CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Manufacturing Engineering) PROGRAMME

FIRST TO FOURTH SEMESTER COURSES
&
ELECTIVES

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

THIAGARAJAR COLLEGE OF ENGINEERING

(A Govt. Aided Autonomous Institution affiliated to Anna University)

MADURAI – 625 015, TAMILNADU
Phone: 0452 – 2482240, 41
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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**	-	-	-	18XXGX0 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

COURSES OF STUDY

(For the candidates admitted from 2018-2019 onwards)

SECOND SEMESTER

Course code	Name of the course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
18MG210	Tool Design Engineering	PC	3	0	-	3
18MGPX0	Programme Elective II	PE	3	0	-	3
18MGPX0	Programme Elective III	PE	3	0	-	3
18MGPX0	Programme Elective IV	PE	3	0	-	3
18PG250	Research Methodology and IPR	CC	2	0	-	2
THEORY CUM PRACTICAL						
18MG260	CNC Machine Tool Technology	PC	2	0	2	3
PRACTICAL						
18MG270	Automation Laboratory	PC	-	-	4	2
18MG280	Mini Project		-	-	4	2
Total						**21**

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

COURSES OF STUDY

(For the candidates admitted from 2018-2019 onwards)

THIRD SEMESTER

Course code	Name of the course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
18MGPX0	Programme Elective-V	PE	3	0	-	3
18XXGX0	Open Elective	OE	2	0	-	2
PRACTICAL						
18MG380	Dissertation Phase – I	PC	-	-	10	10
Total						**15**

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

COURSES OF STUDY

(For the candidates admitted from 2018-2019 onwards)

FOURTH SEMESTER

Course code	Name of the course	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
18MG480	Dissertation Phase – II	PC	-	-	15	15
Total						**15**

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

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
18PGAX0	Audit Course	AC	2	-	-	2
Total						**15**

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)

SECOND 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	18MG210	Tool Design Engineering	3	50	50	100	25	50
2	18MGPX0	Programme Elective II	3	50	50	100	25	50
3	18MGPX0	Programme Elective III	3	50	50	100	25	50
4	18MGPX0	Programme Elective IV	3	50	50	100	25	50
5	18PG250	Research Methodology and IPR	3	50	50	100	25	50
THEORY CUM PRACTICAL								
6	18MG260	CNC Machine Tool Technology*	3	50	50	100	25	50
PRACTICAL								
7	18MG270	Automation Laboratory	3	50	50	100	25	50
8	18MG280	Mini Project	-	150	150	300	75	150

* 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.

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M.E. DEGREE (Manufacturing Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2018-2019 onwards)

THIRD 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	18MGPX0	Programme Elective-V	3	50	50	100	25	50
2	18XXGX0	Open Elective	3	50	50	100	25	50
PRACTICAL								
3	18MG380	Dissertation Phase – I	-	150	150	300	75	150

FOURTH 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
PRACTICAL								
4	18MG380	Dissertation Phase – I	-	150	150	300	75	150

Audit Courses

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
5	18PGAA0	Professional Authoring	-	100	-	100	-	50
6	18PGAB0	Value Education	-	50	50	100	25	50

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
		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.	18IEPD0	Lean Manufacturing and Six Sigma	PE	3
20.	18MGPH0	Machine Vision	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
28.	18IE210	Quality and Reliability Engineering	PE	3
29.	18MGPS0	Additive Manufacturing	PE	3

Sl. No	Course Code	Name of the Course	Category	Credit
30.	18IEPM0	Robust Design	PE	3
31.	18MGPU0	Supply Chain Management	PE	3
32.	18MGPV0	Surface engineering and coating technology	PE	3
33.	18MGPW0	Materials Characterization Techniques	PE	3
		Open Elective Courses		
34.	18MGGA0	Multi Objective Optimization	OE	2

List of Electives Passed

S.No	Course Code	List of Programme Electives
1.	18MGPB0	Composite Materials
2.	18MGPD0	Design for Manufacture and Assembly
3.	18MGPE0	Fluid Power Automation
4.	18MGPF0	Geometric Modeling
5.	18IEPD0	Lean Manufacturing and Six Sigma
6.	18MGPH0	Machine Vision
7.	18MGPJ0	Mechanics of Metal Cutting and Metal Forming
8.	18MGPKO	Metal Joining Engineering
9.	18MGPL0	Micro Electro Mechanical Systems
10.	18MGPM0	Non Destructive Evaluation
11.	18MGPQ0	Plant Layout and Material Handling
12.	18IE210	Quality and Reliability Engineering
13.	18MGPS0	Additive Manufacturing
14.	18IEPM0	Robust Design
15.	18MGPW0	Materials Characterization Techniques
		Open Elective Courses
16.	18MGGA0	Multi Objective Optimization

18MG110	COMPUTATIONAL METHODS	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 $y''+3y'+2y=x,\ y(0)=1,\ y(1)=0$ by using Collocation methods.
3. Solve $y'' + xy = 2, y(0) = 0$ and $y'(1) = 0$ 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 $u(0,t) = u(5,t) = 0, u_t(x.0) = 0$ and $u(x,0) = x^2(5-x)$ 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). $u(0,y) = 0$ for $0 \le y \le 4$ (ii). $u(4,y) = 12 + y$ for $0 \le y \le 4$
   (iii) $u(x,0) = 3x$ for $0 \le x \le 4$ (iv). $u(x,4) = x^2$ for $0 \le x \le 4$

Course Outcome 3 (CO3):

1. Write the finite difference approximation U_{xx} , 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 $u(0,y) = 0$, $u(4,y)=16y$ for $0 < y < 4$ and $u(x,0) = 0, u(x,4) = x^3$ for $0 < x < 4$ by relaxation method dividing the square plate with 16 square meshes of side 1 unit.

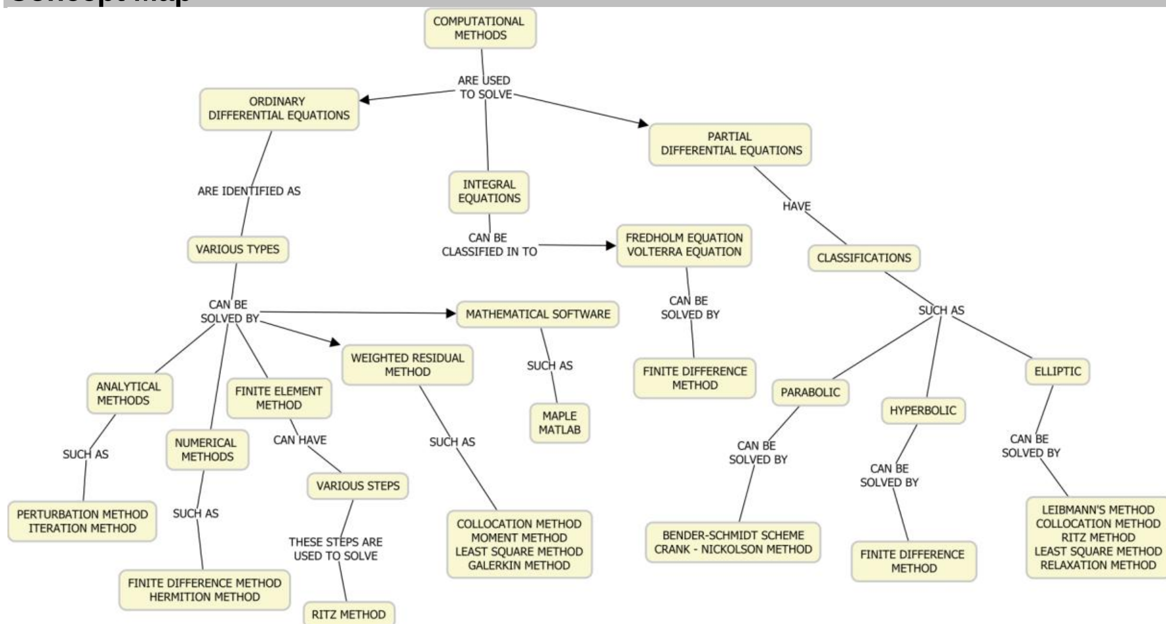
Course Outcome 4 (CO4):

1. State the advantages of finite element method.
2. Using Ritz finite element method solve $y'' = -2$ with $y(0)=0$ and $y(1)=1$ 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 $y'' + (1+\varepsilon x^2)y + 1 = 0,$ given $y(\pm 1) = 0$ 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, or 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

		Category	L	T	P	Credit
18MG120	**MECHANICAL BEHAVIOUR OF MATERIALS**	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.

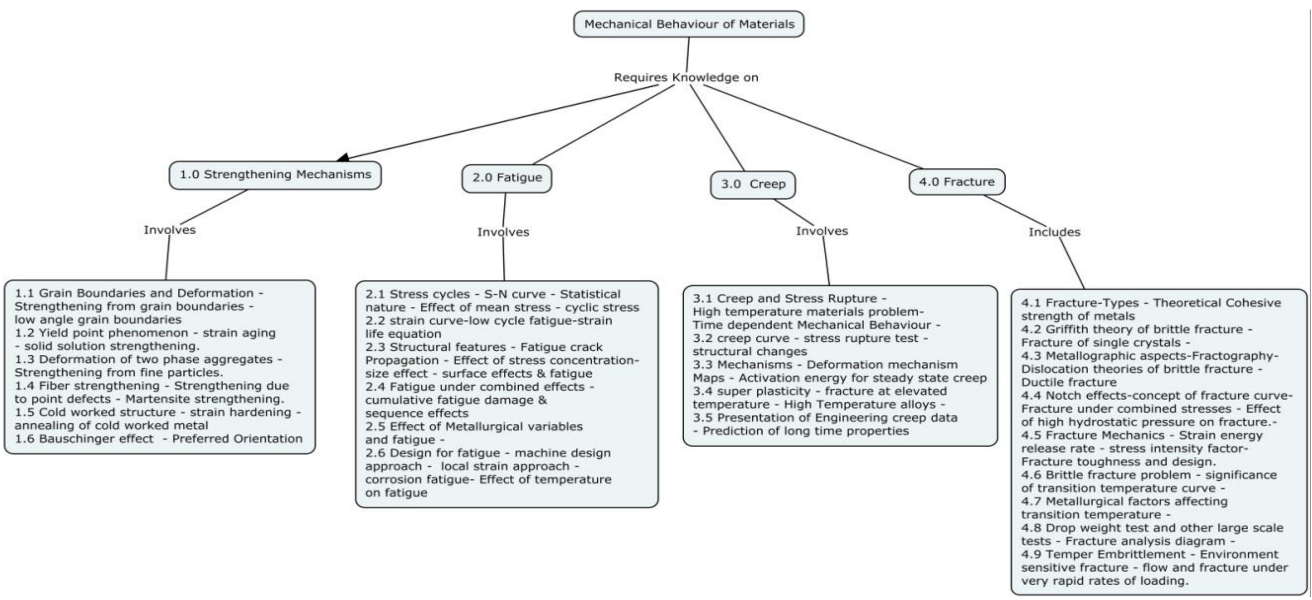
Course Outcome 3 (CO3):

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

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18MG130	**INDUSTRIAL AUTOMATION**	Category L T P Credit	
	(Common to 18IEPC0)	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.

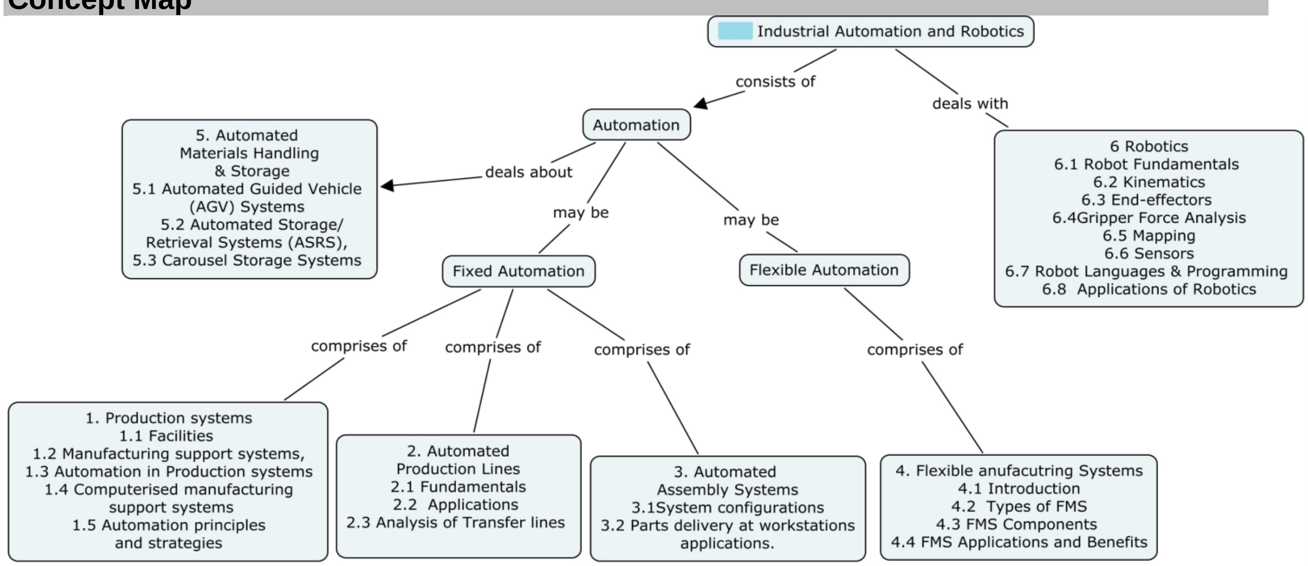
Course Outcome 5 (CO5):

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 $27.5 m/s^2$ 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
1.4	Computerized manufacturing support systems, Manual labour in	1

Module Number	Topics	No. of Lectures
	Production systems	
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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		Category	L	T	P	Credit
18MG160	**PRODUCT DESIGN AND DEVELOPMENT**	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
Analyse	0	0		0		Concept		50	15

						Modeling			
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

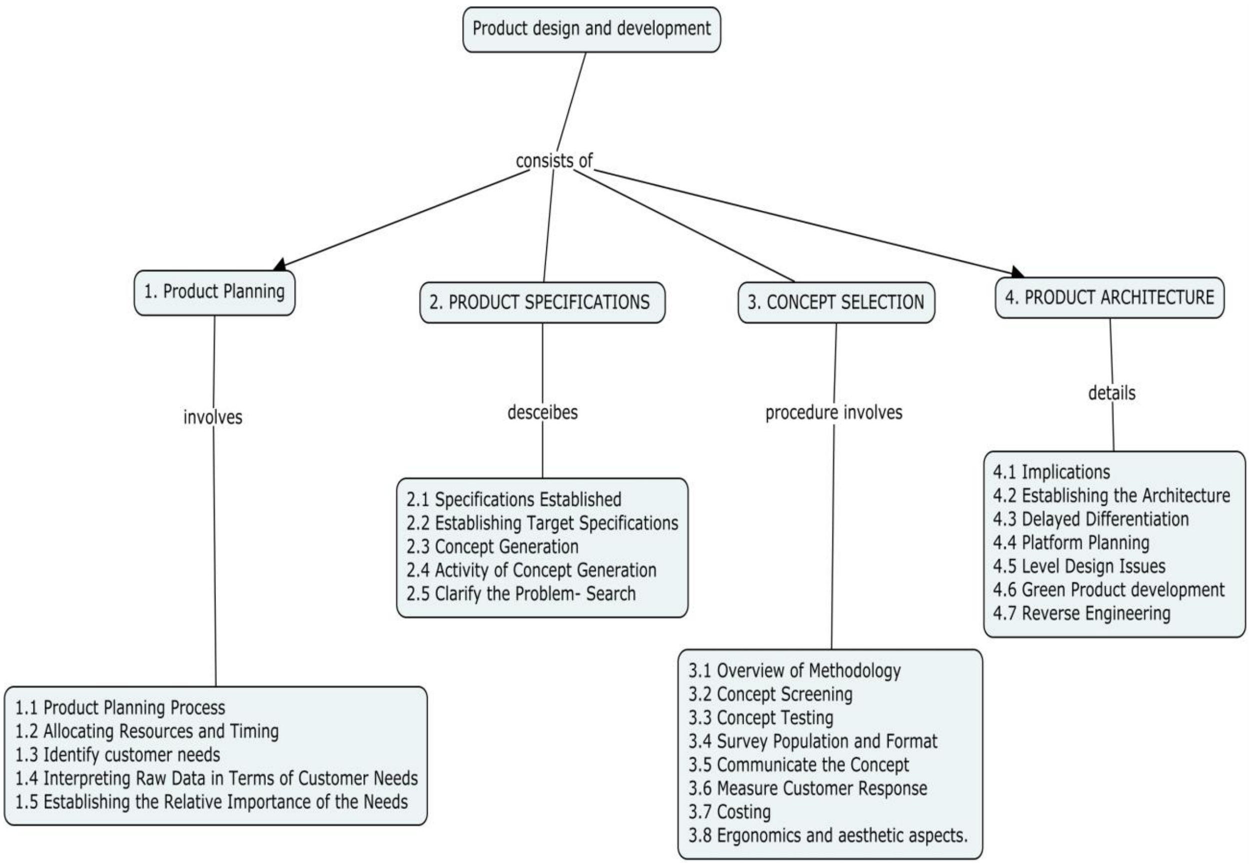
Course Outcome 4(CO4):

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

Reference 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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		Category	L	T	P	Credit
18MG170	**COMPUTER AIDED ENGINEERING LABORATORY**	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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18MGPA0	BIOMATERIALS	Category	L	T	P	Credit
		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.

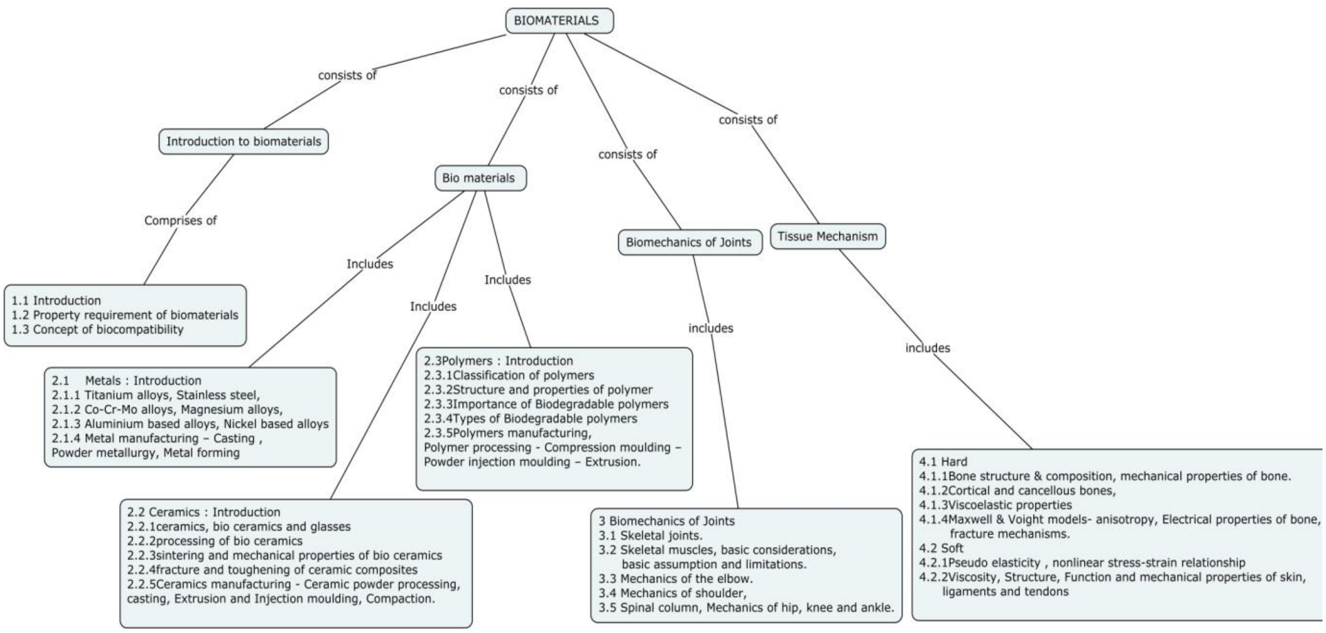
Course outcome 3:

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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2. Mr.T.Prakash tpmech@tce.edu

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

(Common to 18IEPA0)

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

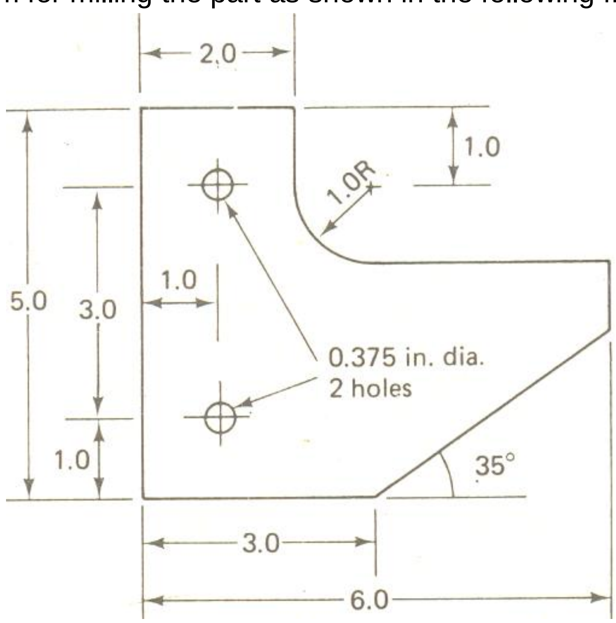
Course Level Assessment Questions

Course Outcome 1 (CO1):

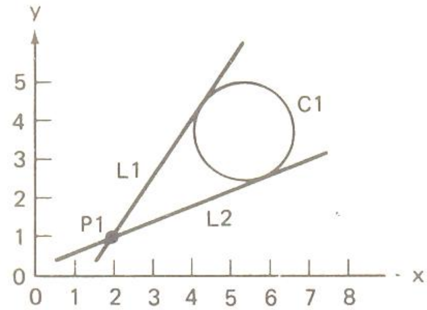
1. Develop a solid model of hollow cylinder of 15 mm thickness with inner diameter of 20 mm using sweep representation technique.
2. Suggest a suitable manipulation technique for joining two different solids.
3. Illustrate the Boundary representation and CSG technique with suitable solid model and compare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

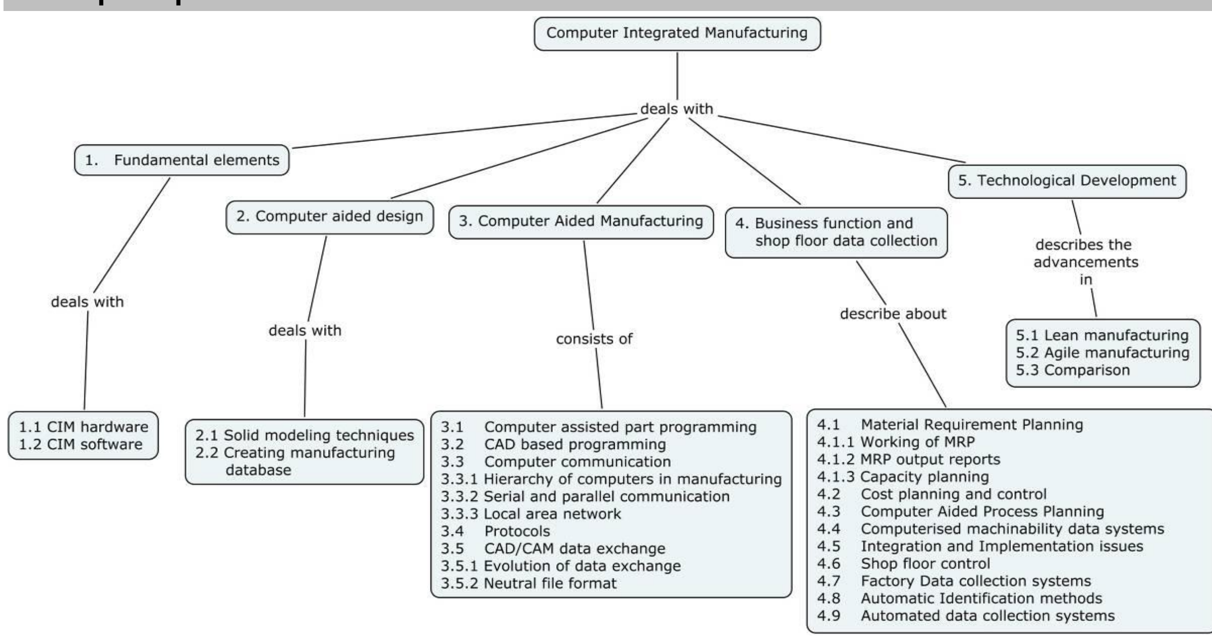
Course Outcome 4 (CO4):

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
3.5.1	Evolution of data exchange	1
3.5.2	Neutral file format-DXF, IGES and PDES	2

Module Number	Topics	No. of Lectures
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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2. Dr.C.Paramasivam cpmech@tce.edu

18MGPNO	**OPERATIONS MANAGEMENT**	Category	L	T	P	Credit
	(Common to 18IEPK0)	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 demand	25 per week
Order cost	$25.00	Lead time	1 week
Annual holding cost (%)	33% of item cost	Service level	95%
Annual demand	25,750		
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?

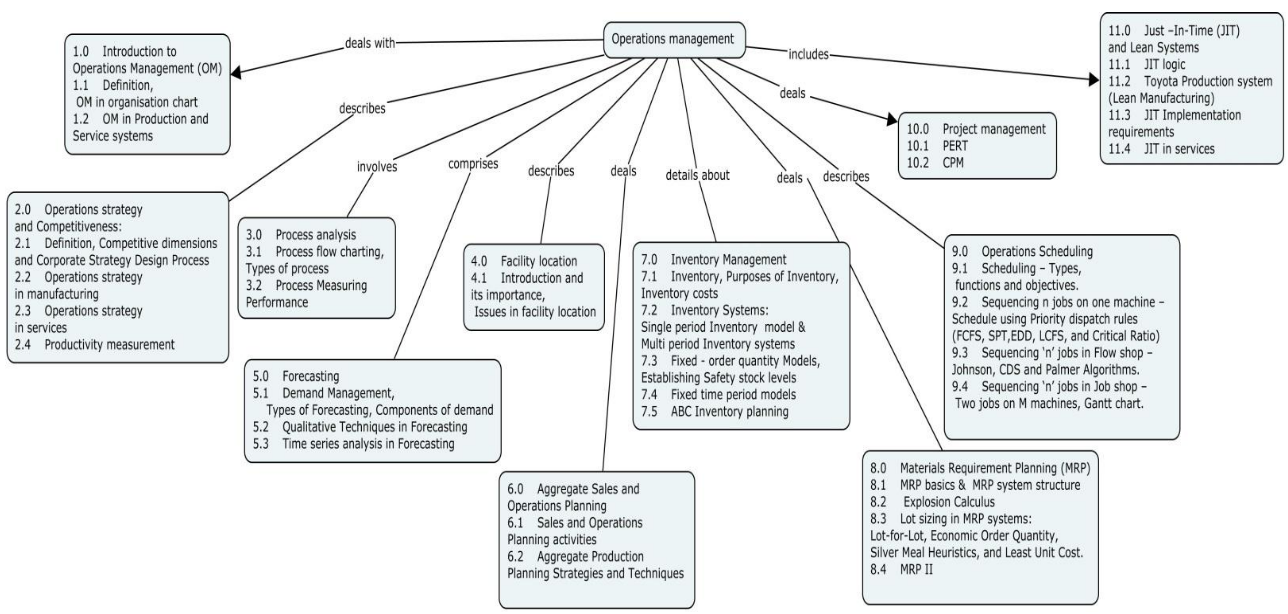
Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

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
2.4	Productivity measurement	1
3.0	**Process analysis**	
3.1	Process flow charting, Types of process	2

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

S.NO	Topics	No. of Lectures
11.4	JIT in services	1
Total		38

Course Designers

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		Category	L	T	P	Credit
18MGPP0	**OPTIMIZATION TECHNIQUES** (Common to 18IE120)	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

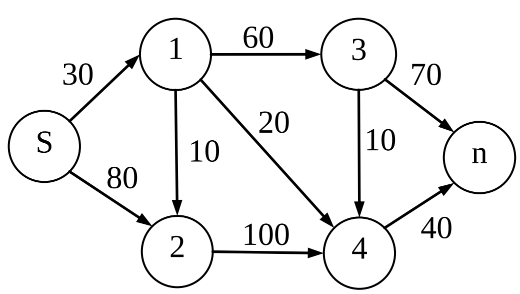
Course Outcome 4 (CO4):

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.

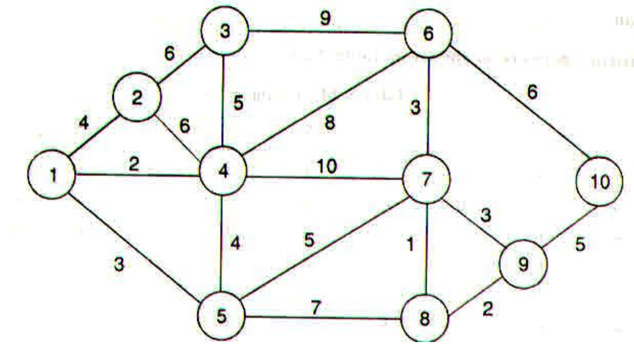
Machines. Returns in Rs.

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 $0 \leq x \leq 5$ 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

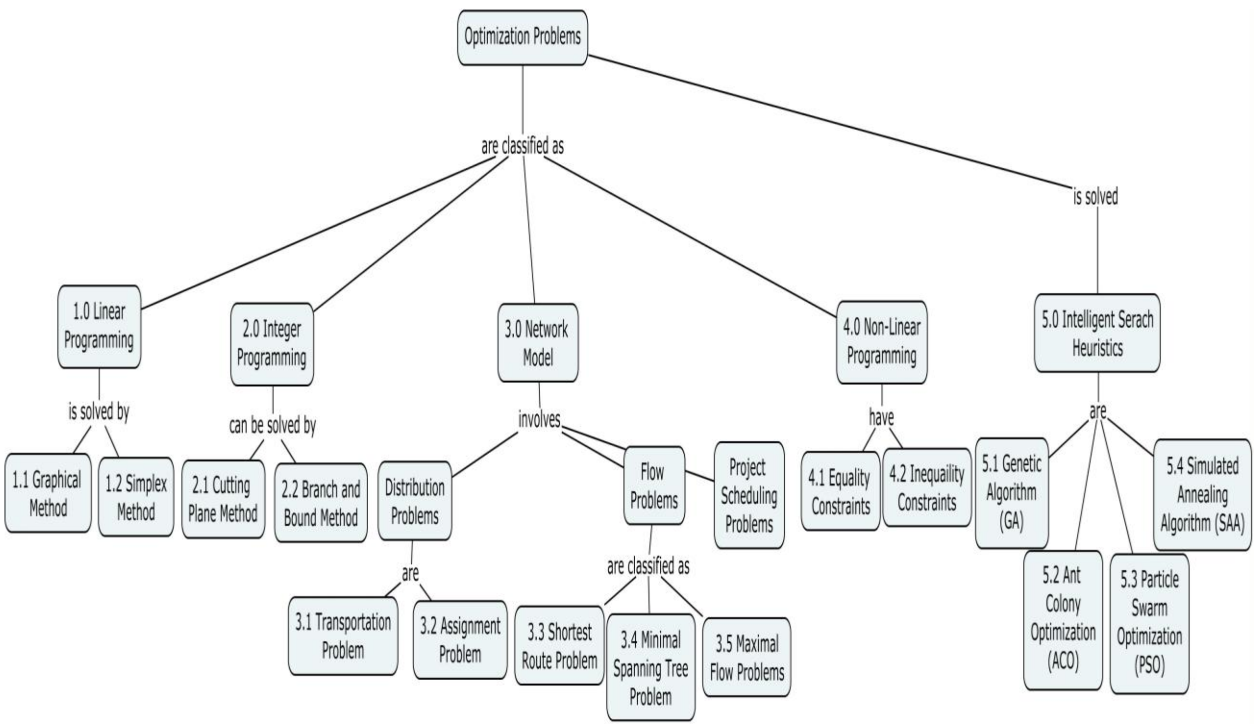
   Maximise $Z = 10x_1 - x_1^2 + 10x_2 - x_2^2$

   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

(Common to 18IEPN0) 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.

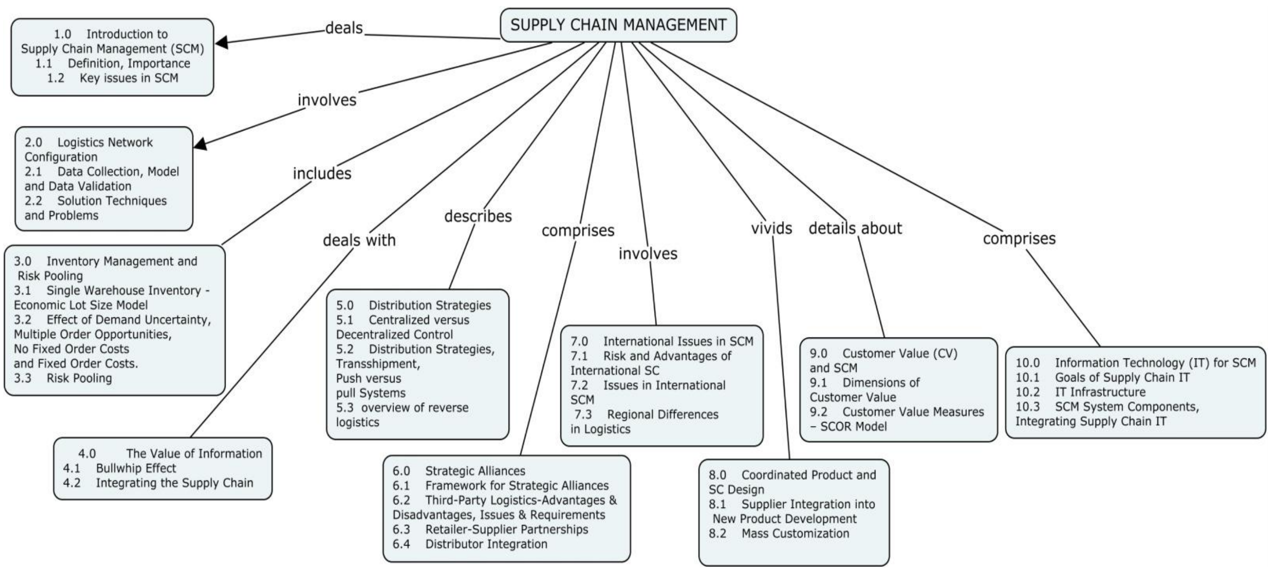
Parameter	**Average Weekly demand**	**Safely stock**	**Reorder point**
Value	44.58	86	176

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.

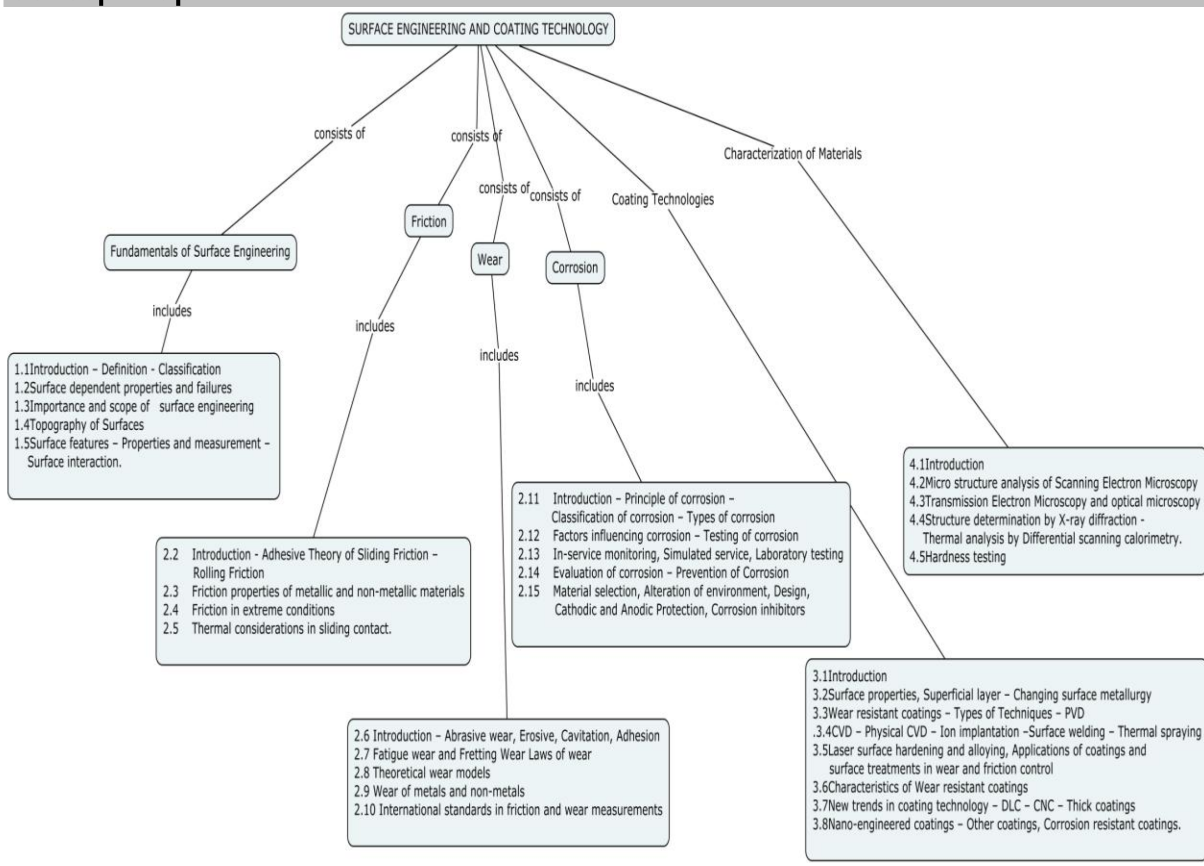
Course outcome 3:

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
1.2	Surface dependent properties and failures	1

S.No.	Topic	No. of Lectures
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	
3.3	Wear resistant coatings – Types of Techniques – PVD	1
.3.4	CVD – Physical CVD – Ion implantation –Surface welding –	2

S.No.	Topic	No. of Lectures
	Thermal spraying	
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

1. Dr.K.Chockalingam kcmech@tce.edu
2. Mr.T.Prakash tpmech@tce.edu

		Category	L	T	P	Credit
18MG210	**TOOL DESIGN ENGINEERING**	PC	3	0	0	3

(Use of approved design data books are permitted in the terminal examination)

Preamble

The objective of this course is to teach the students in the design of sheet metal blanking and piercing dies; design of bending, forming and drawing dies; design of Jigs and Fixtures; design of cutting tools and explain NC machine tooling.

Prerequisite

- Nil

Course Outcomes

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

CO. No.	Course Outcome	Blooms Level	Expected proficiency (%)	Expected attainment level (%)
CO1	Design sheet metal blanking and piercing dies	Apply	70	60
CO2	Design bending, forming and drawing dies	Apply	70	60
CO3	Design jigs and fixtures for a given component.	Apply	70	60
CO4	Design cutting tools	Apply	70	60
CO5	Explain NC machine tooling	Understand	80	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	20	10	10
Understand	40	40	40	40
Apply	50	40	50	50
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

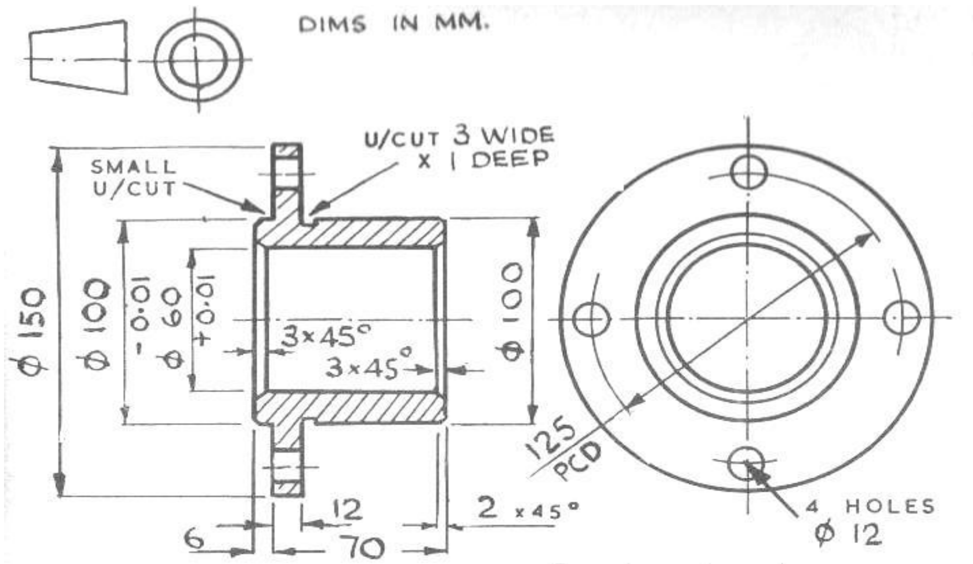
1. Define the shut height of a press.
2. Explain in detail the compound die.
3. Design a blanking die to blank the C15 steel washer of Outer diameter 20mm and Inner diameter 15 mm and of thickness 2 mm.

Course Outcome 2 (CO2):

1. Recall coining.
2. Explain the variables that affect metal flow during drawing?
3. Design a symmetrical cup with a shell height of 38 mm and a shell diameter of 73 mm of C15 steel. The thickness is 1.6 mm and the corner radius is 3.2 mm.

Course Outcome 3 (CO3):

1. Differentiate Locating and Clamping.
2. Describe in detail the boring Fixtures.
3. Design a drill jig for drilling 4 holes in the flange of the housing component shown in figure.



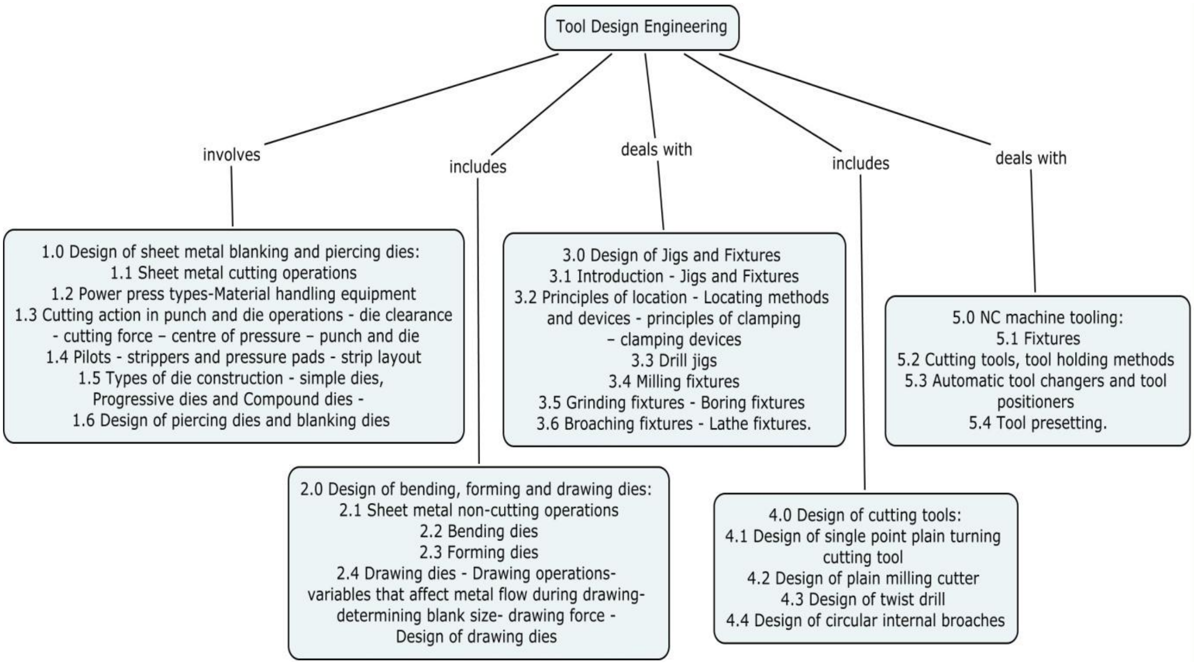
Course Outcome 4 (CO4):

1. List the cutting tools used in a lathe.
2. Explain in detail the twist drill.
3. Illustrate the design steps of a plain milling cutter.

Course Outcome 5 (CO5):

1. List the advantages of magnetic chucks.
2. Explain in detail the automatic tool changers in NC machine tools.
3. Discuss the tool holding methods used in NC system.

Concept Map



Syllabus

Design of sheet metal blanking and piercing dies: Sheet metal cutting operations - Power press types- Press material handling equipment - Cutting action in punch and die operations - die clearance - cutting force – centre of pressure – punch and die - Pilots- strippers and pressure pads -strip layout -Types of die construction-– Simple dies, Progressive dies and Compound dies - Design of piercing dies and blanking dies **Design of bending, forming and drawing dies:** Sheet metal non-cutting operations - Bending dies- Forming dies – Drawing dies - Drawing operations- variables that affect metal flow during drawing- determining blank size- drawing force - Design of drawing dies **Design of Jigs and Fixtures** Introduction - Jigs and Fixtures - Principles of location - Locating methods and devices - Principles of clamping – clamping devices - Drill jigs - Milling fixtures - Grinding fixtures - Boring fixtures - Broaching fixtures - Lathe fixtures. **Design of cutting tools:** Design of single point plain turning cutting tool - Design of plain milling cutter - Design of twist drill -Design of circular internal broaches **NC machine tooling:** Fixtures - Cutting tools, tool holding methods - Automatic tool changers and tool positioners - Tool presetting.

Reference Books/ Learning Resources

1. Cyril Donaldson, George H LeCain, V C Goold, Joyjeet Ghose “**Tool Design**”, Fifth Edition, McGraw Hill Education, New Delhi, 2017.
2. SME, “**Fundamentals of Tool Design**”, Sixth Edition, Society of Manufacturing Engineers, USA, 2010.
3. Edward G. Hoffman, “**Jig and Fixture Design**”, Fifth Edition, Delmar Cengage Learning, 2004.
4. M.H.A. Kempster, “**An Introduction to Jig and Tool Design**”, Third Edition, Viva Books Private Limited, 1998.
5. G. R. Nagpal, “**Tool Engineering and Design**”, Sixth Edition, Khanna Publishers, New Delhi, 2008.

6. William E. Boyes, "**Hand book of Jig and Fixture Design**", Second Edition, Society of Manufacturing Engineers, 1989.
7. PSG College of Technology, "**Design Data: Data Book of Engineers**", Kalaikathir Achchagam, Coimbatore, 2016.
8. http://nptel.ac.in/courses/112107144/1 to http://nptel.ac.in/courses/112107144/9
9. http://nptel.ac.in/courses/112101005/14
10. https://nptel.ac.in/courses/112105127/33
11. https://nptel.ac.in/courses/112105127/34
12. https://nptel.ac.in/courses/112105126/35
13. http://www.nitc.ac.in/dept/me/jagadeesha/Tool_Engineering_and_Design/CHAPTER2.pdf
14. https://nptel.ac.in/courses/112102103/

Course Content and lecture Schedule

Module number	Topics	No. of Lectures
1.0	**Design of sheet metal blanking and piercing dies**	
1.1	Sheet metal cutting operations	1
1.2	Power press types- Press material handling equipment	2
1.3	Cutting action in punch and die operations -die clearance – cutting force – centre of pressure – punch and die	2
1.4	Pilots- strippers and pressure pads -strip layout	1
1.5	Types of die construction-– Simple dies, Progressive dies and Compound dies	2
1.6	Design of piercing dies and blanking dies	2
2.0	**Design of bending, forming and drawing dies**	
2.1	Sheet metal non-cutting operations	1
2.2	Bending dies	2
2.3	Forming dies	1
2.4	Drawing dies - Drawing operations- variables that affect metal flow during drawing- determining blank size- drawing force	2
2.5	Design of drawing dies	2
3.0	**Design of Jigs and Fixtures**	
3.1	Introduction - Jigs and Fixtures	1
3.2	Principles of location - Locating methods and devices - Principles of clamping – clamping devices	2
3.3	Drill jigs	2
3.4	Milling fixtures	1
3.5	Grinding fixtures - Boring fixtures	1
3.6	Broaching fixtures - Lathe fixtures.	1
4.0	**Design of cutting tools**	
4.1	Design of single point plain turning cutting tool	2
4.2	Design of plain milling cutter	1
4.3	Design of twist drill	1
4.4	Design of circular internal broaches	2
5.0	**NC machine tooling**	
5.1	Fixtures	1

Module number	Topics	No. of Lectures
5.2	Cutting tools, tool holding methods	1
5.3	Automatic tool changers and tool positioners	1
5.4	Tool presetting	1
	Total	**36**

Course Designers

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18MG260	CNC MACHINE TOOL TECHNOLOGY	Category	L	T	P	Credit
		PC	2	0	2	3

Preamble

The development of low cost CNC machines radically changed the manufacturing scenario in the field of coding, control, feedback system. With the increased automation of manufacturing processes with CNC machining, considerable improvements in consistency and quality have been achieved with no strain on the operator. CNC system reduces the frequency of errors, improves the productivity and provide the operator to perform additional tasks with in the production environment. This course will impart the knowledge of CNC machine tools and provides the hands-on training on CNC code writing and generation through CAM packages along with machining of parts.

Prerequisite

- NIL

Course Outcomes

On the 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 structure and different components of CNC Machine tool	Understand	80	70
CO2	Describe the assembly procedure for the different elements of CNC machine tool	Understand	80	70
CO3	Write manual CNC program for turning and milling operation for the given diagram	Apply	70	60
CO4	Choose suitable testing and validation method for the given subassemblies of CNC machine tool	Apply	70	60
CO5	Perform machining operation by writing suitable CNC program with CNC lathe and milling machine *(For Continuous assessment only)*	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Theory (70 Marks)		Practical (30 Marks)		
	Continuous	Terminal	Valuation	Conduct of	Continuous

	Assessment Tests			Examination	category	exercises (10)	Assessment Test (20)
	1	2	3				
Remember	20	20	20	20	Exercise	80	-
Understand	80	60	60	60	Record	20	-
Apply	0	20	20	20	Test/viva	-	100
Analyse	0	0	0	0			
Evaluate	0	0	0	0			
Create	0	0	0	0			

NOTE:

- There will be THREE tests in theory component. Syllabus portion for first test will 50% of theory content and remaining 50% for the second test. The portion for third test will be 100% of theory portion.
- Among the three tests, the best TWO test marks will be considered for continuous assessment of 20 marks.
- For the practical component, students need to be completed minimum of 3 exercises in turning and minimum of 3 exercises in milling operation with record of bonafide.
- Only one test will be conducted with full portion of practical component and same will be reduced to 30 marks as per assessment pattern given above.
- Both theory (20 marks) and practical (30 marks) assessments are put together to arrive final continuous assessment of 50 marks.
- Terminal examination will be conducted only for theory component for 100 marks by COE then reduced to 50 marks. Subsequently, it will be added with continuous assessment marks of 50, already obtained for the final declaration of result.

Course Level Assessment Questions

Course Outcome 1 (CO1):

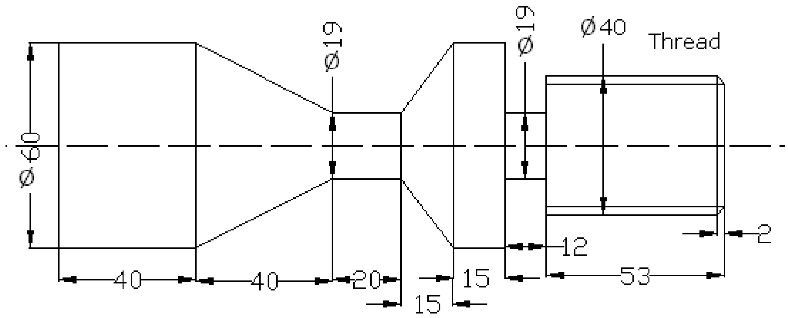
1. List the different sub system of a CNC turning center.
2. Name the important specifications of a CNC machining center.
3. Draw the axes diagram of turning centre.

Course Outcome 2 (CO2):

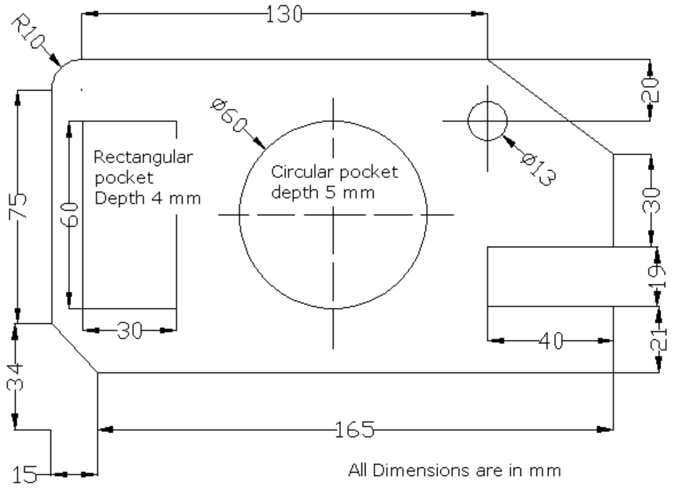
1. Describe the ballscrew and nut assembly with suitable diagram.
2. Explain the working principle of linear scale with suitable diagram.
3. Explain the servo circuit with tacho-generator and the spindle speed is controlled.

Course Outcome 3 (CO3):

1. Write a CNC program for turning operation to produce an aluminum component shown in the following figure. Give all the necessary calculations.



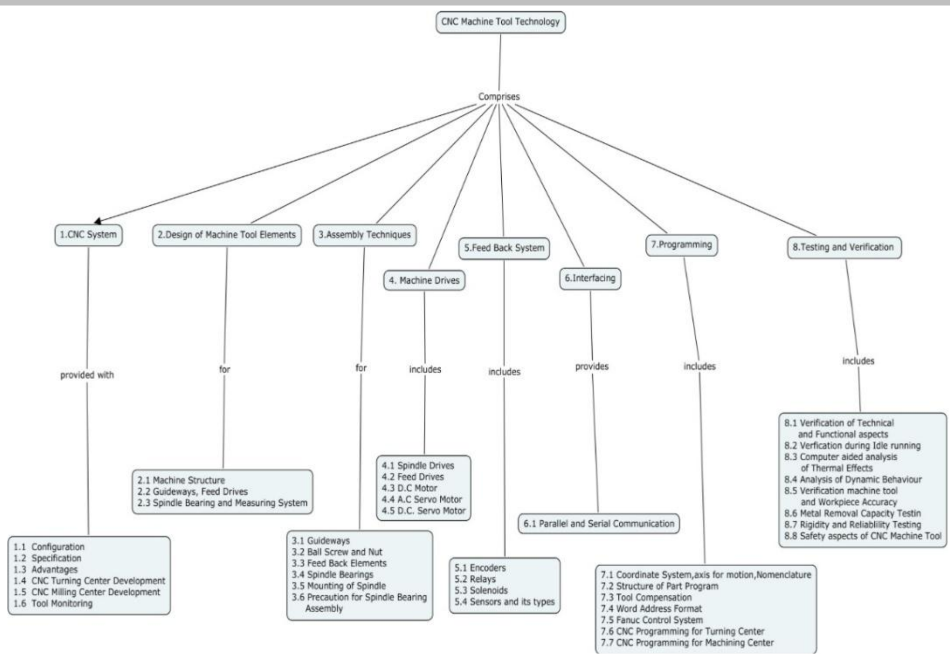
2. Write a CNC program for milling operation to machine a component of your choice and give detailed description with necessary calculation.



Course Outcome 4 (CO4):

1. Describe the general procedure to be followed for verifying technical and functional specifications of a CNC machining center.
2. Suggest a suitable procedure to validate the metal removal rate.
3. Suggest a suitable method to verify thermal aspects in main spindle of CNC machine tool.

Concept Map



Syllabus

CNC Systems: Structure of CNC system, Specifications of CNC Turning and Machining center, Advantages of the CNC machines, Developments in CNC Turning and CNC machining centers, Tool monitoring on CNC machines. **CNC Machine tool elements:** Machine structure, Guide ways, feed drives, Spindle bearing and measuring systems.**CNC Machine Assembly Techniques:** Guide ways, Ball screw and nut assembly, Feedback elements, spindle bearings.
Machine Drives: Spindle drives and Feed drives. **Feedback devices:**Encoders, Relays and Solenoids. **Programming:**Coordinate systems, Structure of part program, Tool compensation, Word address format with reference to FANUC control system, CNC part programming for turning and milling operations.**Testing and Verification:**Verification of technical and functional aspects, Verification of CNC machine during idle running, Computer aided analysis of thermal effects, Analysis of dynamic behavior of CNC machine tools, Verification of machine tool accuracy and work piece accuracy, Metal removal capacity testing, Rigidity and reliability testing of CNC machines.

Reference Books/Learning Resources

1. Hindustan Machine Tool Ltd, “Mechatronics”, Tata McGraw hill, 2000.
2. N. Mathivanan, “Micro processors, PC Hardware and Interfacing”, Prentice Hall of India, 2003.
3. Yusuf Altintas, “Manufacturing Automation”, Cambridge universal Press, 2012
4. Peter Smid, “CNC Programming Handbook”, Industrial Press Inc., 2008
5. Newton C. Braga, “Mechatronics Source Book”, Eswar Press, 2003.
6. Ken Evans, “Programming of CNC Machines”, Industrial Press Inc., 2007
7. P N. Rao, “CAD/CAM Principles and Applications”, Tata McGraw Hill, 2010.
8. NPTEL online course on “Industrial Automation and Control”.https://onlinecourses.nptel.ac.in/noc19_me04/preview

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1.	**CNC Systems**	
	Structure of CNC system, Specifications of CNC Turning and Machining center, Advantages of the CNC machines,	2
1.1	Developments in CNC Turning and CNC machining centers, Tool monitoring on CNC machines.	2
2.	**Design of machine tool elements**	
2.1	Machine structure, Guide ways	2
2.2	Feed drives, Spindle bearing and measuring systems.	1
3.	**CNC Machine Assembly Techniques**	
3.1	Guide ways, Ball screw and nut assembly	2
3.2	Feedback elements, spindle bearings	1
4	**Machine Drives**	
4.1	Spindle drives and Feed drives	2
5.	**Feedback devices**	
5.1	Encoders, Relays and Solenoids	1
6.	**Programming**	
6.1	Coordinate systems, Structure of part program, Tool compensation, Word address format with reference to FANUC control system,	2
6.2	CNC part programming for turning operation	2

6.3	CNC part programming for milling operation	2
7.	**Testing and Verification:**	
7.1	Verification of technical and functional aspects, Verification of CNC machine during idle running	2
7.2	Computer aided analysis of thermal effects, Analysis of dynamic behavior of CNC machine tools	1
7.3	Verification of machine tool accuracy and work piece accuracy	1
7.4	Metal removal capacity testing, Rigidity and reliability testing of CNC machines	1
	Total	24
Practical		
1	**CNC Programming**	**No. of practical hours**
1.1	Develop a manual CNC Program for Step with Taper turning operation along with its tool simulation.	4
1.2	Develop a manual CNC program for Curvature and Threading operation along with its tool simulation.	4
1.3	Programming on CNC Lathe for machining the given part drawing.	4
1.4	Develop a manual CNC Program for Profile milling and drilling operation with simulation.	4
1.5	Develop a manual CNC Program for Pocket milling and pattern operation with simulation.	4
1.6	Programming on CNC Milling machine for machining the given part drawing.	4
	Total	24

Course Designers

1. Dr.C. Paramasivam cpmech@tce.edu
2. M. Balamurali mbmmech@tce.edu

		Category	L	T	P	Credit
18MG270	**AUTOMATION LABORATORY**	PC	0	0	4	2

Preamble

Automation is the use of control systems and technologies to reduce the need for human work in the production of components and processes. Automation Laboratory is the use of instrument and processing equipment, machineries and measuring equipment toperform pneumatic/hydraulic circuits, robotic arm to produce a components/task. This laboratory will impart the knowledge about the automation system through hands-on practice and simulation.

Prerequisite

- NIL

Course Outcomes

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

CO.No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Develop and simulate pneumatic and hydraulic circuits for various application using simulation package	Analyze	70	60
CO2	Develop pneumatic circuits using pneumatic hardware elements	Apply	80	70
CO3	Write on-line robot program to perform pick-and-place operation using robotic arm	Apply	80	70
CO4	Machine a given component and to measure the geometrical dimensions	Apply	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	M	-	S	-	-	M	-	L	-
CO2	S	M	-	-	-	-	-	M	-	L	-
CO3	S	M	-	-	S	-	-	M	-	L	-
CO4	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. **Pneumatic and Hydraulic circuit Simulation:** Development and simulation of hydraulic and pneumatic circuits.
2. **Development of Pneumatic circuits:**Validation of pneumatic circuits using pneumatic hardware elements.
3. **Robot Programming:**Writing on-line robot program for various application using robotic arm.
4. **Machining:** Machining of given part diagram using metal removal and metal addition process.
5. **Mechanical measurements:** Verification of geometrical dimensions using metrological instruments.

List of Exercises

1. Develop a Pneumatic circuit for sequencing using Automation studio package and verify the operation.
2. Develop a Pneumatic circuit for cascading operation using Automation studio package and verify the operation.
3. Develop a Hydraulic circuit for sequencing operation using FluidSIM package and verify the operation.
4. Develop a Hydraulic circuit for cascading operation using HydroSIM package and verify the operation.
5. Develop a pneumatic/hydraulic circuit for sequencing operation using pneumatic elements and verify the sequence.
6. Develop an Electro-pneumatic circuit using pneumatic hardware elements.
7. Write an on-line robot program for pick-and-place operation using robotic arm.
8. Design a sequence of operation and write a program to perform to perform the given task in a robotic environment.
9. Machine the given component using Automatic Lathe/Capstan Lathe and measure the geometric features with coordinate measuring machine.
10. Produce a single point cutting tool using Tool-and-cutter grinder and check the tool signature with profile projector.
11. Obtain a required profile using wire-cut EDM and measure its dimension with CMM, profile projector.
12. Perform an exercise to obtain the optimal process parameters for the given material using CNC/Manual Lathe with an objective of optimal surface roughness.

NOTE:

- **FOR CONTINUOUS INTERNAL ASSESSMENT, ALL THE ABOVE LISTED 12 EXERCISES NEED TO BE COMPLETED BY THE STUDENTS.**
- **FOR TERMINAL PRACTICAL EXAMINATION, TWO EXERCISES WILL BE EVALUATED WITH 50 MARKS EACH.**

Course Designers

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18MGPB0	COMPOSITE MATERIALS	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Composite materials are materials made from two or more constituent materials with significantly different physical or chemical properties, that when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. Composite materials are preferred over traditional materials for their properties which are stronger, lighter or less expensive. This course covers the fundamentals of composite materials and processing of various composite materials

Prerequisite

- Nil

Course Outcomes

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

Co. No.	Course Outcome	Blooms Level	Expected Proficiency	Expected attainment level
CO1	Summarize the various Reinforcements and Matrix used in composite materials	Understand	80	70
CO2	Select the appropriate processing method for polymer matrix composites	Apply	70	60
CO3	Select the proper fabrication method for metal matrix composites	Apply	70	60
CO4	Choose the suitable processing method in ceramic matrix composites and carbon-carbon Composites	Apply	70	60
CO5	Explain the properties, applications and processing of Nanocomposites.	Understand	80	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	40	40	30	30
Apply	40	40	60	60

Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the various types of matrix materials
2. Differentiate between thermosetting and thermo plastics
3. Explain the structure and properties of carbon fiber.

Course Outcome 2 (CO2):

1. List the components manufactured using filament winding technique
2. Discuss the compression moulding technique for the fabrication of PMC.
3. Compare hand lay-up and RTM processes

Course Outcome 3 (CO3):

1. Define Powder metallurgy.
2. Explain the In Situ fabrication technique.
3. Identify a manufacturing method for fabricating aluminium silicon composites.

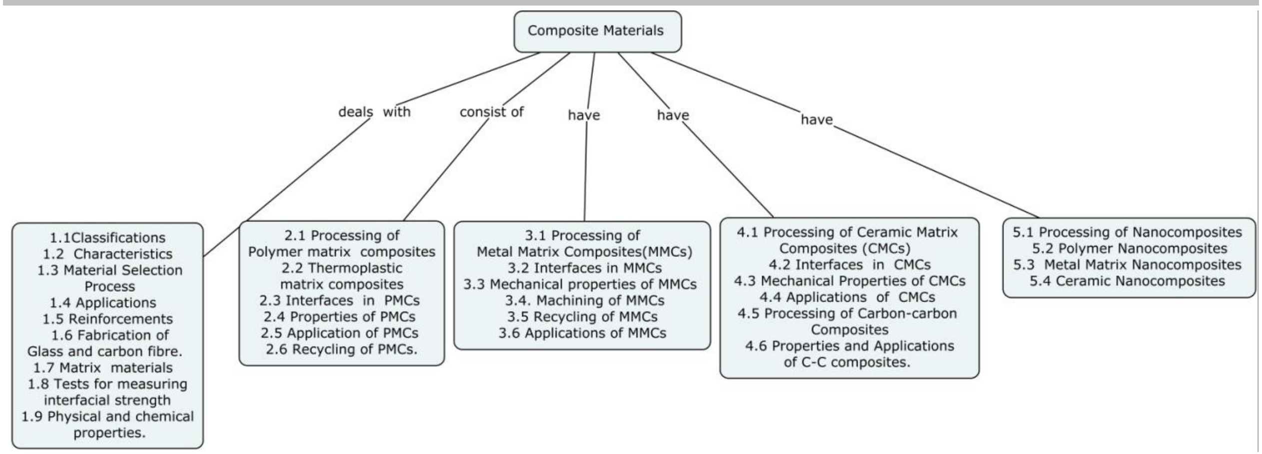
Course Outcome 4 (CO4):

1. State the applications of ceramic matrix composites.
2. Explain the cold pressing technique with necessary illustrations.
3. Suggest a suitable method for fabricating carbon carbon composites.

Course Outcome 5 (CO5):

1. List the benefits of polymer–clay nanocomposites.
2. List the peculiar properties of nanocomposites.
3. Explain the novel method to form PNCs using CNT aggregates.

Concept Map



Syllabus

Composite Materials: Classifications- Characteristics- Applications- Aircraft and Military Applications, Space Applications, Automotive Applications, Sporting Goods Applications, Marine Applications ,Infrastructure. Material Selection Process- Potential Advantages- Strength, Stiffness, Cost and Weight. **Fibers and Matrix Materials**: Fibers – Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - Whiskers– Fabrication of Glass fibre and carbon fibre- Matrix materials– Polymers, Classification of Polymers – Properties of Thermo and Thermosetting Plastics - Metals and ceramics and their properties – Interfaces –

Wettability – Types of bonding at the interface – Tests for measuring interfacial strength - Physical and chemical properties- Applications

Processing of Polymer Matrix Composites (PMCs): Hand layup, Spray, Filament winding, Pultrusion, Resin transfer moulding, Autoclave moulding - Bag moulding, Compression moulding with Bulk Moulding - Compound and sheet Moulding Compound – Thermoplastic matrix composites – Film stacking, Diaphragm forming, Thermoplastic tape laying, Injection moulding – Interfaces in PMCs - Structure, properties and application of PMCs –Recycling of PMCs.

Processing of Metal Matrix Composites (MMCs): Metallic matrices: Aluminum, titanium, magnesium, copper alloys – Processing of MMCs: Liquid state, Solid state, Insitu fabrication techniques – Diffusion bonding – Powder metallurgy techniques - Interfaces in MMCs – Mechanical properties – Machining and Recycling of MMCs – Applications.

Processing of Ceramic Matrix Composites (CMCs) and Carbon-Carbon Composites: Processing of CMC: Pressing, Sintering, Reaction bonding, Liquid infiltration, Lanxide process –Insitu chemical reaction techniques- Chemical vapour deposition, Chemical vapour impregnation, Sol-gel method – Interfaces in CMCs – Mechanical properties and applications of CMCs – Carbon-carbon Composites – Carbon Fiber Reinforcements - Matrix Systems -Processing of Carbon- Carbon Composites - Thermosetting Resin–Based Processing - Chemical Vapor Infiltration - Properties and applications.

Processing of Nanocomposites - Classifications of nanocomposites- Polymer Nanocomposites -Clay–Polymer Nanocomposites -Graphite–Polymer Nanocomposites - Nanofiber-Reinforced Composites -Particulate Nanocomposites -Organic–Inorganic Hybrids (Nano-composites) - Applications of Polymer Nanocomposites - Metal Matrix Nanocomposites - Processing of Metallic Nanocomposites -Applications -Properties - Ceramic Nanocomposites Processing of Ceramic Nanocomposites -applications -properties.

Reference Books /Learning Resources

1. M. Balasubramanian , **Composite materials and Processing**, Taylor & Francis Group, LLC, CRC Press, 2014.
2. Krishnan K Chawla, Composite **Materials: Science and Engineering**, International Edition, Springer, 2012.
3. Mallick P.K., **Fiber Reinforced Composites: Materials, Manufacturing and Design**, CRC press, New Delhi, 2010.
4. Bhagwan D. Agarwal and Lawrence J. Broutman, **Analysis and Performance of Fiber Composites**, John Wiley and Sons Indian Edition, 2018.
5. https://nptel.ac.in/courses/112104221/ - Manufacturing of Composites Prof. J. Ramkumar Department of Mechanical Engineering Indian Institute of Technology, Kanpur
6. https://nptel.ac.in/courses/112104168/ -Introduction to Composite Materials and Structures Nachiketa Tiwari Indian Institute of Technology Kanpur

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Composite Materials**	
1.1	Classifications of composite materials	1
1.2	Characteristics of composite Materials	
1.3	Material Selection Process	1
1.4	Applications - Aircraft and Military Applications, Space Applications,	1

Module Number	Topics	No. of Lectures
	Automotive Applications, Sporting Goods Applications, Marine Applications, Infrastructure -Potential Advantages- Strength, Stiffness, Cost and Weight	
1.5	**Fibers and Matrix Materials**	
1.5.1	Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - whiskers	2
1.5.2	Whiskers -fabrication of Whiskers	1
1.6	Fabrication of Glass fibre and carbon fibre	1
1.7	Matrix materials– Polymers, Classification of Polymers – Properties of Thermo and Thermosetting Plastics - Wettability	1
1.7.1	Metals and ceramics and their properties	1
1.8	Types of bonding at the interface – Tests for measuring interfacial strength	1
1.9	Physical and chemical properties of fibres and Matrix	1
2.0	**Processing of Polymer Matrix Composites**	
2.1	Processing methods of Polymer matrix composites:	1
2.1.1	Hand layup, spray up, filament winding, Pultrusion methods	1
2.1.2	Resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet moulding Compound	2
2.2	Thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding interfaces in PMCs	1
2.3	Interfaces in PMCs	1
2.4	Properties of PMCs	1
2.5	Application of PMCs	1
2.6	Recycling of PMCs	1
3.0	**Processing of Metal Matrix composites (MMCs)**	
3.1	Processing of Metal Matrix Composites (MMCs)	
3.1.0	Metallic matrices: Aluminium, titanium, magnesium, copper alloys	1
3.1.1	Processing of MMCs: liquid state, Solid state, in situ fabrication techniques	1
3.1.2	Diffusion bonding – Powder metallurgy techniques interfaces in MMCs	1
3.2	Interfaces in MMCs	1
3.3	Mechanical properties of MMCs.	1
3.4	Machining and Recycling of MMCs	1
3.5	Applications of MMCs.	1
4.0	**Processing of Ceramic Matrix Composites (CMCs) and Carbon-Carbon Composites (C-Cs)**	
4.1.1	**Processing of CMCs:** Cold pressing, Sintering, Reaction bonding, Liquid infiltration method	1
4.1.2	Lanxide process – In situ chemical reaction techniques: Chemical vapour deposition, Chemical vapour impregnation- Sol-gel methods	1

Module Number	Topics	No. of Lectures
4.2	Interfaces in CMCs –	1
4.3	Mechanical properties of CMCs	
4.4	Applications of CMCs	1
4.5.0	Carbon-carbon Composites – Carbon Fiber Reinforcements -Matrix Systems -	1
4.5.1	Processing of Carbon- Carbon Composites - Thermosetting Resin–Based Processing - Chemical Vapor Infiltration	
4.6	Mechanical Properties and applications of C-C composites	1
5.0	**Nanocomposites**	
5.1	Nanocomposites - Classifications - Polymer Nanocomposites - Clay Polymer Nanocomposites -Graphite Polymer Nanocomposites - Nanofiber-Reinforced Composites -Particulate Nanocomposites.	1
5.2	Processing of Polymer Nanocomposites - Applications of Polymer Nanocomposites	1
5.3	Metal Matrix Nanocomposites - Processing of Metallic Nanocomposites -applications -properties	1
5.4	Ceramic Nanocomposites - Processing of Ceramic Nanocomposites -applications -Properties	1
	Total	36

Course Designers

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18MGPD0	DESIGN FOR MANUFACTURE AND ASSEMBLY	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The term "design for manufacture" (DFM) means the design for ease of manufacture of the collection of parts that will form the product after assembly and "design for assembly" (DFA) means the design of the product for ease of assembly. Thus, "design for manufacture and assembly" (DFMA) is a combination of DFA and DFM. DFMA is used:

- As the basis for concurrent engineering studies to provide guidance to the design team in simplifying the product structure, to reduce manufacturing and assembly costs, and to quantify the improvements.
- As a benchmarking tool to study competitors' products and quantify manufacturing and assembly difficulties.

Prerequisite

Nil

Course Outcomes

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

CO.No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Implement the dimensional and geometrical tolerance requirements for the given part drawing	Apply	70	60
CO2	Redesign the component for ease of sand casting, machining and sheet metal forming in compliance to design guidelines	Apply	70	60
CO3	Determine feasible assembly sequence using Liaison Diagram	Apply	70	60
CO4	Redesign the component for ease of manual, automated and robotic assembly in compliance to design guidelines	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	40	40	30	30
Apply	40	40	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Interpret and write the specification of all the feature control frames in the drawing as shown in figure 1 and draw their respective tolerance zones.

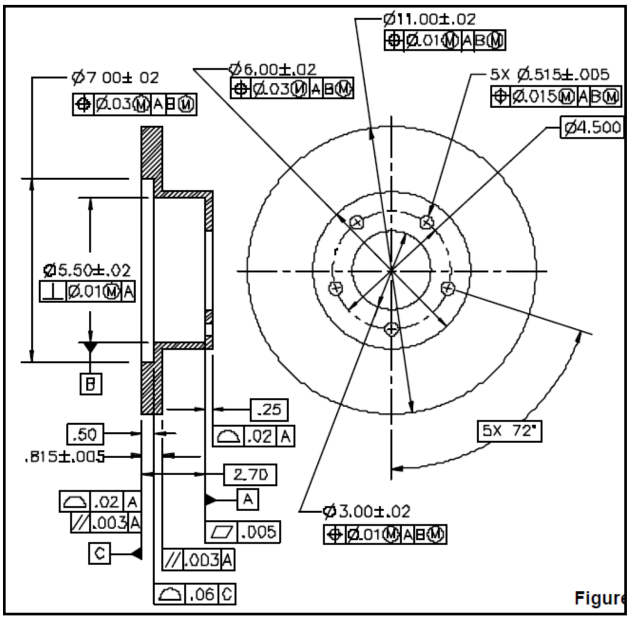
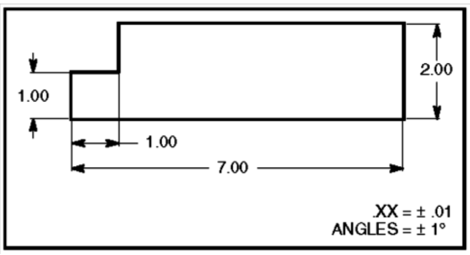
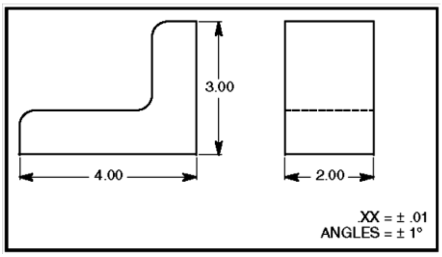


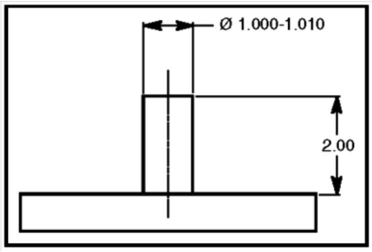
Figure 1

2. Specify the appropriate geometric tolerance on the drawing in Figure 2 and draw its tolerance zone for the following:
   i) to control the top surface of the part in Figure 2 (a) parallel to the bottom surface within .010.
   ii) to control the 3.000 units vertical surface of the part Fi (b) perpendicular to the bottom surface within .005.
   iii) to control the ϕ 1.000 units vertical pin shown in Figure 2 (c) perpendicular to the bottom surface of the plate within .005 at RFS





(a) (b)



(c)

Figure 2

3. Read the drawing given in Figure 3 with the pin and the hole and write the descriptions for the feature control frames available in the figure.

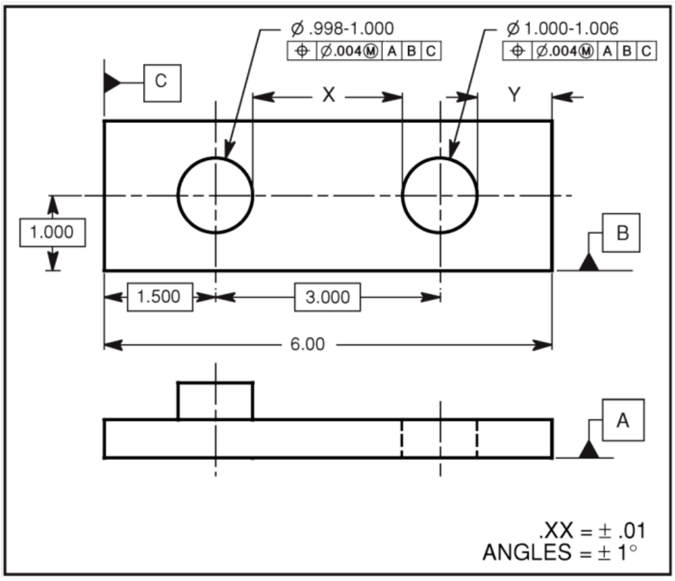
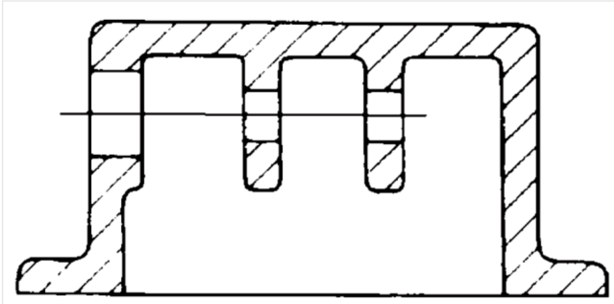
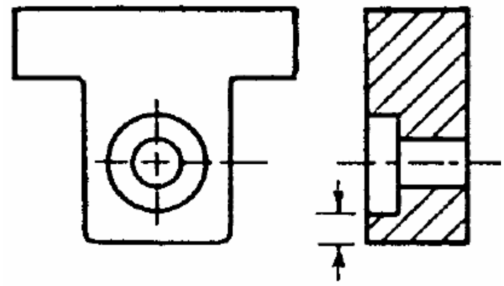


Figure 3

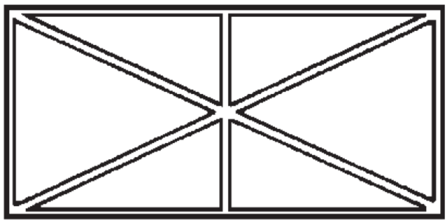
Course Outcome 2 (CO2):

1. Suggest and justify the suitable modifications on the design of the following components as shown in figure 4 for ease of casting.


(i)


(ii)


(iii)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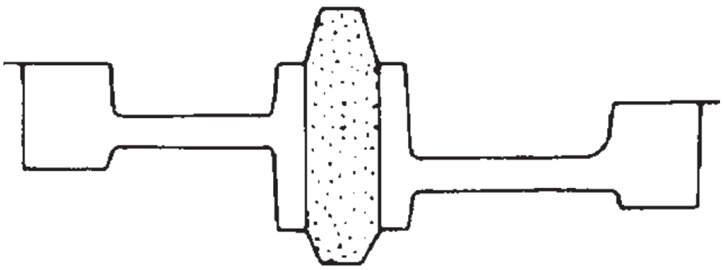
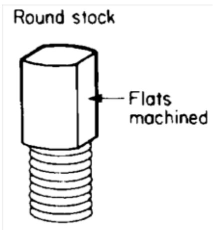
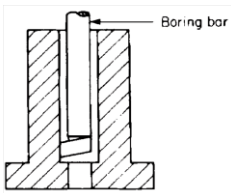

(v)

Figure 4

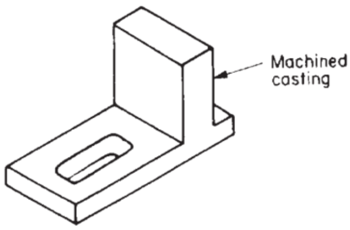
2. The parts shown in figure 5 are to be produced for ease of machining. Suggest suitable modifications in design with its justification.



(i)



(ii)



(iii)

Figure 5

3. Suggest and justify the required modifications on the layout design for components shown in figure 6 for ease of sheet metal processing.

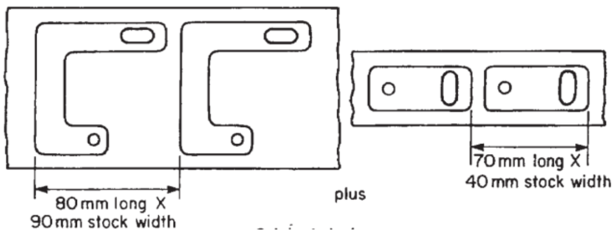


Figure 6

Course Outcome 3 (CO3):

1. Define liaison diagram.
2. Determine the feasible sequence for the coupling assembly as shown in figure 7 using liaison diagram.

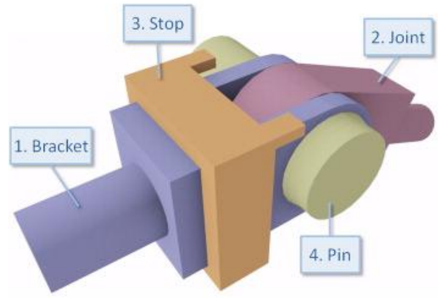


Figure 7

3. Prepare an assembly sequence for the following exploded view of assembly as given in figure 8.

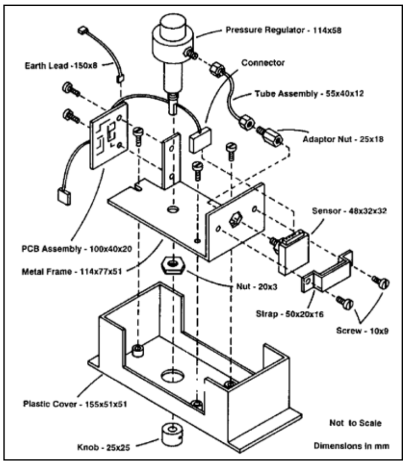
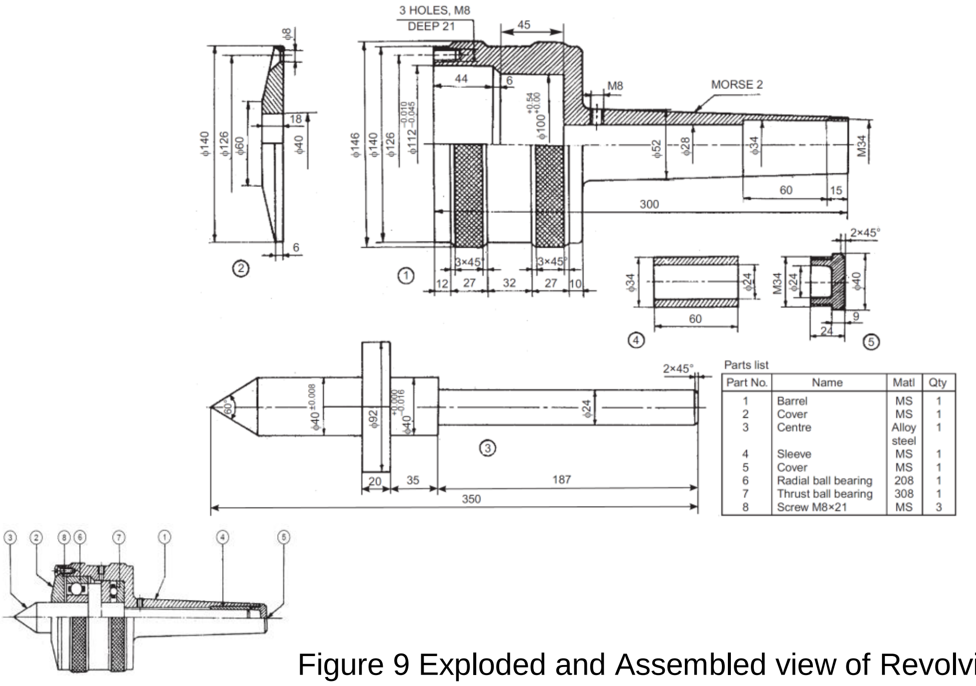


Figure 8

4. Propose a suitable manual assembly sequence and resource requirements for the following *Revolving Centre* as in figure 9. Assume the expected production rate is 50 assemblies per day.



Parts list

Part No.	Name	Matl	Qty
1	Barrel	MS	1
2	Cover	MS	1
3	Centre	Alloy steel	1
4	Sleeve	MS	1
5	Cover	MS	1
6	Radial ball bearing	208	1
7	Thrust ball bearing	308	1
8	Screw M8×21	MS	3

Figure 9 Exploded and Assembled view of Revolving Centre

Course Outcome 4 (CO4):

1. Explain the principles and guidelines of design for assembly of components in manual assembly system
2. Recommend necessary modifications in part design of the following alternator assembly as shown in figure 10 in order to improve the efficiency of its automated assembly.

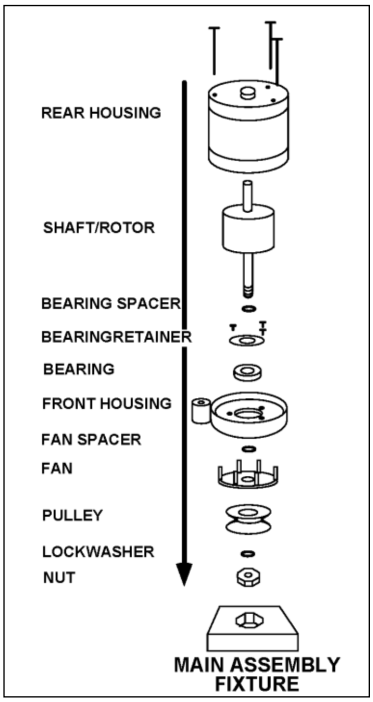


Figure 10

3. The exploded assembly diagram of a power saw has been given in figure 11. Suggest suitable modifications for ease of assembly, if the power saw is assembled manually.

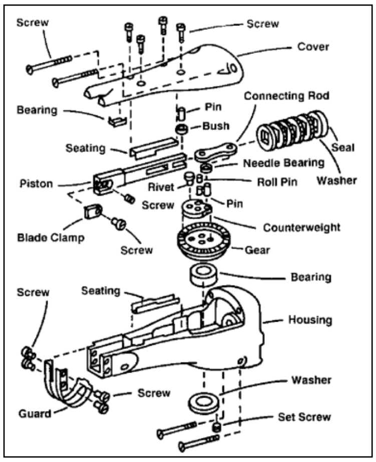
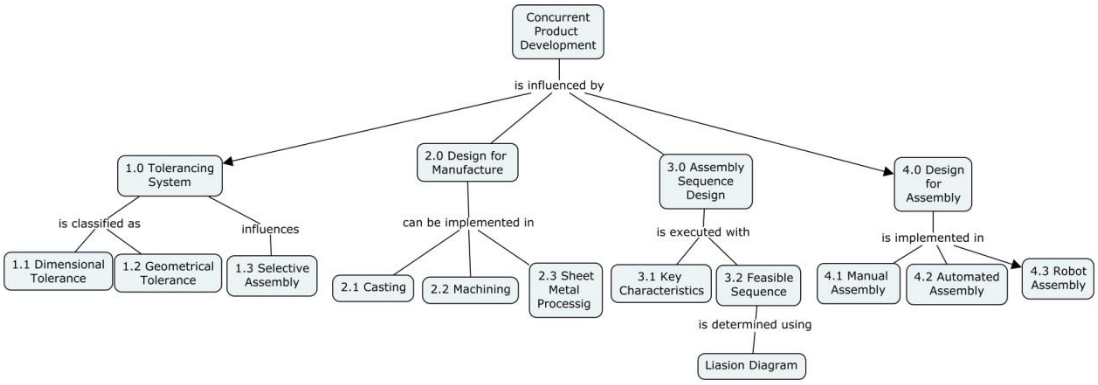


Figure 11

Concept Map



Syllabus

Concurrent Engineering approach: definition, steps involved - Myths and realities of product development - Role of Design for Manufacture and Assembly in concurrent engineering.

Tolerancing System: Importance - Feature and geometric tolerances - Process capability - surface finish - Cumulative effect of tolerances. Datum systems: Degrees of freedom - True position theory: Comparison between co-ordinate and convention method of feature location - Tolerancing and true position tolerancing -Virtual size concept - Projected tolerance zone. Selective Assembly: Interchangeable part manufacture and selective assembly - Deciding the number of groups - Group tolerances of mating parts equal and unequal group tolerances.

Design for Manufacture (DFM): Selection of Materials and processes – General guidelines for design for manufacture – Applications – Design guidelines for Sand casting, machining and Sheet metal forming.

Assembly Sequence Design: Key Characteristics (KC) – Flow down of KC – Ideal KC process – KC Conflicts. Assembly Sequence Design Process: Methods for finding feasible sequences – Liaison diagram – Governing Rule – Generating the feasible sequences

Design for Assembly: Need and applications – General guidelines of Design for Assembly – Design for manual assembly: guidelines for part handling, insertion and fastening – Effect of symmetry, part thickness and size and weight on handling time and on grasping and manipulation – Effect of chamfer design on insertion operations. Design for automated assembly: effect of feed rate on cost – high speed automatic insertion – Design for feeding and orienting – Design for Robot assembly: types of robot assembly system – design rules – design for disassembly and service – Case studies.

Design considerations in 3D printing – Part heights, Build orientation, Overhangs and angled geometry, repeated overhangs, Part thickness and Connected parts.

Reference Books/Learning Resources

1. Geoffrey Boothroyd, Peter Dewhurst, Winston A Knight, “Product Design for Manufacture and Assembly”, Third Edition, CRC Press, 2010
2. Alex Krulikowski, “Fundamentals of Geometric Dimensioning and Tolerancing”, Third Edition, Cengage Learning, 2012.
3. Daniel E Whitney, “Mechanical Assemblies: Their Design, Manufacture, and Role in Product Development”, Oxford University Press, 2004.
4. A.K.Chitale and R.C.Gupta, “Product Design and Manufacture”, Sixth Edition, Prentice Hall Pvt. Ltd. Delhi, 2011
5. James G.Bralla, “Design for Manufacturability Handbook”, Second Edition, The McGraw-Hill Companies, Inc., 1999.
6. Joe Micallef, “Beginning Design for 3D Printing”, First Edition, Apress, 2015.

7. http://www.dfma.com/resources/studies.asp - DFMA Case Studies – Boothroyd Dewhurst Inc.
8. https://nptel.ac.in/courses/107103012/ - Dr. Abinash Kumar Swain Department of Mechanical and Industrial Engineering, Indian Institute of Technology Roorkee

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
	Concurrent Engineering approach: definition, steps involved – Myths and realities of product development – Role of Design for Manufacture and Assembly in concurrent engineering	2
1.0	**Tolerancing System**	
1.1	Feature and Geometric tolerances – Process capability – surface finish	1
1.1.1	Relationship between attainable tolerance grades and different machining processes.	1
1.1.2	Determination of fit of an assembly	1
1.1.3	Cumulative effect of tolerances	1
1.1.4	Geometric tolerancing	1
1.1.5	Tutorial: Dimensional and Geometrical tolerances	1
1.2	Datum systems: Degrees of freedom – 3-2-1 locating principle	1
1.3	True position theory: Comparison between co-ordinate and convention method of feature location	1
1.3.1	Tolerancing and true position tolerancing -Virtual size concept - Projected tolerance zone	1
1.4	Selective Assembly: Interchangeable part manufacture and selective assembly	1
1.4.1	Deciding the number of groups - mating parts with equal and unequal group tolerances.	2
2.0	**Design for Manufacture (DFM)**	
2.1	Selection of Materials and processes	1
2.2	General guidelines for design for manufacture - Applications	1
2.2.1	Design guidelines for Sand casting	2
2.2.3	Design for machining: Guidelines: Standardisation, raw material, component design, assembly, and accuracy and surface finish;	2
2.2.4	Design guidelines for Sheet metal forming	2
3.	**Assembly Sequence Design**	
3.1	Key Characteristics (KC) – Ideal KC process – KC Conflicts.	1
3.2	Assembly Sequence Design Process: Methods for finding feasible sequences	1
3.2.1	Liaison diagram – Governing Rule	1
3.2.2	Generating the feasible sequences	1
4.0	**Design for Assembly (DFA)**	
4.1	General guidelines of Design for Assembly	1
4.1.1	Design for manual assembly: guidelines for part handling, insertion and fastening	1
4.1.1.1	Effect of symmetry, part thickness and size and weight on handling time and on grasping and manipulation	1

Module No.	Topic	No. of Lectures
4.1.1.2	Effect of chamfer design on insertion operations	1
4.1.2	Design for automated assembly: effect of feed rate on cost – high speed automatic insertion	1
4.1.2.1	Design for feeding and orienting	1
4.1.3	Design for Robot assembly: types of robot assembly system - design rules	1
	Case studies	2
4.1.4	Design considerations in 3D printing – Part heights, Build orientation, Overhangs and angled geometry, repeated overhangs, Part thickness and Connected parts	1
	Total	**36**

Course Designers:

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18MGPE0	FLUID POWER AUTOMATION	Category	L	T	P	Credit
		PC	3	0	0	3

Preamble

This course aims at giving adequate exposure to the function of hydraulic and pneumatic components, its selection and application in the design of hydraulic and pneumatic circuits. Design of Electrical and PLC based pneumatic and hydraulic circuits helps the students in developing an innovative mechatronics system.

Prerequisite

- Nil

Course Outcomes

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

CO. No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1.	Explain working principles of Fluid power devices	Understand	80	70
CO2.	Choose suitable pumps, motors and cylinders for the stated applications.	Apply	70	60
CO3.	Calculate speed, pressure, flow and power for the fluid power circuits	Apply	70	60
CO4.	Analyze Hydraulic, Pneumatic circuits for industrial applications	Analyze	70	60
CO5	Design and development of PLC ladder diagram	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	20	20	20	20
Apply	60	50	50	50
Analyse	0	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define positive displacement pump
2. List the parameters for selection a pump
3. What are the various types of hydraulic motors?
4. State the importance of Hydro pneumatic circuits.
5. Discuss in detail the 4/3 direction control valve with example
6. Describe the working principle cushioned cylinder

Course Outcome 2 (CO2):

1. Distinguish between external and internal gear pump.
2. Classify the pumps
3. Design the single cylinder continuous reciprocation system using suitable components
4. Design a hydraulic press circuit which employs double pump unloading principle.

Course Outcome 3 (CO3):

1. A hydraulic cylinder is to compress a car body in 10 seconds. The operation requires a stroke of 3 m and a force of 40,000 N. If a 7.5 N/mm2 pump has been selected. find the following:
   (i) Required piston area and piston diameter
   (ii) the necessary pump flow
   (iii) The hydraulic power capacity in kW
2. Justify the use of compound relief valve
3. Analyse the need for flow control value using an application circuit

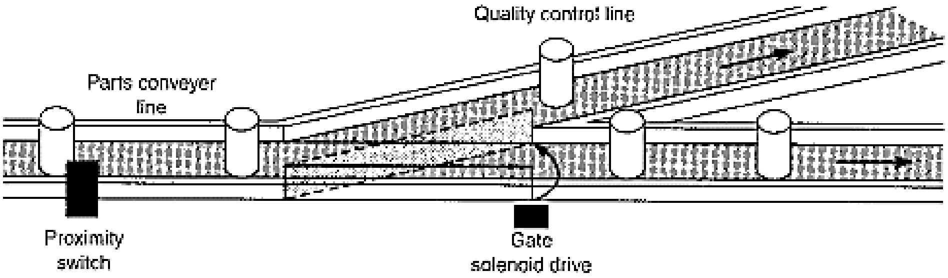
Course Outcome 4 (CO4):

1. Draw the ladder diagram for A+B+C-A-B-C+ and explain its operation
2. Design a circuit for the A+B+A-B- using Karnaugh map method.
3. Design a hydraulic circuit for a material handling in heat treatment plant .
4. A crane is used to lift heavy object of weight upto 1 ton. If the crane is to fail develop a circuit to prevent the object from free falling.
5. Name various methods used for sequential pneumatic circuit design.

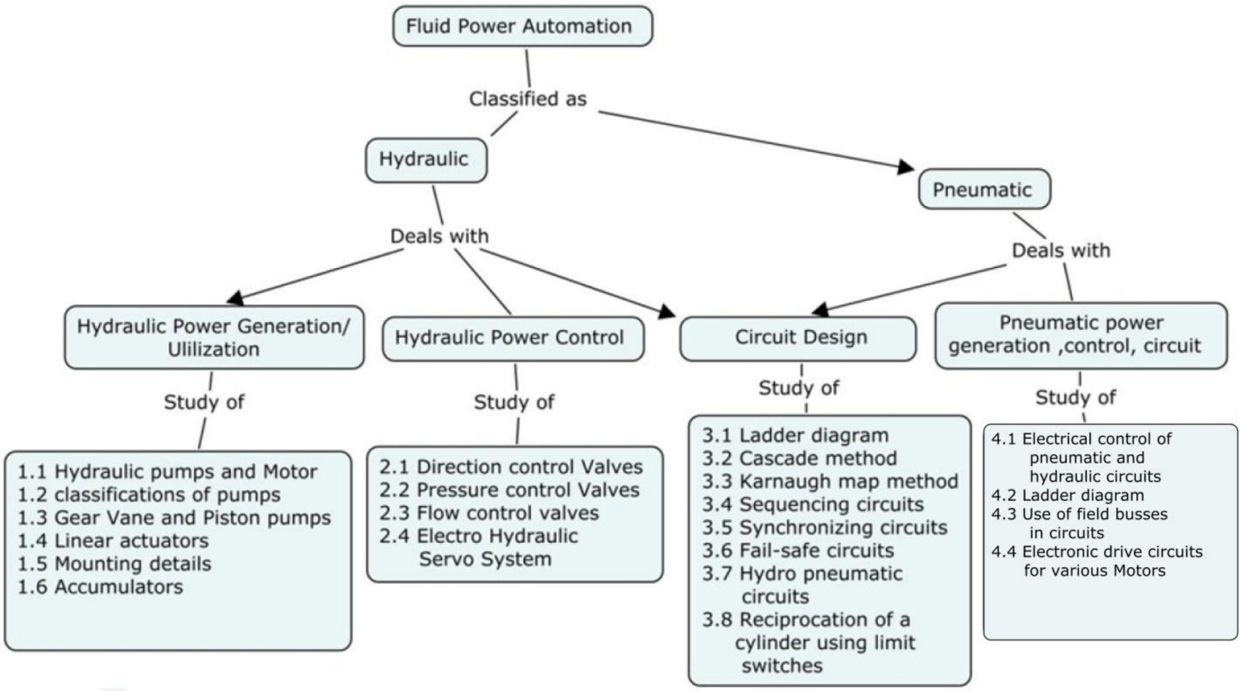
Course Outcome 5 (CO5):

1. A washing machine is to run for a 1-hour cycle when put on a quick wash mode. To get started, construct a ladder logic diagram that performs a basic washing process. Use start switch to initiate the following process. First, filling the drum in the washing machine with hot water for 3 seconds, then activate the drum full indicate light and start washing which is done by alternately rotating forward and backward, each direction for a total 5 seconds. Then, stop the motor and use pump to drain the drum for 3 seconds. Do a 3 seconds fast forward spin afterwards. Finally, shut off the machine.
2. Design a ladder diagram for a PLC sequence A+ B+ A- B-.
3. Four cylinders A, B, C, D are used to lift a car in car washing centre. Use PLC ladder diagram to synchronize the extension and retraction of the four cylinders.
4. Program a ladder diagram to implement the following process which involves diverting 1 part from the parts conveyor line into the quality control line out of every 1000 parts for quality inspection. The positional diagram of the process is shown below and use every component in the ladder diagram. The sequence of operations is as follows.

a) The conveyor is switched on
b) A proximity sensor counts the parts as they pass on the conveyor
c) When 1000 parts are counted, a gate solenoid diverts one part to the quality control line.
d) The gate remains diverted for 5 seconds and automatically returns to its original position.
e) This process continues on till the proximity switch counts zero parts on the parts conveyor line.
f) Then the conveyor is switched off.



Concept Map



Syllabus

Fluid Power Generating / Utilizing Elements: Hydraulic pumps and Motor - classification-positive displacement pumps - Gear, Vane, and Piston pumps - Working principles and Selection. Linear actuators - Single, Double acting and Cushion telescopic cylinder - Working principles - Mounting details. Accumulators - Types - Applications. **Control Components in Hydraulic Systems:** Direction control Valves - types - check valves- two-way, three way and four-way valves -shuttle valves- Rotary shuttle - Pressure control Valves - simple relief valve and compound relief valve - primary and secondary type - Flow control valves - types - Compensated and non-compensated valves. **Circuit Design**- Typical industrial hydraulic circuits Design of hydraulic cylinder sequence circuit, counterbalance application circuit, Pneumo hydraulic circuit and safety circuits. synchronizing circuit. Design methodology for pneumatic circuit – Cascade method – Truth table – Karnaugh map method – Step counter method, Ladder diagram. **Use of Pneumatic Power and Electrical control**- Use of pneumatics for LCA - pneumatic controls FRL unit. Fluidics devices and their application - Electrical Controls for Fluid Power systems - use of relays, Limits switches, timers, counters Reciprocation of a cylinder using limit switches - Tractor hydraulics - Programmable logic control of Hydraulics and Pneumatics circuits, Dual-cylinder sequence circuits - Box sorting systems - Electro Hydraulic Servo System.

Reference Books / Learning Resources

1. Anthony Esposito ,Fluid Power with Applications, Prentice-Hall, March 17, 2016
2. Andrew Parr, Hydraulics and Pneumatics: A technician's and engineer's guide [Kindle Edition]
3. Eaton Hydraulics Training Services (Vickers), Industrial Hydraulics Manual 5th Ed. 2nd Printing 2008
4. Frank Yeaple, Fluid Power Design Handbook, Third Edition, CRC Press
5. https://nptel.ac.in/courses/112105047/ CMTI Handbook, By Professor R. Maiti, IIT, Kharagpur
6. https://www.udemy.com/courses/search/?q=hydraulics%20and%20pneumatics%20&src=sac&kw=hydraulics

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1	**Fluid Power Generating / Utilizing Elements**	
1.1	Hydraulic pumps and Motor	2
1.2	Gear Vane and Piston pumps	2
1.3	Linear actuators	1
1.4	Single, Double acting and Cushion telescopic cylinder	1
1.4.1	Working principles of cylinders	1
1.4.2	Mounting details	1
1.5	Accumulators	1
1.5.1	Types	1
1.6	Applications	1
2	**Control Components in Hydraulic Systems**	
2.1	Direction control Valves	1
2.1.1	check valves- two way	1
2.1.2	Three way and four-way valves	1
2.1.3	Shuttle valves	1
2.2	Pressure control Valves	1
2.2.1	Simple relief valve and compound relief valve	1
2.3	Flow control valves	1
2.3.1	Flow control valves - types	1
2.3.2	Non-compensated valves	1
2.3.3	Compensated valves.	1
3	**Circuit Design**	
3.1	Typical industrial hydraulic circuits design methodology	1
3.2	Sequence circuit and counter balance circuits	1
3.3	Pneumo circuit and safety circuit	1
3.4	Ladder diagram, Tra	1
3.5	Cascade method	1

Module Number	Topics	No. of Lectures
3.6	Karnaugh map method	1
3.7	Step counter method, Synchronizing circuits	1
4	**Use of Pneumatic Power and Electrical control**	
4.1	Use of pneumatics for LCA	1
4.2	Design of pneumatic circuits	1
4.3	pneumatic controls FRL unit	1
4.4	Electrical control of Fluid power systems	2
	Fluidics devices and their application Hydro pneumatic circuits, Tractor hydraulics	2
4.5	Programmable logic control of hydraulic and pneumatic circuits	2
4.6	Dual-cylinder sequence circuits - Box sorting systems	1
	Total	36

Course Designers

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18MGPF0	**GEOMETRIC MODELING**	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

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

Prerequisite

- NIL

Course Outcomes

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

CO.No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Define the coordinate system for the development of geometric models	Understand	80	70
CO2	Develop and manipulate the curves and surfaces using parametric equations	Apply	70	60
CO3	Develop and manipulate the solid models using different modeling approaches	Apply	70	60
CO4	Implement the transformation and projection over the geometric model	Apply	70	60
CO5	Implement the neutral file formats over 2D wireframe models	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	40	40	30	30
Apply	40	40	60	60
Analyse	0	0	0	0

Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Differentiate geometric and display coordinate system.
2. List the desirable properties of curve modeling.
3. Write down any two Euler operators.

Course Outcome 2 (CO2):

1. Plot the resultant shape of Hermite cubic spline curve using P_0(0, 20) and P_1(50, 50) with 30^0 inclination at the starting point and -45^0 inclination at the end point.
2. Generate a segment of Bezier curve using (0, 0), (15, 0), (10, 10) and (5, 10) using polynomial equation.
3. Find the equation of a cubic B-spline surface defined by (4 x 5) control points. Find out all the knot vector.

Course Outcome 3 (CO3):

1. Develop a solid model of hollow cylinder of 20 mm thickness with ASM and sweep schemes.
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 complexity of the two techniques used.

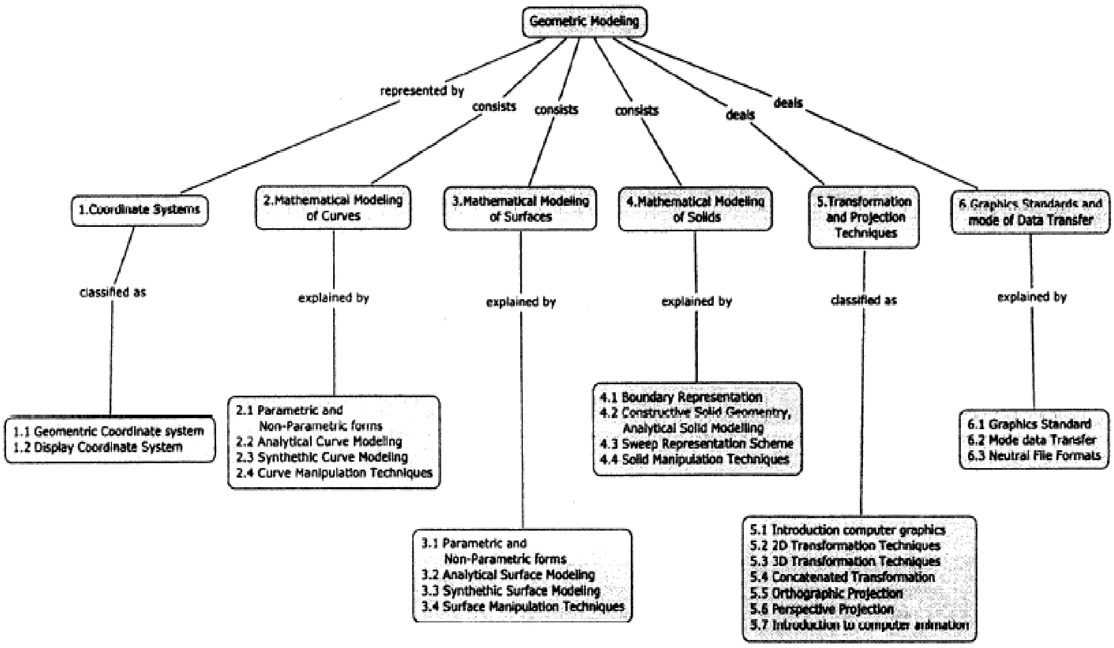
Course Outcome 4 (CO4):

1. Consider a line with (5,5) and (5,0) points. Rotate the line with respect to another point (0, 2.5) by 45 degrees in CW direction and get the transformed position.
2. A point P(2,5,10) is rotated 30° in CCW about z-axis then followed by scaling 200% and refection about Y=0 plane. What happens if this point P transformed in reverse sequence?
3. Obtain the perspective view of a point in space (2,5,8) when projecting along z-direction at a distance of 75 mm.

Course Outcome 5 (CO5):

1. Obtain the IGES format for circle of diameter 30 mm located at (0, 0) and line segment of (10, 5) and (20, 0).
2. Illustrate the structure of DXF neutral file format with a suitable wire frame drawing.
3. Write IGES and DXF code structure for an arc with starting point (0,5) end point (5,0) with center of (0,0).

Concept Map



Syllabus

Coordinate systems: Geometric co-ordinate systems - Cartesian, Cylindrical and Spherical coordinate systems. Display co-ordinate systems - Global, Local, View and Screen coordinate systems.

Mathematical modeling of Curves: Define - Parametric and non- parametric forms of analytical and synthetic curves. Analytical Curve modeling - Line Segment, Circle, Ellipse. Synthetic Curve modeling - Hermite Cubic Spline, Bezier, B-spline and Rational Curves. Manipulation - Analytical and Synthetic Curve manipulation techniques.

Mathematical modeling of Surfaces: Define - Parametric and non- parametric forms of analytical and synthetic surfaces. Analytical surface modeling - Parametric form of plane, loft, Cylindrical, Surface of revolution. Synthetic Surface modeling - Hermite Bicubic Spline, Bezier, B-spline, Coon's, triangular, blending Surfaces. Manipulation - Analytical and Synthetic Surface Manipulation techniques.

Mathematical modeling of Solids: Boundary representation, Constructive Solid Geometry, Analytical Solid Modeling, Sweep representation schemes. Manipulation - Solid Manipulation Techniques.

Transformation and Projection techniques: Introduction computer graphics - Non-interactive interactive Vs computer graphics, applications, graphics system configuration. 2D and 3D transformation techniques - Translation, Rotation, Scaling and Reflection. Principle of concatenated transformation. Orthographic and Perspective Projections of Geometric Models. Introduction to computer aided animation system.
Graphic Standards and mode of data transfer: Define graphics standard, geometrical data, direct and indirect data transfer. Neutral file formats - Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES).

Reference Book/ Learning Resources

1. Ibrahim Zeid, "**Mastering CAD/CAM**", Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2013.
2. Amarendra N Sinha and Arun D Udai, "**Computer Graphics**", Tata McGraw Hill Education (P) Ltd., Second reprint, 2009.
3. Michael E. Mortenson, "**Geometric Modeling**", Industrial Press, Third edition, 2006.
4. Rogers, "**Mathematical Elements for computer Graphics**", Tata Mcgraw Hill Education Private Limited, 2009.
5. Rajiv Chopra, "**Computer Graphics**: A Practical Approach, Concepts, Principles, Case Studies", S.Chand and Company Ltd., First Edition, 2011.
6. NPTEL Course: Computer Aided Design and Manufacturing
URL: http://nptel.ac.in/courses/112102101/#
7. Journal: Computer-Aided Design, Elsevier publication, ISSN: 0010-4485.
URL: https://www.journals.elsevier.com/computer-aided-design

Course Contents and Lecture Schedule

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

Module No.	Topics	No. of Lectures
4.2	Constructive Solid Geometry, Analytical Solid Modeling	1
4.3	Sweep representation scheme	1
4.4	Solid Manipulation Techniques	1
	Demonstration of solids using modeling package	2
5	Transformation and Projection techniques	
5.1	Introduction computer graphics - Non-interactive Vs Interactive computer graphics, applications, graphics system configuration	1
5.2	2D transformation techniques - Translation, Rotation	1
	2D transformation techniques - Scaling and Reflection	1
5.3	3D transformation techniques - Translation, Rotation	1
	3D transformation techniques - Scaling and Reflection	1
5.4	Principle of concatenated transformation	1
5.5	Orthographic Projections of Geometric Models	1
5.6	Perspective Projections of Geometric Models	1
5.7	Introduction to computer aided animation system	1
6	Graphic Standards and mode of data transfer	
6.1	Graphics standard	1
	Geometrical data	1
6.2	Mode of data transfer - Direct and indirect data transfer	1
6.3	Neutral file formats - Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES)	1
	Total	**36**

Course Designers:

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		Category	L	T	P	Credit
18IEPD0	**LEAN MANUFACTURING AND SIX SIGMA**	PE	3	0	0	3

Preamble

Lean manufacturing is a production practice that deals with the Identification and Elimination of waste in all levels of an organization. Lean is centered on preserving value with less work. Six - Sigma is a Business management Strategy that seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing the variability in manufacturing and business processes

Prerequisite

- Nil

Course Outcomes

On the 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 concepts of Lean Manufacturing	Understand	80	70
CO2.	Construct a value stream mapping	Apply	70	60
CO3.	Explain various tools and techniques of six sigma	Understand	80	70
CO4.	Implement six sigma tools to minimize the variations in parameters of business models	Apply	70	60
CO5.	Evaluate Six Sigma practices in manufacturing and service sectors	Analyze	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	60	20	20	20
Apply	20	50	50	50
Analyse	0	20	20	20

Evaluate	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Extend the purpose of reducing waste
2. Explain push vs pull system.
3. Define DFMA

Course Outcome 2 (CO2):

1. For an automobile manufacturing company the following is the summary sheet

SI No	Description	Data
1.	Nature of Production System	Batch Production
2.	Set-up time	
	Heating	30 min
	Squeezing	45 min
	Bending	50 min
3.	Transfer of Material	Manual
4.	Mean time between failure	6 days
5.	Total man power	18 per day
6.	Work -in - Progress	2200 units
7.	Material travel distance	62ft
8.	No of machines involved	7
9.	Space Occupied	899 sq.ft

After several brain storming and a thorough study of the shop floor, it was observed that the tube subassembly line consists various forms of non-value-adding activities as follows: High lead time Accumulation of high inventory Unnecessary material flow High material travel distance Poor Mean-Time-Between-Failure ,underutilized manpower.

Organize the lean manufacturing practice using lean tools such as VSM, change overtime reduction and achieve the following targets

A. Reducing change-over time to 10 minutes.
B. Increasing the line productivity by 25%.
C. Reducing the WIP to 200 units improving the material flow

2. In a Copper smelter Maintenance the following are problems
   A. Frequent Breakdowns
   B.All Planned Maintenance activities are rescheduled
   C. No Preventive maintence available

   Execute the Total Productive Maintenance for solving above said problems

3. A Restaurant conducted consumer surveys and focus groups and identified the most important customer requirements as Healthy food, speedy service, an easy to read menu board, accurate order filling and perceived value. Develop of a set of technical requirements to incorporate into the design of a new facility and a house of quality relationship matrix to assess how well the requirements address these expectations.

Course Outcome 3 (CO3):

1. Explain the various steps in six sigma roadmap.
2. Compare Lean and Six sigma
2. Explain about DFSS methodology

Course Outcome 4 (CO4):

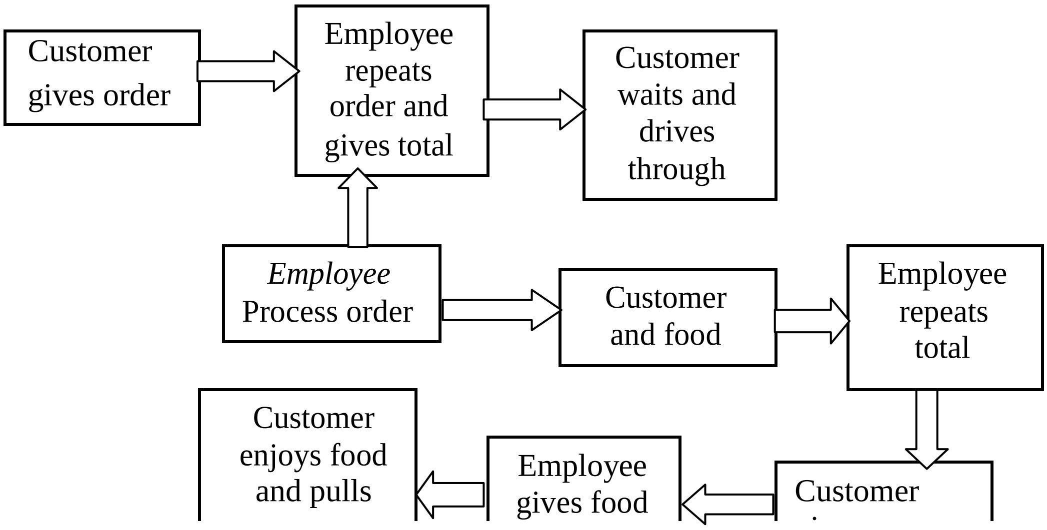
1. A car wash company recently faced a drastic drop in its client and in turn a huge revenue loss. How can this company improve the situation using Six Sigma?

2. From the given information box, draw the current state map, identify the wastes, draw the future state map suitably. Justify your answers. Also compare the takt time in both cases.

Part Number	WP/CAS/001	WP Casting
Family	Casting	Machine shop
Customer demand	4000/month	variation +400
Manufacturing data		Operation
Data collected by		Vinayaga
Cycle time(Minutes)		2
Change over time(Minutes)		20
Uptime		90%
% Defective		5% rework
Batch size		110 (10 numbers added to demand)
Number of shifts		2(8.5 hr per shift)
Number of Operators		1 per shift
Available time (Minutes)		450
Work in progress		650 numbers

Course Outcome 5 (CO5):

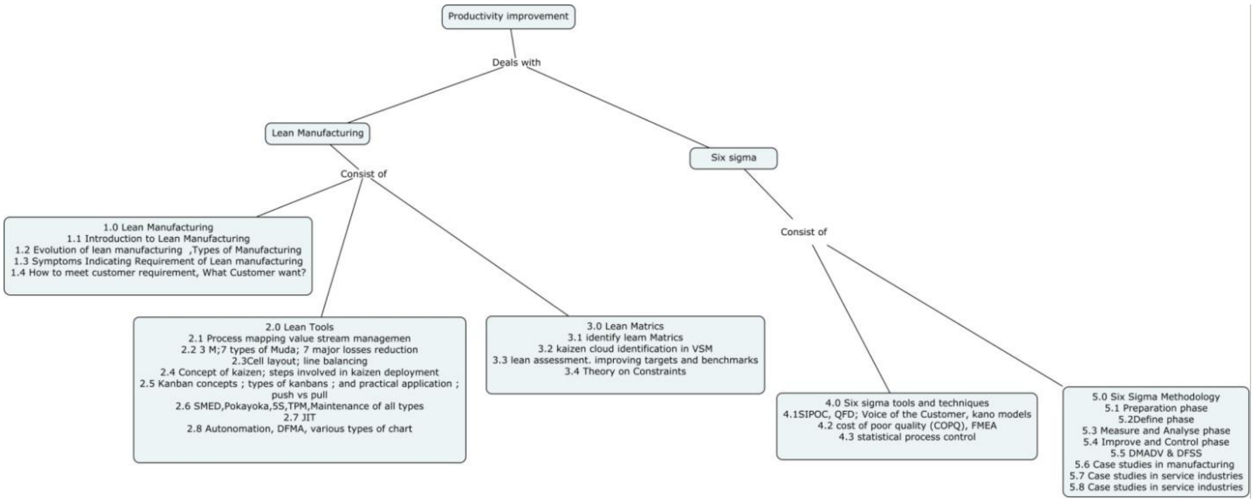
1. A flow chart for a fast food drive through window is shown below. Categorize the important quality characteristics inherent in the process and suggest possible improvements using DMAIC cycle



and change

2. In a Hospital a major dissatisfaction registered by patients is waiting time for surgery. from hospital's perceptive it resulted in increased costs and wasted resources. As for the patients and their family, it is a great inconvenience that their time is wasted. How can this problem has solved using Six Sigma? .

Concept Map



Syllabus

Lean Manufacturing evolution of lean; traditional versus lean manufacturing; ford production system concept of lean; Toyota's foray in lean, Customer Need; **lean tools-** Process mapping value stream management- 3 M;7 types of Muda; 7 major losses reduction. cell layout; line balancing; concept of kaizen; steps involved in kaizen deployment; kanban concepts ; types of Kanban ; and practical application ; push vs pull; changeover time reduction - single minute exchange of die; concept of TPM; poka-yoke; 5S; maintenance - preventive, time based and condition based; autonomous maintenance, JIT, Autonomation, DFMA; **lean metrics** identify lean metrics; kaizen cloud identification in Value Stream Mapping ; lean assessment. improving targets and benchmarks, Theory on Constraints

Six Sigma SIPCO,QFD; voice of the customer, kano models, , cost of poor quality (COPQ), **six sigma tools and techniques-** statistical process control **six sigma methods –** DMAIC, **Preparation phase:** Organizational success factors **–** leadership, six sigma as strategic initiative, internal communication strategy and tactics, formal launch, organizational structure, six sigma training plan, project selection, assessing organizational readiness, pitfalls. work as a process – vertical functions and horizontal processes. **Define phase:** DMAIC phases, overview, project charter – voice of the customer – high level process map –project team – case study. **Measure and analyse phase:** types of measures – use of statistical tools. Six sigma measurements – measurement system analysis –

process capability calculations. analyze– process analysis – hypothesis testing – statistical tests and tables – tools for analyzing relationships among variables – survival analysis. **Improve and control phase**: process redesign – generating improvement alternatives – design of experiments – pilot experiments – cost/benefit analysis – implementation plan. Control phase control plan – process scorecard – failure mode and effects analysis –final project report and documentation. DMADV,DFSS–six sigma in manufacturing and services case studies& Sustainability of Lean Six Sigma

Reference Books/ Learning Resources

1. Thomas Pyzdek, The Six Sigma Handbook , McGraw-Hill, 2014
2. James P. Womack , Daniel T. Jones ,Lean Thinking, Free press business,2013.
3. Kai Yang and Basemel-Haik, "Design for Six-Sigma: A Roadmap or Product Development", McGraw Hill, 2009.
4. N.Gopalakrishnan, simplified lean manufacture:Elements, rules, tools and implementation, Prentice Hall of India, NewDelhi 2013
5. Michael L. George, David Rowlands, Bill Kastle ,What is Lean Six Sigma, Tata McGraw-Hill,2005
6. "Learning to see" by Mike Rother ,John Shook 1999.
7.Lean and Six sigma in service Applications and case Studies by Sandra L.Furterer 2009.
8. MIT Open Courseware – Introduction to Lean Six Sigma Methods. Instructors - Prof. Earll Murman, Dr. Hugh McManus, Prof. Annalisa Weigel, Dr. Bo Madsen. URL:http: //ocw.mit.edu/courses/aeronautics-and-astronautics/16-660j-introduction-to-lean-six-sigma-methods-january-iap-2012/
9. NPTEL Video Lectures – Six Sigma – Prof. Tapan P. Bagchi. URL: http://nptel.ac.in/courses/110105039/

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1.0	**Lean Manufacturing**	
1.1	Introduction to Lean Manufacturing	1
1.1	Evolution of lean manufacturing ,Types of Manufacturing	1
1.2	Symptoms Indicating Requirement of Lean manufacturing	1
1.3	How to meet customer requirement, What Customer want?	1
2.0	**lean tools-**	

2.1	Process mapping value stream management	1
2.2	3 M;7 types of Muda; 7 major losses reduction	1
2.3	Cell layout; line balancing	1
2.4	Concept of kaizen; steps involved in kaizen deployment;	1
2.5	Kanban concepts ; types of kanbans ; and practical application ; push vs pull	1
2.6	SMED,Pokayoka,5S,TPM,Maintenance of all types	2
2.7	JIT	1
2.8	Autonomation, DFMA, various types of chart	2
3.0	**Lean Metrics**	
3.1	identify lean metrics	1
3.2	kaizen cloud identification in VSM	1
3.3	lean assessment. improving targets and benchmarks	1
3.4	Theory on Constraints	
4.0	**Six sigma tools and techniques**	
4.1	SIPOC, QFD; Voice of the Customer, kano models	1
4.2	cost of poor quality (COPQ), FMEA	1
4.3	statistical process control	1
5.0	**Six Sigma Methodology**	
5.1	Preparation phase	1
5.2	Define phase	2
5.3	Measure and Analyse phase	2
5.4	Improve and Control phase	2
5.5	DMADV & DFSS	3
5.6	Case studies in manufacturing	2
5.7	Case studies in service industries	2
5.8	Sustainability of Lean Manufacturing and Six sigma	1
	Total	36

Course Designers

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		Category	L	T	P	Credit
18MGPH0	**MACHINE VISION**	PE	3	0	0	3

Preamble

Machine Vision has become a key technology in the area of manufacturing and quality control. Increasing quality demands require inspection of every single part which in turn will lead to much more wide spread use of visual inspection systems. Furthermore the documentation requirements and quality control standards can only be met by fully automated networked inspection systems. The Success of developing machine vision system depends on the understanding all parts of the imaging chain. Hence this course discusses about image acquisition, lens and illumination systems, image preprocessing and processing, segmentation and classification techniques used in a typical machine vision application.

Prerequisite

- Nil

Course Outcomes

On the 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 the components of a machine vision system.	Understand	70	80
CO 2.	Select appropriate camera, lens and lighting system for a machine vision system to meet the required manufacturing requirement	Apply	60	70
CO 3.	Select appropriate image preprocessing and post processing techniques such as enhancement, segmentation for the given application	Apply	60	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	30	20	20	10
Understand	50	50	40	40
Apply	20	30	40	50

Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the working principle of CCD sensor array
2. Describe in detail about various image acquisition modes.
3. Explain the advantages of CMOS sensors over CCD sensors.

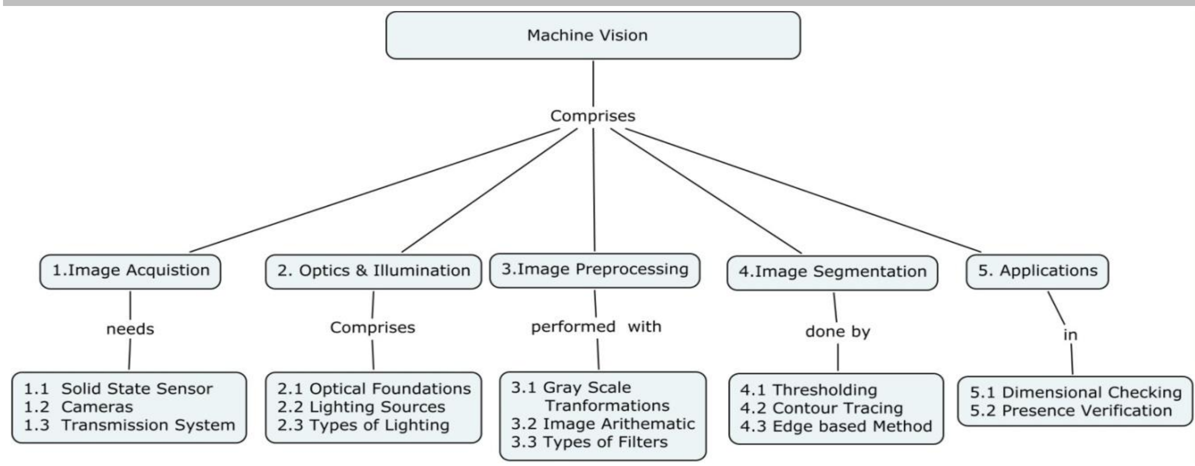
Course Outcome 2 (CO2):

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor. Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm.b F-Stop is 8, and there are 16 grey level and 30 images / second. Object dimensions are 7.5 X 7.5 X 1.2 cm. The object occupies 50% of sensor array.

Course Outcome 3 (CO3):

1. Select and illustrate a suitable Machine Vision Technique used for Inspection of Threads in Nuts in a Batch Production Process.
2. A surveillance camera is embedded in one of the walls of a room . The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is .05m.The X-Z plane of the camera is parallel to the X-Y Plane of the world coordinate system. The image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner
3. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.

Concept Map



Syllabus

Image Acquisition Solid State Sensors CCD Sensor Operation, Properties, Image Degradation. Standard Video Cameras: Basic Structure, Sampling of Line Signal and Extension of Video Standards, Image Quality, Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras, Line Scan Cameras and its Properties. Transmission to Computer: Basic operation of Frame Grabber and Direct Digital transmission. Interfaces: FireWire, Camera Link, GigE, and USB. **Optics and Illumination** Optical foundations: F number, Thin Lens Imaging Equation, Depth of Field, Typical Imaging Situations, Aberrations, Lens Selection, Special Optical devices. Light Sources, Types of Light Filters, Types of Lighting: Diffuse, Directed, Telecentric, Structured, Bright field, Dark Field, Incident and Transmitted Lighting.

Image Preprocessing Gray Scale Transformations: Look up tables, Linear Gray level scaling, Contrast enhancement, Histogram equalization, Local Contrast Enhancement. Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images. Types of Filters: Linear Filters, Median Filter, Morphological and Non Linear Filters. **Image Segmentation** Threshold Determination from Histogram, Gray Level Histogram, Generalizations of Thresholding Contour Tracing: Pixel Connectedness, Generating Object Contours, Contour representation Edge based Methods: Edge probing and Edge Detection Template matching: Basic Operation, Optimizing and Comments on Template Matching. **Applications:** Dimensional Checking: Simple gauging, Shape Checking, Angle Gauging, High accuracy Gauging, Calibration. Presence Verification: Simple Presence verification, Simple Gauging for assembly verification, Glue Check under UV Light, Pin type Verification Alignment Checking.

Reference Books/Learning Resources

1. C. Demant, B.Streicher Abel, P.Waszkewitz "Industrial Image Processing and Visual Quality control in manufacturing". Springer, 2013.
2. Rafel C.Gonzalez, Richard E.Woods, "Digital Image Processing." Third Edition, Prentice Hall India, 2007.
3. Nello Zeuch, "Understanding and Applying Machine Vision, Second Edition, Revised and Expanded (Manufacturing Engineering and Materials Processing)" Marcel Dekker Inc., 2000
4. Alexander Hornberg, "Handbook of Machine Vision", Wiley VCH, 2006
5. https://www.visiononline.org/certified-vision-professional-basic-training
6. Edmund Optics Imaging Lab
7. http://www.cse.usf.edu/~r1k/MachineVisionBook/MachineVision.pdf
8. http://www.machinevision.co.uk/
9. nptel.ac.in/courses/117105079

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1	**Image Acquisition**	
1.1	Solid State Sensors:	1
1.1.1	CCD Sensor Operation	1
1.1.2	CCD Properties, Image Degradation	
1.1.3	CMOS Sensors Operation and its advantages	1
1.2	Standard Video Cameras:	
1.2.1	Basic Structure, Sampling of Line Signal	1

Module Number	Topics	No. of Lectures
1.2.2	Extension of Video Standards, Image Quality	1
1.2.3	Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras and its Properties	1
1.3	Transmission to Computer:	
1.3.1	Basic operation of Frame Grabber	1
1.3.2	Direct Digital transmission	
1.3.3	USB, IEEE1394, Firewire, Gigabit Ethernet, Geni CAM, Cameralink	1
2	**Optics and Illumination**	
2.1	Optical foundations:	1
2.1.1	Basic Laws of Optics, F number, Thin Lens Imaging Equation, Depth of Field	1
2.1.2	Typical Imaging Situations, Aberrations	1
2.1.3	Lens Selection, Special Optical devices	1
2.2	Lighting Sources	
2.2.1	Incandescent Lamps, Metal Vapour Lamps, Xenon Lamps, Fluorescent, LED, Laser.	1
2.2.2	Types of Light Filters – UV Filter, Day Light Filter, IR Filter Gray Filter, Polarization Filter, Color Filter and Combination.	1
2.3	Types of Lighting	
2.3.1	Diffuse and Directed Bright Field Incident Lighting.	1
2.3.2	Telecentric and Structured Bright Field Incident Lighting Diffuse and Directed Dark Field Incident Lighting	2
2.3.3	Diffuse and Directed transmitted Lighting - Bright Field and Dark Field	1
3	**Image Preprocessing**	
3.1	Gray Scale Transformations:	
3.1.1	Look up tables, Linear Gray level scaling	1
3.1.2	Contrast enhancement, Histogram equalization, Local Contrast Enhancement.	2
3.1.3	Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images.	1
3.1.4	Types of Filters: Linear Filters, Median Filter	1
3.1.5	Morphological and Non Linear Filters	1
4	**Image Segmentation**	
4.1	Thresholding:	
4.1.1	Threshold Determination from Histogram	1
4.1.2	Gray Level Histogram, Generalizations of Thresholding	1
4.2	Contour Tracing:	
4.2.1	Pixel Correctedness, Generating Object Contours, Contour representation	2
4.2.2	Edge based Methods: Edge probing and Edge Detection	1
4.2.3	Template matching: Basic Operation, Optimizing and Comments on Template Matching.	1
5	**Applications**	
5.1	Dimensional Checking:	
5.1.1	Simple gauging, Shape Checking	1

Module Number	Topics	No. of Lectures
5.1.2	Angle Gauging, High accuracy Gauging	1
5.1.3	Calibration	1
5.2	Presence Verification:	
5.2.1	Simple Presence verification, Simple Gauging for assembly verification	
5.2.2	Glue Check under UV Light	2
5.2.3	Pin Type Verification	2
5.2.4	Alignment Checking	
	Total	37

Course Designers:

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18MGPJ0	MECHANICS OF METAL CUTTING AND METAL FORMING	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Two prominent methods of converting raw material into a product are metal cutting (machining) and metal forming. Machining is the process of removing the material in the form of chips by means of a wedge-shaped tool. In ductile materials, a significant amount of plastic deformation occurs before the material fractures. In brittle materials, very little plastic deformation takes place. Hence, the mechanics of machining is quite different for ductile and brittle materials. In machining, the work-piece is subjected to shear, bending and compression by the tool. Metal forming involves changing the shape of the material by permanent plastic deformation. After converting non-porous metal into product form by metal forming processes, the mass as well as the volume remains unchanged. However, in the case of metal forming of porous metal, volume does not remain unchanged. The advantages of metal forming processes include no wastage of the raw material, better mechanical properties of the product and faster production rate. In this core course, the fundamental mechanisms of the metal cutting and forming are exposed, which are very essential for any production and manufacturing engineer.

Prerequisite

- Working principles of Metal Cutting and Metal Forming processes

Course Outcomes

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

CO.No.	Course Outcome	Blooms Level	Expected Proficiency %	Expected attainment level %
CO1	Determine the forces, stresses, effect of friction, temperature, heat generation and cutting parameters in an orthogonal machining.	Apply	70	60
CO2	Determine tool life and causes, mechanisms, types of tool wears and effect of cutting parameters on tool life.	Apply	80	70
CO3	Choose appropriate tool materials and cutting fluids for specified machining process.	Apply	70	60
CO4	Analyze the balance between minimum cost and production time in metal cutting operations	Analyze	70	60
CO5	Explain the theory of plasticity and yielding Criteria for ductile materials	Understand	80	70
CO6	Outline the effect of temperature, strain-rate, friction and lubrication in metal forming	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	S	M	M	-	-	-	-	-	-

CO2	S	M	M	M	-	-	-	-	-	-	-
CO3	S	M	-	-	-	-	-	-	-	-	-
CO4	S	M	-	-	-	-	-	-	-	-	-
CO5	S	M	-	-	-	-	-	-	-	-	-
CO6	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	40	40	40
Apply	40	20	40	20
Analyse	0	20	0	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Derive the expression using Merchant's theory for the following
   i) Forces involved in Cutting ii) Stresses iii) Velocity relationship
2. Explain how work-tool temperature is measured during metal cutting process.
3. During orthogonal turning operation on a work piece of diameter 120 mm at 100 m/min with rake angle 15°, the width of the cut and the chip thickness are 0.4 mm and 0.3 mm, respectively. The feed during the operation was 0.2 mm/rev. If the cutting force and the thrust force are 1200 N and 300 N respectively. Calculate the shear angle, friction angle, shear stress and shear strain.

Course Outcome 2 (CO2):

1. Summarize the various forms of tool wear in metal cutting.
2. Discuss the effect of lubrication in metal cutting.
3. Let n = 0.5 and C = 90 in the Taylor equation for tool wear. What is the percent increase in tool life if the cutting speed is reduced by (a) 60% and (b) 65%?

Course Outcome 3 (CO3):

1. Explain the different materials along with their properties that can be used for making the tools.
2. List the situations in which diamonds are used as cutting tools.
3. Determine the value of C and n in the plot as shown in Figure 1 by selecting cutting speed (m/min) and tool Life(min) of three points on the curve and by using simultaneous equations of the form $VT^n=C$.

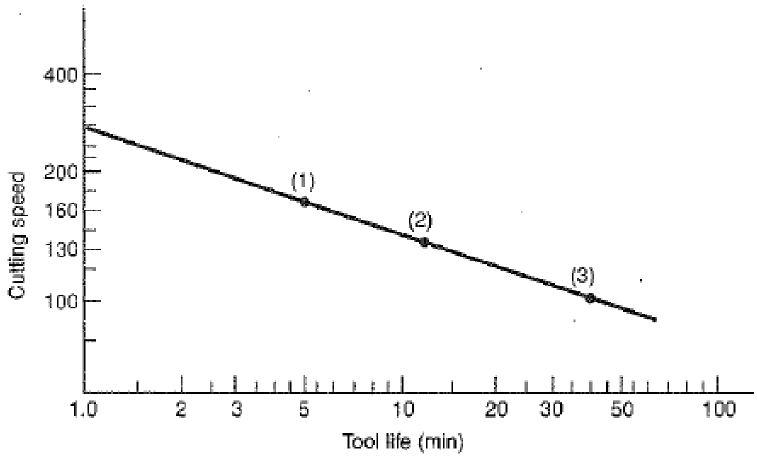


Figure 1

Course Outcome 4 (CO4):

1. A large batch of steel shafts is to be rough turned to 76 mm diameter for 300 mm of their length at a feed of 0.25mm. A brazed type carbide tool is to be used, and the appropriate constants in Taylor's tool life equation for the conditions employed are as follows: n= 0.25, and v_r = 4.064m/s when t_r = 60 s. The initial cost of machine was Rs.10,800 and is to be amortized over 5 years. The operator's wage will be assumed to be Rs.0.0015/sec and the operator and machine overheads are 100 percent. Tool changing and resetting time on the machine is 300 sec and cost of regrinding the tool is Rs.2.00. The initial cost of a tool Rs. 6.00 and on the average, it can be reground 10 times. Finally, the nonproductive time for each component is 120 s. Find the total cost and total production time.

2. A 200 mm long and 60mm diameter bar is to be turned on a lathe with a feed rate of 0.15mm/rev. The operating cost is Rs. 0.50 per minute while the tool cost is Rs.10.00 per edge. The tool changing time is about 2 minutes. Assume weight of workpiece as 0.14 kg. The following two workpiece materials have been used.

Material	Cost/kg	Tool- Life equation
X	Rs.100	$Vt^{0.10} = 67$
Y	Rs.120	$Vt^{0.16} = 90$

   Calculate tool-life values and optimum cutting velocities for minimum cost with no consideration for material cost, and maximum production rate criteria for both workpiece materials. State which material should be chosen for total minimum cost.

3. Derive the relationship for minimum cost, cutting speed in a single point turning of a cylindrical work piece.

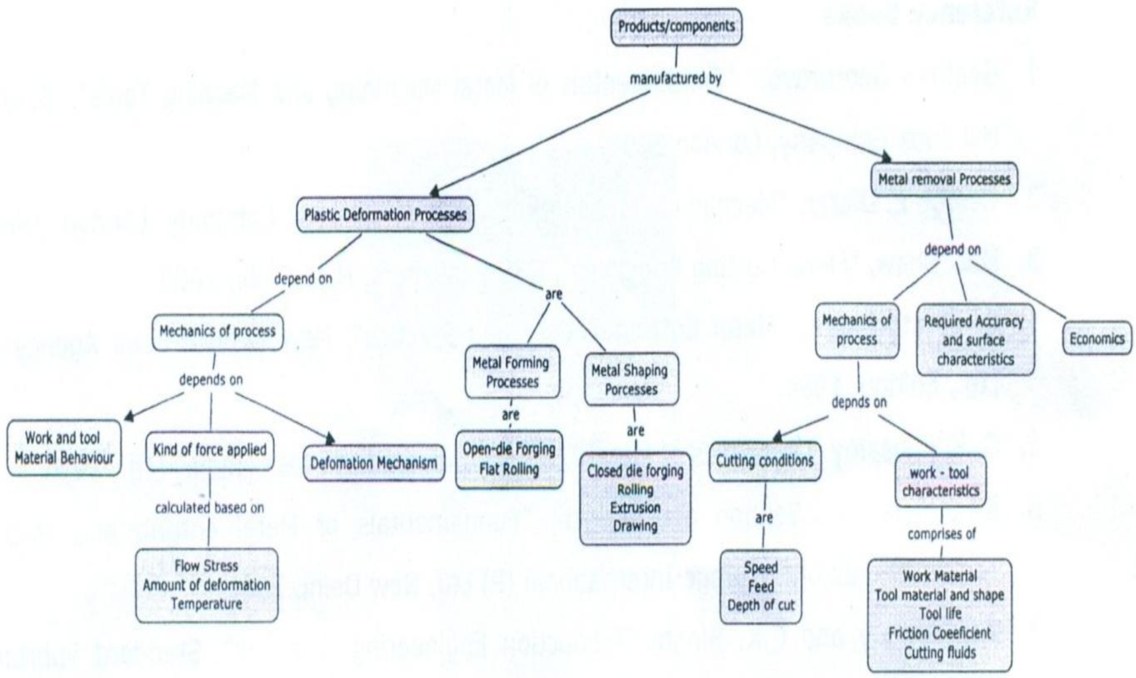
Course Outcome 5 (CO5):

1. Differentiate True Stress – Strain with conventional Stress-strain with a simple illustration.
2. Explain the theory of plasticity in detail.
3. Discuss the effect of combined stresses and anisotropy on forming processes.

Course Outcome 6 (CO6):

1. Explain any two defects in rolling process due to variations in rolling load.
2. Explain in detail about the effect of temperature in metal working processes.
3. Discuss the effects of friction and lubrication in metal forming processes.

Concept Map



Syllabus

Mechanics of Metal Cutting - Terms and Definitions – Chip Formation – Types of chips – Forces in orthogonal cutting – Specific Cutting Energy – Apparent Mean Shear Strength of the work material – Theories of Ernst and Merchant, Lee and Shaffler – Friction in metal Cutting. Temperatures in Metal Cutting - Heat generation in Metal Cutting – Temperature Distribution in Metal Cutting – Temperature in Primary and Secondary Deformation Zones – Effect of Cutting parameters on Temperatures – Tool wear and Tool life- Tool Wear: Causes, Mechanisms and types – Tool life Criteria – Effect of a Built-up Edge, Tool Angles, Speed and Feed on Tool life, Machinability – Factors affecting the Machinability of Metals. Tool material, Cutting Fluids and Surface Roughness. Tool materials – Classification and typical applications of tool Materials – Types, selection and actions of cutting fluids - Coolants and lubricants – Causes of surface roughness - Effect of nose radius on surface roughness. Economics of Metal Cutting Operations - Choice of Feed and Cutting Speed – Tool Life for Minimum Cost and Minimum Production Time – Estimation of factors that determine Optimum Conditions – Machining at Maximum Efficiency.

Elementary Theory of Plasticity - Introduction - Flow Curve – True Stress and True Strain – Yielding Criteria for Ductile Metals – Combined Stress Tests – Yield Locus – Anisotropy in Yielding – Yield Surface and Normality– Plastic Stress-Strain Relations. Mechanics of Metal working - Classification of Forming Process – Mechanics of Metal working – Flow-Stress Determination – Temperature in Metalworking – Friction and Lubrication.

Reference Books / Learning resources

1. Geoffrey Boothroyd, "Fundamentals of Metal Machining and Machine Tools", McGraw Hill Book Company, London 2005.
2. George E. Dieter. "Mechanical Metallurgy", Third Edition, McGraw Hill Education (India) Pvt Ltd, New Delhi, 2013.
3. Bhattacharya, "Metal Cutting Theory and Practice", New Central Book Agency (P), Ltd., Edition. 2008
4. G. Kuppusamy. "Principles of Metal Cutting", Universities Press (India) Ltd., 1996.
5. B.L. Juneja, G.S. Sekhon and N.Seth, "Fundamentals of Metal cutting and Machine Tools", 2nd Edition, New age International (P) Ltd, New Delhi, 2001.
6. P.C. Pandey and C.K. Singh. "Production Engineering Sciences", Standard Publishers Distributors. New Delhi. 2006
7. HMT, "Production Technology", Tata McGraw Hill Publishing Company Ltd., New Delhi. 2004.
8. https://nptel.ac.in/downloads/112105127/-COURSE CO-ORDINATED BY : IIT KHARAGPUR
9. https://nptel.ac.in/courses/112106153/Module%201/Lecture%201/Lecture_1.pdf- Joint Initiative of IITs and IISc – Funded by MHRD- R. Chandramouli Associate Dean-Research SASTRA University, Thanjavur-613 401.
10. https://onlinecourses.nptel.ac.in/noc18_me49/preview- Dr Pradeep K. Jha, Associate Professor, Department of Mechanical & Industrial Engineering, IIT Roorkee.

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1.	Mechanics of Metal Cutting - Terms and Definitions – Chip Formation – Types of chips	2
2.	Forces in orthogonal cutting – Specific Cutting Energy – Apparent Mean Shear Strength of the work material	2
3.	Theories of Ernst and Merchant, Lee and Shaffer	2
4.	Friction in metal Cutting	1
5.	Heat generation in Metal Cutting – Temperature Distribution in Metal Cutting – Temperature in Primary and Secondary Deformation Zones	2
6.	Effect of Cutting parameters on Temperatures	1
7.	Tool Wear: Causes, Mechanisms and types – Tool life Criteria	2
8.	Effect of a Built-up Edge, Tool Angles, Speed and Feed on Tool life, Machinability	1
9.	Factors affecting the Machinability of Metals	1
10.	Tool materials – Classification and typical applications of tool Materials	2
11.	Types, selection and actions of cutting fluids - Coolants and lubricants – Causes of surface roughness	2
12.	Effect of nose radius on surface roughness.	1
13.	Choice of Feed and Cutting Speed	1
14.	Life for Minimum Cost and Minimum Production Time	2
15.	Estimation of factors that determine Optimum Conditions	1
16.	Machining at Maximum Efficiency	1

Module Number	Topic	No. of Lectures
17.	Elementary Theory of Plasticity - Flow Curve	1
18.	True Stress and True Strain – Yielding Criteria for Ductile Metals	2
19.	Combined Stress Tests – Yield Locus – Anisotropy in Yielding – Yield Surface and Normality	2
20.	Plastic Stress-Strain Relations	1
21.	Classification of Forming Process – Mechanics of Metal working	2
22.	Flow-Stress Determination	1
23.	Temperature in Metalworking	1
24.	Friction and Lubrication	2
	Total	**36**

Course Designers:

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18MGPK0	**METAL JOINING ENGINEERING**	Category L T P Credit PE 3 0 0 3

Preamble

Metal joining is employed in the manufacture of various parts of engineering systems including machines, boilers, air crafts, automobiles, ships, nuclear reactors etc. It is often used to join metals / materials permanently in most of the applications. There are several techniques of metal joining of which welding is the most basic form. Welding joins materials, by causing coalescence with heating the workpieces and adding a filler material to form a strong permanent joint. Various energy sources of welding include gas flame, electric arc, laser & electron beam, friction, resistance and ultrasound. The quality of the welded joint depends on the type of welding and associated changes in the metallurgical properties. Welding metallurgy clearly addresses the challenges in welding of specific materials and process parameters. The quality of welded joints are tested for the strength and defects.

Prerequisite

- Mechanical Behaviour of Materials

Course Outcomes

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

CO. No.	Course Outcome	Blooms Level	Expected proficiency (%)	Expected attainment level (%)
CO1	Choose the suitable process parameters of various types of welding techniques	Apply	70	60
CO2	Describe the metallurgical changes during the joining processes in the weld zone.	Understand	80	70
CO3	Interpret the weldability of various ferrous and nonferrous metals	Analyse	70	60
CO4	Identify the defects, distortion, causes and remedial measures in metal joining processes	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	10	10	10	10
Understand	50	40	40	40
Apply	40	30	30	30

Analyse	0	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Classify welding.
2. State the applications of gas tungsten arc welding process.
3. Explain resistance seam welding process with neat sketches.
4. Select a suitable process to weld boiler shell and explain the process with sketches.
5. An aluminium name plate is to be fixed on a cast iron machine member, select a suitable welding process to fix the name plate and justify your selection with necessary illustrations.

Course Outcome 2 (CO2):

1. Explain the one dimensional heat transfer rate with necessary diagram.
2. Discuss the cooling rate of welding in and around the welding.
3. Draw TTT diagram and mark different zones.
4. Explain transformation of phase with CCT diagram.
5. Define weld metallurgy.
6. Explain the weld metal solidification technique.

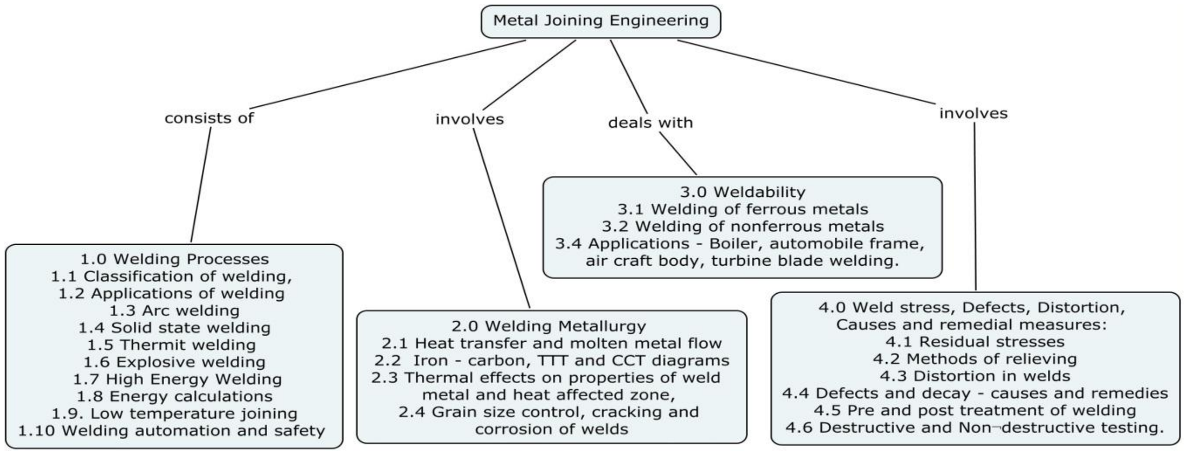
Course Outcome 3 (CO3):

1. Define weldability
2. Discuss how to join the dissimilar material in the welding process.
3. Suggest a suitable welding technique to join stainless steel material.
4. Explain welding of Titanium.
5. Compare the welding of different types of carbon steels.

Course Outcome 4 (CO4):

1. What is weld distortion?
2. Name the various stresses developed during welding process.
3. Discuss how the stresses are relived from the weld surface.
4. Name the various weld crack identification techniques.
5. Explain the dye penetrants technique with necessary sketches.
6. Explain the various pretreatment techniques used in the welding process.

Concept Map



Syllabus

Welding Processes: Classification of welding, Applications of welding, Arc welding - Gas tungsten arc welding, Gas metal arc welding - hard facing and metal spraying. Solid state welding- Ultrasonic, friction, friction stir welding, Resistance welding- spot, seam and projection and resistance butt welding, thermit welding, explosive welding, High Energy Welding- Laser and Electron beam welding - energy calculations. Low temperature joining- Brazing and soldering, welding of plastics. Welding automation and safety. **Welding Metallurgy:** Heat transfer and molten metal flow, two dimensional and three dimensional heat flow, Thermal cycles and temperature distribution, cooling rate in and around weld metal. Iron - carbon, TTT and CCT diagrams, thermal effects on properties of weld metal and heat affected zone, grain size control, cracking and corrosion of welds - Weld metal solidification. **Weldability:** welding of ferrous metals - Carbon steel, stainless steel, Alloy steel - welding of nonferrous metals - Aluminium, Titanium and Copper - welding of dissimilar metals - Applications - Boiler, automobile frame, air craft body, turbine blade welding. **Weld stress, Defects, Distortion, Causes and remedial measures:** Residual stresses, methods of relieving - Distortion in welds. Defects and decay - causes and remedies, pre and post treatment of welding, Destructive and Nondestructive testing.

Reference Books / Learning resources

1. Richard L Little, **"Welding and Welding Technology"** Mc Graw Hill Education, 2001.
2. Sindo Kou, **"Welding Metallurgy",** Wiley Interscience, USA, 2003.
3. Davies, A.C, **"Welding",** 10th Edition, Cambridge University press, 1996.
4. Howard B Cary and Scott Helzer **"Modern Welding Technology",** 6th edition, Pearson, 2004.
5. Parmer R.S, **"Welding Engineering and Technology",** 2nd Edition Khanna publishers, Delhi, 2010.
6. Khanna, O. P, **"A Text Book of Welding Technology",** - Dhanpat Rai Publications (P) Ltd., New Delhi, 2011.
7. **AWS Welding Handbook,** Volume 1, Welding Science & Technology, American Welding Society, 2001.
8. **AWS Welding Handbook,** Volume 2, Welding Processes, Part 1, American Welding Society, 2004.
9. **AWS Welding Handbook,** Volume 3, Welding Processes, Part 2, American Welding Society, 2004.
10. https://nptel.ac.in/courses/112107213/ Prof D.K.Dwivedi ,IITR

Course Content and lecture Schedule

Module number	Topics	No. of Lectures
1	**Welding Processes:**	
1.1	Classification of welding	1
1.2	Applications of welding	
1.3	Arc welding	
1.3.1	Gas Tungsten Arc Welding	1
1.3.2	Gas Metal Arc Welding	1

Module number	Topics	No. of Lectures
1.3.3	Hard facing and metal spraying	1
1.4	Solid state welding	1
1.4.1	Ultrasonic welding	1
1.4.2	Friction welding	
1.4.3	Friction stir welding	1
1.4.4	Resistance welding, Spot, seam welding processes	1
1.4.5	Projection and Resistance butt welding processes	1
1.5	Thermit welding	1
1.6	Explosive welding	
1.7.	High Energy Welding	1
1.7.1	Laser beam welding, Electron beam welding	
1.8	Energy calculations.	2
1.9	Low temperature joining	2
1.9.1	Brazing and soldering	
1.9.2	welding of plastics	
1.10	Welding automation and safety	1
2	**Welding Metallurgy**	
2.1	Heat transfer and molten metal flow,	1
2.1.1	Two dimensional and three dimensional heat flow,	1
2.1.2	Thermal cycles and temperature distribution, cooling rate in and around weld metal.	1
2.2	Iron-carbon, TTT and CCT diagrams	1
2.3	Thermal effects on properties of weld metal and heat affected zone	1
2.4	Grain size control, cracking and corrosion of welds	1
2.5	Weld metal solidification	1
3	**Weldability**	
3.1	welding of ferrous metals - Carbon steel, stainless steel, Alloy steel	2
3.2	welding of nonferrous metals - Aluminium, Titanium and Copper	2
3.3	welding of dissimilar metals	1
3.4	Applications - Boiler, automobile frame, air craft body, turbine blade welding.	2
4	**Weld stress, Defects, Distortion, Causes and remedial measures**	
4.1	Residual stresses	2
4.2	Methods of relieving	
4.3	Distortion in welds.	2
4.4	Defects and Decay- causes and remedies	
4.5	Pre and post treatment	

Module number	Topics	No. of Lectures
4.6	Destructive testing and Non-destructive testing	2
	Total	36

Course Designers

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18MGPL0	MICRO ELECTRO MECHANICAL SYSTEMS	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Micro-Electro-Mechanical Systems, (MEMS) can be defined as miniaturized mechanical and electro-mechanical elements fabricated using microfabrication techniques. Dimensions vary from one micron to several millimeters. MEMS devices can vary from relatively simple structures having no moving elements, to electromechanical systems with multiple moving elements. The objective of this course is to impart knowledge to the students on micro electromechanical systems, principles, materials, fabrication processes, design and packaging.

Prerequisite

- Nil

Course Outcomes

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

CO.No.	Course Outcome	Blooms Level	Expected Proficiency (%)	Expected Attainment Level (%)
CO1	Explain the overview of MEMS and Microsystems	Understand	80	70
CO2	Choose the suitable Microsystems of given environment/application	Apply	70	60
CO3	Select the Materials for MEMS and Microsystems	Apply	70	60
CO4	Choose suitable Microsystem Fabrication Process for the given application/environment	Apply	70	60
CO5	Explain the types of various Microsystems designs	Understand	80	70
CO6	Describe the Microsystem packaging	Understand	80	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	40	40	40	40
Apply	40	40	50	50
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define MEMS.
2. Describe MEMS.as a microactuator.
3. List the application of MEMS

Course Outcome 2 (CO2):

1. Recall the applications of chemiresistor sensors.
2. Describe the working principle of optical sensors with neat diagram.
3. Select the suitable sensor which uses the measurements of biological substances also explain the working principle of selected sensor.
4. Justify the selected sensor that used to detect shape change when they are exposed to chemicals

Course Outcome 3 (CO3):

1. List the applications of quartz material.
2. Explain in detail how polymer materials are used in MEMS applications.
3. Choose the suitable material which act as a sacrificial layer in the surface micromachining

Course Outcome 4 (CO4):

1. Recall the function of a photoresist
2. Explain in detail the various CVD processes for MEMS applications.
3. Choose the suitable microsystem fabrication which work as direct deposition of particles on the hot substrate surfaces
4. Select the suitable fabrication technique that used to create metal films in electronic circuits

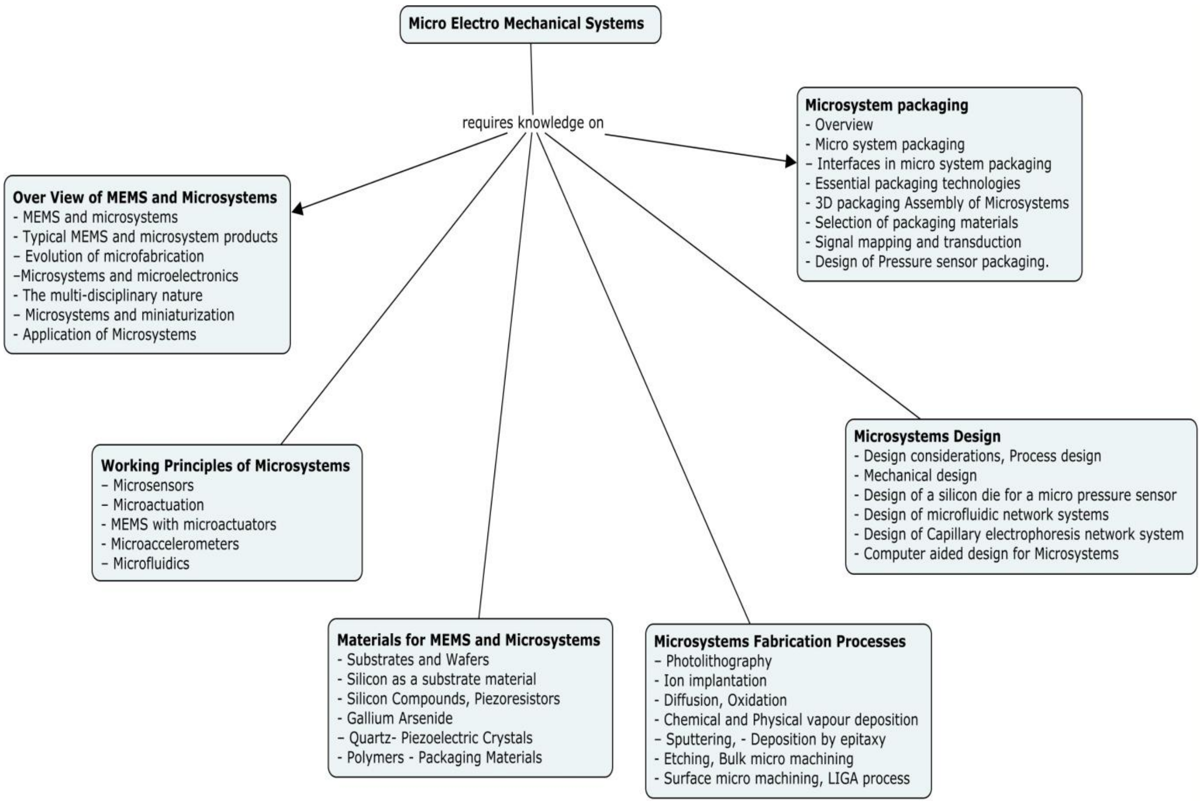
Course Outcome 5 (CO5):

1. List the design considerations in microsystem design.
2. Explain in detail, Capillary electrophoresis (CE) network systems with neat diagram
3. Describe the general structure for CAD for microsystems designs

Course Outcome 6 (CO6):

1. Recall the major reliability issues involved in the packaging of MEMS.
2. Explain in detail, three levels of microsystems packaging.

Concept Map



Syllabus

Over View of MEMS and Microsystems - MEMS and microsystems - Typical MEMS and microsystem products – Evolution of microfabrication –Microsystems and microelectronics - The multi-disciplinary nature of microsystem design and manufacture – Microsystems and miniaturization - Application of Microsystems in Automotive Industry - Application of Microsystems in other industries – Markets for Microsystems

Working Principles of Microsystems – Microsensors – Microactuation - MEMS with microactuators - Microaccelerometers – Microfluidics

Materials for MEMS and Microsystems Substrates and Wafers – Active substrate materials - Silicon as a substrate material - Silicon Compounds - Silicon Piezoresistors - Gallium Arsenide – Quartz- Piezoelectric Crystals - Polymers - Packaging Materials

Microsystems Fabrication Processes – Photolithography - Ion implantation - Diffusion – Oxidation - Chemical vapour deposition - Physical vapour deposition – Sputtering - Deposition by epitaxy - Etching - Bulk micro machining - Surface micro machining - LIGA process

Microsystems Design - Design considerations - Process design - Mechanical design - Design of a silicon die for a micro pressure sensor - Design of microfluidic network systems - Design of Capillary electrophoresis network system - Computer aided design for Microsystems

Microsystem packaging - Overview of mechanical packaging of microelectronics - Micro system packaging – Interfaces in micro system packaging - Essential packaging technologies -

Three dimensional packaging Assembly of Microsystems - Selection of packaging materials - Signal mapping and transduction - Pressure sensor packaging.

Reference Books/ Learning Resources

1. Tai – Ran Hsu, "MEMS and Microsystems Design and Manufacture", First Edition, McGraw Hill Education,.New Delhi, 2002.
2. Marc J. Madou, "**Fundamentals of Microfabrication: The Science of Miniaturization**", Second Edition, CRC Press, 2002.
3. Mohamed Gad-el-Hak, "**The MEMS Handbook- 3 Volume Set",** Second Edition, CRC Press, 2005.
4. Julian W. Hardner, "**Micro Sensors, Principles and Applications**", CRC Press,1994.
5. Prosenjit Rai Choudhury (Ed.), "**MEMS and MOEMS Technology and Applications**" PHI Learning Pvt. Ltd, New Delhi, 2009.
6. Julian W. Gardner and Vijay K. Varadan, "**Microsensors, MEMS, and Smart Devices**" CRC Press, 2001.
7. NPTEL Course: MEMS and Microsystems , https://nptel.ac.in/courses/117105082/#
8. NPTEL Course: Micro and Smart systems, https://nptel.ac.in/courses/112108092/

Course Content and Lecture Schedule

Module Number	Topics	No. of Lectures
1.0	**Over View of MEMS and Microsystems**	
1.1	MEMS and microsystems - Typical MEMS and microsystem products – Evolution of microfabrication –Microsystems and microelectronics -	1
1.2	The multi-disciplinary nature of microsystem design and manufacture – Microsystems and miniaturisation	1
1.3	Application of Microsystems in Automotive Industry - Application of Microsystems in other industries – Markets for Microsystems	1
2.0	**Working Principles of Microsystems**	
2.1	Microsensors	2
2.2	Microactuation - MEMS with microactuators	2
2.3	Microaccelerometers	2
2.4	Microfluidics	2
3.0	**Materials for MEMS and Microsystems**	
3.1	Substrates and Wafers – Active substrate materials - Silicon as a substrate material -	2
3.2	Silicon Compounds - Silicon Piezoresistors - Gallium Arsenide – Quartz	2
3.3	Piezoelectric Crystals	1
3.4	Polymers - Packaging Materials	1
4.0	**Microsystems Fabrication Processes**	
4.1	Photolithography	1

Module Number	Topics	No. of Lectures
4.2	Ion implantation - Diffusion – Oxidation	1
4.3	Chemical vapour deposition - Physical vapour deposition – Sputtering	1
4.4	Deposition by epitaxy - Etching	1
4.5	Bulk micro machining	1
4.6	Surface micro machining	1
4.7	LIGA process	1
5.0	**Microsystems Design**	
5.1	Design considerations	1
5.2	Process design - Mechanical design	1
5.3	Design of a silicon die for a micro pressure sensor	1
5.4	Design of microfluidic network systems	1
5.5	Design of Capillary electrophoresis network system	1
5.6	Computer aided design for microsystems	1
6.0	**Microsystem packaging**	
6.1	Overview of mechanical packaging of microelectronics	1
6.2	Micro system packaging – Interfaces in micro system packaging	1
6.3	Essential packaging technologies - Three dimensional packaging Assembly of microsystems	2
6.4	Selection of packaging materials - Signal mapping and transduction	1
6.5	Pressure sensor packaging	1
	Total	**36**

Course Designers

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18MGPM0	**NON DESTRUCTIVE EVALUATION**	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Non-destructive Evaluation (NDE) is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage. NDE does not permanently alter the article being inspected. It is a highly valuable technique that can save both money and time in product evaluation, troubleshooting, and research. The six most frequently used NDE methods are eddy-current, magnetic-particle, liquid penetrant, radiographic, ultrasonic, and visual testing. This course covers the above mentioned non destructive techniques used for various engineering applications.

Prerequisite

- Mechanical Behaviour of Materials

Course Outcomes

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

CO. No.	**Course Outcome**	**Blooms Level**	**Expected Proficiency %**	**Expected attainment level %**
CO1	Compare the various Non-Destructive Testing.	Understand	80	70
CO2	Elaborate the principle, instrumentation and application of Visual Inspection and Liquid Penetrant Testing.	Understand	80	70
CO3	Compare the suitability of eddy current and acoustic testing for engineering applications	Evaluate	70	60
CO4	Compare the suitability of Magnetic Particle Testing, Thermography, Ultrasonic Testing and Radiography testing for engineering applications	Evaluate	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	-	-	-	-	-	-	-

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**			**Terminal Examination**
	1	**2**	**3**	
Remember	20	10	10	10
Understand	80	30	30	30
Apply	0	30	30	30

Analyse	0	10	10	10
Evaluate	0	20	20	20
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

- Define NDT.
- Compare Non Destructive Testing with Destructive Testing.
- State the benefits of using NDT.

Course Outcome 2 (CO2):

1. Discuss the Liquid Penetrant Testing with necessary illustrations.
2. Explain the various optical aids used for visual inspection.
3. Summarize the advantages applications of Liquid Penetrant Testing.

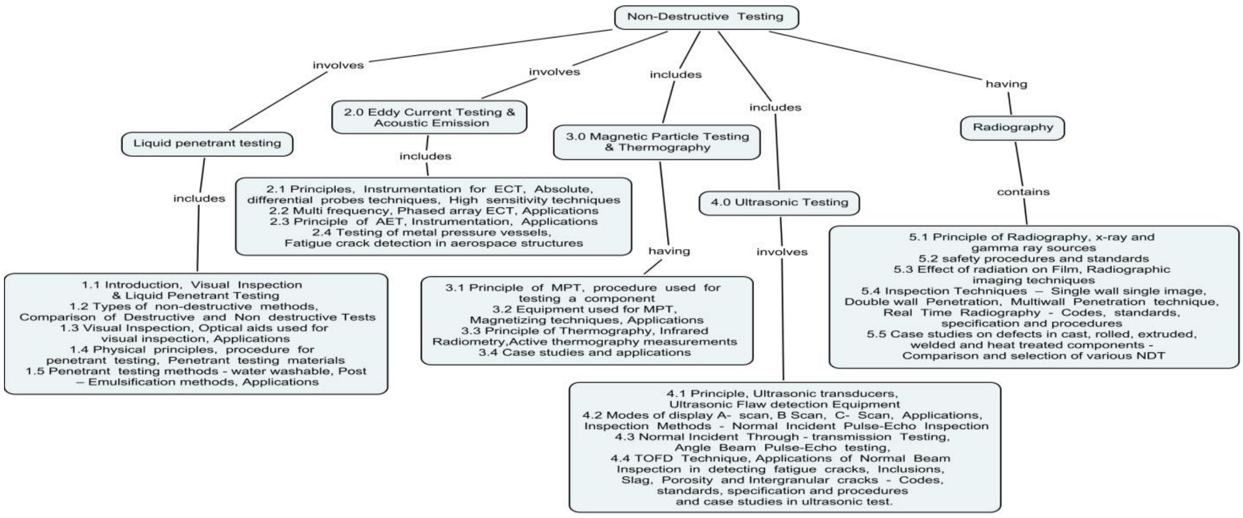
Course Outcome 3 (CO3):

1. Suggest the suitable industrial applications of Magnetic Particle Testing (MPT).
2. Outline how to detect the fatigue crack by using Acoustic emission testing (AET).
3. Discuss how thermography is used to find the cracks on a coated surface.

Course Outcome 4 (CO4):

1. State the principle of ultrasonic testing.
2. Suggest a suitable process to find the porosity and inter granular cracks and also explain the process.
3. Identify a suitable process to find the interior air pocket in an extruded product.

Concept Map



Syllabus

Non-Destructive Testing: An Introduction, Visual Inspection and Liquid Penetrant Testing Types of non-destructive methods, Comparison of Destructive and Non-destructive Tests. **Visual Inspection**- Optical aids used for visual inspection, Applications. **Penetrant Testing**- Physical principles, procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods-water washable, Post – Emulsification methods, Applications.

Eddy Current Testing (ECT) & Acoustic Emission Test (AET): Principles, Instrumentation for ECT, Absolute, differential probes, Techniques – High sensitivity techniques, Multi frequency, Phased array ECT, Applications. **Acoustic Emission Test** -Principle of AET, Instrumentation, Applications - testing of metal pressure vessels, Fatigue crack detection in aerospace structures.

Magnetic Particle Testing (MPT) & Thermography : Principle of MPT, procedure used for testing a component, Equipment used for MPT, Magnetizing techniques, Applications. **Thermography**- Principle, Infrared Radiometry, Active thermography measurements, Applications – Imaging entrapped water under an epoxy coating, Detection of carbon fiber contaminants.

Ultrasonic Testing: Principle, Ultrasonic transducers, Ultrasonic Flaw detection Equipment, Modes of display A- scan, B-Scan, C- Scan, D scan ,Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection, Normal Incident Through-transmission Testing, Angle Beam Pulse-Echo testing, Time of Flight Diffraction (TOFD) Technique, Applications of Normal Beam Inspection in detecting fatigue cracks, Inclusions, Slag, Porosity and Intergranular cracks - Codes, standards, specification and procedures and case studies in ultrasonic test.

Radiography: Principle of Radiography, x-ray and gamma ray sources- safety procedures and standards, Effect of radiation on Film, Radiographic imaging, Inspection Techniques – Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography - Codes, standards, specification and procedures.

Case studies on defects in cast, rolled, extruded, welded and heat treated components - Comparison and selection of various NDT techniques.

Reference Books/ Learning resources

1. M. Thavasimuthu, T. Jayakumar, Baldev Raj "Practical Non Destructive Testing", Third Edition, Narosa Book Distributors Pvt Ltd, New Delhi, 2002
2. Peter J. Shull "Non Destructive Evaluation: Theory, Techniques and Applications", First Edition, Marcel Dekker, Inc., New York, 2002
3. Krautkramer. J., "Ultra Sonic Testing of Materials", Fourth Edition, Springer (India) Private Limited, New Delhi, 2003.
4. ASM Metals Handbook Vol 17: Non Destructive testing.
5. ASME Sec V - Non - Destructive Testing.
6. ASTM Standards
   a. E 94, Standard Guide for Radiographic Examination.
   b. E 142, Standard Method for Controlling Quality of Radiographic Testing.
   c. E 164, Standard Practice for Ultrasonic Contact Examination of Weldments.
   d. E 165, Standard Test Method for Liquid Penetrant Examination.
   e. E 1444, Standard Practice for Magnetic Particle Examination.
7. https://onlinecourses.nptel.ac.in/noc18_mm04/preview- Dr. Ranjit Bauri, Associate Professor, Dept. of Metallurgical and Materials Engineering, IIT Madras.
8. https://nptel.ac.in/courses/113106070/- Dr. Ranjit Bauri, Associate Professor, Dept. of Metallurgical and Materials Engineering, IIT Madras.
9. https://nptel.ac.in/courses/114106035/35- Prof. Dr. Srinivasan Chandrasekaran. Department of Ocean Engineering Indian Institute of Technology, Madras

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures

Module Number	Topics	No. of Lectures
1.0	**Non-Destructive Testing**	
1.1	Introduction, Visual Inspection & Liquid Penetrant Testing	2
1.2	Types of non-destructive methods, Comparison of Destructive and Non destructive Tests	1
1.3	Visual Inspection, Optical aids used for visual inspection, Applications	2
1.4	Physical principles, procedure for penetrant testing, Penetrant testing materials	1
1.5	Penetrant testing methods - water washable, Post – Emulsification methods, Applications	2
2.0	**Eddy Current Testing & Acoustic Emission**	
2.1	Principles, Instrumentation for ECT, Absolute, differential probes techniques, High sensitivity techniques	2
2.2	Multi frequency, Phased array ECT, Applications	1
2.3	Principle of AET, Instrumentation, Applications	2
2.4	Testing of metal pressure vessels, Fatigue crack detection in aerospace structures.	2
3.0	**Magnetic Particle Testing & Thermography**	
3.1	Principle of MPT, procedure used for testing a component,	1
3.2	Equipment used for MPT, Magnetizing techniques, Applications.	2
3.3	Principle of Thermography, Infrared Radiometry, Active thermography measurements	2
3.4	Case studies and applications	2
4.0	**Ultrasonic Testing**	
4.1	Principle, Ultrasonic transducers, Ultrasonic Flaw detection Equipment,	2
4.2	Modes of display A- scan, B Scan, C- Scan, D scan Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection,	2
4.3	Normal Incident Through - transmission Testing, Angle Beam Pulse-Echo testing	1
4.4	Time of Flight Diffraction Technique, Applications of Normal Beam Inspection in detecting fatigue cracks, Inclusions, Slag, Porosity and Intergranular cracks - Codes, standards, specification and procedures and case studies in ultrasonic test.	2
5.0	**Radiography**	
5.1	Principle of Radiography, x-ray and gamma ray sources	1
5.2	safety procedures and standards,	1
5.3	Effect of radiation on Film, Radiographic imaging techniques	1
5.4	Inspection Techniques – Single wall single image, Double wall Penetration, Multiwall Penetration technique, Real Time Radiography - Codes, standards, specification and procedures	2
5.5	Case studies on defects in cast, rolled, extruded, welded and heat treated components - Comparison and selection of various NDT	2
	Total	**36**

Course Designer:

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18MGPQ0	PLANT LAYOUT AND MATERIAL HANDLING	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

The workplace is one of the prime resources to deliver products/services. To achieve the organizational effectiveness, proper utilization of the workplace has to be ensured. This course highlights the fundamental issues, concepts and the methodologies related to Plant layout and material handling.

Prerequisite

NIL

Course Outcomes

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

CO. No	Course Outcome	Bloom's level	Expected Proficiency %	Expected attainment %
CO 1.	Describe the facility location determinants and methods	Understand	80	90
CO 2.	Solve different types of facility location models	Apply	70	75
CO 3.	Design the layouts of manufacturing systems and service organizations	Apply	70	80
CO 4.	Prepare clusters of machine and components using clustering algorithms	Apply	70	80
CO 5.	Solve line balancing problems using heuristic algorithms.	Apply	70	70
CO 6.	Select an appropriate material handling system for manufacturing/ process industry applications	Apply	70	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1.		M	M	-	-	-	M	-	M	M	M
CO2.	S	M	S	M	M	-	M	-	M	-	-
CO3.	S	S	S	-	M	-	M	-	M	-	-
CO4.	M	M	M	-	M	-	-	-	M	M	M
CO5.	S	S	S	-	M	M	M	-	M	-	-
CO6.		M	M	M	M	-	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	10
Understand	30	15	15	15
Apply	60	75	75	75
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 issues of facility location.
2. Identify the factors to be considered for location selection.
3. Write the equation to compute the Euclidian distance.
4. Discuss about different types of facility location problem.

Course Outcome 2 (CO2):

1. The following table shows a matrix of travel times between possible locations for ambulance stations and areas in a city. Governing body's policy suggests that ambulance stations must be at most 30 minutes away from all population areas. Find the best locations for achieving this.

Possible Locations		I	II	III	IV	V	VI	VII
	A	5	11	20	33	27	36	33
	B	33	35	17	10	53	41	18
	C	18	39	41	12	33	22	37
	D	13	6	43	25	38	33	20
	E	35	47	41	45	50	51	43

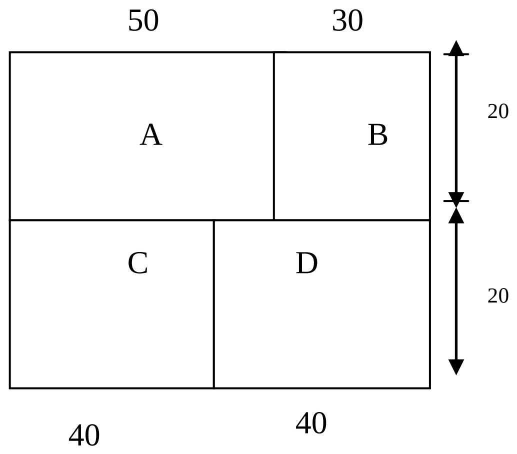
2. Discuss the various techniques of locating a single facility

Course Outcome 3 (CO3):

1. A company consists of the following functional areas. Design a layout using the construction algorithm ALDEP.

A – Wood cutting	1200 Sq. feet
B – Receiving	512
C – Framing	1280
D – Upholstery	1120
E – Fabric Storage	960
F – Fabric cutting	960
G- Sewing	640
H – Shipping	800
I – Offices	800
J – General Storage	480

2. The data for designing a layout are given below. Follow the steps of the CRAFT algorithm & develop a final CRAFT layout using the pair wise interchange technique. Use unit cost matrix. Initial Layout



-	A	B	C	D
A	-	2	4	4
B	1	-	1	3
C	2	1	-	2
D	4	1	0	-

Course Outcome 4 (CO4):

1. Identify the logical part families and machine groups by applying ROC technique. The part-machine incidence matrix is given in the table.

Machine \ Parts	I	II	III	IV	V
1	1	0	0	0	0
2	0	1	0	0	1
3	1	0	0	1	0
4	0	1	1	0	0
5	0	0	0	1	0

2. Identify the logical part families and machine groups by applying ROC-2 technique. The part-machine incidence matrix is shown below.

Machine \ Parts	I	II	III	IV	V
1	1	0	0	0	0
2	0	1	0	0	1
3	1	0	0	1	0
4	0	1	1	0	0
5	0	0	0	1	1

Course Outcome 5 (CO5):

1. A company produces 50 products per hour on its production line. The operations involved are given below. Balance the line for the given production rate using Ranked positional weight method. Determine the workstations required and balance delay.

Work	Immediate	Estimated

Element	Predecessor	time (Sec)
A	-	20
B	-	10
C	-	15
D	B,C	10
E	D	25
F	E	15
G	F	30
H	G	30
I	A,H	20
J	I	25

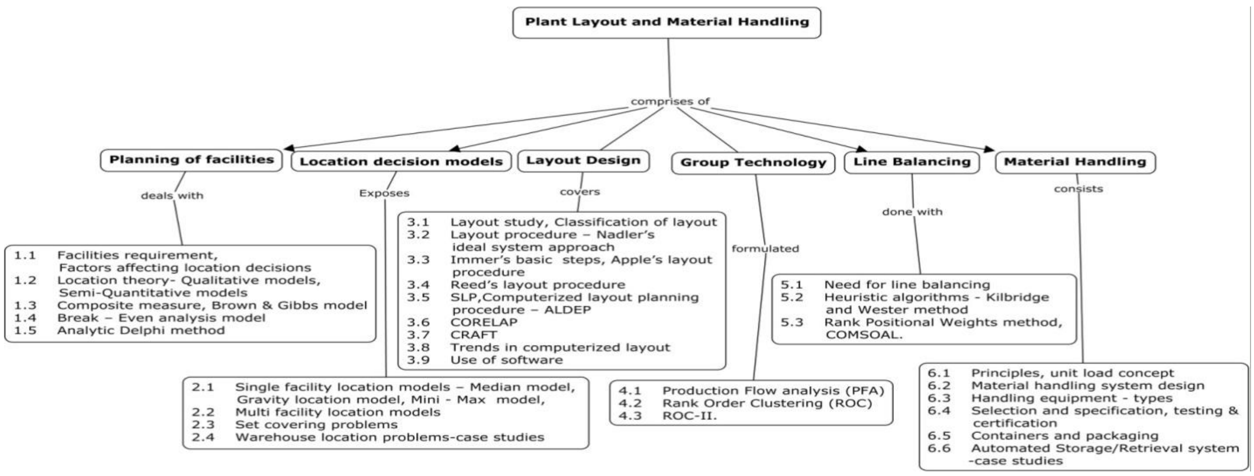
2. The operations involved in an organization are given below. Balance the line using Kilbridge and Wester method. Determine the balance delay. Assume that number of workstations is Three.

Work Element	Immediate Predecessor	Estimated time (Sec)
a	-	10
b	-	10
c	-	15
d	b,c	10
e	d	35
f	e	15
g	f	30
h	g	30
i	a,h	20
j	i	15

Course Outcome 6 (CO6):

1. Illustrate the basic material handling equipments and recommend the choice of MHEs for the chosen industrial scenario.
2. Design the Unit load system for your specific application system.
3. Choice of AS/AR system in comparison with the conventional warehousing system with example.
4. Choice of material handling system for a heavy manufacturing industry, express the pros and cons of the system under study.

Concept Map



Syllabus

Planning of facilities: Facilities requirement; Factors affecting location decisions , Location theory - Qualitative models , Semi-Quantitative models – Composite measure , Brown & Gibbs model , Break – Even analysis model; Analytic Delphi method.

Location decision models: Single facility location models– Median model, Gravity location model, Mini - Max model, Multi facility location models - Set covering problems – Warehouse location problems-case studies.

Layout design: Layout study - Classification of layout , Layout procedure – Nadler's ideal system approach, Immer's basic steps, Apple's layout procedure, Reed's layout procedure Systematic Layout planning (SLP), Computerized layout planning procedure – ALDEP, CORELAP, CRAFT; Trends in computerized layout and algorithm for Group Technology; Use of Software for layout modeling.

Group Technology: Production Flow analysis (PFA), Rank Order Clustering (ROC), ROC-II.

Line balancing: Need, Heuristic algorithms - Kilbridge and Wester method, Rank Positional Weights method (RPW), COMSOAL.

Material Handling: Principles, unit load concept, material handling system design; handling equipment - types, selection and specification, testing and certification; containers and packaging; Automated Storage/Retrieval system-case studies.

Reference Books / Learning resources

1. Tompkins, J.A. and White J.A., "Facilities planning", Fourth Edition, John Wiley, 2010.
2. Richard Francis.L. and John A.White, "Facilities Layout and location - an analytical approach", Prentice Hall of India, 2012.
3. James Apple, M, "Plant layout and "Material Handling", John Wiley, 1991. (No Reprint)
4. Pannerselvam, R, "Production and Operations Management", Third Edition, Prentice Hall of India,2012.
5. Krajewski, J. and Ritzman, "Operations Management – Strategy and Analysis", Addison – Wesley publishing company , 5th Edition, 1999
6. E-learning material- NPTEL videos at https://nptel.ac.in/courses/112102106 by Prof. Arun Kanda, Dept of Mechanical Engineering, IIT, Delhi

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Planning of facilities**	
1.1	Facilities requirement, Factors affecting location decisions	1
1.2	Location theory- Qualitative models, Semi-Quantitative models	1
1.3	Composite measure, Brown & Gibbs model	2

1.4	Break – Even analysis model	2
1.5	Analytic Delphi method	1
2	**Location decision models**	
2.1	Single facility location models – Median model, Gravity location model, Mini - Max model,	1
2.2	Multi facility location models	1
2.3	Set covering problems	1
2.4	Warehouse location problems-case studies	1
3	**Layout design**	
3.1	Layout study, Classification of layout	1
3.2	Layout procedure – Nadler's ideal system approach	2
3.3	Immer's basic steps, Apple's layout procedure	1
3.4	Reed's layout procedure	1
3.5	SLP, Computerized layout planning procedure – ALDEP	2
3.6	CORELAP	1
3.7	CRAFT	2
3.8	Trends in computerized layout and algorithm for Group Technology	1
3.9	Use of Software for layout modeling	1
4	**Group Technology**	
4.1	Production Flow analysis (PFA)	1
4.2	Rank Order Clustering (ROC)	2
4.3	ROC-II.	1
5	**Line balancing**	
5.1	Need for line balancing	1
5.2	Heuristic algorithms - Kilbridge and Wester method	1
5.3	Rank Positional Weights method, COMSOAL.	2
6	**Material Handling**	
6.1	Principles, unit load concept	1
6.2	Material handling system design	2
6.3	Handling equipment - types	1
6.4	Equipment - Selection and specification, testing and certification	1
6.5	Containers and packaging	1
6.6	Automated Storage/Retrieval system-case studies	2
	Total	**39**

Course Designers:

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18IE210	QUALITY AND RELIABILITY ENGINEERING	Category	L	T	P	Credit
		PE	3	0	0	3

(Use of Statistical Tables, Distribution Tables – Normal and Poisson, Control Chart Tables and Dodge Romig tables, IS2500 Part I and II are allowed in the Exam Hall)

Preamble

Quality engineering is the management, development, operation and maintenance of manufacturing systems and enterprise architectures with a high quality standard. It is focusing on quality control and quality assurance management through use of physical technology, standards information, and statistical tools.

Reliability engineering is a sub-discipline of systems engineering that emphasizes dependability in the lifecycle management of a product. Dependability, or reliability, describes the ability of a system or component to function under stated conditions for a specified period of time.

Prerequisite

- NIL

Course Outcomes

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

CO.No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1.	• Develop the process control charts – variables, attributes.	Apply	80	70
CO2.	• Analyse the process control charts.	Analyze	70	70
CO3.	• Explain the concept of Multivariate quality control.	Understand	70	80
CO4.	• Develop and comment the Sampling plans – single, double and multiple.	Apply	80	70
CO5.	• Compute the system Reliability of different system configuration with redundancy and standby modes	Apply	80	70

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10
Understand	30	40	20	20
Apply	30	40	50	50
Analyse	20	0	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course outcomes

Course Outcome 1 (CO1):

1. An automatic lathe machines a specified spindle with diameter 15.00±0.04mm. Control chart for X bar and R charts are maintained for this process. The sub group size is 5. The values for above are computed for each subgroup. After 20 subgroups ΣX bar = 627.48 & ΣR = 125.0. Compute the values of 3 sigma limits for above charts. Estimate the values of sigma on the assumption that the process is in control. (A1=1.6, A2= 0.58, d2=2.326, D3=0, D4=2.11, B3=0, B4=2.09).
2. In a factory producing spark, plug the number of defectives found in inspection of 20 lots of 100 each, is given below:

Lot No.	No. of defectives	Lot No.	No. of defectives
1	5	11	4
2	10	12	7
3	12	13	8
4	8	14	3
5	6	15	3
6	4	16	4
7	6	17	5
8	3	18	8
9	3	19	6
10	5	20	10

   (a) Construct appropriate control chart and state whether the process is in statistical control.

3. The following table shows the results of successive lots of parts produced by a plastic moulding press. As each lot comes of the line, a random sample of 150 pieces each was inspected and the results are as given below.

Lot No.	1	2	3	4	5	6	7	8	9	10
No. of Defects	4	8	2	4	4	6	10	4	6	8

   (i) Compute control limits
   (ii) Plot the appropriate chart

(iii) Draw Conclusion

Course Outcome 2 (CO2):

1. Control charts for *X* bar and *R* are maintained on a certain dimension of a manufactured part measured in cm. The subgroup size is 5. The values of *X bar* and *R* are computed for each subgroup. After 25 subgroups ΣX bar = 41.283 and ΣR = 0.339, compute the values of 3σ limits for *X bar* and *R* chart and estimate the value of sigma on the assumption that the process is in statistical control also determine the process capability and Interpret the results.
2. The percent of water absorption is an important characteristic of common building brick. A certain company occasionally measured this characteristic of its product but records were never kept. It was decided to analyze the process with control chart. Twenty-five samples of four bricks each yielded these results.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13
X	15.01	12.3	7.4	8.7	8.8	11.7	10.2	11.5	11.2	10.2	9.6	7.6	7.6
R	9.1	9.9	9.7	6.7	7.1	9.1	12.1	10.8	13.5	6.9	5.0	8.2	5.4

Sample No.	14	15	16	17	18	19	20	21	22	23	24	25
X	9.8	8.8	8.1	6.3	10.5	9.7	11.7	13.2	12.5	7.5	8.8	8.0
R	17.5	10.5	4.4	4.1	5.7	6.4	4.6	7.2	8.3	6.4	6.9	6.4

Estimate the control limits for X and R chart. If any point lies out of the control limits, estimate the revised control limits and analyse the shift in process mean for both the conditions.

Course Outcome 3 (CO3):

1. Explain about Hotelling T^2 control chart for multivariate analysis.
2. Describe about covariance matrix and its applications.
3. Explain the Difference between dependent and independent variables.
4. Explain the two dependent variables for Multivariate quality control

Course Outcome 4 (CO4):

1. Draw an OC curve for a sampling plan n = 40 and c = 1. From the curve find AQL, Split risk quality and LTPD.

2. Construct the AOQ, AOQL curve for a sampling plan N=4000, n=40, c=2.
3. Compute the probability of acceptance for the following double sampling plan with an incoming fraction defective 0.02

   n_1= 65 c_1 = 1 R_1 = 3

   n_2 = 90 c_2 = 2 R_2 = 3

Also compute ATI, ASN for N = 750.

4. Write the Step by step procedure to construct OC curve for double sampling plan with an incoming fraction defective 0.02

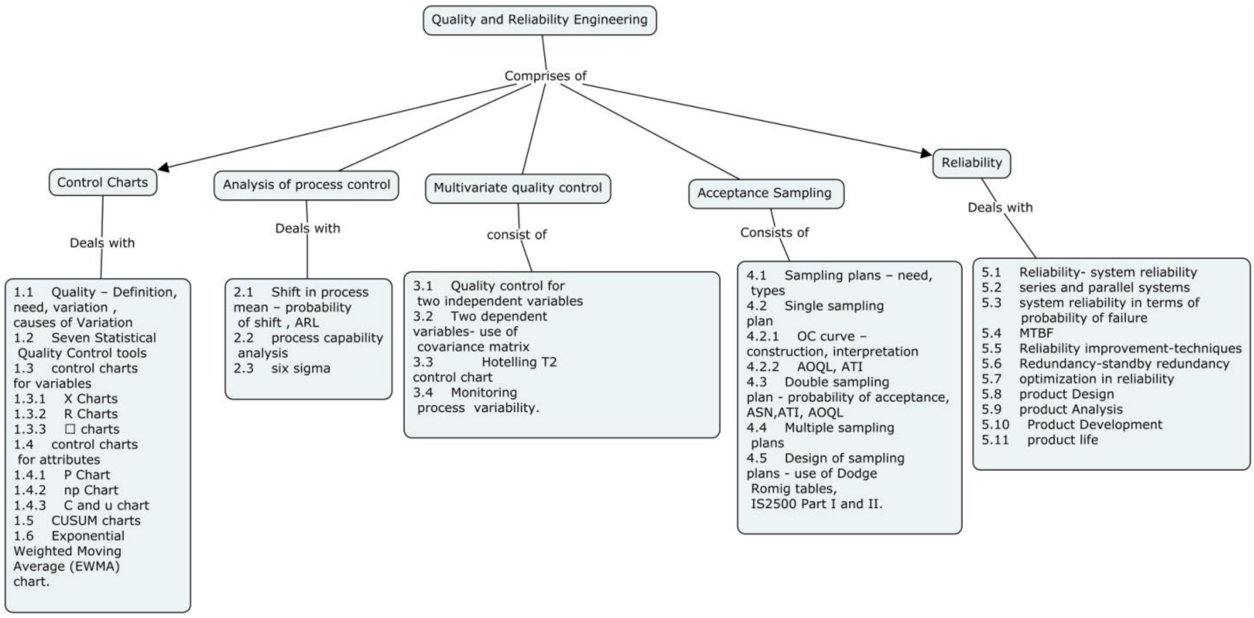
   n_1= 65 c_1 = 1 R_1 = 3

   n_2 = 90 c_2 = 2 R_2 = 3 N = 750.

Course Outcome 5 (CO5):

1. There are 3 modules A, B & C in a system. A is a 2 out of 4 system with component reliability of 0.7. Module B is a 4 out of 7 system with component reliability of 0.65. And module C is of 5/8 system with component reliability of 0.9. Compute the system reliability if A&B is in series and C is in parallel with A&B.
2. An optical sensor has followed the Weibull time to failure distribution with scale parameter of 300 h and shape parameter of 0.6. What is the reliability of the sensor after 500 h of operation?
3. Consider a system with three components A, B and C in parallel. Determine the system reliability for 2000 h of operation, and find the mean time to failure. Assume all the three components have an identical time-to failure distribution that is exponential, with a constant failure rate of 0.0006 per hour. What is the mean time failure of each component?
4. A standby system has a basic unit with four standby components. The time to failure of each component has an exponential distribution with a failure rate of 0.007 per h. For a 400h operation period, find the reliability of the standby system.
5. Propose a system configuration in order to improve its reliability with the known component reliability.
6. A standby system has a basic unit with two standby components. The time to failure of each component has an exponential distribution with a failure rate of 0.004 per h. For a 600h operation period, compute the reliability of the standby system. Develop ways to improve the standby system reliability.

Concept Map



Syllabus

Control charts: Quality – Definition, need- variation – causes- Seven Statistical Quality Control tools – control charts for variables X bar, R and σ charts- control charts for attributes – p, np, c, u chart, CUSUM charts, Exponential Weighted Moving Average (EWMA) chart.

Analysis of process control: Shift in process mean – probability of shift, ARL, process capability analysis, six sigma.

Multivariate quality control: Quality control for two independent variables, two dependent variables- use of covariance matrix – Hotelling T^2 control chart – Monitoring process variability.

Acceptance sampling: Sampling plans – need, types – single sampling plan – OC curve – construction, interpretation, AOQL, ATI- double sampling plan – probability of acceptance, ASN,ATI, AOQL- multiple sampling plans – design of sampling plans – use of Dodge Romig tables, IS2500 Part I and II.

Reliability: Reliability- system reliability-series and parallel systems-system reliability in terms of probability of failure-MTBF- Reliability improvement-techniques-Redundancy-standby redundancy optimization in reliability - product Design-product Analysis-Product Development product life.

Reference Books/ Learning Resources

1. Dougles C. Montgomery, **"Introduction to Statistical Quality Control"**, John Wiley and Sons, Inc, Seventh Edition, 2012.
2. Amitava Mitra, **"Fundamentals of Quality Control and Improvement"**, Wily USA, Fourth Edition, 2016.
3. Grant, Eugene .L, **"Statistical Quality Control"**, McGraw-Hill, Tenth reprint, 2008

4. Monohar Mahajan, "**Statistical Quality Control**", Dhanpat Rai and Co (P) Ltd, Third Edition, 2010.
5. NPTEL Video Lectures – Industrial Engineering, Prof.H.S.Shan, Prof.Pradeep Kumar, Prof. P. K. Jain, IIT-ROORKEE. URL: http://nptel.ac.in/courses/Webcourse-contents/IIT-ROORKEE/INDUSTRIAL-ENGINERRING/
6. Charles E. Ebeling, **"An Introduction to Reliability and Maintainability Engineering",** Tata Mc-graw hill publication, eighth edition 2007.
7. Alessandro Birolini, **Reliability Engineering: Theory and Practice, Springer,** Eighth Edition, 2017.
8. Connor, P.D.T.O., **"Practical Reliability Engineering** ", John Wiley, 2012.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
	Control charts	
1.1	Quality – Definition, need, variation , causes of Variation	1
1.2	Seven Statistical Quality Control tools	1
1.3	control charts for variables	
1.3.1	X Charts	1
1.3.2	R Charts	
1.3.3	σ charts	1
1.4	control charts for attributes	
1.4.1	P Chart	1
1.4.2	np Chart	1
1.4.3	C and u chart	1
1.5	CUSUM charts	
1.6	Exponential Weighted Moving Average (EWMA) chart.	1
2.	**Analysis of process control**	
2.1	Shift in process mean – probability of shift , ARL	2
2.2	process capability analysis	2
2.3	six sigma	
3	**Multivariate quality control**	
3.1	Quality control for two independent variables	1
3.2	Two dependent variables- use of covariance matrix	1
3.3	Hotelling T^2 control chart	1

3.4	Monitoring process variability.	1
4	**Acceptance sampling**	
4.1	Sampling plans – need, types	1
4.2	Single sampling plan	1
4.2.1	OC curve – construction, interpretation	2
4.2.2	AOQL, ATI	1
4.3	Double sampling plan - probability of acceptance, ASN,ATI, AOQL	2
4.4	Multiple sampling plans	1
4.5	Design of sampling plans - use of Dodge Romig tables, IS2500 Part I and II.	1
5	**Reliability**	
5.1	Reliability- system reliability	1
5.2	series and parallel systems	
5.3	system reliability in terms of probability of failure	2
5.4	MTBF	2
5.5	Reliability improvement-techniques	1
5.6	Redundancy-standby redundancy	2
5.7	optimization in reliability	1
5.8	product Design	1
5.9	product Analysis	
5.10	Product Development	1
5.11	product life	
	Total	**36**

Course Designers:

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		Category	L	T	P	Credit
18MGPS0	**ADDITIVE MANUFACTURING**	PE	3	0	0	3

Preamble

Additive Manufacturing (AM) is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. Construction of the part or assembly is usually done using 3D printing or "additive layer manufacturing" technology. Additive manufacturing improves product development by enabling better communication in a concurrent engineering environment and also reduces product development cycle time. This course aims to provide knowledge on the additive manufacturing and its application, advantages, limitations.

Prerequisite

- Nil

Course Outcomes

On the 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 concepts of prototypes and AM process chain	Understand	80	70
CO2.	Select the suitable AM process for a given product/part drawing/Application.	Apply	70	60
CO3.	Choose the suitable AM process for rapid tooling application	Apply	70	60
CO4.	Describe the need and steps involved in reverse engineering	Understand	80	70
CO5.	Create 3D model using Additive manufacturing Method - Practical (Continuous Assessment only)	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	10	10

Understand	60	40	30	30
Apply	20	40	60	60
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Prototyping
2. Explain the process chain of additive manufacturing process
3. Explain the classification of additive manufacturing process

Course Outcome 2 (CO2):

1. Define polymerization Process
2. Explain the process parameters of Solid Ground Curing (SGC).
3. Explain the principle of Stereo lithography (SLA) processes.
4. Discuss the solid ground process steps in details with suitable diagrams.
5. Select the suitable AM process for the development of Pattern for jewellery application
6. Discuss the process parameters to be considered in selective laser sintering
7. Explain the process parameters considered for laminated object manufacturing.
8. Discuss the working principle of Fusion Deposition Modelling (FDM).
9. Select the suitable AM process for the development of Fixture for measurement purpose

Course Outcome 3 (CO3):

1. Differentiate direct and indirect tooling process.
2. Explain silicon rubber tooling processes in detail.
3. Differentiate soft tooling and hard tooling.
4. Select the suitable AM process for fabrication of injection moulding tool.

Course Outcome 4 (CO3):

1. Define reverse engineering
2. Discuss the steps involved in reverse engineering in detail.

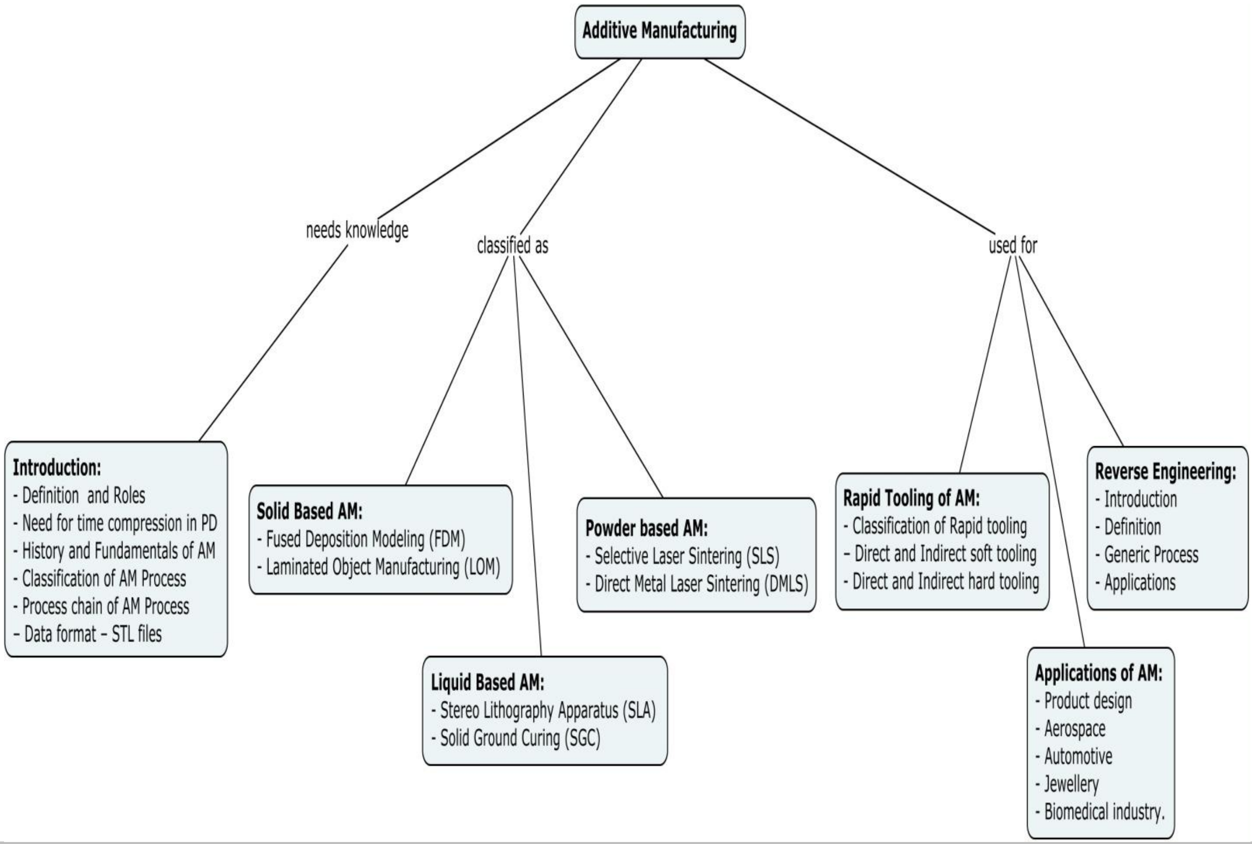
Course Outcome 5: (CO5 - Continuous Assessment only)

Approximately 35cc material (only for FDM) will be given to each student to fabricate 3D Component through any one of the additive manufacturing method.

Evaluation pattern for CO5:

S. No	Description	Marks
1	CAD Model Generation using solid modelling package	30
2	Process chain explanation and report preparation	50
3	Creation of 3D Product using additive manufacturing method	20
	Total Marks	**100**

Concept Map



Syllabus

Introduction: Definition - Roles of Prototypes - Need for time compression in product development, History of AM Process - Fundamentals of AM Process - Classification of AM Process - Process chain of AM Process – Data format – STL files - Benefits of AM.

Solid Based AM: Fused Deposition Modeling (FDM) – Principle – Process parameters – Machine details – Support system - BASS – Water soluble support system – Advantages and limitations, Laminated Object Manufacturing (LOM) – Principle – Processes parameters - Machine details – Advantages and limitations.

Liquid Based AM: Stereo Lithography Apparatus (SLA) – Principle – process parameters – Post processes - Machine details – Advantages and Limitations, Solid Ground Curing (SGC) – Principle – processes parameters – Process details - Machine details - Advantages and Limitations.

Powder based AM: Selective Laser Sintering (SLS) – Principle – process parameters - Machine details – Advantages and Limitations - Direct Metal Laser Sintering (DMLS) – Principle - Machine details - Advantages and Limitations.

Rapid Tooling of AM: Classification of Rapid Tooling – Direct soft tooling - SLS of sand casting – Direct AIM – SL Composite tooling - Indirect soft tooling – Arc spray metal tooling - Silicon rubber molds –Spin casting with vulcanized rubber molds - Direct hard tooling – Rapid tool – Laminated metal tooling – Indirect hard tooling - 3D Keltool – EDM Electrodes - Ecotool.

Applications of AM: Applications of AM in product design, aerospace, automotive, jewellery and biomedical industry.

Reverse Engineering: Introduction – Definition – Generic Process – Scanning – Point Processing – Geometric model development – Applications of reverse engineering.

Demonstration of 3D model generation using additive manufacturing method

Reference Books/ Learning Resources

1. Chua, C.K. Leong, K.F. and Lim, C.S. **"Rapid Prototyping: Principles and Applications"**, World Scientific, New Jersey, 2010.
2. Pham, D.T. and Dimov, S.S., **"Rapid manufacturing",** Springer-Verlag, Londo, 2011.
3. Jacobs, P.F., **"Rapid Prototyping and Manufacturing: Fundamentals of Stereolithography**", McGraw-Hill, New York, 2011.
4. Hilton. P.D., **"Rapid Tooling",** Marcel Dekker, New York, 2000.
5. **Rapid Prototyping Journal**, Emerald Group Publishing Limited
6. http://www.cheshirehenbury.com/rapid/index.html

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1	**Introduction:**	
1.1	Definition and Roles of Prototypes	1
1.2	Need for time compression in product development	1
1.3	History of AM Process - Fundamentals of AM Process	1
1.4	Classification of AM Process - Process chain of AM	1
1.5	Process – Data format – STL files - Benefits of AM.	1
2	**Solid Based AM:**	
2.1	Fused Deposition Modeling (FDM) – Principle – Process parameters	2
2.2	Machine details – Support system - BASS – Water soluble support system	1
2.3	Advantages and limitations	1
2.4	Laminated Object Manufacturing (LOM) – Principle – Processes parameters	2
2.5	Machine details	1
2.6	Advantages and limitations	1
3	**Liquid Based AM:**	
3.1	Stereo Lithography Apparatus (SLA) – Principle – process parameters	2
3.2	Post processes - Machine details	1
3.3	Advantages and Limitations	1
3.4	Solid Ground Curing (SGC) – Principle – processes parameters	2
3.5	Machine details	1

3.6	Advantages and Limitations	1
4	**Powder based AM:**	
4.1	Selective Laser Sintering (SLS) – Principle – process parameters	1
4.2	Machine details - Advantages and Limitations.	1
4.3	Direct Metal Laser Sintering (DMLS) – Principle - Machine details	1
4.4	Advantages and Limitations	1
5	**Rapid Tooling of AM:**	
5.1	Classification of Rapid Tooling – Direct soft tooling - SLS of sand casting – Direct AIM – SL Composite tooling	1
5.2	Indirect soft tooling – Arc spray metal tooling - Silicon rubber molds – Spin casting with vulcanized rubber molds	1
5.3	Direct hard tooling – Rapid tool – Laminated metal tooling	1
5.4	Indirect hard tooling - 3D Keltool – EDM Electrodes - Ecotool	1
6	**Applications of AM:**	
6.1	Applications of AM in product design, aerospace	1
6.2	Automotive, jewellery and biomedical industry.	1
	Reverse engineering:	
6.1	Introduction – Definition	1
6.2	Generic Process – Scanning – Point Processing – Geometric model development	1
6.3	Applications of reverse engineering.	1
7	**Demonstration of 3D model generation using additive manufacturing method**	2
	Total	36

Course Designers:

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		Category	L	T	P	Credit
18IEPM0	**ROBUST DESIGN**	PE	3	0	0	3

Preamble

Robust Design is a proven development philosophy focused on achieving target reliability. Approaching this aggressive goal requires that Robust Design principles be an early and integral part of the development cycle. Cost of Product performance Issues not only leads to erosion of profit, but also leads to loss of reputation and competitive advantage in Global economy. It is absolutely essential to understand the root cause of issues, either in Predictive Design of New Products or in Fixing Field issues of existing products or even enhancing the productivity in a Manufacturing environment. The objective is to make the end-product immune to factors that could adversely affect performance. A Robust Design flow is used to implement and analyze the design to ensure system reliability. The objective of Robust Design flow is to meet performance requirements with the highest possible system reliability and the most reasonable systems cost. Robust design saves considerable time and efforts in trouble shooting, identifying quality inputs and in rectifying the total system.

Prerequisite

- Applied Probability and Statistics

Course Outcomes

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

CO. No.	Course Outcomes	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1.	Explain the concepts and terminology of robust design.	Understand	80	70
CO2.	Illustrate the different models of single factor experiments of robust design.	Understand	80	70
CO3.	Conduct experiments with various factors at different levels to solve using DoE Techniques.	Analyze / apply	70	60
CO4.	Solve the problems for different cases using confounding techniques.	Apply	70	60
CO5.	Examine the optimum operating conditions of process parameters using orthogonal array design	Analyze	70	60

Mapping with Programme Outcomes

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

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	10	10	10
Understand	60	30	10	10
Apply	20	40	40	40
Analyze	0	20	40	40
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Extend fixed effect model?
2. State the advantages of Confounding?
3. Explain about Random effect model?

Course Outcome 2 (CO2):

1. Describe the guidelines for designing experiments and elaborate the key points.
2. Briefly explain about the Blocking in experimental design with suitable examples.
3. State and explain the robust design concepts through quality Loss function.

Course Outcome 3 (CO3):

1. The compressive strength is being studied. Four different mixing techniques are being investigated. The following data have been collected.

Mixing Technique	Compressive strength			
1	313	300	287	289
2	320	330	298	315
3	280	290	299	305
4	260	270	260	277

a) Test the hypothesis that mixing us techniques affect the strength of the concrete. Use

α=0.5

b) Use Tukeys test to make comparisons between pairs of means.

Estimate the treatment effects.

2. A process engineer is trying to improve the life of a cutting tool. He has run a 2^3 experiment using cutting speed (A), metal hardness (B) and cutting angle (c) as the factors. The data from two replicates are shown here. (A) Do any of the factors affect tool life (b) What combination of factor levels produces the longest tool life? (C) C s there a combination of cutting speed and cutting angle that always gives good results regardless of metal hardness.

Run	Replicate	
	I	II
(1)	221	311
a	325	435
b	354	348
ab	552	472
C	440	453
Ac	406	377
Be	605	503
a be	392	419

3. A 2^3 design has been used to investigate the effect of four factors on the resistivity of a silicon wafer. The data from this experiment are shown here.

Run	A	B	B	D	Resistivity
1	-	-	-	-	33.2
2	+	-	-	+	4.6
3	-	+	-	+	31.2
4	+	+	-	-	9.6
5	-	-	+	+	162.4
6	+	-	+	-	39.4
7	-	+	+	-	158.6
8	+	+	+	+	40.6

a) Estimate the factor effects. Plot the effect estimates on a normal probability scale.

b) Plot the residuals from the model Vs the predicted resistivity. Is there any indication on this plot of model adequacy?

Course Outcome 4 (CO4):

1. An annealed copper strip 228 mm wide and 25 mm thick, is rolled to a thickness of 20 mm. The roll radius is 300 mm and rotates at 100 rpm. Calculate the roll force and the power in this operation.

2. A solid cylindrical work piece made of 304 stainless steel is 150 mm in diameter and 100 mm high. It is forged by open die forging at room temperature with flat dies to a 50 % reduction in height. Assuming that the coefficient of friction is 0.2, calculate the forging force at the end of the stroke.

3. A round billet made of 70-30 brass is extruded at a temperature of 675° C. The billet diameter is 125 mm and the diameter of the extrusion is 50 mm. Calculate the extrusion force required.

Course Outcome 5 (CO5):

1. An experiment to investigate the effect of glass type and phosphor type on the brightness of a television tube. The response measured is the current necessary in micro-amps to obtain a specified brightness level. The data are shown here. Analyze the data and draw conclusions.

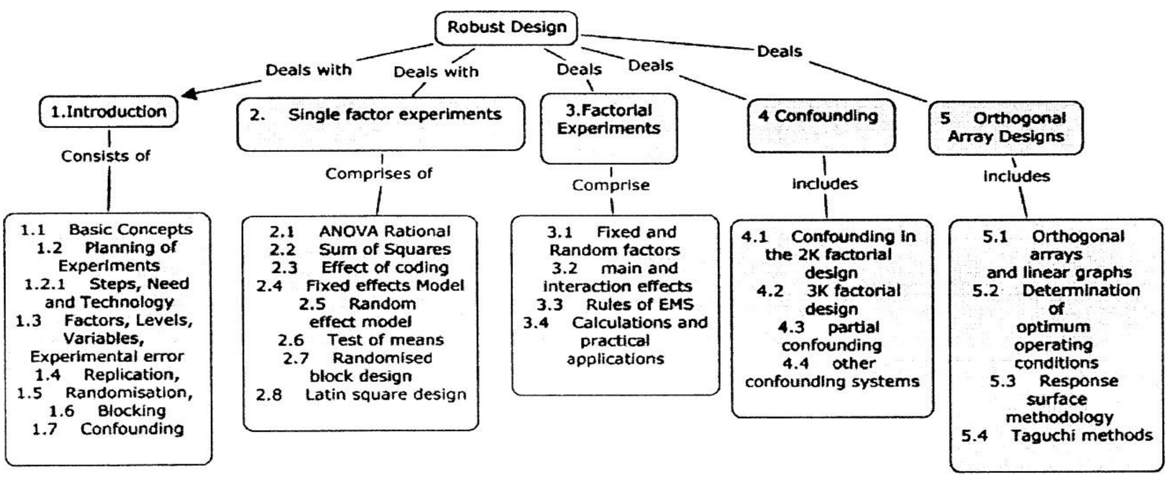
Glass Type	Phosphor type		
	1	2	3
1	280 290	300 310	290 285
2	230 235	260 240	220 225

2. An experiment was run using two factors. Gas flow rate (A) and deposition time (B). Four replicates were run and the epitaxial layer thickness was measured in (microns), The data are shown below.

A	B	Replicate			
		I	Ii	III	IV
-	-	14.03	16.16	13.97	13.9
+	+	13.88	13.86	14.03	13.91
-	+	14.82	14.75	14.84	14.87
+	+	14.88	14.92	14.41	14.93

Analyze this experiment assuming that each one of the four replicates represents a block.

Concept Map



Syllabus

Introduction: Basic Concepts - Planning of Experiments, Steps, Need, and Technology- Factors, Levels, Variables, Experimental error, Replication, Randomization, Blocking, and Confounding. **Single factor experiments:** ANOVA Rational, Sum of Squares, Effect of coding, Fixed effects Model, Random effect model - Test of means - Randomized block design - Latin square design. **Factorial Experiments:** Fixed and Random factors main and interaction effects, rules of EMS, calculations and practical applications - Fractional factorials **Confounding**: Confounding in the 2^K factorial design, 3^K factorial design, partial confounding other confounding systems. **Orthogonal Array Designs:** Orthogonal arrays and linear graphs, Determination of optimum operating conditions, Response surface methodology and Taguchi methods.

Reference Book / Learning Resources

1. Douglas C. Montgomery, "**Design and Analysis of Experiments**", Ninth Edition, John Wiley and Sons, New York, 2013.
2. Angela Dean and Daniel Voss," **Design and Analysis of Experiments**", First Indian reprint, Springer Internationaledition,2013
3. Philips J. Ross, "**Taguchi Techniques for Quality Engineering**", McGraw Hill,1995
4. N. Belavendran, **"Quality by Design"** Prentice Hall International, 1995.
5. MIT Open Courseware – **Robust System Design**. Instructor - Prof. Daniel Frey. URL: http://ocw.mit.edu/courses/aeronautics-and-astronautics/16-881-robust-system-design-summer-1998/
6. NPTEL Video Lectures – Applications to Robust Design. Prof. A. De. IIT Bombay URL:http://nptel.ac.in/courses/112101005/31

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
1.	**Introduction**	
1.1	Basic Concepts	1
1.2	Planning of Experiments	1
1.2.1	Steps, Need and Technology	1
1.3	Factors, Levels, Variables, Experimental error	1
1.4	Replication,	1
1.5	Randomization,	1
1.6	Blocking	1
1.7	Confounding	1
2.	**Single factor experiments**	

2.1	ANOVA Rational	1
2.2	Sum of Squares	1
2.3	Effect of coding	1
2.4	Fixed effects Model	1
2.5	Random effect model	1
2.6	Test of means	1
2.7	Randomized block design	1
2.8	Latin square design	1
3.	**Factorial Experiments**	
3.1	Fixed and Random factors	1
3.2	Main and interaction effects	1
3.3	Rules of EMS	1
3.4	Calculations and practical applications	2
3.5	Fractional Factorials	2
4	**Confounding**	
4.1	Confounding in the 2^K factorial design	2
4.2	3^K factorial design	2
5	**Orthogonal Array Designs**	
5.1	Orthogonal arrays and linear graphs	2
5.2	Determination of optimum operating conditions	2
5.3	Response surface methodology	2
5.4	Taguchi methods	2
	Total	**35**

Course Designers:

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18MGPW0	MATERIALS CHARACTERIZATION TECHNIQUES	Category	L	T	P	Credit
		PE	3	0	0	3

Preamble

Characterization of materials is essential to the systematic development of new materials and Information on a synthesized material remains incomplete unless it is thoroughly analyzed to understand its various characteristics and its suitability in desired application. This course provides fundamental knowledge in microstructure evaluation, crystal structure analysis, electron microscopy and Thermal Analysis

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 Instrumentation, Specimen preparation and working principle of Optical Microscopy and X Ray Diffraction	Understand	80	70
CO2	Apply the principle, operation of characterization equipment and the adjustment of operation variables in SEM/TEM to obtain good images / results.	Apply	70	60
CO3	Explain the concepts of Instrumentation, Specimen preparation and working principle of SPM and AFM.	Understand	80	70
CO4	Select the suitable characterization technique for elemental analysis in materials.	Apply	70	60
CO5	Illustrate the concepts of Instrumentation, working principles of Differential scanning calorimetry and Thermogravimetry.	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	-	-	-	-	S	L	-	-	-
CO2	S	M	-	M	-	-	S	-	-	-	-
CO3	S	M	-	-	-	-	S	L	-	-	-
CO4	S	M	-	-	-	-	S	-	-	-	-
CO5	S	S	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	40	40	40
Apply	20	40	40	40
Analyse	-	-	-	-
Evaluate	-	-	-	-
Create	-	-	-	-

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the optical principles of Light Microscopy.
2. Describe the steps of specimen preparation for light microscopy.
3. Define Diffraction Intensity.

Course Outcome 2 (CO2):

1. select the SEM operation parameters to ensure the whole field is in focus of a Given a specimen with surface fracture features with high differences up to 50 μm.
2. Select the suitable specimen preparation method for metal, ceramics in Transmission Electron Microscopy.

Course Outcome 3 (CO3):

1. Describe the operational modes in the Scanning Tunneling Microscopy.
2. List the characteristics of a tunneling current enable it to be used for imaging atoms?
3. Explain the typical applications of Atomic Force Microscopy.

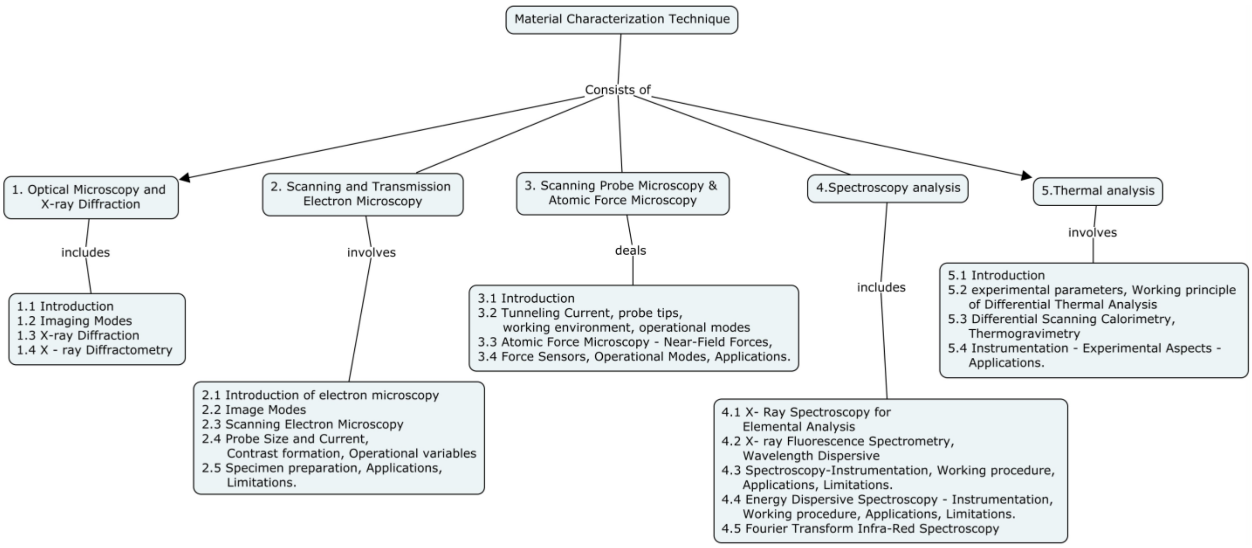
Course Outcome 4 (CO4):

1. Select the analyzing crystals of wavelength dispersive spectroscopy (WDS) to detect the K lines of elements Ca, Si, Na, and N.
2. Suggest the suitable detector commonly used in energy dispersive spectroscopy (EDS) system.

Course Outcome 5 (CO5):

1. Explain the common characterize techniques followed in Thermal analysis.
2. Explain the working principle of Differential thermal analysis.
3. Describe the experimental aspects followed in Thermogravimetry.

Concept Map



Syllabus:

Optical Microscopy and X Ray Diffraction (XRD): Introduction, Optical principles, Instrumentation, Specimen preparation- sectioning, mounting, grinding, polishing, etching, Imaging Modes - Polarized-Light Microscopy - Phase-Contrast Microscopy, Applications, Limitations. XRD - Introduction, Basic principles of diffraction, X - ray generation, X-ray Absorption, X - ray Diffractometry - Instrumentation, Data collection for analysis, Applications, Limitations.

Scanning and Transmission Electron Microscopy: Introduction of electron microscopy, Transmission Electron Microscopy (TEM) - Introduction, Instrumentation, Specimen preparation-pre-thinning, final thinning, Image modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations; Scanning Electron Microscopy (SEM) - Introduction, Instrumentation - Optical Arrangement, Signal Detection, Probe Size and Current, Contrast formation, Operational variables, Specimen preparation, Applications, Limitations.

Scanning Probe Microscopy (SPM) & Atomic Force Microscopy (AFM): Introduction about Scanning Probe Microscopy (SPM), Instrumentation, Scanning Tunneling Microscopy- Tunneling Current, probe tips, working environment, operational modes, Applications, Limitations. Atomic Force Microscopy - Near-Field Forces, Force Sensors, Operational Modes, Applications.

Spectroscopy analysis: X- Ray Spectroscopy for Elemental Analysis - Introduction, Characteristics of X- rays, X- ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy-Instrumentation, Working procedure, Applications, Limitations. Energy Dispersive Spectroscopy - Instrumentation, Working procedure, Applications, Limitations. Fourier Transform Infra-Red Spectroscopy (FTIR)- Principle – instrumentation – Examination technique – Application.

Thermal analysis: Introduction about Thermal analysis, Instrumentation, experimental parameters, Working principle of Differential Thermal Analysis - Differential Scanning Calorimetry, Thermogravimetry – Instrumentation - Experimental Aspects -Applications.

Reference Books

1. Yang Leng: “Materials Characterization-Introduction to Microscopic and Spectroscopic Methods”, John Wiley & Sons (Asia) Pte Ltd., 2008.
2. ASM Handbook: “Materials Characterization”, ASM International, 2008.
3. Robert F. Speyer: Thermal Analysis of Materials, Marcel Dekker Inc., New York, 1994.
4. Culity B.D., Stock S.R& Stock S., “Elements of X ray Diffraction”, (3rd Edition). Prentice Hall, 2001.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Optical Microscopy and X Ray Diffraction (XRD)**	
1.1	Introduction, Optical principles, Instrumentation, Specimen preparation-sectioning, mounting, grinding, polishing, etching,	2
1.2	Imaging Modes - Polarized-Light Microscopy - Phase-Contrast Microscopy, Applications, Limitations.	2
1.3	XRD - Introduction, Basic principles of diffraction, X - ray generation, X-ray Absorption,	2
1.4	X - ray Diffractometry - Instrumentation, Data collection for analysis, Applications, Limitations	2
2	**Scanning and Transmission Electron Microscopy**	
2.1	Introduction of electron microscopy, Transmission Electron Microscopy (TEM) - Introduction, Instrumentation, Specimen preparation-pre-thinning, final thinning,	2

2.2	Image modes- mass density contrast, diffraction contrast, phase contrast, Applications, Limitations;	2
2.3	Scanning Electron Microscopy (SEM) - Introduction, Instrumentation - Optical Arrangement, Signal Detection	2
2.4	Probe Size and Current, Contrast formation, Operational variables,	
2.5	Specimen preparation, Applications, Limitations.	1
3	**Scanning Probe Microscopy & Atomic Force Microscopy:**	
3.1	Introduction about Scanning Probe Microscopy (SPM), Instrumentation, Scanning Tunneling Microscopy-	2
3.2	Tunneling Current, probe tips, working environment, operational modes, Applications, Limitations.	2
3.3	Atomic Force Microscopy - Near-Field Forces,	2
3.4	Force Sensors, Operational Modes, Applications.	1
4	**Spectroscopy analysis**	
4.1	X- Ray Spectroscopy for Elemental Analysis - Introduction, Characteristics of X- rays,	2
4.2	X- ray Fluorescence Spectrometry, Wavelength Dispersive	1
4.3	Spectroscopy-Instrumentation, Working procedure, Applications, Limitations.	2
4.4	Energy Dispersive Spectroscopy - Instrumentation, Working procedure, Applications, Limitations.	2
4.5	Fourier Transform Infra-Red Spectroscopy (FTIR)- Principle – instrumentation – Examination technique – Application.	2
5	**Thermal analysis**	
5.1	Introduction about Thermal analysis, Instrumentation,	1
5.2	experimental parameters, Working principle of Differential Thermal Analysis	2
5.3	Differential Scanning Calorimetry, Thermogravimetry,	1
5.4	Instrumentation - Experimental Aspects -Applications.	1
	Total	**36**

Course Designers:

Dr. K. Chockalingam - kcmech@tce.edu
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		Category	L	T	P	Credit
18MGGA0	**MULTI-OBJECTIVE OPTIMIZATION**	OE	2	0	0	2

Preamble

Optimization techniques are aimed to determine and evaluate the best possible feasible solutions. Most of the researches in the domain of optimization address single objective, multi-variable problems. However, real-world problems need to satisfy more than one objective thereto conflicting objectives and hence, there will not be an optimal solution. Various optimization methods have been proposed to obtain set of trade-off solutions for multi-objective optimization problems. This course aims to provide awareness over contemporary multi-objective optimization techniques for bi-objective optimization problems which will also augment the multi-objective evolutionary computation in addressing complex real-world problems.

Prerequisite

- Nil

Course Outcomes

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

CO. No.	Course Outcome	Bloom's Level	Expected Proficiency (%)	Expected attainment level (%)
CO1	Solve single objective unconstrained and constrained Non-Linear Programming Problems (NLPP) using appropriate techniques.	Apply	70	60
CO2	Solve bi-objective constrained Non-Linear Programming Problems (NLPP) using Utility Function Method and Bounded Objective Function Method.	Apply	70	60
CO3	Construct pareto-front for bi-objective optimization problems with Max-Max, Max-Min, Min-Max and Min-min optimality	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L	L	M					M		
CO2	M	L	L	M					M		
CO3	M	L	L	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	10
Understand	20	20	20	30
Apply	60	60	60	60
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Implement golden section search technique to maximize $f(x) = 2x - 4x^2$, desired with final interval of uncertainty having a length less than of 0.05. Use the initial range as [0, 1] in which optimum lies.
2. Solve the following Non linear Programming Problem (NLPP),

$$Minimize \quad f(x) = x_1^2 + x_2^2 + x_3^2$$

Subject to constraints,

$$x_1 + x_2 + 3x_3 = 2$$

$$5x_1 + 2x_2 + x_3 = 5$$

3. Solve the following NLP: $Minimise \quad Z = x_1^2 + x_2^2$

Subject to $x_1 + 2x_2 \le 15$

$$1 \le x_i \le 10 \qquad i = 1,2$$

Course Outcome 2 (CO2):

1. Explain the classification of multi-objective optimization problems.
2. Solve the bi-objective optimization problem

$f_1(x) = x^2$; $f_2(x) = (x-2)^2$; $x \in [0,2]$;
Variable bounds = [-10^3, 10^3];

3. Solve the bi-objective optimization problem

$f_1(x,y) = x$; $f_2(x,y) = (1+y)exp\left(\frac{-x}{1+y}\right)$;
$g_1(x,y) = y + 9x \ge 6$; $\quad g_2(x,y) = -y + 9x \ge 1$
$x \in [0.1,1]$; y$\in [0,5]$;

Course Outcome 3 (CO3):

1. Discuss the influence of divergence on the quality of pareto-optimal solutions.
2. Construct a pareto-front for the given set of solutions

$f_1(x)$	1.5	2.8	5.2	6.9	7.8	10.2
$f_1(x)$	5.0	3.5	6.2	5.5	6.8	9.3

3. Examine the following solutions in figure 1 and establish relation between them.

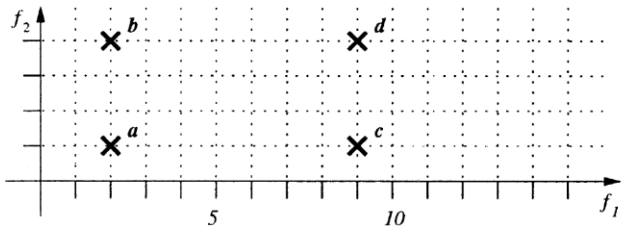
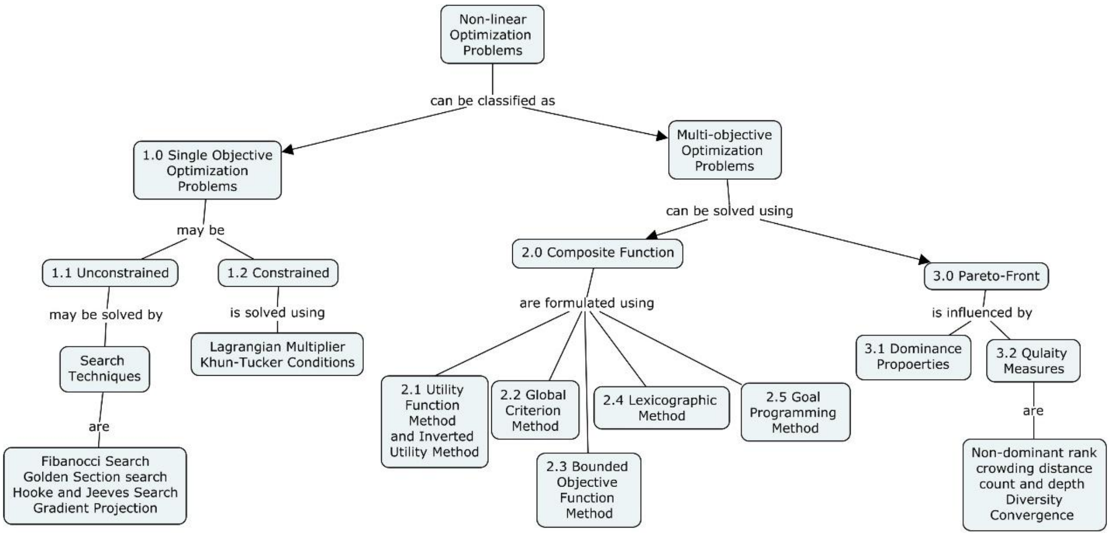


Figure 1

Concept Map



Syllabus

Nonlinear Programming Problems

Nonlinear Programming (Unconstrained Problem) - Basic Concepts - Classification– Fibanocci and Golden Section search - Hooks and Jeeves search - Gradient Projection – Nonlinear Programming (with Equality Constraints) Lagrangian Multiplier - Equality constrained optimization; Nonlinear Programming (Inequality Constraints): Khun concept - Khun Tucker conditions;

Multi-objective optimization methods - Utility Function Method, Inverted Utility Method, Global Criterion Method, Bounded Objective Function Method, Lexicographic Method and Goal Programming Method. Quantitative analysis of bi-objective optimization problems using Utility Function Method and Bounded Objective Function Method.

Pareto-Front – Terminologies – Dominance properties – Utility dominance, Stochastic dominance, Mean-variance dominance and Probability dominance; Quality measures – Non-dominant rank and crowding distance, count and depth - Diversity, Convergence. Pareto optimality: Bi-objective optimization problems with Max-Max, Max-Min, Min-Max and Min-min optimality.

Reference Books / Learning Resources

1. Kalyanmoy Deb, “Optimisation for Engineering Design – Algorithms and Examples”,2^{nd} Edition, Eastern Economy Edition, PHI Learning Pvt. Limited, New Delhi, 2012.
2. Singiresu S.Rao, “Engineering Optimization”, 3^{rd} Edition, New Age International Publishers, New Delhi, 2010.
3. Zitzler, E., Thiele, L., Laumanns, M., Fonseca, C.M. and Fonseca, V.G. “Performance assessment of multiobjective optimizers: an analysis and review”, IEEE Trans. Evlout. Comput., Vol. 7, No. 2, pp. 117-132, 2003.
4. Kalyanmoy Deb, Amrit Pratap, Sameer Agarwal, and T. Meyarivan, “A Fast and Elitist Multiobjective Genetic Algorithm:NSGA-II”, IEEE Transactions On Evolutionary Computation, Vol. 6, No. 2, pp.182-197, April 2002.

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
	Introduction to Optimisation techniques – Classification	1
1.0	**Single Objective Nonlinear Programming Problems**	1
1.1	Basic Concepts – Classification – Search Techniques	1
1.1.1	Nonlinear Programming (Unconstrained Problem) :Fibanocci and Golden Section search	2
1.1.2	Hooks and Jeeves search	1
1.1.3	Gradient Projection	1
1.2	Nonlinear Programming (with Equality Constraints) Lagrangian Multiplier – Equality constrained optimization;	1
1.3	Nonlinear Programming (Inequality Constraints): Khun concept – Khun Tucker conditions;	2
2.0	**Multi-objective optimization methods** – Introduction	1
2.1	Utility Function Method and Inverted Utility Method	1
2.2	Bounded Objective Function Method	2
2.3	Global Criterion Method	2
2.4	Lexicographic Method	1
2.5	Goal Programming Method	3
3.0	**Pareto-Front**	
3.1	Terminologies and Dominance properties	1
3.1.1	Utility dominance, Stochastic dominance, Mean-variance dominance and Probability dominance.	1
3.2	Quality measures – Non-dominant rank and crowding distance, count and depth – Diversity, Convergence.	1
3.3	Bi-objective optimization problems with Max-Max, Max-Min, Min-Max and Min-min optimality	2
Total		**25**

Course Designers:

1. S. Saravana Perumaal sspmech@tce.edu

18PG250	RESEARCH METHODOLOGY AND IPR

Category	L	T	P	Credit
CC	2	0	0	2

Preamble

The course on the Research Methodology and IPR is offered as common Core course. The objective of this course is to understand and analyze Research Methodology and IPR protection.

Prerequisite

NIL

Course Outcomes

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

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R&D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			End Semester 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

Syllabus

Module 1: Meaning of research problem, Sources of research problem, Criteria, Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem, Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Module 2: Effective literature studies approaches, analysis Plagiarism, Research ethics

Module 3: Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Module 4: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Module 5: Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Module 6: New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs

Reference Books

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'" 2nd Edition,
2. "Research Methodology: A Step by Step Guide for beginners"
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall, "Industrial Design", McGraw Hill, 1992.
5. Niebel, "Product Design", McGraw Hill, 1974.
6. Asimov, "Introduction to Design", Prentice Hall, 1962.
7. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
8. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Course Designers:

1. Adapted from AICTE Model Curriculum for Postgraduate Degree Courses in Engineering & Technology, Volume-I, January 2018.

18PGAA0	PROFESSIONAL AUTHORING

Category	L	T	P	Credit
AC	2	0	0	2

Preamble

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

1. Explain how to improve your writing skills and level of readability
2. Write each section of research paper
3. Write good quality technical paper

Syllabus

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Key skills for writing a Title, writing an Abstract, writing an Introduction, writing a Review of the Literature,

Skills for Writing the Methods, Results, Discussion and Conclusions
Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

Assessment Pattern

Abstract	:	10
Introduction	:	10
Literature Review	:	10
Research Question	:	10
Methods	:	10
Results and Discussion	:	10
Conclusions	:	10
Appropriateness of Title	:	05
Quality of the Paper and Plagiarism	:	25

References

1. Goldbort R, 'Writing for Science', Yale University Press, 2006
2. Day R, 'How to Write and Publish a Scientific Paper', Cambridge University Press, 2006
3. Highman N, 'Handbook of Writing for the Mathematical Sciences, SIAM Highman's book, 1998
4. Adrian Wallwork, 'English for Writing Research Papers', Springer New York Dordrecht Heidelberg London, 2011

18PGAB0	VALUE EDUCATION

Category	L	T	P	Credit
AC	2	0	0	2

Preamble

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

1. Experience self-development
2. Explain the importance of Human values
3. Develop the overall personality

Syllabus

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles, Value judgements

Importance of cultivation of values, Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National Unity, Patriotism, Love for nature, Discipline

Personality and Behavior Development, Soul and Scientific attitude, Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship, Happiness Vs suffering, love for truth.

Aware of self-destructive habits, Association and Cooperation, Doing best for saving nature

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence , Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively

Assessment Pattern

Bloom's Category	Continuous Assessment Test	Terminal Examination
Remember	20	20
Understand	40	40
Apply	40	40
Analyse	0	0
Evaluate	0	0
Create	0	0

References

1. Chakroborty, S.K. “Values and Ethics for organizations Theory and practice”, OxforUniversity Press, New Delhi