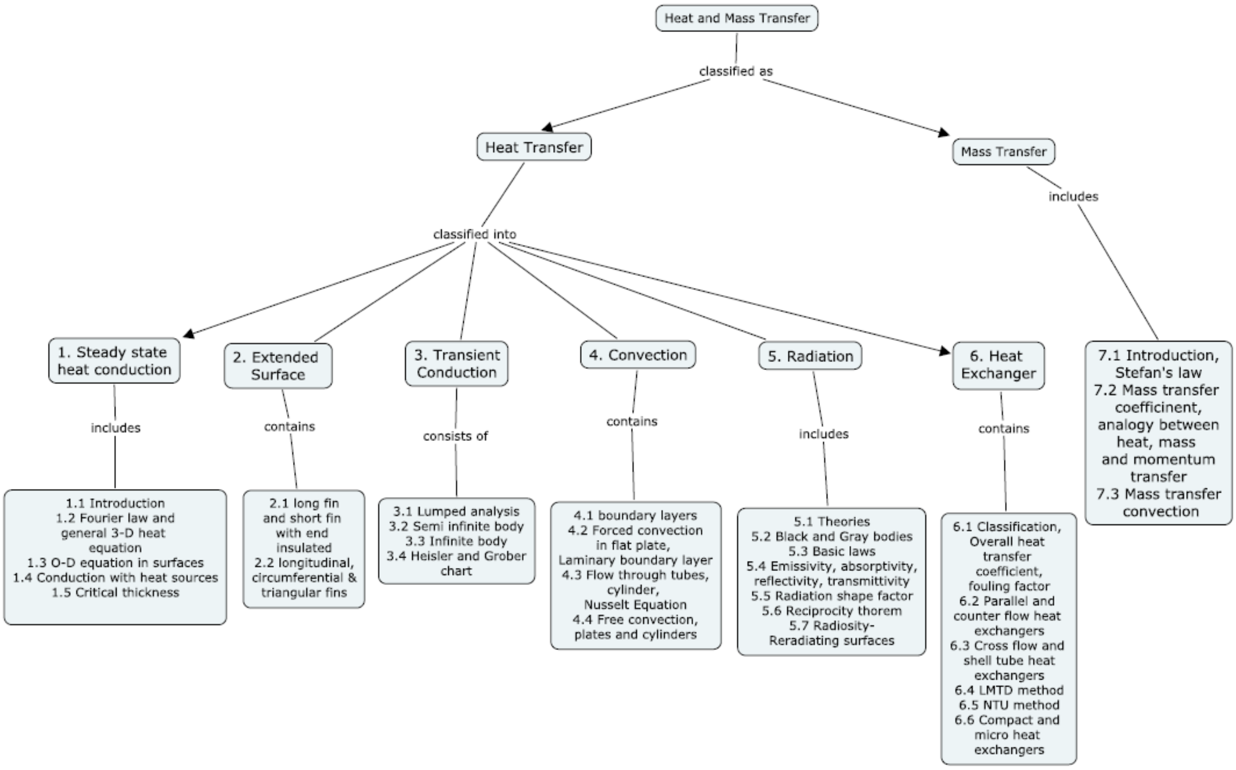
Analyze

1. An array of power transistors, dissipating 5 W of power each, are to be cooled by mounting them on a 250 mm x 250 mm square aluminum plate and

blowing air at 30^0C over the plate with a fan at a velocity of 4 m/s. The average temperature of the plate is not to exceed 60^0 C. Assuming the heat transfer from the back side of the plate to be negligible and disregarding radiation, check how many transistors are required to do the job?

2. A person is found dead at 5 PM in a room whose temperature is 20^0 C. The temperature of the body is measured to be 25^0 C when found, and the heat transfer coefficient is estimated to be h = 8 W/ m^2 K. Modeling the body as 30 cm diameter and 1.7 m long cylinder, and the average human body is 72 percent water by mass and thus assume the properties of water as: k = 0.617 W/m K; ρ = 996 kg/m^3 and C_p = 4178 J/kg K. Select the suitable method and estimate the time of death of that person.
3. During a summer picnic, college students roasting a pig for their lunch. The pig (k = 42.68 x 10^{-3} W/ m K and α = 2.778 x 10^{-7} m^2/s) is roughly cylindrical and about 30 cm in diameter. It is roasted over a propane flame, where the hot gas flows across the pig at 250^0 C and h = 1.42 W/m^2 K. If the meat is served exactly at 2 pm, when the centre temperature of meat reaches 95^0 C, when should cooking commence?
4. A 250^0 C cylindrical copper billet, 4 cm in diameter and 8 cm long, is cooled in air at 25^0 C. The heat transfer coefficient is 5 W/m^2 K. Can this be treated as lumped capacitance cooling? If it so, what could be the temperature of the billet after 5 minutes and 10 minutes?
5. A person tries to keep cool on a hot summer day by turning a fan on and exposing his entire body to air flow. The air temperature is 25^0 C and the fan is blowing air at a velocity of 5 m/s. If the person does light work and generates heat at a rate of 100 W. By suitable heat transfer analysis, determine the temperature of the outer surface of the person. The average human body can be treated as a 0.3 m diameter cylinder with an exposed surface area of 1.6 m^2. Take the property values at free stream temperature of 25^0 C.
6. Air at 2 atm and 200^0 C is heated as it flows through a tube with a diameter of 2.54 cm at a velocity of 10 m/s. Calculate the heat transfer per unit length of tube if a constant heat flux condition is maintained at the wall and the wall temperature is 20^0 C above air temperature all along the length of the tube. How much would the bulk temperature increase over a 3 m length of the tube? Take ρ = 1.493 kg/m^3; Pr = 0.681; μ =2.57 x 10^{-5} kg/ ms and k = 0.0386 W/m K.

Concept Map



Syllabus

Steady state conduction

Introduction, Modes of heat transfer - Fourier law of conduction- general heat conduction equation in Cartesian co-ordinates- One dimensional steady state heat conduction through plane wall- hollow cylinder and sphere- composite systems with combined mechanism - electrical analogy - conduction with inner heat sources - plane wall and solid cylinders- critical thickness of insulation.

Extended surfaces

Heat transfer through extended surfaces - long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip- longitudinal and circumferential and triangular fins - efficiency and effectiveness.

Transient conduction

Lumped heat capacity systems - heat flow in a semi - infinite body: initial temperature with suddenly immersed in liquid and convection boundary conditions - heat flow in an infinite body - Heisler and Grober charts.

Convection

Hydrodynamic and thermal boundary layers - Forced convection - flow over flat plates: laminar boundary layer thickness in terms of Reynolds number - flow through tubes, flow across cylinder- Nusselt equation.

Free convection - horizontal and vertical plates - horizontal and vertical cylinders - Nusselt equation.

Radiation

Wave theory and quantum theory- concepts of black body and gray body - Stefan - Boltzman law - emissive power – monochromatic emissive power - Weins law - Kirchoff's law - Emissivity, absorptivity, reflectivity, transmissivity - Radiation shape factor - heat exchange between surfaces - Reciprocity theorem- radiosity - Reradiating surfaces.

Heat exchangers

Classification- overall heat transfer co-efficient- fouling factor-parallel and counter flow heat exchangers – cross flow and shell tube heat exchangers - LMTD method -NTU method - compact and micro type heat exchangers

Phase change heat transfer

Boiling -Pool boiling, flow boiling- Condensation-drop wise and film wise.

Mass transfer

Introduction to mass transfer – Fick's law of diffusion- mass transfer co-efficient - analogy between heat, mass and momentum transfer - mass transfer in convection.

Text Book:

1. Yunus A.Cengel, "**Heat and Mass Transfer: fundamentals and applications**", Mc Graw Hill, 2010.

Reference Books:

1. Holman, J.P., **"Heat Transfer"**, Fourth Edition, McGraw Hill., 2010.
2. Frank P. Incropera, David P. DeWitt, Theodore L. Bergman, and Adrienne S. Lavine, "**Introduction to Heat Transfer**", John Wiley and Sons, 2010.
3. Mahesh M. Rathore, "**Engineering Heat and Mass Transfer**", University Science Press, 2006.
4. Necati Ozisik, "**Heat Transfer – a Basic Approach**", McGraw Hill, 1994.
5. Rajput, R.K., "**Heat and Mass Transfer**", S.Chand & Company Ltd, 2010.
6. Mills, A.F and Ganesan, V., "**Heat Transfer**", Pearson Education, 2009.
7. Som, S.K. "**Introduction to Heat Transfer**", PHI Learing Private Ltd, 2008.
8. Frank Kreith, Mark S. Bohn, "**Principles of Heat Transfer"**, Sixth Edition, Brooks/cole, Thomson Asia Private Ltd., Singapore, 2001.
9. Sachdeva, R.C., **"Fundamentals of Engineering Heat and Mass Transfer"**, New Age International Publishers, 2010.
10. Kothandaraman, C.P., **"Fundamentals of Heat and Mass Transfer",** Second Edition, New Age International, 2010.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Steady state conduction**	
1.1	Introduction, Modes of heat transfer	1
1.2	Fourier law of conduction, general heat conduction equation in Cartesian co-ordinates	2
1.3	One dimensional steady state conduction through plane wall- hollow cylinder and sphere- composite systems with combined mechanism – electrical analogy	3
1.4	Conduction with inner heat sources – plane wall and solid cylinders	2
1.5	Critical thickness of insulation.	1
2	**Extended surfaces**	
2.1	Heat transfer through extended surfaces – long fins, short fins with negligible heat loss from the fin tip (insulated fin tip) and convection from fin tip	3
2.2	Longitudinal and circumferential and triangular fins – efficiency and effectiveness.	1
3	**Transient conduction**	
3.1	Lumped heat capacity systems	2
3.2	Heat flow in a semi – infinite body: initial temperature with suddenly immersed in liquid and convection boundary conditions	1
3.3	Heat flow in an infinite body	1
3.4	Heisler and Grober charts	1
4	**Convection**	
4.1	Hydrodynamic and thermal boundary layers	1
4.2	Forced convection – flow over flat plates: Laminar boundary layer thickness in terms of Reynolds number	2
4.3	Flow through tubes, flow across cylinder- Nusselt equation.	2
4.4	Free convection – horizontal and vertical plates	2

No.	Topic	No. of Lectures
	– horizontal and vertical cylinders – Nusselt equation	
5	**Radiation**	
5.1	Wave theory and quantum theory	1
5.2	Concepts of black body and gray body	1
5.3	Stefan – Boltzman law – emissive power – monochromatic emissive power – Weins law – Kirchoff’s law	1
5.4	Emissivity, absorptivity, reflectivity, transmissivity	1
5.5	Radiation shape factor – heat exchange between surfaces	2
5.6	Reciprocity theorem	1
5.7	Radiosity – Reradiating surfaces	2
6	**Heat exchangers**	
6.1	Classification- overall heat transfer co-efficient-fouling factor	1
6.2	Parallel and counter flow heat exchangers	1
6.3	Cross flow and shell tube heat exchangers	1
6.4	LMTD method	2
6.5	NTU method	2
6.6	Compact and micro type heat exchangers.	1
7	**Phase change heat transfer**	
7.1	Boiling –Pool boiling, flow boiling-Condensation-drop wise and film wise	2
8	**Mass transfer**	
7.1	Introduction to mass transfer - Fick’s law of diffusion.	1
7.2	Mass transfer co-efficient - analogy between heat, mass and momentum transfer	1
7.3	Mass transfer in convection	1

No.	Topic	No. of Lectures
	Total	**47**

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Sub Code	Lectures	Tutorial	Practical	Credit
G 55	3	0	-	3

G55 Manufacturing Processes and Automation 3:0

Preamble: Manufacturing Processes and Automation deals with special manufacturing processes and automation technologies. It covers the methods of manufacture of threads and gears using special machines and unconventional machining processes and hard automation technologies such as transfer lines, the soft (flexible) automation technologies that comprises of NC, CNC, GT, FMS and Rapid Prototyping.

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduates who can participate and succeed in competitive examinations.

Competencies:

1. Understand the principles of working and features of special machining and unconventional machining processes.
2. Understand the principles and capabilities of machine tools used for fixed and flexible automation systems
3. Suggest manufacturing plans for producing parts in specified volumes

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3/ End-semester examination
1	Remember	20	20	20
2	Understand	50	50	50
3	Apply	30	30	30
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Name the materials used for tool in EDM process.
2. List the process variables of LBM.
3. What is APT?

4. What is AS/RS?
5. Define Group Technology.

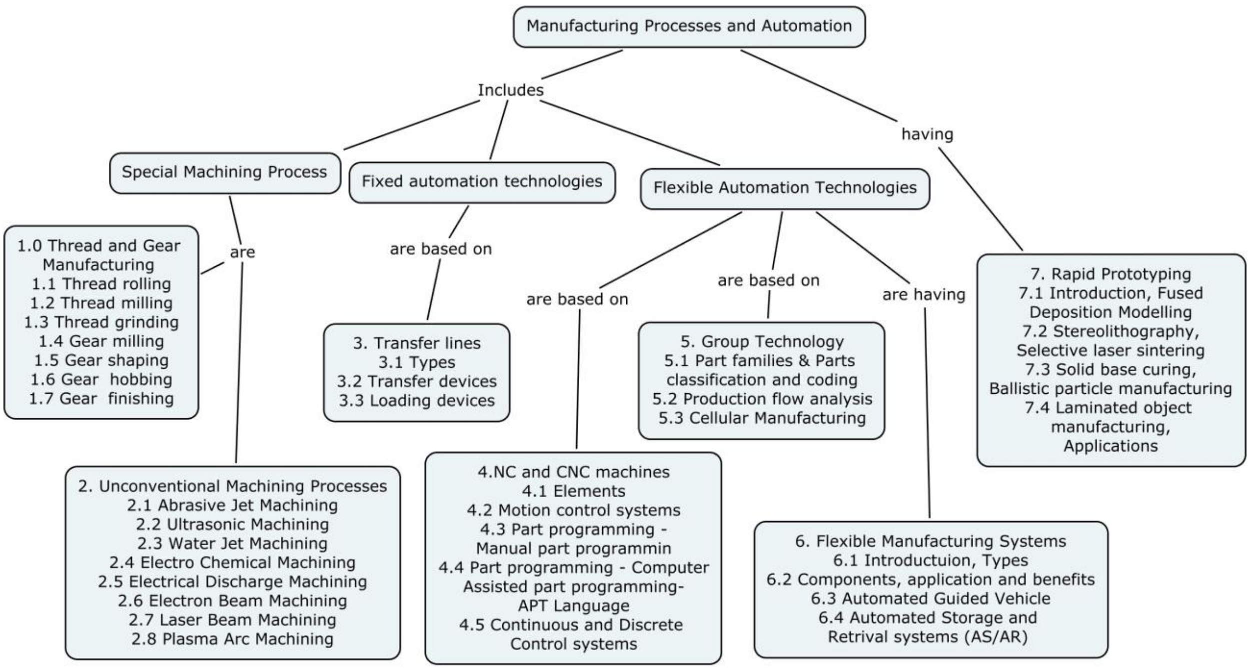
Understand

1. Why are transfer lines not preferred for batch production?
2. Why is thread rolling commonly used for thread manufacture?
3. How do you cut internal threads?
4. Explain how helical gears are manufactured by gear shaping.
5. Discuss the working principle of laser beam machining process.
6. Explain how AGV's are guided and routed.

Apply

1. Write a part program to mill the profile of a prismatic component of your choice.
2. Suggest a method to manufacture spur gears of 5000 components.
3. A hole of 0.1 mm in a sheet of 10 mm thick is be drilled. Suggest the suitable processes and explain the reasons for selection.
4. Select a suitable process to produce the threads in mass production and Justify.
5. Select a suitable process for making prototype of complicated components and explain the process.
6. Select the type of manufacturing system to produce 5000 components and explain the production line.

Concept Map



Syllabus

Thread and gear manufacturing: Thread rolling – thread milling – thread grinding, gear milling - gear shaping and gear hobbing – gear finishing. **Unconventional machining processes:** Abrasive Jet machining – Ultrasonic machining – Water Jet machining- Electrochemical machining – Electric discharge machining – Electron beam machining – Laser beam machining – Plasma arc machining (Working principles and applications only). **Transfer lines:** In-line and rotary transfer lines – automatic transferring and loading devices. **NC and CNC machines:** Elements of NC and CNC machine tools – Coordinates and motion control system – NC part programming – Manual part programming – Computer assisted part programming – APT language- Continuous and discrete control systems. **Group technology:** Part families, Parts classification and coding, Production flow analysis, Cellular Manufacturing. **Flexible manufacturing systems:** Introduction, types, components, applications and benefits. **Automated material handling and storage systems**: Automated guided vehicles (AGVs) – guidance technology – Automated storage and retrieval systems (AS/RS). **Rapid prototyping:** Introduction, Fused deposition modeling, Stereo lithography, Selective laser sintering, Solid base curing, Ballistic particle manufacturing, Laminated object manufacturing (Working principles and applications only).

Text Books:

1. Hasle Hurst, **"Manufacturing Technology"**, Viva Books publications, 1998.
2. Mikell P. Groover, **"Automation, Production systems and Computer Integrated Manufacturing"** Prentice Hall of India Pvt. Ltd., 2nd Edition, 2006.
3. Serope Kalpakjian and Steven R. Schmid. **"Manufacturing Engineering and Technology"** Fourth Edition, Pearson Education, 2000.
4. Pandey P. C., and Shan H.S., "**Modern Machining Processes**" TMH publications, 1990.

Reference Books:

1. Sharma P.C., **"Production Engineering"**, S. Chand and Co., 1995.
2. Pandey P.C. and Singh C.K., **"Production Engineering Sciences"** Standard publishers distributors, 1992.

Course Contents and Lecture schedule

No.	Topics	No. of Lectures
1.	**Thread and Gear Manufacturing**	
1.1	Thread rolling	1
1.2	Thread milling	1
1.3	Thread grinding	1
1.4	Gear milling	1
1.5	Gear shaping	1
1.6	Gear hobbing	2
1.7	Gear finishing	1
2.	**Unconventional Machining Processes**	
2.1	Abrasive Jet machining	2
2.2	Ultrasonic machining	
2.3	Water Jet machining	
2.4	Electrochemical machining	1
2.5	Electric discharge machining	1
2.6	Electron beam machining	2
2.7	Laser beam machining	
2.8	Plasma arc machining	
3.	**Transfer Lines**	
3.1	Transfer lines- types	1
3.2	Transfer devices	1
3.3	Loading Devices	1
4.	**NC and CNC Machines**	
4.1	Elements	1
4.2	Motion Control Systems	1
4.3	Part programming -Manual part programming	2
4.4	Part programming –Computer assisted part programming-APT language	2

No.	Topics	No. of Lectures
4.5	Continuous and discrete control systems	2
5.	**Group Technology**	
5.1	Part families, Parts classification and coding	2
5.2	Production flow analysis	2
5.3	Cellular Manufacturing	1
6	**Flexible Manufacturing Systems**	
6.1	FMS –Introduction, types	2
6.2	components, applications and benefits	1
6.3	Automated guided vehicles (AGVs) – guidance technology	2
6.4	Automated storage and retrieval systems (AS/RS)	1
7	**Rapid Prototyping**	
7.1	Introduction, Fused deposition modeling,	1
7.2	Stereo lithography, Selective laser sintering,	1
7.3	Solid base curing, Ballistic Particle manufacturing	1
7.4	Laminated object manufacturing, Applications	1
	Total	**40**

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Sub Code	Lectures	Tutorial	Practical	Credit
G 56	3	0	-	3

G56 Industrial Engineering 3:0

Preamble: This course deals with productivity measurements, method study techniques, work measurement and production planning and control.

Program Outcomes Addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

i. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.

Competencies:

At the end of the course the student should be able to

1. Understand the theory in industrial engineering and their applications.
2. Evaluate the work methods through work measurement.
3. Establish the efficient work system.
4. Understand the application of forecasting techniques.
5. Able to prepare the production plan.

Assessment Pattern

Sl.No.	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3/ End-semester examination**
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define: Productivity.
2. What do you mean by synthesis?
3. What do you understand by PMTS?
4. Define: Economic order quantity.
5. List the purpose to balance the assembly line.
6. List the techniques for aggregate production planning.

Understand

1. Differentiate between analytical estimation and PMTS.
2. Explain about product flow chart with suitable example.
3. Explain about productivity metric and its functions.
4. Describe about Ranked positional weight method for line balancing.
5. Explain the need of REBA/RULA.
6. Why are you in need of a good forecasting technique?

Apply

1. In a machine shop work sampling study was conducted for 160 hrs in order to estimate the std. time. Total numbers of observation recorded were 3500. There were 600 no. of working activities. Ratio between manual to machine element was 2:1. Avg. rating factor was 1:2 and total no. of jobs produced during the study was 8000. Rest and personal allowances taken together will be 16% of normal time. Determine the std. time per job.
2. Determine July month forecast if the wt. moving avg. with weights of 0.60,0.30 and 0.10

Month	Jan	Feb	Mar	Apr	May	Jun
Demand	120	110	150	120	160	150

3. A work sampling study was conducted to establish the std. Time for a specific operation. The observations of the study: Total no. of observations: 160, manual (hand controlled work) is 14, machine controlled work is 106 and machine idle time is 40, Avg. Performance rating: 80%, study conducted for 3 days and 8 hrs working per day. Calculate the std. time per piece.
4. The observed times and the performance ratings for the five elements are given:

Element	1	2	3	4	5

Observed time (min)	0.2	0.06	0.5	0.12	0.1
Performance rating	85	80	90	85	75

Compute the std. time assuming rest and personal allowances as 10% and contingency allowance as 2% of the basic time.

5. M/s. XY corporation has developed a forecast for a group of items that has the following demand pattern.

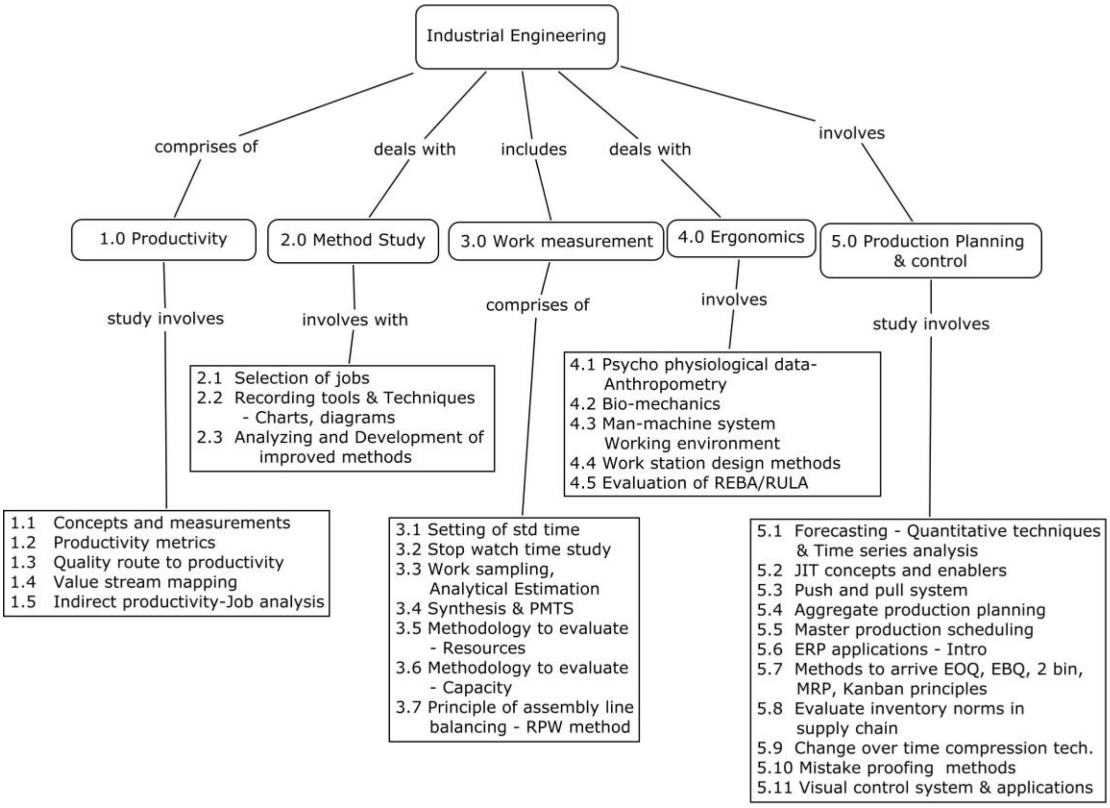
Quarter	**Demand**	**Cumulative demand**
1	270	270
2	220	490
3	470	960
4	670	1630
5	450	2080
6	270	2350
7	200	2550
8	370	2920

Plot the demand as histogram. Determine the production rate required to meet the avg. demand and plot the avg. demand forecast on the graph.

6. Consider the following assembly network relationships of a product. The number of shifts per day is 1 and the no. of working hours is 8. The company aims to produce 40 units of product per shift. Group the activities into optimal no. of stations using RPW method and also compute the balancing efficiency.

Operation No.	**Immediate preceding Tasks**	**Duration (Min)**
1	-	8
2	1	3
3	1	2
4	1	4
5	3,4	7
6	2,7	4
7	2,4,5	5
8	4	6
9	6,8	8

Concept Map



Syllabus

Productivity: concepts and measurements. Productivity metrics – Quality route to productivity - approach to ERCSS, Value Stream mapping, In-direct productivity - Job analysis. **Method study:** Selection of jobs, recording tools and techniques – Flow chart, Process chart, Man-machine chart, two handed process chart, Process flow diagram, Process Flow Analysis, Analyzing, Development of improved methods. **Work Measurement**: Setting of standard time - Stop watch time study, rating, allowances, Work sampling, Analytical estimation, Synthesis and Predetermined Motion Time Standards (PMTS). Methodology to evaluate resources, Methodology to evaluate capacity, Principles of Assembly line balancing- concepts and Rank position weight method problems. **Ergonomics:** Psycho physiological data- Anthropometry, Bio mechanics - information displays - Principles of motion economy - Man machine system – Working environment – Work station design methods, Evaluation procedures of REBA, RULA. **Production planning and control:** Forecasting - Quantitative techniques and time series analysis. JIT concepts and enablers, Push/ Pull systems. Aggregate production planning, Master production scheduling. Introduction about ERP applications in various modules, Methods to arrive EBQ,EOQ values, 2 bin system, MRP, Kanban principles - evaluate inventory norm in the supply chain, Changeover time compression techniques, Various mistake proofing methods & techniques for safety, quality, Visual control systems & applications.

Text Books:

1. Chase R.B, Nicholas J. Aquilano, F.and Jacobs R, "**Production and Operations Management: Manufacturing and Services**, Irwin/McGraw-Hill,Vol. 2, 1998.
2. Khan, M.I, "**Industrial Engineering**", New Age International, 2nd Edition, 2009.

Reference Books:

1. Samuel Eilon, "**Elements of Production Planning and Control**", Universal Publishing Corporation, Bombay, 1994.
2. Panneerselvam R, "**Production and Operations Management**", PHI, New Delhi, 2006.
3. Khanna, O.P, "**Industrial Engineering and Management**", Dhanpat Rai and Sons, 2008.
4. Natha Muhi Reddy, "**Industrial Engineering and Management**", New Age International Ltd, New Delhi, 2002

Course Contents and Lecture schedule

No.	Topics	No. of Lectures
1.0	**Productivity**	
1.1	Concepts and measurements	1
1.2	Productivity metrics	1
1.3	Quality route to productivity – approach to ERCSS	1
1.4	Value stream mapping	1
1.5	In-direct productivity – Job analysis	1
2.0	**Method study**	
2.1	Selection of jobs	1
2.2	Recording tools and techniques – Flow chart, Process chart, Man-machine chart, Two handed process chart, Process flow diagram, Process Flow Analysis	3
2.3	Analyzing and Development of improved methods	1
3.0	**Work Measurement**	
3.1	Setting of standard time	1
3.2	Stop watch time study – rating, allowances	2
3.3	Work sampling, Analytical estimation	1
3.4	Synthesis and Predetermined Motion Time Standards (PMTS)	2
3.5	Methodology to evaluate resources	1

No.	**Topics**	**No. of Lectures**
3.6	Methodology to evaluate capacity	1
3.7	Principle of Assembly line balancing- concepts and RPW problems	2
4.0	**Ergonomics**	
4.1	Psycho Physiological data - Anthropometry	1
4.2	Bio mechanics	1
4.3	Principles of motion economy	1
4.4	Man machine system – Working environment	1
4.5	Work station design methods	1
4.6	Evaluation procedures of REBA/ RULA	1
5.0	**Production planning and control**	
5.1	Forecasting -Quantitative techniques and Time series analysis	2
5.2	JIT Concepts and enablers	1
5.3	Push/ Pull system	1
5.4	Aggregate production planning	1
5.5	Master production scheduling	1
5.6	Introduction about ERP applications in various modules	1
5.7	Methods to arrive Economic Order Quantity, Economic Batch Quantity values, 2 bin system, MRP, Kanban principles	2
5.8	Evaluate inventory norms in supply chain	1
5.9	Change over time compression techniques	1
5.10	Mistake proofing methods and tech. for safety, quality	1
5.11	Visual control system and applications	1
	Total	**39**

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Sub Code	Lectures	Tutorial	Practical	Credit
G 57	0	0	2	1

G57 CAD/CAM Laboratory 0:1

Objective

- To define the coordinate system, sketch plane and reference planes for the development of 3D models.
- To draw the wireframe sketches, 3D modeling, assembly and draft the parts.
- To write manual CNC program for turning operation.
- To define the machining parameters for simulate of the tool path.
- To generate CNC program for milling operation using CAM package.
- To generate sheet metal Models

List of Exercises (Any twelve will be given)

I. Modeling using CAD package

1. Draw the 2D sketch of given part without constraints.
2. Draw the 2D sketch of given part with constraints.
3. Develop 3D model of IC engine piston.
4. Develop 3D model of crankshaft.
5. Develop an assembly models using the components given.
6. Obtain the drafting of the part developed.

II. CAM exercises

1. Write a manual CNC program for step and taper turning and simulate the operation.
2. Write a manual CNC program for curvature and threading and simulate the operation.
3. Identify the machining parameters for turning and milling operations.
4. Draw/Import the 2D diagram of the part using CAM package.
5. Complete the tool path simulation for drilling and pocket milling operations.
6. Generate CNC program for profile milling, drilling and pocket operations using CAD/CAM package.
7. Create a given sheet metal model (both unfold and finished) using 2D CAD and CAM software

Software Required:

Pro/E, CATIA, Denford offline software for Turning, MasterCAM software, AP100CAD, Dr.ABE Bend.

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Sub Code	Lectures	Tutorial	Practical	Credit
G 58	0	0	2	1

G58 HEAT TRANSFER LAB. 0:1

(Use of approved HMT data book is permitted in the terminal examination)

***Objective**: To gain practical knowledge of various heat transfer principles.*

List of Experiments

1. Determination of specific heat capacity of air.
2. Conduction heat transfer test on metal bar, composite walls and guarded hot plate apparatus.
3. Heat transfer performance of pin-fin in natural convection.
4. Heat transfer performance of pin-fin in forced convection.
5. Determination of heat transfer co-efficient in natural convection
6. Determination of heat transfer co-efficient in forced convection
7. Determination of Stefan - Boltzman constant and verification of Stefan's Boltzman law.
8. Emissivity test of the given surface.
9. LMTD comparison between parallel flow and counter flow heat exchangers.
10. Determination of effectiveness and heat transfer rate of heat exchangers (parallel flow, counter flow, cross flow)
11. Test on Fluidised bed heat transfer.
12. Determination of COP in thermo electric heat pump
13. Performance test on solar still.
14. Determination of diffusion angles using air jet diffuser.
15. Measurement of solar radiation intensity.

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Sub Code	Lectures	Tutorial	Practical	Credit
G 59	0	0	2	1

G59 Metrology and Mechanical Measurement lab 0:1

Objective: To get practical knowledge in Metrology and Mechanical Measurement techniques.

The following are the list of experiments. Minimum of 12 experiments are to be given. (At least six experiments in each Lab.)

Metrology Lab.

List of Experiments:

1. Profile measurement of linear, angular and thread elements using Tool Makers Microscope.
2. Profile measurement of linear, angular and thread elements using Profile Projector.
3. Measurement of Surface Roughness using portable surface roughness tester.
4. Straightness / Flatness Testing using Autocollimator.
5. Checking of OD and ID using comparators– Pneumatic, electronic and mechanical.
6. Calibration of micrometer / vernier caliper using Standard slip gauge
7. 2D & 3D measurements using CMM.

Mechanical Measurement Lab.

List of Experiments:

1. Displacement measurement using LVDT.
2. Force measurement using Load cell.
3. Strain measurement using strain measurement trainer.
4. Torque measurement using torque measurement trainer.
5. Speed measurement using DC servo motor control system.
6. Temperature measurement using temperature trainer.
7. Level measurement using level trainer.
8. Verification of gyroscopic principle using motorized gyroscope.

Terminal Examination: Students would be tested in both labs each 1 ½ hours duration.

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

CORE ELECTIVE

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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List of Core Electives

1. G CA Energy Conversion Systems
2. G CB Basics of Aircraft Engineering
3. GCC Experimental Stress Analysis
4. GCD Mechatronics System Design
5. GCE Financial Management
6. GCF Theory of Metal Cutting
7. GCG Principles of Automation
8. GCH Marketing Management
9. GCK Refrigeration and Air Conditioning
10. GCL Computational Fluid Dynamics
11. GCM Finite Element Analysis
12. GCN Design of Jigs Fixtures and Press Tools
13. GCP Foundry Technology
14. GCQ Machine Vision
15. GCR Product Design and Development
16. GCS Metal Forming
17. GCT Welding Technology
18. GCU Computer Integrated Manufacturing
19. GCV Production and Operations Management
20. GCW Internal Combustion Engine
21. GCY Turbomachines
22. GCZ Vibration Engineering

Sub Code	Lectures	Tutorial	Practical	Credit
GCK	3	0	-	**3**

GCK Refrigeration and Air Conditioning 3:0

Preamble: Refrigeration is the action of cooling, in practice this requires removal of heat and discarding it at a higher temperature. Refrigeration is therefore the science of moving heat from low temperature to high temperature. In addition to chilling and freezing applications, refrigeration technology is applied in air conditioning and heat pumps, which therefore fall within the scope of this syllabus. The fundamental principles are those of physics and thermodynamics, and these principles, which are relevant to all applications, are outlined in this course work.

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

c. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.

d. Graduates can participate and succeed in competitive examinations.

Competencies:

1. Explain working principles of air cycle, vapor compression and vapor absorption refrigeration cycles.
2. Understand the properties of refrigerants.
3. Understand various air conditioning processes.
4. Understand various systems in Refrigeration and Air conditioning.
5. Determine the cooling load requirements of the given system.
6. Understand the working refrigeration and air conditioning equipments

Assessment Pattern

Sl. No.	Bloom's Category	Test 1	Test 2	Test3/End-semester examination
1	Remember	10	10	10
2	Understand	30	30	30
3	Apply	30	30	30
4	Analyze	30	30	30
5	Evaluate	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define the term ton of refrigeration
2. Name two important properties of a good refrigerant.
3. What are eco-friendly refrigerants?
4. Mention three important parameters that affect the effective temperature
5. Define RSHF
6. What do you know by bypass factor (BPF)?

Understand

1. Derive an expression for COP of a reversed Brayton cycle
2. Discuss in detail about the points to be considered while selecting a refrigerant.
3. Explain the working of shell and tube condenser using a diagram.
4. Explain evaporative cooling process with the help of psychrometric chart
5. Draw and discuss various features of Comfort chart.
6. In an air conditioning application, some quantity of air from the space is re circulated and mixed with the fresh air. The mixing is done before the cooling coil and the mixed air is conditioned using cooling and dehumidifying coil. The conditioned air is sent to the space after getting heated in a heater. Draw the schematic diagram of the processes. Also show various processes on a psychrometric chart.

Apply

1. A refrigeration unit working on Bell-Coleman cycle takes air from cold chamber at -10^{0}C and compresses it from 1 bar with index of compression being 1.2. The compressed air is cooled to a temperature 10^{0}C above the ambient temperature of 25^{0}C before it is expanded in the expander where the index of expansion is 1.35

   Determine the following: (i) COP, (ii) Quantity of air circulated per minute for the production of 2000 kg of ice per day at 0^{0}C from water at 20^{0}C (iii) Capacity of the plant in ton of refrigeration .

2. A refrigeration uses R12 as refrigerant. The condenser temperature is 50^{0}C and the evaporator temperature is 0^{0}C. The refrigeration capacity is 7 tons. Assume the simple vapour saturation cycle and determine with the help of p-h diagram. (i) The refrigerant flow rate, (ii) COP, (iii) The heat rejected in the condenser.

3. Calculate the following properties of air at 45^{0}C DBT and 30^{0}C WBT

(i) Specific humidity, (ii) Degree of saturation, (iii) Relative Humidity, (iv) Absolute humidity, (v) Enthalpy, (vi) DPT

4. Atmospheric air at 38^0C and 40 per cent RH is to be cooled and dehumidified to a state of saturated air at 10^0C. The mass rate of flow of atmospheric air entering the dehumidifier is 45.5 kg/h. Neglecting any pressure drop, determine : (i) The mass of water removed, (ii) The quantity of heat removed.
5. A class room of 60 seating capacity is air conditioned. The out-door conditions are 32^0 C DBT and 22^0C WBT and the required conditions are 22^0C and 55% RH . The quantity of outdoor air supplied is 0.5 m^3/min/student. The comfort conditions are achieved first by chemical dehumidifying the air and then cooling by the cooling coil. Find the followings:
   - (i) DBT of the air leaving the humidifier
   - (ii) Capacity of the humidifier
   - (iii) Capacity of the cooling coil in tons of refrigeration
   - (iv) If the bypass factor of the cooling coil 0.3. Then find the surface temperature of the cooling coil required.
6. A cinema hall 2000 seating capacity is air conditioned for summer conditions:

   OD: 40 ^{0} C DBT and 45 % RH

   Required comfort conditions: 24^0C and 60 % RH

The quantity of conditioned air supplied is 6.25 m^3/min/person. About 60% of the conditioned air is re-circulated and mixed with 40 % fresh air. The required condition is achieved first by cooling and dehumidifying and then heating. Find the capacity of the cooling coil in KW. Also find the bypass factor of the cooling coil if the dew point temperature of the coil is 13^0C. If the bypass actor of the heating coil is 0.3 then find the surface temperature of the heating coil. What is the condition of air before entering into air conditioning plant?

Analysis

1. The following data relate to a conference room for seating 100 persons.

Inside design conditions	22^0 C DBT, 60 % RH
Outside design conditions	40^0 C DBT, 27^0 C WBT
Sensible and latent heat loads per person	80 W and 50 W respectively
Lights and fans loads	15000 W
Air infiltration	20 m^3/min
Sensible heat gain through glass, walls,	15000 W

ceiling etc	
Fresh air supply	100 m^3/min
By-pass factor of the coils	0.1

If two-third of recirculated room air and one-third of fresh air are mixed before entering the cooling coils. Determine: Apparatus dew point; (ii) Grand total heat load; and (iii) effective room sensible heat factor.

2. An office for seating 25 occupants is to be maintained at 24^0 C DBT, 50 % RH. The outdoor conditions are 34^0 C DBT, 28^0 C WBT. The various loads in the office are:

Solar heat gain	9.12 kW
Sensible heat gain per occupant	0.09 kW
Latent heat gain per occupant	0.105 kW
Lighting load	2.3 kW
Sensible heat load from other sources	11.63 kW
Infiltration load	14 m^3/min

Assuming 40% fresh air and 60 percent of recirculated air passing through the evaporator and the bypass factor of 0.15, determine: (i) Dew point temperature of the coil; and (ii) Capacity of the plant.

3. The following data is avialable for designing an air conditioning system for a restaurant:

   Inside design conditions = 27^0 C DBT, 55 % RH; Outdoor conditions = 35^0 C DBT, 26^0 C WBT; Minimum temperature of air supplied to room = 17^0 C DBT; Total amount of fresh air supplied = 1600 m^3/h; Total infilteration air = 400 m^3/h; seating chairs for dining = 50; Employees serving the meals = 5; Sensible heat gain per person =58 W: Latent heat gain per seating person = 44 W; Latent heat gain per employee = 76 W; Sensible heat added from meals = 0.17 kW; Latent heat added from meals = 0.3 kW; Total heat flow through the walls, roof and floor = 6.2 kW; Solar heat gain through glass = 2 kW; Equipment sensible heat gain = 2.9 kW; Equipment latent heat gain = 0.7 kW; Motor power connected to the fan = 7.5 kW. If the fan is installed before the conditioner, determine: (i) Amount of air delivered to the room in m^3/h; (ii) percentage of recirculated air; (iii) refrigeration load on the coil in tonnes of refrigeration; and (iv) Dew point temperature of the cooling coil and by pass factor.

4. The following data refer to a hall to be air conditioned:

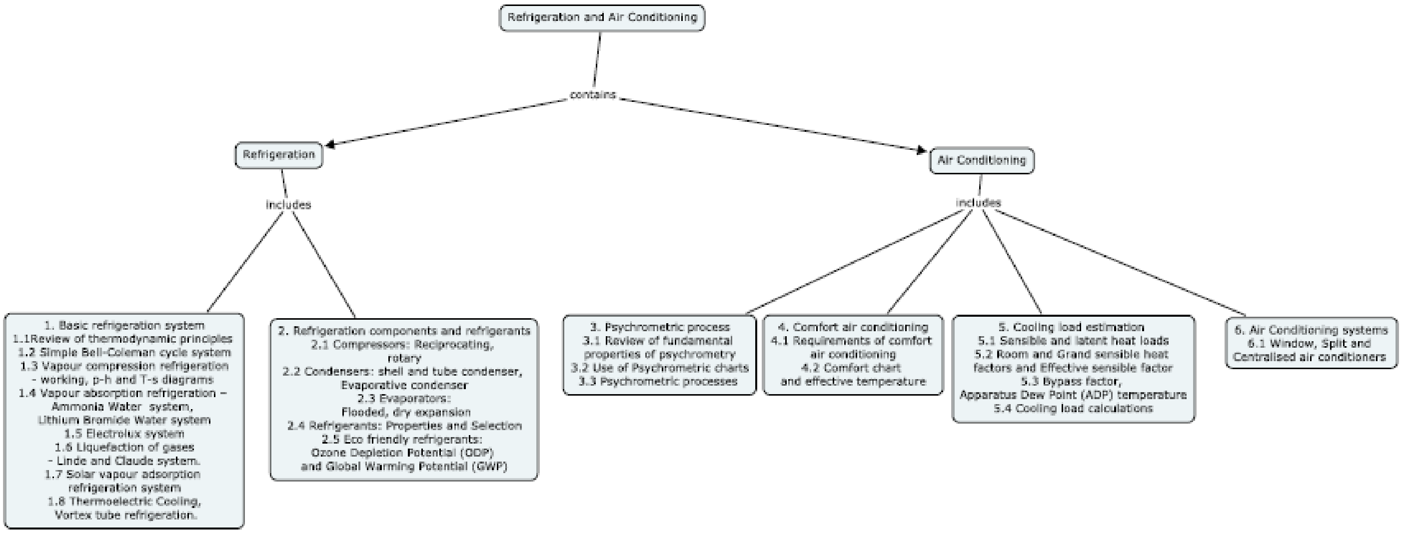
   Inside conditions = 20^0 C DBT, 60 % RH; Outdoor conditions = 38^0 C DBT, 28^0 C WBT; Sensible heat load in the room = 46.4 kW; Latent heat load in the room = 11.6 kW; Total infiltration air = 1200 m^3/h; Apparatus dew point = 10^0 C; Quantitiy of recirculated air from the hall = 60%. If the quantitity of recirculated air is mixed with the conditioned air after the cooling coil. FindA: (i) the condition of air leaving the conditioner coil and before mixing with the recirculated air, (ii) the condition of air before entering the hall, (iii) the mass of air entering the cooler, (iv) the mass of total air passing through the hall, (v) the by-pass factor of the cooling coil and (vi) the refrigeration load on the cooling coil.

5. It is required to design a cold storage for storing 500 tonnes of vegetables with the follwoing available data: Inside design conditions = 20^0 C DBT and 60% RH; Outdoor conditions = 35^0 C DBT and 28^0 C WBT; Infiltrated air = 200 m^3/h; Fresh air supplied from outside = 4400 m^3/h; No. Of person working in the cold storage = 25; Sensible and latent heat gain per person = 250 kJ/h and 210 kJ/h respectively; Sensible heat gain through glass = 5.8 kW; Sensible heat gain through walls and ceiling = 11.6 kW; Water contents of the vegetables = 76%; Loss of water content = 0.01 percent per hour; Heat from equipment and reaction heat of vegetables = 3.5 kW. If the air conditioning is achieved by first cooling and dehumifiying and then heating and the temperature of air entering the room is not to exceed 15^0 C, determine: (i) amount of recirculated air, if the recirculated air is mixed with fresh air before entering the cooling coil; (ii) capacity of the cooling coil in tonnes of refrigeration and its by pass factor if the dew point temperature of the coil is 5^0 C and (iii) capacity of the heating coil in kW.

6. An Air conditioning system is to be designed for cinema hall of 1000 seating capacity when the following date is known: Outdoor conditions = 11^0 C and 70% RH; Indoor required conditions = 20^0 C and 60%RH; Amount of air supplied = 0.35 m^3/min/person. The required conditions are achieved first by heating, then by adiabatic humidifying and finally by heating. If the condition of air coming out the humidifier is 75% RH, then find the followings: (a) Heating capacity of the first heater in kW and condition of the air coming out of the first heating coil. Also find the surface temperature required if the bypass factor is 0.3. (b) Heating

capacity of the second heater in kW and by-pass factor, if the surface temperature of the coil is maintained at 22^0 C.

Concept Map



Basic refrigeration system

Review of thermodynamic principles of refrigeration – simple Bell-Coleman cycle system, Vapour compression refrigeration- working, p-h and T-s diagrams-Vapour absorption refrigeration – Ammonia Water system, Lithium Bromide Water system - Electrolux system – Liquefaction of gases- Linde and Claude system. Solar vapour adsorption refrigeration system, Thermoelectric Cooling, Vortex tube refrigeration. **Refrigeration components and refrigerants**: Compressors: Reciprocating, rotary – condensers: shell and tube condenser, Evaporative condenser – Evaporators: Flooded, dry expansion-Expansion valves: Capillary type, automatic expansion valve, Thermostatic expansion valve – Refrigerants: Properties and Selection, Eco friendly refrigerants: Ozone Depletion Potential (ODP) and Global Warming Potential (GWP). **Psychrometric process:** Review of fundamental properties of psychrometry – Use of psychrometric charts – Psychrometric processes **Comfort air conditioning:** Requirements of comfort air conditioning: oxygen supply, body heat and body moisture removal, sufficient air movement, purity of air – comfort chart and effective temperature. **Cooling load estimation:** Sensible and latent heat loads: Internal heat sources, heat transmission through building, load from occupants, Equipment load, load due to food storage, load due to solar radiation, infiltration, fresh air load, estimation of total load – Room and Grand sensible heat factors and Effective sensible factor –

Bypass factor, Apparatus Dew Point (ADP) temperature. Cooling load calculations: all fresh air system, partly recirculated system (mixing before conditioner and mixing after conditioner), partly recirculated system with heater after conditioner **Air Conditioning systems:** Window, Split and Centralized air conditioners **Applications:** Ice plant – cold storage plants – milk chilling plants –Cryogenic in medicine and biological uses. Air conditioning textile industry, stores, hospitals, transport.

Text Book:

1. Arora C.P, "**Refrigeration and Air Conditioning**", Tata McGraw Hill, New Delhi, 2008.
2. Stoecker W.F. and Jones J.W., "**Refrigeration and Air Conditioning**", McGraw Hill, 1984.

Reference Books:

1. Ibrahim Dincer and Mehmet Kanoglu, "**Refrigeration Systems and Applications**", John Wiley and Sons, 2010.
2. Domkundwar, Arrora and Domkundwar, "**Refrigeration and Air Conditioning**", Dhanpat Rai and Co, 2009.
3. Manohar Prasad, "**Refrigeration and Air Conditioning**", New Age Publishing Ltd, 2010.
4. Tipse, "**Refrigeration and air conditioning**", Jaico publishers, 2005.
5. Jones, W.P., "**Air Conditioning Engineering**",5th Edition, Butterworth Heinemann, 2005.
6. Rex Miller and Mark R. Miller, "**Modern Refrigeration and Air Conditioning**", McGraw-Hill, 2006.
7. Jordan and Priester, "**Air Conditioning and Refrigeration**", Prentice Hall of India, New Delhi, 1985.
8. Edward G. Pita, "**Air Conditioning Principles and Systems**", 4th Edition, Prentice Hall Ltd., 2002.
9. Training material from IIT, Kharagpur, "**40 lessons on Refrigeration and Air Conditioning**.

Tables:

1. Khurmi,R.S, "**Steam Tables with Mollier Diagrams**", S.Chand and Co.Limited, 2010.
2. Maskara, P.N and Sathish Chand, "**Tables and Charts on Refrigerant and Psychrometric properties**", Technical Publishers of India, 2003.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Basic refrigeration system**	
1.1	Review of thermodynamic principles of refrigeration	1
1.2	Simple Bell-Coleman cycle system	3
1.3	Vapour compression refrigeration- working, p-h and T-s diagrams	3
1.4	Vapour absorption refrigeration – Ammonia Water system, Lithium Bromide Water system	2
1.5	Electrolux system	1
1.6	Liquefaction of gases- Linde and Claude system.	1
1.7	Solar vapour adsorption refrigeration system	1
1.8	Thermoelectric Cooling, Vortex tube refrigeration.	1
2	**Refrigeration components and refrigerants**	
2.1	Compressors: Reciprocating, rotary	2
2.2	Condensers: shell and tube condenser, Evaporative condenser	1
2.3	Evaporators: Flooded, dry expansion Expansion valves: Capillary type, automatic expansion valve, Thermostatic expansion valve	2
2.4	Refrigerants: Properties and Selection	1
2.5	Eco friendly refrigerants: Ozone Depletion Potential (ODP) and Global Warming Potential (GWP)	1
3	**Psychrometric process**	
3.1	Review of fundamental properties of psychrometry	2
3.2	Use of Psychrometric charts	1
3.3	Psychrometric processes	3
4	**Comfort air conditioning**	

No.	Topic	No. of Lectures
4.1	Requirements of comfort air conditioning: oxygen supply, body heat and body moisture removal, sufficient air movement, purity of air	1
4.2	Comfort chart and effective temperature	1
5	**Cooling load estimation**	
5.1	Sensible and latent heat loads: Internal heat sources, heat transmission through building	1
	load from occupants, Equipment load, load due to food storage, load due to solar radiation, infiltration	1
	fresh air load, estimation of total load	1
5.2	Room and Grand sensible heat factors and Effective sensible factor	1
5.3	Bypass factor, Apparatus Dew Point (ADP) temperature	1
5.4	Cooling load calculations: all fresh air system,	2
	partly recirculated system (mixing before conditioner and mixing after conditioner),	2
	partly recirculated system with heater after conditioner	2
6	**Air Conditioning systems**	
6.1	Window, Split and Centralised air conditioners	1
7	**Applications**	
7.1	Ice plant	1
7.2	cold storage plants – milk chilling plants	1
7.3	Cryogenic in medicine and biological uses	1
7.4	Air conditioning textile industry, stores, hospitals, transport.	2
	Total	**45**

Course Designers:

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2. G. Kumaraguruparan gkmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
GCR	3	0	-	**3**

GCR Product Design and Development 3:1

Preamble

The course aims at giving adequate exposure to product design and development process and the various methods and techniques that are used in real-life to realize successful products. The course essentially is designed to give a flavour of the design process, even though the students may not be having all the necessary pre-requisites.

Competencies

At the end of the course the student should be able to

1. Explain the concept of product design and its applications.
2. Classify the product planning process based on the customer need.
3. Identify the best concept based on concept selection process
4. Communicate the final specification of the product (product concept)
5. Implement the suitable product architecture.
6. Explain successful product development strategies, product planning activities, specifications, various methods for concept selection and architecture planning.

Assessment pattern

Sl.No	Bloom's category	Test 1	Test 2	Test 3 /End Semester Examinations
1	Remember	10	10	10
2	Understand	20	20	20
3	Apply	30	30	30
4	Analyze	20	20	20
5	Evaluate	20	20	20
6	Create	0	0	0

Course level learning objectives

Remember

1. Define product design.
2. Define the term concept scoring?
3. Define the term concept screening?
4. Define the term concept testing?

5. What is metrics?
6. What is pre project planning?
7. What is Intellectual Property?
8. Define proto type product.
9. What is industrial design?

Understand:

1. Distinguish between functional design and production design, with suitable examples.
2. Draw a schematic for a wrist watch using only functional element.
3. Draw the logic diagram for two claims for patterns with example.
4. Compare concept generation and Concept Screening
5. Compare incidental interaction and fundamental interaction.
6. Draw proposed product architecture for a digital camera with chunks details.

Analyze:

1. Discuss the innovation criteria for product success in the life cycle of a product.
2. Discuss the role of models in product design.
3. How concept selection methods can is used to benchmark or evaluate the existing product?
4. Evaluate concept selection methods for five automobiles you might consider for purchasing.
5. Explain the procedure for applying pattern Perform concept screening for five pencil holder concept. Assume the pencil holders are for the member of product development team who is continually moving from site to site.
6. What the different ways you could communicate a concept for a new user interface for an automotive audio system.

Apply:

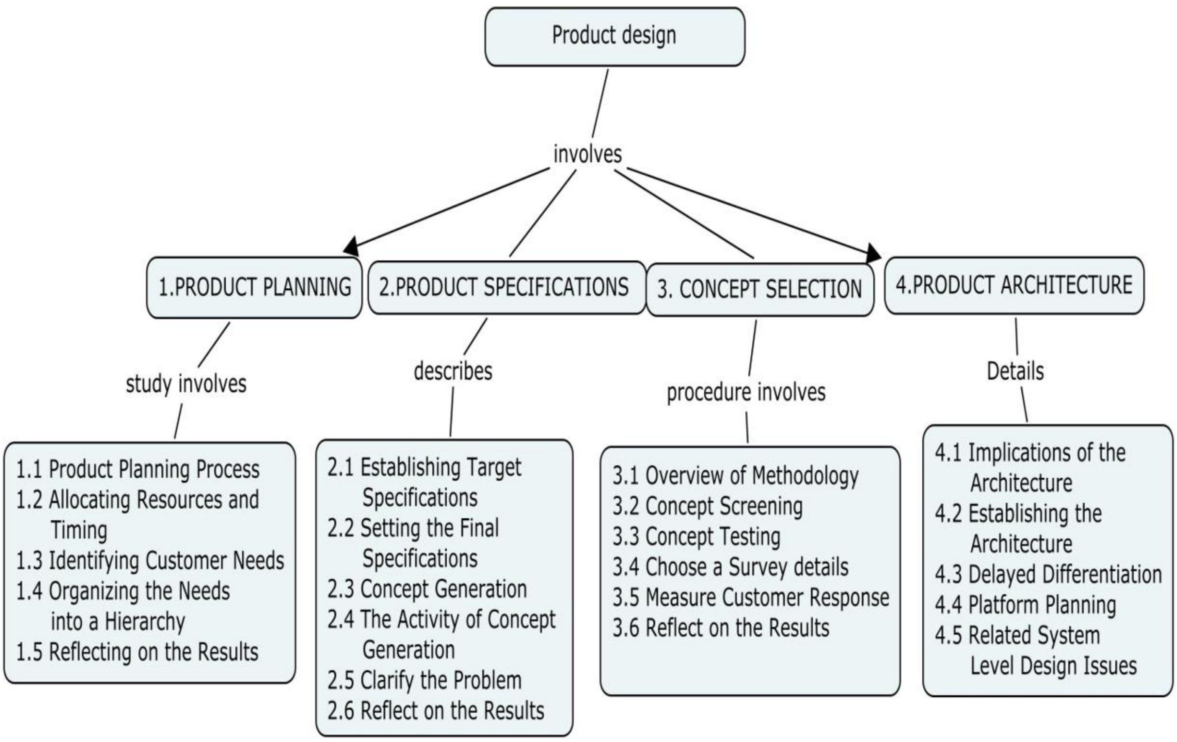
1. As a customer Identify the basic needs while selection a new car
2. Explain the problem solving actions while installing a wall mounted book shelf
3. Decompose a micro oven into its assemblies, components, electrical circuits.
4. Explain the concept selection process with example
5. Describe the steps involved in costing

6. Draw the product architecture for a ink jet printer

Evaluate:

1. Develop different concepts to design an orange ripeness tester and evaluate
2. List your needs with respect to two wheeler motorcycle suspension and convert to a product specification.
3. Draw the new product architecture for a elevator drive system and evaluate
4. Using decision matrix evaluate the concept generated for a two wheeler brake system
5. Determine and evaluate the force flow in a car door being opened
6. Develop a new concept design for a ceiling fan and evaluate the design

Concept Map



Syllabus

PRODUCT PLANNING- Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-

Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs-Case study for motor driven nailer- Reflecting on the Results and the Process -**PRODUCT SPECIFICATIONS** – Specifications - Specifications Established-Establishing Target Specifications–QFD-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation- Clarify the Problem- Search Externally-Search Internally-Explore Systematically- Case study for motor driven nailer -Reflect on the Results and the Process **CONCEPT SELECTION**-Concept Selection- Overview of Methodology- The Decision matrix – Pugh's method - Concept Screening-Concept Testing-Define the Purpose of the Concept Test- Choose a Survey Population- Choose a Survey Format-Communicate the Concept- Measure Customer Response-Interpret the Results-Case study for motor driven nailer -Reflect on the Results and the Process – COSTING – Material – manufacturing –assembly – structure - Ergonomics and aesthetic aspects. **PRODUCT ARCHITECTURE**- Product Architecture-Implications of the Architecture-Establishing the Architecture-Delayed Differentiation-Platform Planning-Related System-Level Design Issues - Case study for motor driven nailer

TEXT BOOK:

1. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.2007

REFERENCE BOOK

2. The mechanical Design Process , David G.Ullman, Tata McGraw Hill , 2011
3. Concurrent Engg. /Integrated Product Development. Kemnneth Crow, DRM Associates, 26/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book
4. Effective Product Design and Development, Stephen Rosenthal, Business One Orwin, Homewood, 1992,ISBN, 1-55623-603-4
5. Tool Design – Integrated Methods for successful Product Engineering, Stuart Pugh, Addison Wesley Publishing,Neyourk,NY,1991, ISBN 0-202-41639-5
6. Product Design – Techniques in Reverse Engineering and New Product Development, Kevin Otto, and Kristin Wood, Pearson Education, ISBN 81-7758-821-4

Course content and lecture schedule

No.	Topic	No. Of Lectures
1	**PRODUCT PLANNING**	
1.1	Product Planning Process- Identify Opportunities	1
1.1.1	Evaluating and Prioritizing Projects	1

1.2	Allocating Resources and Timing	2
1.2.1	Pre-Project Planning-Reflect on the Results and the Process	1
1.5	Identifying Customer Needs- Raw Data from Customers	1
1.6	Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy	2
1.7	Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs	2
1.7.1	Case study for motor driven nailer	1
1.8	Reflecting on the Results and the Process	2
	PRODUCT SPECIFICATIONS	
2	Specifications -Specifications Established	1
2.1	Establishing Target Specifications	1
2.1.1	QFD	1
2.2	Setting the Final Specifications	1
2.3	Concept Generation	1
2.4	The Activity of Concept Generation	1
2.5	Clarify the Problem- Search Externally –Search Internally Explore Systematically	1
2.5.1	Case study for motor driven nailer	1
2.6	Reflect on the Results and the Process Introduction and Classification	1
3	**CONCEPT SELECTION**	
3.1	Overview of Methodology - The Decision matrix – Pugh's method	1
3.2	Concept Screening	2
3.3	Concept Testing	1
3.3.1	Define the Purpose of the Concept Test	1
3.4	Choose a Survey details	1
3.4.1	Choose a Survey Format	1
3.4.2	Communicate the Concept	1
3.5	Measure Customer Response	1
3.5.1	Case study for motor driven nailer	1
3.6	Interpret the Results- Reflect on the Results and the Process	1
3.7	Costing– Material – manufacturing –assembly – structure- Ergonomics and aesthetic aspects	2
4	**PRODUCT ARCHITECTURE**	
4.1	Product Architecture-Implications of the Architecture	1
4.2	Establishing the Architecture-	1

4.3	Delayed Differentiation	1
4.4	Platform Planning	1
4.5	Related System-Level Design Issues	1
	Total	**40**

Course Designers

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3. M.Kannan, TVS motor Ltd, Hosur

CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

SIXTH SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Fax: 0452 2483427
Web: www.tce.edu

Board of studies meeting on 13.10.12 45th Academic Council meeting on 24.11.12

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Mechanical Engineering
Scheduling of Courses

Semester	**Theory Courses**						**Practical/Project**		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0					G88 Project 0:12	
7th (21)	G71 Management Theory & Practice 3:0	G72 Operations Research 3:1	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G76 Manufacturing Systems Simulation Lab 0:1	G77 Mini Project 0:4	
6th (23)	G61 Accounting & Finance 3:0	G62 Design of Transmission System 3:1	G63 Quality & Reliability Engineering 3:0	G64 Mechatronics 3:0	Elective 1 3:0	Elective 2 3:0	G67 Computer Aided Engineering Lab 0:1	G68 Mechatronics Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Kinematics & Dynamics of Machinery 3:1	G53 Metrology and Mechanical Measurements 3:0	G54 Heat & Mass Transfer 3:1	G55 Manufacturing Processes and Automation 3:0	G56 Industrial Engg. 3:0	G57 CAD/CAM Lab 0:1	G58 Heat Transfer Lab 0:1	G59 Mech. Measurement & Metrology Lab 0:1
4th (24)	G41 Numerical Methods 3:1	G42 Design of Machine Elements 3:1	G43 Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Control Systems 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (23)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 4:0	G33 Applied Material & Metallurgy 3:0	G34 Fluid Mechanics 4:0	G35 Metal Casting & Plastic forming processes 2:0	G36 Metal Forming & Joining Processes 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics & CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Ecology and Environment 2:0	G26 Computer Programming 3:0	G27 Strength of Materials & Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

SIXTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week L	T	P	credits
THEORY						
G61	Accounting and finance	HSS	3	0	-	3
G62	Design of transmission system	DC	3	1	-	4
G63	Quality and Reliability Engineering	DC	3	0	-	3
G64	Mechatronics	DC	3	0	-	3
GCX	Elective – 1	DC	3	0	-	3
GCX	Elective – 2	DC	3	0	-	3
PRACTICAL						
G67	Computer Aided Engineering Lab	DC	-	-	3	1
G68	Mechatronics Lab.	DC	-	-	3	1
G69	Production Drawing	DC	2	-	3	2
Total			**20**	**1**	**9**	**23**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

SIXTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G61	Accounting and finance	3	50	50	100	25	50
2	G62	Design of transmission system	3	50	50	100	25	50
3	G63	Quality and Reliability Engineering	3	50	50	100	25	50
4	G64	Mechatronics	3	50	50	100	25	50
5	GCX	Elective - 1	3	50	50	100	25	50
6	GCX	Elective - 2	3	50	50	100	25	50
PRACTICAL								
7	G67	CAE Lab-1	3	50	50	100	25	50
8	G68	Mechatronics Lab.	3	50	50	100	25	50
9	G69	Production Drawing	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

Sub Code	Lectures	Tutorial	Practical	Credit
G 61	3	0	-	3

G61 Accounting and Finance 3:0

Preamble: Engineering profession involves lots of decision making. The decisions may range from operation to non-operation. For taking decisions of these kinds an engineer needs among other things data about the organization's routine operations and non-routine operations. Accounting is a science which provides all the data by recording, classifying, summarizing and interpreting the various transactions taking place in an organization and thereby helps an engineer in taking vital decisions in an effective manner. Finance is an allied but a separate field relying on accounting, and enables engineers in taking useful financial and cost related decisions by providing well defined concepts, tools and techniques.

Program outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

e. Graduates will demonstrate an ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

i. Graduates will demonstrate an ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

Competencies

At the end of the course, the students will be able to

1. Develop an understanding about financing and its importance in decision making.
2. Understand the meaning of financial accounting, accounting concepts and conventions.
5. Understand the financial statements and how to analyze the financial statements.
6. Understand the meaning of cost and cost accounting, elements of cost and cost classification. Prepare cost sheet.
7. Understand budgets and budgetary control, types of budgets. Prepare various types of budgets.
8. Understand standard costing, calculate various types of variances.
9. Understand the meaning of capital budgeting, importance of capital budgeting, process of capital budgeting.

10. Evaluate the capital budgeting proposals by using payback, accounting rate of return, Net present value and internal rate of return methods
11. Understand the concept of working capital, factors influencing working capital, components of working capital.
12. Estimate the working capital requirements of an organization.

Assessment pattern

S.No	Bloom's category	Test 1	Test 2	Test 3	End semester examination
1	Remember	20	20	20	20
2	understand	30	30	30	30
3	Apply	50	50	50	50
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	create	0	0	0	0

Course level learning objectives

Remember

1. The meaning of the term "financing" and definition of financing
2. The meaning of financial accounting, concepts and conventions of accounting.
3. The meaning of financial statements and its importance in decision making.
4. The meaning of conventional and activity based costing, cost drivers.
5. The meaning of the term Budget and budgetary control.
6. The meaning of the term "standard costing" and variances.

Understand

1. Understand the financing functions, objectives of financing
2. Explain the concepts and conventions of accounting.
3. Analyze the financial statements.
4. Understand the process of preparing cost sheet.
5. Understand activity based costing and differentiate it with traditional costing.
6. Explain the cost drivers and their impacts on cost.

Apply

1. Convert the following income statement into comparative income statement.

Particulars	**1997 (in Rs.)**	**1998 (in Rs.)**
Sales	1,50,000	1,80,000
Cost of sales	91,000	1,01,250
Gross profit	**50,000**	**78,250**
Sales expenses	30,000	33,000
Administration expenses	15,000	17,000
Income from operations	**14,000**	**28,850**

2. A factory is currently working at 50% capacity and the product cost is Rs.180 per unit as below:

Material ------------- Rs.100

Labor -------------- Rs.30

Factory overhead— Rs.30 (40% fixed)

Administration overhead Rs.20 (50% fixed)

The product is sold at Rs.200 per unit and the factory produces 10,000 units at 50%capacity.

Estimate profit if the factory works at 60% capacity. At 60% working raw material increases by 20% and selling price falls by 20%.

3. The following are the particulars regarding standard and actual production of X. Standard quantity of materials required to produce one unit of X was 5kg at Rs. 6 per kg. Actual units produced during that period were 500 units. Actual materials used were 2700 kg at Rs. 5.50 per kg. Calculate material cost, price and usage variances.

4. PSG mills Ltd., is considering two mutually exclusive proposals A and B.

Particulars	Year	Proposal A (in Rs.)	Proposal B (in Rs.)
Expected cash outlay	0	2,25,000	3,75,000
Expected cash flows	1	1,50,000	2,50,000
	2	1,00,000	2,00,000
	3	75,000	1,25,000

Assuming a discount rate of 10% suggest which proposal can be accepted?

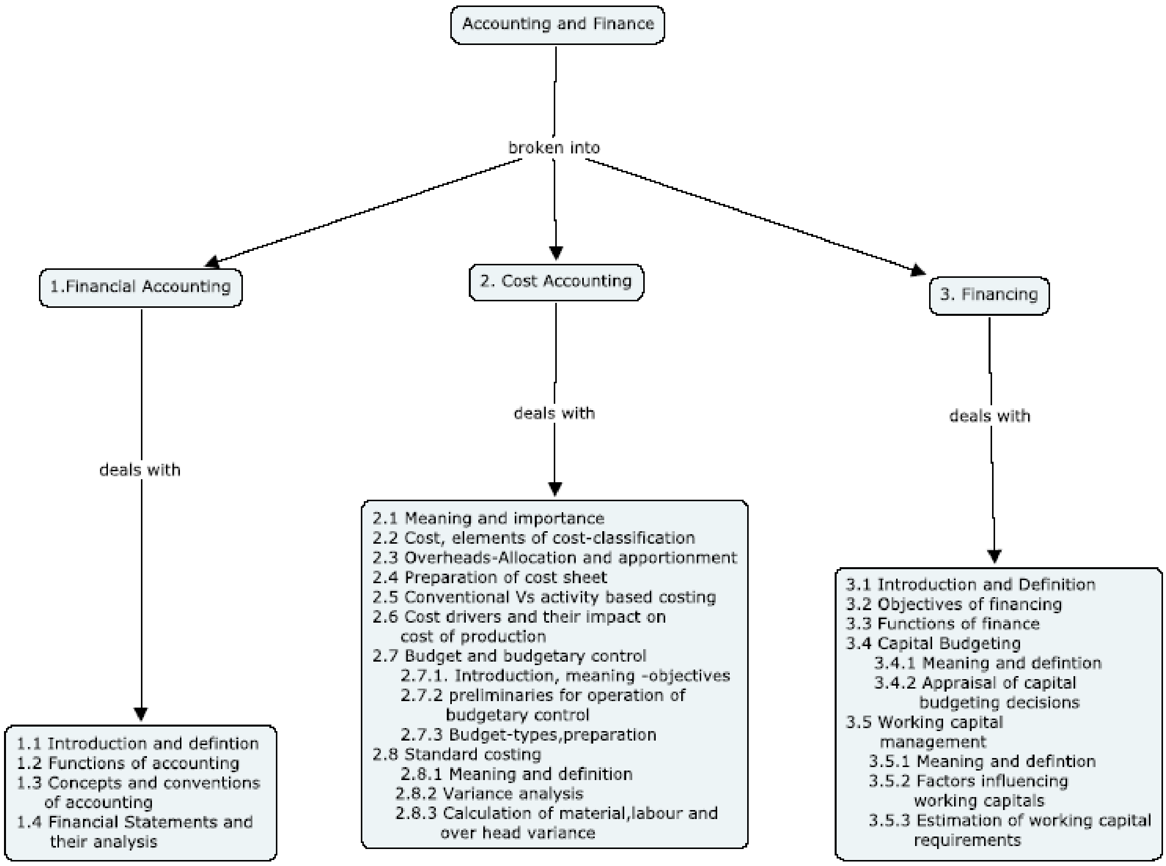
5. Estimated annual sales Rs.12,00,000.

Net profit on sales 20%

Average credit allowed a)by suppliers 2 months b)to customers 3 months.

Average stock of 2 months is to be maintained. Minimum cash balance of Rs.25, 000 is to be maintained. Prepare a statement of working capital to find out the working capital requirement.

Concept Map



Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1.0	**Financial Accounting**	
1.1	Introduction and Definition	1
1.2	Functions of accounting	1
1.3	Concepts and conventions of accounting	2
1.4	Financial statements	

1.4.1	Comparative statement	2
1.4.2	Common size statement	1
1.4.3	Trend percentage	1
2.0	**Cost Accounting**	
2.1	Meaning and importance	1
2.2	Cost-Elements of cost-Cost classification	2
2.3	Overheads – Allocation and apportionment of overheads	3
2.4	Preparation of Cost sheet	2
2.5	Conventional Vs Activity based costing	1
2.6	Cost drivers and their impact on costs of production	1
2.7	Budget and Budgetary control	
2.7.1	Introduction-Meaning -objectives of budgetary control	1
2.7.2	Preliminaries for operation of budgetary control	1
2.7.3	Budget-Types of budgets and their preparation	3
2.8	Standard costing	
2.8.1	Meaning and definition-Importance	2
2.8.2	Variance analysis-calculation of material, labour and overhead variances.	1
2.8.3	Calculation of material, labour and overhead variances.	3
3.0	**Finance**	
3.1	Introduction and Definition	1
3.2	Objectives of financial management	1
3.3	Functions of finance	2
3.4	Capital Budgeting	
3.4.1	Introduction-Meaning and Definition-Importance –process of capital budgeting	1
3.4.2	Appraisal of capital budgeting decisions	1
3.4.3	Payback Period, ARR	2
3.4.4	NPV, IRR and PI methods	3
3.5	Working capital Management	
3.5.1	Meaning and definition-Importance	1
3.5.2	Factors influencing working capital-components of working capital	2
3.5.3	Estimation of working capital requirements	2
	Total	**45**

Syllabus

Financial Accounting - Introduction and Definition -Functions of accounting - Concepts and conventions of accounting -Financial statements and their analysis

Cost Accounting - Meaning and importance -Cost-Elements of cost-Cost classification -Overheads –Allocation and apportionment of overheads - Preparation of Cost sheet-Conventional Vs activity based costing -Cost drivers and their impact on costs of production

Budget and Budgetary control- Introduction-Meaning -objectives of budgetary control -Preliminaries for operation of budgetary control-Budget-Types of budgets and their preparation -Standard costing-Meaning and definition-Importance - Variance analysis-calculation of material, labour and overhead variances.

Finance -Introduction and Definition-Objectives of financing-Profit maximization vs wealth maximization -Functions of finance-Capital Budgeting - Introduction-Meaning and Definition-Importance –process of capital budgeting - Appraisal of capital budgeting decisions

Working capital - Meaning and definition-Importance-Factors influencing working capital-components of working capital -Estimation of working capital requirements

Text Books:

1. M.C.Shukla, T.S.Grewal, S.C.Gupta: "**Advanced Accounts-volume-I**", Reprint, S.Chand & Company Ltd. 2007.
2. S.N.Maheswari, "**Financial Management,principles and practices**", Sultan Chand & Company Ltd. 2007.
3. P.S.Boopathi Manickam, "**Financial and Management Accounting**" PSG Publications, 2009.

Reference Books:

1. Prasanna Chandra, "**Financial Management-Theory and Practice**" Sixth Reprint, Tata McGraw-Hill publishing company Limited, 2007.
2. Ramachandra Aryasri, A, Ramana Moorthy, V.V, "**Engineering Economics and financial Accounting**", Tata McGraw hill, 2007.
3. S.N.Maheswari, "**Advanced accountancy**" Vikas publishing, 2007.

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 62	3	1	-	4

G62 Design of transmission Systems 3:1

Preamble: Engineering Design is the process of deriving a system, component or process to meet desired needs. It is a decision-making process, in which the basic sciences, mathematics and engineering sciences are applied to convert resources optimally to meet the stated objectives. This course is concerned with design of mechanical transmission systems for engineering applications.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

Competencies

At the end of semester students will be able to

1. Explain the working conditions of the given transmission systems in automobiles and machine tools.
2. Explain the effects of different working conditions on the given transmission system.
3. Specify the requirements of elements in different transmission systems.
4. Design the mechanical transmission systems and finalize the layout as per specifications.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test3**	**End-semester examination**
1	Remember	10	10	10	10
2	Understand	20	20	20	20
3	Apply	70	70	70	70
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives

Remember

1. Give the specification of flat belts.
2. List out any four advantages of V-Belt drives.
3. Define speed ratio.
4. Define Step ratio.
5. Write the structural formula for 12 speed gear box.
6. Define helix angle of a gear.

Understand

1. Draw the three different speed diagram for 12 speed gear box for speed ranging from 200 rpm to 2000 rpm.
2. Explain the speed diagram for 9 speed gear box for speed ranging from 200 rpm to 2000 rpm.
3. Differentiate between clutch and brake.
4. Select the best speed diagram for 12 speed gear box
5. Sketch the kinematic arrangement of 12 speed gear box
6. With the help of a neat sketch explain the kinematic arrangement for a 9 speed gear box

Apply

1. The following are the specifications of the branded motorcycle.

Brand:	**Model: Splendor Plus**
Engine	
Type	Air cooled, OHC
Bore x stroke	57.3 x 57.8 mm
Displacement	149.2 cc
Drive Train	
Clutch	Wet –multiple Plate type
Transmission	4 speed Constant mesh , rotary Selector type
Primary Reduction ratio	3.6
Gear ratio 1st	2.75
2nd	1.905
3rd	1.175
4th	0.92
Final reduction Ratio	3.143

Performance	
Maximum Power	7.6 kW @ 8500rpm
Max. Torque	12.80 N-m @ 6500 rpm
Idle Speed	1440 rpm

Design the following:

(a)Clutch shaft and clutch plate

(b) Primary gear drive

(c) No of teeth on gear, speed diagram, kinematic arrangement, centre distance and actual speed of gear box.

(d) Chain drive and draw the final system layout

2. Design a 12 speed gear box for a lathe spindle rotating at a speed ranging from 100 rpm to 1000 rpm. Assume all gears are spur gears. Select suitable motor. Draw the speed diagram. Give the system lay out on designing the following:
   (a) Kinematic arrangement of the gear box.
   (b) Centre distance between gears.
   (c) Number of teeth on all gears in gear box.

3. A transmission system with the following specifications is to be designed for turning operation in a lathe:

   Number of speed = 8

   Maximum Speed = 900rpm

   Minimum Speed = 90 rpm

   Center distance between motor and pulley 1 = 750mm

   Center distance between pulley 1 and pulley 2 = 900mm

   Calculate the design power. Draw the system layout on designing the following:

   . (a) Suitable belt drive

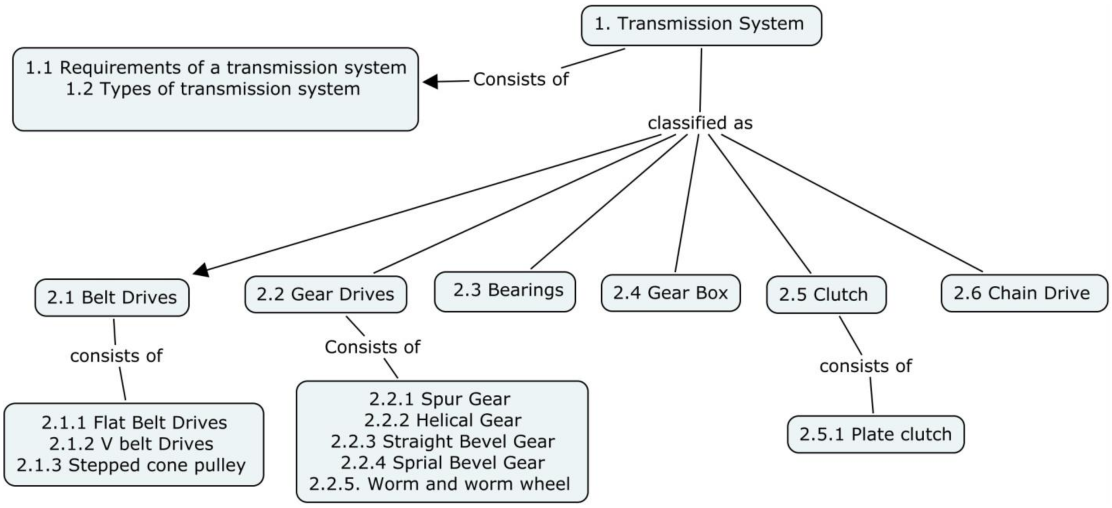
   (b) Suitable stepped cone pulley

4. Design a flat belt drive for the following data: Drive: AC motor, operating speed is 1440 rpm and operates for over 10 hours. which runs at 900 rpm and the required power transmission is 20 kW

5. Design 20o involutes worm and worm wheel to transmitted 10 kW with worm rotating at 1400 rpm . Speed reduction ratio 12:1. Distance between the shafts is 225 mm.

6. Design a chain drive a blower at 600 rpm. The power transmitted is 8 kW, at 1500 rpm. The centre distance is 800 mm.

Concept Map



syllabus

Transmission system- Requirements of a transmission system- Loading conditions- working conditions- technical specifications- Functional requirements – Speed and torque requirements- Limits, Fits and tolerances- SAE flange mounting for transmission aggregates- Types of transmission system- Belt Drives, Gear Drives , Chain, Gear Box, Traction drives- Design of Belt Drives- Design of Flat Belt Drive- Design of V Belt Drive- Design of Stepped cone pulleys- Gear Drives- Design of Spur gears - Gear correction factor - Design of helical and herringbone gears- Design of straight bevel gear- Design of spiral bevel gear- Design of worm and worm wheel- Bearings- Design and Selection of Antifriction bearings- Gear Box- Structural Diagram- Kinematic arrangement- Center distance and number of teeth calculation- Strength calculation and checking- Design of gear shafts and shaft Length- Design of splines- Proper Housing selection- Position tolerance and Rigidity -Gear Shifting mechanism- shifter - Clutch- Single plate clutch -Multi plate Clutch - Chain Drive- Design of chain drive- Strength calculation and checking

Text Books:

1. Joseph Edward Shigley and Charles R. Misucke, "**Machine Engineering Design**" , Sixth Edition , Tata McGraw Hill, 2003.
2. Robert L. Norton, " **Machine design- An Integrated Approach- Third Edition**" Prentice Hall ,2005

Reference Books:

1. M.F. Spotts, T.E.Shoup, " **Design of Machine Elements**" Seventh Edition, Pearson Education Asia ,2003
2. Hall, Holowenko and Laughin, "**Theory and Problems of Machine Design**", Tata McGrawhill Company, 2002.
3. PSG Tech., "**Design Data Book**" ,2007
4. Sundarajamoorthy. T.V., and Shanmugam. N, "**Machine Design**", Anuradha Agencies ,2000
5. K. Ganesh Babu, K. Srithar, "**Design of Machine Elements"**, Tata Mc Graw Hill Education, 2009.
6. Sharma. P.C, and Agarwall. D.K," **Machine design**", S.K. Kataria and Sons, New Delhi , 2000.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.	T**ransmission system**	
1.1	**Requirements of a transmission system**	
1.1.1	Loading conditions- working conditions- technical specifications	1
1.1.2	Functional requirements – Speed and torque requirements -	2
1.1.3	Limits, Fits and tolerances	2
1.1.4	SAE flange mounting for transmission aggregates	1
1.2	**Types of transmission system**	0
1.2.1	Belt Drives, Gear Drives , Chain, Gear Box, Traction drives	2

No.	Topic	No. of Lectures
2.1	Design of Belt Drives	2
2.1.1	Design of Flat Belt Drive	2
2.1.2	Design of V Belt Drive	2
2.1.3	Design of Stepped cone pulleys	2
2.2	**Gear Drives**	0
2.2.1`	Design of Spur gears - Gear correction factor	2
2.2.2	Design of helical and herringbone gears	2
2.2.3	Design of straight bevel gear	2
2.2.4	Design of spiral bevel gear	2
2.2.5	Design of worm and worm wheel	3
2.3	**Bearings**	
2.3.1	Design and Selection of Antifriction bearings	2
2.4	**Gear Box**	
2.4.1	Structural Diagram	2
2.4.2	Kinematic arrangement	2
2.4.3	Center distance and number of teeth calculation	1
2.4.4	Strength calculation and checking	2
2.4.5	Design of gear shafts and shaft Length	2
2.4.6	Design of splines	2
2.4.7	Proper Housing selection- Position tolerance and Rigidity	2
2.4.8	Gear Shifting mechanism- shifter	2
2.5	**Clutch**	
2.5.1	Single plate clutch	2
2.5.1	Multi plate Clutch	2
2.6	**Chain Drive**	
2.6.1	Design of chain drive	2

No.	Topic	No. of Lectures
2.6.2	Strength calculation and checking	1
Total		50

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Sub Code	Lectures	Tutorial	Practical	Credit
G63	3	0	-	3

G63 Quality and Reliability Engineering 3:0

Preamble: Quality control system used in the manufacturing and service industries maintains an improvement environment. Reliability is a measure of the quality of the product over the long run. For any organization, quality is the key for success or even for the survival in this competitive global market. This course covers the foundations of reliability, modern methods of Quality control and improvement.

Program outcomes addressed:

- Graduate will apply knowledge of engineering, mathematics and science
- Graduate will demonstrate an ability to identify, formulate and solve Engineering problems

Competencies:

At the end of the course students should be able to

1. Construct the Xbar, R & σ charts from the available data
2. Construct the p, c & u charts from the available data
3. Analyze the sampling plans
4. Identify the process capability
5. Formulate the procedure for quality system certifications such as ISO 9000,QS9000
6. Apply the tools and techniques of SPC in an organization.
7. Apply Reliability improvement techniques

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3	End Semester examination
1	Remember	20	20	20	20
2	Understand	30	30	30	30
3	Apply	50	50	50	40
4	Analyze	0	0	0	10
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. Define Quality.
2. State the advantages of quality assurance.

3. State the objectives of X bar and R chart.
4. Define process capability.
5. Define Reliability?
6. What is ISO 14000?

Understand

1. Differentiate between Chance causes and Assignable causes.
2. Distinguish between p chart and C chart.
3. The following observations are made in a crankshaft machining process.

Sample No.	Observations			
	1	2	3	4
1	20.21	20.19	20.25	20.15
2	20.21	20.19	20.23	20.17
3	20.17	20.16	20.20	20.18
4	20.10	20.11	20.18	20.09
5	20.01	20.03	20.05	19.97
6	20.01	19.97	19.99	20.01
7	20.09	20.05	20.00	20.03
8	19.99	19.98	20.01	19.97

   (i) Compute the trial control limits for X and R charts.
   (ii) Construct X bar and R chart
4. State and explain the possible causes of low reliability of modern engineering systems.
5. a) Explain about the availability. b) How does the MTBF differ from MTTF? Explain the relationship between them.
6. Explain procedures that might improve the reliability of a system. Distinguish between a system with components in parallel and another with standby components?

Apply

1. The following observations are made in a crankshaft machining process.

Sample No.	Observations			
	1	2	3	4
1	20.21	20.19	20.25	20.15
2	20.21	20.19	20.23	20.17
3	20.17	20.16	20.20	20.18

4	20.10	20.11	20.18	20.09
5	20.01	20.03	20.05	19.97
6	20.01	19.97	19.99	20.01
7	20.09	20.05	20.00	20.03
8	19.99	19.98	20.01	19.97

(i) Calculate the process capability

(ii) Compute percent defective if any

2. Discuss some typical control chart patterns and their likely special causes?

3. Construct an OC curve for a single sampling plan where the lot size is 2000, the sample size is 50, and the acceptance number is 2

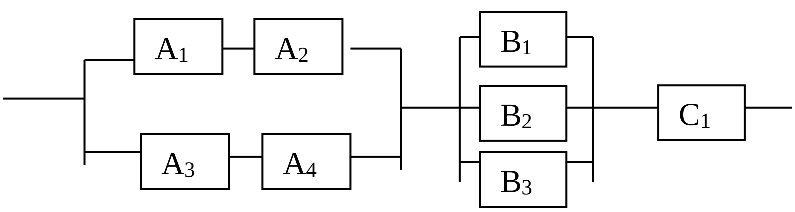
4. The piston for a petrol engine is made in lots of 150 each. The lots are subjected to 100% inspection. 25 such lots are inspected and the number of defectives found was 125.

   (a) Compute the control limits for a *p* charts.

   (b) Compute the control limits for the *np* chart

5. An amplifier has an exponential time-to-failure distribution with a failure rate of 8% per 1000 h. What is the reliability of the amplifier at 5000h? Find the mean time to failure?

6. Find the reliability of the eight component system shown in figure below. Some components are in series and some are in parallel. The reliabilities of the components are as follows : RA1=0.92, RA2=0.90, RA3=0.88, RA4=0.96, RB1=0.95, RB2=0.90, RB3=0.92, and Rc1=0.93



Figure

Analyze

1. The following observations are made in a crankshaft machining process.

Sample No.	Observations			
	1	2	3	4
1	20.21	20.19	20.25	20.15
2	20.21	20.19	20.23	20.17
3	20.17	20.16	20.20	20.18
4	20.10	20.11	20.18	20.09
5	20.01	20.03	20.05	19.97
6	20.01	19.97	19.99	20.01
7	20.09	20.05	20.00	20.03
8	19.99	19.98	20.01	19.97

(i) Is the process within control or not.

2. In plastic moulding process, the results of the inspection of 10 lots of 125 items each

are given in the following table.

Lot No.	1	2	3	1	5	6	7	8	9	10
No. of defectives	1	8	9	2	12	6	7	5	1	7

(i) Compute trial control limits

(ii) Plot the appropriate chart

(iii) Draw the conclusion

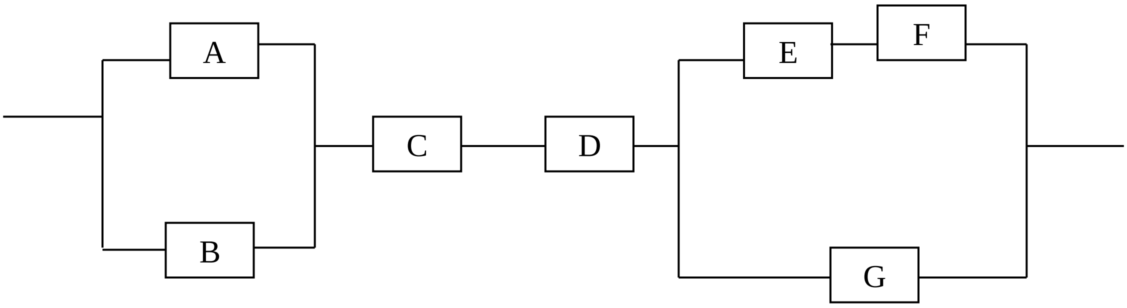
3. Is it easier to bring about a change in the process mean or a decrease in the process variability? Discuss the practical implications

4. Describe the life cycle of a product. What probability distributions would you use to model each phase?

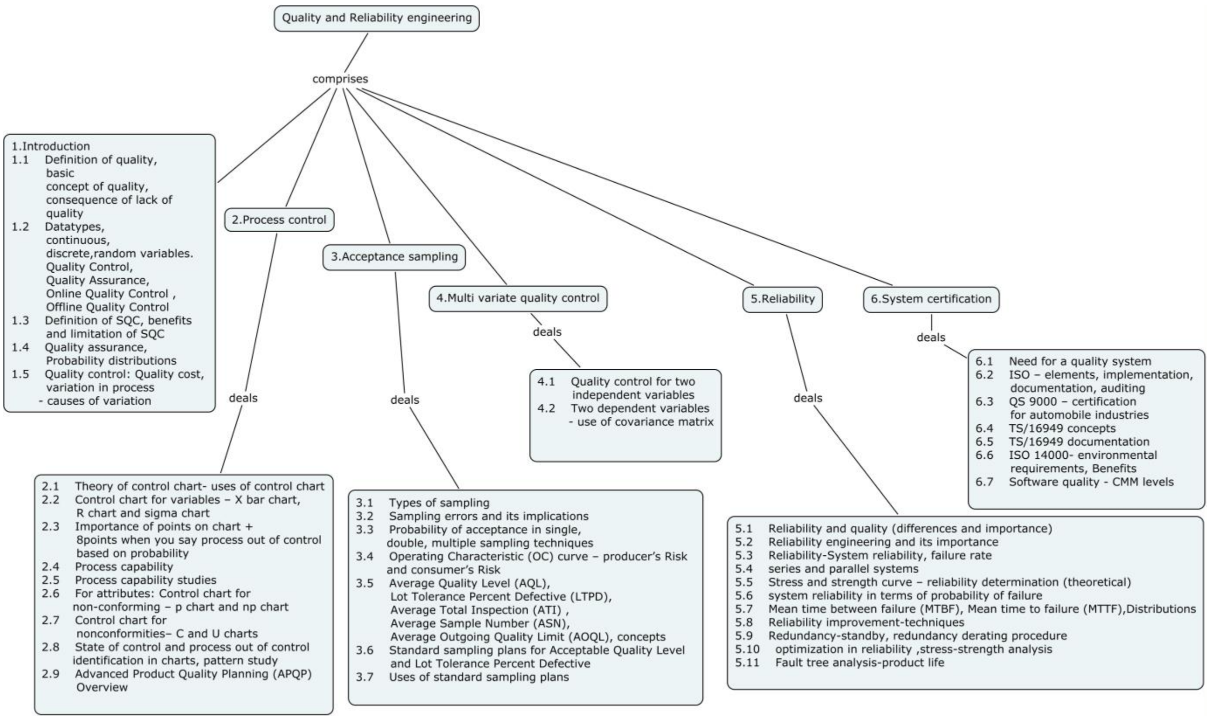
5. A module of a satellite monitoring system has 500 components in series. The reliability of each component is 0.999. Find the reliability of the module. If the number of components in series is reduced to 200, what is the reliability of the module?

5. Consider the seven – component system shown in figure below. The reliabilities of the components are as follows:

R_A =.96,R_B=.92,R_C=.94,R_D=.89,R_E=.95,R_F=.88,R_G=.90.Find the reliability of the system. If you had a choice of improving system reliability by modifying any two components, how would you proceed?



Concept Map



Syllabus

Introduction to Quality Engineering: Definition of quality, basic concept of quality, consequences of lack of quality–Data types, continuous, discrete, random variables. Quality Control,Quality Assurance, Online Quality Control, Offline Quality Control –Definition of SQC, benefits and limitation of SQC–Quality assurance, Probability distributions–Quality control: Quality cost, variation in process - causes of variation**Process Control :** Theory of control chart- uses of control chart – Control chart for variables – X bar chart, R chart and sigma chart –process capability – process capability studies– For attributes: Control chart for non-conforming – p chart and np chart – Control chart for nonconformities– C and U charts –State of control and process out of control identification in charts, pattern study-Advanced Product Quality Planning (APQP) overview.

Acceptance sampling: Types of sampling – Sampling errors and its implications – Probability of acceptance in single, double, multiple sampling techniques – Operating Characteristic (OC) curve – producer's Risk and consumer's Risk– Average Quality Level (AQL), Lot Tolerance Percent Defective (LTPD), Average Total Inspection (ATI) , Average Sample Number (ASN), Average Outgoing Quality Limit (AOQL), concepts-Standard sampling plans for Acceptable Quality Level (AQL) and Lot Tolerance Percent Defective(LTPD)- uses of standard sampling plans. **Multivariate quality control:** Quality control for two independent variables– two dependent variables- use of covariance matrix. **Reliability:** Reliability and Quality (differences and importance)–Reliability engineering and its importance–Reliability-System reliability, failure rate–series and parallel systems–Stress and strength curve – reliability determination (theoretical)–system reliability in terms of probability of failure–Mean time between failure (MTBF), Mean time to failure (MTTF),Distributions–Reliability improvement-techniques–Redundancy-standby, redundancyderating procedure– optimization in reliability ,stress-strength analysis–Fault tree analysis-product life.

System Certification: Need for a quality system, ISO – elements, implementation documentation, auditing– QS 9000 – certification for automobile industries- TS/16949 concepts,TS/16949 documentation– ISO 14000- environmental requirements, Benefits – Software quality - CMM levels

Text Book:

1. Douglas C. Montgomery, **"Introduction to Statistical Quality control",** John Wiley and Sons Inc, Sixth Edition, 2009.

Reference Book:

1. Grant, Eugene .L, **"Statistical Quality Control"**, McGraw-Hill, Tenth reprint, 2008
2. MonoharMahajan, **"Statistical Quality Control"**, DhanpatRai& Sons, 2001.
3. R.C.Gupta, **"Statistical Quality control"**, Khanna Publishers, 1997.
4. Besterfield D.H., **"Quality Control"**, Prentice Hall, Seventh Edition, 2001.
5. AmitavaMitra, **"Fundamentals of Quality Control and Improvement"**, Pearson Education Asia, Second Edition, 1998.
6. Charles E.Ebeling, **"An Introduction to Reliability and Maintainability Engineering",** TataMcGraw-Hill, Eighth reprint, 2007

Course contents and Lecture schedule

No	Topic	No. of Lectures
1	**INTRODUCTION TO QUALITY ENGINEERING**	
1.1	Definition of quality, basic concept of quality, consequences of lack of quality	1
1.2	Datatypes, continuous, discrete, random variables. Quality Control, QualityAssurance, Online Quality Control ,Offline Quality Control	1
1.3	Definition of SQC, benefits and limitation of SQC	1
1.4	Quality assurance, Probability distributions	1
1.5	Quality control: Quality cost, variation in process - causes of variation	1
2	**PROCESS CONTROL**	
2.1	Theory of control chart- uses of control chart	1
2.2	Control chart for variables – X bar chart, R chart and sigma chart	2
2.3	Importance of points on chart + 8points when you say process out of control based on probability	2
2.4	Process capability	1
2.5	Process capability studies	
2.6	For attributes: Control chart for non-conforming – p chart and np chart	1
2.7	Control chart for nonconformities– C and U charts	1
2.8	State of control and process out of control identification in charts, pattern study	1

2.9	Advanced Product quality planning (APQP) overview	1
3	**ACCEPTANCE SAMPLING**	
3.1	Types of sampling	1
3.2	Sampling errors and its implications	
3.3	Probability of acceptance in single, double, multiple sampling techniques	2
3.4	Operating Characteristic (OC) curve – producer's Risk and consumer's Risk	1
3.5	Average Quality Level (AQL), Lot Tolerance Percent Defective (LTPD), Average Total Inspection (ATI), Average Sample Number (ASN), Average Outgoing Quality Limit (AOQL), concepts	2
3.6	Standard sampling plans for Acceptable Quality Level and Lot Tolerance Percent Defective	1
3.7	Uses of standard sampling plans	1
4	**MULTI VARIATE QUALITY CONTROL**	
4.1	Quality control for two independent variables	1
4.2	Two dependent variables- use of covariance matrix	1
5	**RELIABILITY**	
5.1	Reliability and quality (differences and importance)	1
5.2	Reliability engineering and its importance	
5.3	Reliability-System reliability,failure rate	1
5.4	series and parallel systems	
5.5	Stress and strength curve – reliability determination (theoretical)	1
5.6	system reliability in terms of probability of failure	2
5.7	Mean time between failure (MTBF), Mean time to failure (MTTF),Distributions	2
5.8	Reliability improvement-techniques	1
5.9	Redundancy-standby, redundancy derating procedure	1
5.10	optimization in reliability ,stress-strength analysis	2
5.11	Fault tree analysis-product life	2
6	**SYSTEM CERTIFICATION**	
6.1	Need for a quality system	1

6.2	ISO – elements, implementation, documentation, auditing	Self study
6.3	QS 9000 – certification for automobile industries	1
6.4	TS/16949 concepts	Self study
6.5	TS/16949 documentation	
6.6	ISO 14000- environmental requirements, Benefits	1
6.7	Software quality - CMM levels	1
	TOTAL	**42**

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 64	3	-	-	3

G64 Mechatronics 3:0

Preamble: The word Mechatronics was first coined by Mr.Tetsuro Moria, a senior engineer of a Japanese company, Yaskawa, in 1969. Mechatronics is the synergistic combination of precision mechanical engineering, electronic control and systems thinking in the design of products and manufacturing processes. It is a complete integration of mechanical, electrical, electronics, control and computer engineering . This integration has to occur at earlier stages of design process. Mechatronics has to involve a concurrent approach to these disciplines rather than a sequential approach of developing a system. The present course is structured in such a way that it provides an insight into functioning of a mechatronic system and to choose appropriate components for its design.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

c. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

e. Graduates will demonstrate skills to use modern Engineering Tools, Software and equipment to analyze problems.

Competencies

At the end of the course, the student will be able to

1. Explain the advantages of mechatronic approach over traditional approach.
2. Choose appropriate actuators for a mechatronic system design.
3. Develop ladder logic program for accomplishing automation tasks.
4. Design Virtual Instrument (VI) programs for data acquisition from external world.
5. Design simple mechatronic systems as per the specified requirements.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	20	20	20	20
2	Understand	60	20	—	20
3	Apply	20	60	80	60
4	Analyze	—	—	—	—
5	Evaluate	—	—	—	—
6	Create	—	—	—	—

Course level Learning Objectives

Remember

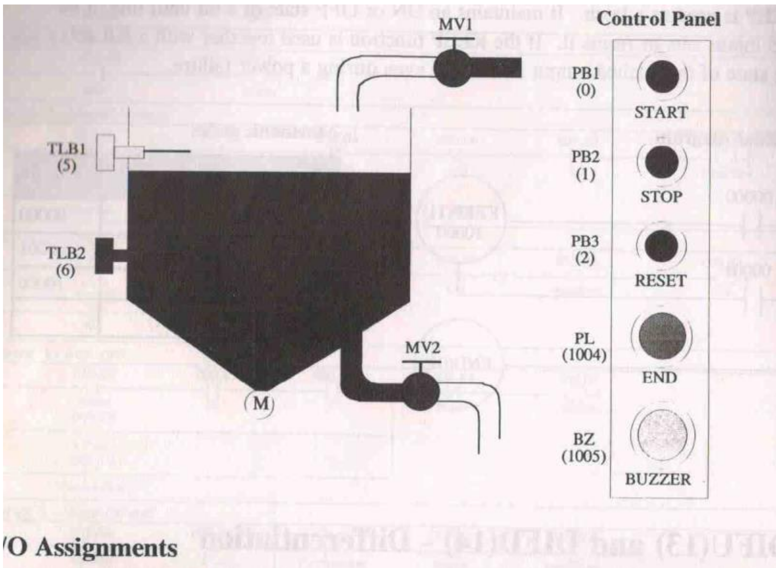
1. State the steps in selection of PLC.
2. List the advantages of PLC over PC.
3. Write the purpose of using internal relay in a ladder logic program
4. Define Virtual Instrument.
5. List the fundamental blocks in building a virtual instrument.
6. Define data flow programming.

Understand

1. Describe about the functioning of stepper motor in Half step mode.
2. Explain the working principle of BLDC Motor with a neat sketch.
3. Explain with any two examples how the mechatronic approach simplifies the traditional mechanism .
4. Explain with any two examples the enhancement of mechanism due to mechatronic approach.
5. Explain the synthesis of new mechanism due to mechatronic approach.
6. Explain the various functions of mechanism in a mechatronic system.

Apply

1. Develop a ladder logic program for the given following Filling/ draining control operation.



Problem statement:

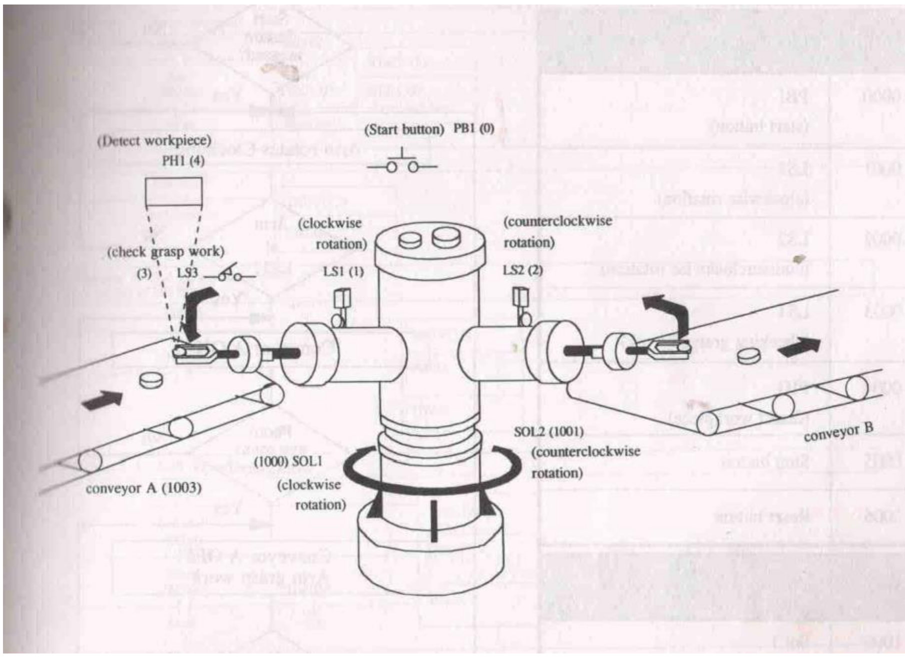
a. As the PB1 is pressed,MV1 opens and water begins to fill the tank.At the same time, the stirring motor M start operations.

b. When the water level passes TLB2 and reaches TLB1, the MV1 closes and the stirring motor stops.

c. Next, MV2 opens and starts draining the water.When the water levels drops below TLB2, MV2 closes.

d. When the cycle of operation has repeated four times, the operation END indicator illuminates and the filling and draining operation will not restart even if PB1 is pressed.

2. Develop a ladder logic program for the given following Robot movement control operation.



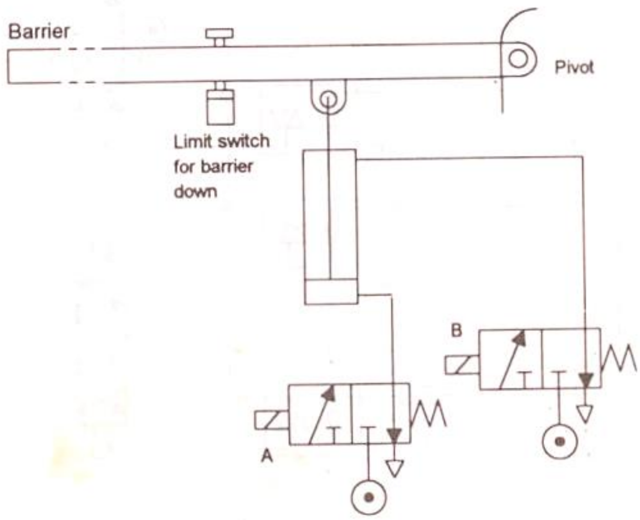
Problem statement:

a. When the start button is pressed, the robot rotates its arm clockwise.
b. When the robot arm has moved to the position of the work on conveyor A arm grasps the work.
c. When the arm has grasped the work, it rotates counter clock wise.
d. When the arm has rotated to the position of conveyor B it releases the work.

3. Develop a ladder logic program for the controlling the parking of car.

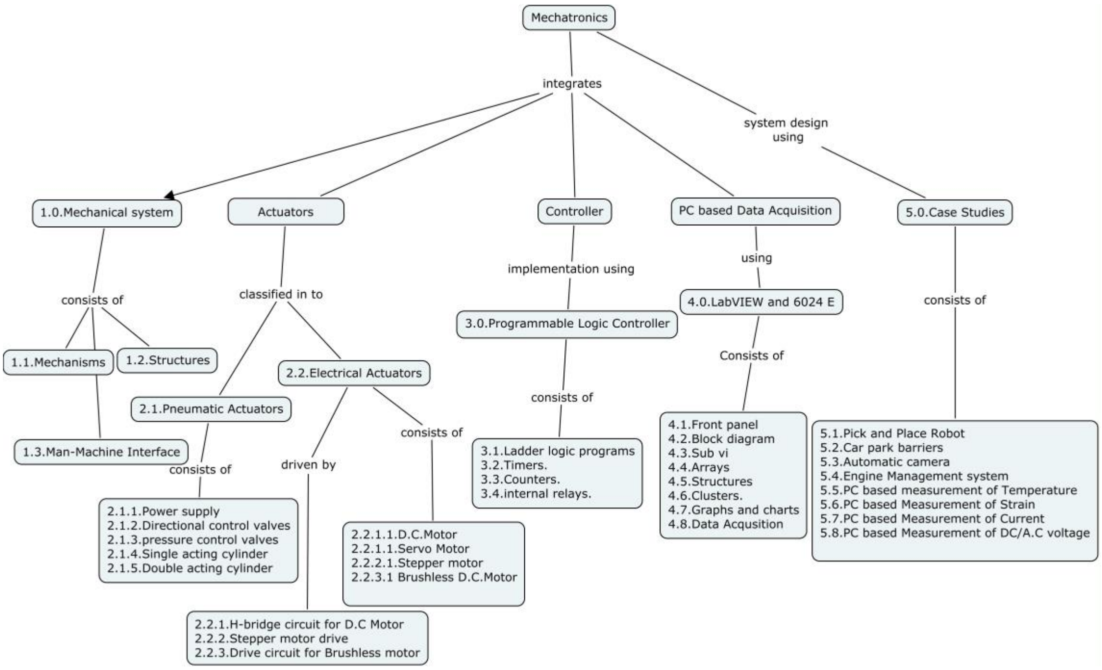
Problem statement:

a. When the coin is inserted the entrance barrier , it gets lifted and stays there for 10 sec for the car to pass.
b. After it the entrance barrier closes.
c. When the car is detected at the exit barrier ,it gets lifted and stays there for 10 sec for the car to pass.
d. After it the exit barrier closes.



4. Design an Automatic Camera with auto focus and film advance using mechatronic approach.
5. Design a Car Engine Management system using mechatronic approach.
6. Design a measurement system using labVIEW for measuring the temperature using thermocouple.
7. Design a strain measurement system using labVIEW.

Concept Map



SYLLABUS

MECHATRONICS- Introduction, Definition, advantage over traditional methods, The Mechatronic approach, Mechanisms, Structures, Man-Machine Interface- **PNEUMATIC & ELECTRIC DRIVES & CONTROLS -** Pneumatic system, Power supplies, Directional control valves, Pressure control valves, cylinders, sequential and cascading circuit for Automation. Permanent magnet D.C motor and its control, Brushless D.C motor and its control, Servo motors, Stepper motors-working, Characteristics, drive circuit, Half step and Full step operation.

PROGRAMMABLE LOGIC CONTROLLER - Introduction, Basic Structure, Input/output Processing, Simple Ladder Logic Programs including timers, counters, internal relays, Applications.- **PC BASED DATA ACQUISITION -** Introduction to Virtual Instruments, Front Panel, Block Diagram, Creating A Sub Vi, Structures, Arrays, Clusters, Graphs And Charts, Data Acquisition using VI.

CASE STUDIES - Car Park Barriers, Pick and Place Robot, Automatic Camera, Car Engine Management, Measuring of Temperature, Strain, Current, Dc Voltage, A/C voltage Using Labview.

Text Books:

1. Bradley Dawson, Burd,N.C and Loader A.J , "**Mechatronics: Electronics in product and processes**", chapman and Hall, London,1991.
2. Bolton "**Mechatronics-Electronic control systems in Mechanical and Electrical Engineeriong**", second Edition, Addison Wesley Longman Ltd 1999.
3. Frank.D.Petruzella "**Programmable Logic controllers**",Third Edition TataMc Graw Hill 2005.
4. "**LabVIEW Basics-I**" user manual, National Instruments 2004.

Reference Books:

1. Newton C.Braga "**Mechatronic source book**" Easwar press, 2003.
2. Dan Necsulescu "**Mechatronics**", Pearson Education Asia, 2002.
3. A.Smaili, F.Mrad "**Mechatronics**", oxford university press, 2009.

Course contents and Lecture schedule

No.	**Topic**	**No. of Lectures**
1.0	Introduction to Mechatronics, advantage over traditional methods, Examples	2
1.0	The Mechatronic approach	1
1.1	Mechanisms	1
1.2	Structures	1
1.3	Man-Machine Interface	1
2.1	**Pneumatic Systems**	
2.1.1	Power supplies,	1
2.1.2	Directional control valves	1
2.1.3	Pressure control valves.	
2.1.4,2.1.5	Cylinders, sequential and cascading circuit for Automation.	2
2.2	**Electric Drives and Controls**	
2.2.1.1	Permanent magnet D.C motor.	1
2.2.1	H-Bridge circuit for D.C. motor control.	1
2.2.1.1	Servo motors.	1
2.2.3.1	Brushless D.C motor.	2
2.2.3	Brushless D.C motor driver circuit	1
2.2.2.1	Stepper motors-working, characteristics, Half step and	2

	Full step operation.	
2.2.2	Stepper motors drive	1
3.0	**Programmable Logic Controller**	
3.0	Introduction, Basic Structure, Input/ Output Processing.	2
3.1	Simple Ladder Logic Programs.	2
3.2	Timers.	1
3.3	Counters.	
3.4	Internal relays,	1
3.4	Applications.	4
4.0	**PC based data acquisition**	
4.1,4.2	Introduction to Virtual Instruments, Front Panel, Block Diagram	1
4.3	Creating A Sub Vi	1
4.5	Structures	1
4.4	Arrays	1
4.6	Clusters	1
4.7	Graphs And Charts	1
4.8	Data Acquisition using VI	2
5.0	**Case Studies**	
5.1	Car Park Barriers,	1
5.2	Pick and Place Robot	1
5.3	Automatic Camera.	1
5.4	Car Engine Management.	1
5.5	PC based Measurement of Temperature.	1
5.6	PC based Measurement of Strain.	1
5.7	PC based measurement of Current.	1
5.8	PC based measurement of Dc Voltage and A/C voltage.	1
	Total number of hours	45

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 67	0	0	2	1

G67 Computer Aided Engineering Lab 0:1

The following are the list of experiments. Minimum of 12 experiments are to be given.

List of Experiments:

1. One dimensional Stress analysis of beams (Cantilever, Simply supported & Fixed ends)
2. Force analysis in simple Truss
3. Stress analysis of a plate with a circular hole
4. Structural analysis of corner bracket
5. Three dimensional Stress analysis on poppet valve stem
6. Stress analysis of an annular ring / Piston ring component
7. Thermal analysis of composite wall
8. Thermal analysis of fins (Circumferential and longitudinal)
9. Modal analysis of beams (Cantilever, Simply Supported, Fixed ends)
10. Harmonic response of two mass spring system
11. Coupled analysis of poppet valve guides (thermal and structural)
12. Kinematic analysis of slider crank chain mechanism
13. Lumped parameter modeling for numerical computation

Course Designer:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 68	0	0	2	1

G68 Mechatronics Lab. 0:1

The following are the list of experiments. Minimum of 12 experiments are to be given.

List of Experiments:

1. Simulation of Cascading circuit A+B+B-A-.
2. Simulation of sequential circuit A+B+A-B- .
3. Design of Cascading circuit A+B+B-A- using electro-pneumatic system.
4. Design of sequential circuit A+B+A-B- using electro- pneumatic system.
5. Design a sequential circuit to realize the sequential operation A+B+A-B- using PLC.
6. Design a Cascading circuit to realize the Cascading operation A+B+B-A- using PLC.
7. Design a car park barrier system using PLC to open and close entrance and exit barriers.
8. Develop a Virtual Instrument program for the measurement of DC / AC voltage.
9. Develop a Virtual Instrument program to generate a triangular wave form with the frequency of 100 Hz.
10. Develop a Virtual Instrument program to measure the frequency of a given signal.
11. Develop a Virtual Instrument program to count the number of events.
12. Develop a Virtual Instrument program to display the digital signal 0011 using LED.
13. Develop a Virtual Instrument program for data logging of a signal.

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
G 69	2	0	3	2

G69 Production Drawing 0:2

Preamble: Production Drawing is the indispensable communicating medium employed in shopfloor, to communicate all details of product, regarding size, shape, material, processes, surface finish, tool and equipment.

Program Outcomes addressed

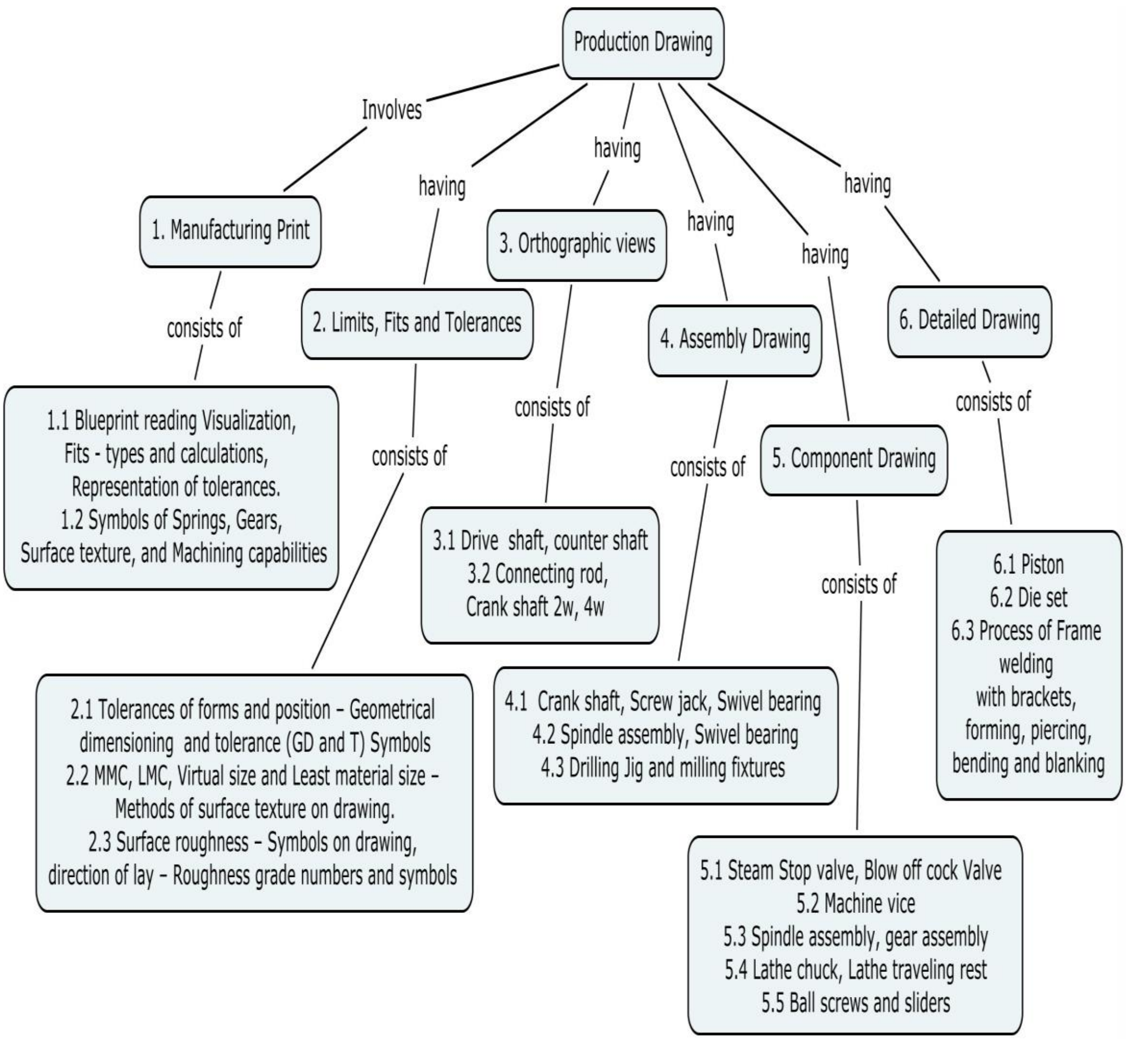
b. Graduates will demonstrate, draft various machine components with all information related to manufacturing environment.

c. Graduates who can participate and succeed in competitive examinations.

Competencies

1. Interpret a given production drawing of machine elements.
2. Able to draw production drawing of machine elements.

Concept Map



Course Contents, Lecture and Practice schedule.

No.	Topic	No. of Lectures/ Practices
1	**Manufacturing Print**	
1.1	Blueprint reading Visualization – Fits - types and calculations, Representation of tolerances.	2
1.2	Symbols of Springs, Gears, Surface texture, and Machining capabilities.	2
2	**Limits, Fits and Tolerances**	
2.1	Tolerances of forms and position – Geometrical dimensioning and tolerance (GD and T) Symbols	2
2.2	MMC, Virtual size and Least material size – Methods of surface texture on drawing.	2
2.3	Surface roughness – Symbols on drawing, direction of lay – Roughness grade numbers and symbols	2
3	**Orthographic views of the following (Any Three exercises only)**	
3.1	Drive shaft, counter shaft	2
3.2	Connecting rod, Crank shaft – 2wheeler , 4 wheeler	2
4	**Assembly drawing (Any five exercises only)**	
4.1	Crank shaft, Screw jack, Swivel bearing	5
4.2	Spindle assembly	2
4.3	Drilling Jig and milling fixtures	5
5	**Component drawing (Any five exercises only)**	
5.1	Steam Stop valve, Blow off cock valve	5
5.2	Machine vice	2
5.3	Spindle assembly, gear assembly	5
5.4	Lathe chuck, Lathe traveling rest	5
5.5	Ball screws and sliders	2
6	**Detailed drawings**	
6.1	Piston	3
6.2	Die set	3
6.3	Piston, Die set, Process drawing of crank shaft, welding brackets, forming piercing, bending and blanking.	6
	Total	**57**

Syllabus

Manufacturing Print: Blueprint reading – Visualization – Fits - types and calculations - Representation of tolerances, Symbols of Springs, Gears, Surface texture – Machining capabilities. **Limits, Fits and Tolerances:** Tolerances of forms and position – Geometrical dimensioning and tolerance (GD and T) Symbols – MMC, Virtual size and Least material size – Methods of surface texture on drawing. Surface roughness –Symbols on drawing, direction of lay – Roughness grade numbers and symbols. **Orthographic views of the following I.C. engine components (Any Three exercises):** Drive shaft, counter shaft, Connecting rod, Crank shaft - 2w, 4w. **Assembly drawing (Any five exercises):** Crank shaft, Screw jack, Swivel bearing, Spindle assembly, Drilling Jig and Milling fixture. **Component drawing: (Any five exercises)** Steam Stop valve, Blow off cock valve, Machine vice, Spindle assembly, gear assembly, Lathe chuck, Lathe traveling rest, Ball screws and sliders. **Detailed drawings:** Piston, Die set, Process drawing of crank shaft, welding brackets, forming piercing, bending and blanking.

Text Books

1. Narayana, K. L. Kannaiah.P and Venkata Reddy, K., **"Production Drawing"**, First edition – Reprint, New Age International Ltd., New Delhi, 2009.
2. Gopalakrishna, K.R. **"Machine Drawing"**, Subhash Stores, Bangalore, 18th Edition, 2004.

Reference Books

1. Warren Hammer **"Blueprint Reading Basics"**, 3rd Edition, Industrial Press Inc, New York, 2003.
2. Narayana K.L, Kannaiah P and Venkata Reddy K, **"Machine Drawing"**, 3rd reprint, New Age International Ltd., New Delhi, 2004.
3. Gill P.S., "**A Text Book of Machine Drawing**" Seventh Edition Reprint, S. K. Kataria & Sons. New Delhi, 2004.
4. Sharma S.C., **"Machine Drawing"**, Standard Publishers and Distributors, Delhi, 2004.
5. Dhawan R.K, **"A Text book of Machine Drawing"**, First Edition, Sultan Chand and Sons, New Delhi, 1996.

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

DEPARTMENT ELECTIVE

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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List of Department Electives

1. G CA Energy Conversion Systems
2. G CB Basics of Aircraft Engineering
3. GCC Experimental Stress Analysis
4. GCD Mechatronics System Design
5. GCE Financial Management
6. GCF Theory of Metal Cutting
7. GCG Principles of Automation
8. GCH Marketing Management
9. GCK Refrigeration and Air Conditioning
10. GCL Computational Fluid Dynamics
11. GCM Finite Element Analysis
12. GCN Design of Jigs Fixtures and Press Tools
13. GCP Foundry Technology
14. GCQ Machine Vision
15. GCR Product Design and Development
16. GCS Automotive Engineering
17. GCT Welding Technology
18. GCU Computer Integrated Manufacturing
19. GCV Production and Operations Management
20. GCW Internal Combustion Engine
21. GCY Turbomachines
22. GCZ Vibration Engineering

Sub Code	Lectures	Tutorial	Practical	Credit
GCH	3	0	-	**3**

GCH Marketing Management 3:0

Preamble: Marketing management is a business discipline which is focused on the practical application of marketing techniques and the management of a firm's marketing resources and activities. Rapidly emerging forces of globalization have compelled firms to market beyond the borders of their home country making International Marketing highly significant and an integral part of a firm's marketing strategy. Marketing managers are often responsible for influencing the level, timing, and composition of customer demand.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of engineering, mathematics and science

i. Graduates will demonstrate an ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

Competencies:

At the end of the course the student should be able to

1. Analyze Market Strategies.
2. Apply four P's to solve market problems.
3. Apply the different techniques for placing product positioning in the market.
4. Apply the various Advertisement Techniques.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test3**	**End-semester examination**
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	30	30	30	30
4	Analyze	30	30	30	30
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. What are the characteristics of an effective marketing mix?
2. State how can informal communication among various departments in an organization facilitate the marketing function?
3. List out the various roles played by consumers in the decisions making process
4. Define the importance for a company to study its environment?
5. List out the important requirements for commissioning a good research.
6. State the essential conditions in designing a questionnaire to elicit a correct response from the respondent?

Understanding

1. Discuss 'Selling Concept"
2. Explain the meaning of strategic marketing plan?
3. Explain the different types of customers?
4. Explain 'competition power' used to motivate channel members?
5. In which organization structure a company can avoid geographic or customer duplication?
6. Differentiate between transformational and transactional leadership.

Apply

1. It is always better to hire a professional marketing research firm rather than engaging one's own staff for this purpose. Comment.
2. Are internally driven businesses geared to meet customer needs? Explain.
3. Differentiate between probability and nonprobability sampling methods? Under what conditions should each of these methods be used?
4. Prominent changes in various demographic segments that have affected businesses globally – comment.
5. List out the sale promotional strategies for promoting the sale of machining tools of a tool manufacturing organization.
6. Suggest the marketing methodologies for a new generation bank in order to enhance its profitability.

Analyze

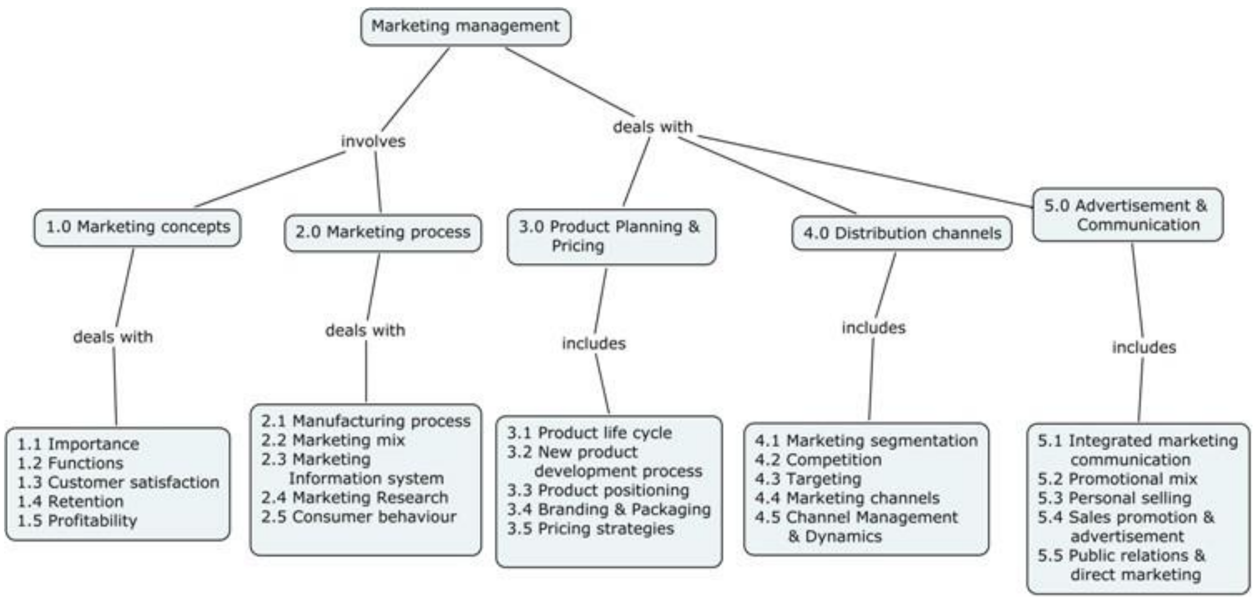
1. How do changes in socio-cultural forces affect businesses? Do some industries get affected more easily than others due to changes in socio-cultural factors?
2. In the Indian rural markets, consumers generally buy sachets / small packs of FMCG products. This also facilitates the process of trial for companies that sell their products to these customers. Traditionally, small,

unorganized players dominated this market. However, now MNCs are increasingly focusing on the rural markets to increase their revenues. A regional player wants to find out what he should do to tackle competition from larger multinationals. What type of research framework will you adopt for this regional player? Keep in mind the social, cultural and economic background of the intended market while designing the research framework?

3. ITC food division launched into toffee segment in December 2005. The market size for toffee in India in 2006-07 was at Rs. 2400 million and it was growing at 13%annually. What sales forecasting methods would you suggest to ITC and why?

4. Analyze the whether the implementation of Core banking solutions has overcome the marketing challenges for a nationalized bank.
5. Analyze the issues in marketing automobile products in a developing country like India.

Concept Map



Syllabus:

MARKETING CONCEPTS :scopeand Process of marketing- Marketing concepts –Importance - Function customer satisfaction and value - customer retention - consumer profitability **MARKETING PROCESS :** marketing plan - marketing mix - Marketing Information system - marketing research - Consumer behaviour. **PRODUCT PLANNING AND PRICING :**Product Life Cycle - New Product development process - Product Positioning - Branding & Packaging - Pricing

Strategies **DISTRIBUTION CHANNELS :**Marketing Segmentation – Competition – Targeting - Marketing Channels – Channel - Management & Dynamics. **ADVERTISEMENT AND COMMUNICATION:**Integrated marketing communication - Promotional mix - Personal selling - Sales promotion & advertisement - Public relations & direct marketing.

Text Books:

1. Philip Kotler, "**Marketing management**" (Milleniumedidtion), Prentice Hall of India P (ltd), New Delhi 2011.

Reference Books:

1. Micheal R. Czinkota & Masaaki Kotabe, "**Marketing management**", Vikas Thomson learning 2010, New Delhi.
2. Douglas, J. Darymple "**Marketing Management**" John Wiley & Sons, 2008, New Delhi.
3. NAG, **marketing successfully A professional perceptive**, Macmilan 2008, New Delhi.
4. Aakar, Day, Kumar, "**Essential of Marketing Research** "**,**8th Edition**,** Wiley Eastern , 2011, New Delhi.
5. Keith Flether, "**Marketing Management and Information Technology**", Prentice Hall of India , 2000, New Delhi.

Course contents and Lecture schedule

No	Topic	No. of Lectures
1.	**Marketing concepts**	
1.1	Importance	2
1.2	Functions	2
1.3	Customer Satisfaction	2
1.4	Retention	1
1.5	Profitability	1
2	**Marketing process**	
2.1	Marketing plan	2
2.2	Marketing Mix	2
2.3	Marketing Information System	2
2.4	Marketing Research	2

2.5	Consumer Behaviour	2
3	**Product Planning & Pricing**	
3.1	Product Life Cycle	2
3.2	New Product development process	2
3.3	Product Positioning	2
3.4	Branding & Packaging	2
3.5	Pricing Strategy	1
4.0	**Distribution Channels**	
4.1	Marketing Segmentation	2
4.2	Competition	2
4.3	Targeting	1
4.4	Marketing Channels	2
4.5	Channel Management & Dynamics	2
5	**Advertisement & Communication**	
5.1	Integrating Marketing Communication	2
5.2	Promotional Mix	1
5.3	Personal Selling	2
5.4	Sales Promotion & Advertisement	2
5.5	Public Relations & Direct Marketing	2
	Total	**45**

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GCL	2	1	-	**3**

GCL Computational Fluid Dynamics 3:0

Preamble: Computational Fluid Dynamics (CFD) provides an introduction to the use of computation techniques to analyze flow and heat transfer in problems of practical engineering interest. By studying a variety of flow situations students will develop a better intuition of fluid mechanics more quickly than is possible with traditional analytical approaches. At the end of the course students will understand the process of developing a geometrical model of the flow, applying appropriate boundary conditions, meshing, specifying solution parameters, and visualizing the results. They will also have an appreciation for the factors limiting the accuracy of CFD solutions.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

c. Graduate will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems

Competencies

1. Explain the physics of various heat flow and fluid flow problems in thermal engineering fields.
2. Apply the governing equations to formulate numerical solution for both heat and fluid flow in the thermal engineering systems.
3. Determine the pressure, velocity and temperature in the computational domain involving steady or unsteady heat transfer and fluid flow.
4. Develop skill to write algorithm / draw flow chart for diffusion or convection-diffusion processes.

Assessment Pattern:

	Bloom's Category	**Test 1**	**Test 2**	**Test3**	**End-semester examination**
1	Remember	20	20	20	20
2	Understand	50	50	50	50
3	Apply	30	30	30	30
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember:

1. Write the governing equations for a heat and fluid flow problem.
2. Write the one dimensional transient heat conduction equation.
3. Write the energy equation for a one dimensional unsteady state convection-diffusion problem?
4. List the types of numerical errors.
5. Give a practical example for one dimensional steady state head conduction.
6. Under what circumstance you will choose a coarse grid in the computational domain.

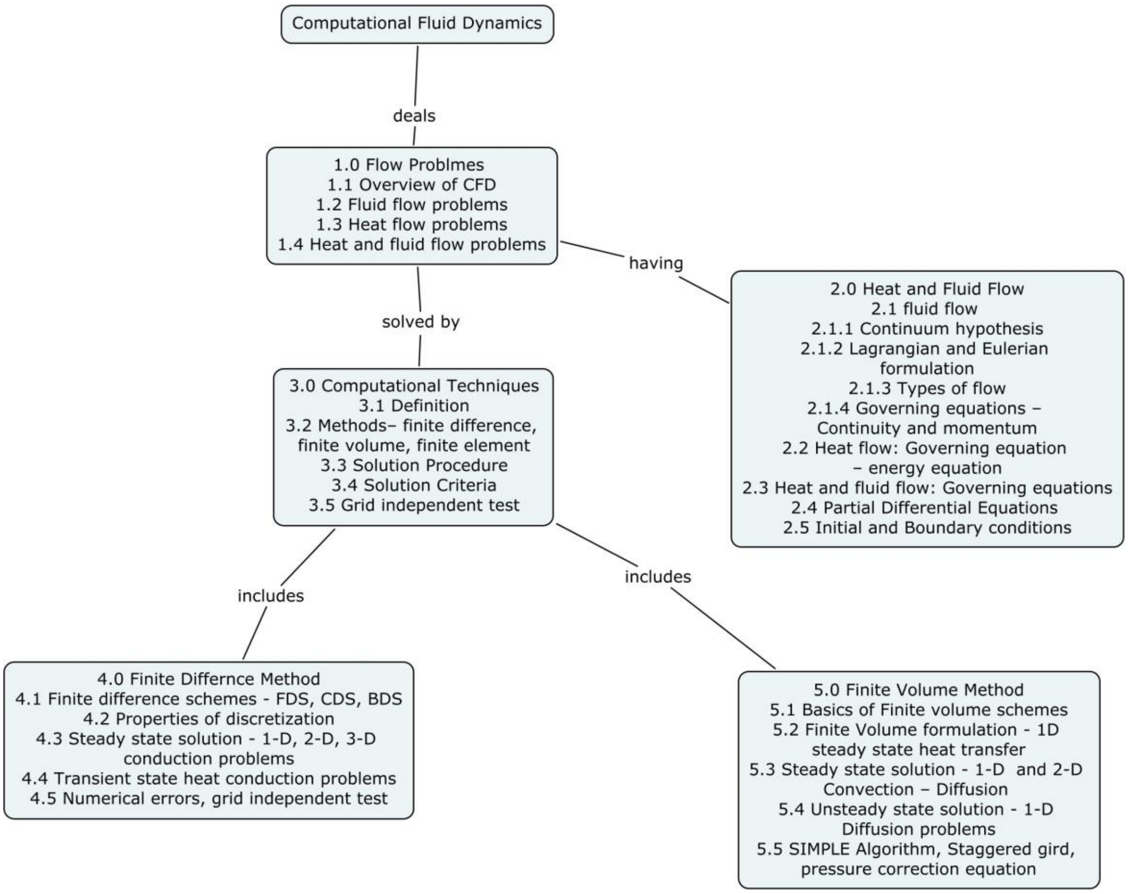
Understand:

1. Explain the types of partial differential equations.
2. With a neat sketch, explain the staggered grid system.
3. Briefly explain the advantages of implicit and explicit methods.
4. Describe the SIMPLE Algorithm.
5. Draw the flow chart for solving a two dimensional convection – diffusion problem
6. Explain the procedure for conducting a grid independent test.

Apply:

1. Compare the temperature distribution in a rod fin having a diameter of 2cm and length of 10 cm and exposed to a convection environment h = 25 W/m^2 K for the three fin materials: a) copper (k=385 W/mK) b) stainless steel (k = 17 W/mK) and c) glass (k=0.8 W/mK). Assume that the tip is convection and T_o = 500 ^oC, T_{inf} =25 ^oC. Also, calculate the relative heat transfer and fin efficiencies. Check your numerical results with analytical solution.
2. Find the steady state temperature distribution using FDM in a square plate of size 40 cm x 40 cm, one side of which is maintained at 500 ^oC, with the other three sides maintained at 200 ^oC. Use five nodes in each side of the plate.
3. A property ϕ is transported by means of convection diffusion in a one dimensional domain having a length of x=0 to x = 1. The boundary conditions are ϕ =1 at x = 0 and ϕ = 0 at x = 1. Using five equally spaced cells and central differencing scheme, calculate the distribution of ϕ in the computational domain.
4. Solve $\frac{\partial^2 T}{\partial x^2} = 0$ in a computational domain of x = 0 to x=1 using five equally divided grid point. T(0) = 620 K and T(1) = 320 K
5. Solve $\frac{\partial^2 T}{\partial x^2} = 200$ in a computational domain of x = 0 to x=1 using five equally divided grid point. T(0) = 900 K and T(1) = 500 K.
6. Solve $\frac{\partial^2 u}{\partial x^2} = 0$ in a computational domain of x = 0 to x=1 using five equally divided grid point. u(0) = 1 and u(1) = 0.

Concept Map:



Syllabus

Flow problems: Overview of CFD – Definition, stages, applications **-** Fluid flow, heat flow, heat and fluid flow problems. Fluid Flow- Continuum hypothesis, Lagrangian and Eulerian formulation, Types of flow, Governing equations - continuity equation and momentum equation. Heat flow: governing equation - energy equation, Heat and fluid flow: Governing equations – continuity, momentum and energy equations. Partial Differential Equations – Initial and Boundary conditions. **Computational Techniques:** Definition, Methods – Finite difference, Finite volume and Finite element, Solution procedure, solution criteria – stability and convergence, grid independent test.

Finite Difference Method: Finite difference schemes-forward, central and backward difference, properties of discretization schemes, Implicit and explicit approaches. FDM for Steady one-dimensional conduction, Two and Three dimensional steady state problems, One dimensional transient state problems, Numerical errors, grid independent test. **Finite Volume Method:** Basics of Finite volume schemes, Finite Volume formulation for 1D steady and unsteady heat transfer. Steady One-Dimensional and Two-Dimensional Convection–Diffusion, Unsteady one dimensional Diffusion - SIMPLE Algorithm, Staggered gird, pressure correction equations.

Text Books:

1. Muralidhar, K., and Sundararajan, T., "**Computational Fluid Flow and Heat Transfer**", Narosa Publishing House, New Delhi, 2009.
2. H.K.Versteeg and W.Malalalsekara, "**An Introduction to CFD,The Finite Volume Method**", Addition Wesley Longman ltd, 2007.

Reference Books :

1. Suhas, V.Patankar "**Numerical heat transfer fluid flow**", Hemisphere Publishing corporation 1980.
2. Ghoshdasdidar, P.S., "**Computer Simulation of flow and heat transfer**" Tata McGraw- Hill Publishing Company Ltd., 1998.
3. Taylor, C and Hughes, T.G. "**Finite Element Programming of the Navier Stoke Equation**", Pineridge Press Limited, U.K, 1981
4. Anderson, D.A., Tannehill, J.C., and Pletcher, R.H., "**Computational fluid Mechanics and Heat Transfer**" Hemisphere Publishing Corporation, Newyork, USA, 1984.
5. Fletcher, C.A.J. "**Computational Techniques for Fluid Dynamics 1 (Fundamental and General Techniques)**", Springer – Verlag,2005.

Course Contents and Lecture Schedule:

No.	Topic	No. of hours
1.0	**Flow Problems**	
1.1	Overview of CFD	2
1.2	Fluid flow problems	1
1.3	Heat flow problems	1
1.4	Heat and fluid flow problems	1
2.0	**Basics of CFD**	
2.1	Fluid Flow	1
2.1.1	Continuum hypothesis	
2.1.2	Lagrangian and Eulerian formulation	1
2.1.3	Types of flow	1
2.1.4	Governing equations – Continuity and momentum	2
2.2	Heat flow: Governing equation – energy equation	1

2.3	Heat and fluid flow: Governing equations - continuity equation, momentum equation, energy equation	1
2.4	Partial Differential Equations	2
2.5	Initial and Boundary conditions	1
3.0	**Computational Techniques**	
3.1	Definition	1
3.2	Methods– finite difference, finite volume, finite element	1
3.3	Solution Procedure	3
3.4	Solution Criteria - stability and convergence	1
3.5	Grid independent test	1
4.0	**Finite Difference Method**	
4.1	Finite difference schemes - forward difference scheme, central difference scheme, backward difference scheme	2
4.2	Properties of discretization	1
4.3	Steady state solution - one-dimensional, Two dimensional, Three dimensional conduction problems	3
4.4	Transient state heat conduction problems	1
4.5	Numerical errors, grid independent test	1
5.0	**Finite Volume Method**	
5.1	Basics of Finite volume schemes	1
5.2	Finite Volume formulation - 1D steady state heat transfer	2
5.3	Steady state solution - One-Dimensional and Two-Dimensional Convection – Diffusion	3
5.4	Unsteady state solution - one dimensional Diffusion problems	2
5.5	SIMPLE Algorithm, Staggered gird, pressure correction equation	2
	Total	**40**

Note: The results of assignment problems can be verified with the results of CFD software.

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GCQ	3	0	-	**3**

GCQ Machine Vision 3:0

Preamble: Machine Vision has become a key technology in the area of manufacturing and quality control. Increasing quality demands require inspection of every single part which in turn will lead to much more wide spread use of visual inspection systems. Furthermore the documentation requirements of ISO 9000 and similar quality control standards can only be met by fully automated networked inspection systems.

The Success of developing machine vision system depends on the understanding all parts of the imaging chain.

Hence this course discusses about image acquisition, lens and illumination systems, image preprocessing and processing, segmentation and classification techniques used in a typical machine vision application.

Program Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science

c. An ability to design a system or component, or process to meet stated specifications

e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

g. An ability to function on multidisciplinary teams

j. An ability to consider issues from global and multilateral views.

Competencies

At the end of the course, student will be able to

1. Explain the components of a machine vision system.
2. Select appropriate camera, lens and lighting system for a machine vision system.
3. Suggest suitable image preprocessing and post processing algorithms like segmentation to solve application and case studies.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1	Remember	40	40	40	20
2	Understand	40	40	40	40
3	Apply	20	20	20	40
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. Define digital image.
2. List the types of Resolution used in Machine Vision.
3. Write the basic components of a machine vision system.
4. Mention the types of cameras used in image acquisition.
5. What is meant by dark current?
6. Expand the acronym NTSC.

Understand

1. Explain the need for frame grabber in image acquisition.
2. Explain the working principle of CCD sensor array
3. Describe in detail about various image acquisition modes.
4. Explain the advantages of CMOS sensors over CCD sensors.
5. Discuss the advantages of direct digital transmission
6. Differentiate between sensor format and lens format

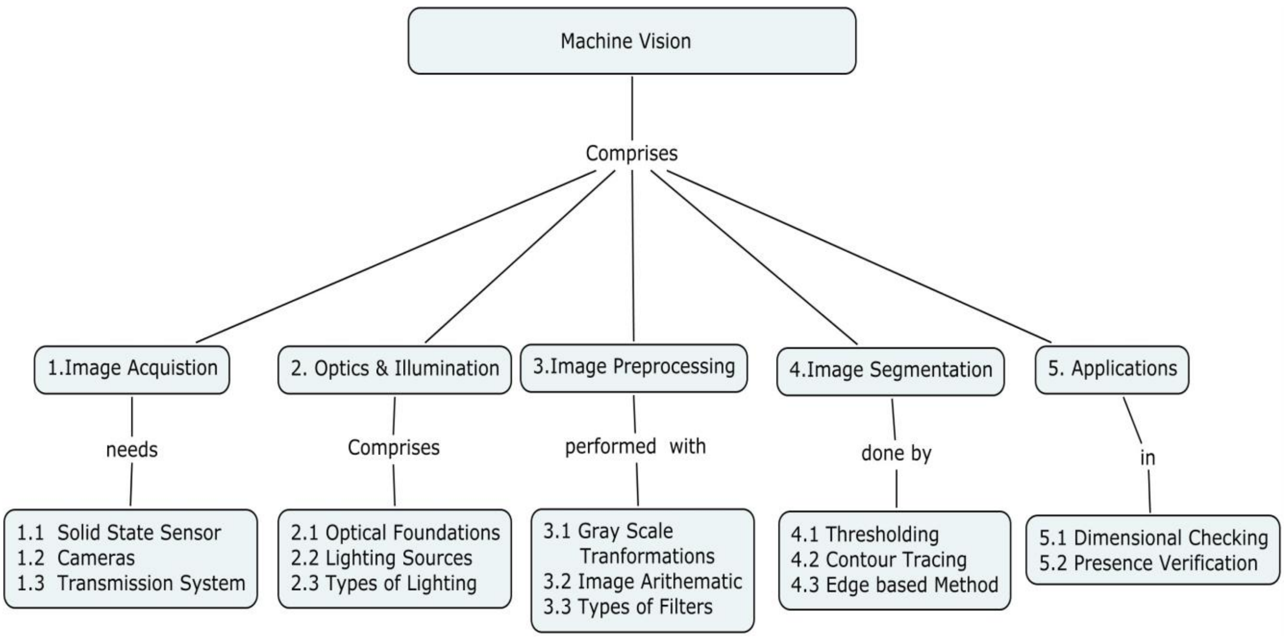
Apply

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor.

Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm. F-Stop is 8, and there are 16 grey level and 30 images / second. Object dimensions are 7.5 X 7.5 X 1.2 cm. The object occupies 50% of sensor array.

4. A surveillance camera is embedded in one of the walls of a room . The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is .05m.The X-Z plane of the camera is parallel to the X-Y Plane of the world coordinate system. The image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner.
5. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.
6. Suggest suitable hardware and algorithms for inspection of threads in a batch production process of bolts.

Concept Map



Syllabus

Image Acquisition: Solid State Sensors CCD Sensor Operation, Properties, Image Degradation. Standard Video Cameras: Basic Structure, Sampling of Line

Signal and Extension of Video Standards, Image Quality, Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras, Line Scan Cameras and its Properties. Transmission to Computer: Basic operation of Frame Grabber and Direct Digital transmission.

Optics and Illumination: Optical foundations: F number, Thin Lens Imaging Equation, Depth of Field, Typical Imaging Situations, Aberrations, Lens Selection, Special Optical devices. Light Sources, Types of Light Filters, Types of Lighting: Diffuse, Directed, Telecentric, Structured, Bright field, Dark Field, Incident and Transmitted Lighting.

Image Preprocessing: Gray Scale Transformations: Look up tables, Linear Gray level scaling, Contrast enhancement, Histogram equalization, Local Contrast Enhancement. Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images. Types of Filters: Linear Filters, Median Filter, Morphological and Non Linear Filters.

Image Segmentation: Threshold Determination from Histogram, Gray Level Histogram, Generalizations of Thresholding Contour Tracing: Pixel Correctedness, Generating Object Contours, Contour representation Edge based Methods: Edge probing and Edge Detection Template matching: Basic Operation, Optimizing and Comments on Template Matching.

Applications: Dimensional Checking: Simple gauging, Shape Checking, Angle Gauging, High accuracy Gauging, Calibration. Presence Verification: Simple Presence verification, Simple Gauging for assembly verification, Glue Check under UV Light and Pin type Verification.

Text book:

1. C.Demant, B.Streicher Abel, P.Waszkewitz "**Industrial Image Processing and Visual Quality control in manufacturing**" Springer, 1999.
2. K.S.Fu,R.C.Gonzalez,C.S.G.Lee "**Robotics Control, Sensing, Vision and Intelligence**" Tata McgrawHill, 2008

Reference Books:

1. Alexander Hornberg, "**Handbook of Machine Vision**", Wiley VCH, 2006
2. Gerald C. Holst, "**CCD Arrays Cameras and Displays**" Second Edition, SPIE Optical Engineering Press, 1998.
3. R.C.Gonzalez, Richard E.Woods, "**Digital Image Processing**" Second Edition, Prentice Hall India, 2005.

Course contents and Lecture Schedule

S.No.	Topics	No. of Lectures
1	**Image Acquisition**	
1.1	Solid State Sensors	
1.1.1	CCD Sensor Operation	1
1.1.2	CCD Properties, Image Degradation	1
1.1.3	CMOS Sensors Operation and its advantages	1
1.2	Standard Video Cameras	
1.2.1	Basic Structure, Sampling of Line Signal	1
1.2.2	Extension of Video Standards, Image Quality	1
1.2.3	Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras and its Properties	2
1.3	Transmission to Computer	
1.3.1	Basic operation of Frame Grabber	1
1.3.2	Direct Digital transmission	1
1.3.3	USB, IEEE1394, Firewire, Gigabit Ethernet, Choosing Computer Bus	2
2	**Optics and Illumination**	
2.1	Optical foundations	
2.1.1	Basic Laws of Optics, F number, Thin Lens Imaging Equation, Depth of Field	2
2.1.2	Typical Imaging Situations, Aberrations	1
2.1.3	Lens Selection, Special Optical devices	2
2.2	Lighting Sources	

S.No.	Topics	No. of Lectures
2.2.1	Incandescent Lamps, Metal Vapour Lamps, Xenon Lamps, Fluorescent, LED, Laser.	2
2.2.2	Types of Light Filters – UV Filter, Day Light Filter, IR Filter Gray Filter, Polarization Filter, Color Filter and Combination.	1
2.3	Types of Lighting	
2.3.1	Diffuse and Directed Bright Field Incident Lighting.	1
2.3.2	Telecentric and Structured Bright Field Incident Lighting Diffuse and Directed Dark Field Incident Lighting	1
2.3.3	Diffuse and Directed transmitted Lighting - Bright Field and Dark Field	1
3	**Image Preprocessing**	
3.1	Gray Scale Transformations:	
3.1.1	Look up tables, Linear Gray level scaling	1
3.1.2	Contrast enhancement, Histogram equalization, Local Contrast Enhancement.	2
3.1.3	Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images.	1
3.1.4	Types of Filters: Linear Filters, Median Filter	1
3.1.5	Morphological and Non Linear Filters	1
4	**Image Segmentation:**	
4.1	Thresholding	
4.1.1	Threshold Determination from Histogram	1
4.1.2	Gray Level Histogram, Generalizations of Thresholding	2

S.No.	Topics	No. of Lectures
4.2	Contour Tracing	
4.2.1	Pixel Correctedness, Generating Object Contours, Contour representation	1
4.2.2	Edge based Methods: Edge probing and Edge Detection	1
4.2.3	Template matching: Basic Operation, Optimizing and Comments on Template Matching.	2
5	**Applications**	
5.1	Dimensional Checking	
5.1.1	Simple gauging, Shape Checking	1
5.1.2	Angle Gauging, High accuracy Gauging	1
5.1.3	Calibration	1
5.2	Presence Verification	
5.2.1	Simple Presence verification, Simple Gauging for assembly verification	2
5.2.2	Glue Check under UV Light	1
5.2.3	Pin Type Verification	1
	Total	42

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
GCS	3	0	0	3

GCS Automotive Engineering 3:0

Preamble:

Automotive engineering is the branch of vehicle engineering, incorporating elements of mechanical, electrical, electronic and safety engineering as applied to the design, manufacture and operation of motorcycles, cars, buses and trucks and their respective engineering subsystems.

Program outcomes Addressed

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems
c. Graduates will develop confidence for self education and ability for life-long learning

Competencies

At the end of the course the student should be able to

1. Explain the constructional features of chassis system.
2. Analyze the various layouts by applying the principles of mobility mechanics.
3. Analyze the different configurations of I.C.Engines by applying the principles of engine kinematics.
4. Explain the transmission system of an automobile.
5. Explain the electrical systems in an automobile.

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1.	Remember	20	20	20	20
2.	Understand	40	40	40	40
3.	Apply	30	30	30	30
4.	Analyze	10	10	10	10
5.	Evaluate	-	-	-	-
6.	Create	-	-	-	-

Course level learning objectives:

Remember

1. List the various components of a chassis.
2. How are clutches classified?
3. What do you mean by over steering and under steering?
4. What is the major advantage of disc brake?
5. How are brakes classified?
6. What are the battery troubles?

Understand

1. With an aid of neat sketch, explain the working principle of a multi-plate clutch.
2. Derive an expression for maximum acceleration of an automobile in terms of load reactions and vehicle dimensions.
3. Explain the construction and working of a starter motor.
4. With a neat sketch, explain the working principle of a limited slip differential in detail.
5. Explain the principle of electronic power steering system used in automobiles.
6. With a neat sketch, explain the working principle of Master cylinder in a hydraulic braking system.

Apply

1. A motor car which weighs 17795 N including the four road wheels each of which has an effective diameter of 0.66 m, a radius of gyration of 0.28 m and a weight of 294 N has an engine developing 66 kW at 2400 RPM. The parts which rotate at engine speed weigh 1069 N, with a radius of gyration 0.115 m. The transmission efficiency is 90% and the total road and air resistance at this engine speed in top gear of 3.84:1 is 873 N on level. Calculate the acceleration in m/s^2, under those conditions and assuming the acceleration to be uniform the time required to increase the speed by 32 km/h.

2. A motor car with wheel base 2.75 m with a centre of gravity 0.85 m above the ground 1.15 m behind the front axle has a coefficient of adhesion 0.6 between the tyre and the ground. Calculate the maximum possible acceleration when the vehicle is

(a) Driven on four wheels

(b) Driven on the front wheels only

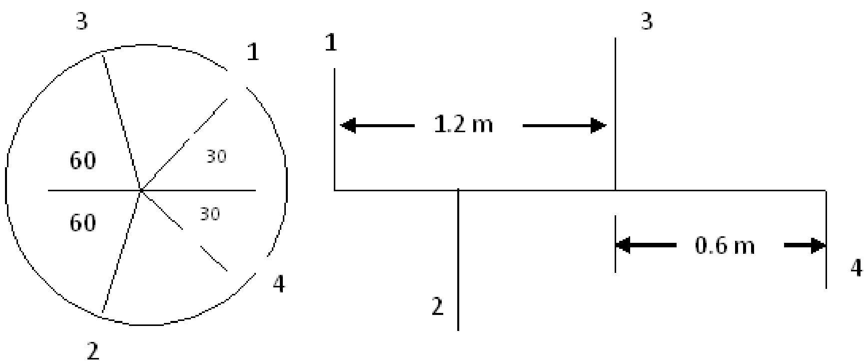
(c) Driven on rear wheels only

3. A motor cycle with a rider weight 1962 N, the centre of the gravity of the machine and the rider combined being 0.6 m above the ground level when the machine is standing upright. Each road wheel has a moment of inertia of 9.8 Nm^2 and a rolling diameter 0.6 m. The engine rotates at six times the speed of the road wheels and in the same sense. The moment of inertia of the rotating part of the engine is 1.57 Nm^2. Determine the angle of wheel necessary if the unit is travelling at the speed of 64 km/h in a curve of radius of 30.5 m.

4. A motor car engine develops maximum torque at 1900 rpm and maximum power at 3200 rpm. If the bottom gear ratio is 3:1, find the approximate ratios of speed for a gear box having 4 forward speeds when the ratios are in geometrical progression.

   If the same car at top gear has speeds of near about 48 km/h and 80 km/h at the corresponding engine speeds at maximum torque and maximum power respectively and the effective diameter of the driving wheels is 0.61 m, find a suitable back axle ratio.

5. A four cylinder is arranged as shown in figure. The reciprocating masses in planes 1 and 4 are each 100 kg and in planes 2 and 3 are 173 kg each. If the crank radius is 0.3 m, the length of the connecting rod is 1.2 m and the speed 120 rpm, determine secondary forces and couples.



6. An I.C.Engine runs at 1500 rpm. The length of the connecting rod is 480 mm and the crank radius is 120 mm. Determine at 25% of the outstroke,
   (a) The angular position of the crank
   (b) The angular velocity of the connecting rod
   (c) The linear acceleration of the piston
   (d) The angular acceleration of the connecting rod

Analyze

1. A bus chassis 5.2 m long consists of two longitudinal members and many cross members. The distance between front and rear axle is 3.6 m. Front axle is at 0.9 m from the front of the chassis frame. The details of the load and distances are given below.

Load	Magnitude (kN)	Distance from the front of the frame (m)
Engine weight (at front)	2	0.6
Engine weight (at rear)	25	1.8
Gear box weight	0.5	2.4
Vehicle body weight	W	3

   If the reaction by front axle is 8.5 kN, determine the magnitude of vehicle body weight W, and the support reaction at B. Suggest suitable cross section to the chassis frame to account for maximum bending moment.

2. A car weighing 21336.75 N, has a static weight distribution on the axles 50:50. The wheel base is 3 m and the height of the centre of gravity above ground is 0.55 m. If the coefficient of friction on the highway is 0.6, prove that rear wheel drive offers higher gradability than front wheel drive, if engine power is not a limitation.

3. Prove that firing order of 1-2-4-3 / 1-3-4-2 is better than any other sequence as far as engine balancing is concerned.

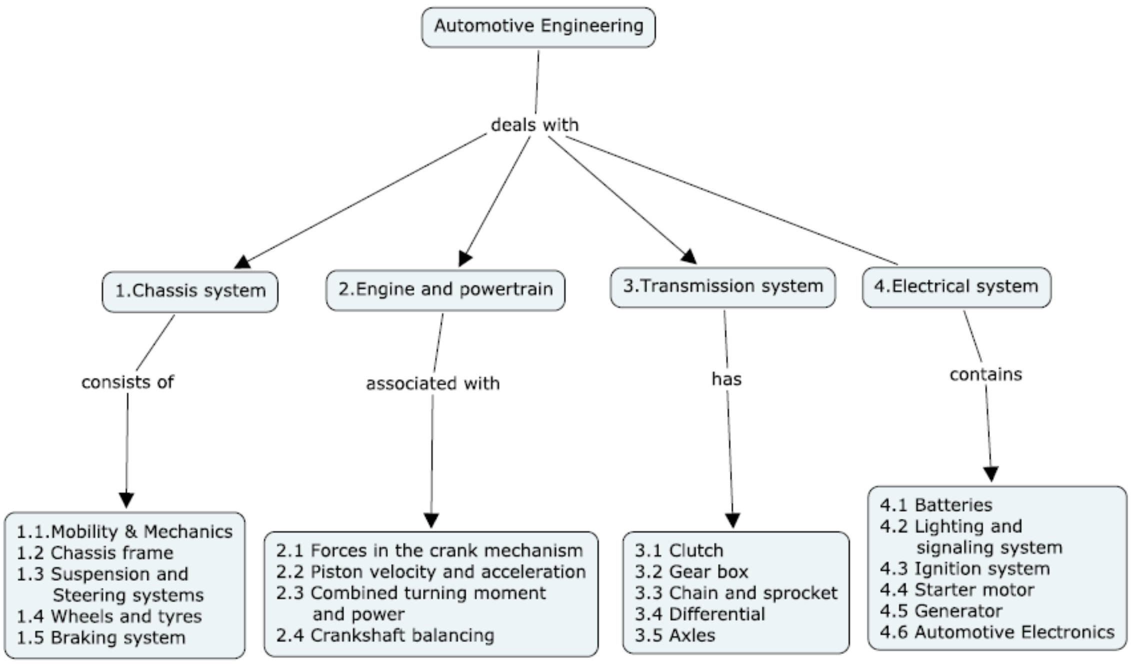
4. A motor vehicle of weight 13341.6 N has road wheels of effective diameter 0.635 m. The engine can develop a maximum torque of 189.82 Nm and the transmission efficiency is 80%. The moment of inertia of road wheels and axles is 66.22 Nm^2 and that of the engine and flywheel is 5.89 Nm^2. Calculate the gear ratio required to give a maximum acceleration of 0.455

m/s^2 up a slope of 1 in 10 with a road resistance of 311.46 N under maximum torque condition. Also suggest gear ratios for higher gears and validate your answer.

5. Analyze the possibility of two crankshaft arrangements in two cylinder engine, and propose the better one based on engine balancing.

6. Propose vehicle design data for a passenger car for maximum vehicle weight of 15000 N and maximum vehicle speed of 150 km/h.

Concept map:



Course contents and Lecture schedule:

S.No	Topics	No. of periods
1	**Chassis systems**	
1.1	***Mobility& mechanics***	
1.1.1	Introduction to mobility, Resistance and inertia, Road loads and acceleration,	2
1.1.2	Tractive and drag forces, Vehicle layout and kinematics Motorcycle physics and gyroscopic effects,	3
1.1.3	Motion & load transfer, Vehicle geometry & balance	1

1.1.4	Squat-dive and roll, Structural systems and performance	1
1.1.5	Equilibrium and inertia, Materials.	
1.2	***Chassis frame***	
1.2.1	Frame and its elements,	1
1.2.2	Loads acting on frame members	2
1.3	***Suspension & Steering system***	
1.3.1	Elements and functions, Types, Working principle, front and rear suspension	1
1.3.2	Spring rate and preload, Damper and damping	1
1.3.3	Wheel rate and wheel travel, Pitch and bounce	
1.3.4	Sprung and unsprung mass and ratio, Stabilizer	
1.3.5	Modeling & natural frequency ,Bearing types & loads- Upper & lower bracket	1
1.4	***Wheels and tyres***	
1.4.1	Type of wheels, functions & classification, Tyre fundamentals, types and characteristics	1
1.4.2	Tyre construction	1
1.4.3	Wheel balancing	
1.5	***Braking system***	
1.5.1	Braking fundamentals, classification, Drum brakes, Disc brakes	1
1.5.2	Hydraulic braking system. Major parts and their functions	1
2	**Engine and Power train**	
2.1	Forces in the crank mechanism	2
2.2	Piston velocity and acceleration	1
2.3	Combined turning moment and power	1
2.4	Crankshaft balancing	2
3	**Transmission system**	
3.1	**Clutch**	
3.1.1	Centrifugal type	1
3.1.2	Diaphragm clutch	
3.1.3	Torque converter	1
3.2	***Gear Box***	
3.2.1	Selection of gear ratio	1
3.2.2	Synchromesh gear box	1
3.2.3	Planetary gear box	1
3.2.4	Continuous Variable Transmission	

3.3	***Chain and Sprocket***	
3.3.1	Selection of speed ratio	1
3.3.2	Chain tension and slackness	
3.4	***Differential***	
3.4.1	Principle of operation	2
3.4.2	Limited slip differential	
3.4.3	Centre differential	
3.5	***Axles***	
3.5.1	Types of front and rear axles	2
3.5.2	Loads acting on front and rear axles	
3.5.3	Joints used in front axle	
4	**Electrical and Electronic Systems**	
4.1	***Automotive Batteries***	
4.1.1	Construction	1
4.1.2	Rating	1
4.1.3	Charging system	
4.2	***Lighting and signaling systems***	
4.2.1	Head light	2
4.2.2	Horns,Trafficators	
4.3	***Ignition system***	
4.3.1	Battery ignition system	1
4.3.2	Magneto ignition system	
4.3.3	Electronic ignition system	
4.4	***Starter motor***	
4.4.1	Principle of operation	1
4.4.2	construction	
4.5	***Generator***	
4.5.1	Principle of operation	1
4.5.2	Construction and characteristics	
4.6	***Automotive Electronics***	
4.6.1	Electronic fuel injection system (MPFI & CRDI)	1
4.6.2	Antilock braking system (ABS)	1
		42

Syllabus:

Chassis systems: ***Mobility& mechanics-*** Introduction to mobility, Resistance and inertia, Road loads and acceleration, Tractive and drag forces, Vehicle layout and kinematics Motorcycle physics and gyroscopic effects, Motion & load transfer, Vehicle geometry and balance, Squat-dive and roll, Structural systems and performance, Equilibrium and inertia, Materials. ***Chassis frame-*** Frame and its elements, Loads acting on frame members. ***Suspension & Steering system*** -Elements and functions, Types, Working principle, front and rear suspension, Spring rate and preload- Damper and damping- Wheel rate and wheel travel- Pitch and bounce -Sprung and unsprung mass and ratio- Stabilzer- Modeling & natural frequency - Bearing types and loads- Upper & lower bracket .***Wheels and tyres*** -Type of wheels-functions and classification- Tyre fundamentals, types and characteristics-tyre construction- Wheel balancing. ***Braking system***- Braking fundamentals-classification- Drum brakes- Disc brakes -Hydraulic braking system, Major parts and their functions.

Engine and Power train: Engine kinematics-Forces in the crank mechanism- Piston velocity and acceleration- Combined turning moment and power. Crankshaft balancing.

Transmission system: Clutch- Centrifugal type, Diaphragm clutch, Torque converter- ***Gear Box*** -Selection of gear ratio- Synchromesh gear box-Planetary gear box-Continuous Variable Transmission. ***Chain and Sprocket***- Selection of speed ratio-Chain tension and slackness. ***Differential-***Principle of operation-Limited slip differential-Centre differential. ***Axles-*** Types of front and rear axles-Loads acting on front and rear axles- Joints used in front axle.

Electrical and Electronic systems: ***Automotive Batteries***-Construction, Rating, Charging system- ***Lighting and signaling systems-***Head light, Horns,Trafficators- ***Ignition system-***Battery ignition system, Magneto ignition system, Electronic ignition system. ***Starter motor-*** Principle of operation, construction-***Generator/Alternator-***Principle of operation, construction, characteristics. **Automotive Electronics**- Electronic fuel injection system (MPFI & CRDI)- Antilock braking system (ABS).

Text books:

1. N.K.Giri, "**Automobile Mechanics**", Khanna Publishers, 2006.
2. Kirpal Singh, "**Automobile Engineering**", Volume-1&2, Standard Publishers Distributers, 2009.

Reference Books:

1. Tony Foale, "**Motorcycle Handling and Chassis Design**", 2nd Edition, Tony Foale, 2006.
2. William Crouse, "**Automobile Engineering Series** ", McGraw-Hill, 1988.
3. Newton and Steeds, "**Motor Vehicles** ", ELBS, 1985.
4. Richard Stone and Jeffrey K. Ball, "**Automotive Engineering Fundamentals**" SAE International, 2011.
5. Joseph Heitner, "**Automotive Mechanics, Principle and practices**", East West Press, (Second Edition), 2001.

Course designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GCV	3	0	-	**3**

GCV PRODUCTION AND OPERATIONS MANAGEMENT 3:0

Preamble: Operations Management is the science of managing operations for an enterprise or organization. The operations are the activities completely related with manufacturing of products or delivering the services. It has become an essential need to analyze the basic requirements for the production of goods or delivering the services in accordance with the demand of current market. The course work highlights the systematic approach in design, operation and improvement of the production systems that create the firm's primary products or services.

Programme outcomes addressed

a. Graduates will demonstrate the knowledge of engineering, mathematics and science.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

e. Graduates will demonstrate an ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints.

Competencies

At the end of the semester students will be able to

1. Explain the operations strategy for a Manufacturing Plant
2. Explain the concepts of product design and process selection.
3. Explain the concepts of Strategic Capacity Planning.
4. Explain the principles of location decision and layout planning.
5. Select the suitable forecasting method for a given environment.
6. Determine the product mix of a firm.
7. Determine the inventory level for independent and dependent demand.
8. Develop the schedule for Single/Flow/Job shop problems.

Assessment Pattern

SNo	Blooms Category	Tet1	Test2	Test3	Terminal Examination
1	Remember	20	20	20	20
2	Understand	30	30	30	30
3	Apply	50	50	50	50
4	Analyze				
5	Evaluate				
6	Create				

Course Level Learning Objectives

Remember

1. What is operations strategy?
2. What are order winners and order qualifiers?
3. What are the typical phases of product development?
4. Mention the factors considered before introducing a new product.
5. What do you understand by the term 'factor rating system'?
6. What are the various costs associated with inventory control?

Understand

1. How have the major priorities associated with operations strategy changed over years?
2. Explain the production line approach of service design.
3. Explain the significance of capacity utilization rate? How can that be improved?
4. Explain any one technique for locating single facility.
5. How will you use exponential smoothing method in forecasting?
6. Explain the sources of demand in MRP systems.

Apply

1. Suggest a suitable layout for a small scale automobile workshop?
2. Identify the high contact and low contact operations of the following services : a) an airline b) an automobile agency.
3. Suppose you were the manager of a restaurant and you were told honestly that a couple eating dinner had just seen a mouse. What would say to them? How will you recover from the service crisis?
4. Daily demand for a product is 100 units with a standard deviation of 25 units. The review period is 10 days and the lead time is 5 days. At the

time of review there is 50 units in stock. If 90 % of all demand is to be satisfied from the items in stock, how many units should be ordered?

5. Consider the following case where

   D = 10000 units, Ordering cost per order = Rs. 100

   Inventory carrying cost – 20 % of cost

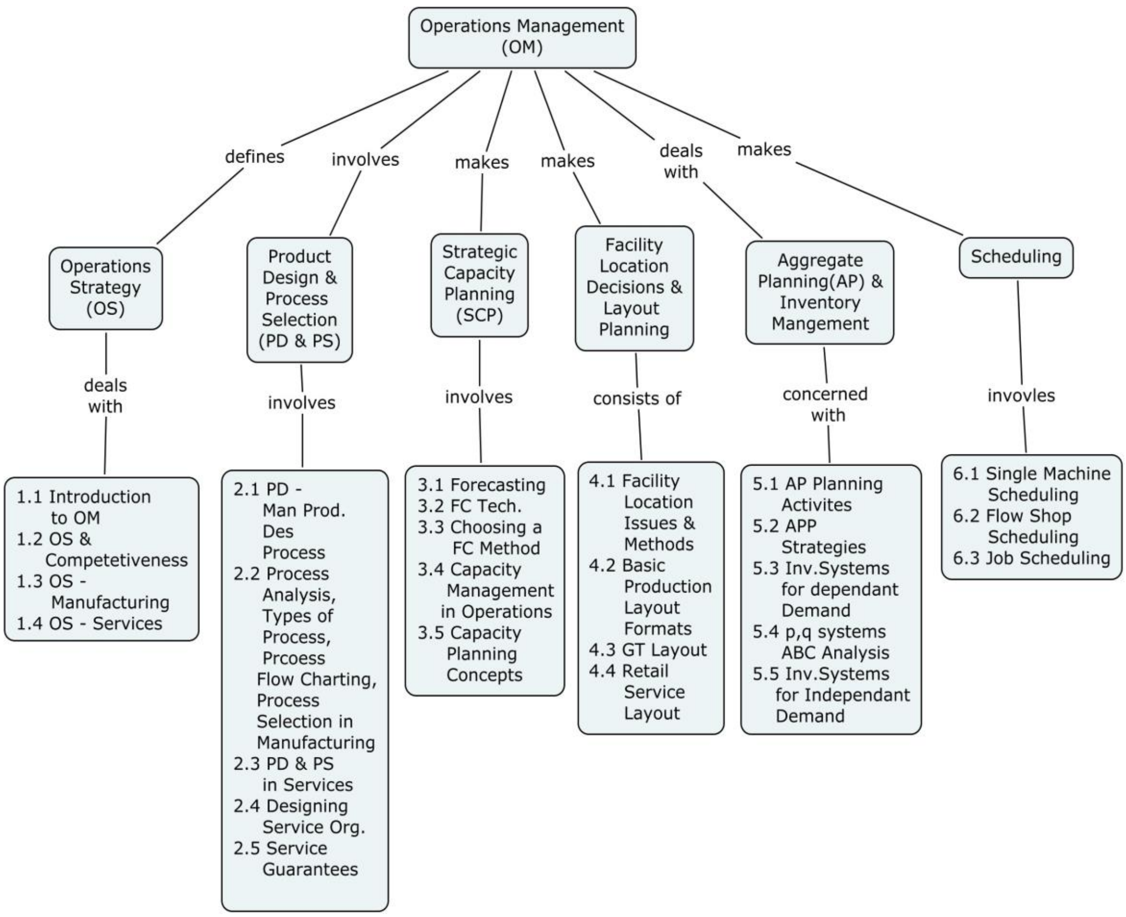
   Cost per unit is according to order of size and is as follows

Order size	0-499	500-999	1000 and above
Cost per unit	5	4.5	4

   What quantity should be ordered?

6. Product M is made up of 2 units of N and 3 of P. N is made up of 2 units of R and 4 units of S. R is made up of 1 unit of S and 3 units of T. P is made of 2 units of T and 4 units of U.
   a) Show the bill of materials (product structure tree)
   b) If 100 M are required, how many units of each component are needed?
   c) Show both a single level parts list and an indented parts list.

Concept map



Syllabus

Operations Strategy - Introduction to Operations Management

Operations Strategy and Competitiveness, Frame work for Operations Strategy in Manufacturing, Operations strategy in Services. **Product Design and Process Selection -** Product Design and Process Selection in Manufacturing - Product Design process, Process Analysis, Types of processes, Process Flow Charting and Process selection in Manufacturing- Product Design and Process Selection in Services - Nature of Services, Classification of Services, Designing Service Organizations, Contrasting Service Designs, Service Guarantees as Design Drivers

Strategic Capacity Planning- Forecasting - Forecasting techniques, Choosing a forecasting method- Capacity Management in operations, Capacity Planning Concepts.-**Facility Location and Layout Planning-** Issues in Facility Location, Plant Location Methods-Factor rating system, Gravity location method and Analytic Delphi Method, Locating service facilities-Basic production layout formats, process layout, group technology layout, retail service layout, office layout-**Aggregate Planning and Inventory Control -** Operations Planning Activities, Hierarchical Production Planning, aggregate production planning strategies - Inventory Systems for Independent Demand - Inventory costs, Independent Vs Dependent demand, Inventory systems, fixed order quantity models, fixed time period models, ABC analysis - Inventory Systems for Dependent Demand - MRP Type systems-MRP systems structure, MRP-II Lot sizing in MRP systems, Advanced MRP-Type systems.- **Scheduling-**Concept of single machine scheduling, Earliest Due Date Model to minimize Maximum lateness, Gantt Chart, Flow Shop- Johnsons Algorithm and CDS heuristics. Job shop scheduling – Types of schedule, use of priority dispatch rules.

Text Books:

1. Chase, Jacobs, Aquilano, "**Production and Operations Management**" 8th Edition, Tata McGraw Hill Companies Inc 2008.
2. Paneer Selvam R " **Production and Operations Management**" Prentice Hall of India, 2010

Reference Books:

1. Chary "**Theory and Problems in Production and Operations Management**" Tata Mc-Hraw Hill, 2009.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Operations Strategy**	
1.1	Introduction to Operations Management	2
1.2	Operations Strategy and Competitiveness	2
1.3	Frame work for Operations Strategy in Manufacturing	1
1.4	Operations Strategy in Servicing	1
2	**Product Design and Process Selection**	
2.1	PD and PS in Manufacturing - Product Design process	2
2.2	Process Analysis, Types of processes, Process Flow Charting and Process selection in Manufacturing	2
2.3	PD and PS in Services - Nature of Services, Classification of Services	1
2.4	Designing Service Organizations, Contrasting Service Designs	1
2.5	Service Guarantees as Design Drivers	1
3	**Strategic Capacity Planning**	
3.1	Forecasting	1
3.2	Forecasting techniques	2
3.3	Choosing a forecasting method	1
3.4	Capacity Management in operations	1
3.5	Capacity Planning Concepts	2
4	**Facility Location and Layout Planning**	
4.1	Issues in Facility Location, Plant Location Methods	2
4.2	Basic production layout formats	1
4.3	Group Technology Layout	1
4.4	Retail service layout, Office Layout	1

No.	Topic	No. of Lectures
5	**Aggregate Planning and Inventory Control**	
5.1	Operations Planning Activities, Hierarchical Production Planning	2
5.2	Aggregate Production Planning Strategies	2
5.3	Inventory Systems for Independent Demand - Inventory costs, Independent Vs Dependent demand	2
5.4	Inventory Systems, Fixed Order Quantity Models, Fixed Time Period Models, ABC Analysis	2
5.5	Inventory Systems for Dependent Demand - MRP Type systems-MRP systems structure, MRP-II Lot sizing in MRP systems, Advanced MRP-Type systems	2
6	**Scheduling**	
6.1	Concept of single machine scheduling, Earliest Due Date Model to minimize Maximum lateness, Gantt Chart	2
6.2	Flow Shop- Johnsons Algorithm and CDS heuristics	2
6.3	Job shop scheduling – Types of schedule, use of priority dispatch rules.	2
	Total	**42**

Course Designers:

1. Pl.K.Palaniappan plkpmech@tce.edu

2. R.Muruganandham rmmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
GCT	3	0	-	**3**

GCT Welding Technology 3:0

Preamble: Welding is one among the Metal joining processes for joining. Welding is required in the manufacture of various parts of boiler, air craft, automobiles, ships, nuclear reactor etc. The end product is obtained by joining the two similar or dissimilar materials by selecting suitable welding process. Advanced welding processes are developed to improve the quality of the product

Competencies:

At the end of the course students will be able to

1. Demonstrate the concepts of welding processes.
2. Understand the principles of various welding processes.
3. Understand the concepts of welding processes.
4. Apply the tool and techniques for welding process.
5. Analyze the applicability and limitations of the welding processes.

Assessment Pattern

Sl. No.	Bloom's Category	Test 1	Test 2	Test 3	End Semester examination
1	Remember	20	20	20	20
2	Understand	50	50	50	50
3	Apply	30	30	30	30
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. State the applications of gas tungsten arc welding process.
2. What are the factors that influence the coating formulation of electrodes for manual arc welding?
3. Define heat source efficiency.
4. What is hot tracking?
5. What are the problems encountered in HAZ when joining austenitic stainless steel in arc welding?
6. What are the considerations governing post heating of welds?

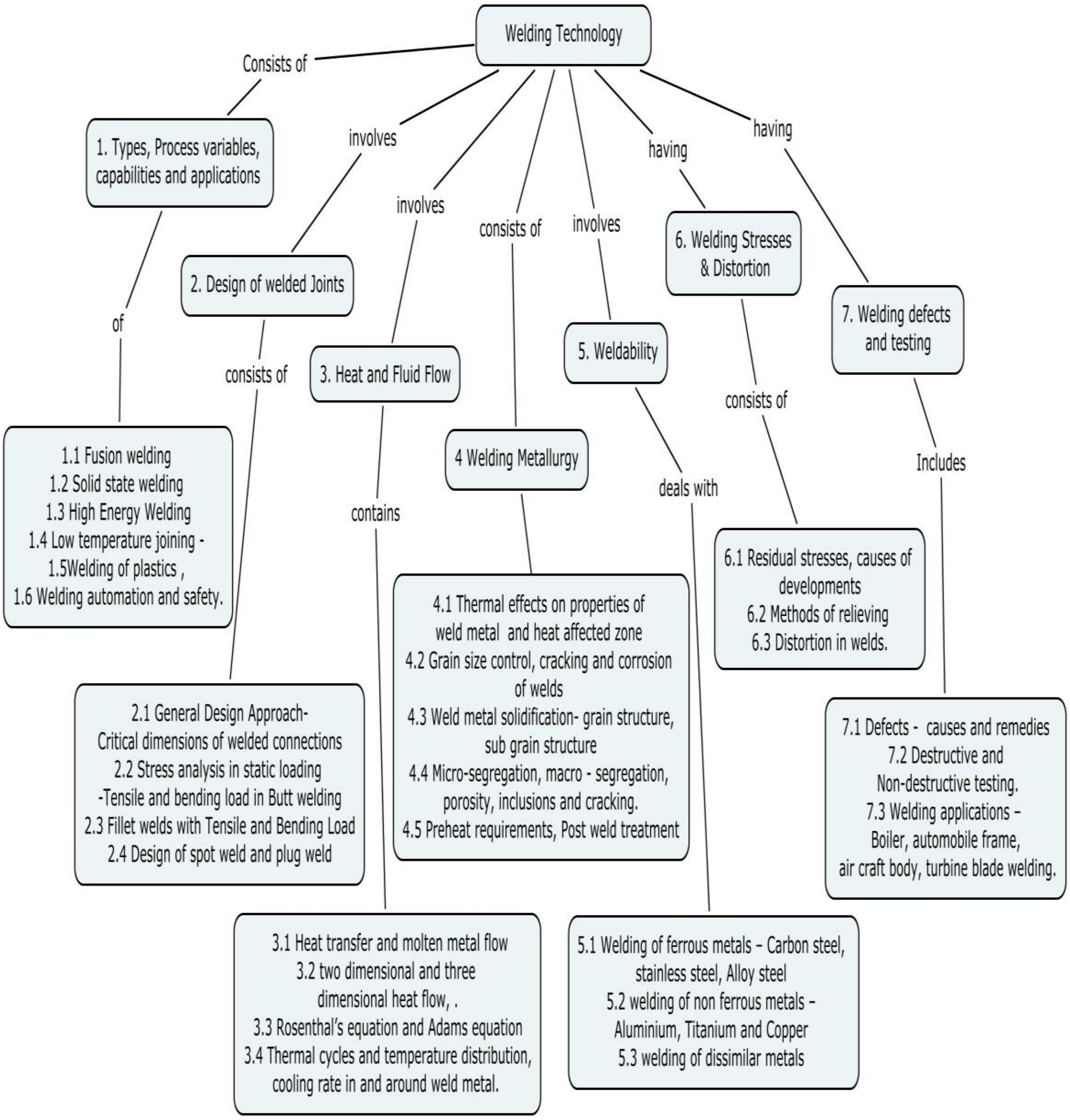
Understand

1. Explain how group geometry becomes critical for root pass.
2. Explain the role of frictional speed and pressure in deciding the shape of HAZ of frictional weld.
3. Discuss why manganese content is restricted to 1.4 % in steel weld metal.
4. Explain the effects of flashing current in flash butt welding process in quality of welds.
5. Explain any two non-destructive testing of welded joints.
6. Discuss the relation between weldability and hardenability of unalloyed steel.

Apply

1. Micro cracking is typical problem in welding of nickel base alloy. Suggest suitable techniques to prevent cracks.
2. A Rectangular plate 15 mm thick and 30 mm width is welded to another plate. The length of the plate is 75 mm. if the tensile strength of the weld is 30 MPa and its shear strength 15 MPa, find in each case separately, (a). The tensile load, (b). The bending moment and (c). The twisting moment that could be applied on the joint.
3. Two MS plates each 4 mm thick are to be spot welded. If the strength of the weld is 200 MPa. Determine (a). Weld nugget diameter, (b). Distance between spot weld, (c). Overlay distance and (d). Strength of the joints.
4. Select a suitable process to weld boiler shell and explain with necessary sketches.
5. Conventional CCT diagrams developed for heat treatment of steels are not all that useful for assessing the micro-structural aspects of HAZ of weldments. True or false? Give reasons.
6. Suggest a suitable method to weld a dissimilar metal. Justify your selection.

Concept Map



Syllabus

Types, Process variables, capabilities and applications: Fusion welding – Types, Process variables, capabilities and application , Solid state welding – Types, Process variables, capabilities and application, High Energy Welding - Types, Process variables, capabilities and application , Low temperature joining - Types, Process variables capabilities and application , Welding of plastics. , Welding automation and safety. **Design of welded Joints-** General Design Approach-Critical dimensions of welded connections, Stress analysis in static loading -Tensile and bending load in Butt welding, Fillet welds with Tensile and Bending Load, Design of spot weld and plug weld. **Heat and Fluid Flow-** Heat transfer and molten metal flow, two dimensional and three dimensional heat flow, Rosenthal's equation and Adams equation - Thermal cycles and temperature distribution, cooling rate in and around weld metal. **Welding Metallurgy -** Thermal effects on properties of weld metal and heat affected zone, grain size control, cracking and corrosion of welds, Weld metal solidification-grain structure, sub grain structure, Micro - segregation, macro-segregation, porosity, inclusions and cracking, reheat requirements, Post weld treatment. **Weldability**: welding of ferrous metals – Carbon steel, stainless steel, Alloy steel – welding of non ferrous metals – Aluminium, Titanium and Copper – welding of dissimilar metals – **Welding Stresses & Distortion:** Residual stresses, causes of developments, methods of relieving - Distortion in welds. **Welding defects and testing**: Defects and decay - causes and remedies, Destructive and Non-destructive testing, Welding applications – Boiler, automobile frame, air craft body, turbine blade welding-case study.

Text Book

1. Little R.L, "**Welding and Welding Technology**" - Tata McGraw Hill Publishing Ltd, New Delhi, 1989.
2. Parmer R.S, "**Welding Engineering and Technology**", 2nd Edition Khanna publishers, Delhi, 2010.

Reference Books:

1. Sindo Kou, "**Welding Metallurgy**", Wiley Interscience, USA, 2003.
2. Davies, A.C, **"Welding**", 10th Edition, Cambridge University press, 1996.
3. Radhakrishnan V.M **"Welding Technology and Design"**- New Age International Pvt Ltd Publishers, New Delhi, 2010 Reprint.
4. Howard B. Cary, "**Modern Welding Technology**", Prentice Hall Inc, New Jersey, 1979.
5. Khanna, O.P, "**A Text Book of Welding Technology**", – Dhanpat Rai Publications (P) Ltd., New Delhi, 1998.
6. AWS Welding Handbook**, Volume 1, Welding Science & Technology, American Welding Society, 2001.**
7. AWS Welding Handbook**, Volume 2, Welding Processes, Part 1**, **American Welding Society, 2004.**
8. AWS Welding Handbook**, Volume 3, Welding Processes, Part 2, American Welding Society, 2004.**

Course contents and Lecture schedule

No	Topics	No. of Lectures
1	**Process variables, capabilities and applications**	
1.1	Fusion welding - Types	1
1.2	Solid state welding – Types	1
1.3	High Energy Welding – Types	1
1.4	Low temperature joining - Types	1
1.5	Welding of plastics	1
1.6	Welding automation and safety	1
2	**Design of welded Joints**	
2.1	General Design Approach-Critical dimensions of welded connections	1
2.2	Stress analysis in static loading -Tensile and bending load in Butt welding	2
2.3	Fillet welds with Tensile and Bending Load	2
2.4	Design of spot weld and plug weld	2
3.	**Heat and Fluid Flow**	
3.1	Heat transfer and molten metal flow	1
3.2	two dimensional and three dimensional heat flow	2
3.3	Rosenthal's equation and Adams equation	2
3.4	Thermal cycles and temperature distribution, cooling rate in and around weld metal.	2
4	**Welding Metallurgy**	
4.1	Thermal effects on properties of weld metal and heat affected zone	2
4.2	grain size control, cracking and corrosion of welds	2
4.3	Weld metal solidification-grain structure, sub grain structure	1
4.4	Micro - segregation, macro-segregation, porosity, inclusions and cracking.	2
4.5	Preheat requirements, Post weld treatment	2
5	**Weldability**	
5.1	Welding of ferrous metals – Carbon steel, stainless steel, Alloy steel	2
5.2	welding of non ferrous metals – Aluminium, Titanium and Copper	2

No	Topics	No. of Lectures
5.3	welding of dissimilar metals	1
6	**Welding Stresses & Distortion:**	
6.1	Residual stresses, causes of developments,	1
6.2	methods of relieving	1
6.3	Distortion in welds.	1
7	**Welding defects and testing**:	
7.1	Defects and Decay- causes and remedies	1
7.2	Destructive testing and Non-destructive testing	2
7.3	Welding applications – Boiler, automobile frame, air craft body, turbine blade welding-case study.	2
	Total	**45**

Course Designers

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

SEVENTH and EIGHTH SEMESTERS

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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Web: www.tce.edu

Board of studies meeting on 27.04.13 Approved in 46th Academic Council meeting on 10.08.13

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Mechanical Engineering
Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0				G84 Project 0:12		
7th (21)	G71 Management Theory and Practice 3:0	G72 Operations Research 3:1	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G77 Manufacturing System Simulation Lab 0:1	G78 Project 0:4	
6th (23)	G61 Accounting and Finance 3:0	G62 Design of Transmission System 3:1	G63 Quality and Reliability Engineering 3:0	G64 Mechatronics 3:0	Elective 1 3:0	Elective 2 3:0	G67 Computer Aided Engineering Lab 0:1	G68 Mechatronics Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Kinematics and Dynamics of Machinery 3:1	G53 Metrology and Mechanical Measurements 3:0	G54 Heat and Mass Transfer 3:1	G55 Manufacturing Processes and Automation 3:0	G56 Industrial Engg. 3:0	G57 CAD/CAM Lab 0:1	G58 Heat Transfer Lab 0:1	G59 Mech. Measurement and Metrology Lab 0:1
4th (24)	G41 Numerical Methods 3:1	G42 Design of Machine Elements 3:1	G43 Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Control Systems 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (23)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 4:0	G33 Applied Material and Metallurgy 3:0	G34 Fluid Mechanics 4:0	G35 Metal Casting and Plastic forming processes 2:0	G36 Metal Forming and Joining Processes 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics and CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Ecology and Environment 2:0	G26 Computer Programming 3:0	G27 Strength of Materials and Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

SEVENTH SEMESTER

Subject code	Name of the subject	Category	No. of Periods / Week			credits
			L	T	P	
THEORY						
G71	Management Theory and Practice	DC	3	0	-	3
G72	Operations Research	DC	3	1	-	4
GCX	Elective – 3	DC	3	0	-	3
GCX	Elective – 4	DC	3	0	-	3
GCX	Elective – 5	DC	3	0	-	3
PRACTICAL						
G77	Manufacturing System Simulation Lab.	DC	-	-	3	1
G78	Project	DC	-	-	8	4
Total			**15**	**1**	**11**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

SEVENTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G71	Management Theory and Practice	3	50	50	100	25	50
2	G72	Operations Research	3	50	50	100	25	50
3	GCX	Elective – 3	3	50	50	100	25	50
4	GCX	Elective – 4	3	50	50	100	25	50
5	GCX	Elective – 5	3	50	50	100	25	50
PRACTICAL								
7	G77	Manufacturing System Simulation Lab.	3	50	50	100	25	50
8	G78	Project	-	150	150	300	75	150

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

EIGHTH SEMESTER

Subject code	Name of the subject	Category	No. of Periods / Week			credits
			L	T	P	
THEORY						
GCX	Elective – 6	DC	3	0	-	3
GCX	Elective – 7	DC	3	0	-	3
GCX	Elective – 8	DC	3	0	-	3
PRACTICAL						
G84	Project	DC	-	-	24	12
	Total		**9**	**-**	**24**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

EIGHTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	GCX	Elective – 6	3	50	50	100	25	50
2	GCX	Elective – 7	3	50	50	100	25	50
3	GCX	Elective – 8	3	50	50	100	25	50
PRACTICAL								
4	G84	Project	-	150	150	300	75	150

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

Sub Code	Lectures	Tutorial	Practical	Credit
G 71	3	0	-	3

G71 Management Theory and Practice 3:0

Preamble: Management is the science of managing operations for an enterprise or organization. It deals with managing men, material, machinery and money. It has become an essential need to analyze the basic concepts of management theory and to understand the ways and means of implementing them in practice. The course work highlights the systematic approach for the management of various departments in an organization.

Program outcomes addressed

b) An ability to design and conduct experiments, as well as to analyze and interpret data

e) An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

g) An ability to function on multidisciplinary teams

i) An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.

Competencies

At the end of the course, the student will be able to

1. Manage the operations in total for an enterprise.
2. Work with team spirit and group coordination.
3. Ability to design Organizational Structure
4. Facilitate an effective communication both within and outside a firm.
5. Formulate the selection and recruitment procedures for a department
6. Evolve proper performance appraisal system
7. Analyze and identify an effective site selection and design a proper layout.
8. Prepare maintenance schedules for an organization.
9. Ability to measure overall productivity and suggest means to improve it
10. Plan the material handling systems for the organization.

Assessment Pattern

S.No.	Blooms Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	20	20	20	20
2	Understand	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	-	-	-	-
5	Evaluate	-	-	-	-
6	Create	-	-	-	-

Course Level Learning Objectives

Remember

1. Define Management.
2. What are the various functions of management?
3. Distinguish between MBO and MBE.
4. Define Group Cohesiveness.
5. What do you mean by semantic barrier of communication?
6. What type of industry requires process type layout?

Understand

1. Briefly explain all the functions of Management
2. Explain various controlling techniques.
3. Compare job enrichment with job enlargement.
4. Compare the merits and demerits of product and process layouts.
5. Enumerate all the human factors associated with productivity.
6. Enumerate all the ways of measuring productivity.

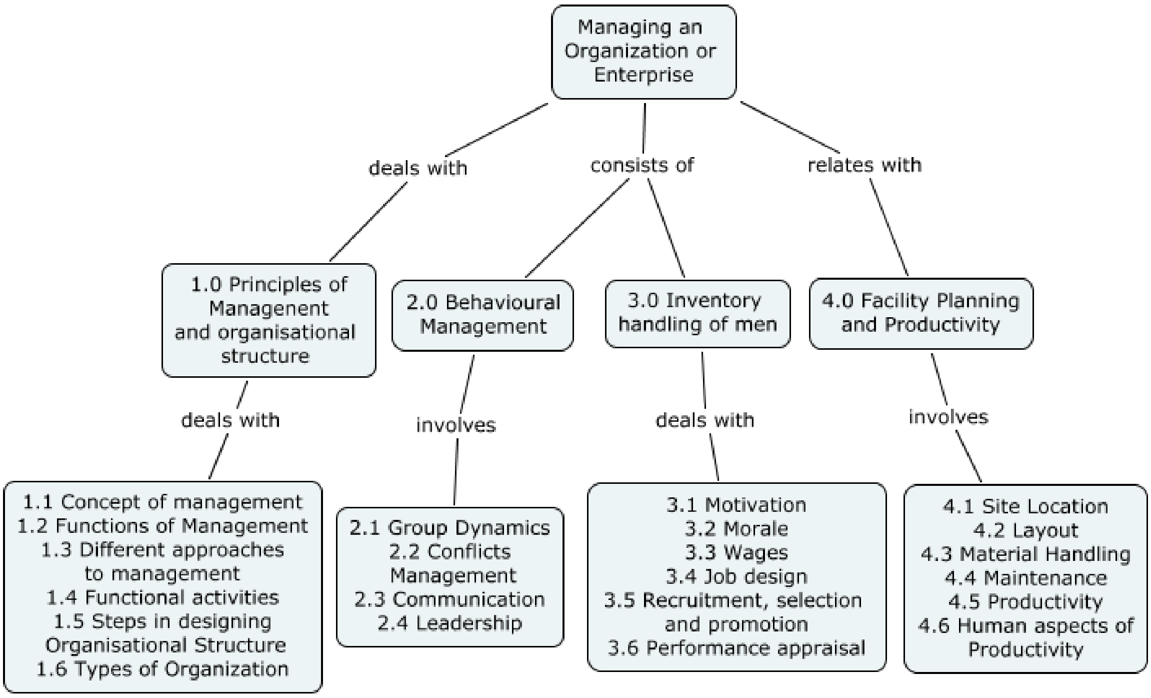
Apply

1. Bring out all the steps in the formation of a Quality Circle in an educational institution.
2. Suggest the modalities of selection of a trainee engineer to be recruited for a software firm.
3. You as a manager prepare a proposal to locate a site to establish a telecommunication industry.
4. Suggest all the possible ways to increase the overall productivity of a manufacturing sector.
5. Prepare a preventive maintenance schedule for an electronic equipment manufacturing company which operates for three shifts in 24 hours for 8

hours per shift by 6.00 AM to 2.00 PM, 2.00 PM to 10.00 PM and 10.00 PM to 6.00 AM.

6. Prepare a list of factors considered for a site location for an Educational institution in around in your city.

Concept map



Syllabus

Management and Functions of Management

Concept of management, Management, organization, Administration-Management is Science or Art, Taylors Scientific Management – Henry Fayol's Principles of management -Functions of management, planning, Organizing, Staffing, Coordinating, Directing and Controlling, different approaches to management, various functional activities of different departments, Strategic planning, MBO, Management by exception, Organization Structure- Principles, Steps in designing an Organization-Types of Organization.

Behavioural Management

Group dynamics, types of groups, formation of group, Group cohesiveness, conflicts management, Communication –meaning and types, barriers in communication, communication in Groups, Leadership styles

Human Resources Management

Objectives-employer-employee relations-Motivation-Morale-Ways of achieving high morale-collective bargaining - Psychology - Wage and wage payments-incentives-job design, job analysis-job description, job rotation, job evaluation and merit rating-Recruitment, Selection and training of employees-Promotion-Performance appraisal-Outsourcing Management-issues.

Facility Planning and Productivity

Site location-Factors to be considered-layout-objectives, types, factors influencing layout, layout procedure-Materials handling-principles, factors affecting the choice of materials handling, Materials handling equipment-Plant maintenance-need functions and types-Productivity-definition and concept, measurement-techniques for productivity measurement-Human aspects of productivity.

Note: Faculty members to give case studies for different sector like IT, construction sectors and also manufacturing sectors with visual aids.

Text Books

1. Koontz O'donnel, "**Essentials of Management**", Tata Mc-Graw Hill, 2004.
2. O.P. Khanna, "**Industrial Engineering and Management**", Khanna Publishers, 2008.

References

1. Chase, Jacobs, Aquilano, "**Production and Operations Management**" 8th Edition, Tata McGraw Hill Companies Inc, 1999.
2. Fred Luthans "**Organizational Behaviour**", Tata McGraw Hill, 2005.
3. Edwin Flippo, "**Personnel Management**", Tata McGraw Hill,2004.
4. R.N. Gupta, "**Principles of Management**", S.Chand and Co Ltd, 2008.

Course Contents and Lecture Schedule

No.	**Topic**	**No. of Lectures**
1	**Management and Functions of Management**	
1.1	Concept of management, Organization, Administration, Management is science or art, Taylor's Scientific Management, Henry Fayol's Principles of management	3
1.2	Functions of management, Planning, organizing, Staffing, Coordinating, Directing and controlling	3
1.3	Different approaches to management	1
1.4	Functional activities, Strategic Planning, MBO, MBE	1
1.5	Principles and Steps Designing Organization structure	2
1.6	Types of Organization	1
2	**Behavioural Management**	
2.1	Group Dynamics, types of group, formation of group,	3

No.	Topic	No. of Lectures
	group cohesiveness	
2.2	Conflicts management	2
2.3	Communication, meaning and types, barriers in communication , communication in groups	3
2.4	Leadership styles	2
3	**Human Resources Management**	
3.1	Employer employee relations, Motivation	3
3.2	Morale, ways of achieving high morale, collective bargaining, Psychology	1
3.3	Wages, wage and wage payments, incentives	1
3.4	Job Design, job analysis-job description, job rotation, job evaluation and merit rating	3
3.5	Recruitment, Selection and Promotion	3
3.6	Performance appraisal-Outsourcing Management-issues.	3
4	**Facility Planning and Productivity**	
5.1	Site Location , factors to be considered	1
5.2	Layout objectives, types , factors influencing layout, layout procedure	2
5.3	Material Handling, principles, factors affecting the choice of materials handling, materials handling equipments	2
5.4	Maintenance, need, functions and types	2
5.5	Productivity, definition and concept, measurement-techniques for productivity measurement	1
5.6	Human aspects of Productivity	2
	Total	**45**

Course Designers

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2. S. Karthikeyan skarthikeyanlme@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
G 72	3	1	-	4

G72 Operations Research 3:1

Preamble: Operations research is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources.

The term *operations research* was coined during World War II when British military leaders asked scientists and engineers to analyze several military problems such as the deployment of radar and the management of convoy, bombing, antisubmarine, and mining operations. Because of the complexity of most real-world problems, it has been necessary for researchers and practitioners, when applying mathematical approaches, to reduce the complexity of the problem by either simplifying the problem or constraining it by making numerous assumptions.

A model is an abstraction or mathematical representation of a problem of interest and is an essential part of the process of solving that problem optimally. However, it is difficult, and sometimes impossible, to develop a mathematical model that addresses all aspects of the problem and its planning environment, since most real-world problems are too complex and involved. As the modelling approach provides solutions to the simplified or approximated problem, there may exist a significant discrepancy between those solutions and the subjectively expected realistic solution to the original problem.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

i. Graduates will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

k. Graduate can participate and succeed in competitive examinations.

Competencies: At the end of the course the student should be able to

1. Understand the phases of Operations Research study
2. Formulate allocation problems mathematically in the frameworks of Linear Programming (LP) and Integer Programming (IP)
3. Solve LP problems by graphical, simplex methods
4. Solve IP problems using branch and bound method

5. Formulate transportation and assignment problems as LPP
6. Solve transportation and assignment problems using special algorithms
7. Model project scheduling problem as a Network.
8. Solve project scheduling problems using PERT and CPM.
9. Solve inventory problems formulated as purchase, production, and news-paper boy models
10. Solve single channel and multi-channel queuing problems
11. Solve replacement problems
12. Solve sequencing and production scheduling problems

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test 3**	**End-semester examination**
1	Remember	10	10	10	10
2	Understand	10	10	10	10
3	Apply	80	80	80	80
4	Analyze	0	0	0	0
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. What are the phases of operations research?
2. What do you mean by degeneracy in transportation problem?
3. Define Lead time.
4. What do you mean by Kendall's notation.
5. What is dummy activity and when is it needed?
6. Define Traffic Intensity.

Understand

1. What is the importance of the slack variables in simplex method?
2. How to find that a LPP has got an alternate optimal solution from the optimal simplex table?
3. Write the mathematical formulation of Assignment problem.
4. Differentiate PERT and CPM.
5. How does a fixed order quantity system (Q-system) and periodic review system (P-system) differ in placing an order?
6. What is a queuing problem and explain transient and steady state?

Apply

1. A company manufacturer two types of products, P1 and P2. Each product uses lathe and milling machine. The processing time per unit of P1 on the lathe is 5 hours and on the milling machine is 4 hours. The processing time per unit of P2 on the lathe is 10 hours and on the milling machine is 4 hours. The maximum number of hours available per week on the lathe and milling machine are 60 hours and 40 hours, respectively. Also, profit per unit of selling P1 and P2 are Rs.6 and Rs.8, respectively. Formulate a linear programming model to determine the production volume of each of products such that the total profit is maximized.
2. Solve the following transportation problem

	I	II	III	IV	Supply
A	4	6	8	13	50
B	13	11	10	8	70
C	14	4	10	13	30
D	9	11	13	8	50
Demand	25	35	105	20	

3. A travelling salesman has to visit five cities. He wishes to start from a particular city, visit each city once and then return to his starting point. Cost of travel from one city to another is shown below. Determine the least cost route.

		To				
		A	B	C	D	E
	A	∞	4	10	14	2
	B	12	∞	6	10	4
From	C	16	14	∞	8	14
	D	24	8	12	∞	10
	E	2	6	4	16	∞

4. The following table provide the activities in a construction project and other relevant information:

Activity	Normal		Crash	
	Time (Days)	Cost (Rs.)	Time (Days)	Cost (Rs.)
1-2	8	100	6	200
1-3	4	150	2	350
2-4	2	50	1	90
2-5	10	100	5	400

3-4	5	100	1	200
4-5	3	80	1	100

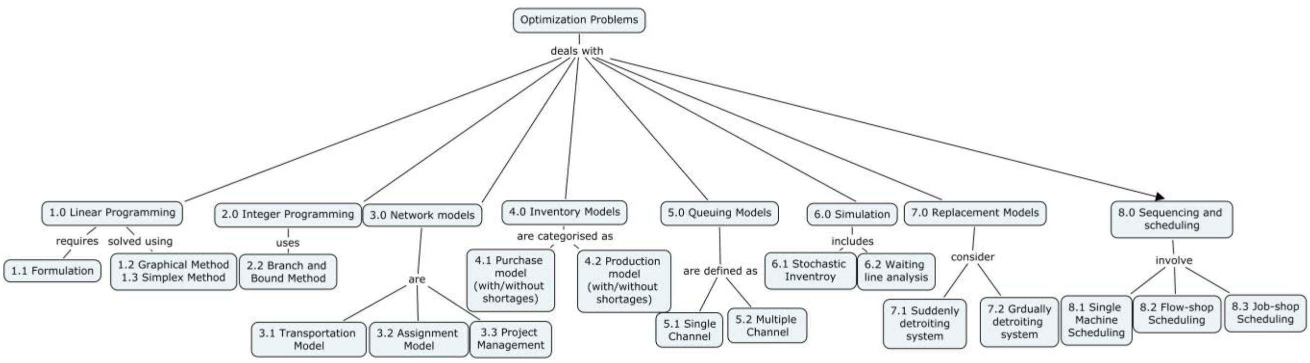
Assume indirect cost is Rs. 100 per day. Suggest the project duration for least cost by analyzing the effect of reduction in cost by crashing.

5. A self service store employs one cashier at its counter. Nine customers arrive on an average every 5 minutes while the cashier can serve 10 customers in 5 minutes. Assuming poisson distribution for arrival rate and exponential distribution for service time , find (i) Average number of customers in the system and queue (ii) Average time a customer spends in the system (iii) Average time a customer waits before being served.

6. Use graphical method to minimize the time required to process the following jobs on the machines. For each machine specify the job which should be done first. Also calculate the total elapsed time to complete both jobs.

Job 1	sequence:	A	B	C	D	E
	Time(hrs)	6	8	4	12	4
Job 2	sequence:	B	C	A	D	E
	Time(hrs)	10	8	6	4	12

Concept Map



Syllabus

Linear Programming

Phases of Operations Research - Linear Programming: Formulation - Graphical Method and Simplex Method (2 variable problems only)

Integer Programming

Integer Programming: Formulation - Branch and Bound Method (2 variable problems only)

(Note: Problems with more than 2 variables and more number of constraints to be practiced in LINDO/LINGO/Excel/ILog as Programming Assignments)

Network Problems

Transportation Problem: Formulation - Initial solutions using North West Corner Method, Least Cost Method and Vogel's Approximation Method - Modified Distribution Method (MODI)

Assignment Problem: Formulation - Hungarian Method

Project Management: Network Construction – Terminologies - Critical Path Method (CPM) – crashing - Programme Evaluation and Review Technique (PERT)

Inventory Models

Purchase Model (without and with shortages) - Production Model (without and with shortages) - Newspaper Vendor Problem - P-System and Q-System

Queuing Models

(Poisson Arrival and Exponential Service pattern)

Basic Terminologies - Single Channel with infinite population queue - Single Channel with finite population queue - Multiple Channel with infinite population Queue

Simulation

Stochastic inventory models – Waiting line analysis.

Replacement Models

Replacement of suddenly detroiting system - gradually detroiting system

Sequencing and Scheduling

Scheduling objectives – setup dependent single machine – Johnson's algorithm for 'n' jobs 2/3-machines flow-shop – Graphical method for '2' jobs 'k'-machines job-shop.

Text Book:

1. Sharma.J.K., "**Operations Research : Theory and applications**", Macmillan India Ltd., Fourth Edition, 2009.

Reference Books:

1. Hamdy A. Taha, "**Operations Research - An Introduction**", Macmillan Co., Seventh Edition 2003.
2. Panneerselvam, R., "**Operations Research**", Prentice Hall, Second Edition, 2007.
3. Ravindran A., Don. T. Phillips, and James J. Solberg, "**Operations Research - Principles and Practice**", John Wiley and Sons, Second Edition, 2000.
4. Hiller / Lieberman, "**Introduction to Operations Research**" Tata McGraw Hill, Seventh Edition, 2001
5. Wayne L. Winston, "**Operations Research: Applications and Algorithms**", Thomson Brooks/Cole, Fourth Edition, 2003.

6. Ronald L Rardin, "**Optimisation in Operations Research**" Pearson Education Asia, First Indian reprint, 2002.

Course Contents and Lecture schedule

S.No	Topics	No. of Lectures
	Introduction: Phases of Operations Research	1
1	**Linear Programming**	
1.1	Linear Programming (LP): Formulation	2
1.2	Graphical Method for LP problems	2
1.3	Simplex Method for LP problems	2
2	**Integer Programming**	
2.1	Integer Programming(IP): Formulation	1
2.2	Branch and Bound Method for IP problems	2
3	**Network Models**	
3.1	Transportation Problem(TP): LP Formulation	1
3.2	Initial Basic Feasible solutions for TP using North West Corner Method, Least Cost Method and Vogel's Approximation Method	1
3.3	Optimal solution for TP using Modified Distribution Method (MODI)	2
3.4	Assignment Problem (AP): Formulation	1
3.5	Hungarian Method for AP	1
3.6	Project Management: Network Construction – Terminologies – LP Formulation	2
3.7	Critical Path Method (CPM) and crashing	3
3.8	Programme Evaluation Review Technique (PERT)	2
4	**Inventory Models**	
4.1	Purchase Model (with and without shortages)	2
4.2	Production Model (with and without shortages)	2
4.3	Newspaper Vendor Problem	1
4.4	P-System and Q-System	1
5	**Queuing Models** (Poisson Arrival and Exponential Service pattern)	
5.1	Queuing Terminologies and applications	1
5.2	Single Channel – Infinite population Queue	1
5.3	Single Channel – Finite population Queue	1

S.No	**Topics**	**No. of Lectures**
5.4	Multiple Channel – Infinite population Queue	1
6	**Simulation**	
6.1	Stochastic inventory models	2
6.2	Waiting line analysis	1
7	**Replacement Models**	
7.1	Replacement of suddenly detroiting system	2
7.2	Replacement of gradually detroiting system	2
8	**Sequencing and Scheduling**	
8.1	Scheduling objectives	1
8.2	Setup time dependent single machine scheduling	1
8.3	Johnson's algorithm for 'n' jobs 2-machines flow-shop scheduling	1
8.4	Johnson's algorithm for 'n' jobs 3-machines flow-shop scheduling	1
8.5	Graphical method for '2' jobs 'k'-machines job-shop scheduling	1
	Total	**45**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G 77	0	0	2	1

G77 Manufacturing System Simulation Lab 0:1

The following are the list of experiments.

List of Experiments:

1. Development of a simulation model for manufacturing / assembly system
2. Simulation analysis of capacity balancing of manufacturing / assembly system
3. Capacity increment analysis of manufacturing / assembly system by insertion of a new automated machine
4. Discrete event Simulation analysis of a Paint shop of manufacturing / assembly system
5. Simulation analysis of allocation of resources in a show room based on labor cost.
6. Validation of cast design methods for the given component by simulation
7. Job sequencing analysis in single machine job shop.
8. Capacited plant location analysis
9. Construction and analysis of control charts for variables using SPCIV software
10. Construction and analysis of control charts for attributes using SPCIV software
11. Construction and analysis of control charts for defects using SPCIV software
12. Conduct a two way analysis of variance of manufacturing process using MiniTab software

Course Designer:

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAM

DEPARTMENT ELECTIVES

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

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List of Department Electives

G CA	Energy Conversion Systems
G CB	Basics of Aircraft Engineering
GCC	Automotive Engine Systems
GCD	Mechatronics System Design
GCE	Material Handling Systems and Engineering
GCF	Theory of Metal Cutting
GCG	Manufacturing System Engineering
GCH	Marketing Management
GCK	Refrigeration and Air Conditioning
GCL	Computational Fluid Dynamics
GCM	Finite Element Analysis
GCN	Design of Jigs, Fixtures and Press Tools
GCP	Metal Forming Technology
GCQ	Machine Vision
GCR	Product Design and Development
GCS	Automotive Engineering
GCT	Welding Technology
GCU	Computer Integrated Manufacturing
GCV	Production and Operations Management
GCW	Vehicle Design Engineering
GCY	Turbo Machines
GCZ	Mechanical Vibration

Electives passed on 44th Academic Council Meeting on 09.06.12

GCK	Refrigeration and Air Conditioning
GCR	Product Design and Development

Electives passed on 45th Academic Council Meeting on 24.11.12

GCH	Marketing Management
GCL	Computational Fluid Dynamics
GCQ	Machine Vision
GCS	Automotive Engineering
GCT	Welding Technology
GCV	Production and Operations Management

Electives to be passed in 46th Academic Council Meeting on 10.08.13

G CA	Energy Conversion Systems
GCC	Automotive Engine Systems
GCE	Material Handling Systems and Engineering
GCF	Theory of Metal Cutting
GCG	Manufacturing System Engineering
GCM	Finite Element Analysis
GCN	Design of Jigs, Fixtures and Press Tools
GCP	Metal Forming Technology
GCW	Vehicle Design Engineering
GCY	Turbo Machines
GCZ	Mechanical Vibration

Sub Code	Lectures	Tutorial	Practical	Credit
G CA	3	0	0	3

G CA Energy Conversion Systems 3:0

Preamble: This course is designed to enable the students to understand and Graduates will demonstrate an ability to identify, formulate and solve Engineering compare the various energy conversion systems and its applications. The course focuses on fossil fuels and renewable energy utilization for power generation.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

f. Graduates will demonstrate skills to use modern Engineering tools, software and equipments to analyze problems.

Competencies:

At the end of the course the student will be able to

1. Explain the energy status and the availability of energy resources for future.
2. Describe the principle of various energy conversion systems
3. Examine various energy conversion technologies and compare their potential.
4. Explain the most viable choices of energy sources and conversion techniques.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test 3**	**End-semester examination**
1	Remember	20	20	20	20
2	Understand	60	60	60	60
3	Apply	20	20	20	20
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. Define High pressure boiler
2. What is the advantage of using fluidized bed in boilers?
3. Name the types of reactors.

4. Name any two combined power cycles.
5. What are the advantages of wind power generation?
6. Name the different biofuels available for power generation.

Understand

1. Explain different methods of starting of Diesel Engine Plant.
2. Describe the different methods to improve efficiency of gas turbine.
3. Explain applications of solar energy.
4. Explain the ash handling plant of thermal power station.
5. Describe the hydraulic ash handling system.
6. Describe the fast breeder reactor.

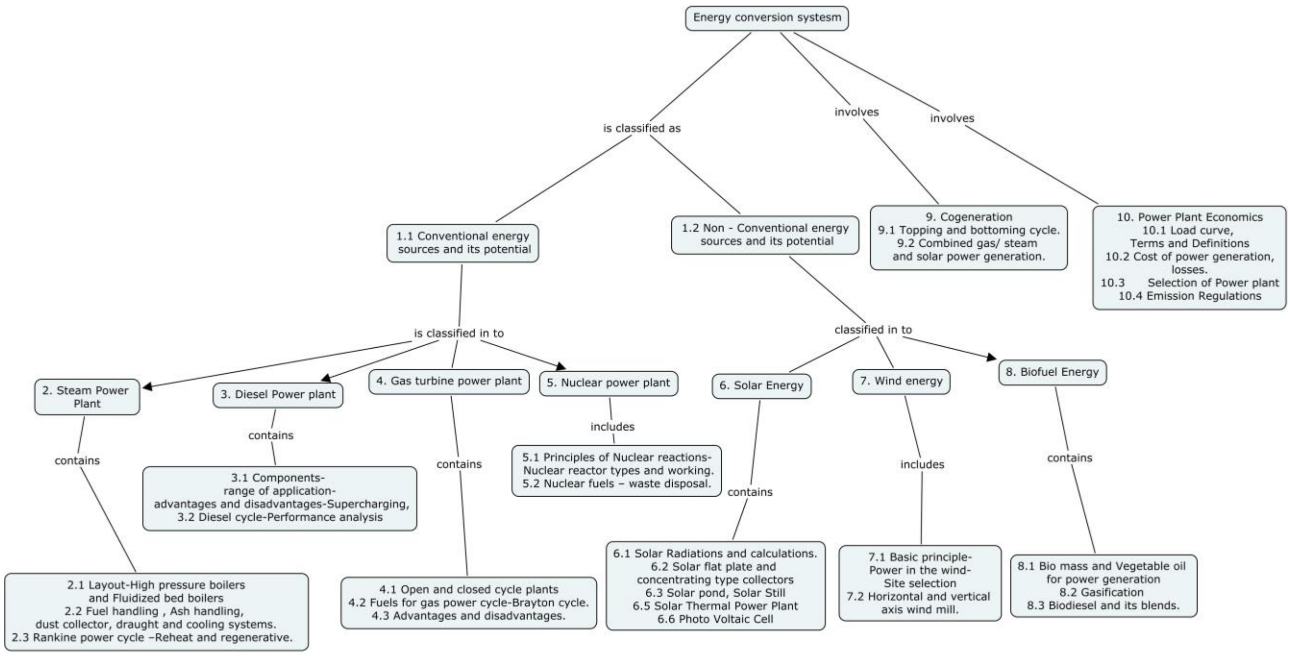
Apply

1. In a test on a single cylinder oil engine with 30 cm bore and 45 cm stoke and working on four stroke cycle, the following observations were made:
   Duration of trial = 1 hour, TFC = 7.6 kg, Calorific value of the fuel = 45000 kJ/kg, Total revolution made = 12000, Room temperature = 20^0 C, IMEP = 6 bar, Net brake load = 150 kg, Brake drum diameter = 180 cm, Rope diameter = 3 cm, Mass of the jacket cooling water = 550 kg, Inlet temperature of the jacket cooling water = 15^0 C, Outlet temperature of the jacket cooling water = 60^0 C, Temperature of exhaust gases = 300^0 C, Total air consumption = 365 kg, Specific heat of exhaust gases = 1 kJ/kg K.
   Calculate the Indicated power, brake power, mechanical efficiency, and indicated thermal efficiency.
2. A gas turbine power plant consists of one turbine as compressor drive and the other to drive a generator. Each turbine has its own combustion chamber getting air directly from the compressor. Air enters the compressor at 1 bar and 15^o C and compressed with isentropic efficiency of 76 %. The gas inlet pressure and temperature in both the turbines are 5 bar and 680^o C respectively. Take isentropic efficiency of both the turbines as 86%. The mass flow rate of air entering compressor is 23 kg/s. The calorific value of the fuel is 42,000 kJ/kg. Determine the power output and thermal efficiency of the plant.
3. Estimate the average daily global radiation on a horizontal surface at Ahmadabad (22° N 73°10 E) during the month of April. If the average sunshine hours per day is 10. Assume a = 0.28 and b=0.48.
4. A 5 metre diameter rotor is rotating at 15 revolutions per minute (rpm) and the wind speed is 3 m/s, calculate tip speed ratio of the rotor.
5. A generating station has a maximum demand of 30 MW, a load factor of 0.6, a plant capacity factor of 0.48 and a plant use factor of 0.82. Find, i) the daily energy produce, ii) the reserve capacity of the plant iii) the maximum

energy that could be produced if the plant were running all the time and iv) the maximum energy that could be produced daily, if the plant when running according to the operating schedule were fully loaded.

6. A base load power station having a capacity of 18 MW and a standby station having a capacity of 20 MW share a common load. Find i) annual load factor ii) use factor and iii) capacity factor of the two stations from the following data: Annual standby station output = 7.35 x 10^6 kWh
Annual base load station output = 101.35 x 10^6 kWh
Peak load on the stand by station = 12 MW
Hours of use of stand by station during the year = 2190 hours

Concept Map



Syllabus

Energy Source: Conventional energy sources-global and national potential- Non-conventional energy sources-global and national potential.

Steam power plant: Layout - High pressure boilers and Fluidized bed boilers- Fuel handling, Ash handling, dust collector, draught and cooling systems. Rankine power cycle –Reheat and regenerative.

Diesel power plant: Components- range of application- advantages and disadvantages-Supercharging, advantages. Diesel cycle-Performance analysis

Gas turbine power plant: Open and closed cycle plants- components- intercooling and regeneration. Fuels for gas power cycle-Brayton cycle. Advantages and disadvantages.

Nuclear power plant: Principles of Nuclear reactions- Nuclear reactor types and working. Nuclear fuels – waste disposal.

Solar Energy: Solar Radiations and calculations of various angles. Solar flat plate and concentrating type collectors. Solar pond, Solar Still. Solar Thermal Power Plant– Power cost. Photo Voltaic Cell – Power cost.

Wind energy: Basic principle- Power in the wind- Site selection- Horizontal and vertical axis wind mill.

Biofuel Energy: Bio mass and Vegetable oil for power generation – Gasification-Biodiesel and its blends.

Cogeneration: Topping and bottoming cycle. Combined gas turbine and steam power plants.

Power Plant Economics: Load curve, Terms and Definitions - Cost of power generation, losses. Selection of Power plant - cost, load, availability of resources. Emission Regulations.

Text Books

1. El-Wakil M.M., **"Power Plant Technology"**, McGraw Hill, 2002.
2. A.K. Raja, Amit Prakash Srivastava, Manish Dwivedi, **"Power Plant Engineering**", New Age International Publishers, 2006.
3. Aldo V. Da Rosa **"Fundamentals of Renewable Energy Process"**, Elsevier Academic Press, 2005.

Reference Books

1. Volker Quaschning, "**Understanding Renewable Energy Systems**", Earth scan, 2005.
2. Rajput R.K., **"A Text Book of Power Plant Engineering",** Laxmi Publications (P) Ltd., New Delhi, 2001.
3. Nag P.K., "**Power Plant Engineering**"- second edition, Tata McGraw Hill, New Delhi, 2001.
4. Rai G.D., **Non- Conventional Energy Sources**, Khanna Publishers, New Delhi, 1995.
5. John R Fanchi, **"Energy in the 21st Century"**, World Scientific Publishing Co. Pvt Ltd, 2005.
6. John R Fanchi, **"Energy – Technology and directions for future"**, Elsevier Academic Press, 2004.
7. David Pimentel, "**Bio Fuels, Solar and Wind as Renewable Energy Systems**", Springer, 2008.
8. Bent Sorensen, "**Renewable Energy**", Elsevier Academic Press, 2004.

Course contents and Lecture schedule

No	Topic	No. of Lectures
1.	**Energy Source:**	
1.1	Conventional energy sources-global and national potential	1
1.2	Non-conventional energy sources-global and national potential	1
2	**Steam power plant:**	
2.1	Layout - High pressure boilers and Fluidized bed boilers	2
2.2	Fuel handling, Ash handling, dust collector, draught and cooling systems.	3
2.3	Rankine power cycle –Reheat and regenerative.	1
3.	**Diesel power plant:**	
3.1	Components- range of application- advantages and disadvantages-Supercharging, advantages.	2
3.2	Diesel cycle-Performance analysis	2
4.	**Gas turbine power plant:**	
4.1	Open and closed cycle plants- components- intercooling and regeneration.	2
4.2	Fuels for gas power cycle-Brayton cycle.	1
4.3	Advantages and disadvantages.	1
5.	**Nuclear power plant**:	
5.1	Principles of Nuclear reactions- Nuclear reactor types and working	2
5.2	Nuclear fuels – waste disposal.	2
6.0	**Solar Energy:**	
6.1	Solar Radiations and calculations of various angles.	2
6.3	Solar flat plate and concentrating type collectors	1
6.4	Solar pond, Solar Still	1
6.5	Solar Thermal Power Plant – power cost	2
6.6	Photo Voltaic Cell – power cost	1
7.0	**Wind energy:**	
7.1	Basic principle- Power in the wind- Site selection	2
7.2	Horizontal and vertical axis wind mill.	2
8.0	**Biofuel Energy:**	
8.1	Bio mass and Vegetable oil for power generation	1
8.2	Gasification	1

8.3	Biodiesel and its blends.	1
9.0	**Cogeneration:**	
9.1	Topping and bottoming cycle.	2
9.2	Combined gas turbine and steam power plants	1
10.0	**Power Plant Economics:**	
10.1	Load curve, Terms and Definitions	1
10.2	Cost of power generation, losses.	2
10.3	Selection of Power plant - cost, load, availability of resources.	2
10.4	Emission Regulations	2
	Total	**44**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCC	3	0	-	**3**

GCC Automotive Engine Systems 3:0

Preamble: Automotive engine systems deals with functions and features to design sub systems of an engine. It also involves with performance and emission characteristics of different engines and fuels.

Program outcomes Addressed

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems
c. Graduates will develop confidence for self education and ability for life-long learning

Competencies

At the end of the course the student will be able to

1. Explain the engine power train system and make conceptual layout.
2. Analyze and estimate the cooling and lubrication requirement of an IC engine.
3. Analyze gas exchange process and explain the functional requirement of induction and exhaust of an IC engine.
4. Explain the emission trends, controlling techniques and norms for two and three wheeler application.
5. Explain various engine performance and emission characteristics, measuring methods and principles of devices and sensors used.
6. Explain the advances in IC engines and identify its merits and demerits.

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1.	Remember	30	20	20	20
2.	Understand	40	50	50	50
3.	Apply	30	15	15	15
4.	Analyze	-	15	15	15
5.	Evaluate	-	-		-
6.	Create	-	-		-

Course level learning objective

Remember

1. State different exhaust after treatment devices.
2. List functions of induction system.
3. State emission norms followed for 4 wheeler (cars).
4. State different lubricating oil and its major properties.
5. Define multigrade oil with example.
6. State different sensors used in engine emission measurements.

Understand

1. Explain in detail various subsystems of engine and its functions.
2. Define volumetric efficiency and explain parameters that affect it.
3. Explain with graphs relation between engine (SI) performance and Ignition timing, define MBT.
4. Explain relation between emission and AFR. Compare Emission graphs with SI and LPG/Alcohol fuels.
5. List important fuel properties of petrol and diesel, define Knocking and explain its behavior with respect to Octane number.
6. Explain CI and SI engine combustion; also using typical operating AFRs derive equation of combustion (products and reactants).

Apply

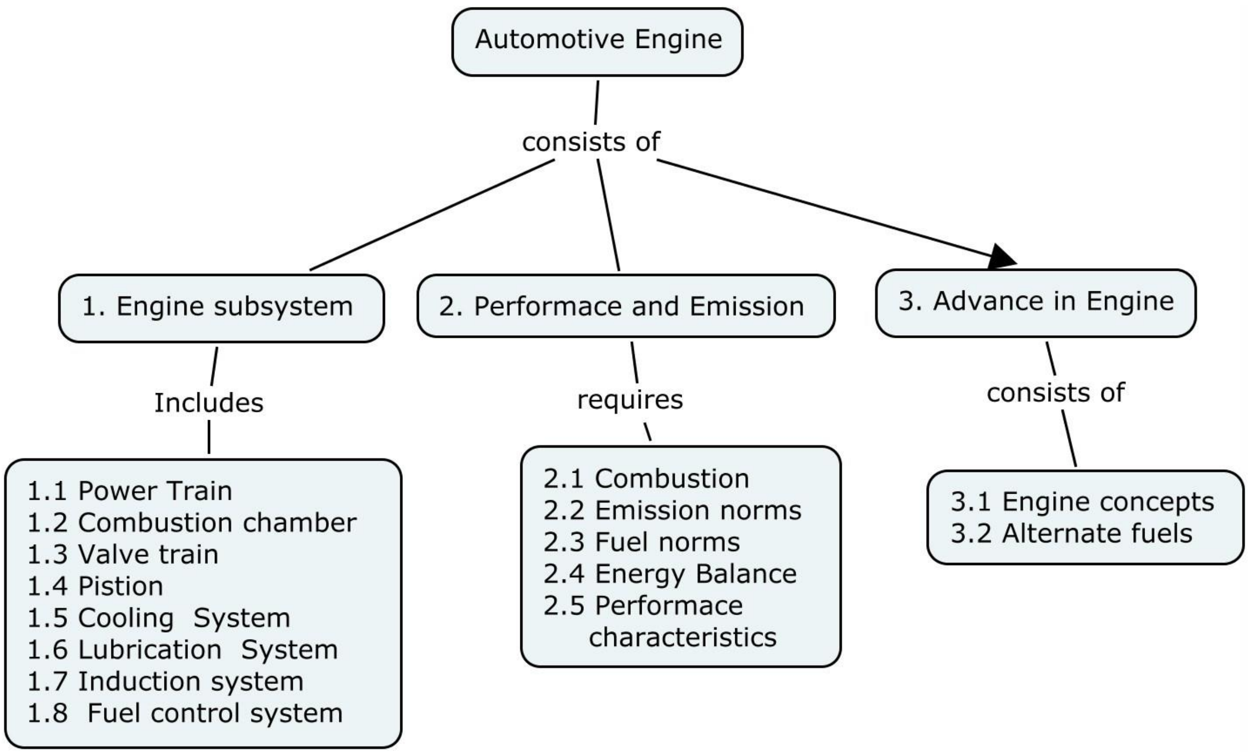
1. Plot energy balance of typical engine (1litre SI with petrol engine), draw its PV and TS cycle, calculate its potential benefit if its compression ratio increased by 10%.
2. Design a cooling system for engine generating power of 15 BHP.
3. Derive Stoichiometric combustion equation, 6% CO, 12% CO. with AFR 17:1.
4. Compare performance graphs of different fuels of same engine capacity. and its emission characteristics (Petrol, Diesel of 1Ltre engine and 200 CC engine).
5. Suggest different solutions for after burn and knocking?
6. Correlate air-fuel mixture ratios with changing vehicle demands with driving conditions?

Analyze

1. Compare performance graphs of different fuels of same engine capacity and its emission characteristics (Petrol, Diesel of 1Ltre engine and 200 CC engine).

2. Calculate valve sizes, bore, stroke which has generate power of 50kW (SI engine) should peak at speed of 6000 rpm.
3. Use the given engine performance graph to find wheel force in different gears. Plot road resistance and power; predict the maximum possible acceleration of vehicle. (with the available data).

Concept map:



Syllabus

Engine and subsystems: Power train and its types, engine (SI and CI), Engine and its subsystems, torque converter. Combustion chamber and its types, Valve train layout & Crank train layout, valve timing and timing chain layout, piston and piston rings, gaskets, importance of B/S and L/r, crank offset. Energy balance and cooling load estimation, types of cooling system. Typical operating temperatures of engine parts, Cooling system design (Air cooled and water cooled), Schematic layout of Cooling system for a two wheeler engine, Lubrication requirements of engine, Functions of Lubricating oil, Parts to be lubricated and not to be lubricated, Schematic layout of lubricating system, oil filtering, Engine friction, Lubricating oils and its types and properties, Functions of Induction system, Schematic layout (2W and 4W), Air Filtering and its importance, Exhaust and after treatment, Functions of exhaust system, Schematic layout of exhaust system (2W and 4W), Noise and Emission norms, Volumetric efficiency, factors affecting volumetric efficiency, ram effect, engine tuning, Fuel control systems

(Carburetor, Fuel Injection) Meeting demands of Vehicle (drivability, emissions and fuel economy) by controlling air and fuel, Sensors- Muffler layout. Fuel properties/characteristics (temperatures, Octane, Cetane no. etc).

Engine performance and emission: Chemistry of combustion, Stoichiometric equations of combustion. Emission relation with AFR - combustion chamber design – temperature - fuel (include load /speed) - Alternate fuels (performance, emission and practical issues). After treatment devices (include SAI,2WC), Chemical reactions involved in after treatment-Emission norms (Indian, European, US emission norms, Emission testing and certification), Fuel Norms(BS1, BS2), Environmental effects of Emissions, SI and CI combustion introduction, engine knocking, Vehicle performance characteristics, Road resistance, Wheel force in different gears, predict acceleration from engine performance graph, Energy balance chart, Various relations between AFR – Ignition timing - injection timing –emission – performance - fuel consumption. Sensors and devices used for performance and emission measurements.

Advanced engine concepts: Engines (Wankel, six stroke, lean burn, GDI, HCCI etc.) Hybrid vehicles, VVT, Turbo/super charging, Benefits of different engine concepts, Alternate fuels, compare performance, fuel economy & emission with fuels (alcohol, vegetable oils, LPG, CNG etc), Limiting factors, and practical problems.

Text books:

1. Edward F. Obert, "**Internal Combustion Engines and Air Pollution"** First Edition, Addison-Wesley Educational Publishers, Incorporated, reprint, 2012.
2. V. Ganesan, **"Internal Combustion Engines"** McGraw-Hill, reprint 2012,

Reference Books:

1. John B. Heywood, **"Internal Combustion Engine Fundamentals"**, McGraw-Hill, reprint 2012.
2. Richard Stone, **"Introduction to Internal Combustion Engines"**, Third edition, Society of Automotive Engineers, Incorporated 1999.

Course contents and Lecture schedule:

S.No	Topics	No. of Lectures
	Engine Subsystems	
1.1	Power train and its types - engine (SI and CI)	2
1.2	Combustion chamber and its types	2

1.3	Valve train layout & Crank train layout, valve timing and timing chain layout, torque converter	2
1.4	Piston and piston rings, gaskets, importance of B/S and L/r, crank offset.	2
1.5	Cooling and its types. Typical operating temperatures of engine parts, Cooling system design (Air cooled and water cooled).	1
1.5.1	Schematic layout of Cooling system for a two wheeler engine	1
1.6	Lubrication requirements –Functions, Types of lubricating oils and its properties, Parts to be lubricated and not to be lubricated, ,	1
1.6.1	Schematic layout of lubricating system (include oil filtering mechanisms) Engine friction, friction loss and measurement,	1
1.7	Induction system its functions , Schematic layout (2W and 4W), Air Filtering and its importance, Exhaust and after treatment Functions of system,	1
1.7.1	Schematic layout (2W and 4W), Noise and Emission norms, Volumetric efficiency, factors affecting volumetric efficiency, ram effect, engine tuning	1
1.8	Fuel control systems (Carburetor, Fuel Injection) Meeting demands of Vehicle (drivability, emissions and fuel economy) by controlling air and fuel,	1
1.8.1	Sensors used in the system. Detailed muffler layout. Fuel properties/characteristics (temperatures, Octane, Cetane etc)	1
	Performance and emission	
2.1	Chemistry of combustion. Stoichiometric equations of combustion.	2
2.1.1	Emission relation with AFR, combustion chamber design, temperature, fuel (include load /speed) Alternate fuels (performance, emission and practical issues),	2
2.1.2	After treatment devices (include SAI,2WC), Chemical reactions involved in after treatment SI and CI combustion introduction, engine knocking	2

2.2	Emission norms (Indian, European, US emission norms, Emission testing and certification),	2
2.3	Fuel Norms(BS1, BS2), Environmental effects of Emissions,	2
2.4	Vehicle performance characteristics : Road resistance, Wheel force in different gears, predict acceleration from engine performance graph, Energy balance chart	2
2.4.1	Various relations between AFR; Ignition timing; injection timing; emission; performance; fuel consumption; speed; load,	2
2.4.2	Sensors and devices used for performance, emission measurements	2
	Advanced Engine concepts	
3.1	Engine concepts(Wankel, six stroke, lean burn, GDI, HCCI)	2
3.1.1	Hybrid vehicles, VVT, throttles engines, Turbo/super charging	2
3.1.2	Benefits of different engine concepts	2
3.2	Alternate fuels, compare performance, fuel economy & emission with fuels (alcohol, vegetable oils, LPG, CNG etc)	2
3.2.1	Limiting factors and its practical problems	1
	Total	**41**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCE	3	0	0	3

GCE Material Handling Systems and Engineering 3:0

Preamble: Material handling is an important activity within larger system by which materials are moved, stored and tracked in any industrial/commercial infrastructure. Applying ergonomic principles in the design of material handling and storage system considering the physical properties, quantities and distance to be moved and type of production facility.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

k. Graduate who can participate and succeed in competitive examinations.

Competencies

At the end of the course the student will be able to

1. Map the process and material flow.
2. Assess the potential failure modes in material storage and handling between POM/POS to POC.
3. Design material storage and handling system to prevent potential failure modes.
4. Verify produced part quality is delivered to the point of consumption.
5. Use REBA/RULA tools and techniques in storage and material handling design.
6. Develop standardized storage and handling work procedures.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	20	20	20
2	Understand	40	40	40
3	Apply	40	40	40
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. What do you understand by process flow mapping?
2. State the importance of REBA/RULA.
3. Define: Maintainability
4. Write down the scope of TPM for MHS.
5. What do you understand by the term feasibility analysis?
6. List the importance of AGVs.

Understand

1. Explain about process flow charting technique and its outcomes.
2. Describe different types of Material handling equipments and its limitations.
3. Explain about the various selection criteria for Material handling equipment systems.
4. Explain about supportability analysis and functional analysis.
5. Discuss about different types of storage system and its merits.
6. Explain about the various analysis of vehicle based material transport system.

Apply

1. In one of the manufacturing industry, painted fuel tanks to be transported from paint shop to vehicle assembly. Allowable handling system size is 1.2 m x 1m x 2 m (L x B x H). The parts size is 400 mm x 250 mmx 120 mm (L x B XH). Assuming the shape of the fuel tank, design suitable material handling system along with manufacturing BOM and estimated cost. The system should be low cost and should ensure zero quality defect during transportation.
2. AGV’s are proposed for material handling of parts from stores to vehicle assembly line. The distance between POS and POC is 200 m. The quantity per container is 12 and weight of the container is 130 Kg. The AGVs has to feed for the line at 600/shift capacity. The maximum speed of the AGV is 0.4 m /sec and allowable weight is 500 Kg. Calculate the how many AGVs are required considering the return logistics and establish optimised route map.
3. At particular un-loading dock every 15 minutes one truck arrives. The window time for truck servicing is 25 minutes. Make the necessary assumptions and based on that find a) The average que length b) the average waiting time for two shift based operations
4. The company has three stores S1, S2 & S3. It is required to deliver a product from these stores to three assembly lines A, B and C. The stock in stores and the assembly line requirement are as follows. Find the optimal transportation route.

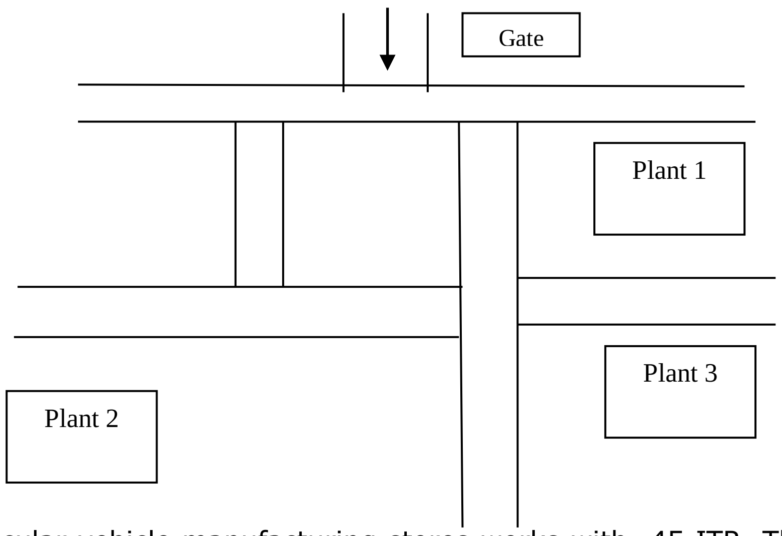
Stores

		S1	S2	S3	Requirement
Assembly Line	A	5	7	8	70
	B	4	4	6	30
	C	6	7	7	50
	Stock	65	42	43	150

5. To manufacture one 450CC vehicle, 450 parts to be moved from POS to POC with classification of A – 50, B – 100 and C - 300 parts. The tact of vehicle production is 30 seconds. Design a suitable handling and transportation system to meet the product quality and process quality requirements.

6. To manufacture an engine of 150 cc, it is required metal parts, plastic parts, fabricated parts and machined parts. Design a suitable handling system between feeder shop to assembly line with selection of the material and application of REBA/RULA.

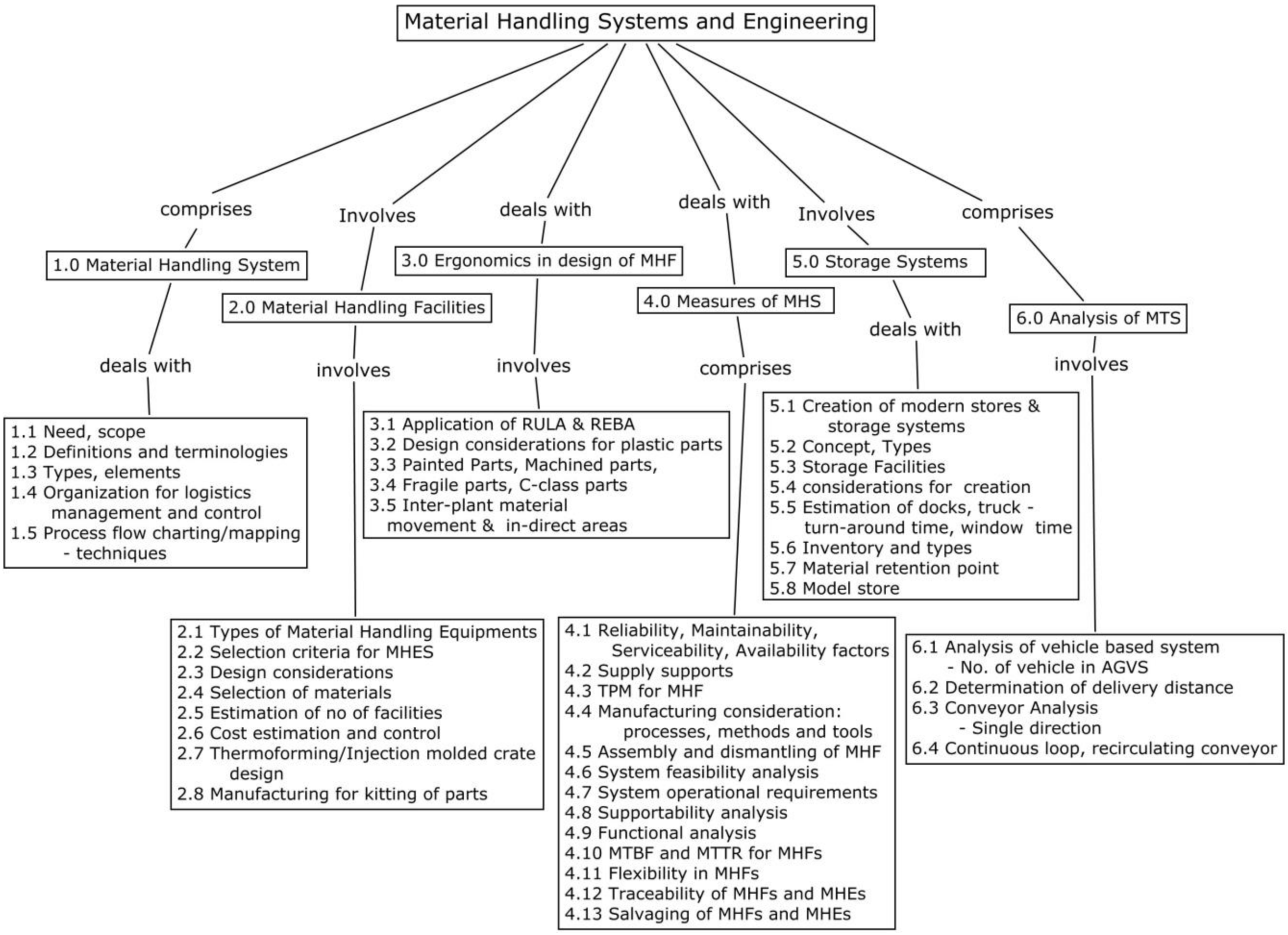
7. In an automotive company, the total inflow of material supply vehicles is 500 trucks/day. The company has two vehicle assembly plants and one supportive machining plant. 150 trucks will be going for plant 1, 100 for Plant 2 and 250 for plant 3 (machining) and from plant 3, 150 will go to plant 1 and 100 will go to plant 2. Considering the plant layout as below, applying the suitable OR tool, propose the optimised truck path to ease traffic without congestion.



8. The particular vehicle manufacturing stores works with 45 ITR. The total no. Of pats to be stored is 12,000 out of which 200 are A class parts requiring 1

off, 400 are B class parts requiring 2 off and remaining are C class parts requiring 3 off. The production rate is 5000 /day. Calculate the required inventory and design the suitable storage system with adherence of FIFO.

Concept Map



Syllabus

Material Handling System - Need, scope, definitions and terminologies, types, elements, Organization for logistics management and control. Introduction Process flow charting/mapping techniques.

Material Handling Facilities - Types of Material Handling Equipments (AGVs, Fork lift, prime movers, stackers, lifts etc), selection criteria for MHES. Design considerations, selection of materials. Estimation of number of facilities required; cost estimation and control. Introduction to thermoforming/injection molded crate design and manufacturing for kitting of the parts.

Ergonomics in design: Application of RULA & REBA in MHF design, MHF design considerations for plastic parts, painted Parts, machined parts, fragile parts, c class parts, inter-plant material movement, and in-direct areas.

Measures of material handling system: reliability, maintainability, serviceability, availability factors, Supply supports, TPM for MHF, manufacturing consideration: processes, methods and tools, assembly and dismantling of MHF, system feasibility analysis, system operational requirements, Supportability analysis, functional analysis, MTBF and MTTR for MHFs, flexibility in MHFs, traceability of MHFs and MHEs, salvaging of MHFs and MHEs

Storage systems: Creation of modern stores and storage systems: concept of stores, types of stores, storage facilities, considerations for creation of stores, estimation of docks, truck turn-around time, truck window time, inventory and types, WIP, material retention point, model store concept.

Analysis of Material Transport Systems: Analysis of Vehicle based system- determination of number of vehicles in AGVs and determination of delivery distance. Conveyor analysis – single direction, continuous loop and re-circulating conveyors.

Reference Books:

1. Blanchard S. Benjamin, "**Logistics Engineering and Management**", 6th International Edition, Prentice Hall Inc, 2004.
2. Christopher M, "**Logistics and Supply Chain Management - Creating Value Adding Networks**", Prentice Hall, 2005.
3. James M. Apple, **"Plant Layout and Material Handling**" John Wiley, 3rd Edition, 1977.
4. Mikel P.Grrover, "**Automation, Production Systems, and Computer-Integrated Manufacturing**", PHI Publishers, 3rd Edition 2008.
5. Prauss L, "**The Green Multiplier - a Study of Environmental Protection and Supply Chain**", Antonn Rauss Limited, Palgrave Macmillan, 2005.
6. Taylor G.D, "**Logistics Engineering Handbook**", CRC Press, 2008.
7. TVSM Material Handling Facilities Design Guidelines and Manuals

Course Contents and Lecture schedule

No	Topic	No. of Lectures
1	**Material Handling System**	
1.1	Need, scope	1
1.2	Definitions and terminologies	
1.3	Types, elements	1
1.4	Organization for logistics management and control	
1.5	Process flow charting/Mapping - techniques	2
2	**Material Handling Facilities**	
2.1	Types of Material Handling Equipments	2
2.2	Selection criteria for MHES	1

2.3	Design considerations	1
2.4	Selection of materials	1
2.5	Estimation of number of facilities	1
2.6	Cost estimation and control	2
2.7	Thermoforming/Injection molded crate design	1
2.8	Manufacturing of kitting of parts	1
3	**Ergonomics in design**	
3.1	Application of RULA & REBA	2
3.2	MHF design considerations for plastic parts	1
3.3	Painted Parts, machined parts	1
3.4	Fragile parts, c class parts	1
3.5	Inter-plant material movement, and in-direct areas	1
4	**Measures of material handling system**	
4.1	Reliability, Maintainability, Serviceability, Availability factors	1
4.2	Supply supports	1
4.3	TPM for MHF	1
4.4	Manufacturing consideration: processes, methods and tools	1
4.5	Assembly and dismantling of MHF	1
4.6	System feasibility analysis	1
4.7	System operational requirements	1
4.8	Supportability analysis	1
4.9	Functional analysis	1
4.10	MTBF and MTTR for MHFs	1
4.11	Flexibility in MHFs	
4.12	traceability of MHFs and MHEs,	1
4.13	Salvaging of MHFs and MHEs	1
5	**Storage systems**	
5.1	Creation of modern stores and storage systems	1
5.2	Concept, types of stores	
5.3	Storage facilities	1
5.4	Considerations for creation of stores	1
5.5	Estimation of docks, truck turn-around time, truck window time,	1
5.6	Inventory and types	1
5.7	Material retention point	1

5.8	Model store concept	1
6	**Analysis of Material Transport Systems**	
6.1	Analysis of Vehicle based system - number of vehicles in AGVs	1
6.2	Determination of delivery distance	1
6.3	Conveyor analysis – single direction	1
6.4	Continuous loop and re-circulating conveyors	1
	Total	**43**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCF	3	0	-	**3**

GCF Theory of Metal Cutting 3:0

Preamble: Metal cutting processes are the core production processes and the economy of these processes depend on the proper selection and control of parameters. Mechanical engineer requires the knowledge of the mechanisms involved in those processes. In this elective course, the fundamental mechanisms of the metal cutting are presented, which are very essential for manufacturing.

Programme Outcomes addressed

c. Graduates will demonstrate knowledge of mathematics, science and engineering.
d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
k. Graduate will participate and succeed in competitive examinations.

Competencies

At the end of the course, students will be able to:

1. Describe the mechanisms involved in the metal cutting processes.
2. Determine the tool life and machinability.
3. Select suitable tool material for an operation.
4. Estimate the machining cost.
5. Describe the tool vibration and its effect on surface finish.
6. Select the appropriate cutting fluid for an operation.

Assessment Pattern

S.No	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3**	**End-semester examination**
1	Remember	20	20	20	20
2	Understand	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	0	0	0	0
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. Define chip reduction coefficient.
2. Name the types of chips.
3. State the factors responsible for surface roughness.
4. State the functions of cutting fluid.
5. What is ideal surface roughness?
6. List the factors needed to determine optimum conditions in metal cutting.

Understand

1. Explain the Ernst-Merchant theory.
2. Explain the mechanism of flank wear.
3. How does the cutting fluid reach the tool-chip interface?
4. Discuss the various forces encountered in metal cutting.
5. Discuss the Taylor's relationship for cutting speed-tool life.
6. Derive the expression for finding shear angle in chip formation.

Apply

1. Select a suitable cutting fluid for a key way cutting operation on mild steel work piece using an end mill.
2. A seamless tubing 35mm outside diameter is turned orthogonally on a lathe. The following data are available; rake angle 15º, cutting speed 15 m/min, feed rate 10 mm/rev, length of continuous chip in one revolution 50 mm, cutting force 2000 N, feed force 800 N. Calculate the coefficient of friction, shear plane angle, velocity of chip along tool face and chip thickness.
3. In a tool wear test with HSS cutting tool, the following values of tool life were obtained. Calculate the values of n and C of Taylor's equation.

Tool life min	Cutting speed m/min
30	25
1.5	70

4. In a machining efficiency test on turning, the following data were obtained for a feed search:

Feed, mm/rev	0.2	0.22	0.24
Speed m/min	51	51	51
Tool Life min	360	410	82
Rate, cm^3/min	27.20	29.34	31.63

Tool usage cost = Rs 2.58

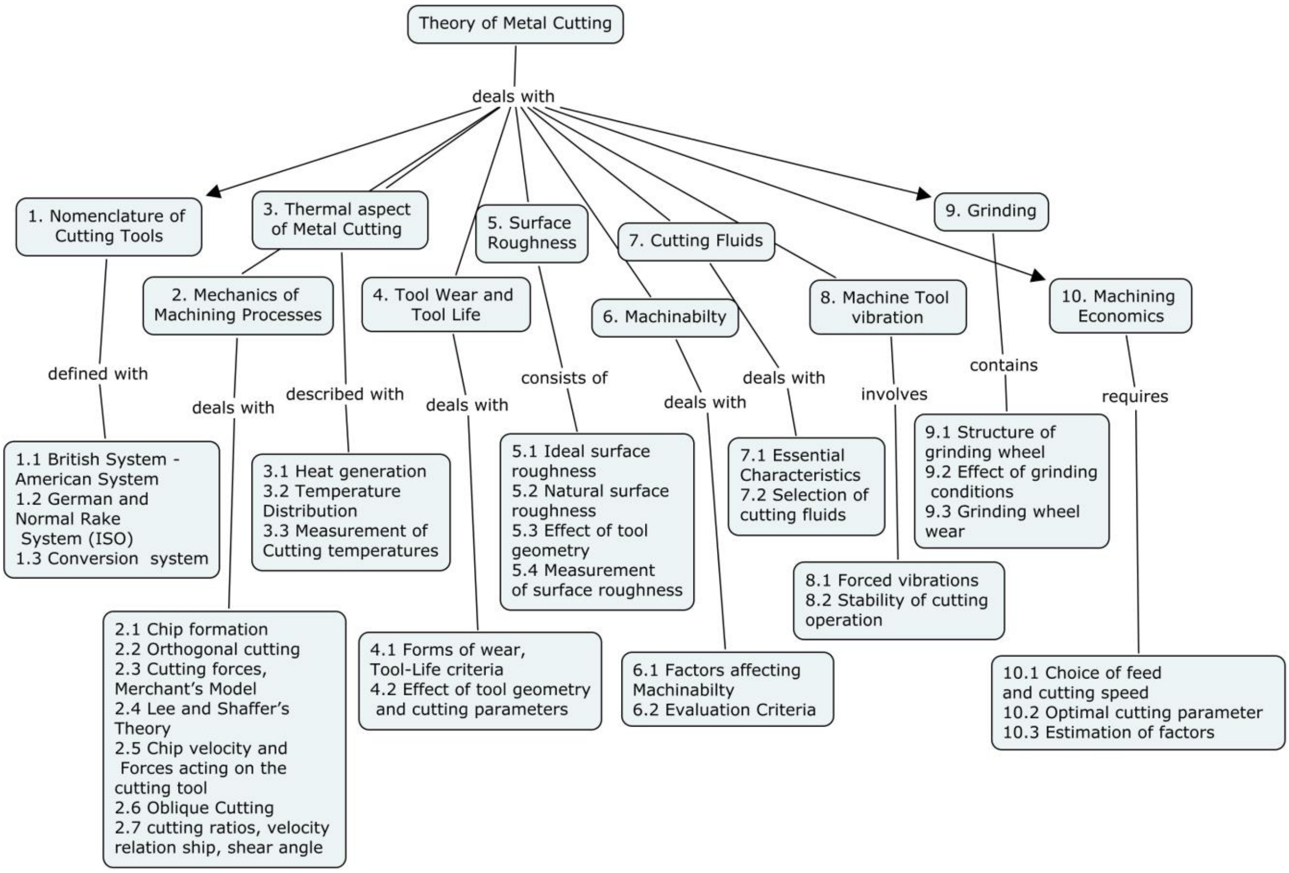
Tool change cost = 1.00

Operating cost = 1.16 per min. Find the optimum feed.

5. Select the proper cutting fluid for machining a component of aluminum alloy having a machinability rating of 100% in high speed lathe.

6. A large batch of steel shaft is to be rough-turned to 76 mm diameter for 300 mm of their length at a feed of 0.25 mm. A brazed-type carbide tool is to be used, and the appropriate constants in Taylor's tool-life equation for the conditions employed are as follows: n=0.25 and V**=** 4.064 m/sec, when T = 60 sec (C = 250 m/min). The initial cost of the machine was Rs. 5,00,000 and is to be amortized over 5 years. The operator's wage will be assumed to be Rs.250/hr and the operator and machine overheads are 100%. Tool changing and resetting time on the machine is 300 sec and the cost of regrinding the tool is Rs 100. The initial cost of a tool is Rs.300, and on the average, it can be reground 10 times. Finally, the non-productive time for each component is 120 sec. Find the total production time under the following conditions: i) minimum production time and ii) minimum production cost.

Concept Map



Syllabus

Nomenclature of Cutting Tools: British System - American System, German and Normal Rake System (ISO). Conversion of various rake angle systems into Normal Rake angle system.

Mechanics of Machining Processes: Chip formation, Orthogonal cutting – Thin Zone models, Determination of shear plane angle, Cutting forces, Merchant Models, Lee and Shaffer's Theory, Stress distribution on rake face, Chip velocity, Forces acting on the cutting tool and their measurement, and Specific cutting energy. Oblique Cutting – Direction of chip flow, Rake angles, cutting ratios, velocity relation ship, shear angle.

Thermal aspects of Metal Cutting: Heat generation in Metal Cutting – Temperature Distribution in Metal Cutting, Measurement of Cutting temperatures.

Tool Wear and Tool Life: Forms of wear, Tool-Life criteria, Effect of tool geometry and cutting parameters.

Surface Roughness: Ideal surface roughness, Natural surface roughness, Effect of tool geometry and cutting parameters, Measurement of surface roughness.

Machinability: Factors affecting Machinability of Metals, Evaluation Criteria (Qualitative treatment only).

Cutting Fluids: Essential Characteristics, selection of cutting fluids.

Machine Tool vibration: Forced vibrations, self-induced vibration, stability of cutting operation.

Grinding: Structure of grinding wheel, Effect of grinding conditions on wheel behavior, Testing of grinding wheel, and Grinding wheel wear.

Machining Economics: Choice of feed and cutting speed, Optimal cutting parameters for minimum cost and minimum production time, Estimation of factors needed to determine optimum conditions.

Text Books:

1. Juneja, B.L., Sekhon, G.S., and Seth, N., **"Fundamentals of Metal Cutting and Machine Tools",** Second Edition, New Age International Pvt. Ltd, New Delhi, 2003.
2. Geoffrey Boothroyd, "**Fundamentals of Metal Machining and Machine Tools",** Third Edition, Taylor & Francis Group, 2005.

Reference Books:

1. Bhattacharya, A., **"Metal Cutting Theory and Practice",** New Central Book Agency (P) Ltd., Edition, 1984.
2. Sharma, P.C., "**Production Engineering"** S.Chand & Co., New Delhi, Fifth Edition, 2005.

3. Kuppusamy, G., **"Principles of Metal Cutting",** Universities Press (India) Ltd., 1996.
3. Pandey, P.C. and Singh, C.K. **"Production Engineering Sciences",** Standard Publishers Distributors, New Delhi, 1992.
4. HMT, **"Production Technology",** Tata McGraw Hill Publishing Company Ltd., New Delhi, 1980.
5. George E. Dieter, **"Mechanical Metallurgy",** McGraw-Hill Book Company, London, 1988.

Course Contents and Lecture schedule

S.No	Topics	No. of Lectures
1.	**Nomenclature of Cutting Tools**	
1.1	British System - American System	1
1.2	German and Normal Rake System (ISO)	1
1.3	Conversion of various rake angle systems into Normal Rake angle system	2
2.	**Mechanics of Machining Processes**	
2.1	Chip formation	1
2.2	Orthogonal cutting – Thin Zone models, Determination of shear plane angle	2
2.3	Cutting forces, Merchant's Model	1
2.4	Lee and Shaffer's Theory, Stress distribution on rake face	1
2.5	Chip velocity, Forces acting on the cutting tool and their measurement, and Specific cutting energy	2
2.6	Oblique Cutting – Direction of chip flow, Rake angles,	2
2.7	cutting ratios, velocity relation ship, shear angle	1
3.	**Thermal aspects of Metal Cutting**	
3.1	Heat generation in Metal Cutting	1
3.2	Temperature Distribution in Metal Cutting	1
3.3	Measurement of Cutting temperatures	1
4.	**Tool Wear and Tool Life**	
4.1	Forms of wear, Tool-Life criteria	1
4.2	Effect of tool geometry and cutting parameters	2
5.	**Surface Roughness**	
5.1	Ideal surface roughness	1
5.2	Natural surface roughness	1
5.3	Effect of tool geometry and cutting parameters	1

5.4	Measurement of surface roughness	1
6.	**Machinabilty**	
6.1	Factors affecting Machinabilty of Metals	2
6.2	Evaluation Criteria (Qualitative treatment only)	1
7.	**Cutting Fluids**	
7.1	Essential Characteristics	2
7.2	Selection of cutting fluids	1
8.	**Machine Tool vibration**	
8.1	Forced vibrations, self-Induced vibrations	1
8.2	Stability of cutting operation	2
9.	**Grinding**	
9.1	Structure of grinding wheel	1
9.2	Effect of grinding conditions on wheel behavior, Testing of grinding wheel	2
9.3	Grinding wheel wear	1
10.	**Machining Economics**	
10.1	Choice of feed and cutting speed	2
10.2	Optimal cutting parameters for minimum cost and minimum production time	2
10.3	Estimation of factors needed to determine optimum conditions	1
	Total	**42**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCG	3	0	-	**3**

GCG Manufacturing System Engineering 3:0

Preamble: Manufacturing Systems Engineering is a systematic approach to integrate the entire manufacturing process, from raw material purchase through production to sales, in order to produce the maximum volume of high-quality product at the lowest cost and in the shortest time. Manufacturing Systems Engineering is a discipline built upon a collection of methodological tools brought together to effect an integrated or "total" approach to problem-solving in Manufacturing Engineering, Industrial Economics and Production Management with productivity improvement as its overall objective.

Programme outcomes addressed

a. Graduates will demonstrate the knowledge of engineering, mathematics and science.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

e. Graduates will demonstrate an ability to use techniques, skills and modern engineering tools to implement and organize engineering works under given constraints.

Competencies

At the end of the course the students will be able to:

1. Explain the components and characteristics of manufacturing systems engineering
2. Identify seven types of waste through value added and non value added analysis
3. Determine flow production and level production using "JIT" tools (Kanban, flow, level, synchronization)
4. Determine appropriate performance metrics for different manufacturing systems
5. Develop cell level standardized work procedures
6. Apply concepts of "JIT Manufacturing System" at cell level.

Assessment Pattern

Sl. No.	Bloom's Category	Test 1	Test 2	Test 3	End Semester examination
1	Remember	30	25	25	25
2	Understand	30	25	25	25
3	Apply	40	50	50	50
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. What is the purpose of reducing waste?
2. What do you understand by Push and Pull Production?
3. What are the ten arguments against JIT Implementation?
4. Define Jidoka.
5. Why standardization is needed in industries?
6. Define Muda, Mura & Muri.

Understand

1. Explain the seven requirements of flow manufacturing.
2. Differentiate Value added activity and Non Value added activity.
3. Explain why Inventory is not an investment.
4. Explain the various Production Levelling techniques.
5. Explain in detail how waste occurs.
6. Discuss the ways to prevent defects.

Apply

1. From the following data select the most advantageous location for setting a plant for making automobile axles.

Sl.No.	Category	Site X Rs.	Site Y Rs.	Site Z Rs.
1	Total initial investment	2,00,000	2,00,000	2,00,000
2	Total expected sales	2,50,000	3,00,000	2,50,000
3	Distribution expenses	40,000	40,000	75,000
4	Raw material expenses	70,000	80,000	90,000
5	Power and water supply expenses	40,000	30,000	20,000
6	Wages and salaries	20,000	25,000	20,000
7	Other expenses	25,000	40,000	30,000
8	Community attitude	Indifferent	Want business	Indifferent
9	Employee housing facilities	Poor	Excellent	Good

2. The MS 800 car is to be assembled on a conveyor belt. Five hundred cars are required per day. Production time per day is 420 minutes, and the assembly steps and times for the wagon are given below. Find the balance that minimizes the number of workstations, subject to cycle time and precedence constraints.

Task	Task time(in seconds)	Description	Tasks that must precede
A	45	Position rear axle support - and hand fasten	-
B	11	Four screws to nuts	A
C	9	Insert rear axle	B
D	50	Tighten rear axle support screws to nuts	-
E	15	Position front axle assembly	D
F	12	Fasten with four screws to nuts	C
G	12	Tighten front axle assembly screws	C
H	12	Position rear wheel 1 and fasten hubcap	E
I	12	Position rear wheel 2 and fasten hubcap	E
J	8	Position front wheel 1 and fasten hubcap	F, G, H, I
K	9	Position front wheel 2 and fasten hubcap	J

3. The Westerville Auto Parts Company produces rocker-arm assemblies. A container of parts spends 0.02 day in processing and 0.08 day in materials handling and waiting, Daily demand for the part is 2,000 units, Safety stock is equivalent to 10 percent of inventory.

a. If each container contains 22 parts, how many containers should be authorized?

b. Suppose that a proposal to revise the plant layout would cut materials handling and waiting time per container to 0.06 day. How many containers would be needed?

4. The forecast for a group of items manufactured in a firm is shown below

Quarter	1	2	3	4	5	6	7	8
Demand	370	320	570	670	550	370	350	480

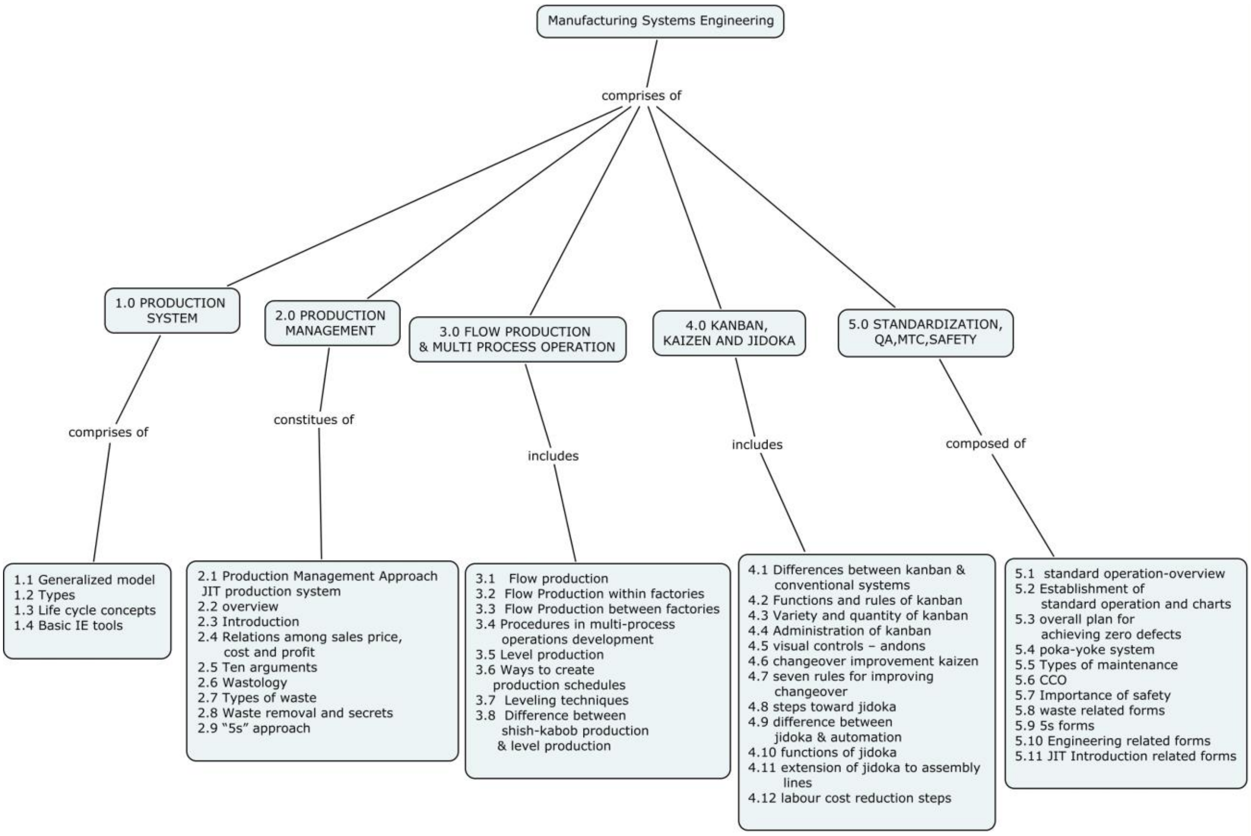
The firm estimates that it costs Rs.200 per unit to increase the production rate, Rs.250 per unit to decrease the production rate, Rs.75 per unit per quarter to carry the items on inventory and Rs.125 per unit if subcontracted. Compare the cost incurred in each of the strategy and arrive at a decision if the three strategies planned are varying the workforce, changing the inventory levels and subcontracting.

5. A production manager is working in a cellular manufacturing system for automobile parts. He has to process an average of 250 parts per hour in the cell. The capacity of each container is 30 parts and one kanban is attached to all the containers. The time to receive new parts from the previous workstation is 25 minutes. Factory maintains a safety stock factor of 15%. Determine the kanbans needed for the plant.

6. From the given information box, identify the wastes and suggest suitable methods for removal.

Part Number	WP/CAS/001	WP Casting
Family	Casting	Machine shop
Customer demand	4000/month	variation +400
Manufacturing data		Operation
Data collected by		Vinayaga
Cycle time(Minutes)		2
Change over time(Minutes)		20
Uptime		90%
% Defective		5% rework
Batch size		110 (10 numbers added to demand)
Number of shifts		2(8.5 hr per shift)
Number of Operators		1 per shift
Available time (Minutes)		450
Work in progress		650 numbers

CONCEPT MAP



Syllabus

PRODUCTION SYSTEM: Generalized model of production systems, types of production systems and its impact on system design, lifecycle concepts of production systems, Basic IE tools. **PRODUCTION MANAGEMENT AND JIT PRODUCTION MANAGEMENT:** Approach to production management, Introduction & overview of JIT production system, Relations among sales price, cost and profit, ten arguments against the JIT production revolution, "wastology", types of waste, waste removal and secrets for not creating waste, the "5s" approach. **FLOW PRODUCTION AND MULTI PROCESS OPERATION:** Introduction to flow production, flow production within factories & between factories, precautions and procedures for developing multi-process operations, level production, various ways to create production schedules, leveling techniques, difference between shish-kabob production and level production. **BASICS OF KANBAN, KAIZEN AND JIDOKA:** Differences between kanban and conventional systems, functions and rules of kanban, variety and quantity of kanban, administration of kanban, visual controls – andons, changeover improvement kaizen, seven rules for improving changeover, steps toward jidoka, difference between jidoka and automation, functions of jidoka, extension of jidoka to the assembly lines, labour cost reduction steps. **STANDARD OPERATIONS, QUALITY ASSURANCE, MAINTENANCE AND SAFETY:** overview of standard operation, establishment of standard operation and charts, overall plan for achieving zero defects, the poka-yoke system, types of maintenance, CCO -three lessons in maintenance, importance of safety, waste related forms, 5s forms, engineering related forms, JIT Introduction related forms

Text Books:

1. Chase, Jacobs, Aquilano, **"Production and Operations Management"**, 8th Edition, Tata McGraw Hill Companies Inc, 2008.
2. Paneer Selvam R**, "Production and Operations Management"**, Prentice Hall of India, 2010.
3. Hiroyuki Hirano, **"JIT Implementation Manual"**, English Translation Copy Right, Productivity Press, 1990.

REFERENCE BOOKS:

1. Katsundo Hitomi, **"Manufacturing Systems Engineering",** Second Edition 1996, Taylor & Francis.
2. Adam Jr., Everette E. and Ebert, Ronald J, **"Production and Operations Management- Concepts- Models and Behavior"**, 5th Edition Prentice-Hall of India, 1992.
3. Samuel Eilon, **"Elements of Production Planning and Control"**, 1st Edition, Collier Macmillan Ltd, 1962.
4. Chary, "**Theory and Problems in Production and Operations Management"** Tata Mc-Hraw Hill, 2009.
5. Buffa, E.S. and Sarin, R. K., **"Modern Production/Operations Management"**, Eighth Edition, John Wiley & Sons, 1987.

Course Contents and Lecture schedule

S.No	Topics	No. of Lectures
1.0	**INTRODUCTION TO PRODUCTION SYSTEM**	
1.1	Generalized model of production systems	1
1.2	Types of production systems and its impact on system design	1
1.3	Lifecycle concepts of production systems	1
1.4	Basic IE tools	1
2.0	**PRODUCTION MANAGEMENT AND JIT PRODUCTION MANAGEMENT**	
2.1	Approach to production management	1
2.2	Overview of JIT production system	1
2.3	Introduction of JIT production system	1
2.4	Relations among sales price, cost and profit	1

S.No	Topics	No. of Lectures
2.5	Ten arguments against the JIT production revolution	1
2.6	Wastology	1
2.7	Types of waste	1
2.8	Waste removal and secrets for not creating waste	1
2.9	“5s” approach	1
3.0	**FLOW PRODUCTION AND MULTI PROCESS OPERATION**	
3.1	Flow production- Introduction	1
3.2	Flow production within factories	1
3.3	Flow production between factories	1
3.4	Precautions and procedures for developing multi-process operations	1
3.5	Level production	1
3.6	Various ways to create production schedules	1
3.7	Leveling techniques	1
3.8	Difference between shish-kabob production and level production	1
4.0	**BASICS OF KANBAN, KAIZEN AND JIDOKA**	
4.1	Differences between kanban and conventional systems	1
4.2	Functions and rules of kanban	1
4.3	Variety and quantity of kanban	1
4.4	Administration of kanban	1
4.5	Visual controls – andons	1
4.6	Changeover improvement kaizen	1
4.7	Seven rules for improving changeover	1
4.8	Steps toward jidoka	1
4.9	Difference between jidoka and automation	1
4.10	Functions of jidoka	1
4.11	Extension of jidoka to the assembly lines	1
4.12	Labour cost reduction steps	1
5.0	**STANDARD OPERATIONS, QUALITY ASSURANCE, MAINTENANCE AND SAFETY**	
5.1	Overview of standard operation	1
5.2	Establishment of standard operation and charts	1
5.3	Overall plan for achieving zero defects	1
5.4	The Poka-yoke system	1
5.5	Types of maintenance	1

S.No	Topics	No. of Lectures
5.6	CCO -three lessons in maintenance	1
5.7	Importance of safety	1
5.8	Waste related forms	1
5.9	5s forms	1
5.10	Engineering related forms	1
5.11	JIT Introduction related forms	1
	TOTAL	**45**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCM	3	0	-	**3**

GCM Finite Element Analysis 3:0

Preamble: FEA can produce accurate, reliable approximate solutions, at a small fraction of the cost of more rigorous, closed-form analyses. This course provides the basic theoretical knowledge to competently perform finite element analysis for structural and thermal analyses. It also provides an introduction to the finite element analysis from engineering point of view.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

f. Graduates will demonstrate skills to use modern engineering tools, software's and equipment to analyze problems.

Competencies

At the end of the course the student will be able to

1. Describe the basic finite element procedure.
2. Discretize any given problem into finite element models.
3. Describe the higher order and isoparametric elements.
4. Apply Finite Element analysis to engineering applications.
5. Develop computer programs for the solution of engineering problems.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test3**	**End-semester examination**
1	Remember	20	10	10	10
2	Understand	40	30	30	30
3	Apply	40	60	60	60
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

1. Draw any three dimensional finite elements.
2. Define the Bandwidth of a assembled Global stiffness matrix
3. Write down the interpolation polynomial of cubic model finite element for one dimensional and two dimensional cases.
4. Give the displacement expression for tetrahedron element.
5. What is the meaning of Gauss Quadrature method?
6. Give some techniques used in direct integration method.

Understand

1. Derive the system equation for one dimensional Linear bar Element using potential energy approach.
2. Derive the shape functions for the quadratic bar element in terms of global coordinates
3. Derive the shape functions of Linear Strain Triangle element
4. Derive the Element stiffness matrix for one dimensional bar element.
5. Derive the Element stiffness matrix for Constant Strain Triangle element.
6. Derive the shape functions for eight node Quadrilateral element

Apply

1. Solve the simultaneous systems of equation using Gauss-Elimination method.

$3x + y - z = 3;$

$2x - 8y + z = 3;$

$x - 2y + 9z = 8.$

2. Find the stresses induced in the axially loaded stepped bar shown in Figure 1 The bar has cross-sectional areas of $A^{(1)}$ and $A^{(2)}$ over the lengths $l^{(1)}$ and $l^{(2)}$, respectively. Assume the following data: $A^{(1)} = 2$ cm^2; $A^{(2)} = 1$ cm^2; $l^{(1)} = 1^{(2)} = 10$ cm; $E^{(1)} = E^{(2)} = 2 \times 10^7$ N/cm^2; $P_3 = 1$ N.

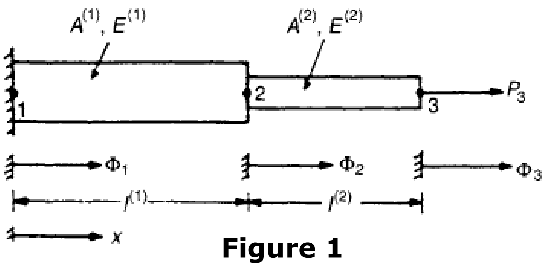


Figure 1

3. Find the distribution of temperature in the one-dimensional fin shown in Figure 2. Assume the following data: h - 10 W/cm^2 K, k - 70 W/cm K, T∞. = 40°C, To =140 °C and L = 5 cm, and the cross section of fin is circular with a radius of 1 cm.

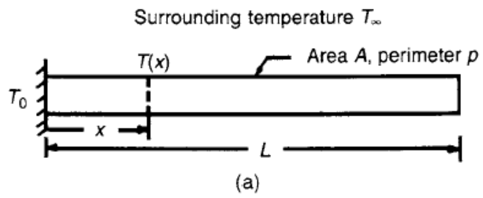


Figure 2

4. Consider the circular heat transfer pin shown in Figure 3 . The base of the pin is held at constant temperature of 100◦C (i.e., boiling water). The tip of the pin and its lateral surfaces undergo convection to a fluid at ambient temperature *Ta.* The convection coefficients for tip and lateral surfaces are equal. Given k_x = 380 W/m-◦C, *L* = 8 cm, *h* = 2500 W/m^2-◦C, *d* = 2 cm, *Ta* = 30◦C*.* Use a two element finite element model with linear interpolation functions (i.e., a two-node element) to determine the nodal temperatures and the heat removal rate from the pin. Assume no internal heat generation.

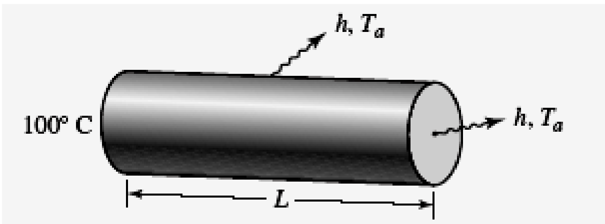


Figure 3

5. Consider a 4-bar truss as shown in figure 4 . It is given that E= 200 GPa and A= 500 mm^2 for all the elements. Dtermine the (a)nodal displacements (b) support reactions (c) element stress.

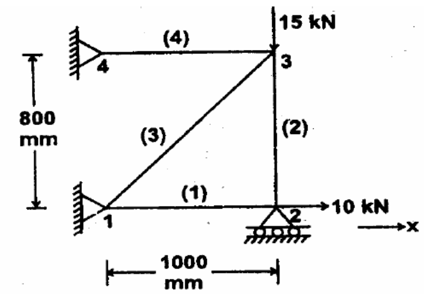
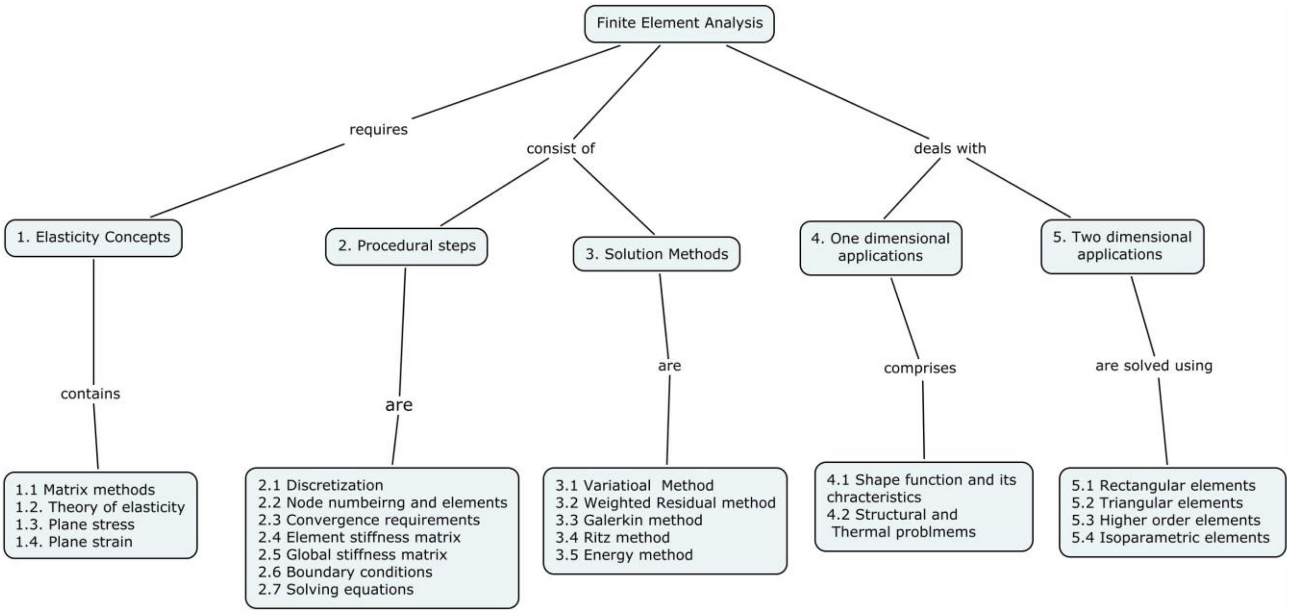


Figure 4

6. Evaluate the integral $I = \int \frac{(r^2 - 1)}{(r+3)^2} dr$ using Gaussian integration with one, two and three integration.

Concept Map



Syllabus

Finite element analysis- Basic Concepts: Matrix methods, Theory of Elasticity, Plane stress, Plane strain Modeling **Procedural steps:** Modelling, Discretization, Node Numbering and elements, Convergence requirements, Element stiffness matrix, Global stiffness matrix ,Boundary conditions, Solving equations **Solution Methods:** Variational Method, Weighted Residual approach, Galerkin Method, Ritz Method, Energy method **One dimensional problems:** Shape functions and its characteristics - Bar element, Beam element and Truss element, Structural and Thermal problems **Two dimensional problems:** Rectangular elements, Triangular elements, Higher order elements, Isoparametric elements, Structural and Thermal problems.

Text Book

1. Singuresu S. Rao, **"Finite Element method in Engineering"**, Fourth edition, Elsevier Science & Technology Books, 2008.
2. Tirupathi R. Chandrupatla, Ashok D. Belegundu, **"Introduction to Finite Elements in Engineering"**, Third Edition, Reprint, Prentice Hall, 2012.

Reference Books

1. R. D. Cook, D. S. Malkus, and M. E. Plesha, **"Concepts and Applications of Finite Element Analysis"**, Third Edition, John Wiley and Sons, New York, Reprint 2010.

2. O. C. Zienkiewicz and R. L. Taylor, **"The Finite Element Method: Volume 1 The Basis"**, 5th Edition, Butterworth-Heinemann, Oxford. Reprint 2011.
3. Daryl L. Logan A, **"First Course in the Finite Element Method"**, Fourth Edition, Cengage Learning, 2007.
4. K. J. Bathe, **"Finite Element Procedures"**, Second Edition, Prentice-Hall Inc., Englewood Cliffs, New Jersey, Reprint 2012.
5. David S. Burnett, **"Finite element analysis: from concepts to applications"**, Addison-Wesley Pub. Co., 1987.

Course Contents and Lecture Schedule

S.No.	**Topic**	**No. of Lectures**
1	**Finite element analysis- Basic Concepts**	
1.1	Matrix methods	2
1.2	Theory of Elasticity	1
1.3	Plane stress	1
1.4	Plane strain	
2	**Procedural steps**	
2.1	Modeling	1
2.2	Discretization and Node Numbering and elements	2
2.3	Convergence requirements	1
2.4	Element stiffness matrix	2
2.5	Global stiffness matrix	1
2.6	Boundary conditions	1
2.7	Solving equations	1
3	**Solution Methods**	
3.1	Variational Method	1
3.2	Weighted Residual approach	1
3.3	Galerkin Method	1
3.4	Ritz Method	1
3.5	Energy method	2
4	**One dimensional problems**	
4.1	Shape functions and its characteristics- Bar element, Beam element and Truss element	2
4.2	Structural problems	2
4.3	Thermal problems	2

S.No.	Topic	No. of Lectures
5	**Two dimensional problems**	
5.1	Rectangular elements	3
5.2	Triangular elements	3
5.3	Higher order elements	2
5.4	Isoparametric elements	3
5.5	Structural problems	3
5.6	Thermal problems	2
	Total	**40**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
GCN	3	0	-	**3**

GCN Design of Jigs, Fixtures and Press Tools 3:0

(Use of Approved Design Data Book is permitted in the Examination)

Preamble: Keeping pace with the latest advances in jigs and fixtures, this course covers thoroughly how and why jigs and fixtures are designed and built. From simple template and plate-type work holders to complex channel and box-type tooling, economy and simplicity in tool design is stressed throughout. This course is also an introduction to the design of cutting and forming dies including material, punches, dies, die sets, stops, strippers, gages, pilots and presses. The purpose of this course is to enable the student to completely design simple tooling.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies

At the end of the course, student will be able to:

1. Identify the requirements for jigs and fixtures.
2. Select the suitable locating and clamping devices.
3. Design the jig for the given component.
4. Design the fixtures for the given component.
5. Draw the strip layout and calculate the tonnage requirement.
6. Design the die for the given component.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test3**	**End-semester examination**
1	Remember	20	20	20	20
2	Understand	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

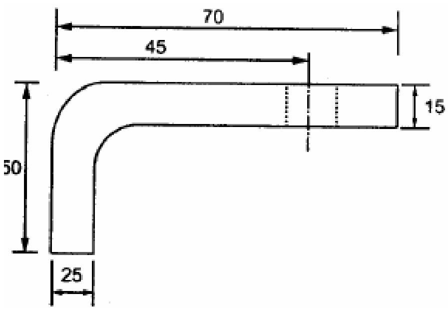
1. What is jig?
2. What is the need of fool proof device in jig?
3. What is locator?
4. State the applications of modular fixture.
5. What is the function of a stripper?
6. What is the difference between compound die and combination die?

Understand

1. Explain quick acting clamps used in jigs.
2. Describe 3-2-1 pin principle.
3. How will you calculate shut height of a press?
4. Explain the elements of a drawing die.
5. Differentiate between jigs and fixtures.
6. Discuss the types of press tools used.

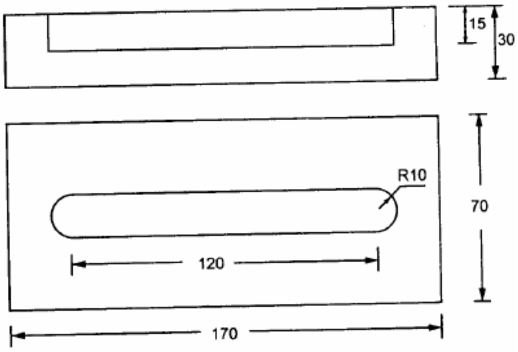
Apply

1. Design a jig to drill equally spaced four holes of 8 mm diameter on 100 mm PCD on a circular disc of diameter 150 mm having a hole of 40 mm diameter at the centre.
2. Design a milling fixture to mill a slot of 3x3 mm at the centre of the circular part of 30 mm diameter and 50 mm length.
3. Design a progressive die to manufacture a washer of diameter 20 mm with a hole of 8 mm diameter from 2mm thick mild steel sheet.
4. Design a drill jig to make a hole of diameter 8mm in the part shown in figure and also mention the parts list.



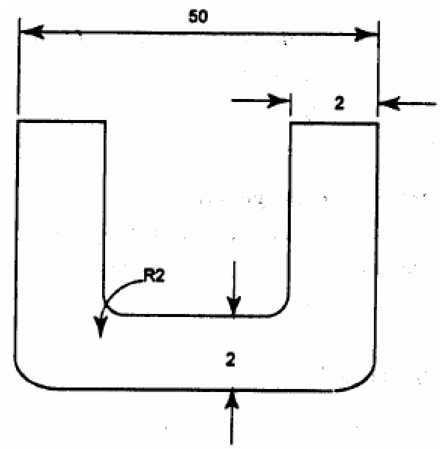
All dimensions are in mm

5. Design a milling fixture to make a slot of size 120 x 20 x 15 mm as shown in figure.



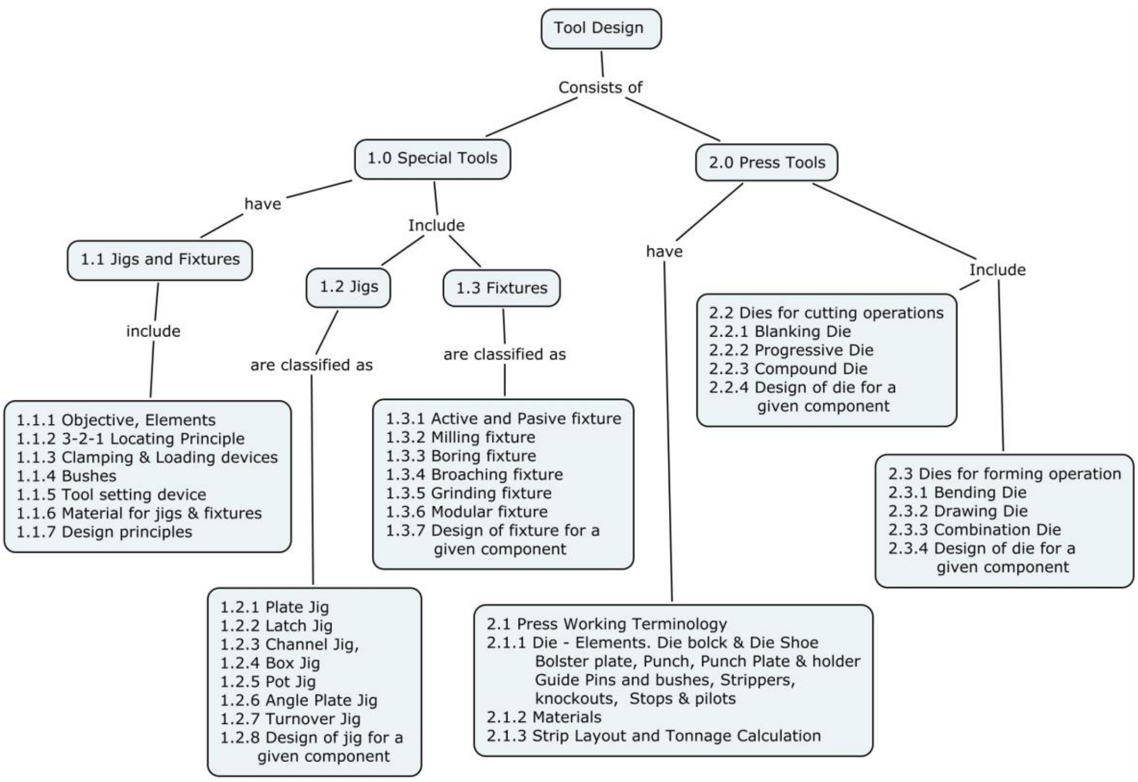
All dimensions are in mm

6. Sketch and design a drawing die for the part shown in figure from medium carbon steel of strength 3600 Kg/cm^2.



All dimensions are in mm

Concept Map



Syllabus

Special tools: Jigs and Fixtures – Objectives - Elements - 3-2-1 location principle – Clamping and locating devices- Bushes - tool setting device - Materials for jigs and fixtures - Design principles of jigs and fixtures

Jigs: Plate Jig, Latch Jig, Channel Jig, Box Jig, Pot Jig, Angle Plate Jig, Turnover Jig- Design of jig for a given component

Fixtures: Active and passive fixture**,** Milling fixture- Boring fixture-Broaching fixture-Grinding fixture- -Modular fixture- Design of fixture for a given component

Press Tools: Press working terminology - Die, Basic elements, Die block - die shoe-Bolster plate- punch -punch plate – punch holder-guide pins and bushes – strippers – knockouts-stops – pilots - Materials - Strip Layout and Tonnage Calculation

Dies for cutting operation, Blanking Die, Progressive Die, Compound Die – Design of die for a given component

Dies for forming operation, Bending Die, Drawing Die, Combination Die – Design of die for a given component

TEXT BOOKS

1. Cyril Donaldson, George H Le Cain, V C Goold and Joyjeet Ghose, **"Tool Design"**, Tata McGraw Hill Education Pvt. Ltd, New Delhi, Fourth Edition, 2012.
2. Edward G Hoffman, **"Jigs & Fixture Design"**, Thomson – Delmar Learning, Singapore 2004.

REFERENCES

1. Kempster M.H.A, **"Fundamentals of Tool Design"**, Prentice Hall of India, 2003.
2. Joshi, P.H., **"Jigs & Fixtures"**, Tata McGraw-Hill Publishing Company Limited, New Delhi, Second Edition, 2004.
3. Hiram E Grant, **"Jigs and Fixture"**, Tata McGraw-Hill, New Delhi, 2003.
4. ASTME, **"Fundamentals of Tool Design"**, Prentice Hall of India, 2003.
5. Nagpal, G.R, **"Tool Engineering & Design"**, Khanna Publishers, Delhi, Sixth edition, Fourth Reprint, 2011.
6. **"Fundamentals of Tool Design"**, CEEE Edition, ASTME, 1983.
7. **"Design Data Handbook"**, PSG College of Technology, Coimbatore, 2007.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1.0	**Special Tools**	
1.1	**Jigs and Fixtures**	
1.1.1	Objective, Elements	1
1.1.2	3-2-1 location principle	
1.1.3	Clamping and locating devices	1
1.1.4	Bushes	1
1.1.5	Tool setting device	
1.1.6	Materials for jigs and fixtures	1
1.1.7	Design principles of jigs and fixtures	2
1.2	**Jigs**	
1.2,1	Plate Jig	1
1.2.2	Latch Jig	1
1.2.3	Channel Jig	1
1.2.4	Box Jig	1
1.2.5	Pot Jig	1
1.2.6	Angle Plate Jig	1
1.2.7	Turnover Jig	1
1.2.8	Design of jig for a given component	2
1.3	**Fixtures**	
1.3.1	Active and Passive fixture	1
1.3.2	Milling fixture	2
1.3.3	Boring fixture	1
1.3.4	Broaching fixture	1
1.3.5	Grinding fixture	1
1.3.6	Modular fixture	1
1.3.7	Design of fixture for a given component	2
2.0	**Press Tools**	
2.1.	**Press working terminology**	
2.1.1	Die Elements, Die block & Die shoe, Bolster plate, Punch, Punch plate & punch holder, Guide pins and bushes, strippers – knockouts-stops – pilots.	2
2.1.2	Materials	1
2.1.3	Strip Layout and Tonnage Calculation	1

No.	Topic	No. of Lectures
2.2	**Dies for cutting operation**	
2.2.1	Blanking Die	2
2.2.2	Progressive Die	2
2.2.3	Compound Die	2
2.2.4	Design of Die for a given component	2
2.3	**Dies for forming operation**	
2.3.1	Bending Die	1
2.3.2	Drawing Die	2
2.3.3	Combination Die	2
2.3.4	Design of Die for a given component	2
	Total	**43**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCP	3	0	-	**3**

GCP Metal Forming Technology 3:0

Preamble: Metal forming technology, which is concerned with the ease with which the materials may be formed into useful shapes such as tubes, rods and sheets plays an important role as a basic as well secondary manufacturing process. The enhancement of its application potential relies on the understanding the following: Plastic behaviour of materials, mechanics of metal forming, methods for analysis & testing and newer/modern forming techniques. On these considerations, this course attempts to provide the fundamental knowledge on the above aspects.

Programme Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering
problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies

At the end of the course, the student will be able to:

1. Explain the elements of theory of plasticity.
2. Explain the mechanics of metal working processes.
3. Determine the forces in various metal forming processes like forging, rolling, extrusion, drawing and bending.
4. Explain the different Powder Metallurgy Forming techniques.
5. Describe the various Special Forming processes.

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3	End-semester Examination
1	Remember	20	20	20	20
2	Understand	40	40	80	40
3	Apply	40	40	-	40
4	Analyze	-	-	-	-
5	Evaluate	-	-	-	-
6	Create	-	-	-	-

Course Level Learning Objectives

Remember

1. What is the importance of yield criteria?
2. Write the influence of strain hardening exponent in plastic work done.
3. What are the design considerations for a closed impression forging die?
4. Mention the advantages of powder metallurgy forming.
5. State the requirements for isothermal forging.
6. What is rubber pad forming?

Understand

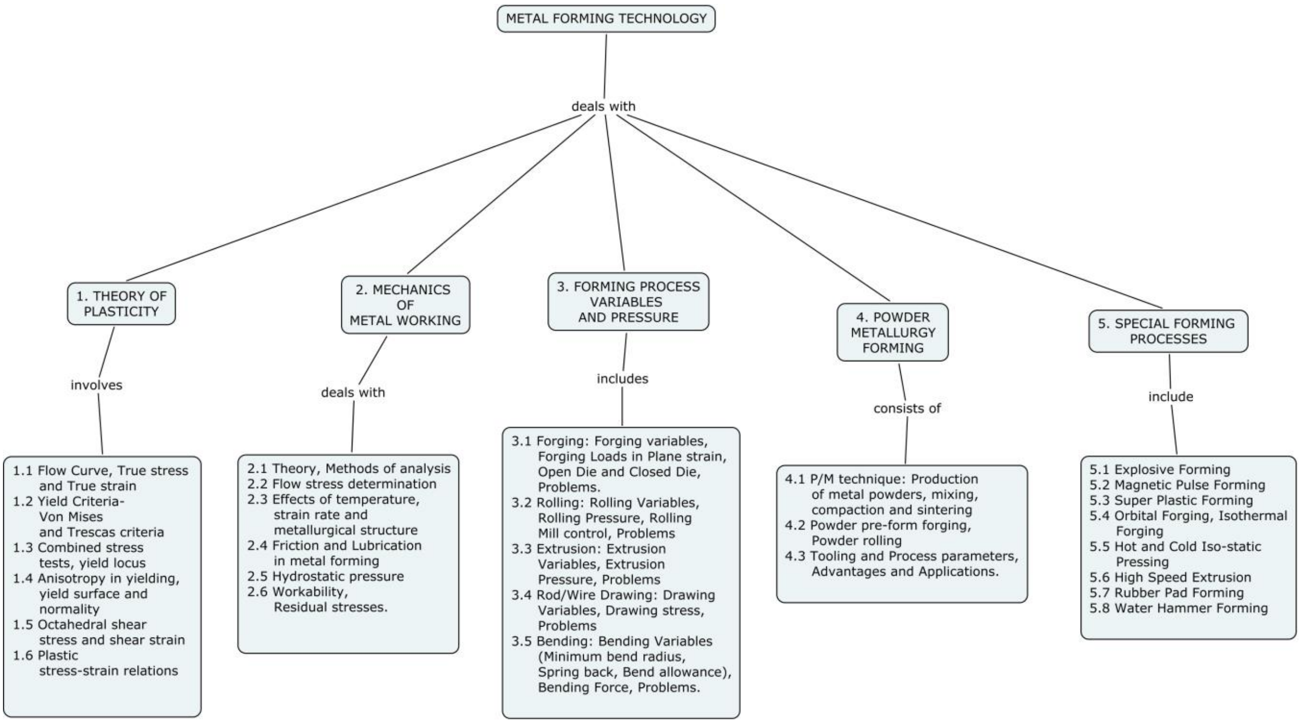
1. Derive the expression for Von Mises yield criteria.
2. Explain the effects of temperature and strain rate on metal working.
3. Derive the expression for average drawing load in wire drawing process.
4. Show how minimum bend radius may be predicted by the tensile reduction of area.
5. Explain the principle, process parameters and applications of powder pre-form forging.
6. Explain the principle, requirements and applications of super plastic forming.

Apply

1. Find out elastic and plastic work done for a specimen 100 mm length, 10 mm diameter being stretched upto 156 mm. Yield strength is 520 MPa and final strength is 960 MPa, Strain hardening exponent is 0.32. Young's modulus is 2.1 GPa.
2. Calculate the average forging load for a block of length 100 mm, width 100 mm and thickness 10 mm. Yield strength is 350 MPa and coefficient of friction is 0.25. Assume sticking friction. Press capacity is 50 tonnes. Give your comments.
3. A block of lead 25 mm x 25 mm x 150 mm is pressed between flat dies to a size 6.25 mm x 100 mm x 150 mm. If the uniaxial flow stress is 6.9 MPa and coefficient of friction is 0.25, determine the pressure distribution over the 100 mm dimension and the total forging load.
4. Calculate the peak pressure and thickness of neutral plane for a two high rolling mill with a roller diameter of 300 mm. Initial and final thicknesses are 15 mm and 14 mm respectively. Width of sheet is 100 mm. Coefficient of friction is 0.25. Yield strength is 300 MPa.
5. Determine the drawing stress to produce a 20-percent reduction in a 10 mm stainless steel wire. Cone angle of die is 12^0. Coefficient of friction is 0.09. The flow stress is given by $1300e^{0.30}$ (MPa).

6. For extruding a rod from 50 mm to 40 mm, find the stress required to push the material. Flow stress is 300 MPa. Coefficient of friction is 0.25. Half cone angle is 5^0.

Concept Map



Syllabus

Elements of Theory of Plasticity:

Flow curve - True stress and true strain - Yielding criteria for ductile materials: Von Mises yield criteria and Tresca's yield criteria - Combined stress tests - Yield locus - Anisotropy in yielding - Yield surface and Normality - Octahedral shear stress and shear strain - Plastic stress-strain relations.

Mechanics of Metal-working:

Theory – Methods of analysis - Flow stress determination - Effects of temperature, strain rate and metallurgical structure - Friction and Lubrication in metal forming - Hydrostatic pressure – Workability - Residual stresses.

Forming Process Variables and Pressure:

Forging: Forging variables – Forging Loads in Plane strain, Open Die and Closed Die - Problems.

Rolling: Rolling Variables – Rolling Pressure – Rolling Mill control – Problems.

Extrusion: Extrusion Variables – Extrusion Pressure – Problems.

Rod / Wire Drawing: Drawing Variables – Drawing stress – Problems.

Bending: Bending Variables (Minimum bend radius, Spring back, Bend allowance) – Bending Force – Problems.

Powder Metallurgy Forming:

P/M technique: Production of metal powders, mixing, compaction and sintering - Powder pre-form forging - Powder rolling – Tooling and Process parameters - Advantages and Applications.

Special Forming Processes:

Explosive Forming – Magnetic Pulse Forming - Super Plastic Forming - Orbital Forging - Isothermal Forging - Hot and Cold Iso-static Pressing – High speed Extrusion – Rubber Pad Forming – Water Hammer Forming.

Text Books:

1. Dieter, G.E., "**Mechanical Metallurgy**", (Revised Edition II), McGraw Hill Co, 1990.
2. Serope Kalpakjian and Steven R.Schmid, "**Manufacturing Engineering and Technology**", Prentice Hall, 6th Edition, 2009.

Reference books:

1. Hosford,W.F and Cad DellL, R.M, "**Metal Forming Mechanics and Metallurgy**", Prentice Hall, Englewood Cliffs, 1993.
2. Altan, T, "**Metal forming - Fundamentals and applications**", American society of metals, Metals park, 1983.
3. Shiro Kobayshi, Soo-Ik-Oh, Altan, T, "**Metal forming and Finite Element Method**", Oxford University Press, 1989.
4. ASM Hand book, "**Forming and Forging**", Ninth Edition, Vol-14, 1998.
5. NAGPAL G.R., "**Metal Forming Processes**", Khanna publishers, New Delhi, 2000.

Course contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Elements of Theory of Plasticity	
1.1	Flow curve, True stress and true strain	2
1.2	Yielding criteria for ductile materials: Von Mises and Trescas criteria	2
1.3	Combined stress tests, Yield locus	1

S.No.	Topic	No. of Lectures
1.4	Anisotropy in yielding, Yield surface and Normality	1
1.5	Octahedral shear stress and shear strain	1
1.6	Plastic stress-strain relations.	1
2.	**Mechanics of Metal Working**	
2.1	Theory, Methods of Analysis	1
2.2	Flow stress determination	1
2.3	Effects of temperature, strain rate and metallurgical structure	1
2.4	Friction and Lubrication in metal forming	1
2.5	Hydrostatic pressure	1
2.6	Workability, Residual stresses	1
3.	**Forming Process Variables and Pressure**	
3.1	Forging: Forging variables, Forging Loads in Plane strain, Open Die and Closed Die, Problems.	3
3.2	Rolling: Rolling Variables, Rolling Pressure, Rolling Mill control, Problems	3
3.3	Extrusion: Extrusion Variables, Extrusion Pressure, Problems	3
3.4	Rod/Wire Drawing: Drawing Variables, Drawing stress, Problems	2
3.5	Bending: Bending Variables (Minimum bend radius, Spring back, Bend allowance), Bending Force, Problems.	2
4	**Powder Metallurgy Forming**	
4.1	P/M technique: Production of metal powders, mixing, compaction and sintering	2
4.2	Powder pre-form forging , Powder rolling	2
4.3	Tooling and Process parameters, Advantages and Applications.	1
5	**Special Forming Processes**	
5.1	Explosive Forming	1
5.2	Magnetic Pulse Forming	1
5.3	Super Plastic Forming	1
5.4	Orbital Forging, Isothermal Forging	1
5.5	Hot and Cold Iso-static Pressing	1
5.6	High speed Extrusion	1

S.No.	Topic	No. of Lectures
5.7	Rubber Pad Forming	1
5.8	Water Hammer Forming	1
	Total	**40**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCW	3	0	-	**3**

GCW Vehicle Design Engineering 3:0

Preamble: Vehicle Design and Engineering deals with design of static and dynamic sub systems of an automobile based on customer requirements, material selection, manufacturing process and cost. It involves designing system, analyzing failure, proposing counter-measures meeting design and regulation standards.

Program outcomes Addressed

d. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
e. Graduates will demonstrate an ability to identify, formulate and solve engineering problems
f. Graduates will develop confidence for self education and ability for life-long learning

Competencies

At the end of the course the student will be able to

1. Convert/Formulate customers' voice into vehicle specifications using HoQ.
2. Explain the function of structural parts and dynamic sub systems and identify the key specifications.
3. Design and analyze the part of a sub-system or the entire sub-system like Structural parts, suspension, brakes and wheels.
4. Explain the various material/design standards applicable globally for automobile industry.
5. Design tests for testing parts/subsystem of the vehicle as per the requirements of stake holders/regulation standards.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1.	Remember	20	20	20	20
2.	Understand	40	40	40	40
3.	Apply	40	20	20	20
4.	Analyze	-	20	20	20
5.	Evaluate	-	-		-
6.	Create	-	-		-

Course level learning objectives

Remember

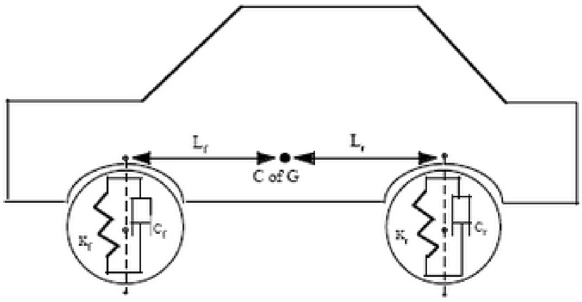
1. Define "House of Quality".
2. List the various failure modes of Structural parts (Frame, Footrest, Pillion handles, etc.).
3. List the various failure modes of various dynamic systems (Suspension, wheels, brakes, etc.).
4. State the advantages of disc brakes over drum brakes.
5. State the effect of manufacturing conversion element on cost of the product.
6. List the standards and methods of vehicle testing.

Understand

1. Demonstrate using House of Quality diagram, how typical customer needs are converted into specifications.
2. Discuss the design procedure of Structural parts of a vehicle.
3. Explain the different form and geometry of suspension to deliver the required functions.
4. Discuss on identification of key specification of brake sub systems to deliver the required functions and the impact of their non conformance.
5. Discuss on optimization of design specification by material selection and manufacturing process taking a part of a sub-system as an example.
6. Explain the ARAI standards related to safety of an automobile.

Apply

1. Draw a HoQ for braking system for a 100 cc bike with prior generation product and benchmark product, assuming different customer feedback. Suggest suitable ideas/plans based on HoQ.
2. Calculate CG position for the vehicle of 5 subsystems packaged in different location, different mass. Suggest ideas to balance the Lateral CG of the vehicle.
3. The automobile has a ratio of 40:60 load sharing between Front vs rear. The LH side of the car is pictorially represented below. The car load factor shall rise to 3 times max during poor road conditions. Design the required spring characteristics of front and rear suspension. Explain what will happen to the front spring stiffness when they are fitted in 75 degrees with respect to ground.



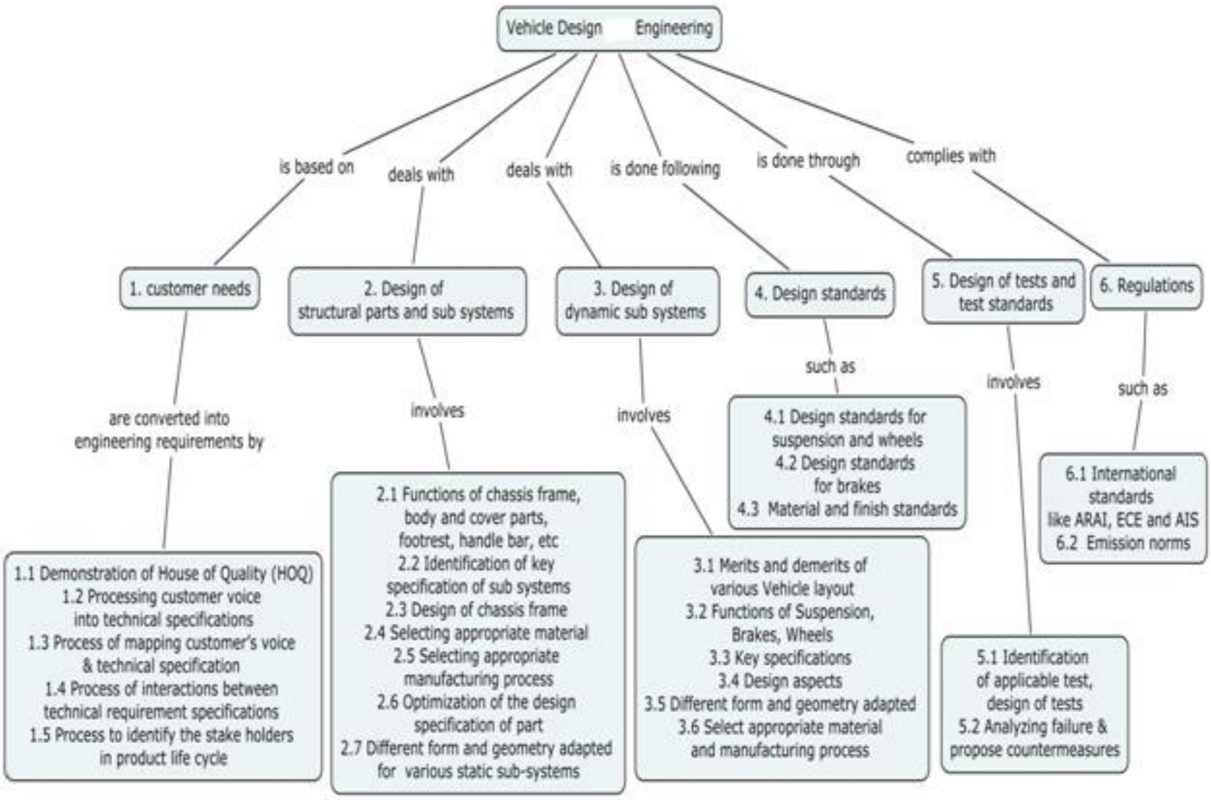
4. A grabber is designed to withstand a Pull load of 200 N. Calculate and choose the best design out of following
   a. Welded of Fillet size 3 and length 20mm X 2 pitch 20 mm.
   b. Riveted of rivet size diameters 5, 3 qty& pitch 15mm
   c. fastened by two bolts of M6 & pitch 25 mm.
   Explain your selection.
5. A) Determine the force required to stop a vehicle of 100 kg moving at 60 kmph speed within stopping distance of a.10m & b.30 m. Explain the methods to reduce the effort required for the customer?
   B) Given the tyre of two stiffness rates 10kg/mm & 15 kg/mm, explain which tyre is most suitable for bad road condition.
6. A motor cycle with a rider, weighing 2000 N, has the centre of the gravity at 0.5 m above the ground level when it is standing upright. Each road wheel has a moment of inertia of 8.8 Nm^2 and a rolling diameter 0.66 m. The overall gear ratio is 6:1. The moment of inertia of the rotating parts of the engine is 1.67 Nm^2. Calculate the angle of heel necessary if the bike is moving at a speed of 70 km/h in a curve of radius of 35 m.

Analyze

1. Analyze the feasibility of drum brake at the front and disc brake at the rear taking into consideration, the weight transfer, braking efficiency and handling for a motor bike and validate your answer.
2. For a 100 cc motor bike, analyze and compare the cost involved in adding the peripheral feature "automatic side stand remover" through various techniques.
3. Analyze the cost involved in adding the feature "dashboard display of kilometers left before empty fuel tank" in an automobile.
4. Compare the technical specifications of air cooled and water cooled engine for a 150 cc bike and suggest the better one by analyzing the cost involved.

5. Suggest the gear ratios of a four speed gear box for a two wheeler of weight 1800 N powered by an engine giving 8.5 kW at 6000 rpm. The vehicle has a wheel diameter 0.75 m. The maximum gradient that the vehicle has to negotiate is 1 in 6. The tractive resistance may be taken as 10 N per 500 N of the vehicle. The wind resistance is given by 0.03679 AV^2, where A is frontal area in m^2 and V is the vehicle speed in km/h. Assume that the transmission efficiency is 0.85 and at top gear, the bike is expected to go over a grade of 1 in 20. State any other assumptions you make.
6. Suggest the practices for a consumer to follow for achieving minimum fuel consumption/maximum mileage. Analyze the effects of your suggestion on performance and ride control/handling of the vehicle.

Concept map



Syllabus

Translation of customer's voice into engineering requirements – HOQ for converting customer voice into technical specifications & enlisting design parameters against each voice -Mapping customers voice & technical specification of different manufacturers -Interactions between technical requirement &specifications – Identification &contribution of stake holders in product life cycle.

Static sub-systems - Functions of structural parts and sub systems - frame, body and cover parts, footrest, handle bar, parking systems & other peripheral system - Key specification of sub systems to deliver the required functions and the impact of their non conformance.

Various forms and geometries adopted for delivering the functions of various static sub-systems **-** Basic design calculations of various forms and geometries of chassis frame- calculation of Section modulus, Moment of Inertia and dimensions of various cross sections. Selection of material manufacturing process and costing for the part / sub-system - Optimization of design specification of the parts including special requirements to achieve target cost.

Dynamic sub-systems–Functions–Influence of Vehicle layout - Suspension, Brakes and Wheels -Various forms and geometries adopted for delivering the functions of various dynamic sub-systems. Basic design calculations of various dynamic sub-systems -Selection of material & manufacturing process and costing for the part / sub-system - Optimization of design specification of the parts including special requirements to achieve target cost.

Tests, standards and regulations - Design of tests & test conditions to verify part against all failure modes - Design of test fixtures, loads – case studies - Failure analysis & counter-measures, Formulation of design verification plan - Working environment of part / sub system / vehicle in usage & handling by various stake holders –Identification of various applicable tests - Stake holders requirements including handling, touch & feel areas and visual appeal.

Global material/design/regulatory & automotive standards for automobile industry - Introduction of standards like IS, ARAI, ECE, AIS and other test standards, automotive emission norms.

Text book

1. Tony Foale, **"Motorcycle Handling and chassis design"** Tony Foale designs, 2006.

References

1. Jason C. Brown, A. John Robertson, Stan T. Serpento, **"Motor vehicles structures: Concepts and Fundamentals - Automotive Engineering Series"**, Butterworth-Heinemann Limited, 2002.
2. Tom Birch, Thomas Wesley Birch, **"Automotive Chassis Systems"**, Delmar, Thomson Learning, 1999.
3. http://www.derby.ac.uk/courses/motorcycle-engineering-beng-hons/- Website of Derby University.

Course contents and Lecture schedule

S.No	Topics	No. of Lectures
1	**Translation of customer's voice into engineering requirements**	
1.1	Demonstration of House of Quality (HOQ).	2
1.2	Processing customer voice into technical specifications & enlist design parameters.	1
1.3	Process of mapping customer's voice & technical specification of different manufacturers.	1.5
1.4	Process of interactions between technical requirement specifications	1.5
1.5	-Process to identify the stake holders in product life cycle and the contribution of each stake holder	1
2	**Functions and design of structural parts and sub systems**	
2.1	Functions of chassis frame, body and cover parts, footrest, handle bar, parking systems & other peripheral system.	1.5
2.2	Identification of key specification of sub systems to deliver the required functions and the impact of their non conformance.	1.5
2.3	Design of chassis frame (calculation of Section modulus, Moment of Inertia etc) of various cross sections (Circular, Square etc)	2
2.4	Selecting appropriate material for the given part / sub-system	1.5
2.5	Selecting appropriate manufacturing process for the given part / sub-system	1.5
2.6	Optimization of the design specification of part including special requirements to achieve target cost	2
2.7	Different form and geometry adapted for delivering the functions of various static sub-systems	1
3	**Functions and design of dynamic sub systems**	
3.1	Merits and demerits of various Vehicle layout.	2
3.2	Functions of Suspension, Brakes, Wheels.	1.5
3.3	Key specification of suspension, brakes, wheels to deliver	1

	the required functions and the impact of their non conformance.	
3.4	Design aspects of Suspension, Brakes and Wheels.	2
3.5	Different form and geometry adapted for delivering the functions of Suspension, Brakes, and Wheels.	1.5
3.6	Select appropriate material and manufacturing process for the production of parts of Suspension and braking system and Wheels.	2.5
4	**Design Standards**	
4.1	Design standards for suspension and wheels	1
4.2	Design standards for brakes	1
4.3	Material and finish standards for components of sub systems (suspension, brakes and wheels)	2
5	**Design of tests and test standards**	
5.1	Identification of various applicable test, design of tests & test condition to verify part against all failure modes - design of test fixtures, loads, case studies	2
5.2	Analyzing failure & propose countermeasures, formulate design verification plan – understand the working environment of part / sub system / vehicle in usage & part handling at various stake holders	2
6	**Regulations**	
6.1	Requirements of Regulation standards, International standards like ARAI, ECE and AIS.	2
6.2	Automotive emission norms	1.5
	Total	**40**

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Sub Code	Lectures	Tutorial	Practical	Credit
GCY	3	0	-	**3**

GCY Turbo Machines 3:0

Preamble: Turbo machines are energy conversion devices in which energy is transferred either to, or from, a continuously flowing fluid by the dynamic action of one or more moving blade rows on a rotor. This course deals with the study of energy transfer, thermodynamic analysis and performance calculations of compressible and incompressible flow turbo machines like turbines, compressors, pumps, fans and blowers, through the laws of fluid mechanics and thermodynamics.

Program Outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

c. Graduate will demonstrate an ability to design a system, component or process as per needs and specifications.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

k. Graduates can participate and succeed in competitive examinations.

Competencies:

At the end of the course, students will be able to:

1. Explain the working of various types of compressible and incompressible flow turbo machines, like compressors, turbines, pumps and fans.
2. Deduce dimensionless groups by applying dimensional analysis on turbo machines.
3. Determine the performance parameters of various turbo machines both analytically and using velocity triangles.

Assessment Pattern:

Sl.No	Bloom's Category	Test 1	Test 2	Test3	End-semester examination
1	Remember	20	20	20	20
2	Understand	30	30	30	30
3	Apply	40	40	40	40
4	Analyze	10	10	10	10
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember

1. Classify a turbo machine based on the direction of fluid flow?
2. Define polytrophic efficiency of a turbine.
3. List out the various losses in cascades.
4. Define dynamic similarity.
5. Define degree of reaction of axial flow turbine.
6. Define cavitation in pumps.

Understand

1. By using Buckingham's Pi theorem, show that dimensionless expression ΔP is given by $\Delta P = \frac{4flV^2}{2D}\rho$

   Where ΔP- pressure drop in a pipe, V- mean velocity of the flow, l - length of the pipe, D - diameter of the pipe, f - average roughness of the pipe, and ρ - density of the fluid.
2. Derive the Euler's energy equation for turbine.
3. A pump discharges liquid at the rate of Q against a head of H. If specific weight of the liquid is w, find the expression for the pumping power.
4. Distinguish between various methods of compounding steam turbines.
5. Derive an expression for degree of reaction in an axial flow gas turbine.
6. Show that for 50% reaction, the blades are symmetrical in axial flow compressors (i.e., $\alpha_1 = \beta_2$ and $\alpha_2 = \beta_1$).

Apply

1. Consider an axial flow gas turbine in which air enters at the stagnation temperature of 1050 K. The turbine operates with a total pressure ratio of 4:1. The rotor turns at 15500 rpm and the overall diameter of the rotor is 30 cm. If the total-to-total efficiency is 0.85, find the power output per kg per second of airflow if the rotor diameter is reduced to 20 cm and the rotational speed is 12,500 rpm. Take γ = 1.4.
2. Steam enters the first row of a series of stages at a static pressure of 10 bars and a static temperature of 300°C. The blade angles for the rotor and stator of each stage are: α_1 = 25°, β_1 = 60°, α_2 =70.2°, β_2 = 32°.If the blade speed is 250 m/s, and the rotor efficiency is 0.94, find the degree of reaction and power developed for a 5.2 kg/s of steam flow. Also find the static pressures at the rotor inlet and exit if the stator efficiency is 0.93 and the carryover efficiency is 0.89.
3. A small inward radial flow gas turbine operates at its design point with a total-to-total efficiency of 0.90. The stagnation pressure and temperature

of the gas at nozzle inlet are 310 kPa and 1145 K respectively. The flow leaving the turbine is diffused to a pressure of 100 kPa and the velocity of flow is negligible at that point. Given that the Mach number at exit from the nozzles is 0.9, find the impeller tip speed and the flow angle at the nozzle exit. Assume that the gas enters the impeller radially and there is no whirl at the impeller exit. Take Cp_g = 1.147 kJ/kg K; □ =1.33

4. The impeller tip speed of a centrifugal compressor is 370 m/s, slip factor is 0.90, and the radial velocity component at the exit is 35 m/s. If the flow area at the exit is $0.18m^2$ and compressor efficiency is 0.88, determine the mass flow rate of air and the absolute Mach number at the impeller tip. Assume air density = 1.57 kg/m^3 and inlet stagnation temperature is 290 K. Neglect the work input factor. Also, find the overall pressure ratio of the compressor.
5. A centrifugal pump impeller runs at 1400 rpm, and vane angle at exit is 25°. The impeller has an external diameter of 0.4m and an internal diameter of 0.2 m. Assuming a constant radial flow through the impeller at 2.6 m/s; calculate (1) the angle made by the absolute velocity of water at exit with the tangent, (2) the inlet vane angle, and (3) the work done per kg of water.
6. An inward flow reaction turbine develops 70 kW at 370 rpm. The inner and outer diameters of the wheel are 40 and 80 cm, respectively. The velocity of the water at exit is 2.8 m/s. Assuming that the discharge is radial and that the width of the wheel is constant, find the actual and theoretical hydraulic efficiencies of the turbine and the inlet angles of the guide and wheel vanes. Turbine discharges 545 liters/s under a head of 14 m.

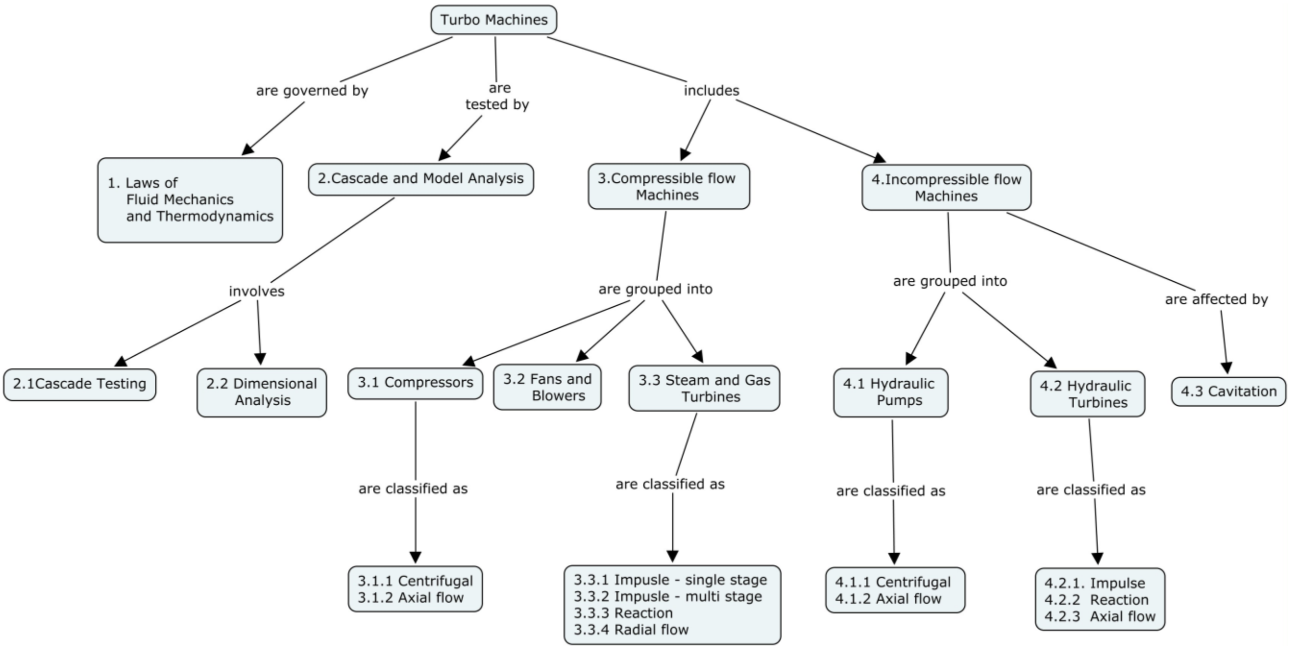
Analyze

1. At a particular operating condition an axial flow compressor has a reaction of 0.6, a flow coefficient of 0.5 and a stage loading, defined as 1h0=U2 of 0.35. If the flow exit angles for each blade row may be assumed to remain unchanged when the mass flow is throttled, determine the reaction of the stage and the stage loading when the air flow is reduced by 10% at constant blade speed. Sketch the velocity triangles for the two conditions. Comment upon the likely behavior of the flow when further reductions in air mass flow are made.
2. A turbine model of 1:10 develops 1.84 kW under a head of 5m of water at 480 rpm. Find the power developed by the prototype under a head of 40 m. Also find the speed of the prototype. Compare the specific speeds of

the model and prototype of turbines if the efficiencies are same for both the turbines.

3. Water is to be lifted through 110 m height from a well. Identical pumps having speed 1000 rpm, specific speed 25 rpm with a rated discharge of 6000 lpm are available. Identify the number of pumps required to do the work. Also, examine the method of arranging the pumps.
4. A compressor has been designed for normal atmospheric conditions (101.3 kPa and 15°C).In order to economize on the power required it is being tested with a throttle in the entry duct to reduce the entry pressure. The characteristic curve for its normal design speed of 4000 rev/min is being obtained on a day when the ambient temperature is 20°C. At what speed should the compressor be run? At the point on the characteristic curve at which the mass flow would normally be 58 kg/s the entry pressure is 55 kPa. Calculate the actual rate of mass flow during the test. Illustrate the relationship between geometry and specific speed for pumps.
5. Water is to be supplied to the Pelton wheel of a hydroelectric power plant by a pipe of uniform diameter, 400m long; from a reservoir whose surface is 200m vertically above the nozzles. The required volume flow of water to the Pelton wheel is 30m3/s. If the pipe skin friction loss is not to exceed 10% of the available head and f = 0.0075, determine the minimum pipe diameter. You are required to select a suitable pipe diameter from the available range of stock sizes to satisfy the criteria given. The range of diameters (m) available is: 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, and 2.8. For the diameter you have selected, determine: (i) the friction head loss in the pipe; (ii) the nozzle exit velocity assuming no friction losses occur in the nozzle and the water leaves the nozzle at atmospheric pressure; (iii) the total power developed by the turbine assuming that its efficiency is 75% based upon the energy available at turbine inlet.
6. A Kaplan turbine develops 10,000 kW under an effective head 8 m. The overall efficiency is 0.86, the speed ratio 2.0, and flow ratio 0.60. The hub diameter of the wheel is 0.35 times the outside diameter of the wheel. Find the diameter and speed of the turbine. Investigate the effect of increasing the hub diameter of the turbine to 0.5 times the outer diameter, on the speed of the turbine.

Concept Map



Syllabus

Turbo Machines: Basic Concepts: Definition, classification, Governing laws- continuity equation, first and second law of thermodynamics, Newton's second law of motion, law of affinity, Euler's Equation, components of energy transfer equation, polytrophic, stage and overall efficiencies. **Cascade and Model Analysis**: blade types, co-efficient, blade nomenclature, cascade- nomenclature, testing and cascade losses. Dimensional Analysis: dimensions and equations, Buckingham Pi Theorem, types of similarities, specific speeds, unit quantities. **Compressible flow Machines:** Centrifugal Compressors – velocity triangles, work output, slip factor, stage pressure rise, reaction ratio, blade Shapes, characteristics-stall, surging and choking. Axial Flow Compressors-velocity triangles, stage Loading, degree of reaction, multi-Stage compressor, Characteristics. Fans and Blowers – types and applications. Steam and Gas Turbines- Impulse Turbine -single stage – velocity triangle, work output, multi stage-pressure compounding, velocity compounding. Reaction Turbine- velocity triangles, stage efficiency, reheat factor, losses in turbines, governing of turbines, free vortex design. Radial Flow -velocity triangles, spouting velocity, stage efficiency. **Incompressible flow machines:** Hydraulic Pumps- Centrifugal Pumps – velocity triangles, work output, slip Factor, pump Losses and efficiencies, blade shapes, NPSH, Specific Speed. Axial flow pump- velocity triangles, work output. Hydraulic Turbines -Impulse turbine -Pelton Wheel, Velocity triangles, work done, efficiencies- Reaction Turbine-Francis turbine, work done, efficiencies. Axial Flow Turbine- Kaplan turbine-velocity triangles, work done, efficiencies. Cavitation: effects and prevention of cavitation in pumps and turbines.

TEXT BOOKS

1. S. M. Yahya, **"Turbines, Compressors & Fans"**, Tata-McGraw Hill, 3rd edition, 2005.
2. A.Valan Arasu, **"Turbo Machines"**, Second Edition, Vikas publishing house Pvt Ltd, New Delhi, 2013.

REFERENCES

1. S.L.Dixon, **"Fluid Mechanics, Thermodynamics of Turbo machinery"** Butterworth-Heinemann Publishers, 4th edition, 1998.
2. Rama S. R. Gorla and Aijaz A. Khan, **"Turbo machinery Design and Theory"**, Marcel Dekker Inc. USA, 2003.
3. V. Kadambi and Manohar Prasad **"An Introduction to energy conversion, Volume III – Turbo machinery"**, New Age International Publishers (P) Ltd. 2005.
4. William W Perg, **"Fundamentals of Turbo machinery"**, John Wiley & Sons, Inc. 2008.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
	Turbo machines	
1	**Governing laws** Continuity equation, first and second law of thermodynamics, Newton's second law of motion, efficiency and losses	1
1.1	Efficiency of Nozzles, Diffusers, Turbines and Compressors, polytropic efficiency	3
1.2	Energy Transfer in Turbo machinery- Euler's Turbine Equation, components of energy transfer	1
2.	**Model Analysis**	
2.1	Flow through cascades	
2.1.1	Blade nomenclature, cascade of blades, turbine cascade and compressor cascade nomenclatures	2
2.1.2	Cascade testing and losses	1
2.2	Dimensional analysis	
2.2.1	Dimensions and equations, Buckingham Pi Theorem	2

No.	Topic	No. of Lectures
2.2.2	Model Analysis -Geometric Similarity, Kinematic Similarity, Dynamic Similarity, specific speeds, unit quantities	3
3.	**Compressible flow machines**	
3.1	**Compressors**	
3.1.1	Centrifugal Compressors - velocity triangle, Slip Factor, Work Done, The Effect of Blade Shape on Performance, Diffuser, Characteristics-Stall, Surging and Choking	3
3.1.2	Axial Flow Compressors - velocity triangle, Degree of Reaction, Stage Loading, Lift-and-Drag Coefficients, Multi-Stage Performance, Characteristics.	3
3.2	**Fans** and **blowers** – Types, Applications	1
3.3	**Steam Turbines**	
3.3.1	Impulse Turbine-Single stage – velocity triangle, work output	2
3.3.2	Multi Stage-Pressure Compounding (Rateau Turbine), Velocity Compounding (Curtis Turbine)	2
3.3.3	Reaction Turbine- velocity diagram, Stage efficiency. Reheat factor, Losses on turbines, Governing of turbines	3
3.4	**Gas turbines**	
3.4.1	Axial Flow Gas Turbines-Velocity Triangles and Work Output, Degree of Reaction, Blade-Loading Coefficient ,Stator (Nozzle) and Rotor Losses, Free Vortex Design	3
3.4.2	Radial Flow Gas Turbine-Velocity Diagrams and Thermodynamic Analysis, Spouting Velocity, Turbine Efficiency	3
4	**Incompressible flow machines:**	
4.1	**Hydraulic Pumps**	
4.1.1	Centrifugal Pumps - Slip Factor, Pump Losses, The Effect of Impeller Blade Shape on Performance, Volute or Scroll Collector, Vane less Diffuser, Vaned Diffuser, NPSH, Specific Speed.	3
4.1.2	Axial flow pump- velocity triangle and work output	1
4.2	**Hydraulic turbines**	
4.2.1	Impulse turbine -Pelton Wheel, velocity triangles, work done and efficiencies	3
4.2.2	Reaction Turbine-Francis turbine, velocity triangles, work	3

No.	Topic	No. of Lectures
	done, efficiencies, Turbine Characteristics	
4.2.3	Axial Flow Turbine- Kaplan turbine, velocity triangles, work done, efficiencies	1
4.3	**Cavitation**	
4.3.1	Effects and prevention of cavitation in pumps and turbines.	1
	Total	**45**

Course Designers:

1. A.Valan Arasu avamech@tce.edu
2. B.Karthikeyan bkmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
GCZ	3	0	-	**3**

GCZ Mechanical Vibrations 3:0

Preamble: Vibration is the motion of a particle or a body or a system of connected bodies displaced from a position of equilibrium. Most vibrations produce increased stresses, energy losses, wear and bearing loads. Predicting and measuring the vibration in a dynamic system is essential to improve the system performance. This course covers the basic principles of vibration, modeling and their application in mechanical systems.

Program Outcomes addressed

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies

At the end of the course the student will be able to

1. Explain the importance of vibrations in design of machine parts.
2. Develop the models and derive equations of motion of vibratory systems.
3. Determine vibratory responses of systems with single/multi degrees of freedom.
4. Suggest suitable method(s) for measuring and controlling of vibrations in mechanical systems.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test 3**	**End-semester examination**
1	Remember	10	10	10	10
2	Understand	10	10	10	10
3	Apply	80	80	80	80
4	Analyze	-	-	-	-
5	Evaluate	-	-	-	-
6	Create	-	-	-	-

Course Level Learning Objectives

Remember

1. What do you mean by Vibration Isolation and Transmissibility
2. Explain the term Logarithmic Decrement as applied to damped vibrations?
3. What is torsionally equivalent shaft?
4. What is the basic principle used in Holzer's method?
5. Name a few methods for finding the fundamental natural frequency of a multidegree of freedom system.
6. What is the function of a vibration isolator?

Understand

1. Differentiate between free vibrations and forced vibrations.
2. Why experimental modal analysis is done in vibration measurement?
3. Differentiate between micrometer and micrograph.
4. How balancing is influencing in dynamic systems?
5. Differentiate between viscous, coulomb and hysteretic damping.
6. Why critical speed is determined in rotary systems?

Apply

1. The mass of an electric motor is 120 kg and it runs at 1500 r.p.m. The armature mass is 35 kg and its C.G. lies 0.5 mm from the axis of rotation. The motor is mounted on five springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the five springs. Determine the stiffness of each spring and the dynamic force transmitted to the base at the operating speed.

2. A steel shaft ABCD 1.5 m long has flywheel at its ends A and D. The mass of the flywheel A is 600 kg and has a radius of gyration of 0.6 m. The mass of the flywheel D is 800 kg and has a radius of gyration of 0.9 m. The connecting shaft has a diameter of 50 mm for the portion AB which is 0.4 m long; and has a diameter of 60 mm for the portion of BC which is 0.5 m long: and has a diameter of 40 mm for the portion CD which is 0.6 m long. Determine the natural frequency of the torsional vibrations. Also draw the node positions. The modulus of rigidity for the shaft material is 80 GN/ m^2.

3. Estimate the fundamental frequency of lateral vibration of a shaft carrying three rotor system as shown in Fig. 1 with m_1 = 20 kg, m_2 = 50 kg, m_3 =

40 kg, l_1 = 1 m l_2 = 3 m; l_3= 4 m, and l_4 = 2 m. The shaft is made of steel with solid circular cross section diameter of 10 cm.

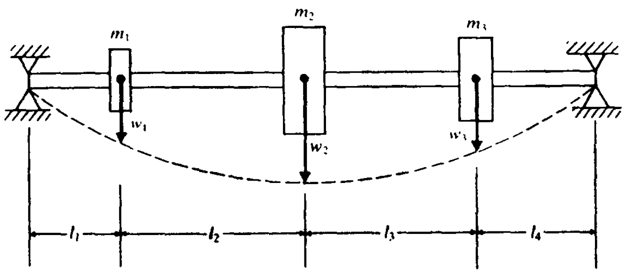


Fig. 1

4. The arrangement of the compressor, turbine, and generator in a thermal power plant is shown in Fig.2. Find the natural frequencies and mode shapes of the system.

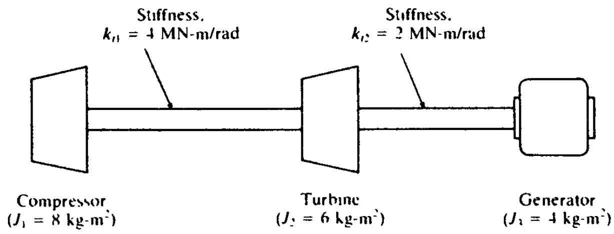


Fig.2.

5. Estimate the fundamental frequency of vibration of the astern shown in Fig.3, Assume that m_1, = m_2, = m_2, = m. k_1, = k_2, = k_3, = k, and the mode shape is X={1 2 3}

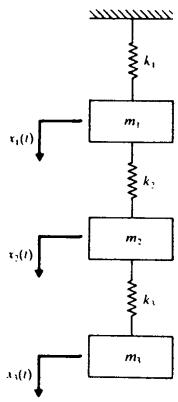


Fig.3

6. The arrangement of cranks in a 6-cylinder in-line engine is shown in Fig. 9.34. The cylinders are separated by a distance a in the axial direction and the angular positions of the cranks are given by $\alpha_1 = \alpha_6 = 0°$, $\alpha_2 = \alpha_5 = 120°$, and $\alpha_3 = \alpha_4 = 240°$. If the crank length, connecting rod length, and the reciprocating mass of each cylinder is r, l, and m, respectively, find the

primary and secondary unbalanced forces and moments with respect to the reference plane indicated in Fig.4.

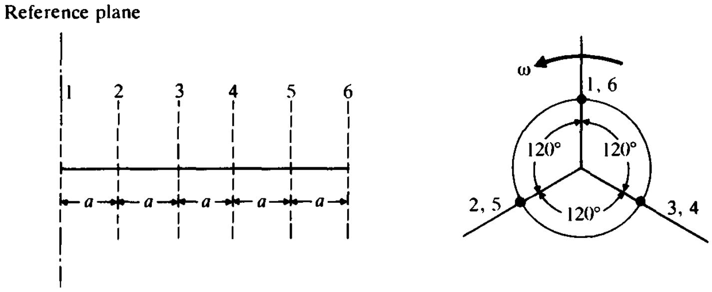
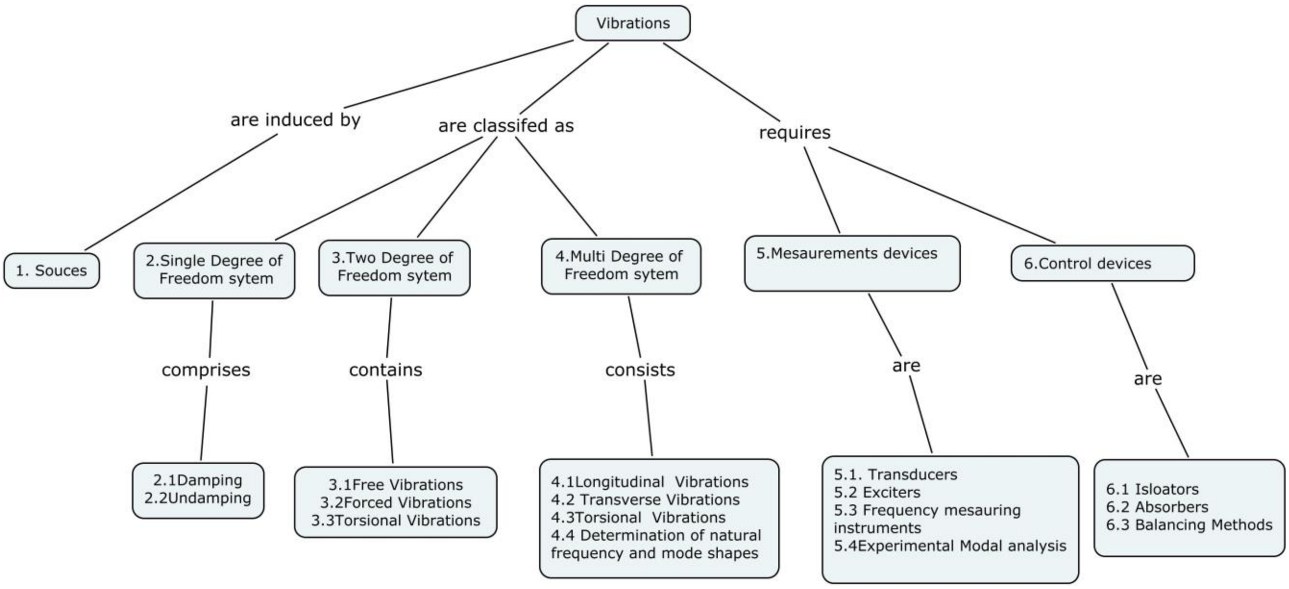


Fig.4.

Concept Map



Syllabus

Fundamentals of Vibration: Sources of vibration-Elements of vibrating system-Mathematical models-Types of vibration-Free and forced –Single degree freedom systems with and without damping –Types of Damping-Viscous coulomb and hysteretic damping, translational system and torsional system, logarithmic decrement- vibration isolation and force transmissibility- vibration analysis - Critical speed.

Two Degree Freedom System: Equations of motions-free, forced and torsional vibration of Undamped and damped system. Torsional system-Spring coupled system – mass coupled system –coordinates coupling and principles coupling, orthogonal properties. **Multi-Degree Freedom System:** Free vibrations of damped and Undamped system, Longitudinal, Transverse, Torsional systems, influence coefficients – Eigen values and Eigen vectors –– Determination of natural frequencies- Rayleigh, Dunkerley and Holzer methods. **Measurements and Control:** Vibration Measuring Devices: Transducers, vibration pickups-

Vibration exciters: mechanical, hydraulic, –Frequency measuring instruments: single reed, multi reed and stroboscope. Experimental modal analysis. Vibration control devices-isolators, absorbers and balancing.

TEXT BOOKS:

1. Rao, S.S.,” **Mechanical Vibrations,”** Addison Wesley Longman, Reprint 2010.
2. G.K.Grover., **“Mechanical Vibrations”**, New Chand & Bros , Roorkee, 1996,

REFERENCES:

1. Thomson, W.T. **“Theory of Vibration with Applications”**, CBS Publishers and Distributors, New Delhi, 1990.
2. Ambekar.A.G. **“Mechanical Vibrations and Noise Engineering”**, Prentice Hall of India, New Delhi, 2006.
3. Den Hartog, J.P, **“Mechanical Vibrations”**, Dover Publications, 1990.
4. Ramamurti. V, **“Mechanical Vibration Practice with Basic Theory”**, Narosa, New Delhi, Reprint 2011.
5. Rao V. Dukkipati and J,Srinivas, **“Text book of Mechanical Vibrations”**, Prentice Hall of India, New Delhi, Reprint 2011.

Course Contents and Lecture Schedule

S.No.	**Topic**	**No. of Lectures**
1	**Fundamentals of Vibration – Basic Concepts**	
1	Sources of vibration	2
1.1	Elements of vibrating system-Mathematical models	1
1.2	Types of vibration-Free and forced	1
2	**Single degree freedom systems**	
2.1	Single degree freedom systems – with damping	1
2.1.1	Types of Damping-Viscous coulomb and hysteretic damping	2
2.1.2	Logarithmic decrement	2
2.1.3	Vibration isolation and force transmissibility	1
2.2	Single degree freedom systems- with and without damping	2
2.2.1	Vibration analysis	1
2.2.2	Critical speed	1
3	**Two Degree Freedom System:**	
3.1	Equations of motions-free vibration of Undamped and damped system.	2

S.No.	Topic	No. of Lectures
3.2	Equations of motions-forced vibration of Undamped and damped system.	2
3.3	Equations of motions-torsional vibration of Undamped and damped system.	2
3.3.1	Coordinates coupling and principles coupling, Orthogonal properties.	2
4	**Multi-Degree Freedom System**	
4.1	Longitudinal –Free vibrations of damped and Undamped system,	2
4.2	Transverse vibrations	1
4.4	Torsional systems, influence coefficients – Eigen values and Eigen vectors	2
4.4.1	Determination of natural frequencies – Rayleigh method	1
4.4.2	Dunkerley method	1
4.4.3	Holzer methods	2
5	**Measurement Devices**	
5.1	Transducers- vibration pickups	1
5.2	Vibration exciters: Mechanical and Hydraulic	1
5.3	Frequency measuring instruments: single reed, multi reed and stroboscope	1
5.4	Experimental modal analysis.	2
6	**Vibration Control Devices**	
6.1	Vibration Isolators	1
6.2	Absorbers	1
6.3	Balancing devices.	1
	Total	**40**

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAMME

ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
Fax: 0452 2483427
Web: www.tce.edu

Department of Mechanical Engineering

Graduating Students of BE program of Mechanical Engineering will be able to

1. Analyze, design and evaluate mechanical components and systems using state-of-the-art IT tools
2. Plan the manufacturing of given mechanical components and systems (methods design, process plan, process automation and manufacturing methods)
3. Analyze and design quality assurance systems
4. Apply modern management methods to manufacturing of components and systems
5. Work in a team using common tools and environments to achieve project objectives

Thiagarajar College of Engineering, Madurai-625015
Department of Mechanical Engineering
Scheduling of Courses

Semester	Theory Courses						Practical/Project		
8th (21)	Elective 6 3:0	Elective 7 3:0	Elective 8 3:0				G84 Project 0:12		
7th (21)	G71 Management Theory and Practice 3:0	G72 Operations Research 3:1	Elective 3 3:0	Elective 4 3:0	Elective 5 3:0		G77 Manufacturing System Simulation Lab 0:1	G78 Project 0:4	
6th (23)	G61 Accounting and Finance 3:0	G62 Design of Transmission System 3:1	G63 Quality and Reliability Engineering 3:0	G64 Mechatronics 3:0	Elective 1 3:0	Elective 2 3:0	G67 Computer Aided Engineering Lab 0:1	G68 Mechatronics Lab 0:1	G69 Production Drawing 0:2
5th (24)	G51 Applied Statistical Techniques 4:0	G52 Kinematics and Dynamics of Machinery 3:1	G53 Metrology and Mechanical Measurements 3:0	G54 Heat and Mass Transfer 3:1	G55 Manufacturing Processes and Automation 3:0	G56 Industrial Engg. 3:0	G57 CAD/CAM Lab 0:1	G58 Heat Transfer Lab 0:1	G59 Mech. Measurement and Metrology Lab 0:1
4th (24)	G41 Numerical Methods 3:1	G42 Design of Machine Elements 3:1	G43 Geometric Modeling 3:0	G44 Thermal Engineering 3:0	G45 Machining Processes 3:0	G46 Control Systems 3:0	G47 Machining Practice Lab 0:1	G48 Thermal Engineering Lab 0:1	G49 Professional Communication. 1:1
3rd (23)	G31 Engineering Mathematics-III 4:0	G32 Mechanics of Materials 4:0	G33 Applied Material and Metallurgy 3:0	G34 Fluid Mechanics 4:0	G35 Metal Casting and Plastic forming processes 2:0	G36 Metal Forming and Joining Processes 2:0	G37 Manufacturing Processes Lab 0:1	G38 Fluid Mechanics and CFD Lab 0:1	G39 Machine Drawing 0 :2
2nd (23)	G21 Engineering Mathematics-II 3:1	G22 Free Body Mechanics 3:1	G23 Material Science 3:0	G24 Thermodynamics 3:1	G25 Ecology and Environment 2:0	G26 Computer Programming 3:0	G27 Strength of Materials and Composite materials Lab 0:1	G28 Computer Programming Lab 0:1	G29 Workshop 0:1
1st (25)	H11 Engineering Mathematics –1 4:0	H12 Physics 3:0	H13 Chemistry 3:0	H14 English 3:0	H15 Basics of Mechanical & Civil Engg. 4:0	H16 Basics of EE and ECE 4:0	H17 Physics Lab. 0:1	H18 Chemistry Lab. 0:1	H19 Engineering Graphics 0:2

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

SIXTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
G61	Accounting and finance	HSS	3	0	-	3
G62	Design of transmission system	DC	3	1	-	4
G63	Quality and Reliability Engineering	DC	3	0	-	3
G64	Mechatronics	DC	3	0	-	3
GCX	Elective – 1	DC	3	0	-	3
GCX	Elective – 2	DC	3	0	-	3
PRACTICAL						
G67	Computer Aided Engineering Lab	DC	-	-	3	1
G68	Mechatronics Lab.	DC	-	-	3	1
G69	Production Drawing	DC	2	-	3	2
Total			**20**	**1**	**9**	**23**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

SIXTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G61	Accounting and finance	3	50	50	100	25	50
2	G62	Design of transmission system	3	50	50	100	25	50
3	G63	Quality and Reliability Engineering	3	50	50	100	25	50
4	G64	Mechatronics	3	50	50	100	25	50
5	GCX	Elective - 1	3	50	50	100	25	50
6	GCX	Elective - 2	3	50	50	100	25	50
PRACTICAL								
7	G67	CAE Lab-1	3	50	50	100	25	50
8	G68	Mechatronics Lab.	3	50	50	100	25	50
9	G69	Production Drawing	3	50	50	100	25	50

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

SEVENTH SEMESTER

Subject code	Name of the subject	Category	No. of Periods / Week			credits
			L	T	P	
THEORY						
G71	Management Theory and Practice	DC	3	0	-	3
G72	Operations Research	DC	3	1	-	4
GCX	Elective – 3	DC	3	0	-	3
GCX	Elective – 4	DC	3	0	-	3
GCX	Elective – 5	DC	3	0	-	3
PRACTICAL						
G77	Manufacturing System Simulation Lab.	DC	-	-	3	1
G78	Project	DC	-	-	8	4
Total			**15**	**1**	**11**	**21**

BS : Basic Science
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ES : Engineering Science
DC : Department core

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T : Tutorial
P : Practical

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2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

SEVENTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	G71	Management Theory and Practice	3	50	50	100	25	50
2	G72	Operations Research	3	50	50	100	25	50
3	GCX	Elective – 3	3	50	50	100	25	50
4	GCX	Elective – 4	3	50	50	100	25	50
5	GCX	Elective – 5	3	50	50	100	25	50
PRACTICAL								
7	G77	Manufacturing System Simulation Lab.	3	50	50	100	25	50
8	G78	Project	-	150	150	300	75	150

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SUBJECTS OF STUDY
(For the candidates admitted from 2010-2011 onwards)

EIGHTH SEMESTER

Subject code	Name of the subject	Category	No. of Periods / Week			credits
			L	T	P	
THEORY						
GCX	Elective – 6	DC	3	0	-	3
GCX	Elective – 7	DC	3	0	-	3
GCX	Elective – 8	DC	3	0	-	3
PRACTICAL						
G84	Project	DC	-	-	24	12
Total			**9**	**-**	**24**	**21**

BS : Basic Science
HSS : Humanities and Social Science
ES : Engineering Science
DC : Department core

L : Lecture
T : Tutorial
P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit
2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015

B.E Degree (Mechanical Engineering) Program

SCHEME OF EXAMINATIONS
(For the candidates admitted from 2010-2011 onwards)

EIGHTH SEMESTER

S.No.	Sub. Code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	GCX	Elective – 6	3	50	50	100	25	50
2	GCX	Elective – 7	3	50	50	100	25	50
3	GCX	Elective – 8	3	50	50	100	25	50
PRACTICAL								
4	G84	Project	-	150	150	300	75	150

* Continuous Assessment evaluation pattern will differ from subject to subject and for different tests. This will have to be declared in advance to students. The department will put a process in place to ensure that the actual test paper follow the declared pattern.

** Terminal Examination will be conducted for maximum marks of 100 and subsequently be reduced to 50 marks for the award of terminal examination marks.

List of Department Electives

GCA	Energy Conversion Systems
GCB	Basics of Aircraft Engineering
GCC	Automotive Engine Systems
GCD	Mechatronics System Design
GCE	Material Handling Systems and Engineering
GCF	Theory of Metal Cutting
GCG	Manufacturing System Engineering
GCH	Marketing Management
GCK	Refrigeration and Air Conditioning
GCL	Computational Fluid Dynamics
GCM	Finite Element Analysis
GCN	Design of Jigs, Fixtures and Press Tools
GCP	Metal Forming Technology
GCQ	Machine Vision
GCR	Product Design and Development
GCS	Automotive Engineering
GCT	Welding Technology
GCU	Computer Integrated Manufacturing
GCV	Production and Operations Management
GCW	Vehicle Design Engineering
GCY	Turbo Machines
GCZ	Mechanical Vibration
GC1	Integrated Product Development
GC2	Spark Ignition Engines
GC3	Spark Ignition Engines – Design & Engineering
GC4	Vehicle Design Engineering – Statics
GC5	Vehicle Design Engineering-Dynamics
GC6	Assembly Engineering
GC7	Metal Cutting Processes Engineering
GC8	Design for Welding
GC9	Sheet Metal Drawing and Bending

Electives passed on 44th Academic Council Meeting on 09.06.12

GCK	Refrigeration and Air Conditioning
GCR	Product Design and Development

Electives passed on 45th Academic Council Meeting on 24.11.12

GCH	Marketing Management
GCL	Computational Fluid Dynamics
GCQ	Machine Vision
GCS	Automotive Engineering
GCT	Welding Technology
GCV	Production and Operations Management

Electives passed in 46th Academic Council Meeting on 10.08.13

G CA	Energy Conversion Systems
GCC	Automotive Engine Systems
GCE	Material Handling Systems and Engineering
GCF	Theory of Metal Cutting
GCG	Manufacturing System Engineering
GCM	Finite Element Analysis
GCN	Design of Jigs, Fixtures and Press Tools
GCP	Metal Forming Technology
GCW	Vehicle Design Engineering
GCY	Turbo Machines
GCZ	Mechanical Vibration

Electives to be passed on 47th Academic Council Meeting

GC1	Integrated Product Development
GC2	Spark Ignition Engines
GC3	Spark Ignition Engines – Design & Engineering
GC4	Vehicle Design Engineering – Statics
GC5	Vehicle Design Engineering-Dynamics
GC6	Assembly Engineering
GC7	Metal Cutting Processes Engineering
GC8	Design for Welding
GC9	Sheet Metal Drawing and Bending

LIST OF ONE CREDIT SUBJECTS

G1A	Introduction to Value Engineering
G1B	Six Sigma
G1C	Geometric Dimensioning and Tolerancing
G1D	Product Life Cycle Management
G1E	Welding Technology
G1F	Project Management Fundamentals
G1G	Mechanical Engineering Perspectives in Rocketry Systems
G1H	Basics of HVAC
G1K	Nuclear Engineering – Basics
G1L	Industrial Hydraulics

ONE credit subjects passed during 44th to 46th Academic Council Meeting

G1A	Introduction to Value Engineering
G1B	Six Sigma
G1C	Geometric Dimensioning and Tolerancing
G1D	Product Life Cycle Management
G1E	Welding Technology
G1F	Project Management Fundamentals

One Credit Subjects to be passed on 47th Academic Council Meeting

G1G	Mechanical Engineering Perspectives in Rocketry Systems
G1H	Basics of HVAC
G1K	Nuclear Engineering – Basics
G1L	Industrial Hydraulics

General Electives to be passed on 47th Academic Council Meeting

GGE	Automotive Engineering

Sub Code	Lectures	Tutorial	Practical	Credit
GC1	3	0	-	3

GC1 Integrated Product Development 3:0

Preamble: A dynamic and highly competitive business environment requires an increasingly efficient and controllable product development process. This dynamic process demand more creative and innovative solutions that provide the challenging and diverse requirements of the customer. This is the focus of the course in Integrated Product Development, aiming to prepare the students to move forward in innovative settings.

Programme Outcomes addressed:

a. An ability to design a system or component, or process to meet stated specifications
b. An ability to function on multidisciplinary teams
c. An ability to consider social, environmental, economic and ethical impact of engineering activities in a given context.
d. An ability to consider issues from global and multilateral views

Competencies: At the end of the course the student will be able to

1. Explain the concept of product design and its applications.
2. Classify the Product Development methodologies.
3. Perform the PESTLE Analysis and Requirement Engineering Analysis.
4. Explain System Integration, Testing, Certification and Documentation.
5. Identify the specific product development process for a given industry.
4. Communicate the final specification of the product (product concept).
5. Explain Sustenance Engineering and End-of-Life disposal principles.
6. Explain Product development in Industry versus Academia, Product development Trade-offs, Intellectual Property Rights and Confidentiality.

Assessment pattern:

S.No	**Bloom's category**	**Test 1**	**Test 2**	**Test 3**	**End Semester Examinations**
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	60	60	60	60
4	Analyse	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember

1. Define product design.
2. What is sustenance?
3. Define the term concept screening?
4. What is Intellectual Property?
5. Define proto typing.
6. What is requirement?

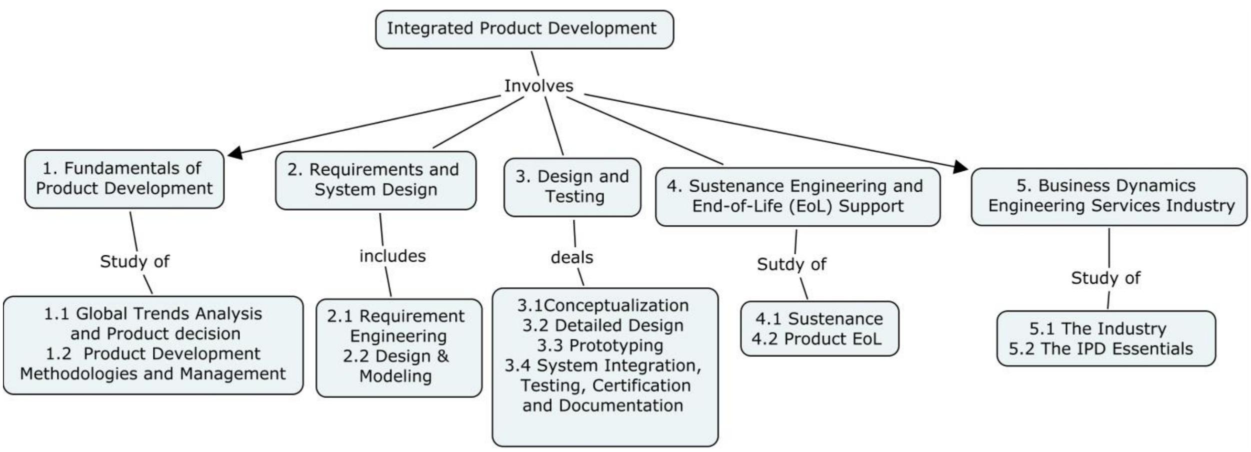
Understand

1. Distinguish between functional design and production design, with suitable examples.
2. Discuss the different types of product validation techniques.
3. Describe the essential parts of requirement pyramid.
4. Describe the steps involved in costing.
5. Explain the concept selection process with example.
6. Explain the traceability matrix.

Apply

1. As a customer identify the basic needs in the selection of a new car.
2. Select the suitable product development methodology for software companies and criticize your selection.
3. Construct the house of quality for a basic mobile phone.
4. Explore the phases of new product development process.
5. A product requires incremental changes to the current process for its improvement. Identify the suitable approach for this product and clarify the process.
6. Interpret the differences between Re-engineering and Reverse Engineering.

Concept Map:



Syllabus:

Product Development -Global Trends Analysis and Product decision- Types of various trends affecting product decision - Social Trends (Demographic, Behavioral, Psychographic), Technical Trends(Technology, Applications, Tools, Methods), Economical Trends(Market, Economy, GDP, Income Levels, Spending Pattern, target cost, Total Cost of Ownership), Environmental Trends (Environmental Regulations and Compliance), Political/Policy Trends(Regulations, Political Scenario, IP Trends and Company Policies) PESTLE Analysis- **Introduction to Product Development Methodologies and Management** Overview of Products and Services (Consumer product, Industrial product, Specialty products etc.,)- Types of Product Development (NPD/ Re-Engineering (Enhancements, Cost Improvements)/ Reverse Engineering/ Design Porting & Homologation)- Overview of Product Development methodologies (Over the Wall/ Waterfall/ V-Model/ Stage-Gate Process/ Spiral/Systems Engineering/ Agile)- Product Life Cycle (S-Curve, Reverse Bathtub Curve)- Product Development Planning and Management (Budgeting, Risk, Resources and Design Collaboration, Scheduling, Change Management, Product Cost Management) **Requirements and System Design- Requirement Engineering-**Types of Requirements (Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific)- Requirement Engineering (Gathering (VOC), Analysis (QFD), Design Specification)- Traceability Matrix and Analysis- Requirement Management- **Design and Testing-Conceptualization** Industrial Design and User Interface Design-Introduction to Concept generation Techniques- Concept Screening & Evaluation -Concept Design -S/W Architecture -Hardware Schematics and simulation - **Detailed Design -c**omponent Design and Verification-High Level Design/Low Level Design of S/W Programs, S/W Testing Hardware Schematic, Component design, Layout and Hardware Testing **Prototyping -**Types of Prototypes (Mockups, Engineering Assessment Prototype, Alpha, Beta, Gama)- **System Integration, Testing, Certification and Documentation -** Manufacturing/Purchase and Assembly of Systems-: Integration of Mechanical, Embedded and S/W systems-: Introduction to Product verification processes and stages – Industry specific (DFMEA, FEA)- Introduction to Product validation processes and stages - Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing)- Product Testing standards and Certification – Industry specific- Product Documentation overview only (Compliance Documentation, Catalogue, Brochures, user manual, maintenance Manual, Spares Parts List, Warranty, Disposal Guide, Interactive Electronic Technical Manual, Web Tools)-**Sustenance Engineering and End-of-**

Life (EoL) Support-Sustenance-Maintenance and Repair-Enhancements, **Obsolesce -** Obsolescence Management- Configuration Management- EoL Disposal- **Business Dynamics –** Engineering Services Industry-The Industry-Engineering Services Industry – overview- Product development in Industry versus Academia **The IPD Essentials -**Introduction to vertical specific product development processes- Product development Trade-offs-: Intellectual Property Rights and Confidentiality- Security and configuration management.

Text Book:

1. Karl T.Ulrich and Steven D.Eppinger , "**Product Design and Development**", McGraw –Hill International Edns.2007.

Reference Books:

1. David G.Ullman, "**The Mechanical Design Process**", Tata McGraw Hill, 2011.
2. Stephen Rosenthal, "**Effective Product Design and Development**", Business One Irwin, Homewood, 1992.
3. Stuart Pugh, "**Tool Design – Integrated Methods for Successful Product Engineering**", Addison Wesley Publishing, Newyork,NY,1991.
4. Kevin Otto, and Kristin Wood, "**Product Design – Techniques in Reverse Engineering and New Product Development**", Pearson Education, 2003.

Course contents and lecture schedule:

S.No.	**Topic**	**No. of Lectures**
1.1	Global Trends Analysis and Product decision	
1.1.1	Types of various trends affecting product decision - Social Trends (Demographic, Behavioral, Psychographic), Technical Trends(Technology, Applications, Tools, Methods),	1
1.1.2	Economical Trends(Market, Economy, Gross Domestic Product, Income Levels, Spending Pattern, target cost, Total Cost of Ownership)	1
1.1.3	Environmental Trends(Environmental Regulations and Compliance), Political/Policy Trends(Regulations, Political Scenario, IP Trends and Company Policies.	2
1.1.4	PESTLE Analysis	2
1.2	Introduction to Product Development Methodologies and Management	
1.2.1	Overview of Products and Services (Consumer product,	1

S.No.	Topic	No. of Lectures
	Industrial product, Specialty products etc.,)	
1.2.2	Types of Product Development (NPD/ Re-Engineering (Enhancements, Cost Improvements)/ Reverse Engineering/ Design Porting & Homologation)	2
1.2.3	Overview of Product Development methodologies (Over the Wall/ Waterfall/ V-Model/ Stage-Gate Process/ Spiral/Systems Engineering/ Agile)	1
1.2.4	Product Life Cycle (S-Curve, Reverse Bathtub Curve)	1
1.2.5	Product Development Planning and Management (Budgeting, Risk, Resources and Design Collaboration, Scheduling, Change Management, Product Cost Management)	2
2.1	Requirement Engineering	
2.1.1	Types of Requirements (Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific)	2
2.1.2	Requirement Engineering (Gathering (VOC), Analysis (QFD), Design Specification)	2
2.1.3	Traceability Matrix and Analysis	1
2.1.4	Requirement Management	2
3.1	Conceptualization	
3.1.1	Industrial Design and User Interface Design	1
3.1.2	Introduction to Concept generation Techniques	
3.1.3	Concept Screening & Evaluation -Concept Design – Software Architecture- Hardware Schematics and simulation	1
3.2	Detailed Design	
3.2.1	Component Design and Verification	1
3.2.2	High Level Design/Low Level Design of Software Programs, Software Testing	1
3.2.3	Hardware Schematic, Component design, Layout and Hardware Testing	1
3.3	Prototyping	
3.3.1	Types of Prototypes (Mockups, Engineering Assessment Prototype, Alpha, Beta, Gama)	2
3.4	System Integration, Testing, Certification and Documentation	
3.4.1	Manufacturing/Purchase and Assembly of Systems -	2

S.No.	Topic	No. of Lectures
	Integration of Mechanical, Embedded and S/W systems	
3.4.2	Introduction to Product verification processes and stages – Industry specific (DFMEA, FEA)	1
3.4.3	Introduction to Product validation processes and stages - Industry specific (Sub-system Testing/ Integration Testing/ Functional Testing/ Performance Testing / Compliance Testing)	1
3.4.4	Product Testing standards and Certification – Industry specific	2
3.4.5	Product Documentation – overview only (Compliance Documentation, Catalogue, Brochures, user manual, maintenance Manual, Spares Parts List, Warranty, Disposal Guide, Interactive Electronic Technical Manual, Web Tools)	1
4.1	Sustenance	
4.1.1	Maintenance and Repair, Enhancements.	2
4.2	Obsolesce	
4.2.1	Obsolescence Management - Configuration Management- EoL Disposal	2
5.1	Business Dynamics – Engineering Services Industry	
5.1.1	Engineering Services Industry – overview-	1
5.1.2	Product development in Industry versus Academia	2
5.2	The IPD Essentials	
5.2.1	Introduction to vertical specific product development processes	1
5.2.2	Product development Trade-offs	1
5.2.3	Intellectual Property Rights and Confidentiality Security and configuration management	2
	Total	**45**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
GC2	3	-	-	3

GC2 Spark Ignition Engines 3:0

Preamble: Internal combustion engines and the industries that develop and manufacture them and support their use, now play a dominant role in the fields of power, propulsion and energy. Spark ignition engines find major applications in the two wheeler manufacturing industries because of their high speed and light weight. This course deals with the following spark ignition engine's important features: fuel requirements, methods of mixture preparation, combustion chamber design, details of combustion process, emission formation mechanisms and performance characteristics from a fundamental point of view.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems
c. Graduates will develop confidence for self education and ability for life-long learning

Competencies: At the end of the course the student will be able to

1. Explain the detailed concepts of engine thermodynamics.
2. Explain and analyze the engine dynamics.
3. Explain the normal and abnormal combustion phenomenon in spark ignition engines.
4. Explain the SI engine pollutant formation mechanisms and their control methods.
5. Analyze gas exchange process and explain the functional requirement of induction and exhaust of SI engine.
6. Analyze the performance of Spark Ignition (SI) engines.

Assessment pattern:

S.No	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3**	**End semester examination**
1.	Remember	20	20	20	20
2.	Understand	50	50	50	50
3.	Apply	20	20	20	20
4.	Analyze	10	10	10	10
5.	Evaluate	-	-		-
6.	Create	-	-		-

Course level learning objectives:

Remember

1. Define mean piston speed.
2. List the assumptions made in fuel air cycle analysis.
3. Give the firing order normally used for a 4 stroke 4 cylinder petrol engines.
4. Define 'pre-ignition' in SI engines.
5. Name any two methods of controlling NOx.
6. Define L/R ratio.

Understand

1. Explain the types of flames associated with the process of combustion in SI engines.
2. Explain how a rich mixture is produced in a carburetor for starting.
3. Describe any one mechanism of ignition advance.
4. Discuss the process of turbo charging.
5. Explain the factors influencing combustion knock in SI engines.
6. Explain how a swirl meter measures swirl.

Apply

1. Find out the speed at which a four-cylinder engine using natural gas can develop a brake power of 50 kW working under following conditions. Air-fuel ratio 9:1, calorific value of the fuel = 34 MJ/m^3, Compression ratio 10:1, volumetric efficiency = 70%, indicated thermal efficiency = 35% and the mechanical efficiency = 80% and the total volume of the engine is 2 litres.
2. Fuel supplied to an SI engine has a calorific value 42000 kJ/kg. The pressure in the cylinder at 30% and 70% of the compression stroke are 1.3 bar and 2.6 bar respectively. Assuming that the compression follows the law $pV^{1.3}$ = constant, find the compression ratio. If the relative efficiency of the engine compared with the air-standard efficiency is 50%, calculate the fuel consumption in kg/kW h.
3. Find the mean effective pressure for the ideal air-standard Otto cycle having a maximum pressure of 40 bar and minimum pressure of 1 bar. The compression ratio is 5:1. Take γ = 1.4
4. A four-cylinder, four-stroke square engine running at 40 rev/s has a carburetor venturi of 3 cm throat. Assuming the bore to be 10 cm, volumetric efficiency of 75%, and the density of air to be 1.15 kg /m^3 and coefficient of air flow to be 0.75, calculate the suction at the throat.
5. John's automobile has a three-litre SI V6 engine that operates on a four-stroke at 3600 rpm. The compression ratio is 9.5, the length of connecting

rods is 16.6 cm, and the engine is square. At this speed, combustion ends at 20° ATDC. Calculate: (i) cylinder bore and stroke length (ii) average piston speed (iii) clearance volume of one cylinder (iv) piston speed at the end of combustion (v) distance the piston has traveled from TDC at the end of combustion (vi) volume in the combustion chamber at the end of combustion.

6. The table shows air density at 1 bar over a range of temperatures. If half the total fuel is evaporated before the inlet valve shuts we can expect the inlet charge temperature to have been reduced, due to the latent heat of evaporation, by some 20 deg C. If the air temperature at the carburetor inlet is 30 deg C, what volume would the fuel vapour have to occupy, as a percentage of the whole, for there to be no net benefit to volumetric efficiency?

deg C	Air density at constant pressure
35	1.1455
30	1.1644
25	1.1839
20	1.2041
15	1.225
10	1.2466
5	1.269
0	1.2922
−5	1.3163
−10	1.3413
−15	1.3673
−20	1.3943
−25	1.4224

Analyze

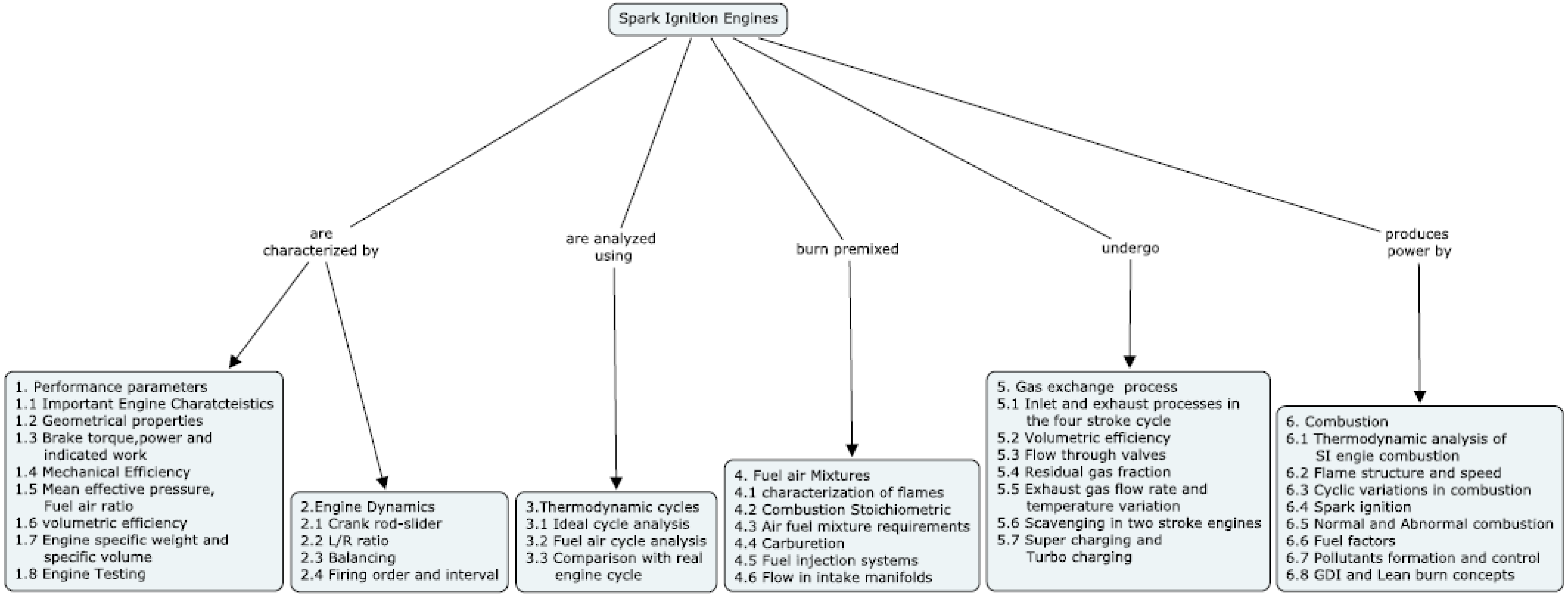
1. It is desired to increase the output of an SI engine working on ideal Otto cycle, either by (i) increasing the compression ratio or by (ii) increasing the inlet pressure from 1 to 1.5 bar. Which one will give higher peak pressure in the cycle and what is its value? Assume heat supplied at the constant volume process is the same in both the cases which is 420 kJ. Take T_1 = 300 K, p_1 = 1 bar, γ = 1.4. Comment on the result.

2. As an old-car collector enthusiast is cruising along in his 1950 chrome-covered Buick "dream car", he realizes he is running low on fuel, so he pulls up to the fuel pump at the local convenience store and fills the fuel tank. The car has a large-displacement straight-eight engine with a carburetor adjusted to supply Stoichiometric air at normal operating conditions using gasoline fuel. The man does not notice that the fuel he is putting in to his automobile contains 10% methanol (M10), but he does

notice a slight loss in power as the fuel is consumed in the following days. Calculate the actual equivalence ratio the carburetor is supplying to the engine when it is adjusted to give $\phi = 1$ with gasoline but is actually operating with M10 fuel.

3. Compare the indicated power generated in an engine using Stoichiometric gasoline, Stoichiometric methanol, Assume the same combustion efficiency, thermal efficiency, and air flow rate for both fuels.
4. A 2.8-litre four-cylinder square engine (bore = stroke) with two intake valves per cylinder is designed to have a maximum speed of 7500 RPM and intake temperature is 873 K. Calculate: intake valve area, diameter of intake valves and valve lift. Compare the results for an under square engine with a ratio of 0.9 with the same speed and intake temperature.
5. What will be the effect on the efficiency of an Otto cycle having a compression ratio of 8, if C_v increases by 1.6%?
6. You have been benchmarking your engine against 3 competitor products because your engine is significantly less powerful that they are. The compression ratios are all similar; your power loop is clearly smaller although P_{max} is at the right timing. You notice that the cylinder pressure during the induction stroke is 15% lower than it is for your competitors. What design features would you compare and why?

Concept map:


Spark Ignition Engines
are characterized by
are analyzed using
burn premixed
undergo
produces power by
1. Performance parameters
1.1 Important Engine Charatcteistics
1.2 Geometrical properties
1.3 Brake torque,power and indicated work
1.4 Mechanical Efficiency
1.5 Mean effective pressure, Fuel air ratio
1.6 volumetric efficiency
1.7 Engine specific weight and specific volume
1.8 Engine Testing
2.Engine Dynamics
2.1 Crank rod-slider
2.2 L/R ratio
2.3 Balancing
2.4 Firing order and interval
3.Thermodynamic cycles
3.1 Ideal cycle analysis
3.2 Fuel air cycle analysis
3.3 Comparison with real engine cycle
4. Fuel air Mixtures
4.1 characterization of flames
4.2 Combustion Stoichiometric
4.3 Air fuel mixture requirements
4.4 Carburetion
4.5 Fuel injection systems
4.6 Flow in intake manifolds
5. Gas exchange process
5.1 Inlet and exhaust processes in the four stroke cycle
5.2 Volumetric efficiency
5.3 Flow through valves
5.4 Residual gas fraction
5.5 Exhaust gas flow rate and temperature variation
5.6 Scavenging in two stroke engines
5.7 Super charging and Turbo charging
6. Combustion
6.1 Thermodynamic analysis of SI engie combustion
6.2 Flame structure and speed
6.3 Cyclic variations in combustion
6.4 Spark ignition
6.5 Normal and Abnormal combustion
6.6 Fuel factors
6.7 Pollutants formation and control
6.8 GDI and Lean burn concepts

Syllabus:

Introduction-Engine classifications, Terminology and abbreviations, Engine components, SI Engine operation-**Performance Parameters**- Important engine characteristics, Geometrical properties, Brake torque, power and Indicated work per cycle, Mechanical Efficiency, Mean effective pressure, Fuel air ratio, Volumetric efficiency, Engine specific weight and specific volume-**Engine dynamics-**Crank rod-slider/R ratio, Balancing, Firing order and interval-**Thermodynamic cycles**- Ideal cycle analysis, Fuel air cycle analysis, Comparison with real engine cycle-**Fuel air mixtures**-Characterization of flames, Combustion Stoichiometric, Air fuel mixture requirements, Carburetion, Fuel injection systems, Flow in intake manifolds-**Gas exchange process**- Inlet and exhaust processes in the four-stroke cycle, Volumetric efficiency, Flow through valves, Residual gas fraction, Exhaust gas flow rate and temperature variation, Scavenging in two stroke engines, Supercharging and Turbo charging-**Combustion**-Thermodynamic analysis of SI engine combustion, Flame structure and speed, Cyclic variations in combustion, Spark ignition, Normal and Abnormal combustion, Fuel factors, Carbon monoxide, Unburned Hydrocarbon emissions, Oxides of Nitrogen, Exhaust gas treatment.

Text books:

1. Willard W. Pulkrabek, **"Engineering Fundamentals of the Internal Combustion Engine"**, 2nd Edition, Prentice Hall, 2003.
2. K.K.Ramalingam, "**Internal Combustion Engines-Theory and Practice",** Sci Tech Publications (India) Pvt Ltd, 2011.
3. V. Ganesan, **"Internal Combustion Engines"** McGraw-Hill, reprint 2012.

Reference books:

1. John B. Heywood, **"Internal Combustion Engine Fundamentals"**, McGraw-Hill, reprint 2012.
2. Charles Fayette Taylor, **"The Internal Combustion Engine in Theory and Practice: Revised: Thermodynamics, Fluid flow, Performance"**, Vol.1-2nd edition, MIT Press, 1985.
3. Charles Fayette Taylor, **"The Internal Combustion Engine in Theory and Practice: Revised: Combustion, Fuels, Materials, Design "**, Vol.2, 2nd edition, MIT Press, 1985
4. Richard Stone, **"Introduction to Internal Combustion Engines"**, Third edition, Society of Automotive Engineers, Incorporated 1999.

Course contents and lecture schedule:

S.No	Topic	No.of Lectures
	Introduction	1
	Engine classifications	
	Terminology and abbreviations	
	Engine components	
	Cooling and Lubrication systems	
	SI Engine operation	
1	**Performance Parameters**	
1.1	Important engine characteristics	1
1.2	Geometrical properties	1
1.3	Brake torque, power and Indicated work per cycle	1
1.4	Mechanical Efficiency	1
1.5	Mean effective pressure, Fuel air ratio	2
1.6	Volumetric efficiency	
1.7	Engine specific weight and specific volume	
1.8	Engine Testing	1
2	**Engine Dynamics**	
2.1	Crank rod-slider	1
2.2	L/R ratio	1
2.3	Balancing	1
2.4	Firing order and interval	1
3	**Thermodynamic Cycles**	
3.1	Ideal cycle analysis	2
3.2	Fuel air cycle analysis	2
3.3	Comparison with real engine cycle	1
4	**Fuel air Mixtures**	
4.1	Characterization of flames	1
4.2	Combustion Stoichiometric	2
4.3	Air fuel mixture requirements	1
4.4	Carburetion	2
4.5	Fuel injection systems	2
4.6	Flow in intake manifolds	1

5	**Gas exchange process**	
5.1	Inlet and exhaust processes in the four-stroke cycle	1
5.2	Volumetric efficiency	1
5.3	Flow through valves	
5.4	Residual gas fraction	1
5.5	Exhaust gas flow rate and temperature variation	
5.6	Scavenging in two stroke engines	1
5.7	Supercharging and Turbo charging	1
6	**Combustion**	
6.1	Thermodynamic analysis of SI engine combustion	1
6.2	Flame structure and speed	1
6.3	Cyclic variations in combustion	1
6.4	Spark ignition	2
6.5	Normal and Abnormal combustion	3
6.6	Fuel factors	1
6.7	Pollutants formation and control	
6.7.1	Carbon monoxide	3
6.7.2	Unburned Hydrocarbon emissions	
6.7.3	Oxides of Nitrogen	
6.7.4	Exhaust gas treatment	
6.8	Gasoline Direct Injection and Lean Burn concepts	1
Total		**45**

Course designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GC3	3	0	0	3

GC3 Spark Ignition Engines – Design & Engineering 3:0

Preamble: Internal combustion engines and the industries that develop and manufacture them and support their use, now play a dominant role in the fields of power, propulsion and energy. Spark ignition engines find major applications in the two wheeler manufacturing industries because of their high speed and light weight. This course deals with from a design and engineering point of view, following the complexity involved in it.

Programme outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

k. Graduates who can participate and succeed in competitive examinations.

Competencies: At the end of the course the student will be able to

1. Explain general ideas and concepts behind various engine layout schemes
2. Perform mechanical design calculations to arrive at the design specs for critical mechanical elements comprising the engine
3. Select appropriate materials to be used in the engine based on functional and life requirements
4. Propose and develop a design verification process to prove engine for performance, durability and reliability
5. Explain various NVH, thermal and other issues that are connected with the engine behaviour
6. Articulate solution for design of engines from manufacturing, service and assembly perspective

Assessment pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	20	20	20	20
2	Understand	20	20	20	20
3	Apply	40	40	40	40
4	Analyze	20	20	20	20
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember

1. List the major differences between liquid cooled engines and air cooled engines.
2. Mention the most common material used for piston in compact engines and its composition.
3. Mention a drive cycle when vehicles are evaluated for emissions? Give example.
4. List the major sources of engine noise.
5. Name few tools which are used for design purposes.
6. Define mean piston speed.

Understand

1. Explain knock and its influence on engine performance and reliability of parts
2. List out the benefits of offset crank design and how does it functions?
3. What is the material and heat treatment processes followed for connecting rod? What is the basis of this selection?
4. Discuss the elements to be considered and taken care in valve train dynamic analysis?
5. Discuss the primary and secondary functions of engine design calculation.
6. Explain the loads on various engine parts and requirements.

Apply

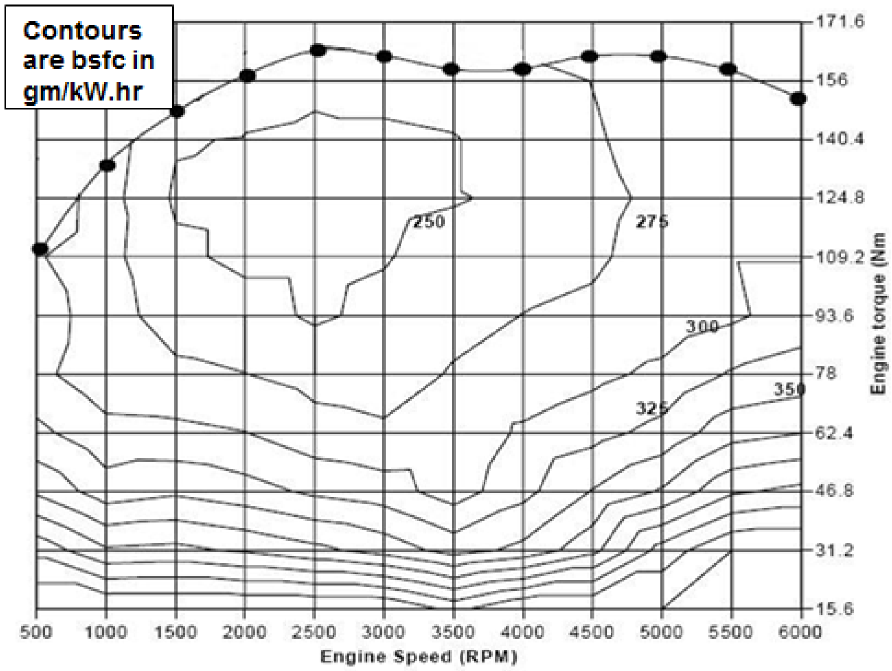
1. A single cylinder engine with bore: 50 mm, stroke: 50 mm is designed to operate at 7000 rpm. Size the induction and exhaust system for maximum power. List the assumptions.
2. Draw a schematic layout for a 4 valve and 3 valve cylinder head concept for the same bore size. Assuming a single overhead cam, determine the power potential for these two configurations, considering dynamic limitations.
3. Show how the PV diagram would change if a much slower burning fuel were used with unchanged ignition timing.
4. Would you expect engine torque to change if inlet air temperature was reduced? If so how would it change and why?
5. The spark-ignition engine (details are given below) is operating at a mean piston speed of 10 m/s. The measured air flow is 60 g/s. Calculate the volumetric efficiency based on atmospheric conditions.
   - 2.2-liter displacement four-cylinder spark-ignition engine.
     Bore 87.5 mm, stroke 92 mm, compression ratio 8.9,
     maximum power 65 kW at 5000 rpm
6. Design a six-liter race car engine that operates on a four-stroke cycle. Decide what the design speed will be, and then give the number of cylinders, bore,

stroke, piston rod length, average piston speed, imep, brake torque, fuel used, AF, and brake power, all at design speed. All parameter values should be within typical, reasonable values and should be consistent with the other values. State what assumptions you make (e.g. mechanical efficiency, volumetric efficiency, etc.)

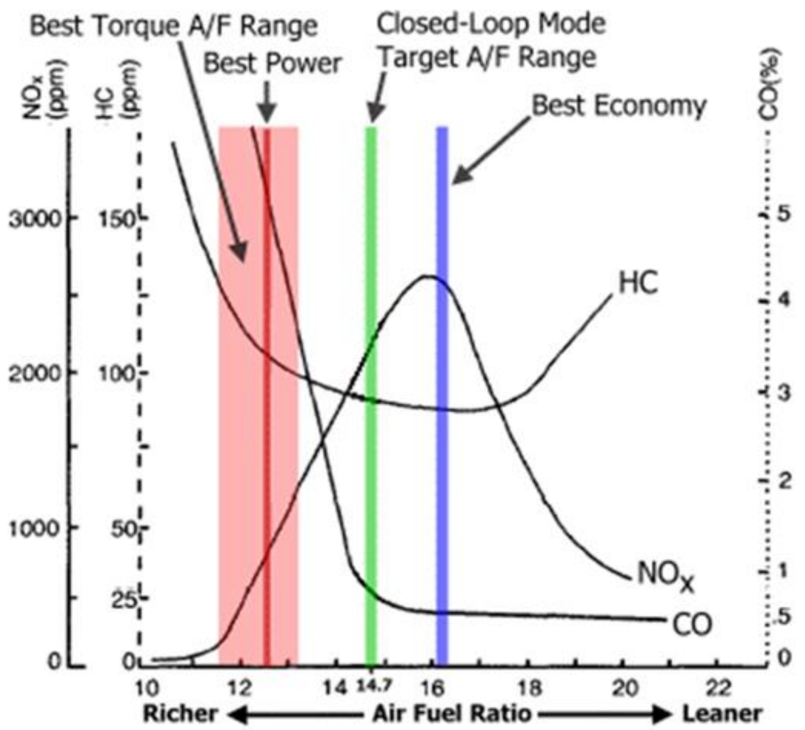
Analyze

1. Two automobile engines have the same total displacement volume and the same total power produced within the cylinders.
   List the possible advantages of: (a) A V6 over a straight six.
   (b) A V8 over a V6.
   (c) A V6 over a V8.
   (d) An opposed cylinder four over a straight four.
   (e) An in-line six over an in-line four.
2. A SI engine operating on a four-stroke air-standard cycle using Stoichiometric gasoline is to have a maximum cylinder pressure of 11,000 kPa at WOT. Inlet pressure can be 100 kPa without supercharging, or it can be as high as 150 kPa with a supercharger. Pick a compression ratio and inlet pressure combination to give maximum indicated thermal efficiency. Pick a compression ratio and inlet pressure to give maximum imep.
3. It has been suggested that to reduce crevice volume in a cylinder, the top piston compression ring should be located at the top of the piston (i.e., the top of the compression ring is flush with the piston face). Design a piston-ring-groove system in which this is possible. Give careful attention to reducing crevice volume and blowby.
4. A man wants to work on his automobile in his garage on a winter day. Having no heating system in the garage, he runs the automobile in the closed building to heat it. At idle speed the engine burns 2.27 kg of Stoichiometric gasoline per hour, with 0.6% of the exhaust being carbon monoxide. The inside dimensions of the garage are 6 m ×6m × 2.5 m and the temperature is 4.4°C. It can be assumed that 10 parts per million (ppm) of CO in the air is dangerous to health. Calculate the time to when the CO concentration in the garage is dangerous.
5. You are using an engine to drive an electrical generator. The bsfc map for the engine is shown below. The electrical power is required at 50Hz so the engine must run at 3000 RPM. The electrical machine efficiency is 95%. Identify i) the electrical power output range over which most fuel efficient generation will be obtained. ii) The maximum generating capability of the gen-set regardless of fuel consumption and iii) the electrical load in kW below which fuel consumption in gm/electrical kWhr generated will have increased by at least

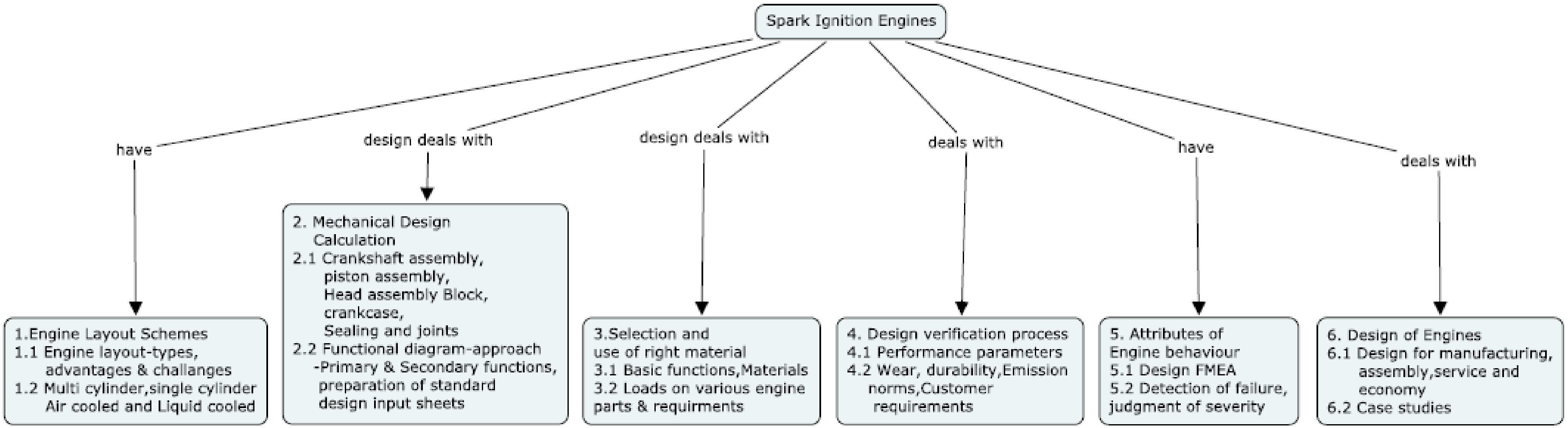
50% compared with your optimum rating. Accuracy of calculation will be constrained by scaling from the map



6. Give the reasons why the curves in the diagram below are the shapes that they are. The "Best economy" line can be moved by improving combustion system design - what chamber performance parameter must be changed in order to move that line and why will the HC curve shape change with it?



Concept map:


Spark Ignition Engines
have
design deals with
design deals with
deals with
have
deals with
1.Engine Layout Schemes
1.1 Engine layout-types, advantages & challanges
1.2 Multi cylinder,single cylinder Air cooled and Liquid cooled
2. Mechanical Design Calculation
2.1 Crankshaft assembly, piston assembly, Head assembly Block, crankcase, Sealing and joints
2.2 Functional diagram-approach -Primary & Secondary functions, preparation of standard design input sheets
3.Selection and use of right material
3.1 Basic functions,Materials
3.2 Loads on various engine parts & requirments
4. Design verification process
4.1 Performance parameters
4.2 Wear, durability,Emission norms,Customer requirements
5. Attributes of Engine behaviour
5.1 Design FMEA
5.2 Detection of failure, judgment of severity
6. Design of Engines
6.1 Design for manufacturing, assembly,service and economy
6.2 Case studies

Syllabus:

Engine layout schemes: Various types of engine layout – Advantages and challenges of a layout, Multicylinder, Single Cylinder, Aircooled, Liquid cooled engines –Layout- **Mechanical Design Calculation** Mechanical construction details of Crank shaft assembly, piston assembly, Head assembly, Block, crank case, sealings and joints, Functional diagram – approach – Primary & Secondary functions – preparation of standard design input sheets- **Selection and use of right material for engine:** Introduction – case study - Basic functions of critical parts – Materials used in automotive engines, Types of loads on various engine parts – thermal load, mechanical load, life requirements- **Design verification Process:** Introduction – case study – performance parameters, Types of wear – wear limit study – Durability – Emission norms – Customer requirements**- Attributes of engine behaviour:** Various attributes contributing to engine behaviour – Design FMEA – function, cause, occurrence level, Detection of failure – judgment of severity – opportunities to detect severity- **Design of Engines:** Design for manufacturing – Design for assembly – design for service – Design for economy - Design for performance, Case study – one each for each Design function.

Text Books:

1. Charles Fayette Taylor, **"The Internal Combustion Engine in Theory and Practice: Revised: Thermodynamics, Fluid flow, Performance"**, Vol.1-2nd edition, MIT Press, 1985.
2. Charles Fayette Taylor, **"The Internal Combustion Engine in Theory and Practice: Revised: Combustion, Fuels, Materials, Design"**, Vol.2-2nd edition, MIT Press, 1985
3. Kevin L. Hoag**, "Vehicular Engine Design**", Springer Wein, New York and SAE (Joint Publication in 2005)

Reference Book:

1. John Heywood, "**Internal Combustion Engines Fundamentals**", Tata McGraw Hill Publications, 2011.

Course contents and lecture schedule:

S.No	Topic	No. of Lectures
1	**Engine layout schemes**	
1.1	Various types of engine layout – Advantages and challenges of a layout	2
1.2	Multicylinder, Single Cylinder, Aircooled, Liquid cooled engines – Layout	2

S.No	Topic	No. of Lectures
2	**Mechanical Design Calculation**	
2.1	Mechanical construction details of Crank shaft assembly, piston assembly, Head assembly, Block, crank case, sealings and joints	8
2.2	Functional diagram – approach – Primary & Secondary functions – preparation of standard design input sheets	8
3	**Selection and use of right material for engine**	
3.1	Introduction – case study - Basic functions of critical parts – Materials used in automotive engines	2
3.2	Types of loads on various engine parts – thermal load, mechanical load, life requirements	3
4	**Design verification Process**	
4.1	Introduction – case study – performance parameters	2
4.2	Types of wear – wear limit study – Durability – Emission norms – Customer requirements	2
5	**Attributes of engine behaviour**	
5.1	Various attributes contributing to engine behaviour – Design FMEA – function, cause, occurrence level	3
5.2	Detection of failure – judgment of severity – opportunities to detect severity	2
6	**Design of Engines**	
6.1	Design for manufacturing – Design for assembly – design for service – Design for economy - Design for performance	3
6.2	Case study – one each for each Design function	3
	Total	**40**

Course Designers:

1. V Lakshmi Narasimhan V.LakshmiNarasimhan@tvsmotor.co.in
2. B.Karthikeyan bkmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
GC4	3	0	-	**3**

GC4 Vehicle Design Engineering-Statics 3:0

Preamble: Engineering statics finds application in various branches of engineering such as civil, mechanical and automobile. Vehicle Design Engineering – Statics is a course which emphasizes the application of engineering statics in design of an automobile. It deals with partial fulfillment of design of Parts, Sub Systems and systems of an automobile based on customer requirement, function, manufacturing process and service meeting design and regulation standards.

Program outcomes addressed:

d. Graduates will demonstrate knowledge of Mathematics, Science and Engineering.
e. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
f. Graduates will develop confidence for self education and ability for life-long learning.

Competencies: At the end of the course, students will be able to

1. Understand the function of parts, sub system and system of an automobile
2. Apply principles of engineering statics
3. Design the vehicle layout for two wheelers
4. Design brake system and suspension system for an automobile
5. Design the structural parts for two wheelers

Assessment pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1.	Remember	20	20	20	20
2.	Understand	40	40	40	40
3.	Apply	40	20	20	20
4.	Analyze	-	20	20	20
5.	Evaluate	-	-		-
6.	Create	-	-		-

Course level learning objectives:

Remember

1. List the different methods for collecting customer requirements for an automobile.

2. State the techniques used to convert customer requirements into engineering requirements.
3. Define “Mechanical Advantage” in brake system of an automobile.
4. Define “Damping coefficient” of a suspension system.
5. State the equation for “Pure Bending” used in design of structural parts of an automobile.
6. List the different plastic parts of a two wheeler and the manufacturing method of each part.

Understand

1. Discuss in detail the design procedure of plastic parts of a two wheeler.
2. Explain the importance of each vehicle layout parameter.
3. Explain the significance of strength and stiffness of structures of an automobile.
4. Discuss the design procedure of various brake systems of a two wheeler.
5. Discuss the design procedure of Structural parts of a vehicle.
6. Explain how an actual suspension system is modeled and discuss how a suspension system is designed for an automobile.

Apply

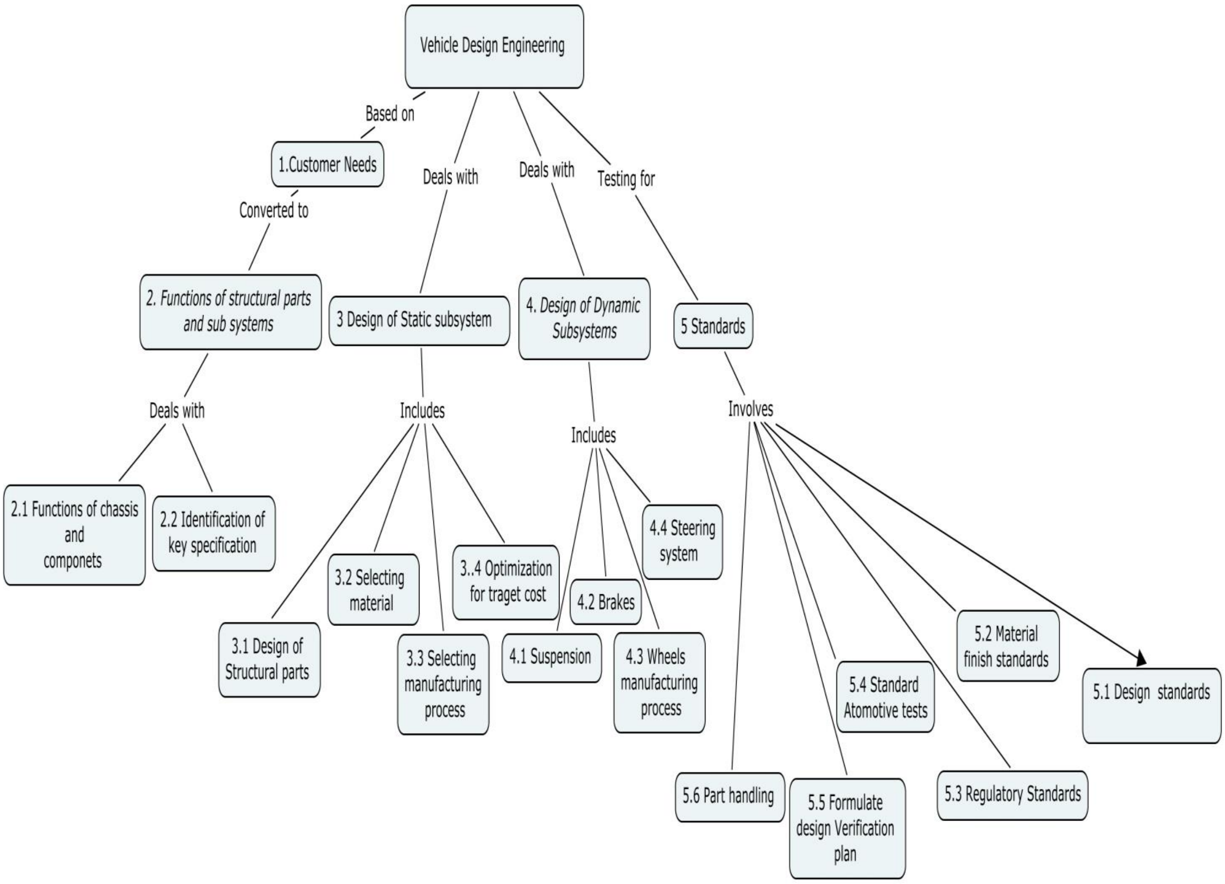
1. Calculate Center distance change between sprockets for the given rotation of swing arm.
2. Calculate mechanical trail, squat ratio for given vehicle layout parameters.
3. Calculate stiffness of mono-shock for a given wheel rate and load carrying capacity. Compare wheel rate of different rear suspension layouts.
4. Estimate spring stiffness for front and rear considering 5 subsystems packaged at different location.
5. Calculate CG and MI for the vehicle of 5 subsystems packaged in different location, different mass. Suggest ideas to balance the Lateral CG of the vehicle.
6. Determine the force required for stopping a vehicle of 100 kg moving at 60 kmph speed within stopping distance of (a) 10 m (b) 30 m. Design the brake system considering effort required to stop the vehicle.

Analyze

1. Compare the requirements of vehicle layout for moped, scooter and motorcycle.
2. Discuss and propose wheel rate and spring design for rural road conditions. Justify your design. Discuss in detail why can’t we increase suspension stroke to 1 m.
3. Analyze the differences between front and rear suspension. Why the rear suspension is stiffer compared to front?

4. Analyze the swing arms with rectangular section and circular cross section. How do you choose the cross section?
5. Compare 110 diameter drum and 130 diameter drum brake at rear for a Motorcycle. Will you choose more diameter at front or rear? Why?
6. Analyze the structural differences between moped, scooter and motorcycle and connect them to the customer requirements.

Concept map:



Syllabus:

Design of Vehicle layout: Various methods of capturing customer requirements - Translation of customer's requirements into engineering requirements – Design Philosophy – Engineering requirements –Introduction to vehicle layout and packaging – Vehicle layout parameters and definitions – Design calculations for vehicle layout. **Design of brake systems:** Basics of Brake systems – Types of brake system – Design calculations of brake systems. **Design of Suspension System:** Suspension characteristics – Types of suspension – Design calculation on various aspects – Design of Spring and Damper. **Design of Structural parts:** Various factors affecting structure - Loads and boundary conditions – Simple problems – Design calculation for various structures. **Design of Plastic parts:** Introduction to plastic parts – Fit and finish of plastic parts – Design of plastic parts. **Concept of**

Part, Sub System and System: Importance of the system design approach and part design – Study of part design in different systems and its applications.

Text books:

1. Tony Foale, **"Motorcycle Handling and chassis design"** Tony Foale designs, 2006.
2. V Cossalter, "**Motorcycle Dynamics**" Published by Race dynamics, 8421 Midland Dr., Greendale, 2002.
3. Thomas D.Gillespie, "**Fundamentals of vehicle dynamics"** Published by Society of Automotive Engineers, Inc, 1992.

References:

1. Jason C. Brown, A. John Robertson, Stan T. Serpento, **"Motor vehicles structures: Concepts and Fundamentals - Automotive Engineering Series"**, Butterworth-Heinemann Limited, 2002.
2. Tom Birch, Thomas Wesley Birch, **"Automotive Chassis Systems"**, Delmar, Thomson Learning, 1999.
3. http://www.derby.ac.uk/courses/motorcycle-engineering-beng-hons/-Website of Derby University.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1	**Design of vehicle layout**	
1.1	Customer requirements, Capturing methods, Design philosophy	2
1.2	Engineering requirements, Introduction to vehicle layout and packaging.	2
1.3	Vehicle layout parameters and definitions	2
1.4	Design calculations for vehicle layout	3
2	**Design of brake system**	
2.1	Brake system, Physics behind it, types of brake systems.	3
2.2	Design calculations of brake systems- Mechanical advantage, lever ratio, shoe factor, heat dissipation etc.	3
3	**Design of suspension system**	
3.1	Suspension characteristics- Spring and damper, types of suspension, Function of spring and damper, Important definitions.	2
3.2	Design calculation-Stroke, wheel rate, Load carrying capacity etc.	2

3.3	Design of spring and damper- Front and rear	3
4	**Design of structural parts**	
4.1	Stress, strain, strength, stiffness, Beams and boundary conditions, Bending moment, Torsional moment.	4
4.2	Loads and boundary conditions, simple problems	2
4.3	Design calculation for frame, swing arm, fork and brake pedal	3
5	**Design of Plastic parts**	
5.1	Introduction, Material properties and selection, Fit and finish	2
5.2	Design of plastic parts-Structural design for failure and NVH , Design for Fit and finish, Design for manufacturing, Design for assembly etc.	3
6	**Concept of part, subsystem and System**	
6.1	Importance of the system design approach and part design.	2
6.2	Study of part design in different systems and applications-Illustration with case studies.	2
	Total	**40**

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Sub Code	Lectures	Tutorial	Practical	Credit
GC5	3	0	-	**3**

GC5 Vehicle Design Engineering-Dynamics 3:0

Preamble: Vehicle Design Engineering – Dynamics is a course which emphasizes the application of engineering dynamics in design of an automobile. It deals with various motorcycle dynamics such as dynamics of brake, dynamics of suspension, stability and maneuverability, tyre dynamics, ergonomics which form the base for designing brake and suspension systems. In addition, significance of aerodynamics and its effect on vehicle performance is also covered.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering

d. Graduates will demonstrate an ability to identify, formulate and solve engineering problems

h. Graduates will develop confidence for self education and ability for life-long learning

Competencies: At the end of the course the student will be able to

1. Understand the basics of vehicle dynamics.
2. Design a brake system applying dynamics of brake.
3. Design a suspension applying dynamics of suspension.
4. Understand stability, maneuverability and apply it for design of various sub system of a two wheeler.
5. Understand tyre dynamics.
6. Apply ergonomic and aerodynamic principles in two wheeler design.

Assessment pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1	Remember	20	20	20	20
2	Understand	30	30	30	30
3	Apply	50	30	30	30
4	Analyze	-	20	20	20
5	Evaluate	-	-		-
6	Create	-	-		-

Course level learning objectives:

Remember

1. Define "preload" of a suspension system.
2. How is a tyre specified? Give an example.
3. State how is load transferred during braking and how is it encountered.
4. Define "Time period", "amplitude" and "frequency" with regard to vibration of vehicle.
5. Define the terms "Lift" and "drag" with regard to aerodynamics of an automobile.
6. List the different elements of ergonomics of in the design of a two wheeler.

Understand

1. Explain the working of combined braking system. Compare it with anti-lock braking system.
2. Discuss on the dynamics of a two wheeler in steady turn.
3. Demonstrate the influence of sprung mass and un-sprung mass on ride comfort.
4. Discuss ergonomics and its importance in detail for two wheeler design.
5. Explain the construction of different types of tyres stating their merits and demerits.
6. Discuss various vibration modes and their causes for a two wheeler.

Apply

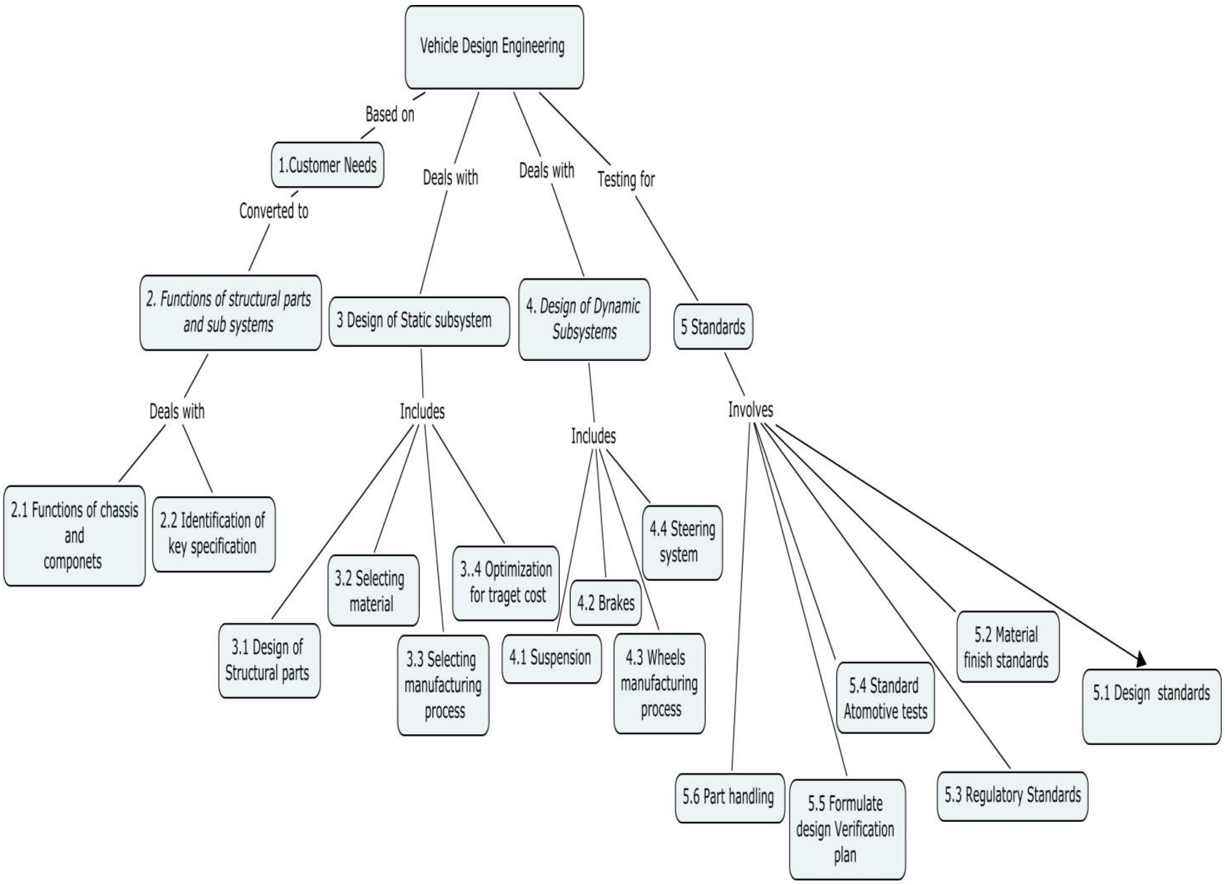
1. Calculate optimal braking curves for a given motorcycle. Calculate limit braking force for rear brake and front brake. Design a braking system considering dynamics of the brake.
2. Using half car model calculate vibration modes of a scooter and a motorcycle. Compare the results and discuss on ride comfort.
3. Discuss roll, steering angle and steering torque of various two wheelers using analytical equations.
4. Explain how various design parameters affect stability and maneuverability of a two wheeler.
5. Demonstrate the significance of camber stiffness and rolling resistance in tyre dynamics of a two wheeler.
6. Explain how various aerodynamic parameters affect vehicle performance.

Analyze

1. Distinguish between weave and wobble modes. If you are given the option to improve one of the modes, which one wills you chose? Why?
2. Analyze the requirements for "stability" and "maneuverability" for various two wheelers lay outs.

3. Analyze the effect of the following with regard to stability of moped, scooter and motorcycles in steady turn. A) Steering torque B) Roll angle C) steering angle.
4. Analyze the feasibility of drum brake at the front and disc brake at the rear taking into consideration, the weight transfer, braking efficiency and handling for a motor bike and validate your answer.
5. Discuss the coupling between in-plane vibrations modes and out-of plane vibration modes. Is it important to consider them? How will you separate the coupling of modes?
6. Prove that balancing is easier with increase in speed. Analyze how various vehicle parameters affect balancing.

Concept map:



Syllabus:

Basics of Motorcycle Dynamics: Introduction to Motorcycle dynamics – Basics of motorcycle dynamics – Coordinate system and important definitions. **Dynamics of brake:** Frictional force, deceleration & Simple brake calculations – Dynamics during braking – Introduction to CBS, ABS. **Dynamics of Suspension:** Sprung mass, Un-sprung mass and vibration modes Quarter car and half car models – Suspension elements and design parameters. **Stability and Maneuverability:** Introduction –

Definitions – Vibration modes – Study of dynamics in steady turn – SHM, Transient maneuvers, input & output parameters – Design parameters for stability and maneuverability, geometrical, mass and structural stiffness. **Tyre Dynamics:** Introduction to tyre – Types of tyres – Tyre characteristic curve, vertical, cornering, camber stiffness, rolling resistance, magic formula. **Ergonomics:** Introduction and importance – Elements of ergonomics – Riding posture design, 'H' point, seat design. **Aerodynamics:** Introduction – Definitions – Aerodynamics parameters – Effect on vehicle performance

Text books:

1. V Cossalter**, "Motorcycle Dynamics"**, Published by Race dynamics, 8421 Midland Dr., Greendale, 2002.
2. Tony Foale, **"Motorcycle Handling and chassis design",** Tony Foale designs, 2006.
3. Thomas D.Gillespie, "**Fundamentals of vehicle dynamics",** Society of Automotive Engineers, Inc., 1992.
4. G.K.Grover, "**Mechanical Vibrations",** Nem Chand, 2009.
5. L.M.Miline.Thomson, "**Theoretical Aerodynamics",** Dover Publications, Inc., U.S.A., 1973.

References:

1. Venkata Mangaraju K, "**Studies in the dynamics of two and three wheeled vehicles**", Ph D thesis-2012, IISc, Bangalore.
2. Jason C. Brown, A. John Robertson, Stan T. Serpento, **"Motor vehicles structures: Concepts and Fundamentals - Automotive Engineering Series"**, Butterworth-Heinemann Limited, 2002.
3. Tom Birch, Thomas Wesley Birch, **"Automotive Chassis Systems"**, Delmar, Thomson Learning, 1999.
4. http://www.derby.ac.uk/courses/motorcycle-engineering-beng-hons/-Website of Derby University.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1	**Introduction**	
1.1	DOF, joints, Spring and mass system, Simple pendulum, Time period, frequency, Stability.	2
1.2	Introduction to Motorcycle dynamics	1

1.3	Coordinate system and important definitions	1
2	**Dynamics of brake**	
2.1	Frictional force, deceleration, simple brake calculations	2
2.2	Dynamics during braking-Load transfer during braking, braking limit for rear and front wheels	3
2.3	Introduction to CBS, ABS	2
3	**Dynamics of Suspension**	
3.1	Sprung mass, un-sprung mass, Vibration modes- pitch, bounce;	2
3.2	Quarter car and half car models	2
3.3	Suspension elements and Design parameters.	3
4	**Stability and Maneuverability**	
4.1	Introduction, Definitions-Roll, yaw, etc, Vibration modes- Capsize, weave, wobble	3
4.2	Study of dynamics in Steady turn	2
4.3	SHM, Transient maneuvers, input and output parameters.	3
4.4	Design parameters for stability and Maneuverability, geometrical, mass and structural stiffness	3
5	**Tyre dynamics**	
5.1	Introduction to tyre, slip, stiffness, tyre specification, types of tyres	2
5.2	Tyre characteristic curve, vertical, cornering, camber stiffness, rolling resistance, Magic formula.	2
6	**Ergonomics**	
6.1	Introduction and Importance, Elements of Ergonomics	2
6.2	Riding posture design, ‘H’ point, seat design	2
7	**Aerodynamics**	
7.1	Introduction, Important definitions	1
7.2	Aerodynamics parameters, effect on vehicle performance	2
	Total	**40**

Course designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GC6	3	0	-	**3**

GC6 Assembly Engineering 3:0

Preamble: The increasing need for finishing goods in large quantities has led engineers to search for and to develop new methods for manufacturing. As a result of developments in the various manufacturing processes, it is now possible to mass-produce high quality durable goods at low cost. One of the manufacturing processes is assembly process that is required when two or more components are to be secured together. The history of assembly process development is closely related to the history of the development of mass-production methods. Design for assembly provides systematic procedures for evaluating and improving product design for both economic manufacture and assembly. The assembly process is concerned with prediction of time taken to accomplish the various tasks such as grasp, orient, insert and fasten. This process can be carried out manually and/or automatically based on its cost estimation.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.

b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

d. Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

Competencies: At the end of the course, students will be able to

1. Explain the manufacturing methods in assembly engineering process
2. Explain the basic facilities used for processing, inspection and testing in an assembly
3. Prepare a assembly plan for the given assembly
4. Choose a assembly process for the given specification and expected assembly tolerance
5. Explain the effect of assembly defects in product performance
6. Explain the expectations of the customer in a vehicle

Assessment pattern:

S.No.	Bloom's Category	Test 1	Test 2	Test 3	End Semester examination
1	Remember	20	20	10	10
2	Understand	60	60	50	50
3	Apply	20	20	40	40
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember

1. Name any four secondary assembly processes.
2. State the importance of fastening tools.
3. Define multi-model assembly line.
4. List the characteristics of automatic assembly lines.
5. List the assembly hygiene factors.
6. Mention counter measures of operator safety.

Understand

1. Explain the classification of assembly processes.
2. Explain the construction of pneumatic type fastening tool.
3. Describe process of cost estimation based on time and man planning.
4. With neat sketch, explain how defects in assembly are classified.
5. Explain how conveyors are classified and explain any two types conveyor systems used in automated assembly line.
6. With an illustration, explain the importance of the assembly sequencing.

Apply

1. Prepare an assembly sequence for the following exploded view of assembly as given in figure 1.

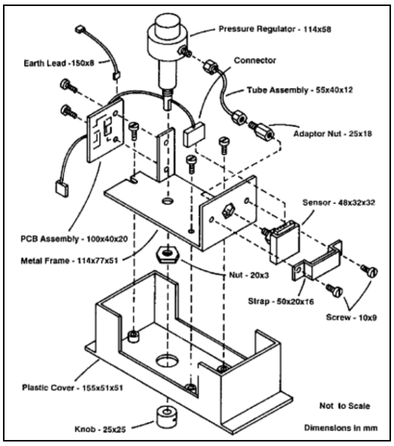


Figure 1

2. Suggest a suitable assembly technique for an automatic assembly of the following assembly given in figure 2.

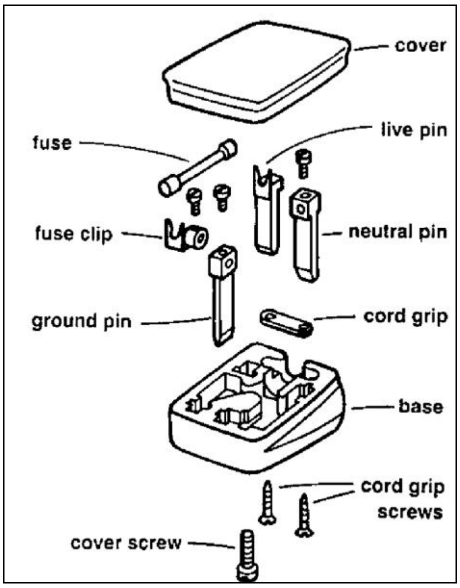


Figure 2

3. Suggest suitable methods for identification of missing of parts in the following assembly as given in figure 3.

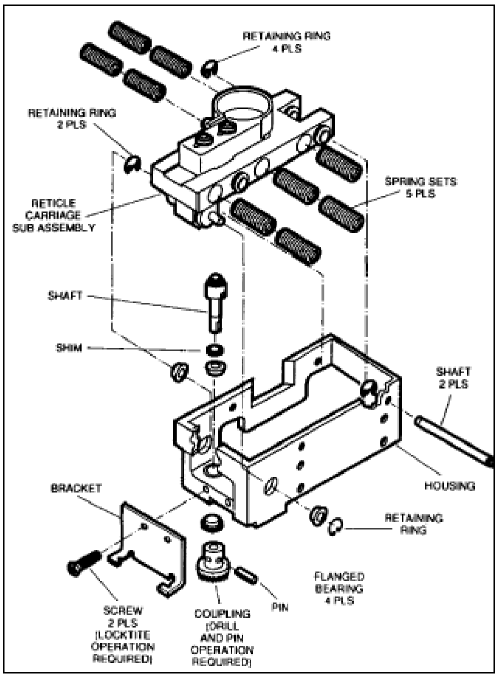
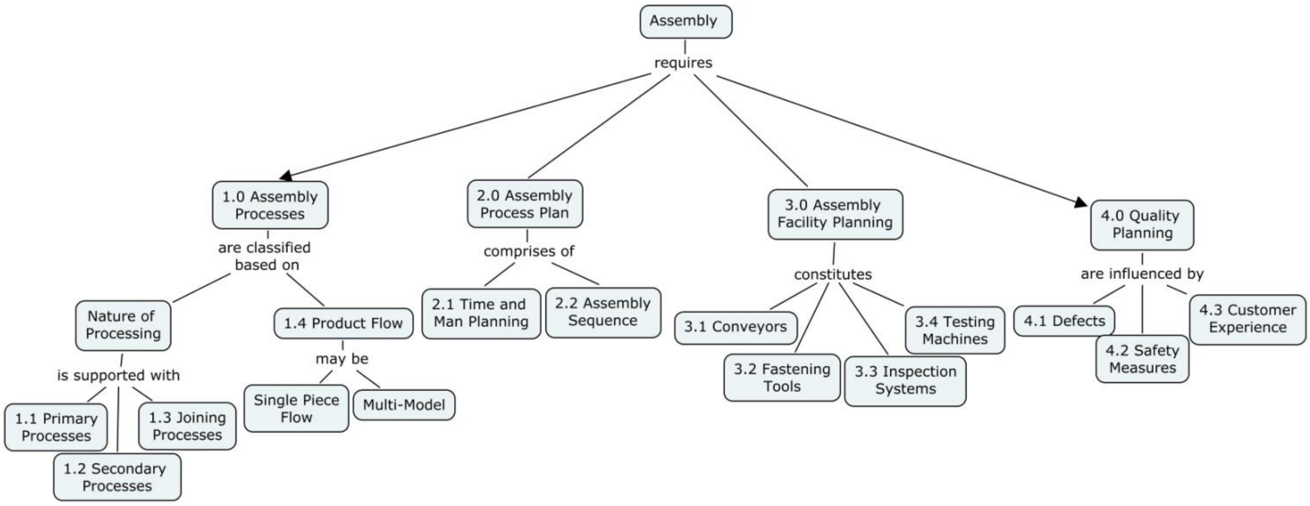


Figure 3

Concept map:



Syllabus:

Introduction to Assembly –Introduction Parts configuration and classification. Subassembly– Definition - Subsystem and system. **Assembly Processes:** Assembly process - Definition - Primary assembly processes -Secondary assembly processes: Washing, Numbering, Pressing, Fastening, Leak testing and Oil filling. Joining process: Permanent joining - welding, pressing, riveting; Semi permanent joining - fastening; Types of fasteners and their applications - Bolt grade class. Product Flow: Single piece flow, Multi-model, Automatic assembly line – definition, Importance, merits and demerits. **Assembly Plan:** Time and man power planning - Assembly Sequence with Mechanical Toy - Case studies. **Assembly Facility Planning:** Conveyors - purpose, importance and working principle and types - Fastening tools – importance- Classification based on source of energy (pneumatic, hydro-pneumatic, electric), shape (straight, L- type), mechanism (impact, oil pulsed, clutch type, reversible mechanism, stall types), control (torque, angle, time), number of spindles (single & multi) tool RPM, power to weight ratio, air consumption -Types of sockets, pliers, bits, holding tools, folding tools and their function & importance – Types of torque wrenches, setting procedure - Calibration of tools & torque wrenches – Types of fixtures gauges and special tools with examples – orientation & location principles - Materials, life monitoring, fixture tool calibration techniques -Assembly Inspection Systems: Inspection and Assurance in assembly systems - Testing Machines: washing, numbering, riveting, pressing (bearing, oil seal, bush) - Fire testing machines and adhesive application machines, leak testing, chassis dynamometer, emission analyser, stacking - Performance testing: Engine testing, test parameter and capturing method of engine health -Vehicle testing, test parameter and capturing method of vehicle road test simulator - Types of automations - assembly, testing & inspection. **Quality Planning:** Defects in Assembly - Classification of defects based on type, assembly (Missing , Wrong part, Wrong orientation, reverse assembly, loose assembly), Types of controls (detection, prevention, poka-yoke,) - Effect of missing of these parts in relation to product performance - Safety aspects in machines, aspect impact study, hazard risk areas and importance of PPE. Customer experience in mileage, ride comfort.

Text Books:

1. Daniel E Whitney, "**Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development**", Oxford University Press, 2004.
2. James A. Speck, "**Mechanical Fastening, Joining, and Assembly**", CRC Press, 1997.

Reference Books:

1. Kjell B. Zandin, "**Maynard's Industrial Engineering Handbook**", Fifth edition, McGraw-Hill, 2001 (Chapter 14.4).
2. Dean A.Shafer, PE, "**Successful Assembly Automation**", a development and implementation guide, Society of Manufacturing Engineers, 1999.
3. Frank J.Riley, "**Assembly Automation**", Second edition, A Management Handbook, Industrial Press Inc, 1996.
4. Geoffrey Boothroyd, Peter Dewhurst, Winston A Knight, "**Product Design for Manufacture and Assembly**", Third Edition, CRC Press, 2010.
5. Anthony Martyr and Michael Alexander Plint, "**Engine Testing: The Design, Building, Modification and Use of Power train Test Facilities**", Elsevier, 2012.
6. "**Emissions measurement & testing**", Society of Automotive Engineers, 2004.
7. We-Min Chow, "**Assembly Line Design; Methodology & Applications**", CRC Press; first edition, 1990.
8. Brahim Rekiek , Alain Delchambre, "**Assembly Line Design: The Balancing of Mixed-Model Hybrid Assembly Lines with Genetic Algorithms**", Springer Series in Advanced Manufacturing, 2006.
9. Shimon Y. Nof, Wilbert E. Wilhelm, H. Warnecke, "**Industrial Assembly**", Springer, 1997.

Course contents and lecture schedule:

S.No	Topic	No. of Lectures
	Introduction to assembly - Parts configuration and classification of parts - Assembly stages – sub assembly, Sub system and system	2
1	**Assembly Processes**	

S.No	Topic	No. of Lectures
1.1	Primary & Secondary assembly processes	3
1.2	Joining process and Semi permanent joining - fastening; Types of fasteners and their applications - Bolt grade class	1
1.3	Product Flow: Single piece flow, Multi-model, Automatic assembly line – definition, Importance, merits and demerits.	2
2	**Assembly Process Planning**	
2.1	Time and man power planning	2
2.2	Assembly Sequence with Mechanical Toy	2
2.3	Case studies	2
3	**Assembly Facility Planning**	
3.1	Conveyors - purpose, importance and working principle and types	1
3.2	Fastening tools – importance	1
3.2.1	Classification based on source of energy (pneumatic, hydro-pneumatic, electric), shape (straight, L- type), mechanism (impact, oil pulsed, clutch type, reversible mechanism, stall types), control (torque, angle, time), number of spindles (single & multi) tool RPM, power to weight ratio, air consumption	2
3.2.2	Types of sockets, pliers, bits, holding tools, folding tools and their function & importance – Types of torque wrenches, setting procedure	1
3.2.3	Calibration of tools & torque wrenches – Types of fixtures gauges and special tools with examples – orientation & location principles	1
3.2.4	Materials, life monitoring, fixture tool calibration techniques	2
3.3	Assembly Inspection Systems: Inspection and Assurance in assembly systems	1
3.4	Testing Machines: washing, numbering, riveting, pressing (bearing, oil seal, bush)	2
3.4.1	Fire testing machines and adhesive application machines, leak testing, chassis dynamometer, emission analyser, stacking	2
3.4.2	Performance testing: Engine testing, test parameter and capturing method of engine health	2

S.No	Topic	No. of Lectures
3.4.2.1	Vehicle testing, test parameter and capturing method of vehicle road test simulator	2
3.5	Types of automations - assembly, testing and inspection.	2
3.6	Case Studies	2
4	**Quality Planning**	
4.1	Defects in Assembly - Classification of defects and Types of controls (detection, prevention, poka-yoke)	1
4.1.1	Effect of missing of parts in relation to product performance	2
4.2	Safety aspects in machines, aspect impact study, hazard risk areas and importance of Personal Protective Equipment (PPE).	1
4.3	Customer experience in mileage, ride comfort	1
4.4	Case studies	2
	TOTAL	**41**

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Sub Code	Lectures	Tutorial	Practical	Credit
GC7	3	0	-	**3**

GC7 Metal Cutting Processes Engineering 3:0

Preamble: Metal cutting processes are the core production processes and the economy of these processes depends on the proper selection and control of parameters. Production engineer requires the knowledge of the mechanisms involved in those processes. In this elective course, the fundamental mechanisms of the metal cutting are presented, which are very essential for any manufacturing engineer.

Programme outcomes addressed:

e. Graduates will demonstrate knowledge of mathematics, science and engineering.
f. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
g. Graduate who can participate and succeed in competitive examinations.

Competencies: At the end of the course the students will be able to

1. Explain the principles and describe the process details of various metal cutting and finishing.
2. Describe the mechanisms involved in the metal cutting processes.
3. Determine the cutting forces, tool life and machinability.
4. Select tools and cutting parameters for a given work piece
5. Determine the cycle time and cost analysis of the metal cutting processes.
6. Explain the various work holding methods and devices
7. Explain the part programme for the given component
8. Describe various control systems and dimension control methods.

Assessment pattern:

S.No.	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3**	**End-semester examination**
1	Remember	30	30	30	30
2	Understand	40	40	40	40
3	Apply	30	30	30	30
4	Analyze	0	0	0	0
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course level learning objectives:

Remember

1. What are major types of cutting tools used for machining metals?
2. Define the term machinability
3. State the factors responsible for surface roughness.
4. Define part program
5. Name the various elements of control system.
6. Define NC machine tool.

Understand

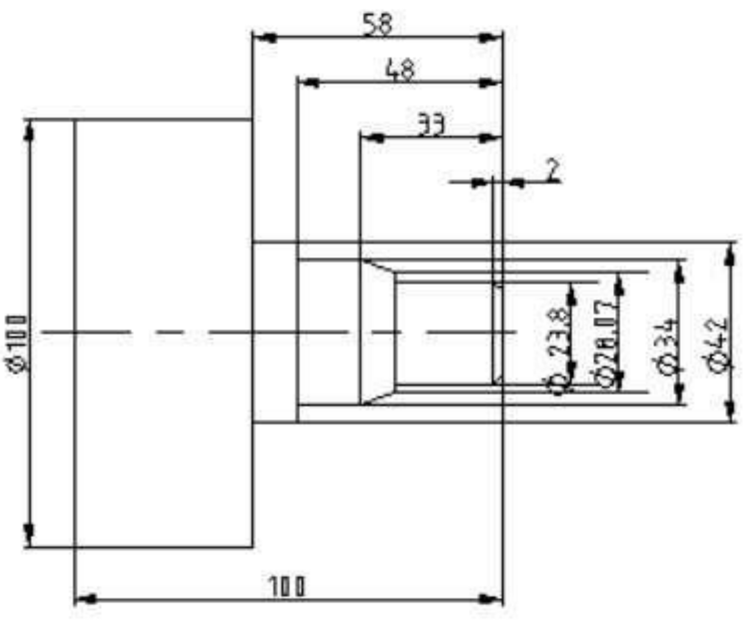
1. Describe the various types of fits.
2. Discuss the effect of critical dimensions in the stage drawing.
3. Discuss how to calculate the cyclic time for turning operation.
4. Discuss the functions of various of control system elements.
5. Describe the various types of gauges used in dimensional control
6. Discuss the working principle of any one surface tester with necessary illustrations.

Apply

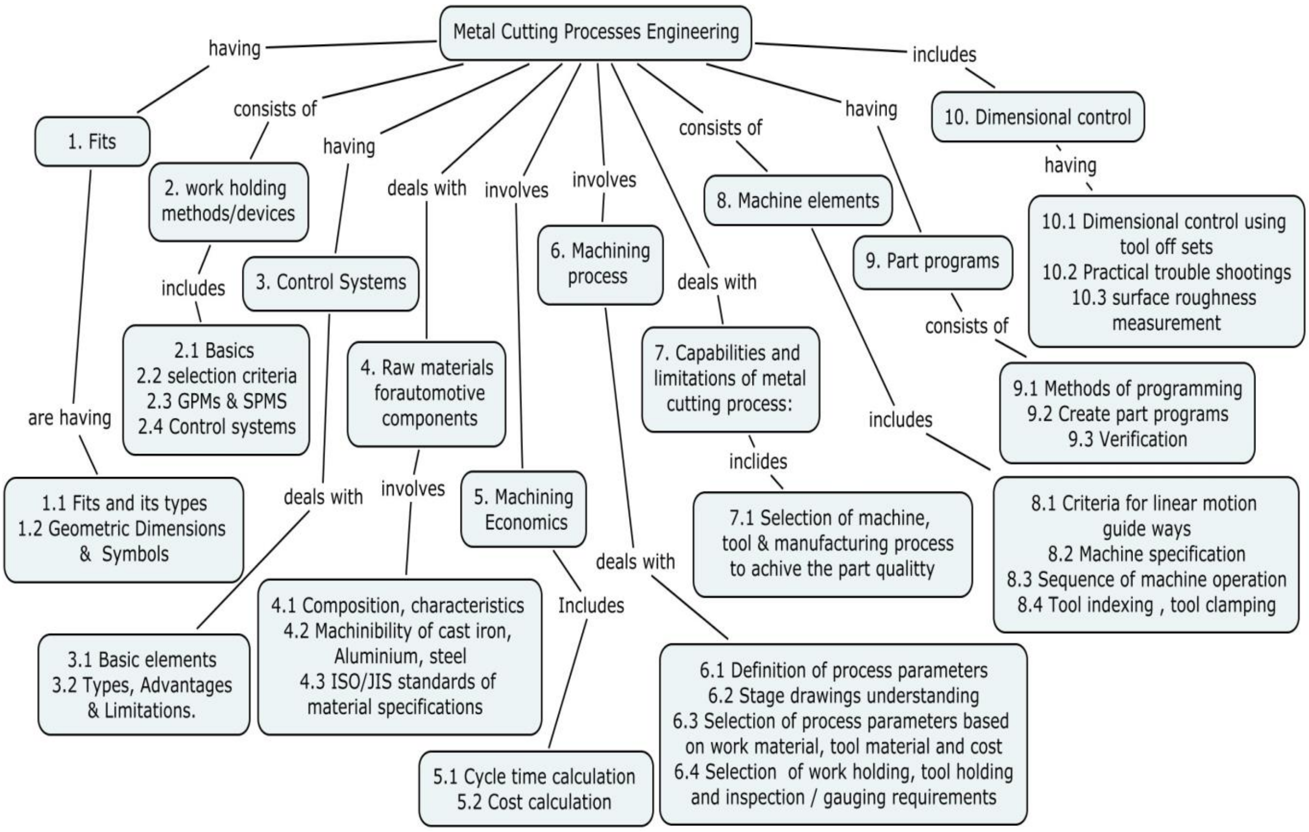
1. In a tool wear test with HSS cutting tool, the following values of tool life were obtained. Calculate the values of n and C of Taylor's equation.

Tool life min	*Cutting speed m/min*
30	25
1.5	70

2. In a turning operation, it was observed that the tool life was 100 minutes and 50 minutes at cutting speeds of 25m/min and 100m/min respectively. Find out the tool life at 200m/min under the same cutting conditions.
3. An engine block is to be made from the aluminum block. Justify the parameters which are to be accounted to achieve the dimensional quality.
4. If the life of a turning tool is 40 minutes and 25 minutes when used at speeds of 80m/min and 100m/min respectively, what would be its life at 150 m/min.
5. The surface of the IC engine bore is to be inspected to verify the dimensions. Suggest the suitable techniques to achieve the dimensional quality.
6. Write the part program for the given component as shown in the following figure


58
48
33
2
Ø100
Ø23.8
Ø28.07
Ø34
Ø42
100

Concept map:


Metal Cutting Processes Engineering
having
consists of
having
deals with
involves
involves
deals with
consists of
having
includes
1. Fits
are having
1.1 Fits and its types
1.2 Geometric Dimensions & Symbols
2. work holding methods/devices
includes
2.1 Basics
2.2 selection criteria
2.3 GPMs & SPMS
2.4 Control systems
3. Control Systems
deals with
3.1 Basic elements
3.2 Types, Advantages & Limitations.
4. Raw materials forautomotive components
involves
4.1 Composition, characteristics
4.2 Machinibility of cast iron, Aluminium, steel
4.3 ISO/JIS standards of material specifications
5. Machining Economics
Includes
5.1 Cycle time calculation
5.2 Cost calculation
6. Machining process
deals with
6.1 Definition of process parameters
6.2 Stage drawings understanding
6.3 Selection of process parameters based on work material, tool material and cost
6.4 Selection of work holding, tool holding and inspection / gauging requirements
7. Capabilities and limitations of metal cutting process:
inclides
7.1 Selection of machine, tool & manufacturing process to achive the part qualitty
8. Machine elements
includes
8.1 Criteria for linear motion guide ways
8.2 Machine specification
8.3 Sequence of machine operation
8.4 Tool indexing , tool clamping
9. Part programs
consists of
9.1 Methods of programming
9.2 Create part programs
9.3 Verification
10. Dimensional control
having
10.1 Dimensional control using tool off sets
10.2 Practical trouble shootings
10.3 surface roughness measurement

Syllabus:

Fits: Introduction - Clearance fit, Transition fit, Interference fit, Hole basis system - Shaft basis system. Product - examples

Introduction to GD & T - Geometric characteristic and symbols - straightness - flatness - parallelism - cylindricity - circularity - perpendicularity - angularity - position - symmetry - concentricity - run out

Basics of work holding methods/devices - vice, collets, chucks, face plates, jigs and fixtures; types, Explain selection criteria - DOF, location, orientation & clamping. Construction/design parameters (brief of material, part description), selection criteria, GPMs & SPMS - brief description, features, supporting accessories, safety features.

Control systems – Basic elements used in control systems, Types, Advantages and Limitations.

Raw materials for automotive components (cast iron, Aluminium, steel): composition, characteristics, Machinability of cast iron, Aluminium, steel (alloying element vs machinability), ISO/JIS standards of material specifications

Machining Economics: Cycle time and Cost calculation for processes of turning, milling, drilling, grinding and thread chasing.

Process parameters - Definition of cutting speed, feed, Depth of cut, tool life vs process parameters. Selection of parameters based on work material, tool material and cost.

Machining process selection: Selection of work holding, tool holding and inspection / gauging requirements for the component for different operations.

Capabilities and limitations of metal cutting process: Selection of appropriate machine, tool and manufacturing process required to achieve the part quality.

Machine elements - Guide ways, ball screw, lead screw and spindles. Criteria for linear motion guide ways or hard & ground guide ways. Machine specification - axis limits, over travel alarm, part-tool collision lay outs, referencing of axis, machine starting procedure, Machine operating modes-Jog,MDI,Single,Auto and edit. Sequence of machine operation - machine power on, axes referencing, movement of axes, tool indexing, tool clamping, reading of part programs, tool memory, reading of alarms, concept of origin and coordinate systems

Part programs - Methods of programming - absolute, incremental, basic G codes and M codes, structure of a CNC program - syntax requirements for turning centres and for machining centres (Exercises – drilling, reaming, boring, turning, milling and grinding).

Dimensional control- Using tool off sets (wear off sets), Exercises. Practical trouble shootings: Ovality, chattering marks, run outs, flatness, surface roughness. Usage of surface roughness tester, gauges and Coordinate Measuring Machine.

Text books:

1. Juneja, B L, Sekhon K L and Nitin Seth, "**Fundamentals of Metal Cutting and Machine Tools**", New Age International (P) Ltd., Publishers, 2003.
2. David A. Stephenson and John S Agapiou, "**Metal Cutting Theory and Practice**", CRC Press, 2005.
3. Paul K Wright and Edward M Trent, "**Metal Cutting**" 4th Edition, Butterworth-Heinemann, 2000.
4. Milton C Shaw, "**Metal Cutting Principles**" Oxford Series on Advanced Manufacturing, Second Edition, Oxford University Press, 2005.
5. Yusuf Altintas, "**Manufacturing Automation**" Cambridge University Press, 2012.

Reference books:

1. Geoffrey Boothroyd, "**Fundamentals of Metal Machining and Machine Tools**", McGraw-Hill Book Company, London, 1995.
2. Bhattacharya, A., "**Metal Cutting Theory and Practice**", New Central Book Agency (P) Ltd., Edition. 1984.
3. Serope Kalpakjian and Steven R. Schmid, "**Manufacturing Engineering and Technology**", Fourth Edition, Pearson Education, 2000.

Course contents and lecture schedule:

S.No.	**Topic**	**No. of Lectures**
1	**Fits**	
1.1	Introduction – Types – Clearance fit – Transition fit – Interference fit – Hole basis system – Shaft basis system. Product – examples	1
1.2	Introduction to GD & T – Geometric characteristic and symbols – straightness – flatness – parallelism – cylindricity – circularity – perpendicularity – angularity – position – symmetry – concentricity – runout	2
2.	**work holding methods/devices**	
2.1	Basics of work holding methods / devices - vice, collets, chucks, face plates, jigs and fixtures; types	1

S.No.	Topic	No. of Lectures
2.2	Explain selection criteria – Degrees of freedom, location, orientation & clamping. Construction / design parameters (brief of material, part description), selection criteria	2
2.3	General purpose and special purpose machines, Description features, supporting accessories, safety features.	2
3.	**Control systems**	
3.1	Basic elements	2
3.2	Types, advantages and Limitations of control systems.	1
4	**Raw materials for automotive components** (cast iron, Aluminum, steel)	
4.1	Composition, characteristics	1
4.2	Machinability of cast iron, Aluminium, steel (alloying element vs machinability)	2
4.3	ISO/JIS standards of material specifications	2
5.0	**Machining Economics**	
5.1	Cycle time calculation formula for processes of turning, milling, drilling and grinding	2
5.2	Cost calculation data for processes of turning, milling, drilling, grinding and thread chasing.	2
6	**Machining process selection**	
6.1	Definition of process parameters - cutting speed, feed, Depth of cut, tool life vs process parameters, selection of parameters based on work material and tool material	2
6.2	Stage drawing understanding	
6.3	Selection of process parameters based on the work material, tool material and cost.	1
6.3	Selection of work holding / tool holding based on considerations of inspection / gauging requirements	2
7	**Metal cutting processes**	
7.1	Capabilities and limitations of various metal cutting process	1
7.2	Select the appropriate machine tool and manufacturing process required to achieve the part quality	2
8	**Machine elements**	
8.1	Machine elements like - guide ways, ball screw, lead screw, spindles, Criteria for LM (linear motion) guide ways or hard &	2

S.No.	Topic	No. of Lectures
	ground guide ways.	
8.2	Machine specification - axis limits, over travel alarm, part-tool collision lay outs, referencing of axis, machine starting procedure, Machine operating modes-Jog, MDI, Single, Auto and edit	2
8.3	Sequence of machine operation - machine power on, axes referencing, movement of axes,	2
8.4	tool indexing, tool clamping, reading of part programs, tool memory, reading of alarms, concept of origin and coordinate systems	2
9	**Part programs**	
9.1	Methods of programming - absolute, incremental, basic G codes and M codes, structure of a CNC program - syntax requirements for turning centres & machining centres	3
9.2	Create part programs - simple to complex	1
9.3	Verify the graphical simulation, dry run in single block mode Machine the part to required dimensions	2
10	**Dimensional control**	
10.1	Dimensional control using tool off sets (wear off sets)	1
10.2	practical trouble shooting for - ovality, chattering marks, run outs, flatness, surface roughness	1
10.3	Usage of surface roughness tester, gauges and CMM	1
	Total	**45**

Course Designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
GC8	3	0	-	**3**

GC8 Design for Welding 3:0

Preamble: Welding is an inevitable process in the fabrication of parts. So inorder to make the process effective and improve the quality of the product, there is a need to design weld joints and know the engineering and science behind the process. In order to perform Welding in some applications, the design of Welding fixtures is also essential to improve productivity of the process. This course aims to provide knowledge on Welding joints and its design techniques to optimize productivity and cost and design of Welding Fixtures based on applications.

Programme outcomes addressed:

a. An ability to apply knowledge of engineering, information technology, mathematics and science
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system or component, or process to meet stated specifications
d. An ability to identify, formulate and solve engineering problems
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints
f. An ability to engage in life-long learning

Competencies: At the end of the course the students will be able to

1. Select appropriate welding process as per the application.
2. Design a weld joint for given function, manufacturing and cost
3. Develop MIG/MAG Welding process for a given application.
4. Develop Resistance Welding process for a given application
5. Specify the quality requirement for welders and processes
6. Optimize the welding process for productivity, manufacturability and cost
7. Design a welding fixture with reference of datum, location, orientation ,resting & clamping of the part & materials used for fixture(Manual/Robot)
8. Understand the fixture inspection ,validation & Fixture maintenance & calibration

Assessment pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	30	20	20	20
2	Understand	40	40	40	40
3	Apply	30	40	40	40
4	Analyze	-	-	-	-
5	Evaluate	-	-	-	-
6	Create	-	-	-	-

Course level learning objectives:

Remember

1. List the types of Welding Processes.
2. State the Principles of Welding.
3. Mention the Power Source required for Resistance Welding.
4. List the skill sets that are required for a Welding Operator.
5. Mention the different elements of Weld fixture.
6. Name few tool materials that are used for pressing operations.

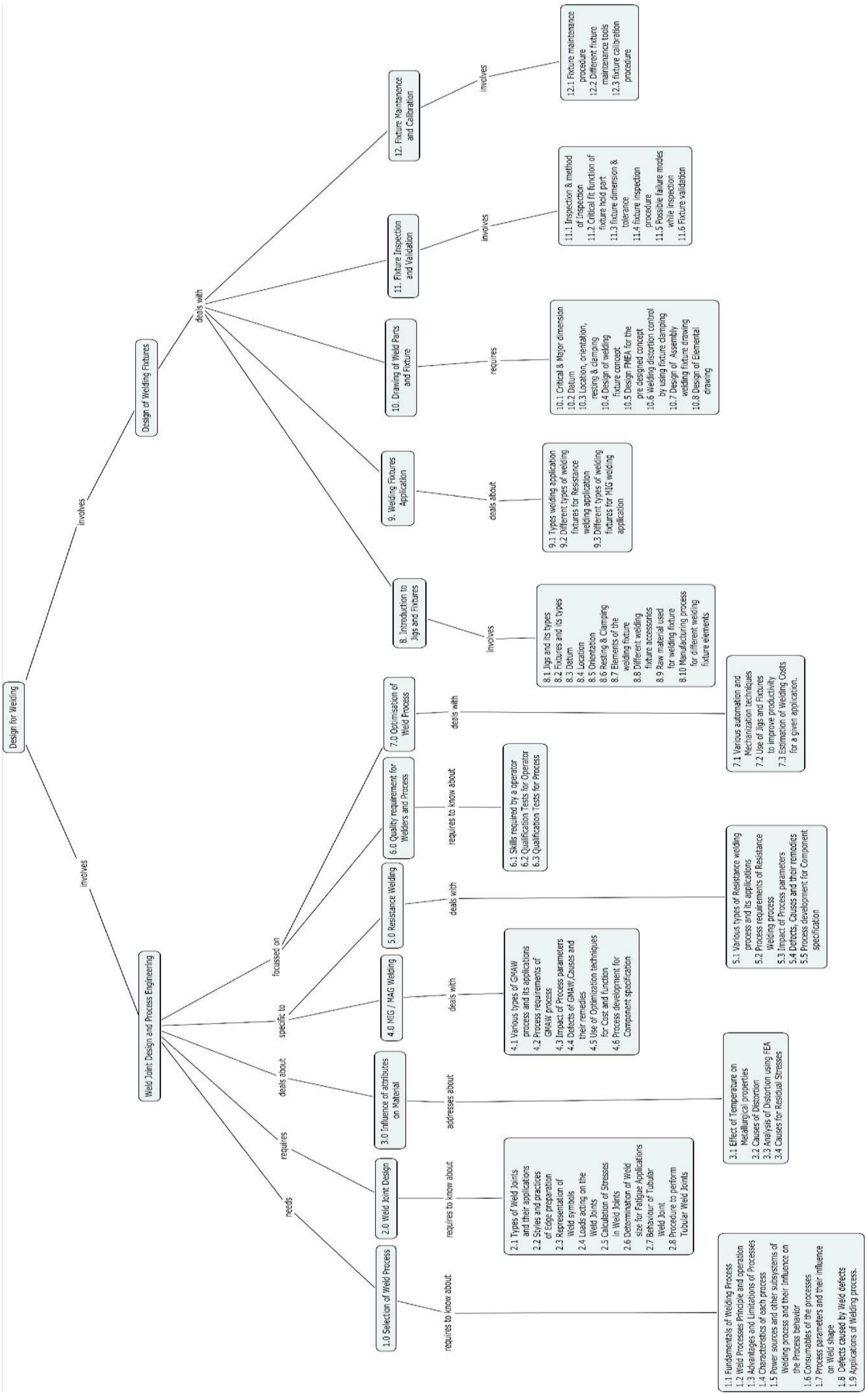
Understand

1. Discuss about the various automation and mechanization techniques in Welding.
2. Describe about the various parameters and its influence on Weld shape.
3. Discuss about the causes for Welding Defects in MIG/MAG Welding.
4. Summarize about the calibration procedure of Weld fixture.
5. Classify the different types of fixture based on the types of applications.
6. Distinguish between Welding fixture and machining fixture.

Apply

1. Design a lap joint for a plate of 10 mm thickness as per AWS 1.1.
2. Draw the Weld Symbol for the joint with Fillet Weld of 10 mm leg and 10 no. of Stich welds of length 1000 mm with a gap of 50 mm.
3. Write the steps involved in determining the Cutting force in blanking process.
4. Draw the Individual tool Elements and create the process plan for a given part.
5. Choose a welding process that requires no filler material and explain its types and factors influencing the Weld with suitable applications.
6. Illustrate the procedure to perform Tool cost estimation for a given part.

Concept map:


Design for Welding
involves
Design of Welding Fixtures
involves
Weld Joint Design and Process Engineering
deals with
8. Introduction to Jigs and Fixtures
involves
8.1 Jigs and its types
8.2 Fixtures and its types
8.3 Datum
8.4 Location
8.5 Orientation
8.6 Resting & Clamping
8.7 Elements of the welding fixture
8.8 Different welding fixture accessories
8.9 Raw material used for welding fixture
8.10 Manufacturing process for different welding fixture elements
9. Welding Fixtures Application
deals about
9.1 Types welding application
9.2 Different types of welding fixtures for Resistance welding application
9.3 Different types of welding fixtures for MIG welding application
10. Drawing of Weld Parts and Fixture
requires
10.1 Critical & Major dimension
10.2 Datum
10.3 Location, orientation, resting & clamping
10.4 Design of welding fixture concept
10.5 Design FMEA for the pre designed concept
10.6 Welding distortion control by using fixture clamping
10.7 Design of Assembly welding fixture drawing
10.8 Design of Elemental drawing
11. Fixture Inspection and Validation
involves
11.1 Inspection & method of Inspection
11.2 Critical fit function of fixture hold part
11.3 fixture dimension & tolerance
11.4 fixture inspection procedure
11.5 Possible failure modes while inspection
11.6 Fixture validation
12. Fixture Maintenance and Calibration
involves
12.1 Fixture maintenance procedure
12.2 Different fixture maintenance tools
12.3 fixture calibration procedure
focussed on
specific to
deals about
requires
needs
1.0 Selection of Weld Process
requires to know about
1.1 Fundamentals of Welding Process
1.2 Weld Processes Principle and operation
1.3 Advantages and Limitations of Processes
1.4 Characteristics of each process
1.5 Power sources and other subsystems of Welding process and their Influence on the Process behavior
1.6 Consumables of the processes
1.7 Process parameters and their influence on Weld shape
1.8 Defects caused by Weld defects
1.9 Applications of Welding process.
2.0 Weld Joint Design
requires to know about
2.1 Types of Weld Joints and their applications
2.2 Styles and practices of Edge preparation
2.3 Representation of Weld symbols
2.4 Loads acting on the Weld Joints
2.5 Calculation of Stresses in Weld Joints
2.6 Determination of Weld size for Fatigue Applications
2.7 Behaviour of Tubular Weld Joint
2.8 Procedure to perform Tubular Weld Joints
3.0 Influence of attributes on Material
addresses about
3.1 Effect of Temperature on Metallurgical properties
3.2 Causes of Distortion
3.3 Analysis of Distortion using FEA
3.4 Causes for Residual Stresses
4.0 MIG / MAG Welding
deals with
4.1 Various types of GMAW process and its applications
4.2 Process requirements of GMAW process
4.3 Impact of Process parameters
4.4 Defects of GMAW,Causes and their remedies
4.5 Use of Optimization techniques for Cost and function
4.6 Process development for Component specification
5.0 Resistance Welding
deals with
5.1 Various types of Resistance welding process and its applications
5.2 Process requirements of Resistance Welding process
5.3 Impact of Process parameters
5.4 Defects, Causes and their remedies
5.5 Process development for Component specification
6.0 Quality requirement for Welders and Process
requires to know about
6.1 Skills required by a operator
6.2 Qualification Tests for Operator
6.3 Qualification Tests for Process
7.0 Optimisation of Weld Process
deals with
7.1 Various automation and Mechanization techniques
7.2 Use of Jigs and Fixtures to improve productivity
7.3 Estimation of Welding Costs for a given application.

Syllabus:

Selection of Weld Process Fundamentals of Welding Process - Weld Processes Principle and operation - Advantages and Limitations of Processes - Characteristics of each process - Power sources and other subsystems of Welding process and their Influence on the Process behavior - Consumables of the processes - Process parameters and their influence on Weld shape - Defects caused by Weld defects Applications of Welding process. **Design of Weld Joints** Types of Weld Joints and their applications - Styles and practices of Edge preparation - Representation of Weld symbols - Loads acting on the Weld Joints - Calculation of Stresses in Weld Joints - Determination of Weld size for Fatigue Applications - Behaviour of Tubular Weld Joint - Procedure to perform Tubular Weld Joints **Influence of Attributes on Material -** Effect of Temperature on Metallurgical properties - Causes of Distortion - Analysis of Distortion using FEA - Causes for Residual Stresses - **MIG / MAG Welding -** Various types of GMAW process and its applications - Process requirements of GMAW process - Impact of Process parameters - Defects of GMAW, Causes and their remedies - Use of Optimization techniques for Cost and function - Process development for Component specification - **Resistance Welding -** Various types of Resistance welding process and its applications - Process requirements of Resistance Welding process - Impact of Process parameters - Defects, Causes and their remedies - Process development for Component specification - **Quality requirement for Welders and Process -** Skills required by a operator - Qualification Tests for Operator - Qualification Tests for Process - **Optimization of Weld Process -** Various automation and Mechanization techniques - Use of Jigs and Fixtures to improve productivity - Estimation of Welding Costs for a given application. **Introduction to Jigs and Fixtures -** Jigs and its types - Fixtures and its types - Datum and its importance of the Part - Location and its importance of the Part - Orientation and its importance of the Part - Resting & Clamping and its importance of the Part - Elements of the welding fixture - Different welding fixture accessories used for different welding application - Raw material used for welding fixture - Manufacturing process for different welding fixture elements - **Welding Fixtures Application -** Types of welding application -Different types of welding fixtures for Resistance welding application (Manual/Auto) -Different types of welding fixtures for MIG welding application (Manual/Auto) -**Drawing of Weld Parts and fixtures -** Critical & Major dimension of the part -Datum used in the weld part - Location, orientation, resting & clamping for the weld part - Design of welding fixture concept for given part- Design FMEA for the pre designed concept fixture -Welding distortion control by using fixture clamping - Design of Assembly welding fixture drawing for a given part - Design of Elemental drawing of given welding fixture - **Fixture Inspection and Validation -** Inspection & method of Inspection -Critical fit function of fixture hold part - fixture dimension & tolerance - fixture inspection procedure - Possible failure modes while inspection - Fixture validation - **Fixture Maintenance and Calibration -** Fixture maintenance procedure - Different fixture maintenance tools - fixture calibration procedure

Text book:

1. Robert and Messler, "**Principles of Welding (Processes, Physics, Chemistry and Metallurgy)**", Wiley Interscience Publishers, 1st Edition, 1999.

Reference books:

1. O. P Khanna "**A Textbook of Welding Technology**", Dhanpat Rai & Sons, Twentieth Reprint, 2011.
2. "**Welding Hand Book**" Vol. 5; 7th edition, AWS, 1984.
3. S.J Maddox, "**Fatigue Strength of Welded Structures**", Woodhead Publishing, 1991.
4. T.R Gurney, Tim Gurney, "**Fatigue Strength of Transverse Fillet Welded Joints: A Study of the Influence of Joint Geometry**", Woodhead Publishing, 1991.
5. Omer. W.Blodgett, James F.Lincoln, "**Design of Welded Structures, Arc Welding Foundation**", 1st Edition 1996.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1.	**Selection of Weld Process**	
1.1	Fundamentals of Welding Process	1
1.2	Weld Processes Principle and operation	
1.3	Advantages and Limitations of Processes	1
1.4	Characteristics of each process	
1.5	Power sources and other subsystems of Welding process and their Influence on the Process behavior	1
1.6	Consumables of the processes.	
1.7	Process parameters and their influence on Weld shape.	1
1.8	Defects caused by Weld defects.	
1.9	Applications of Welding process.	1
2.	**Design of Weld Joints**	
2.1	Types of Weld Joints and their applications	1
2.2	Styles and practices of Edge preparation	

S.No.	Topic	No. of Lectures
2.3	Representation of Weld symbols	1
2.4	Loads acting on the Weld Joints	
2.5	Calculation of Stresses in Weld Joints	1
2.6	Determination of Weld size for Fatigue Applications	
2.7	Behaviour of Tubular Weld Joint	1
2.8	Procedure to perform Tubular Weld Joints	
3.	**Influence of Attributes on Material**	
3.1	Effect of Temperature on Metallurgical properties	1
3.2	Causes of Distortion	
3.3	Analysis of Distortion using FEA	2
3.4	Causes for Residual Stresses	1
4.	**MIG / MAG Welding**	
4.1	Various types of GMAW process and its applications	1
4.2	Process requirements of GMAW process	1
4.3	Impact of Process parameters	1
4.4	Defects of GMAW, Causes and their remedies	1
4.5	Use of Optimization techniques for Cost and function	
4.6	Process development for Component specification	1
5.	**Resistance Welding**	
5.1	Various types of Resistance welding process and its applications	1
5.2	Process requirements of Resistance Welding process	1
5.3	Impact of Process parameters	1
5.4	Defects, Causes and their remedies	
5.5	Process development for Component specification	1
6.	**Quality requirement for Welders and Process**	
6.1	Skills required by a operator	1
6.2	Qualification Tests for Operator	
6.3	Qualification Tests for Process	1
7.	**Optimization of Weld Process**	
7.1	Various automation and Mechanization techniques	1
7.2	Use of Jigs and Fixtures to improve productivity	
7.3	Estimation of Welding Costs for a given application	1
8.	**Introduction to Jigs and Fixtures**	
8.1	Jigs and its types	1

S.No.	Topic	No. of Lectures
8.2	Fixtures and its types	
8.3	Datum and its importance of the Part	1
8.4	Location and its importance of the Part	
8.5	Orientation and its importance of the Part	1
8.6	Resting & Clamping and its importance of the Part	
8.7	Elements of the welding fixture	1
8.8	Different welding fixture accessories used for different welding application	1
8.9	Raw material used for welding fixture	1
8.10	Manufacturing process for different welding fixture elements	
9.	**Welding Fixtures Application**	
9.1	Types of welding application	1
9.2	Different types of welding fixtures for Resistance welding application (Manual/Auto)	1
9.3	Different types of welding fixtures for MIG welding application (Manual/Auto)	
10.	**Drawing of Weld Parts and Fixture**	
10.1	Critical & Major dimension of the part	1
10.2	Datum used in the weld part	
10.3	Location, orientation, resting & clamping for the weld part	1
10.4	Design of welding fixture concept for given part.	
10.5	Design FMEA for the pre designed concept fixture	1
10.6	Welding distortion control by using fixture clamping	1
10.7	Design of Assembly welding fixture drawing for a given part	1
10.8	Design of Elemental drawing of given welding fixture	1
11.	**Fixture Inspection and Validation**	
11.1	Inspection & method of Inspection	1
11.2	Critical fit function of fixture hold part	
11.3	fixture dimension & tolerance	1
11.4	fixture inspection procedure	
11.5	Possible failure modes while inspection	1
11.6	Fixture validation	

S.No.	Topic	No. of Lectures
12.	**Fixture Maintenance and Calibration**	
12.1	Fixture maintenance procedure	1
12.2	Different fixture maintenance tools	
12.3	fixture calibration procedure	1
	Total	**45**

Course Designer:

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Sub Code	Lectures	Tutorial	Practical	Credit
GC9	3	0	-	**3**

GC9 Sheet Metal Drawing and Bending 3:0

Preamble: Forming process make use of suitable stresses like compression, tension, shear or combined stresses to cause plastic deformation of the materials to produce required shapes. In forming, no material is removed i.e. they are deformed and displaced. Sheet Metal forming involves deformation of sheet metal to achieve the desired shape. Many products like panels, car doors, PC panels, computer casing, utensils are manufactured using sheet metal. Tube bending is the umbrella term for metal forming processes used to permanently form pipes or tubing. A tube can be bent in multiple directions and angles. Common simple bends consist of forming *elbows*, which are bends that range from 2 to 90°, and *U-bends*, which are 180° bends. More complex geometries include multiple two-dimensional (2D) bends and three-dimensional (3D) bends. The first and second parts of this course aim to provide knowledge on the working, advantages, limitations, applications and cost drivers of various Sheet metal forming and Tube Bending processes.

Programme Outcomes addressed

a. An ability to apply knowledge of engineering, information technology, mathematics and science.
b. An ability to design and conduct experiments, as well as to analyze and interpret data
c. An ability to design a system or component, or process to meet stated specifications
e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

Competencies: At the end of the course the student will be able to

1. Explain why Sheet metal & forming process is used in Automotive Parts.
2. Select appropriate forming process for sheet metal components
3. Explain about the Component drawing and its pre requisites.
4. Explain about the Types of defects and its trouble shooting & Remedy of sheet metal forming processes.
5. Explain tube bending and its types and Equipments that are used for manufacturing tube bending parts.
6. Explain the Cost drivers that are important to decide the cost of tube bend part.

Assessment Pattern

S.No	Bloom's Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	20	20	20	20
2	Understand	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	-	-	-	-
5	Evaluate	-	-	-	-
6	Create	-	-	-	-

Course level learning objective

Remember

1. What is bending operation?
2. Define the term Forgeability.
3. What are the defects in roll plates and sheets?
4. Name the metals commonly used in sheet metal work.
5. What parameter you will check in petrol tank and wego panel?
6. What is process planning chart?

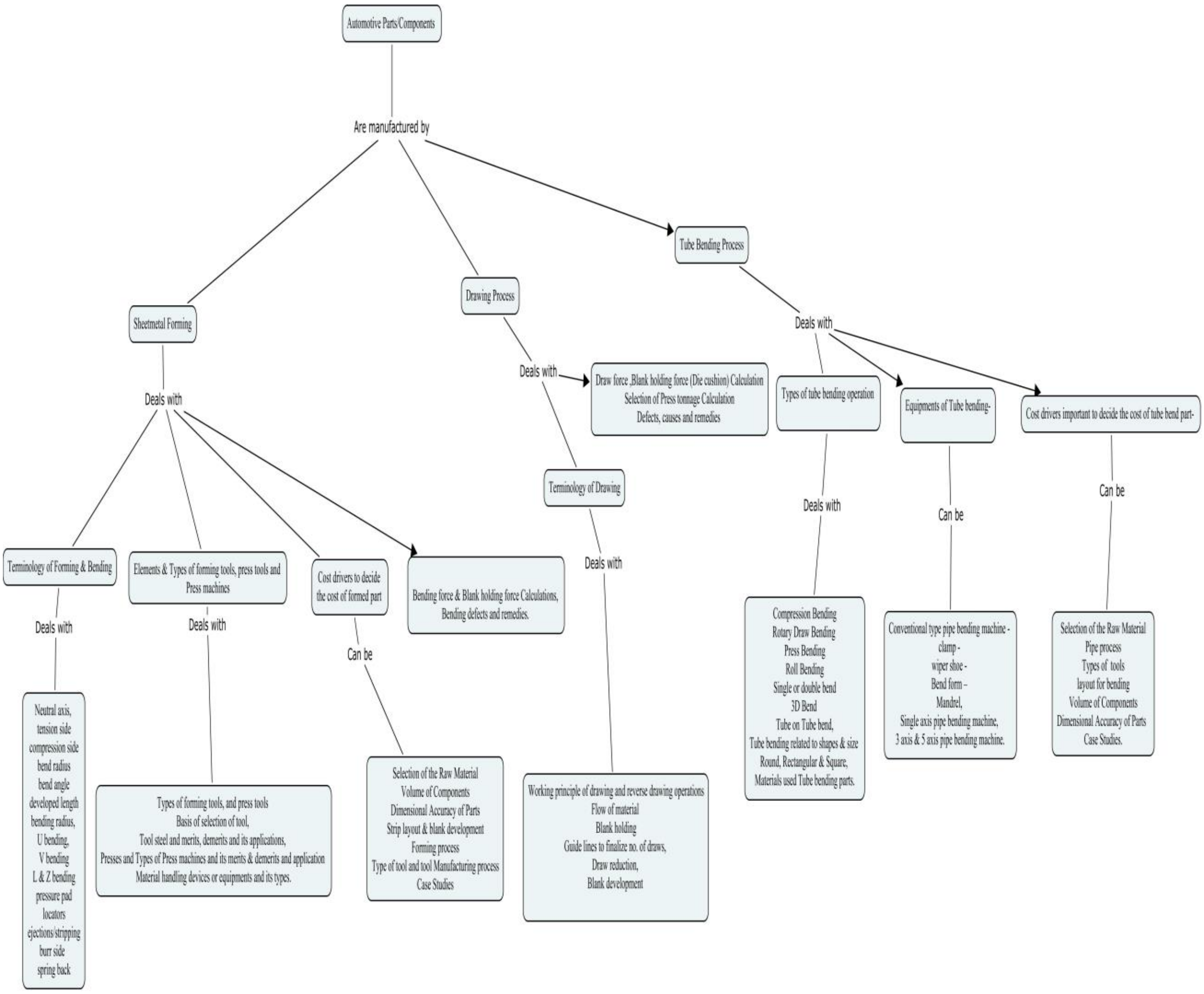
Understand

1. Distinguish between forming and draw operation.
2. Explain bending operation and the elements of bending tool.
3. Explain about the Types of presses used for part manufacturing.
4. Explain about 'Merits & Demerits of presses on basis of selection of press.
5. Explain about the Pre requite to draw a simple press tool(Bending & Forming)
6. Explain the cost estimation simple bending tool with detailing of weight, rate of raw material, machining rate, assembly cost & profit.

Apply

1. Estimate the force required in punching a 25 mm diameter hole through a 3.2 mm thick annealed titanium alloy Ti-6Al-4V sheet at room temperature.
2. Suggest a suitable forming process for sheet metal of 3 mm thickness through induce of very high pressure suddenly and explain its principle.
3. Suggest a technique you adapt for making pot like vessels for household utility? Give its principle.
4. Suggest a suitable method for tube bending with simple diagram.
5. How you will inspect complicated part like petrol tank?
6. Identify and list the possible defects in wego panel and suggest the suitable remedies to avoid these defects.

Concept Map



Syllabus

Sheet metal & forming process- Basics of forming, bending & drawing process, Advantages and its Applications in Automotive Parts.

Terminology of Forming & Bending-Neutral axis, tension side, compression side, bend radius, bend angle, developed length, bending radius, U bending, V bending, L & Z bending, pressure pad, locators, ejections/stripping, burr side , spring back, methods of overcoming spring back, Relief and Types of relief - Bending force & Blank holding force Calculations, Bending defects and remedies.

Terminology of Drawing-Working principle of drawing operations and reverse drawing, flow of material ,blank holding, guide lines to finalize no. of draws, draw reduction, blank development , Calculation of Draw force ,Blank holding force (Die cushion),Blank development - No of Draws - Selection of Press tonnage, defects, causes and remedies in drawing operation.

Elements & Types of forming and press tools and Press machines –Types of forming and press tools, Basis of selection of forming and press tool, Tool steel and merits, demerits and its applications**,** Tool Design, Tool Maintenance, Punches Types of Punches and Punch tool requirements, **Presses-** Types of Press machines based on Source of Power, Slide Actuation & Capacity and its merits & demerits and application of presses and Material handling devices or equipments and its types.

Cost drivers important to decide the cost of formed part –Effect of the Raw Material, Volume of Components, Dimensional Accuracy of Parts, strip layout & blank development, forming process, type of tool and tool Manufacturing process on the cost of pressed part-Case Studies.

Determination of Sequence and Tool selection - Sequence of operation available in the given part - Merits & Demerits of Selection of operations - appropriate type of Tools for given sequence - Merit & De merit of selection of tool for the given Sequence.

Blanking tool & Piercing tool design - Component drawing and its pre requisites - Draw the component drawing & Strip layout - Calculation of cutting force - stripping force - Press tonnage - Economic factor & selection of press - Draw the assembly of tool drawing & BOM - Draw the individual tool elements part drawing for Manufacturing

Prepare the process planning chart

Tool cost estimation - weight of each element of tool and its raw material cost - Rate for each machining process (As per the process planning sheet) - brought elements of blanking tool - assembly, Trial & Inspection cost overhead cost & profit

Inspection, trials and Troubleshooting - checklist for tool in static condition - checklist for tool in Dynamic condition - general inspection methods. Specific inspection methods (Panel checker/acceptance gauge)

Tube bending process-Types of tube bending operation - Compression Bending, Rotary Draw Bending, Press Bending, Roll Bending, Single or double bend ,3D Bend ,Tube on Tube bend, Tube bending related to shapes & size -Round, Rectangular & Square, Materials used Tube bending parts.

Equipments of Tube bending-Conventional type pipe bending machine - clamp - wiper shoe - Bend form – Mandrel, Single axis pipe bending machine, 3 axis & 5 axis pipe bending machine.

Cost drivers important to decide the cost of tube bend part- Effect of the Raw Material, Pipe process, Types of tools, layout for bending, Volume of Components, Dimensional Accuracy of Parts on the cost of tube bend part-Case Studies.

Text Books:

1. Serope Kalpakjian and Steven R. Schmid, "**Manufacturing Engineering and Technology**", Addition Wesley Longman Pvt. Ltd., First Indian reprint, 2000.

2. S.K.HajraChoudhury and A.K. HajraChoudhury, **"Elements of Work shop Technology"**, Vol – I Manufacturing Processes, Media Promoters and Publishers Pvt. Ltd, 1986.

Reference Books:

1. Prof. P.C. Pandey & Prof. C.K. Singh **"Production Engineering Science",** Standard Publishers Distributors, 2006.
2. George E. Dieter "**Mechanical Metallurgy**", Mc Graw-Hill Book Company, 1998.
3. E.Paul Degarmo, J.T.Black, and Ronald A. Konser, "**Materials and Processes in Manufacturing**", 5th Edition, Prentice Hall India Ltd., 1997.
4. Philip F. Oswald, and Jairo Munoz, "**Manufacturing Process and Systems**", John Wiley and Sons, 1992.
5. John E. Neeley and Richard R.Kibbe, "**Modern Materials and Manufacturing Processes**", John Wiley and Sons, 1992.
6. P.N.Rao, "**Manufacturing Technology**", Tata McGraw Hill, New Delhi, 1998.
7. S.L. Semiatin "**ASM Handbook Volume 14B: Metalworking: Sheet Forming",** 2006.
8. Schuler **"Metal Forming Handbook"**, Springer-Verlag Berlin Heidelberg 1998
9. Kurt Lange, **"Handbook of Metal Forming"**, Society of Manufacturing Engineers,1985

Course contents and Lecture Schedule

S.No	**Topic**	**No. of Lectures**
1.	**Sheet metal & forming process**	
	Basics of forming, bending & drawing process, Advantages and its Applications in Automotive Parts	2
2	**Terminology of Forming & Bending**	
2.1	Neutral axis, tension side, compression side, bend radius, bend angle, developed length, bending radius	2
2.2	U bending, V bending, L & Z bending, pressure pad, locators, ejections/stripping, burr side , spring back, methods of overcoming spring back	2
2.3	Relief and Types of relief	1
2.4	Bending force & Blank holding force Calculations	1
2.5	Bending defects and remedies.	1
3	**Terminology of Drawing**	
3.1	Working principle of drawing and reverse drawing	2

S.No	Topic	No. of Lectures
	operations, flow of material ,blank holding, guide lines to finalize no. of draws, draw reduction, blank development	
3.2	Calculation of Draw force, Blank holding force (Die cushion),Blank development - No of Draws - Selection of Press tonnage, simple draw tool design.	2
3.3	Defects, causes and remedies in drawing operation.	1
4	**Elements & Types of forming and press tools and Press machines**	
4.1	Types of forming and press tools, Basis of selection of tools, Tool steel and merits, demerits and its applications	1
4.2	Tool Design, Tool Maintenance, Punches Types of Punches and Punch tool requirements	3
4.3	**Presses-** Types of Press machines based on Source of. Power, Slide Actuation & Capacity and its merits & demerits and application of presses	1
4.4	Material handling devices or equipments and its types.	2
5	**Cost drivers to decide the cost of formed part**	
5.1	Effect of the Raw Material on the cost of pressed part-Case Studies.	1
5.2	Effect of the Volume of Components on the cost of pressed part-Case Studies.	1
5.3	Effect of the Dimensional Accuracy of Parts on the cost of pressed part-Case Studies.	1
5.4	Effect of the strip layout & blank development on the cost of pressed part-Case Studies.	1
5.5	Effect of the forming process on the cost of pressed part-Case Studies.	1
5.6	Effect of the type of tool on the cost of pressed part-Case Studies.	1
5.7	Effect of the tool Manufacturing process on the cost of pressed part-Case Studies.	1
6	**Determination of Sequence and Tool selection**	
6.1	Sequence of operation available in the given part Merits & Demerits of Selection of operations appropriate type of Tools for given sequence Merit & De merit of selection of tool for the given Sequence	1

S.No	Topic	No. of Lectures
7	**Blanking tool & Piercing tool design**	
7.1	Component drawing and its pre requisites	1
7.2	Draw the component drawing & Strip layout	1
7.3	Calculation of cutting force - stripping force - Press tonnage - Economic factor & selection of press	1
7.4	Draw the assembly of tool drawing & BOM	1
7.5	Draw the individual tool elements part drawing for Manufacturing	1
7.6	Prepare the process planning chart	1
8	**Tool cost estimation**	
8.1	Weight of each element of tool and its raw material cost	2
8.2	Rate for each machining process (As per the process planning sheet)	
8.3	Brought elements of blanking tool	
8.4	Assembly, Trial & Inspection cost	
8.5	Overhead cost & profit	
9	**Inspection, trials and Trouble shooting**	
9.1	checklist for tool in static condition	1
9.2	checklist for tool in Dynamic condition	
9.3	general inspection methods	
9.4	Specific inspection methods (Panel checker/acceptance gauge)	
10	**Tube bending process**	
10.1	Types of tube bending operation - Compression Bending, Rotary Draw Bending, Press Bending, Roll Bending, Single or double bend, 3D Bend, Tube on Tube bend.	1
10.2	Tube bending related to shapes & size -Round, Rectangular & Square, Materials used in tube bending parts.	1
11	**Equipments of Tube bending**	
11.1	Conventional type pipe bending machine - clamp - wiper shoe - Bend form – Mandrel, Single axis pipe bending machine, 3 axis & 5 axis pipe bending machine.	1
12	**Cost drivers to decide the cost of tube bend part**	
12.1	Effects of Raw Material on the cost of tube bend part-Case Studies.	1
12.2	Effects of the pipe process on the cost of tube bend part-	1

S.No	Topic	No. of Lectures
	Case Studies.	
12.3	Effects of types of tools on the cost of tube bend part-Case Studies.	1
12.4	Effects of the layout for bending on the cost of tube bend part-Case Studies.	1
12.5	Effects of the Volume of Components on the cost of tube bend part-Case Studies.	1
12.6	Effects of the dimensional accuracy of Parts on the cost of tube bend part-Case Studies.	1
	Total	**45**

Course Designer:

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CURRICULUM AND DETAILED SYLLABI

FOR

GENERAL ELECTIVE SUBJECT
FOR B.E/B.TECH. PROGRAMME

GGE AUTOMOTIVE ENGINEERING

FOR THE STUDENTS ADMITTED FROM THE
ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING
(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

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Sub Code	Lectures	Tutorial	Practical	Credit
GGE	3	0	-	**3**

GGE Automotive Engineering 3:0

Preamble: Automotive engineering is the branch of vehicle engineering, incorporating elements of mechanical, electrical, electronic and safety engineering as applied to the design, manufacture and operation of motorcycles, cars, buses and trucks and their respective engineering subsystems.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of Mathematics, Science and Engineering
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems
c. Graduates will develop confidence for self education and ability for life-long learning

Competencies: At the end of the course the student should be able to

1. Explain the constructional features of chassis system.
2. Analyze the various layouts by applying the principles of mobility mechanics.
3. Analyze the different configurations of I.C.Engines by applying the principles of engine kinematics.
4. Explain the transmission system of an automobile.
5. Explain the electrical systems in an automobile.

Assessment pattern:

S.No	Bloom's Category	Test 1	Test 2	Test 3	End semester examination
1.	Remember	20	20	20	20
2.	Understand	40	40	40	40
3.	Apply	30	30	30	30
4.	Analyze	10	10	10	10
5.	Evaluate	-	-	-	-
6.	Create	-	-	-	-

Course level learning objectives:

Remember

1. List the various components of a chassis.
2. How are clutches classified?
3. What do you mean by over steering and under steering?
4. What is the major advantage of disc brake?
5. How are brakes classified?
6. What are the battery troubles?

Understand

1. With an aid of neat sketch, explain the working principle of a multi-plate clutch.
2. Derive an expression for maximum acceleration of an automobile in terms of load reactions and vehicle dimensions.
3. Explain the construction and working of a starter motor.
4. With a neat sketch, explain the working principle of a limited slip differential in detail.
5. Explain the principle of electronic power steering system used in automobiles.
6. With a neat sketch, explain the working principle of Master cylinder in a hydraulic braking system.

Apply

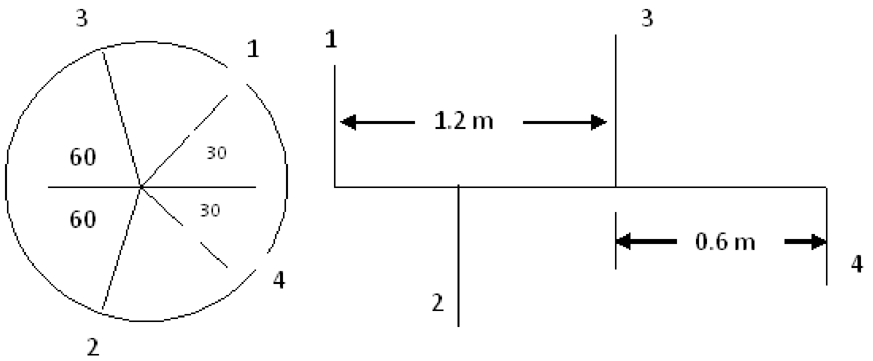
1. A motor car which weighs 17795 N including the four road wheels each of which has an effective diameter of 0.66 m, a radius of gyration of 0.28 m and a weight of 294 N has an engine developing 66 kW at 2400 RPM. The parts which rotate at engine speed weigh 1069 N, with a radius of gyration 0.115 m. The transmission efficiency is 90% and the total road and air resistance at this engine speed in top gear of 3.84:1 is 873 N on level. Calculate the acceleration in m/s^2, under those conditions and assuming the acceleration to be uniform the time required to increase the speed by 32 km/h.
2. A motor car with wheel base 2.75 m with a centre of gravity 0.85 m above the ground 1.15 m behind the front axle has a coefficient of adhesion 0.6 between the tyre and the ground. Calculate the maximum possible acceleration when the vehicle is
   (a) Driven on four wheels
   (b) Driven on the front wheels only
   (c) Driven on rear wheels only
3. A motor cycle with a rider weight 1962 N, the centre of the gravity of the machine and the rider combined being 0.6 m above the ground level when the machine is standing upright. Each road wheel has a moment of inertia of 9.8 Nm^2 and a rolling diameter 0.6 m. The engine rotates at six times the speed of

the road wheels and in the same sense. The moment of inertia of the rotating part of the engine is 1.57 Nm^2. Determine the angle of wheel necessary if the unit is travelling at the speed of 64 km/h in a curve of radius of 30.5 m.

4. A motor car engine develops maximum torque at 1900 rpm and maximum power at 3200 rpm. If the bottom gear ratio is 3:1, find the approximate ratios of speed for a gear box having 4 forward speeds when the ratios are in geometrical progression.

   If the same car at top gear has speeds of near about 48 km/h and 80 km/h at the corresponding engine speeds at maximum torque and maximum power respectively and the effective diameter of the driving wheels is 0.61 m, find a suitable back axle ratio.

5. A four cylinder is arranged as shown in figure. The reciprocating masses in planes 1 and 4 are each 100 kg and in planes 2 and 3 are 173 kg each. If the crank radius is 0.3 m, the length of the connecting rod is 1.2 m and the speed 120 rpm, determine secondary forces and couples.



6. An I.C.Engine runs at 1500 rpm. The length of the connecting rod is 480 mm and the crank radius is 120 mm. Determine at 25% of the outstroke,
   (a) The angular position of the crank
   (b) The angular velocity of the connecting rod
   (c) The linear acceleration of the piston
   (d) The angular acceleration of the connecting rod

Analyze

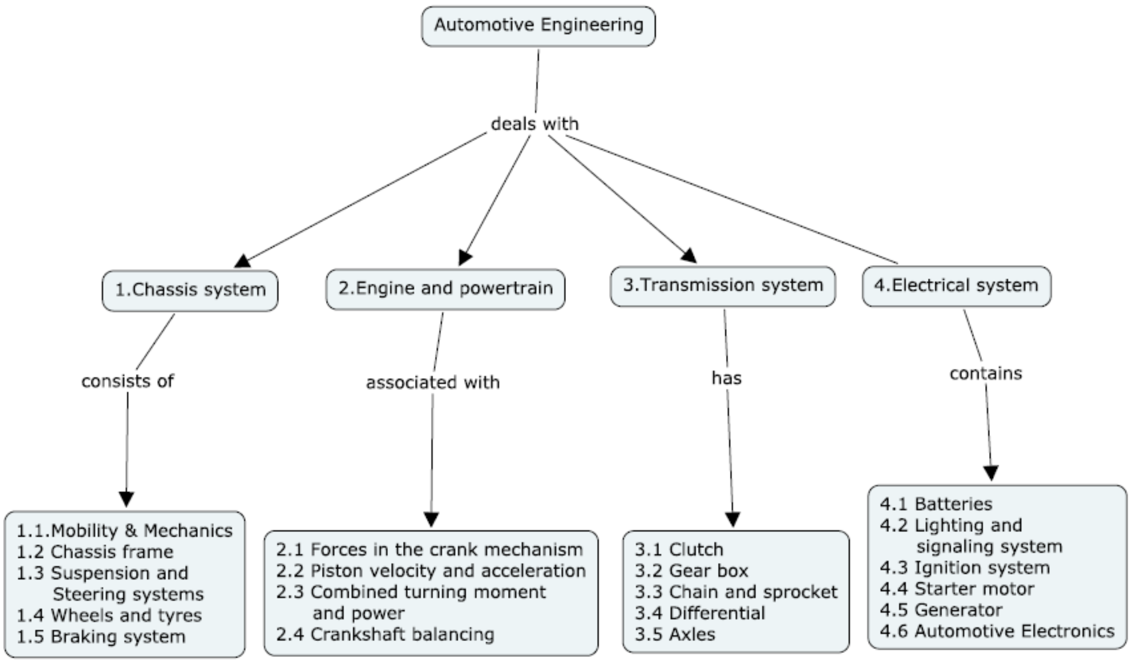
1. A bus chassis 5.2 m long consists of two longitudinal members and many cross members. The distance between front and rear axle is 3.6 m. Front axle is at 0.9 m from the front of the chassis frame. The details of the load and distances are given below.

Load	Magnitude (kN)	Distance from the front of the frame (m)
Engine weight (at front)	2	0.6
Engine weight (at rear)	25	1.8
Gear box weight	0.5	2.4
Vehicle body weight	W	3

If the reaction by front axle is 8.5 kN, determine the magnitude of vehicle body weight W, and the support reaction at B. Suggest suitable cross section to the chassis frame to account for maximum bending moment.

2. A car weighing 21336.75 N, has a static weight distribution on the axles 50:50. The wheel base is 3 m and the height of the centre of gravity above ground is 0.55 m. If the coefficient of friction on the highway is 0.6, prove that rear wheel drive offers higher gradability than front wheel drive, if engine power is not a limitation.
3. Prove that firing order of 1-2-4-3 / 1-3-4-2 is better than any other sequence as far as engine balancing is concerned.
4. A motor vehicle of weight 13341.6 N has road wheels of effective diameter 0.635 m. The engine can develop a maximum torque of 189.82 Nm and the transmission efficiency is 80%. The moment of inertia of road wheels and axles is 66.22 Nm^2 and that of the engine and flywheel are 5.89 Nm^2. Calculate the gear ratio required to give a maximum acceleration of 0.455 m/s^2 up a slope of 1 in 10 with a road resistance of 311.46 N under maximum torque condition. Also suggest gear ratios for higher gears and validate your answer.
5. Analyze the possibility of two crankshaft arrangements in two cylinder engine, and propose the better one based on engine balancing.
6. Propose vehicle design data for a passenger car for maximum vehicle weight of 15000 N and maximum vehicle speed of 150 km/h.

Concept map:



Course contents and lecture schedule:

S.No	Topics	No. of periods
1	**Chassis systems**	
1.1	**Mobility& mechanics**	
1.1.1	Introduction to mobility, Resistance and inertia, Road loads and acceleration,	2
1.1.2	Tractive and drag forces, Vehicle layout and kinematics Motorcycle physics and gyroscopic effects,	3
1.1.3	Motion & load transfer, Vehicle geometry & balance	1
1.1.4	Squat-dive and roll, Structural systems and performance	1
1.1.5	Equilibrium and inertia, Materials.	
1.2	**Chassis frame**	
1.2.1	Frame and its elements,	1
1.2.2	Loads acting on frame members	2
1.3	**Suspension & Steering system**	
1.3.1	Elements and functions, Types, Working principle, front and rear suspension	1
1.3.2	Spring rate and preload, Damper and damping	
1.3.3	Wheel rate and wheel travel, Pitch and bounce	1
1.3.4	Sprung and unsprung mass and ratio, Stabilizer	

1.3.5	Modeling & natural frequency ,Bearing types & loads- Upper & lower bracket	1
1.4	**Wheels and tyres**	
1.4.1	Type of wheels, functions & classification, Tyre fundamentals, types and characteristics	1
1.4.2	Tyre construction	1
1.4.3	Wheel balancing	
1.5	**Braking system**	
1.5.1	Braking fundamentals, classification, Drum brakes, Disc brakes	1
1.5.2	Hydraulic braking system. Major parts and their functions	1
2	**Engine and Power train**	
2.1	Forces in the crank mechanism	2
2.2	Piston velocity and acceleration	1
2.3	Combined turning moment and power	1
2.4	Crankshaft balancing	2
3	**Transmission system**	
3.1	**Clutch**	
3.1.1	Centrifugal type	1
3.1.2	Diaphragm clutch	
3.1.3	Torque converter	1
3.2	**Gear Box**	
3.2.1	Selection of gear ratio	1
3.2.2	Synchromesh gear box	1
3.2.3	Planetary gear box	1
3.2.4	Continuous Variable Transmission	
3.3	**Chain and Sprocket**	
3.3.1	Selection of speed ratio	1
3.3.2	Chain tension and slackness	
3.4	**Differential**	
3.4.1	Principle of operation	2
3.4.2	Limited slip differential	
3.4.3	Centre differential	
3.5	**Axles**	
3.5.1	Types of front and rear axles	2
3.5.2	Loads acting on front and rear axles	
3.5.3	Joints used in front axle	

4	**Electrical and Electronic Systems**	
4.1	**Automotive Batteries**	
4.1.1	Construction	1
4.1.2	Rating	1
4.1.3	Charging system	
4.2	**Lighting and signaling systems**	
4.2.1	Head light	2
4.2.2	Horns, Trafficators	
4.3	**Ignition system**	
4.3.1	Battery ignition system	1
4.3.2	Magneto ignition system	
4.3.3	Electronic ignition system	
4.4	**Starter motor**	
4.4.1	Principle of operation	1
4.4.2	construction	
4.5	**Generator**	
4.5.1	Principle of operation	1
4.5.2	Construction and characteristics	
4.6	**Automotive Electronics**	
4.6.1	Electronic fuel injection system (MPFI & CRDI)	1
4.6.2	Antilock braking system (ABS)	1
	Total	**42**

Syllabus:

Chassis systems: **Mobility& mechanics-** Introduction to mobility, Resistance and inertia, Road loads and acceleration, Tractive and drag forces, Vehicle layout and kinematics Motorcycle physics and gyroscopic effects, Motion & load transfer, Vehicle geometry and balance, Squat-dive and roll, Structural systems and performance, Equilibrium and inertia, Materials. **Chassis frame-** Frame and its elements, Loads acting on frame members. **Suspension & Steering system** - Elements and functions, Types, Working principle, front and rear suspension, Spring rate and preload- Damper and damping- Wheel rate and wheel travel- Pitch and bounce -Sprung and unsprung mass and ratio- Stabilizer- Modeling & natural frequency - Bearing types and loads- Upper & lower bracket .**Wheels and tyres** - Type of wheels-functions and classification- Tyre fundamentals, types and characteristics-tyre construction- Wheel balancing. **Braking system**- Braking fundamentals-classification- Drum brakes- Disc brakes -Hydraulic braking system, Major parts and their functions.

Engine and Power train: Engine kinematics-Forces in the crank mechanism-Piston velocity and acceleration- Combined turning moment and power. Crankshaft balancing.

Transmission system: Clutch- Centrifugal type, Diaphragm clutch, Torque converter- **Gear Box** -Selection of gear ratio- Synchromesh gear box-Planetary gear box-Continuous Variable Transmission. **Chain and Sprocket**- Selection of speed ratio-Chain tension and slackness. **Differential-**Principle of operation-Limited slip differential-Centre differential. **Axles-** Types of front and rear axles- Loads acting on front and rear axles- Joints used in front axle.

Electrical and Electronic systems: **Automotive Batteries**- Construction, Rating, Charging system- **Lighting and signaling systems-**Head light, Horns, Trafficators- **Ignition system-**Battery ignition system, Magneto ignition system, Electronic ignition system. **Starter motor-** Principle of operation, construction- **Generator/Alternator-**Principle of operation, construction, characteristics. **Automotive Electronics**- Electronic fuel injection system (MPFI & CRDI)- Antilock braking system (ABS).

Text books:

1. N.K.Giri, "**Automobile Mechanics**", Khanna Publishers, 2006.
2. Kirpal Singh, "**Automobile Engineering**", Volume-1&2, Standard Publishers Distributers, 2009.

Reference books:

1. Tony Foale, "**Motorcycle Handling and Chassis Design**", 2nd Edition, Tony Foale, 2006.
2. William Crouse, "**Automobile Engineering Series** ", McGraw-Hill, 1988.
3. Newton and Steeds, "**Motor Vehicles** ", ELBS, 1985.
4. Richard Stone and Jeffrey K. Ball, "**Automotive Engineering Fundamentals**" SAE International, 2011.
5. Joseph Heitner, "**Automotive Mechanics, Principle and practices**", East West Press, (Second Edition), 2001.

Course Designers:

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CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAMME

ONE CREDIT SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2010-2011 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

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Sub Code	Lectures	Tutorial	Practical	Credit
G1G	1	0	0	1

G1 G Mechanical Engineering Perspectives in Rocketry Systems 1:0

Preamble: Rocketry is the branch of science that deals with rockets and rocket propulsion. In order to understand the behavior of rockets it is necessary to have a basic grounding in physics, in particular some of the principles of statics and dynamics, The course provides a fundamental Knowledge in rocketry system, selection of aerospace materials, control and navigation system, usage of avionics packages.

Program Outcomes addressed:

a. An ability to apply knowledge of engineering, information technology, mathematics and science.

c. An ability to design a system or component, or process to meet stated specifications

g. An ability to function on multidisciplinary teams.

Competencies: At the end of the course the students will be able to

1. Understand dynamics of rocketry systems.
2. Select suitable aerospace materials.
3. Explain the working principles of propulsion system.
4. Understand the current avionics packages and technologies.

Assessment Pattern

1. Out of 100 marks , 50 marks (Internal) will be assignment/case study and 50 marks will be for end semester exam
2. End semester question pattern will be a combination of both multiple choice and descriptive questions.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1	Introduction	
1.1	overview of flight vehicle systems, Flight vehicle configuration, configuration management, types of flight vehicles, multistage flight vehicles, hot and cold launch, stage sizing, technologies in flight vehicle systems, launch platforms, ground system,	2
1.2	Structural Dynamics in rocket systems, fundamentals, mechanical parameters in vibration, mass spring system, quantifying vibration, signal types, resonance, isolation, base excitation, shock, isolation of vibration and shock.	3

S.No.	Topic	No. of Lectures
1.3	Aerospace Materials-types of aerospace materials, reentry environment, materials properties, airframe and motor case materials, specific modulus, wave velocity, composites, testing and qualification, QA aspects.	2
1.4	Aerospace Fasteners-Flight section joints, fasteners, classification of fasteners, methods of fastening, washers, corrosion, corrosion resistant fasteners, hydrogen embrittlement & de-embrittlement, stainless steel fasteners, fastener manufacturing, torque estimation.	2
1.5	Propulsion –Requirement- definition, types of propulsion, choosing a propulsion system, staging of flight vehicle, ordnances in flight system,	2
1.6	Control, Guidance And Navigation System -Basic rocket motion, powered phase, coasting, center of pressure and gravity, stability, gimballing, trajectory management, radars, actuators [hydraulics, electro mechanical],	2
1.7	Mechanical Aspects Of Avionics Packages-EMI/EMC requirements, battery &power systems, telemetry systems , Centre of gravity and Moment of Inertia measurements, packaging acceptance and qualification,	1
1.8	Challenges In Aerospace Technologies -ABC [Atomic Biological Chemical Weapon] systems, MIRVS[Multiple Independent Reentry Vehicle System], ENEC, thrust termination, ABMS [anti ballistic missile systems], Space Defence.	2
	Total	**16**

Course Designers:

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3. M.S.Govardhanan, govardhanans07@gmail.com

Sub Code	Lectures	Tutorial	Practical	Credit
G1H	1	0	0	1

G1H Basics of HVAC 1:0

Preamble: Heating Ventilating and Air Conditioning (HVAC) consumes nearly 25 % of the power being generated in India. Designing energy efficient HVAC system is inevitable, in order to save the energy. In addition to the text book knowledge, it is essential to expose the students and train them on the application part of HVAC as seen in the industry. When got exposed and trained students will come forward to take up HVAC for their career. They will design and develop energy efficient HVAC systems, which in turn benefit the society in energy saving aspects.

Program outcomes addressed:

a. Graduate will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
d. Graduates will demonstrate an ability to design a system, component or process as per needs and specification.

Competencies: At the end of the course students will be able to

1. Independently assess the HVAC requirements of a project.
2. Recommend the most suitable HVAC system with sustainability in focus.
3. Find out ways and means to reduce energy at design level.
4. Plan for proper Installation and Maintenance activity.

Assessment pattern:

1. Out of 100 marks, 50 marks (Internal) will be for assignment/case study on estimating heat load for given space.
2. End semester question paper will be combination of Short questions descriptive and problematic questions.

Course content and lecture schedule:

S.No	Topic	No of Lectures
1,1	Definition of HVAC, Market size, Growth, Penetration, opportunities, challenges, definition of Comfort, Benefits of air-conditioning, Difference between comfort / process air-conditioning., Energy usage of HVAC, Scope of Energy saving, HVAC and environment, Greenhouse effect, Global warming, Ozone Layer Depletion,	1
1.2	Basic HVAC terminologies- Temperature, Heat, Types of Heat, Modes of Heat transfer, Tons of Refrigeration, BTU/Hr / Dry	1

S.No	Topic	No of Lectures
	bulb, Wet Bulb, Relative humidity, Specific Humidity, Psychrometry, Change of phase,	
1.3	Refrigeration cycle, Components of Refrigeration Cycle. Different types of Compressors,	1
1.4	Comfort conditions, Different types of Heat Load, Building Survey, Sources of Heat, SHGC and U value of Glass, Factors to be considered before deciding on AC	1
1.5	Life Cycle Cost, Total cost of ownership, Star Rating of Air-conditioners, Energy Conservation Building Codes, Refrigerant Phase out Schedule, Indoor Air Quality – IAQ, Sick Building Syndrome – SBS, ASHRAE standard 62.1, Green Buildings, LEED Certification,	1
1.6	Categories of HVAC System like Unitary, Semi-Central, Central HVAC and its Selection, Air-Cooled Systems – Water Cooled Systems	1
1.7	Variable Refrigerant Flow Systems – VRF, Vapour Absorption Systems, Air Distribution System and its Design	1
1.8	Study of Cost verses Benefit of different systems, Installation procedures of different types of HVAC System, Electrical Safety Precautions, Different types of Maintenance activities, Safety at Work.	1
2.1	Detailed heat load estimation as done in industry	4
2.2	Estimation heat load by students for different types of building	4
	Total	**16**

Course Designers:

1. D.Balaji shreesrb@yahoo.com
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3. G.Kumaraguruparan gkgmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
G1K	-	-	-	1

G1K Nuclear Engineering - Basics 1:0

Preamble: Nuclear engineering is the branch of science that deals with theory of fission and fusion, nuclear reactors and preventive maintenance such as protection from radiation. In order to understand the construction and operation of nuclear reactors, it is necessary to have a basic grounding in atomic physics. The course provides a fundamental knowledge in nuclear power generation and nuclear power plant operation.

Program outcomes addressed:

a. Graduates will demonstrate knowledge of mathematics, science and engineering.
b. Graduates will demonstrate an ability to identify, formulate and solve engineering problems.
c. Graduates will demonstrate skills to use modern engineering tools, software's and equipment to analyze problems.

Competencies: At the end of the course the students will be able to

1. Explain theory of fission and fusion
2. Explain nuclear plant description
3. Explain the working of nuclear power plants
4. Explain prevention of radiation from nuclear power plants

Assessment pattern:

1. Out of 100 marks, 50 marks (Internal) will be for assignments / seminars with presentation and 50 marks will be for end semester exam.
2. End semester question pattern will be a combination of both multiple choice and descriptive questions.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1	**Introduction**	
1.1	National and international scenario on nuclear power	1
1.2	Atoms, electrons, Protons, Nucleus, Neutrons, Scattering, Thermal neutrons, controlled and uncontrolled chain reactions	1
1.3	Fission of nucleus, basis for power generation, future power generation by fusion	2

2	**Nuclear power generating systems**	
2.1	Boiling water reactors (BWR), Pressurized water reactors (PWR), Pressurized heavy water reactors (PHWR)	1
2.2	Gas cooled thermal reactors (HTGR), Liquid metal cooled fast breed reactor (LMFBR), Light water breed reactor (LWBR)	
3	**Description of plant**	
3.1	Site characteristics, structures, components, equipment & systems, reactor	1
3.2	Coolant systems, safety features, instrumentation & controls	1
3.3	Electric power systems, auxiliary systems, radiative waste management	1
4	**Radiation Protection**	
4.1	History, units of radiation (Roentgen, exposure rate, imparted energy, Rad, Rem), Effects on the human cell	2
4.2	Radiation protection and dose limiting recommendation	1
5	**World's Nuclear reactors and plant operation**	
5.1	Nuclear plants in Limerick, south Texas and Kudan Kulam	1
5.2	Accidents occurred in three mile island plant, Chernobile and Fukushima plants and the variable causes (cooling water loss, control rod drive failure and insufficient training of operating personnel)	1
5.3	Plant operation in i) start-up (cold, hot and normal) ii) shut down (unloading of turbine-generator, maintain steam generator level, Boron dilution)	1
5.4	Preventive maintenance and corrective maintenance	1
5.5	Safety Standards for Nuclear power plant	1
	Total	**16**

Course Designer:

1. Prof.C.Kothandaraman
2. A. Samuel Raja

Sub Code	Lectures	Tutorial	Practical	Credit
G1L	1	0	0	1

G1L Industrial Hydraulics 1:0

Preamble: The use of hydraulics for power and motion control has been increasing dramatically in the fields of industrial automation, aviation, automotive, defense, construction and material handling. Unlike many mechanical systems, hydraulic systems can deliver a brute force with pin point accuracy in a split second – and all at the same time. With the advent of proportional and servo hydraulic technology, PLCs and PCs have started to interact with hydraulic actuators directly delivering the ultimate in precision and power transmission. Today industrial hydraulics is an important and matured topic, without which any discussion on power and motion control is incomplete.

This course attempts to expose the students to the basics of industrial hydraulics, fundamental design aspects, associated components, contemporary technologies in the field and application areas.

Program outcomes addressed:

a An ability to apply knowledge of engineering, information technology, mathematics and science.

c. An ability to design a system or component, or process to meet stated specifications.

g. An ability to function on multidisciplinary teams.

Competencies: At the end of the course the students will be able to

1. Explain the basics of hydraulics system.
2. Select suitable Hydraulics components for the given Industrial application.
3. Explain the working principles of Hydraulic circuits.
4. Develop the hydraulics circuits for the given application
5. Understand the approach to logical troubleshooting.

Assessment pattern:

1. Out of 100 marks , 50 marks (Internal) will be for assignment and 50 marks will be for end semester exam
2. End semester question pattern will be a combination of both multiple choice and descriptive questions.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1.1	Introduction- Types of fluid power systems- Method of power transmission Application areas - Advantages of fluid power- Limitations of Fluid power	1
1.2	Viscosity- Corrosiveness - Pour point -Flash and Fire Points – Demulsibility- Oxidation Stability- Types of Hydraulic Fluid - Mineral Oils- Water Glycols Phosphate esters	1
1.3	Standards for representing fluid power components- Basic Symbol Types -Energy Transmission- Pumps –Motors- Directional Control Valves-Pressure Valves-Flow control Valves- Actuation Methods-Measuring devices-Cylinders- Energy Storage devices- Hybrid or combined circuits-Servo / Proportional valves-Accessories	1
1.4	Reservoir-Pump - Prime Mover-Safety / Control Valves- Measuring gauges- Actuators- Function of reservoir- Atmospheric Vented-Pressurized-Stationary –Mobile Typical Cross section	1
1.5	Pump-Positive Displacement Vs Non Positive Displacement type-Gear-Vane-Piston-Screw-Internal Gear Pump -Principle / Construction –Operation--Advantages / Limitations-Flow , Pressure range-Cost and Brands --Preferred Application Areas - External Gear Pump , Vane Pump ,Axial Piston Pump ,Radial Piston Pump ,Screw pump-	1
1.6	Control valves for hydraulics –function types – flow / pressure / direction; Actuation types – mechanical / electrical / pneumatic –design, working and use of variants in each function type.	1
1.7	Proportional and servo technology – advantages - differences between conventional valves / proportional valves / servo valves – typical application areas.	1
1.8	Fluid contamination control – importance of clean fluid – key factor affecting reliability - evaluating cleanliness level – Setting target cleanliness levels – design philosophies to achieve and maintain the set target levels – filter types, element designs and criteria to select like Beta ratio.	2

S.No.	Topic	No. of Lectures
1.9	Mobile hydraulics – Special requirements – Reservoir design – Types of control valves – Hydraulic Power steering – Construction equipments.	1
2.0	Selection criteria for components for hydraulic circuits – Application based – Cost based and working environment based.	1
2.1	Complete design of a typical industrial hydraulic system for an automatic drilling machine – define requirement and constraints – arrive at required power – design the circuit – choose the Bill Of Material – finalize design.	2
2.2	Hydraulics controlled by PLC / PC – Typical set up details – Types of sensors – Solenoids – Preferred software platforms for control coding	1
2.3	Troubleshooting hydraulics – standard tools – logical approach – preventive maintenance	2
	Total	**16**

Course Designers:

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2. M.Elango, Assistant Professor , TCE, Madurai, memech@tce.edu

CURRICULUM AND DETAILED SYLLABI

FOR

B.E DEGREE (Mechanical Engineering) PROGRAMME

ONE CREDIT COURSES

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

(A Government Aided ISO 9001-2008 certified
Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU

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LIST OF ONE CREDIT COURSES

G1A	Introduction to Value Engineering
G1B	Six Sigma
G1C	Geometric Dimensioning and Tolerancing
G1D	Product Life Cycle Management
G1E	Welding Technology
G1F	Project Management Fundamentals
G1G	Mechanical Engineering Perspectives in Rocketry Systems
G1H	Basics of HVAC
G1K	Nuclear Engineering – Basics
G1L	Industrial Hydraulics
G1M	Non Destructive Testing
G1N	Gas Turbine Engines

ONE credit courses passed during 44th to 46th Academic Council Meeting

G1A	Introduction to Value Engineering
G1B	Six Sigma
G1C	Geometric Dimensioning and Tolerancing
G1D	Product Life Cycle Management
G1E	Welding Technology
G1F	Project Management Fundamentals

One Credit courses passed during 47th Academic Council Meeting

G1G	Mechanical Engineering Perspectives in Rocketry Systems
G1H	Basics of HVAC
G1K	Nuclear Engineering – Basics
G1L	Industrial Hydraulics

One Credit courses to be passed on 48th Academic Council Meeting

G1M	Non Destructive Testing
G1N	Gas Turbine Engines

Sub Code	Lectures	Tutorial	Practical	Credit
G1M	1	0	0	1

G1M NON DESTRUCTIVE TESTING 1:0

Preamble: Non destructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or assemblies for discontinuities, or differences in characteristics without destroying the serviceability of the part or system. In other words, when the inspection or test is completed the part can still be used. Today modern nondestructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and reliability, to control manufacturing processes, lower production costs and to maintain a uniform quality level. During construction, NDT is used to ensure the quality of materials and joining processes during the fabrication and erection phases, and in-service NDT inspections are used to ensure that the products in use continue to have the integrity necessary to ensure their usefulness and the safety of the public. Common NDT methods include ultrasonic, magnetic-particle, liquid penetrant, radiographic, remote visual inspection (RVI), eddy-current testing, and low coherence interferometry. This course aim to provide knowledge on the working, types, advantages, limitations, and applications of various NDT techniques.

Program Outcomes Addressed:

a. An ability to apply knowledge of engineering, information technology, mathematics and science

b. An ability to design and conduct experiments, as well as to analyze and interpret data

e. An ability to use techniques, skills, and modern engineering tools to implement and organize engineering works under given constraints

Competencies: At the end of the course students will be able to

1. Explain basic concepts of Non Destructive Testing (NDT).
2. Explain the various NDT methods and their principles, testing techniques, advantages, limitations and applications.
3. Apply the various NDT techniques like Penetrant Testing , Magnetic particle testing, Visual Testing, Radiography testing, Ultrasonic Testing.

Assessment Pattern

1. Out of 100 Marks, 50 Marks (Internal) will be for Mini project/Assignments and 50 Marks will be for End Semester Exam.

2. End Semester Question pattern will be a combination of both multiple choice and descriptive questions.

Sl.No.	**Bloom's Category**	**End Semester Examination**
1	Remember	20
2	Understand	40
3	Apply	40
4	Analyze	-
5	Evaluate	-
6	Create	-

Syllabus

Introduction to NDT - Requirement for NDT - Basic NDT methods, Surface NDT methods – Penetrant Testing – Principle – consumables – testing techniques – advantages –Limitations - Application – Codes – Standards, Practicals – PT, Magnetic particle testing - Principle – consumables – testing techniques – advantages – Limitations - Application – Codes, Practicals – MT, Surface NDT method – Visual Testing – principle – testing Techniques – advantage – limitation – applications – Application – Codes, Practicals – VT, Radiography testing – Principle – equipment, Radiography testing – Consumables- Techniques, Radiography testing – Film interpretation, Safety- codes – standards, Radiography testing – Film interpretation – practicals, Ultrasonic Testing – principle – equipment, Ultrasonic Testing - techniques, Ultrasonic Thickness measurement, Through transmission testing technique, Resonance testing, Ultrasonic Testing practicals –Thickness measurement, weld testing

Text Book

1. R Halmshaw, **"Introduction to the Non-Destructive Testing of Welded Joints"**- 2nd Edition ,Woodhead Publishing, 1997.
2. Little R.L, "**Welding and Welding Technology**" - Tata McGraw Hill Publishing Ltd, New Delhi, 1989.
3. Parmer R.S, **"Welding Engineering and Technology",** 2nd Edition, Khanna publishers, Delhi, 2010.

Reference Books:

1. Davies, A.C, **"Welding"**, 10th Edition, Cambridge University press, 1996.
2. Howard B. Cary, Scott Helzer "**Modern Welding Technology**", 6th Edition, Prentice Hall , 2005.
3. **ASM metals handbook** Vol 17: Non Destructive testing.
4. **ASME Sec V** - Non - Destructive Testing.
5. **ASTM standards**
    a. E 94, Standard Guide for Radiographic Examination.
    b. E 142, Standard Method for Controlling Quality of Radiographic Testing.
    c. E 164, Standard Practice for Ultrasonic Contact Examination of Weldments.
    d. E 165, Standard Test Method for Liquid Penetrant Examination.
    e. E 1444, Standard Practice for Magnetic Particle Examination.
6. AWS Welding Handbook**, Volume 1, Welding Science & Technology, American Welding Society, 2001.**
7. AWS Welding Handbook**, Volume 2, Welding Processes, Part 1**, **American Welding Society, 2004.**
8. AWS Welding Handbook**, Volume 3, Welding Processes, Part 2, American Welding Society, 2004.**

Course contents and Lecture schedule

S.No	Topics	No. of Lectures
1	Introduction to NDT - Requirement for NDT - Basic NDT methods	1
1.1	Surface NDT methods – Penetrant Testing (PT) – Principle – consumables – testing techniques – advantages –Limitations - Application – Codes - Standards	2
1.2	Magnetic particle testing (MT) - Principle – consumables – testing techniques – advantages –Limitations - Application – Codes	2
1.3	Surface NDT method – Visual Testing (VT) – principle – testing Techniques – advantage – limitation – applications – Application – Codes	2
1.4	Radiography testing (RT) – Principle – equipment	2
1.4.1	Radiography testing – Consumables- Techniques	
1.4.2	Radiography testing – Film interpretation, Safety- codes - standards	
1.4.3	Radiography testing – Film interpretation	
1.5	Ultrasonic Testing (UT) – principle - equipment	2
1.5.1	Ultrasonic Testing - techniques	

S.No	Topics	No. of Lectures
1.5.2	Ultrasonic Thickness measurement, Through transmission testing technique, Resonance testing	
2.0	Practical Sessions-PT,MT, VT, RT, UT (Thickness measurement , weld testing)	5
	Total	**16**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
G1N	1	0	0	1

G1N GAS TURBINE ENGINES 1:0

Preamble: The course provides a fundamental knowledge in gas turbine system, different types of gas turbine engines, its components and sub systems including the starting and fuel control systems. The course also deals with the airframe-engine integrations aspects.

Program Outcomes addressed:

a. An ability to apply knowledge of engineering, information technology, mathematics and science.

c. An ability to design a system or component, or process to meet stated specifications

g. An ability to function on multidisciplinary teams.

Competencies: At the end of the course the students will be able to

1 Understand the working principle and purpose of jet propulsion.

2. Select suitable engine cycle parameters for different aircraft applications like civil, military, business jets etc.
3. Understand the different components and sub systems of the gas turbine engine.
4. Understand the fundamental digital fuel control system of the aero engine.

Assessment Pattern

1. Out of 100 marks , 50 marks (Internal) will be assignment/case study and 50 marks will be for end semester exam
2. End semester question pattern will be a combination of both multiple choice and descriptive questions.

Course contents and lecture schedule:

S.No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Principle of operation of Gas turbine engine	1
1.2	Principle and purpose of jet propulsion, Propulsion system classification	1
1.3	Gas turbine engine Components and Sub systems	1
1.4	Single and twin spool gas turbine engines, different types of Gas turbine engines	1

S.No.	Topic	No. of Lectures
1.5	Overview of Fuel control system, Starting and Ignition system	1
1.6	Engine testing and qualification	1
2	**Gas turbine engine components**	
2.1	Compressors, Combustors, Turbine	3
2.2	Exhaust system and Afterburner	2
3	**Full authority Digital engine Control (FADEC) system**	
3.1	Control system overview, Advantaged of FADEC system over Hydro mechanical system	1
3.2	Digital Electronic Control Unit(DECU) design features, Control laws, Control system testing aspects	1
4	**Airframe- Engine integration**	
4.1	Integration aspects	1
4.2	Installation effects and installed engine performance	1
	Total	**16**

Course Designers:

1. Sundararajan V,
   Former Director GTRE and presently HEAD, Technology Excellence Group, QuEST Global Services, Bangalore. sundararajan.v@quest-global.com
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