CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

CATEGORIZATION OF COURSES
AND
FIRST SEMESTER COURSES

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2018-2019 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015, TAMILNADU
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DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

"Be a globally renowned school of engineering in mechanical sciences"

Mission:

As a department, we are committed to

- Develop ethical and competent engineers by synergizing world class teaching, learning and research
- Establish state-of-art laboratories and to provide consultancy services to fulfill the expectations of industry and needs of the society
- Inculcate entrepreneurial qualities for creating, developing and managing global engineering ventures
- Motivate the students to pursue higher studies and research

Programme Outcomes (POs) of M.E. (Manufacturing Engineering)

Post Graduating Students of M.E. Manufacturing Engineering programme will have

PO No.	Graduate Attributes	Programme Outcomes
PO1	Scholarship of Knowledge	Acquire in-depth knowledge with wider and global perspective with an ability to discriminate, evaluate, analyse and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge in Manufacturing Engineering.
PO2	Critical Thinking	Analyse complex manufacturing engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.
PO3	Problem Solving	Think laterally and originally, conceptualize and solve manufacturing engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.
PO4	Research Skill	Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/ technological knowledge in manufacturing engineering.
PO5	Usage of modern tools	Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex manufacturing engineering activities with an understanding of the limitations.
PO6	Collaborative and Multidisciplinary work	Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.
PO7	Project Management and Finance	Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in manufacturing engineering and multidisciplinary environments after considering the economical and financial factors.
PO8	Communication	Communicate with the engineering community, and with society at large, regarding complex manufacturing engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make

PO No.	Graduate Attributes	Programme Outcomes
		effective presentations, and give and receive clear instructions.
PO9	Life-long Learning	Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.
PO10	Ethical Practices and Social Responsibility	Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.
PO11	Independent and Reflective Learning	Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI-625015.

Department of Mechanical Engineering

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses					Theory cum practical	Practical/ Project	
4th (15)							18MG480 Dissertation Phase – II **15**	
3rd (15)	18MGPX0 Programme Elective-V **(PE)** **3**	-	-	-	18GPX0 Open Elective **(OE)** **2**	-	18MG380 Dissertation Phase – I **10**	
2nd (21)	18MG210 Tool Design Engineering **(PC)** **3**	18MGPX0 Programme Elective-II **(PE)** **3**	18MGPX0 Programme Elective-III **(PE)** **3**	18MGPX0 Programme Elective-IV **(PE)** **3**	18PG250 Research Methodology and IPR **(CC)** **2**	18MG260 CNC Machine tool Technology **(PC)** **3**	18MG270 Automation Laboratory **(CL)** **2**	18MG280 Mini Project **2**
1st (17)	18MG110 Computational Methods in Engineering **(FC)** **3**	18MG120 Mechanical Behaviour of Materials **(PC)** **3**	18MG130 Industrial Automation **(PC)** **3**	18MGPX0 Programme Elective-I **(PE)** **3**	-	18MG160 Product Design and development **(PC)** **3**	18MG170 Computer Aided Engineering Laboratory **(CL)** **2**	

Total Credits to be earned for the award of degree: 68

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

COURSES OF STUDY

(For the candidates admitted from 2018-2019 onwards)

FIRST SEMESTER

Course code	Name of the course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
18MG110	Computational Methods in Engineering	FC	3	0	-	3
18MG120	Mechanical Behaviour of Materials	PC	3	0	-	3
18MG130	Industrial Automation	PC	3	0	-	3
18MGPX0	Program Elective I	PE	3	0	-	3
THEORY CUM PRACTICAL						
18MG160	Product Design and Development	PC	2	0	2	3
PRACTICAL						
18MG170	Computer Aided Engineering Laboratory	PC	-	-	4	2
Total						**17**

FC- Foundation Core; PC- Programme Core; PE-Programme Elective; OE-Open Elective; AC-Audit Course; CC- Common Core

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

FIRST SEMESTER

S.No.	Course Code	Name of the Course	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	18MG110	Computational Methods in Engineering	3	50	50	100	25	50
2	18MG120	Mechanical Behaviour of Materials	3	50	50	100	25	50
3	18MG130	Industrial Automation	3	50	50	100	25	50
3	18MGPX0	Program Elective I	3	50	50	100	25	50
4	*18MG160	Product Design and Development	3	50	50	100	25	50
PRACTICAL								
8	18MG170	Computer Aided Engineering Laboratory	3	50	50	100	25	50

* Theory Cum Practical Course

** 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.

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

CATEGORIZATION OF COURSES
(Choice Based Credit System)

Sl. No	Course Code	Name of the Course	Category	Credit
		Programme Core		
1.	18MG110	Computational Methods in Engineering	PC	3
2.	18MG120	Mechanical Behaviour of Materials	PC	3
3.	18MG130	Industrial Automation	PC	3
4.	18MG210	Tool Design Engineering	PC	3
		Common Core		
5.	18PG250	Research Methodology and IPR	CC	2
		Theory cum Practical		
6.	18MG160	Product Design and Development	PC	3
7.	18MG260	CNC Machine Tool Technology	PC	3
		Programme Practical		
8.	18MG170	Computer Aided Engineering Laboratory	PC	2
9.	18MG270	Automation Laboratory	PC	2
10.	18MG280	**Mini Project**	PC	2
11.	18MG380	**Dissertation Phase – I**	PC	10
12.	18MG480	**Dissertation Phase – II**	PC	15
		List of Programme Electives		
13.	18MGPA0	Biomaterials	PE	3
14.	18MGPB0	Composite Materials	PE	3
15.	18MGPC0	Computer Integrated Manufacturing	PE	3
16.	18MGPD0	Design for Manufacture and Assembly	PE	3
17.	18MGPE0	Fluid Power Automation	PE	3
18.	18MGPF0	Geometric Modeling	PE	3
19.	18MGPG0	Lean Manufacturing and Six Sigma	PE	3
20.	18MGPH0	Machine Vision and its applications in manufacturing	PE	3
21.	18MGPJ0	Mechanics of Metal Cutting and Metal Forming	PC	3
22.	18MGPKO	Metal Joining Engineering	PE	3
23.	18MGPL0	Micro Electro Mechanical Systems	PE	3
24.	18MGPM0	Non Destructive Evaluation	PE	3
25.	18MGPN0	Operations Management	PE	3
26.	18MGPP0	Optimization Techniques	PE	3
27.	18MGPQ0	Plant Layout and Material Handling	PE	3

Sl. No	Course Code	Name of the Course	Category	Credit
28.	18MGPR0	Quality and Reliability Engineering	PE	3
29.	18MGPS0	Rapid Prototyping	PE	3
30.	18MGPT0	Robust Design	PE	3
31.	18MGPU0	Supply Chain Management	PE	3
32.	18MGPV0	Surface engineering and coating technology	PE	3
		Open Elective Courses		
33.	18MGGA0	Advanced Finite Element Analysis	OE	2
34.	18MGGB0	Energy Management	OE	2
35.	18MGGC0	Financial Management	OE	2
		Audit Course		
36.	18MGA10	Industry 4.0	AC	0
37.	18MGA20	Computer Aided Inspection	AC	0
38.	18MGA30	Sensors in Automation	AC	0
39.	18MGA40	English for Research paper writing	AC	0
40.	18MGA50	Pedagogical studies	AC	0
41.	18MGA60	Learning Assurance	AC	0
42.	18MGA70	Personality development through life enlighten skills	AC	0
43.	18MGA80	Entrepreneurship Development	AC	0

List of Electives

S.No	Course Code	List of Programme Electives
1.	18MGPA0	Biomaterials
2.	18MGPC0	Computer Integrated Manufacturing
3.	18MGPN0	Operations Management
4.	18MGPP0	Optimization Techniques
5.	18MGPU0	Supply Chain Management
6.	18MGPV0	Surface engineering and coating technology

18MG110	COMPUTATIONAL METHODS IN ENGINEERING	Category	L	T	P	Credit
		FC	3	0	0	3

Preamble

The course aims at giving adequate exposure in the theory of Initial Value Problems (IVPs) and Boundary Value Problems(BVPs) in Ordinary Differential Equations (ODEs) and Partial Differential Equations(PDEs) and various methods (Computational methods) for getting both Analytical as well as Numerical solutions for them

Prerequisite

- Numerical Methods

Course Outcomes

On successful completion of the course, students will be able to

CO. No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1.	Compute Numeric/ Approximate solutions for BVPs using several weighted residual methods	Apply	70	60
CO2.	Solve PDEs numerically using the available familiar methods	Apply	70	60
CO3.	Solve the special type of PDEs using some methods involving implicit and explicit schemes	Apply	70	60
CO4.	Compute the solution for the IVPs using finite element methods and grasp the advantages of them over the other traditional methods	Apply	70	60
CO5.	Interpret the theory of Boundary Value Problems arising in the study of engineering problems and their applications	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	M	M							
CO2	S	M	M	M							
CO3	S	M	M	M							
CO4	S	M	M	M							
CO5	S	M	M	M							

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	0
Understand	30	30	30	30
Apply	60	60	60	70
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Describe Hermitian method of solving a BVP.
2. Solve $y''+3y'+2y=x, \mathrm{y}(0)=1, \mathrm{y}(1)=0$ by using Collocation methods.
3. Solve $y''+xy=2, y(0)=0 \text{ and } \mathrm{y}'(1)=0$ by using Galerkin method.

Course Outcome 2 (CO2):

1. Classify the following equation: $(1+x^2)f_{xx}+(5+2x^2)f_{xy}+(4+x^2)f_{yy}=2\sin(x+y).$
2. Solve $16u_{xx}-u_{tt}=0$ for u at the pivotal points given

   $u(0,t)=u(5,t)=0, u_t(x.0)=0 \text{ and } \mathrm{u(x,0)}=x^2(5-\mathrm{x}) \text{ for one half peroid of vibration}.$
3. *Solve* $u_{xx}+u_{yy}=0$ over the square mesh of side 4 units satisfying the following boundary conditions:

   (i). $u(0,y)=0 \text{ for } 0\le \mathrm{y}\le 4$ (ii). $u(4,y)=12+y \text{ for } 0\le \mathrm{y}\le 4$

   (iii) $u(x,0)=3x \text{ for } 0\le \mathrm{x}\le 4$ (iv). $u(x,4)=x^2 \text{ for } 0\le \mathrm{x}\le 4$

Course Outcome 3 (CO3):

1. Write the finite difference approximation U_{xx} , $\mathrm{U_{yy}}$ to partial derivatives.
2. Obtain finite difference approximation for $\frac{\partial^2 u}{\partial x^2}(x+2h, y-5k)$.
3. Solve $\Delta^2 u=0$ given $u(0,y)=0$, $\mathrm{u(4,y)}=16\mathrm{y} \text{ for } 0<\mathrm{y}<4 \text{ and}$ $u(x,0)=0, \mathrm{u(x,4)}=\mathrm{x}^3 \text{ for } 0<\mathrm{x}<4$ by relaxation method dividing the square plate with 16 square meshes of side 1 unit.

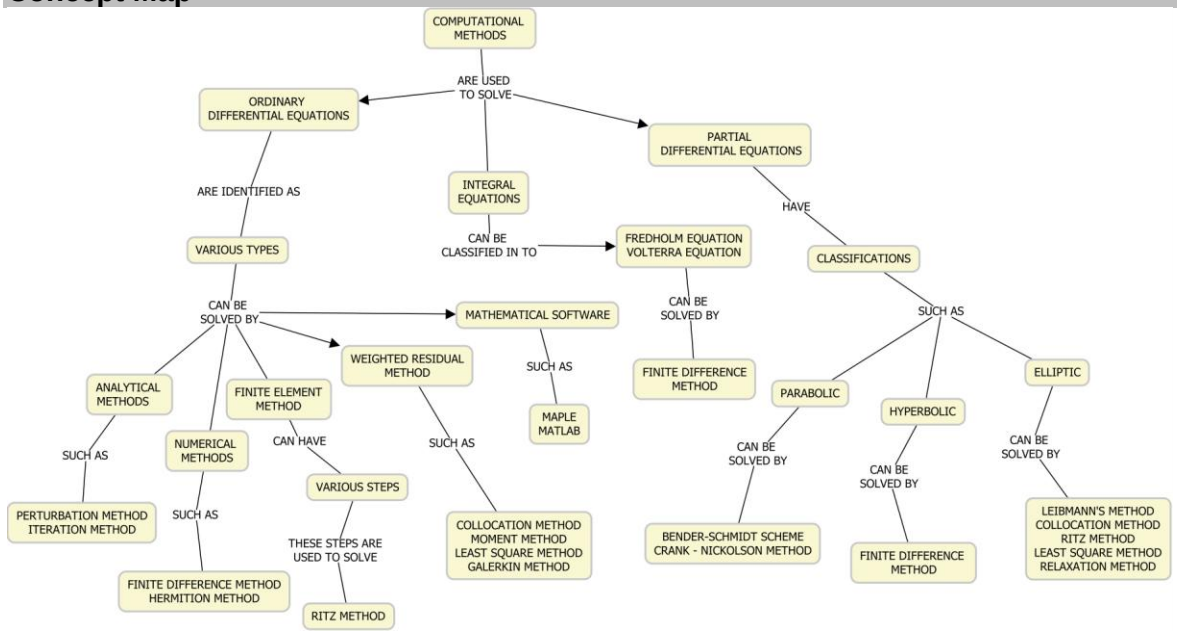
Course Outcome 4 (CO4):

1. State the advantages of finite element method.
2. Using Ritz finite element method solve $y''=-2 \text{ with } \mathrm{y}(0)=0 \text{ and } \mathrm{y}(1)=1$ by taking nodes at x=0.3 & x=0.5
3. State the fredholm Integral equation of second kind. Using the method of successive approximation, solve the integral equation $y(x)=\lambda\int_0^1 x(t)\,y(t)\,dt+1$

Course Outcome 5 (CO5):

1. Define Boundary value problem and name any four methods to solve the Boundary value problems.
2. Solve $y''+(1+\varepsilon x^2)y+1=0, \text{given } \mathrm{y}(\pm 1)=0$ by perturbation method.

Concept Map



Syllabus

Boundary value problems: Boundary value problems in ODE - Different kinds of BVP Analytical method - perturbation method - Iteration method- Numerical Methods- Hermitian method , Finite difference method – Mathematical Foundation of the Finite element method - Rayleigh-Ritz finite element method ,Weighted residual methods- collocation method, moment method, least square method, Galerkin method.

Partial Differential Equations: Classification of PDE – Solution to Parabolic equation - Bender Schmidt scheme, Crank Nicholson method - Solution to Elliptic equation- Leibmann's iterative scheme - collocation method - least square method - Relaxation method - Solution to Hyperbolic equations .

Integral Equations: Classification – Solution to Integral equations by iteration and finite difference methods.

Solution through software (Hands on practice only): Introduction to software - Solution of Boundary Value Problems from Ordinary Differential Equations through Maple and Matlab- Solution of Boundary Value Problems from Partial Differential Equations through Maple Matlab, and Scilab

Reference Book

1. M. K. Jain*, S. R. K. Iyengar* and R. K. Jain*, Numerical Methods for Scientific and Engineering Computations, 5th Edition, New Age International Publishers, 2008.
2. Collatz , " The Numerical Treatment of Differential Equations " , Springer Verlog, 1966.
3. S.S. Sastry ,"Introductory Methods of Numerical Analysis", 5th Edition , Prentice Hall of India, 2012..
4. Robert J.Schilling, Sandra.L Harris, "Applied Numerical Methods for Engineers using Matlab and C ", Thomson books / Cole , 2000.
5. M. Asghar Bhatti , " Fundamental Finite Element Analysis and Applications with Mathematica and MATLAB Computations", John Wiley & Sons, Inc, 2017.

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1	**Boundary value problems**	
1.1	Boundary value problems in ODE and their various types.	1
1.2	Analytical methods	
1.2.1	Perturbation method	2
1.2.2	Iteration method	2
1.3	Numerical methods	
1.3.1	Finite difference method	2
1.3.2	Hermitian method	2
1.4	Finite element method	
1.4.1	Introduction	1
1.4.2	Rayleigh Ritz's finite element method	2
1.5	weighted residual methods	
1.5.1	Introduction	1
1.5.2	collocation method	2
1.5.3	moment method	1
1.5.4	least square method	1
1.5.5	Galerkin method.	1
2	**Partial Differential Equations**	
2.1	Introduction and Classification	1
2.2	Parabolic equations	
2.2.1	Bender Schmidt scheme	1
2.2.2	Crank – Nicholson method	2
2.3	Elliptic equations	
2.3.1	Leibmann's iterative scheme.	2
2.3.2	collocation method	2
2.3.3	least square method	1
2.3.4	Relaxation method.	2
2.4	Hyperbolic equations	2
3	**Integral Equations**	
3.1	Classification of integral Equations	1
3.2	Solution by Finite difference method	2
4	**Solution through software (Hands on practice only)**	
4.1	Introduction to software	1
4.2	Solution of BVPs from ODEs through Maple and Matlab	1
4.3	Solution of BVPs from PDEs through Maple and Matlab	1
	Total	**36**

Course Designer

1. Dr. A . Anitha anithavalli@tce.edu

18MG120 MECHANICAL BEHAVIOUR OF MATERIALS

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

Mechanical engineers are often called on to design alloys having high strengths yet some ductility and toughness; ordinarily, ductility is sacrificed when an alloy is strengthened. Since hardness and strength are related to the ease with which plastic deformation can be made to occur, by reducing the mobility of dislocations, the mechanical strength may be enhanced. All strengthening mechanisms operate on the principle of restricting or hindering dislocation motion making a material harder and stronger. The design of a component or structure often calls upon the engineer to minimize the possibility of failure. Thus, it is important to understand the mechanics of the various failure modes i.e., fatigue, creep and fracture..

The objective of this course is to impart knowledge in the fields of Strengthening Mechanisms, Fatigue, Creep and Fracture of metals.

Prerequisite

- Nil

Course Outcomes

On successful completion of the course, students will be able to

Co. No.	Course Outcome	Blooms Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Employ the various strengthening mechanisms.	Apply	70	60
CO2	Illustrate the fatigue properties of Metals	Apply	70	60
CO3	Describe the creep mechanisms	Understand	80	70
CO4	Illustrate the fracture and fracture mechanics of metals.	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	S	M	L	L							
CO 2	S	M	L	L							
CO 3	M	L									
CO 4	S	M	L	L							

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the various strengthening mechanisms in metals.
2. Discuss the yield point phenomenon.
3. Illustrate the mechanisms of fiber strengthening with applications.

Course Outcome 2 (CO2):

1. List the surface effects on fatigue.
2. Describe the effects of metallurgical variables and fatigue.
3. Illustrate the machine design approach of fatigue.

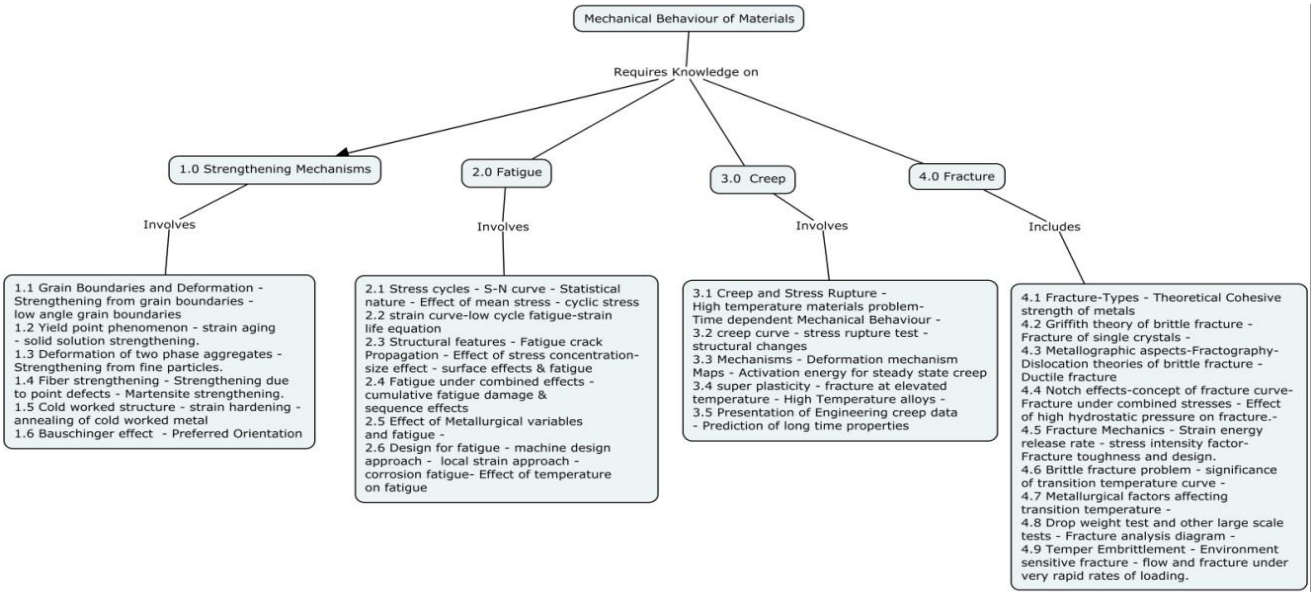
Course Outcome 3 (CO3):

1. Define creep.
2. Explain the mechanisms of creep.
3. Discuss the applications of High Temperature alloys.

Course Outcome 4 (CO4):

1. Define fracture toughness
2. Teach the fracture toughness and design.
3. Illustrate the metallurgical factors affecting transition temperature.

Concept Map



Syllabus

Strengthening Mechanisms: Introduction - Grain Boundaries and Deformation - Strengthening from grain boundaries - low angle grain boundaries - Yield point phenomenon - strain aging - solid solution strengthening - Deformation of two phase aggregates - Strengthening from fine particles - Fiber strengthening - Strengthening due to point defects - Martensite strengthening - cold worked structure - strain hardening - annealing of cold worked metal - Bauschinger effect - Preferred Orientation. **Fatigue:** Stress cycles - S - N curve - Statistical nature - Effect of mean stress - cyclic stress - strain curve - low cycle fatigue - strain life equation - structural features - Fatigue crack Propagation - Effect of stress concentration - size effect - surface effects & fatigue - Fatigue under combined effects - cumulative fatigue damage & sequence effects - Effect of

Metallurgical variables and fatigue - Design for fatigue - machine design approach - local strain approach - corrosion fatigue - Effect of temperature on fatigue. **Creep:** Creep and Stress Rupture - High temperature materials problem - Time dependent Mechanical Behaviour - creep curve - stress rupture test - structural changes - Mechanisms - Deformation mechanism Maps - Activation energy for steady state creep - super plasticity - fracture at elevated temperature - High Temperature alloys - Presentation of Engineering creep data - Prediction of long time properties. **Fracture:** Fracture - Types of fracture in Metals - Theoretical Cohesive strength of metals - Griffith theory of brittle fracture - Fracture of single crystals - Metallographic aspects - Fractography - Dislocation theories of brittle fracture - Ductile fracture - Notch effects - concept of fracture curve - Fracture under combined stresses - Effect of high hydrostatic pressure on fracture.- Fracture Mechanics - Strain energy release rate - stress intensity factor - Fracture toughness and design. Brittle fracture - Brittle fracture problem - significance of transition temperature curve - metallurgical factors affecting transition temperature - Drop weight test and other large scale tests - Fracture analysis diagram - Temper Embrittlement - Environment sensitive fracture - flow and fracture under very rapid rates of loading.

Reference Books

1. George E. Dieter, **"Mechanical Metallurgy",** McGraw Hill Education, Third Edition, New Delhi, 2013.
2. Marc Andr'e Meyers and Krishan Kumar Chawla, **"Mechanical Behavior of Materials"** Cambridge University Press, 2009.
3. Bhargava, A. K and Sharma, C. P, **"Mechanical Behaviour and testing of Materials"** PHI Learning Pvt. Ltd., Delhi. 2014.
4. Thomas H. Courtney, **"Mechanical Behavior of Materials",** Mc Graw Hill , Second Edition, 2012.
5. Norman E. Dowling, **"Mechanical Behavior of Materials",** Pearson Education, Fourth Edition, Inc., NJ, 2012.

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Strengthening Mechanisms**	
1.1	Introduction - Grain Boundaries and Deformation - Strengthening from grain boundaries - low angle grain boundaries	1
1.2	Yield point phenomenon - strain aging - Solid solution strengthening	1
1.3	Deformation of two phase aggregates - Strengthening from fine particles	1
1.4	Fiber strengthening - Strengthening due to point defects - Martensite strengthening	1
1.5	Cold worked structure - strain hardening - annealing of cold worked metal	1
1.6	Bauschinger effect - Preferred Orientation	1
2.0	**Fatigue**	
2.1	Stress cycles - S-N curve - Statistical nature - Effect of mean stress	2
2.2	Cyclic stress - strain curve - Low cycle fatigue - strain life equation	2

Module Number	Topics	No. of Lectures
2.3	Structural features - Fatigue crack Propagation - Effect of stress concentration - size effect - surface effects & fatigue	2
2.4	Fatigue under combined effects - Cumulative fatigue damage & sequence effects	2
2.5	Effect of Metallurgical variables and fatigue	1
2.6	Design for fatigue - machine design approach - local strain approach - corrosion fatigue - Effect of temperature on fatigue	2
3.0	**Creep**	
3.1	Creep and Stress Rupture - High temperature materials problem- Time dependent Mechanical Behaviour	2
3.2	Creep curve - stress rupture test - structural changes	1
3.3	Mechanisms - Deformation mechanism Maps - Activation energy for steady state creep	1
3.4	Super plasticity - fracture at elevated temperature - High Temperature alloys	1
3.5	Presentation of Engineering creep data - Prediction of long time properties	1
4.0	**Fracture**	
4.1	Fracture - Types of fracture in Metals - Theoretical cohesive strength of metals	1
4.2	Griffith theory of brittle fracture - Fracture of single crystals	1
4.3	Metallographic aspects – Fractography - Dislocation theories of brittle fracture - Ductile fracture	2
4.4	Notch effects - concept of fracture curve - Fracture under combined stresses - Effect of high hydrostatic pressure on fracture	2
4.5	Fracture Mechanics - Strain energy release rate - stress intensity factor - Fracture toughness and design.	2
4.6	Brittle fracture - Brittle fracture problem - significance of transition temperature curve	1
4.7	Metallurgical factors affecting transition temperature	1
4.8	Drop weight test and other large scale tests - Fracture analysis diagram	1
4.9	Temper Embrittlement - Environment sensitive fracture - flow and fracture under very rapid rates of loading.	2
	Total	**36**

Course Designers

1. Dr. T. Sornakumar tskmech@tce.edu
2. Dr. M. Kathiresan umkathir@tce.edu

18MG130 **INDUSTRIAL AUTOMATION**

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

Automation is a technology concerned with the application of mechanical, electronic, and computer-based systems to operate and control production. Automation and Robotics are two closely related technologies. This course aims at learning the basics of automation, , Automated Materials Handling and Storage Systems, Robot Anatomy and its industrial applications.

Prerequisite

- Nil

Course Outcomes

On successful completion of the course, students will be able to

CO .No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Explain the principles, types of automation, production systems, management support systems and material handling equipment used for automation.	Understand	80	70
CO2	Explain the basic components and their functions of automated production line, automated assembly system.	Understand	80	70
CO3	Analyze the cycle time, process time, indexing time of indexing devices, efficiency of the production line, production rate and production cost.	Analyse	70	60
CO4	Analyse manual and automated assembly systems.	Analyse	70	60
CO5	Determine the gripper force of robotic arm.	Apply	70	60
CO6	Select the suitable layout, material handling devices and sensors for various industrial applications.	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	M				L		L	
CO2	S	M	M	M				L		L	
CO3	S	S	S	M				L		L	
CO4	S	S	S	M				L		L	
CO5	S	S	M	M				L		L	
CO6	S	M	M	M				L		L	

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Learning Objectives

Course Outcome 1 (CO1):

1. Define production system.
2. Name four conditions under which automated production lines are appropriate.
3. Explain briefly three problem areas that must be considered in the analysis and design of an automated production line.

Course Outcome 2 (CO2):

1. Discuss the hardware used in parts delivery system.
2. Analyse the several possible layouts of the in-line configuration of an automated production line.
3. Discuss the three basic control functions that must be accomplished to operate an automated production line.

Course Outcome 3 (CO3):

1. A rotary work table is driven by a Geneva mechanism with 5 slots. The driver rotates at 48 rev/min. Determine (a) cycle time, (b) available process time, and (c) indexing time.
2. A 30- station transfer line has an ideal cycle time of 0.75 min, an average downtime of 6.0 min per line stop occurrence, and a station failure frequency of 0.01 for all stations. A proposal has been submitted to locate a storage buffer between stations 15 and 16 to improve line efficiency. Determine (a) the current line efficiency and production rate that would result from installing the storage buffer.
3. A machine tool builder submits a proposal for a 20-station transfer line to machine a certain component currently produced by conventional methods. The proposal states that the line will operate at a production rate of 50 pieces per hour at 100% efficiency. On similar transfer lines, the probability of station breakdown per cycle is equal for all stations and p=0.005 breakdowns/cycle. It is also estimated that the average downtime per line stop will be 0.8min. The starting casting that is machined on the line costs Rs.120 per part. The line operates at a cost of Rs.4000 per hour. The 20 cutting tolls (one tool per station) last for 50 parts each, and the average cost per tool = Rs80 per cutting edge. Based on this data, compute (a) production rate, (b) line efficiency, and (c) cost per unit piece produced on the line.

Course Outcome 4 (CO4):

1. A synchronous assembly machine has 8 stations and must produce at a rate of 400 completed assemblies per hour. Average downtime per jam is 2.5 minutes. When a breakdown occurs, all subsystems (including the feeder) stop. The frequency of breakdowns of the machine is once every 50 parts. One of the eight stations is an automatic assembly operation that uses a feeder-selector. The components fed into the selector can have any of five possible orientations, each with equal probability, but only one of which is correct for passage into the feed track to the assembly workhead. Parts rejected by the selector are fed back into the hopper. What minimum

rate must the feeder deliver components to the selector during system uptime in order to keep up with the assembly machine?

2. A six-station automatic assembly machine has an ideal cycle time of 12 sec. Downtime occurs for two reasons. First, mechanical and electrical failures of the workheads occur with a frequency of once per 50 cycles. Average downtime for these causes is 3 minutes. Second, defective components also result in downtime. The fraction defect rate of each of the six components added to the base part at the six stations is q = 2%. The probability that a defective component will cause a station jam is m = 0.5 for all stations. Downtime per occurrence for defective parts is 2 minutes. Determine: (a) yield of assemblies that are free of defective components, (b) proportion of assemblies that contain at least one defective component, (c) average production rate of good product, and (d) uptime efficiency.

3. A single station robotic assembly system performs a series of five assembly elements, each of which adds a different component to a base part. Each element takes 6 seconds. In addition, the handling time needed to move the base part into and out of position is 4 seconds. For identification, the components, as well as the elements which assemble them, are numbered 1, 2, 3, 4, and 5. The fraction defect rate q = 0.005 for all components, and the probability of a jam by a defective component m = 0.7. Average downtime per occurrence = 5.5 minutes. Determine: (a) production rate, (b) yield of good product in the output, (c) uptime efficiency, and (d) proportion of the output that contains a defective type 3 component.

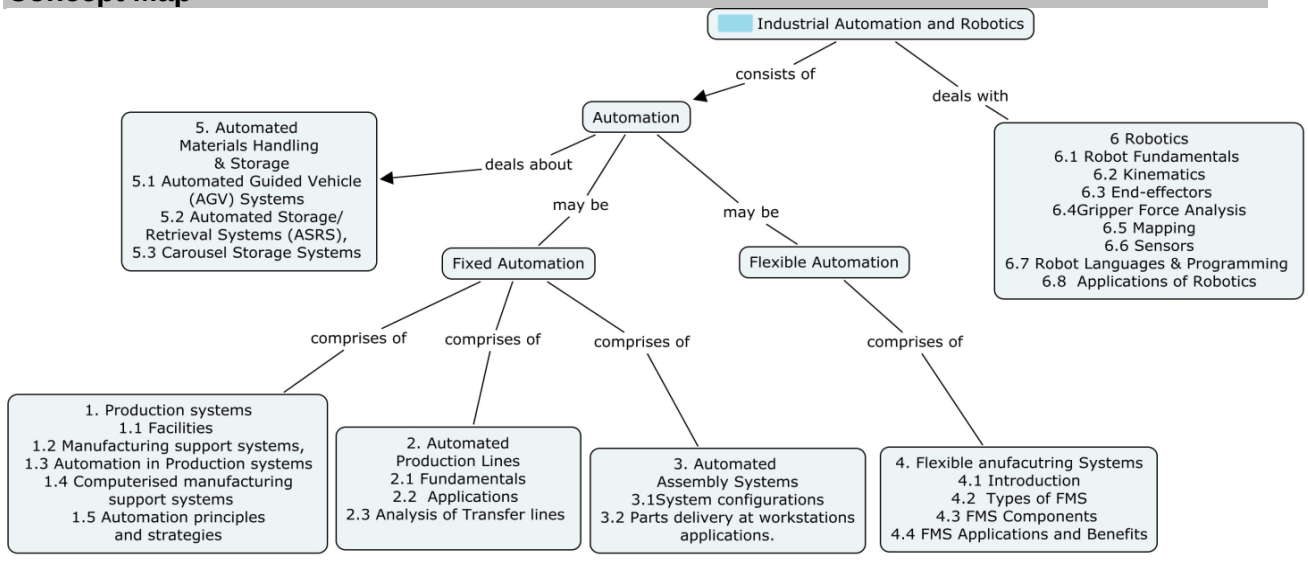
Course Outcome 5 (CO5):

1. A 5 kg rectangular block is gripped in the middle and lifted vertically at a velocity of 1 m/s. If it accelerates to a velocity of 27.5m/s^2 and the coefficient of friction between the gripping pads and the block is 0.48, calculate the minimum force that would prevent the slippage.
2. Discuss the Robot programming languages in brief.
3. Distinguish between the first generation and second generation robot languages.

Course Outcome 6 (CO6):

1. How do external sensors differ from internal sensors?
2. Select the suitable sensor for the following applications (a) to indicate distance (b) to indicate the presence (c) Inspection.
3. Suggest the several possible layouts of the segmented in-line configuration of an automated production line.

Concept Map



Syllabus

Production systems: Facilities – Manual work systems, worker-machine systems and automated systems. Manufacturing support systems, Automation in Production systems – Automated Manufacturing systems, Computerized manufacturing support systems, Manual labour in Production systems, Automation principles and strategies.

Automated Production Lines: Fundamentals- System configurations, work part transfer mechanisms, Storage buffers, and Control of the production line. Applications – Machining systems and System Design Considerations. Analysis of Transfer lines – Transfer lines with No internal parts storage, Transfer lines with internal storage buffers.

Automated Assembly Systems: System configurations, Parts delivery at workstations, and applications, quantitative analysis of assembly systems-Parts Delivery System at Workstations, Multi-Station Assembly Machines, Single Station Assembly Machines, Partial Automation

Automated Material Transport & Storage systems: Automated Guided Vehicle (AGV) Systems, Types and applications, Vehicle Guidance Technology, Vehicle Management and Vehicle safety. Automated Storage/Retrieval Systems (ASRS) and Carousel Storage Systems.

Robotics: Definition, Robot fundamentals, anatomy, specifications, Robot arm, Robot end effectors – Classification, Types of grippers, Drive systems for grippers, Gripper force analysis. Sensors, types of sensors, actuators, applications of robots. Introduction to swarm robot, Industry 4.0.

Reference Books

1. Mikell P. Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, Pearson Publisher, Fourth Edition, 2016.
2. P. Radhakrishnan, S. Subramanyan and V. Raju, ‘CAD/CAM/CIM’, New Age International (P) Ltd., New Delhi, 2009.
3. S.R.Deb and Sankha Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill, Second Edition, New Delhi 2010.
4. Popov and E.I. Yurevih, “Robotics", MIR Publications, Moscow, 1987.
5. Yoram Koren, "Robotics for Engineers", Tata McGraw Hill - International Edition, 1989.

Course contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1	**Production systems**	
1.1	Facilities – Manual work systems	1
1.2	Worker-machine systems and Automated systems, Manufacturing support systems	1
1.3	Automation in Production systems – Automated Manufacturing system	1

Module Number	Topics	No. of Lectures
1.4	Computerized manufacturing support systems, Manual labour in Production systems	1
1.5	Automation principles and strategies.	1
2	**Automated Production Lines**	
2.1	Fundamentals- System configurations	1
	Work part transfer mechanisms, Storage buffers, and Control of the production line.	1
2.2	Applications – Machining systems and System Design Considerations.	1
2.3	Analysis of Transfer lines – Transfer lines with No internal parts storage	2
2.4	Transfer lines with internal storage buffers.	2
3	**Automated Assembly Systems**	
3.1	System configurations	1
3.2	Parts delivery at workstations, and applications.	1
3.3	Quantitative analysis of assembly systems-Parts Delivery System at Workstations	1
3.4	Multi-Station Assembly Machines	2
3.5	Single Station Assembly Machines	2
3.6	Partial Automation	2
4	**Automated Material Transport systems**	
4.1	Types of vehicles, Automated Guided Vehicle (AGV) applications, Vehicle Guidance Technology, Vehicle Management and Vehicle safety.	2
4.2	Automated Storage systems: Automated Storage/Retrieval Systems (ASRS)	1
4.3	Carousel Storage Systems	2
5	**Robotics**	
5.1	Robot Fundamentals - Definition - Anatomy – Specifications	2
5.2	Robot arm , Robot end effectors – Classification, Types of grippers, Drive systems for grippers	2
5.3	Gripper Force Analysis	2
5.4	Sensors, types of sensors, actuators	2
5.5	Applications of robots.	2
5.6	Introduction to swarm robot, Industry 4.0.	1
	Total	37

Course Designers

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18MG160 PRODUCT DESIGN AND DEVELOPMENT

Category	L	T	P	Credit
PC	2	0	2	3

Preamble

The focus of Product Design and Development is integration of the marketing, design, and manufacturing functions of the firm in creating a new product.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. It also deals with impart knowledge on the use of various media such as clay, wood and RP techniques fordevelopment of prototypes.

Course Outcomes

On successful completion of the course, students will be able to

Sl. No	Course Outcomes	Blooms level	Expected Proficiency (%)	Expected Attainment Level (%)
CO 1.	Classify the product planning process based on the customer need.	Understand	75	65
CO 2.	Communicate the final specification (product concept) of the product with cost, aesthetic and ergonomics aspects.	Apply	70	60
CO 3.	Identify the best concept based on concept evaluation process	Apply	70	60
CO 4.	Implement the suitable product architecture.	Apply	70	60
CO 5.	Develop the physical products using any one of the following: clay, wood, sheet metal, machined or RP model. **(Continuous assessment only)**	Create	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S									
CO2	S	S	M	S							
CO3	S	S	M	S							
CO4	S	S	M	S							
CO5	S	S	S	S	S	S	S		M	S	

S- Strong; M-Medium; L-Low

Assessment Pattern

Theory (70 marks)						Practical (30 marks)			
Bloom's Category	Continuous Assessment Tests (20)			Terminal Examination (50)		Valuation category	Review 1 (15)	Review 2 (15)	Review 3 (20)
	1	2							
Remember	20	20		20		Survey	50		10
Understand	60	50		50		Product specification	50		10
Apply	20	30		30		Concept Selection		50	15

Board of Studies meeting held on 07.07.2018 Academic Council Meeting on 21.07.2018

Analyse	0	0		0		Concept Modeling		50	15
Evaluate	0	0		0		Prototype			50
Create	0	0		0		Total	100	100	100

Theory cum Practical Courses:

- There shall be three tests:
- The first two tests (Maximum 50 marks for each test) will be from theory component and the third test (Maximum 50 Marks) will be for practical component.
- The sum of marks of first two tests shall be reduced to 20 Marks and the third test (practical component) mark shall be reduced to 30 marks.
- The sum of these 50 Marks would be rounded to the nearest integer for internal.

Course Level Assessment Questions

Course Outcome 1,2(CO1, CO2):

1. Define product design.
2. Distinguish between functional design and production design, with suitable examples.
3. What is pre project planning?
4. What is Intellectual Property?
5. Define proto type product.
6. What is industrial design?

Course Outcome 3(CO3):

1. Evaluate concept selection methods for five automobiles you might consider for purchasing.
2. Develop five pencil holder concepts. Assume the pencil holders are for the member of product development team who is continually moving from site to site. Evaluate the best concept.
3. As a customer Identify the basic needs while selection a new car

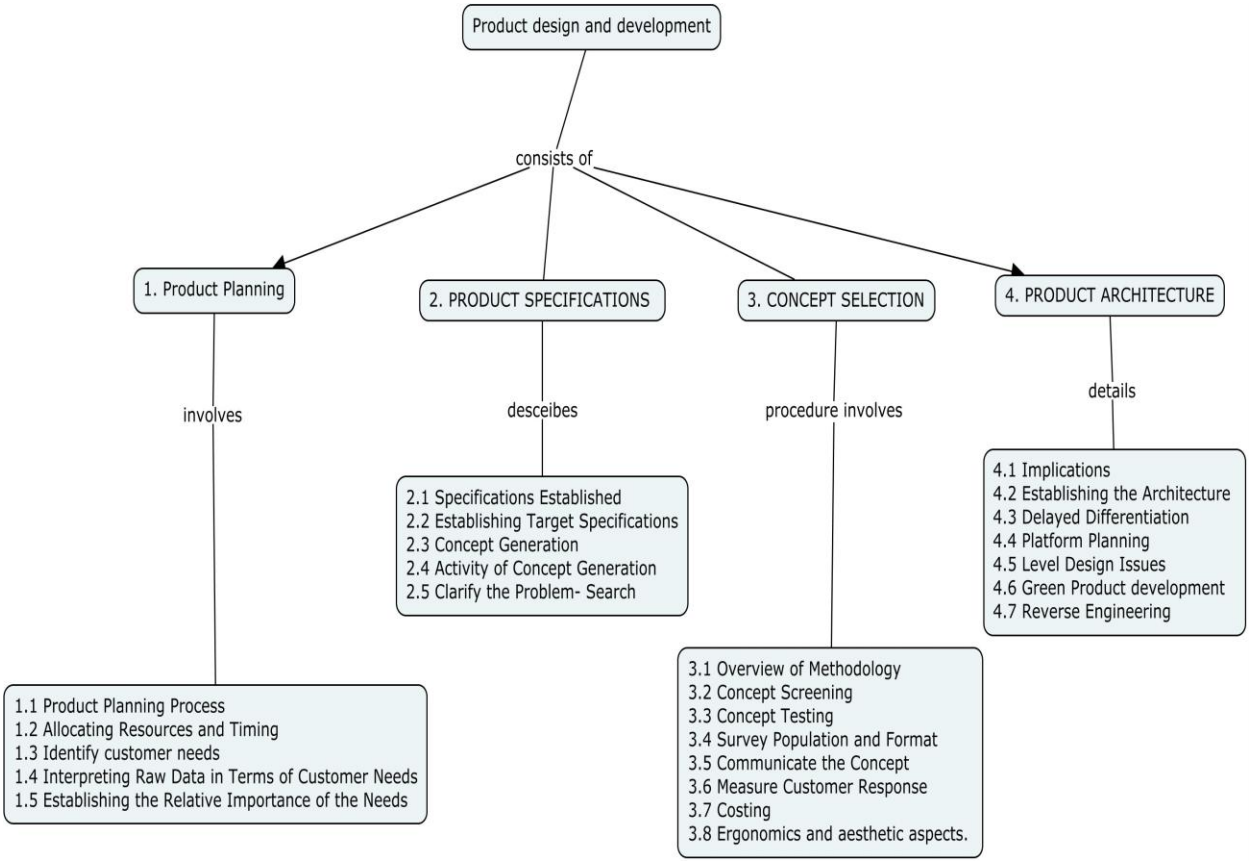
Course Outcome 4(CO4):

1. What is metrics?
2. List your needs with respect to two wheeler motorcycle suspension and convert to a product specification.
3. How concept selection methods can is used to benchmark or evaluate the existing product?

Course Outcome 5(CO5):

1. Draw a schematic for a wrist watch using only functional element and analyze its incidental interaction and fundamental interaction
2. Analyze the various product architecture for a laser printer in terms paper tray and feed system
3. Draw proposed product architecture for a digital camera with chunks details. and analyze the various interaction

Concept Map



Syllabus

PRODUCT PLANNING: Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning - Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy-Establishingthe Relative Importance of the Needs

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

CONCEPT SELECTION-Concept Selection- Overview of Methodology- 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 - COSTING – Material – manufacturing –assembly - Ergonomics and aesthetic aspects.

PRODUCT ARCHITECTURE- Implications of the Architecture-Establishing the Architecture-Delayed Differentiation-Platform Planning-Related System-Level Design Issues – Green Product development – Reverse Engineering

Text Book

1. Ulrich, Karl T. and Steven D. Eppinger, '"**Product Design and Development**", Irwin/McGraw-Hill, 6th Edition, 2015.

2. Chitale. A.K and Gupta. R.C., "**Product design and manufacturing**" Fifth Edition, Prentice-Hall of India Learning Private Limited, New Delhi, 2011.
3. David G.Ullman, "**The Mechanical Design Process**", Tata McGraw Hill , 2011
4. Kevin Otto, and Kristin Wood, "**Product Design – Techniques in Reverse Engineering and New Product Development**", Pearson Education, First edition,2000, ISBN 81-7758-821-4'

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1.0	PRODUCT PLANNING	
1.1	Product Planning Process- Identify Opportunities	1
1.2	Evaluating and Prioritizing Projects- Allocating Resources and Timing	2
1.3	Pre-Project Planning - Identifying Customer Needs, Raw Data from Customers.	2
1.4	Interpreting Raw Data in Terms of Customer Needs, Organizing the Needs into a Hierarchy	1
1.5	Establishing the Relative Importance of the Needs	1
2.0	PRODUCT SPECIFICATIONS	
2.1	Specifications - Specifications Established-Establishing Target Specifications	2
2.2	QFD-Setting the Final Specifications-Concept Generation.	2
2.3	The Activity of Concept Generation	1
2.4	Clarify the Problem- Search Externally-Search Internally, Explore Systematically	2
3.0	CONCEPT SELECTION	
3.1	Concept Selection- Overview of Methodology	1
3.2	Concept Screening-Concept Testing-Define the Purpose of the Concept Test	1
3.3	Choose a Survey Population- Choose a Survey Format-Communicate the Concept.	1
3.4	Measure Customer Response-Interpret the Results.	1
3.5	COSTING: Material – manufacturing –assembly	1
3.6	Ergonomics and aesthetic aspects	1
4.0	PRODUCT ARCHITECTURE	
4.1	Implications of the Architecture-Establishing the Architecture	1
4.2	Delayed Differentiation, Platform Planning-Related System-Level Design Issues.	1
4.3	Green Product development	1
4.4	Reverse Engineering	1
	TOTAL	**24**

Practical Component

The individual student / group of students of maximum number of two have to develop digital and physical functional or non-functional prototype models of a new product/ existing product with enhanced feature involving the following areas:

- Automotive components
- Tool and die components
- Press tool components

- Consumer product
- Agricultural equipments., etc

The fabricated models may be in the form of RP models, clay models, Machined models, sheet metal models or cardboard models etc… The design and development of the product will be reviewed in three stages.The third review mark will be based on the demonstration of the new product developed,report submission and oral examination on the same by team of faculties/course handling faculties

Practical Schedule

S.No	List of activities	No. of hours
1	Survey	2
2	Product specification	2
3	Concept Selection	2
4	Concept Modeling	2
5	Prototype	6
6	Review	10
	Total	**24**

Course Designers:

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18MG170	COMPUTER AIDED ENGINEERING LABORATORY	Category	L	T	P	Credit
		PC	0	0	4	2

Preamble

Manufacturing needs automation in order to reduce the time-to-market of any new products. CAE Laboratory course provides the Computer Aided Modeling, Manufacturing, and analysis for given mechanical components. Computer-aided Modelling is the use of computer systems to aid in the creation, modification, analysis or optimization of parts using simulation packages. Computer Aided Manufacturing (CAM) is to control of machine tools and related machineries to make mechanical components using CAM packages.

Prerequisite

- Nil

Course Outcomes

On successful completion of the course, students will be able to

CO.No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Develop 3D part and Assembly models for the given diagram using CAD package	Apply	70	60
CO2	Perform Structural, Modal and harmonic analysis of given mechanical component	Analyze	70	60
CO3	Generate CNC codes for machining the given 2D diagram using the appropriate CAM package	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1		L	M		S					M	L
CO2		M	M		S					M	M
CO3		L	M		S					M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	0	0	0	0
Understand	0	0	0	0
Apply	0	0	100	100
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Syllabus

1.Develop part model, assembly and detailed drawing of given mechanical components such as (any 4 exercises)

a. Universal joint
b. Screw jack
c. Machine vice
d. Tail stock
e. Milling Fixture
f. Four pillar Die set
g. Piston head
h. Swivel bearing
i. Drill Jig
j. Steam stop valve
k. Rams bottom safety valve
l. Spring loaded safety valve
m. Plumber block

2. Static analysis of loaded simple truss
3. Static analysis of a loaded structural beam
4. Modal analysis of structural beam
5. Harmonic analysis of mechanical components
6. Generate CNC Program for profile milling and drilling operations for the given sketch and verify the tool path.
7. Generate CNC Program for profile milling and pocketing operations for the given sketch and verify the tool path.
8. Generate CNC Program for profile milling and patterns for the given sketch and verify the tool path.
9. Generate CNC Program for profile milling, drilling and pocketing operations for the given sketch and verify the tool path.

NOTE:

- Self learning Component-Dimensioning and Tolerance
- For continuous assessment test, totally 12 exercises must be completed by the students among which FOUR exercises from assembly solid modeling, FOUR from analysis and FOUR from CAM exercises.
- All three course outcomes are to be evaluated and three questions will be given in the final practical examination.

Course Designers

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		Category	L	T	P	Credit
18MGPA0	**BIOMATERIALS**	PE	3	0	0	3

Preamble

Biomaterials can be derived either from nature or synthesized in the laboratory using a variety of chemical approaches utilizing metallic components, polymers, ceramics or composite materials. It can be used every day in orthopaedic application, dental applications, surgery, and drug delivery. Biomechanics is the study of the structure and function of the mechanical aspects of biological systems, at any level from whole organisms to organs, cells and cell organelles using the methods of mechanics. The primary objective of this course is to impart the knowledge on biomaterials needed to solve challenges in the bioengineering.

Prerequisite

Nil

Course Outcomes

On successful completion of the course, students will be able to

CO No	Course Outcome	Blooms Level	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Illustrate the concepts of biomaterials and biocompatibility.	Understand	80	70
CO2	Identify the suitable material and Manufacturing methods for bio implant applications.	Apply	70	60
CO3	Illustrate the concepts of biomechanics joints.	Understand	80	70
CO4	Explain the principle of hard and soft tissue mechanism	Understand	80	70
CO5	Investigate the stress analysis for implant systems using Finite element analysis package (Continuous Assessment only)	Analyse	60	50

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	-	-	-	-	-	-	-	-	-
CO2.	S	M	-	M	-	M	-	-	M	-	L
CO3.	S	M	-	-	-	-	-	-	-	-	-
CO4.	S	M	-	-	-	-	-	-	-	-	-
CO5.	S	S	S	M	S	M	-	M	M	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	30	30	20
Understand	60	70	70	60
Apply	20	0	0	20
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

CO5: Assignments for Continuous Assessment (10 Marks)

- The individual student / group of students of maximum number of two have to analyse stress distribution for implant system using different material using finite element package.
- The internal assignment mark will be based on the presentation, report submission and oral examination on the same by team of faculties/course handling faculties

Course Level Assessment Questions

Course outcome 1:

1. Define the term 'biomaterials'. Classify biomaterials with appropriate examples.
2. Explain the basic criteria of biomaterials
3. Define the term 'biocompatibility'

Course outcome 2:

1. Classify polymers and define each group.
2. Classify bio-ceramics with appropriate examples. Give the advantage and disadvantage of ceramic materials
3. Explain the primary use of metallic implant materials? Mention the uses of Co-Cr alloy, Ti alloys and its alloys in orthopaedic.

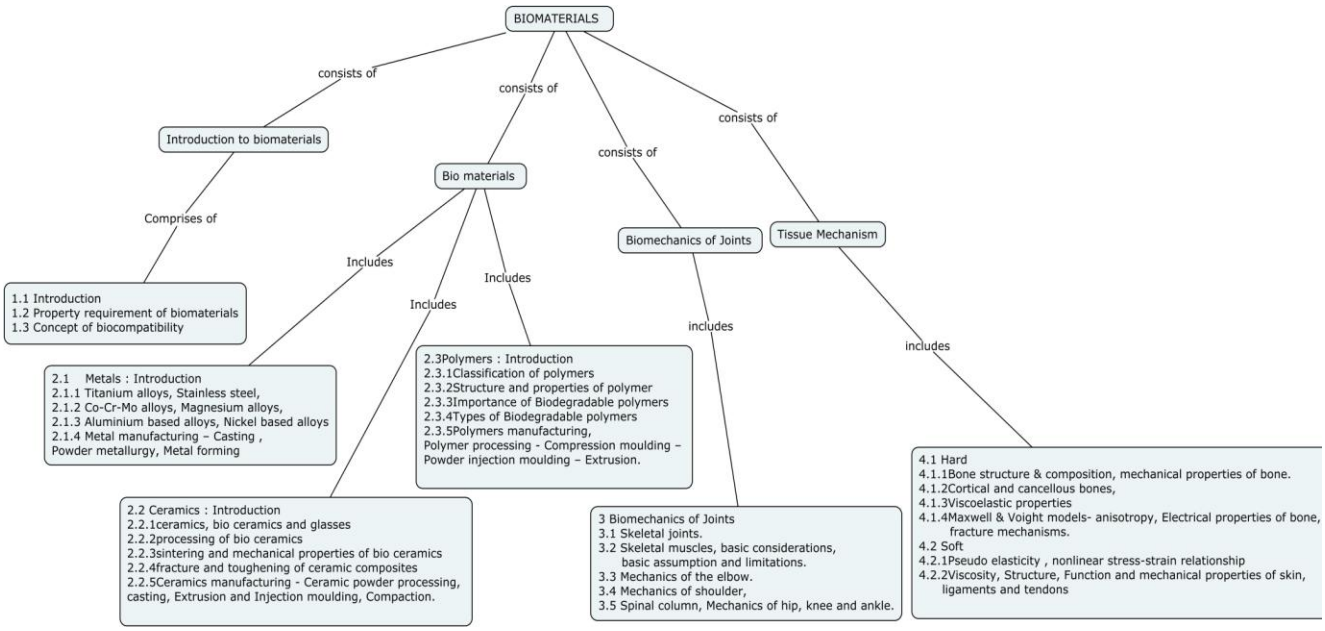
Course outcome 3:

1. List the considerations for skeletal joints design.
2. Explain the mechanics involved in shoulder, knee and angle.
3. Explain the various ways of gait analysis.

Course outcome 4:

1. Explain the mechanical properties of bone.
2. Define: Pseudo elasticity.

Concept Map



Syllabus

Introduction to Biomaterials: Introduction - Property requirement of biomaterials; Concept of biocompatibility

Bio materials:

Metals: Introduction - Titanium alloys, Stainless steel, Co-Cr-Mo alloys, Magnesium alloys, Aluminium based alloys, and Nickel based alloys - Metal manufacturing – Casting , Powder metallurgy, Metal forming.

Ceramics – Introduction - processing of bio ceramics- ceramics, bio ceramics and glasses-sintering and mechanical properties of bio ceramics-fracture and toughening of ceramic composites.- Ceramics manufacturing , Ceramic powder processing, casting, Extrusion and Injection molding , Compaction.

Polymers – Introduction – classification of polymers - Structure and properties of polymer – Importance of Biodegradable polymers- Types of Biodegradable polymers - Polymers manufacturing, polymer processing – compression moulding – powder injection moulding – extrusion.

Biomechanics of Joints: Skeletal joints, skeletal muscles, basic considerations, basic assumption and limitations, mechanics of the elbow, mechanics of shoulder, Spinal column, mechanics of hip, knee and ankle.

Tissue Mechanism:

Hard: Bone structure & composition, mechanical properties of bone, cortical and cancellous bones, viscoelastic properties, Maxwell & Voight models- anisotropy, Electrical properties of bone, fracture mechanisms.

Soft: Pseudo elasticity, nonlinear stress-strain relationship, Viscosity, Structure, Function and mechanical properties of skin, ligaments and tendons.

Text Book

1. Ratner, Hoffman, Schoet and Lemons, "Biomaterials Science: An introduction to Materials in Medicine", Second Edition: Elsevier Academic Press, 2004.
2. B. Basu, D. Katti and Ashok Kumar; "Advanced Biomaterials: Fundamentals, Processing and Applications", John Wiley & Sons, Inc., USA, 2009.
3. Fredrick H. Silver and David L Christiansen, "Biomaterials Science and Biocompatibility", Springer, 1999
4. Jonathan Black, "Biological Performance of Materials: Fundamentals of Biocompatibility" Fourth Edition: CRC Taylor & Francis Group, London, 2006.
5. NPTEL (http://nptel.ac.in/courses/113104009/#)

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Introduction to Biomaterials**	
1.1	Introduction	1
1.2	Property requirement of biomaterials;	1
1.3	Concept of biocompatibility	1
2	**Bio materials**	
2.1	**Metals :** Introduction	1
2.1.1	Titanium alloys, Stainless steel,	1
2.1.2	Co-Cr-Mo alloys, Magnesium alloys,	1
2.1.3	Aluminium based alloys, Nickel based alloys	1
2.1.4	Metal manufacturing – Casting , Powder metallurgy, Metal forming	2
2.2	**Ceramics** : Introduction	1
2.2.1	ceramics, bio ceramics and glasses	1
2.2.2	processing of bio ceramics	1
2.2.3	sintering and mechanical properties of bio ceramics	1
2.2.4	fracture and toughening of ceramic composites	1

S.No.	Topic	No. of Lectures
2.2.5	Ceramics manufacturing - Ceramic powder processing, casting, Extrusion and Injection moulding, Compaction.	2
2.3	**Polymers** : Introduction	1
2.3.1	Classification of polymers	1
2.3.2	Structure and properties of polymer	1
2.3.3	Importance of Biodegradable polymers	1
2.3.4	Types of Biodegradable polymers	1
2.3.5	Polymers manufacturing, Polymer processing - Compression moulding – Powder injection moulding – Extrusion.	2
3	**Biomechanics of Joints**	
3.1	Skeletal joints.	1
3.2	Skeletal muscles, basic considerations, basic assumption and limitations.	1
3.3	Mechanics of the elbow.	1
3.4	Mechanics of shoulder,	1
3.5	Spinal column, Mechanics of hip, knee and ankle.	1
4	**Tissue Mechanism**	
4.1	**Hard**	
4.1.1	Bone structure & composition, mechanical properties of bone.	1
4.1.2	Cortical and cancellous bones,	1
4.1.3	Viscoelastic properties	1
4.1.4	Maxwell & Voight models- anisotropy, Electrical properties of bone, fracture mechanisms.	1
4.2	**Soft**	
4.2.1	Pseudo elasticity , nonlinear stress-strain relationship	2
4.2.2	Viscosity, Structure, Function and mechanical properties of skin, ligaments and tendons	2
	Total	

Course Designers

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18MGPC0	COMPUTER INTEGRATED MANUFACTURING	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Computer Integrated Manufacturing (CIM) is a manufacturing approach of using computers to control the entire production process. The integration of all elements of CIM environment allows individual process to exchange information with other elements and initiate actions. These activities encompass all functions necessary to translate customer needs into a final product. It includes computer aided design (CAD), computer aided manufacturing (CAM), computer aided process planning (CAPP), computer numerical control machine tools, computer integrated production management system and other business functions integrated by a common data base.

Prerequisite

- NIL

Course Outcomes

On successful completion of the course, students will be able to

CO.No.	Course Outcome	Blooms Level	Expected Proficiency	Expected Attainment Level
CO1	Develop solid models using B-rep. scheme, CSG technique and sweep representation technique	Apply	70	60
CO2	Write offline program for simulating the machining operation	Apply	70	60
CO3	Explain the concept of computer data communication, Protocol and graphics standards	Understand	80	70
CO4	Explain the structure of CAPP, factory data collection system, and principle of lean and agile manufacturing	Understand	80	70
CO5	Demonstrate the working of material requirement planning	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L					M		S	M
CO2	S	M	L					M		S	M
CO3	S							M		S	
CO4	S							M		S	
CO5	S	M	L					M		S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	60	50	50
Apply	40	20	30	30
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

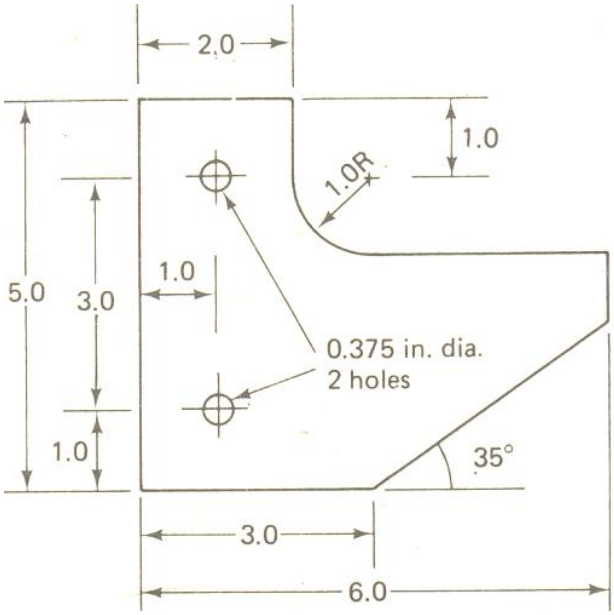
Course Level Assessment Questions

Course Outcome 1 (CO1):

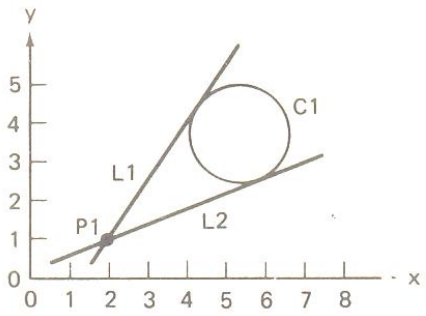
1. Develop a solid model of hollow cylinder of 15 mm thickness with inner diameter of 20 mm using sweep representation technique.
2. Suggest a suitable manipulation technique for joining two different solids.
3. Illustrate the Boundary representation and CSG technique with suitable solid model and compare the complexity of the two techniques used

Course Outcome 2 (CO2):

1. Write an APT program for milling the part as shown in the following figure.



2. Develop an APT code for 12 mm diameter drill at centre of a MS plate of size 20 x 40 mm with 3 mm thickness.
3. Write an APT codes for describing lines 1 and 2 shown in the following figure.



Course Outcome 3 (CO3):

1. Develop IGES neutral format for circle of radius 20 mm with centre (10, 5, 0) and a straight line with two ends (0, 0) and (15, 25).
2. Develop DXF neutral format for a point located at (10, 2, 8) and circle of diameter 40 mm with (0, 0, 0) as centre.
3. Explain the general procedure for framing of data along with the types of data error.

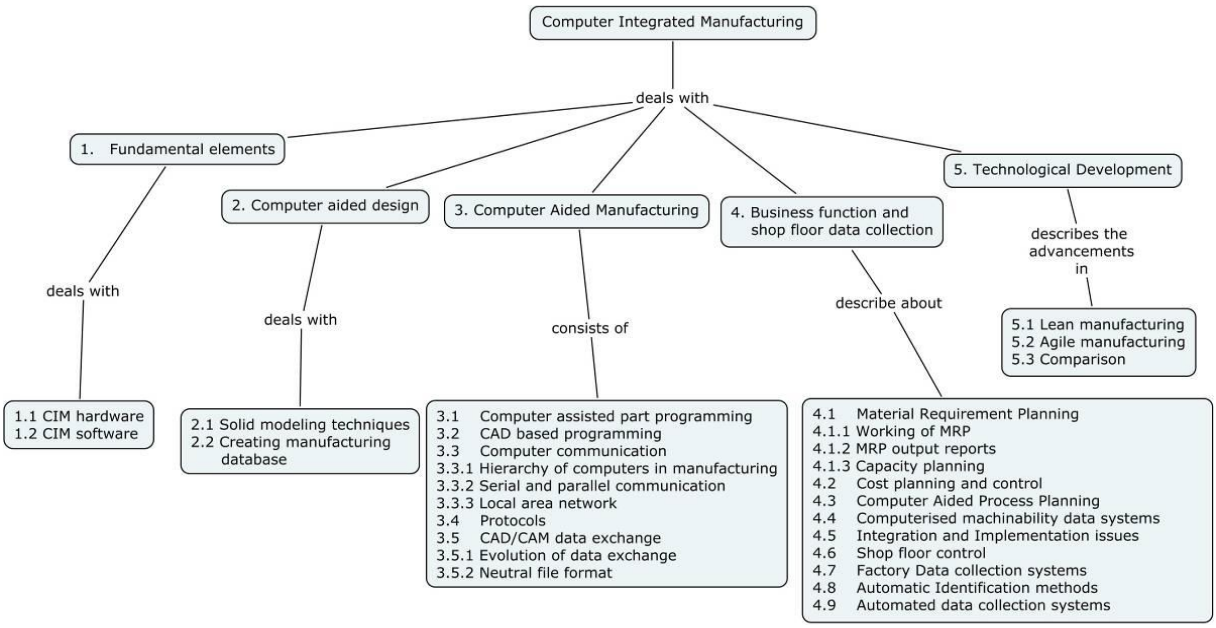
Course Outcome 4 (CO4):

1. Explain the concept of Generative type CAPP.
2. Describe about the computerised machinability data systems.
3. Discuss about the integration and implementation issues of CAPP and its advantage and limitation.

Course Outcome 5 (CO5):

1. Illustrate the principle of MRP functioning with suitable master scheduling data.
2. Suggest a suitable data collection method for mass production of oil seal and explain.
3. Discuss about any two automatic identification methods generally followed in a job shop production environment.

Concept Map



Syllabus

Fundamentals Elements: Nature of CIM, Evolution of CIM, CIM hardware and software. **Computer Aided Design:** Design process, solid modeling techniques, creating manufacturing

database. **Computer Aided Manufacturing:** Elements of CNC machine tools, Offline program through APT language for machining operation, CAD based programming, **Computer Communication:** Hierarchy of computers in manufacturing, Serial and parallel communication, Local area network, **Protocols:** Manufacturing Automation Protocol and Technical Office Protocol, CAD/CAM data exchange-Method of data exchange, Evolution of data exchange, **Neutral file format:** DXF, IGES and PDES. **Business function and shop floor data collection:** Material Requirement Planning, Inputs to MRP, Working of MRP, MRP output reports, Capacity Planning, Cost planning and control, **Computer Aided Process Planning:** Retrieval type and Generative type CAPP, Benefits, Computerised machinability data systems, Integration and Implementation issues, **Shop floor control:** Functions, information flow, Factory Data collection systems, Automatic Identification methods, automated data collection systems, **Technological Development:** Agile manufacturing, Lean manufacturing, Comparison of Agile and Lean manufacturing.

Reference Books

1. Vajpayee S. Kant, “Principles of Computer Integrated Manufacturing”, Prentice Hall of India Learning, 2009.
2. Ibrahim Zeid, “Mastering CAD/CAM”, Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2008.
3. Mikell P. Groover, “Automation, Production Systems and Computer-Integrated Manufacturing”, Pearson Publisher, Fourth Edition, 2016.
4. M. Groover, E. Zimmers, “CAD/CAM: Computer-Aided Design and Manufacturing”, Pearson Publisher, First Edition, 2003.
5. K.C. Jain and Sanjay Jain, “Principles of Automation and Advanced Manufacturing Systems”, Khanna Publishers, First Edition, 2003.

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1.	**Fundamentals Elements:** Nature of CIM, Evolution of CIM	1
1.1	CIM hardware	1
1.2	CIM software	
2.	**Computer Aided Design:** Design process	1
2.1	Solid modeling techniques	2
2.2	Creating manufacturing database	1
3.	**Computer Aided Manufacturing:** Elements of CNC machine tools	1
3.1	Offline program through APT language for machining operation	2
3.2	CAD based programming	1
3.3	Computer Communication	1
3.3.1	Hierarchy of computers in manufacturing	1
3.3.2	Serial and parallel communication	1
3.3.3	Local area network	
3.4	Protocols-Manufacturing Automation Protocol and Technical Office Protocol	1
3.5	CAD/CAM data exchange-Method of data exchange	1

Module Number	Topics	No. of Lectures
3.5.1	Evolution of data exchange	1
3.5.2	Neutral file format-DXF, IGES and PDES	2
4.	**Business function and shop floor data collection**	
4.1	Material Requirement Planning-Inputs to MRP	1
4.1.1	Working of MRP	2
4.1.2	MRP output reports	1
4.1.3	Capacity Planning	
4.2	Cost planning and control	1
4.3	Computer Aided Process Planning-Retrieval type	1
	Generative type CAPP, Benefits of CAPP	1
4.4	Computerised machinability data systems	1
4.5	Integration and Implementation issues	1
4.6	Shop floor control-functions, information flow	1
4.7	Factory Data collection systems	2
4.8	Automatic Identification methods	2
4.9	Automated data collection systems	2
5.	**Technological Development**	
5.1	Agile manufacturing	1
5.2	Lean manufacturing	
5.3	Comparison of Agile and Lean manufacturing	1
	Total	36

Course Designers

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18MGPNO **OPERATIONS MANAGEMENT** Category L T P Credit

PE 3 0 0 3

Preamble

Operation Management (OM) is the process of managing people and resources in order to create a product or a service. OM has been the key element in the improvement in the productivity around the world. The major concerns of operations management study are Strategies, Process analysis, Demand forecasting, Aggregate Sales and Operations Planning, Inventory Management, Materials Requirement Planning (MRP), Operations Scheduling, Just –In-Time and Lean Systems. The goal is to create a competitive advantage for industrial and production engineering students of post graduate level by conveying a set of skills and tools that they can apply in their profession.

Prerequisites

- Nil

Course Outcomes

On successful completion of the course, students will be able

CO.No	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected Attainment Level (%)
CO 1.	Explain Aggregate Production Planning Strategies and Techniques, Forecasting methods, Inventory Management models and costs, MRP structure, and Concept of JIT and Lean manufacturing.	Understand	80	70
CO 2.	Draw process flow chart and determine process performance and productivity measures.	Apply	70	60
CO3.	Determine, demand forecast, order quantity, and safety stock levels and develop MRP schedules	Apply	70	60
CO 4.	Examine inventory models and lot sizing methods.	Analyse	70	60
CO 5.	Determine optimal sequence and Schedule the jobs in single machine, flow shop and job shop environments.	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	M	M	M						
CO2.	S	M	M	M	M						
CO3.	S	S	S	M	M						
CO4.	S	S	S	M	M						
CO5.	S	S	S	M	M						

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	30	30	30	30
Apply	50	50	50	50
Analyze	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Operation Management.
2. How does mixed strategy differ from pure strategy?
3. Describe the Frame work for operations strategy in manufacturing.
4. Compare and contrast JIT and MRP, stating their main features

Course Outcome 2 (CO2):

1. onsider the construction of a simple 8" X 10" wood picture frame. The picture frame consists of four wood pieces that are cut from the wood molding, four staples to hold the frame together, a piece of glass, a backing board made of cardboard, six points to hold the glass and backing board to the frame, and a clip for hanging the picture frame from the wall.
   i) Construct an assembly chart for the picture frame.
   ii) Construct a flow process chart for the entire process from receiving materials to final inspection

2. Various financial data for 2010 and 2011 are given. Calculate the total productivity measure and partial measures of labour, capital, and raw materials for this company for both years. What do these measures indicate?

Parameter		Year 2010 in Rs.	Year 2011 in Rs.
Output	Sales	2,00,000	2,20,000
Input	Labour	30,000	40,000
	Raw Materials	35,000	45,000
	Energy	5,000	6,000
	Capital	50,000	50,000
	Other	2,000	3,000

3. Draw the process flow chart for an example product of industrial importance.

Course Outcome 3 (CO3):

1. Historical demand for a product is:

Month	**Demand**
January	12
February	11
March	15
April	12
May	16
June	15

   a. Using weighted moving average with weights of 0.60, 0.30, and 0.10, find the July forecast.

   b. Using a simple three-month moving average, find the July forecast.

   c. Using single exponential smoothing with a = 0.2 and a June forecast = 13, find the July forecast. Make whatever assumptions you wish.

   Using simple linear regression analysis, calculate the regression equation for the preceding demand data.

2. From the following information, formulate an inventory management system. The item is demanded 50 weeks a year.

Item cost	$10.00	Standard deviation of weekly	
Order cost	$25.00	demand	25 per week
Annual holding cost (%)	33% of item cost	Lead time	1 week
Annual demand	25,750	Service level	95%
Average demand	515 per week		

   i) State the order quantity and recorder point.

   ii) Determine the annual holding and order costs.

   iii) How many units per order cycle would you expect to the short?

   iv) It a price break of $50 per order was offered for purchase quantities of over 2,000, would you take advantage of it? How much would you save on an annual basis?

3. Product X is made of two units of Y and three of Z. Y is made of one unit of A and two units of B.Z is made of two units of A and four units of C. Lead time for X is one week; Y, two weeks; Z, three weeks; B, one week; and C, three weeks.
   i). Draw the bill of materials (product tree structure)
   ii). If 200 units of X are needed in week 10, develop a planning schedule showing when each item should be ordered and in what quantity.

Course Outcome 4 (CO4):

1. The annual demand of a product is 48000 units the average lead time is 4 weeks. The standard deviation of demand during average lead time is 75 units per week. The cost of ordering is Rs400 per order. The cost of purchase of the product per unit is Rs.10. The cost of carrying per unit per year is 15% of the purchase price. The maximum delay in lead time is 2 weeks and the probability of the delay is 0.25. Assume service level of 0.95.

   (i) If Q system is followed find the reorder level,

   (ii) If P system is followed find the maximum inventory level.

2. Compare P and Q Inventory models.

3. A company manufacture iron box the MPS of the final assembly is shown below.

Month	1	2	3	4	5	6	7	8
Projected Requirements	-	3500	3000	45000	-	1000	4000	5500

The initial stock on hand is 1150 units. The carrying cost is R2.5 per unit per month and the lead time is one month. The ordering cost per order is Rs.6000. Develop an EOQ solution and compares it with LUC method.

Course Outcome 5 (CO5):

1. Use graphical method to minimize the time needed to process the following jobs on the machines. Shown (i.e. for each machine the job which should be scheduled first). Also, calculate the total time elapsed to complete both jobs.

	Sequence	A	B	C	D	E
Job 1	Time (Hrs)	2	6	5	4	7

	Sequence	C	B	D	A	E
Job 2	Time (Hrs)	6	5	7	4	8

2. Consider the following 3 machines and 5 jobs flow shop problem. Check whether Johnson's rule can be extended to this problem. If so, what is the optimal schedule and

corresponding makespan?

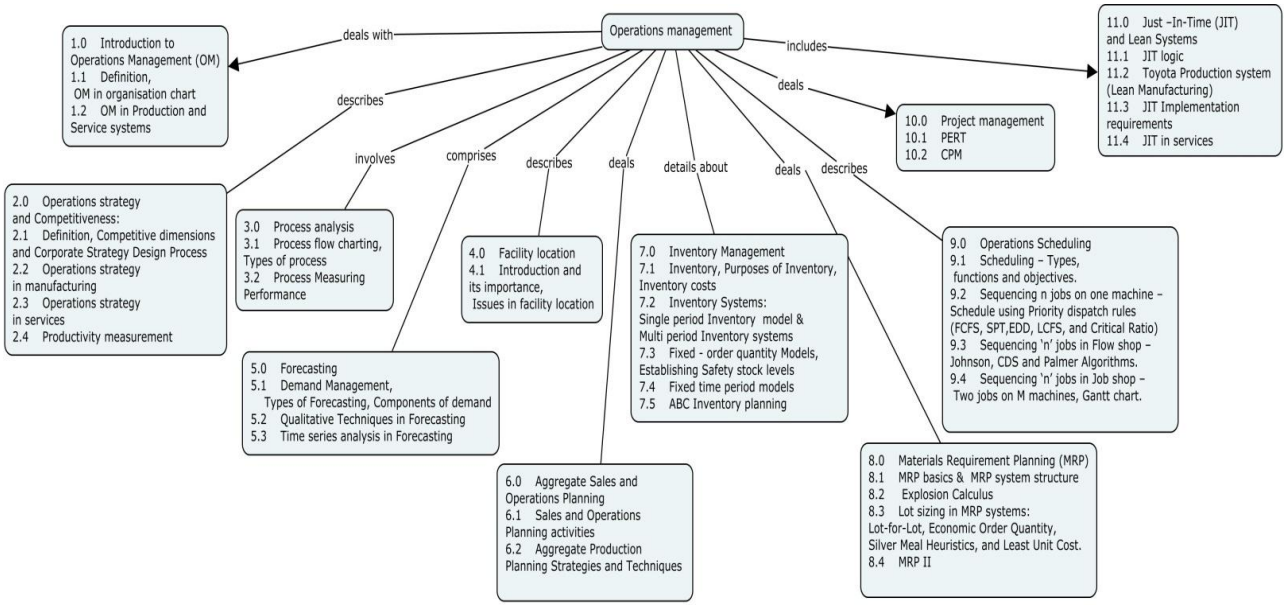
Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

3. Consider the following single machine scheduling problem with weights.

Job	1	2	3	4	5
Processing time	15	4	5	14	8
Weights	1	2	1	2	3

Determine the sequence which will minimize the weighted mean flow time of the problem.

Concept Map



Syllabus

Introduction to Operations Management (OM): Definition, OM in organisation chart, OM in Production and Service systems. **Operations strategy and Competitiveness:** Definition, Competitive dimensions and Corporate Strategy Design Process, Operations strategy in manufacturing, Operations strategy in services, Productivity measurement.

Process analysis: Process flow charting, types of processes and Process Measuring Performance. **Facility location**- Introduction and its importance, Issues in facility location.

Forecasting: Demand Management, Types of Forecasting, Components of demand, Qualitative Techniques, and Time series analysis in Forecasting.

Aggregate Sales and Operations Planning: Sales and Operations Planning activities, Aggregate Production Planning Strategies and Techniques. **Inventory Management:** Inventory, Purposes of Inventory, Inventory costs, Inventory Systems: Single period Inventory model & Multi period Inventory systems. Fixed - order quantity Models, Establishing Safety stock levels, Fixed time period models and ABC Inventory planning.

Materials Requirement Planning (MRP): MRP basics & MRP system structure, Explosion Calculus, Lot sizing in MRP systems: Lot-for-Lot, Economic Order Quantity, Silver Meal Heuristics, and Least Unit Cost. MRP II.

Operations Scheduling: Scheduling – Types, functions and objectives, Sequencing n jobs on one machine – Schedule using Priority dispatch rules (FCFS, SPT,EDD, LCFS, and Critical Ratio). Sequencing 'n' jobs in Flow shop – Johnson, CDS and Palmer Algorithms. Sequencing 'n' jobs in Job shop – Two jobs on M machines, Gantt chart.

Project management - PERT and CPM. **Just –In-Time (JIT) and Lean Systems:** JIT logic, Toyota Production system (Lean Manufacturing), JIT Implementation requirements and JIT in services.

Reference Books

1. Chase, Jacobs, Aquilano, "**Production and Operations Management**", Tenth Edition, Irwin McGraw Hill Companies Inc., 2008.
2. B.Mahadevan, **" Operations Management : Theory and practice"**, Pearson Education India, 2010.
3. Paneer Selvam.R, "**Production and Operations Management**", Prentice-hall of India, 2012.
4. William J.Stevenson, **"Operations Management",** Seventh Edition, McGraw Hill Irwin, 2002.
5. Steven Nahmias, "**Production and Operations Analysis**", Third Edition, Irwin McGraw Hill Companies Inc., 2008.
6. Chary, "**Theory and Problems in Production and Operations Management**", Second reprint, Tata McGraw Hill, 2013
7. Monks, Joseph.G, "**Operations management : theory and problems",** Third Edition, McGraw-Hill series in management, 1987.

Course Contents and Lecture schedule

S.NO	Topics	No. of Lectures
1.0	**Introduction to Operations Management (OM)**	
1.1	Definition, OM in organisation chart	1
1.2	OM in Production and Service systems	1
2.0	**Operations strategy and Competitiveness**	
2.1	Definition, Competitive dimensions and Corporate Strategy Design Process	1
2.2	Operations strategy in manufacturing	1
2.3	Operations strategy in services	1

S.NO	Topics	No. of Lectures
2.4	Productivity measurement	1
3.0	**Process analysis**	
3.1	Process flow charting, Types of process	2
3.2	Process Measuring Performance	1
4.0	Facility location	
4.1	Introduction and its importance, Issues in facility location	1
5.0	Forecasting	
5.1	Demand Management, Types of Forecasting, Components of demand	1
5.2	Qualitative Techniques in Forecasting	1
5.3	Time series analysis in Forecasting	1
6.0	Aggregate Sales and Operations Planning	
6.1	Sales and Operations Planning activities	1
6.2	Aggregate Production Planning Strategies and Techniques	1
7.0	Inventory Management	
7.1	Inventory, Purposes of Inventory, Inventory costs	1
7.2	Inventory Systems: Single period Inventory model & Multi period Inventory systems	1
7.3	Fixed - order quantity Models, Establishing Safety stock levels	2
7.4	Fixed time period models	1
7.5	ABC Inventory planning	1
8.0	Materials Requirement Planning (MRP)	
8.1	MRP basics & MRP system structure	1
8.2	Explosion Calculus	1
8.3	Lot sizing in MRP systems: Lot-for-Lot, Economic Order Quantity, Silver Meal Heuristics, and Least Unit Cost.	2
8.4	MRP II	1
9.0	Operations Scheduling	
9.1	Scheduling – Types, functions and objectives.	1
9.2	Sequencing n jobs on one machine – Schedule using Priority dispatch rules (FCFS, SPT,EDD, LCFS, and Critical Ratio)	1
9.3	Sequencing ‘n’ jobs in Flow shop – Johnson, CDS and Palmer Algorithms.	2
9.4	Sequencing ‘n’ jobs in Job shop – Two jobs on M machines, Gantt chart.	2
10.0	Project management	
10.1	PERT	1
10.2	CPM	1
11.0	Just –In-Time (JIT) and Lean Systems	

S.NO	Topics	No. of Lectures
11.1	JIT logic	1
11.2	Toyota Production system (Lean Manufacturing)	1
11.3	JIT Implementation requirements	1
11.4	JIT in services	1
Total		38

Course Designers

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		Category	L	T	P	Credit
18MGPP0	**OPTIMIZATION TECHNIQUES**	PC	3	0	0	3

Preamble

Optimization 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. Various techniques of optimization have been dealt on the title “Operations Research”. Because of the complexity of most real-world optimization problems, it has been necessary for researchers and practitioners to reduce the complexity of the problem by either simplifying the problem or constraining it by making reasonable assumptions. Besides, the decisive factor is significant in bringing the products to market in order to guarantee profit in today’s challenging environment of manufacturing industries, with its changing needs, shorter product life cycle, and tighter deadlines. On this consideration, a major focus on the techniques and stratagems relevant to manufacturing applications has been given. Linear, integer and non-linear programming problems, and network models are addressed primarily. Further, intelligent search heuristics are introduced to appreciate the concepts so as to apply them in solving large-scale manufacturing problems.

Prerequisite

- Nil

Course Outcomes

On successful completion of the course, students will be able to

CO. No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Formulate mathematical models of Linear Programming (LP), Integer Programming (IP), Networks and Non-linear Programming (NLPP) problems.	Apply	70	60
CO2	Solve Linear Programming Problems (LPP) by appropriate techniques (i.e. Graphical, Simplex method) and evaluate the behaviour under different range of parameters.	Analyse	60	50
CO3	Solve Integer Programming Problems (IPP) using branch and bound, and cutting plane method	Apply	70	60
CO4	Examine the performance characteristics such as time and cost in solving shortest route, flow, transportation and assignment problems with an appropriate model	Analyse	60	50
CO5	Solve unconstrained and constrained Non-Linear Programming Problems (NLPP) using appropriate techniques.	Apply	70	60
CO6	Explain the concept and working of emerging intelligent search techniques such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), and Simulated Annealing Algorithm (SAA).	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	M	M					M		
CO2	S	S	M	M					M		
CO3	S	M	M	M					M		
CO4	S	S	M	M			M		M		
CO5	S	M	M	M					M		
CO6	M	L							L		

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	-	10	-	5
Understand	20	10	20	10
Apply	60	60	40	45
Analyse	20	20	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. A company produces two types of goods A and B that require gold and silver. Each unit of type A requires 3 grams of silver and 1 gram of gold while B requires 1 grams of silver and 2 grams of gold. The company can produce 9 grams of silver and 8 grams of gold. If each unit of type A brings a profit of Rs.40 and that of type B Rs.50, determine the number of units of each type that should be produced to maximize the profit. Formulate the LP Model and find the optimal product mix and the corresponding profit of the company using simplex method.
2. A firm manufactures two products A and B on which the profits earned per unit are Rs. 3 and Rs. 4, respectively. Each product is processed on two machines M1 and M2. Product A requires one minute of processing time on M1 and two minutes on M2, while B requires one minute on M1 and one minute on M2. Machine, M1 is available for not more than 7 hours 30 minutes, while machine M2 available for 10 hours during any working day. Formulate the problem as LPP to find the number of units of products A and B to be manufactured to get maximum profit and solve this LPP using the result of the its dual problem.

3. Four factories, A, B, C and D produce sugar and the capacity of each factory is given below: Factory A produces 10 tons of sugar and B produces 8 tons of sugar, C produces 5 tons of sugar and that of D is 6 tons of sugar. The sugar has demand in three markets X, Y and Z. The demand of market X is 7 tons, that of market Y is 12 tons and the demand of market Z is 4 tons. The following matrix gives the transportation cost of 1 ton of sugar from each factory to the destinations. Develop a mathematical model for determining least cost transportation cost.

Factories.	*Cost in Rs. per ton (× 100) Markets.*			*Availability in tons.*
	X	*Y*	*Z*	
A	4	3	2	10
B	5	6	1	8
C	6	4	3	5
D	3	5	4	6
Requirement in tons.	7	12	4	

Course Outcome 2 (CO2):

1. A company produces both interior and exterior paints from two raw materials, M_1 and M_2.The following table 1 provides the basic data of the problem:

Table 1

	Tonnes of raw material per tonne of		
	Exterior Paint	Interior Paint	Maximum Daily Availability (Tonnes)
Raw Material, M1	6	4	24
Raw Material, M2	1	2	6
Profit per tonne(Rs.'000)	5	4	

A market survey indicates that the daily demand for interior paint cannot exceed that for exterior paint by more than 1 tonne. Also, the maximum daily demand for interior paint is 2 tonnes. The company wants to determine the optimum (best) product mix of interior and exterior paints that maximizes the total daily profit. Use simplex method to obtain the optimal solution.

2. The problem of maximising the overall profits for product mix with given the resource constraints is formulated as linear program given as: Maximise $Z = 3x_1 + 5x_2$; Subject to: $x_1 \leq 4$; $3x_1 + 2x_2 \leq 0$; $x_1, x_2 \geq 0$. The optimal table is given in Table 2.

Table 2

C_j		3	5	0	0	b_i
C_B	Basic Variables	x_1	x_2	S_1	S_2	
0	S_1	1	0	1	0	4
5	x_2	$\frac{3}{2}$	1	0	$\frac{1}{2}$	9
C_j-Z_j		$\frac{-9}{2}$	0	0	$\frac{-5}{2}$	Z = 45

If a new product (variable) x_3 is included in the existing product mix. The profit per unit of the new product is Rs. 7 and its rates of consumption in the constraints are 1 and 2, respectively. Check whether the inclusion of the new product changes the optimality and if it changes the optimality, find the revised optimal solution.

3. Solve the dual of the following LPP and determine the values of the primal decision variables.

Maximise $Z = 3x_1 + 2x_2$

Subject to constraints, $x_1 + x_2 \geq 1$

$x_1 + x_2 \leq 7$
$x_1 + 2x_2 \leq 10$
$x_1, x_2 \geq 0$

Course Outcome 3 (CO3):

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 as integer programming model and determine the production volume of each of product such that the total profit is maximized.
2. Solve the following:

Maximise $Z = 5x_1 + 10x_2 + 8x_3$

Subject to $2x_1 + 5x_2 + x_3 \leq 10$

$x_1 + 4x_2 + 2x_3 \leq 12$

$x_1, x_2, x_3 \geq 0$ and are integers

3. Solve the following integer programming problem using Branch and Bound method.

Maximise $Z = 2x_1 + 3x_2$

Subject to $6x_1 + 5x_2 \leq 25$

$x_1 + 3x_2 \leq 10$

$x_1, x_2 \geq 0$ and are integers

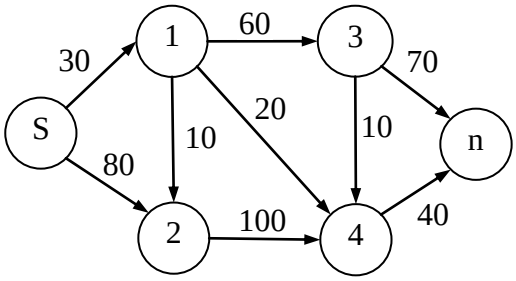
Course Outcome 4 (CO4):

1. A company has five jobs V, W, X, Y and Z and five machines A, B, C, D and E. The given matrix shows the return in Rs. of assigning a job to a machine. Assign the jobs to machines using Hungarian Method so as to maximize the total returns.

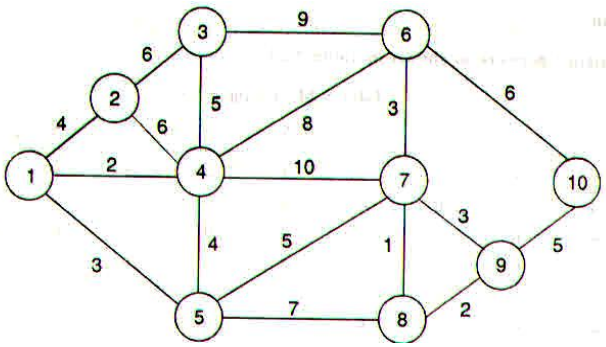
Machines. Returns in Rs.

Jobs	*A*	*B*	*C*	*D*	*E*
V	5	11	10	12	4
W	2	4	6	3	5
X	3	12	5	14	6
Y	6	14	4	11	7
Z	7	9	8	12	5

2. A network as shown in figure 3, has the maximum flow of 70 units between ‘S’ and ‘n’. If the direction of the arc between nodes 1 and 4, has been reversed, is there any changes in the flow? If so, determine the revised maximum flow between the source, *S* to sink, *n* and justify the same.



3. A company is interested in laying telephone cable in an area with 10 major locations, as shown in figure. The number on each arc represents the distances between the nodes connected by the arc. Suggest the company to provide the optimal lay scheme to connect all the locations.



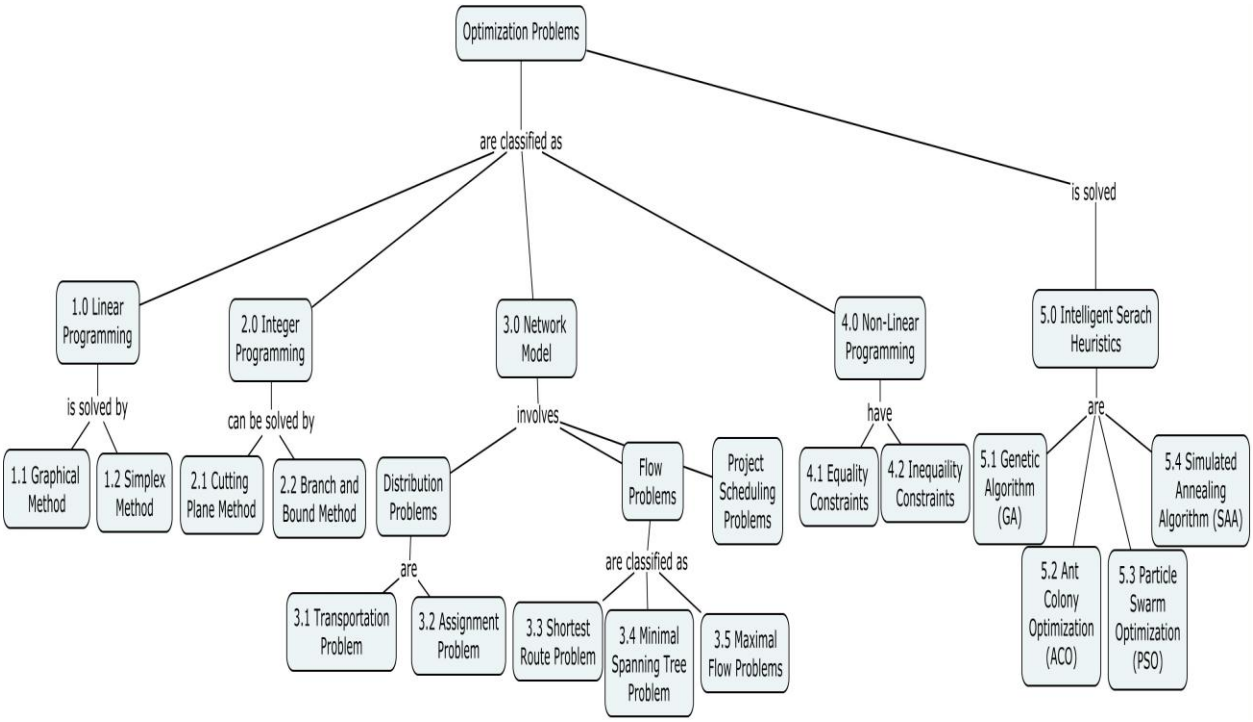
Course Outcome 5 (CO5):

1. Use Fibonacci search to: Maximize f(x) = $x^2 + \frac{54}{x}$; Subject to 0 ≤ x ≤ 5 with six evaluations and its final interval of uncertainty having a length less than 0.5.
2. Solve the following Non linear Programming Problem (NLPP),
   Minimise $z = x_1^2 + x_2^2 + x_3^2$
   Subject to, $4x_1 + x_2^2 + 2x_3 - 14 = 0$
3. Determine the value of x_1 & x_2 using Kuhn-Tucker's conditions
   Maximise $Z = 10\, x_1 - x_1^2 + 10x_2 - x_2^2$
   Subject to constraints, $x_1 + x_2 \leq 9$; $x_1 - x_2 \geq 6$

Course Outcome 6 (CO6):

1. Draw the flowchart for solving non-linear programming problem using Binary Genetic Algorithm and explain the step by step procedure with an illustration.
2. Explain the principle of Particle Swarm Optimization (PSO) and mention its advantages and limitations over Genetic Algorithm.
3. Discuss the parameters involved in Ant Colony Optimization (ACO) to solve the non-linear programming problem with constraints.

Concept Map



Syllabus

Linear Programming: Formulation - Graphical Method and Simplex Method – Primal Vs. Dual relationships - Sensitivity Analysis. **Integer Programming**: Formulation - Branch and Bound Method - Cutting Plane Method; **Network Model:** Network Construction – Terminologies - Transportation problems – Solution using u-v method – Assignment problems – Solution using Hungarian Method - Shortest route problems, Minimal Spanning Tree problems, Maximal Flow problems; **Nonlinear Programming Nonlinear Programming (with Equality Constraints)** Lagrangian Multiplier - Equality constrained optimization -Projected Gradient Methods with equality constraints; **Nonlinear Programming (Inequality Constraints):** Khun concept - Khun Tucker conditions; **Intelligent search heuristics**: Concept – principle and parameters of Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO) and Simulated Annealing Algorithm (SAA).

Reference Books / Learning Resources

1. Winston, Wayne L, and Jeffrey B. Goldberg. Operations Research: Applications and Algorithms, 7th Edition, Thomson/Brooks/Cole Belmont, CA, 2004.
2. David R. Anderson, Dennis J. Sweeney, Thomas A. Williams, Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, “Quantitative Methods for Business, Twelfth Edition, Cengage Learning, South-Western, 2013.
3. Ravindran, Don. T. Phillips, and James J. Solberg, “Operations Research - Principles and Practice”, Second Edition, John Wiley and Sons, 2007.
4. Frederick Hillier, Gerald Lieberman, “Introduction to Operations Research” Tenth Edition, Tata McGraw Hill, 2015.
5. Hamdy A. Taha, “Operations Research - An Introduction”, 7th Edition, MacMillan Co., 2010.
6. Kalyanmoy Deb, “Optimisation for Engineering Design – Algorithms and Examples”,2nd Edition, Eastern Economy Edition, PHI Learning Pvt. Limited, New Delhi, 2012.

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
	Introduction to Optimisation techniques - Classification	1
1.0	Linear Programming – Concept – Applications - Formulation – Single Objective problems	2
1.1	Graphical Method	1
1.2	Simplex Method	2
1.2.1	Primal Vs. Dual relationships	1
1.2.2	Sensitivity Analysis	2
2.0	Integer Programming Problem (IPP) - Formulation	2
2.1	Cutting Plane Method	1
2.2	Branch and Bound Method	2
3.0	Network Model: Network Construction– Terminologies	1
3.1	Transportation problems – Solution using u-v method	2
3.2	Assignment problems – Solution using Hungarian Method	1
3.3	Flow Problems – Concepts – Terminologies - Shortest route problems	2
3.4	Minimal Spanning Tree problems	1
3.5	Maximal Flow problems	2
4.0	Nonlinear Programming (NLP) - Concepts – Terminologies – Classification - Constrained NLP Problems - Basic Concepts - Formulation	2
4.1	NLP problems with Equality Constraints - Basic Concepts- Applications	1
4.1.1	Lagrangian Multiplier Method	1
4.2	NLP problems with Inequality Constraints - Basic Concepts – Applications – Formulation	1
4.2.1	Khun concept - Khun Tucker conditions	2
5.0	Intelligent search heuristics: Concept	1
5.1	Principle and parameters of Genetic Algorithm (GA)	1
5.2	Principle and parameters of Ant Colony Optimisation (ACO)	1
5.3	Principle and parameters of Particle Swarm Optimisation (PSO)	1
5.4	Principle and parameters of Simulated Annealing Algorithm (SAA)	1
Total		**35**

Course Designers:

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18MGPU0 SUPPLY CHAIN MANAGEMENT Category L T P Credit

PE 3 0 0 3

Preamble

Supply Chain Management (SCM) is the management of a network of interconnected businesses in the ultimate provision of product and service packages required by end customers. Supply chain management spans all movement and storage of raw materials, work-in-process inventory,and finished goods from point of origin to point of consumption. Organizations increasingly find that they must rely on effective Supply Chain, or networks, to compete in the global market and networked economy. Concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize entire business processes throughout a value chain of multiple components. During the past decades, globalization, outsourcing and information technology have enabled to successfully operate solid collaborative supply networks in which each specialized business partner focuses on only a few key strategic activities. This inter-organizational supply network can be acknowledged as a new form of organization.

Prerequisite

- Probability and statistics

Course Outcomes

On successful completion of the course, students will be able to

CO.No	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected Attainment Level (%)
CO 1.	Explain important issues in the design of the logistics network, inventory management and risk pooling	Understand	80	70
CO 2.	Explain the value of information, Distribution strategies, and strategic alliances	Understand	80	70
CO 3.	Explain the International Supply Chain Management, supplier integration, customer value and Information Technology	Understand	80	70
CO 4.	Calculate the distribution cost, bullwhip effect, order quantity, and safety stock levels	Apply	70	60
CO 5.	Demonstrate case studies about distribution strategies, strategic alliances, and coordinated product design	Apply	70	60
CO 6.	Identify the ways of improving customer value, supplier integration, mass customization and integrating SC and IT.	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	M	M	M	M	L	L	L	L	L	L
CO2.	S	M	M	M	M	L	L	L	L	L	L
CO3.	S	S	M	M	S	L	L	L	L	L	L
CO4.	S	S	M	M	S	L	L	L	L	L	L
CO5.	S	S	S	M	S	M	M	S	L	L	M
CO6.	S	S	S	S	S	M	M	L	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	40	40	40	40
Apply	40	40	40	40
Analyze	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define SCM.
2. Give the issues important in the design of the logistics network.
3. Explain the key requirements and features of any decision-support system for network design.

Course Outcome 2 (CO2):

1. Explain the three distinct outbound distribution strategies.
2. Describe various types of Retailer-Supplier Partnerships?
3. Explain the factors that are to be considered to determine whether a particular strategic alliance is appropriate or not.

Course Outcome 3 (CO3):

1. Why SC integration is difficult? Explain.
2. What is Electronic Commerce?
3. Explain the requirements for global strategy implementation.

Course Outcome 4 (CO4):

1. Consider a manufacturer shipping a single fully loaded truck form Chennai to Indore. The manufacturer is using a TL carrier whose rate is Rs16.00 per mile per truck load. Calculate the transportation cost for this shipment. The longitude and latitude of Chennai is 13° 04' and 80° 17' and longitude and latitude of Indore is 22º43' and 75º49'.

2. A distribution company is involved in the distribution of TV sets. Whenever the distributor places an order for TV sets, there is a fixed cost of Rs2,00,000/- which is independent of the order size.

Parameter	Average Weekly demand	Safely stock	Reorder point
Value	44.58	86	176

The cost of TV set to the distributor is Rs12,000 and annual holding cost is about 16% of the product cost. Find the weekly inventory holding cost, optimal order quantity and Order- up-to level.

3. Weekly demand for HP printers at Sam's club store is normally distributed, with a mean of 250 and a standard deviation of 150. The store manager continuously monitors inventory and currently orders 1,000 printers each time the inventory drops to 600 printers. HP currently takes two weeks to fill an order. How much safety inventory does the store carry? What CSI does Sam's club achieve as a result of this policy? What fill rate does the store achieve?

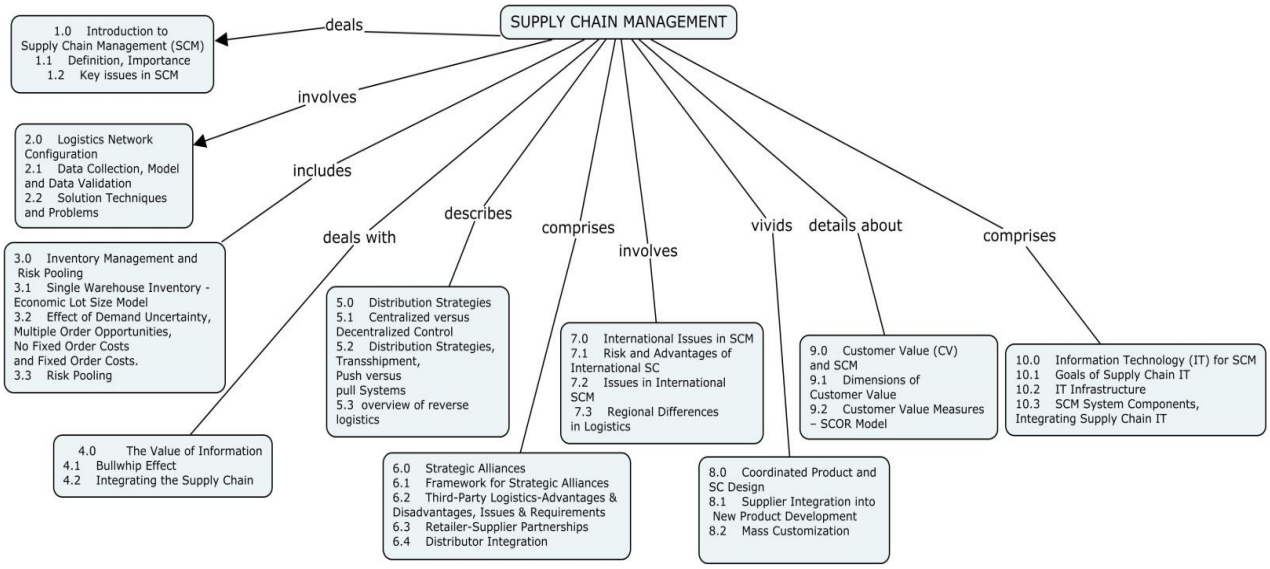
Course Outcome 5 (CO5):

1. Demonstrate the functioning of Amazon's supply chain network.
2. Review the effects of VMI implementation with two cases study examples.
3. Comment the statement "Information is the key enabler of integrating different SC stages with trade-offs.

Course Outcome 6 (CO6):

1. Clarify with example case studies, how information technology is used to enhance customer value in supply chain?
2. Identify and expose a case study for the successful implementation of delayed product differentiation.
3. Comment on the ERP implementation experiences of the coffee producers M/s Starbucks and M/s Green Mountain.

Concept Map



Syllabus

Introduction to Supply Chain Management (SCM): Definition, Importance, Key issues in SCM **Logistics Network Configuration**: Data Collection, Model and Data Validation, Solution Techniques and Problems, **Inventory Management and Risk Pooling:** Single Warehouse Inventory - Economic Lot Size Model, Effect of Demand Uncertainty, Multiple Order Opportunities, No Fixed Order Costs and Fixed Order Costs. Risk Pooling. **The Value of Information**: Bullwhip Effect Integrating the SC. **Distribution Strategies:** Centralized versus Decentralized Control, Distribution Strategies, Transshipment, Push versus pull Systems, overview of Reverse Logistics . **Strategic Alliances**: A Framework for Strategic Alliances, Third-Party Logistics- Advantages & Disadvantages, Issues and Requirements, Retailer-Supplier Partnerships, Distributor Integration. **International Issues in SCM:** Risk and Advantages of International SC, Issues in International SCM, Regional Differences in Logistics. **Coordinated Product and SC Design**: Supplier Integration into New Product Development, Mass Customization. **Customer Value (CV) and SCM**: Dimensions of Customer Value, Customer Value Measures – SCOR Model. **Information Technology (IT) for SCM**: Goals of Supply Chain IT, IT Infrastructure, SCM System Components, Integrating Supply Chain IT.

Reference Books

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi Edith, “Designing and Managing the Supply Chain”, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2008
2. A.RaviRavindran, Donald P.Waesing Jr “Supply Chain Engineering: Models and Applications” CRC Press, 2013

3. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Second Edition, Prentice Hall India Pvt. Ltd, New Delhi, 2012.
4. R.P.Mohanty, S.G.Deshmukh, “Supply Chain Management Theories & Practices”, biztantra 2012
5. Sahay B S, “Supply Chain Management”, Macmillan Company, 2001.
6. David Brunt and David Taylor, “Manufacturing Operations and Supply Chain Management : The Lean Approach”, Vikas Publishing House, New Delhi, 2002.

Course Contents and Lecture schedule

Sl.No	TOPICS	No. of Lectures
1.0	**Introduction to Supply Chain Management (SCM)**	
1.1	Definition, Importance	1
1.2	Key issues in SCM	1
2.0	**Logistics Network Configuration**	
2.1	Data Collection, Model and Data Validation	2
2.2	Solution Techniques and Problems	2
3.0	**Inventory Management and Risk Pooling**	
3.1	Single Warehouse Inventory - Economic Lot Size Model	2
3.2	Effect of Demand Uncertainty, Multiple Order Opportunities, No Fixed Order Costs and Fixed Order Costs.	1
3.3	Risk Pooling	2
4.0	**The Value of Information**	
4.1	Bullwhip Effect	1
4.2	Integrating the Supply Chain	1
5.0	**Distribution Strategies**	
5.1	Centralized versus Decentralized Control	1
5.2	Distribution Strategies, Transshipment, Push versus pull Systems	2
5.3	Overview of Reverse Logistics	1
6.0	**Strategic Alliances**	
6.1	Framework for Strategic Alliances	2
6.2	Third-Party Logistics-Advantages & Disadvantages, Issues & Requirements	1
6.3	Retailer-Supplier Partnerships	2
6.4	Distributor Integration	1
7.0	**International Issues in SCM**	
7.1	Risk and Advantages of International SC	2
7.2	Issues in International SCM	1

7.3	Regional Differences in Logistics	1
8.0	**Coordinated Product and SC Design**	
8.1	Supplier Integration into New Product Development	1
8.2	Mass Customization	2
9.0	**Customer Value (CV) and SCM**	
9.1	Dimensions of Customer Value	2
9.2	Customer Value Measures – SCOR Model	1
10.0	**Information Technology (IT) for SCM**	
10.1	Goals of Supply Chain IT	2
10.2	IT Infrastructure	1
10.3	SCM System Components, Integrating Supply Chain IT	2
	Total	38

Course Designers

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18MGPV0	SURFACE ENGINEERING AND COATING TECHNOLOGY	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Failure of engineering components mostly occurred at surface of materials because stress region are often highest at surface and surface encounters the environment. The selection of material with appropriate mechanical, thermal, Optical and electrical properties is crucial. The engineering material should have high resistance to wear, Friction and corrosion. This course is aims to impart knowledge about various failure of metals such as wear, Friction and corrosion also surface modification through various coating technologies to improve the functionality and life of components.

Prerequisite

- Nil

Course Outcomes

On successful completion of the course, students will be able to

CO No	Course Outcome	Blooms Level	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Explain the fundamentals of surface engineering	Understand	80	70
CO2	Illustrate principle and evaluation of surface tribology such as friction, Wear and corrosion	Understand	80	70
CO3	Select the suitable coating technique for surface treatment.	Apply	70	60
CO4	Identify the surface modification of components using suitable characterization techniques	Apply	70	60
CO5	Calculate the wear coefficient of given material and analyse the micro structure using scanning electron microscope (Practical – continuous assessment only)	Analyse	60	50

Mapping with Programme Outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.	S	S	-	M	-	-	-	-	-	-	-
CO2.	S	S	-	M	-	-	-	-	-	-	-
CO3.	S	S	-	S	-	-	M	-	M	-	-
CO4.	S	S	-	S	-	-	M	-	M	-	-

CO5.	S	S	S	S	S	-	M	M	M	-	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	60	60	60
Apply	0	20	20	20
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

CO5: Assignments for Continuous Assessment (10 Marks)

The individual student / group of students of maximum number of two have to determine wear coefficient of the different materials using pin on disc tribometer and analyse the microstructure using scanning electron microscope involving the following areas:

- Selection of bio material based on application and cost
- Experimentation for calculation of wear coefficient of the different materials using pin on disc tribometer
- Microstructure analysis using scanning electron microscope

The internal assignment mark will be based on the presentation, report submission and oral examination on the same by team of faculties/course handling faculties.

Course Level Assessment Questions

Course outcome 1:

1. Define Root Mean Roughness.
2. Explain the various surface interaction

Course outcome 2:

1. Define rolling friction
2. Discuss the various components and elements of surface topolography.
3. Define Fretting Wear.
4. Briefly explain the fatigue wear and abrasive wear with examples.
5. Explain the factors to be considered in preventing the wear of metals and non-metals.
6. Define Pilling-Bedworth ratio.
7. Explain the corrosion control by proper designing and selection of materials Give some practical examples.

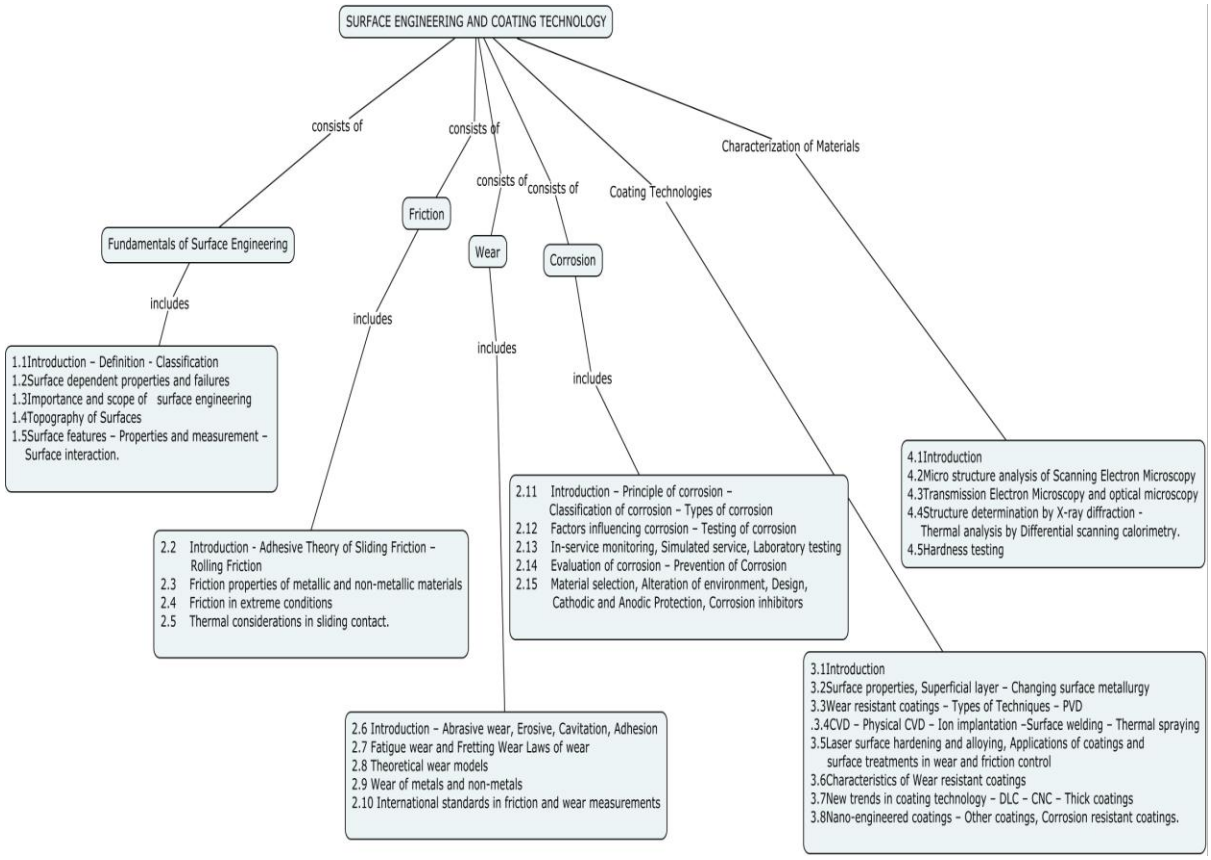
Course outcome 3:

1. Explain in detail the Ion implantation, surface welding and thermal spraying. Give examples for each.
2. Explain the process of Laser surface hardening.
3. Select suitable coating techniques which is used for producing thin films by depositing different kind of foreign materials over the surface of silicon substrates and explain in detail.

Course outcome 4:

1. Explain the working principle of Transmission electron microscopy with neat diagram.
2. Explain the working principle of thermal analysis by Differential scanning calorimetry.

Concept Map



Syllabus

Fundamentals of Surface Engineering: Introduction - Definition,- Classification – surface dependent properties and failures, importance and scope of surface engineering - Topography of Surfaces – Surface features – Properties and measurement – Surface interaction.

Surface Tribology: Introduction – Classification - Friction, Wear and corrosion, **Friction:** Introduction - Adhesive Theory of Sliding Friction – Rolling Friction – Friction properties of metallic

and non-metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact. **Wear :**Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear Laws of wear – Theoretical wear models – Wear of metals and non-metals – International standards in friction and wear measurements

Corrosion: Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion – Factors influencing corrosion – Testing of corrosion – In-service monitoring, Simulated service, Laboratory testing – Evaluation of corrosion – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors

Coating Technologies: Introduction – Surface properties, Superficial layer – Changing surface metallurgy – Wear resistant coatings – Types of Techniques – PVD – CVD – Physical CVD – Ion implantation –Surface welding – Thermal spraying – Laser surface hardening and alloying, Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology – DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coatings.

Characterization of Materials: Introduction – Micro structure analysis of Scanning Electron Microscopy, Transmission Electron Microscopy and optical microscopy - Structure determination by X-ray diffraction - Thermal analysis by Differential scanning calorimetry.-Hardness testing.

Calculate the wear coefficient of given material and analyse the micro structure using scanning electron microscope (Practical – continuous assessment only)

Text Book

1. G.W.Stachowiak & A.W .Batchelor , “Engineering Tribology”, Third Edition ,Butterworth Heinemann, UK,2005
2. Rabinowicz.E, “Friction and Wear of materials”, Second Edition: John Willey &Sons ,UK,2013
3. S.K.Basu, S.N.Sengupta & B.B.Ahuja ,”Fundamentals of Tribology”, Prentice –Hall of India Pvt Ltd , New Delhi, 2005
4. NPTEL (https://onlinecourses.nptel.ac.in/noc17_mm05/preview)
5. NPTEL (https://onlinecourses.nptel.ac.in/noc18_me66/preview)

Course Contents and Lecture Schedule

S.No.	Topic	No. of Lectures
1	**Fundamentals of Surface Engineering**	
1.1	Introduction – Definition - Classification	1

S.No.	Topic	No. of Lectures
1.2	Surface dependent properties and failures	1
1.3	Importance and scope of surface engineering	1
1.4	Topography of Surfaces	1
1.5	Surface features – Properties and measurement – Surface interaction.	1
2	**Surface Tribology**	
2.1	Introduction – Classification - Friction, Wear and corrosion	1
	Friction	
2.2	Introduction - Adhesive Theory of Sliding Friction – Rolling Friction	1
2.3	Friction properties of metallic and non-metallic materials	1
2.4	Friction in extreme conditions	1
2.5	Thermal considerations in sliding contact.	1
	Wear	
2.6	Introduction – Abrasive wear, Erosive, Cavitation, Adhesion	1
2.7	Fatigue wear and Fretting Wear Laws of wear	1
2.8	Theoretical wear models	1
2.9	Wear of metals and non-metals	1
2.10	International standards in friction and wear measurements	1
	Corrosion:	
2.11	Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion	2
2.12	Factors influencing corrosion – Testing of corrosion	1
2.13	In-service monitoring, Simulated service, Laboratory testing	1
2.14	Evaluation of corrosion – Prevention of Corrosion	1
2.15	Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors	1
3	**Coating Technologies**	
3.1	Introduction	1
3.2	Surface properties, Superficial layer – Changing surface metallurgy	

S.No.	Topic	No. of Lectures
3.3	Wear resistant coatings – Types of Techniques – PVD	1
.3.4	CVD – Physical CVD – Ion implantation –Surface welding – Thermal spraying	2
3.5	Laser surface hardening and alloying, Applications of coatings and surface treatments in wear and friction control	1
3.6	Characteristics of Wear resistant coatings	1
3.7	New trends in coating technology – DLC – CNC – Thick coatings	2
3.8	Nano-engineered coatings – Other coatings, Corrosion resistant coatings.	2
4	**Characterization of Materials**	1
4.1	Introduction	1
4.2	Micro structure analysis of Scanning Electron Microscopy	1
4.3	Transmission Electron Microscopy and optical microscopy	1
4.4	Structure determination by X-ray diffraction - Thermal analysis by Differential scanning calorimetry.	
4.5	Hardness testing	1
Total		36

Course Designers

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