CURRICULUM AND DETAILED SYLLABI

FOR

M.E DEGREE (Manufacturing Engineering) PROGRAMME

CORE AND ELECTIVE COURSES

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2014-2015 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

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THIAGARAJAR COLLEGE OF ENGINEERING, MADURAI – 625 015
(A Govt. Aided ISO 9001 – 2008 Certified, Autonomous Institution Affiliated to Anna University)
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 Educational Objectives (PEOs) of M.E. (Manufacturing Engineering)

The post graduate programme in Manufacturing Engineering provides education and training to:

PEO 1

- Graduates will apply a broad and fundamental knowledge, and up-to-date skills in performing professional work in manufacturing engineering and management.

PEO 2

- Graduates will offer complete manufacturing solutions incorporating the use of standards and practical constraints with due consideration to the economic, environmental, and social concerns.

PEO3

- Graduates will play a productive role in industrial or governmental organizations as an associate of multi-disciplinary and cross-functional teams, with an appreciation for the value of ethic and cultural diversity and an understanding of contemporary issues.

PEO 4

- Graduates will engage in manufacturing research and consultancy to pursue lifelong learning.

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, conceptualise 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 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

PO No.	Graduate Attributes	Programme Outcomes
		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.

M.E. (Manufacturing Engineering) PROGRAMME

Scheduling of Courses

Semester	Theory Courses						Practical / Project
4th (12)							14MG410 Project - II 0:12
3rd (16)	14MG310 Computer Integrated Manufacturing 4:0	14MGPX Elective-V 4:0	14MGPX Elective-VI 4:0				14MG340 Project - I 0:4
2nd (24)	14MG210 Mechanics of Metal Cutting and Metal Forming 4:0	14MG220 Tool Design Engineering 3:0	14MGPX Elective-I 4:0	14MGPX Elective -II 4:0	14MGPX Elective-III 4:0	14MGPX Elective-IV 4:0	14MG270 Advanced Manufacturing Engineering Laboratory - II 0:1
1st (24)	14MG110 Computational Methods in Engineering 3:1	14MG120 Optimisation Techniques 4:0	14MG130 Mechanical Behaviour of Materials 4:0	14MG140 Industrial Automation and Robotics 4:0	14MG150 CNC Machine Tool Technology 3:0	14MG160 Micro Electro Mechanical Systems and Nano Technology 4:0	14MG170 Advanced Manufacturing Engineering Laboratory -I 0:1

Total Credits to be earned for the award of degree: 76

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M.E Degree (Manufacturing Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

FIRST SEMESTER

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14MG110	Computational Methods in Engineering	BS	3	1	-	4
14MG120	Optimization Techniques	PC	4	-	-	4
14MG130	Mechanical Behaviour of Materials	PC	4	-	-	4
14MG140	Industrial Automation and Robotics	PC	3	1	-	4
14MG150	CNC Machine Tool Technology	PC	3	-	-	3
14MG160	Micro Electro Mechanical Systems and Nano Technology	PC	4	-	-	4
PRACTICAL						
14MG170	Advanced Manufacturing Engineering Laboratory - I	PC	-	-	2	1
					Total	**24**

*** BS- Basic Sciences; HSS-Humanities and Social Sciences; ES-Engineering Sciences; PC-Programme Core; PE-Programme Elective; GE-General Elective; OC-One Credit Course; TC-Two Credit Course; SS-Self-Study Course (in the list of Programme Electives)*

Note:

1 Hour Lecture / 1 Hour Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

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M.E. DEGREE (Manufacturing Engineering) PROGRAMME
SCHEME OF EXAMINATIONS
(For the candidates admitted from 2014-2015 onwards)

FIRST SEMESTER

Sl. 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	14MG110	Computational Methods in Engineering	3	50	50	100	25	50
2	14MG120	Optimisation Techniques	3	50	50	100	25	50
3	14MG130	Mechanical Behaviour of Materials	3	50	50	100	25	50
4	14MG140	Industrial Automation and Robotics	3	50	50	100	25	50
5	14MG150	CNC Machine Tool Technology	3	50	50	100	25	50
6	14MG160	Micro Electro Mechanical Systems and Nano Technology	3	50	50	100	25	50
PRACTICAL								
7	14MG170	Advanced Manufacturing Engineering Laboratory I	3	50	50	100	25	50

** 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
SUBJECTS OF STUDY
(For the candidates admitted from 2014-2015 onwards)

SECOND SEMESTER

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14MG210	Mechanics of Metal Cutting and Metal Forming	PC	4	-	-	4
14MG220	Tool Design Engineering	PC	3	-	-	3
14MGPX	Elective-I	PE				4
14MGPX	Elective –II	PE				4
14MGPX	Elective –III	PE				4
14MGPX	Elective-IV	PE				4
PRACTICAL						
14MG270	Advanced Manufacturing Engineering Laboratory II	PC	-	-	2	1
Total						**24**

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SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 onwards)

SECOND SEMESTER

Sl. 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	14MG210	Mechanics of Metal Cutting and Metal Forming	3	50	50	100	25	50
2	14MG220	Tool Design Engineering	3	50	50	100	25	50
3	14MGPX	Elective - I	3	50	50	100	25	50
4	14MGPX	Elective –II	3	50	50	100	25	50
5	14MGPX	Elective - III	3	50	50	100	25	50
6	14MGPX	Elective- IV	3	50	50	100	25	50
PRACTICAL								
7	14MG270	Advanced Manufacturing Engineering Laboratory II	3	50	50	100	25	50

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THIRD SEMESTER

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14MG310	Computer Integrated Manufacturing	PC	4	-	-	4
14MGPX	Elective – V	PE	4	-	-	4
14MGPX	Elective – VI	PE	4	-	-	4
PRACTICAL						
14MG340	Project - I	PC	-	-	4	4
Total						**20**

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2 Hours Practical is equivalent to 1 credit

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M.E. DEGREE (Manufacturing Engineering) PROGRAMME
SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 onwards)

THIRD SEMESTER

Sl. 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	14MG310	Computer Integrated Manufacturing	3	50	50	100	25	50
2	14MGPX	Elective – V	3	50	50	100	25	50
3	14MGPX	Elective – VI	3	50	50	100	25	50
PRACTICAL								
4	14MG340	Project - I	-	150	150	300	75	150

** 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
SUBJECTS OF STUDY
(For the candidates admitted from 2014-2015 onwards)

FOURTH SEMESTER

Course code	Name of the Course	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
14MG410	Project - II	PC	-	-	12	12
Total						**12**

*** BS- Basic Sciences; HSS-Humanities and Social Sciences; ES-Engineering Sciences; PC-Programme Core; PE-Programme Elective; GE-General Elective; OC-One Credit Course; TC-Two Credit Course; SS-Self-Study Course (in the list of Programme Electives)*

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

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SCHEME OF EXAMINATIONS
(For the candidates admitted from 2014-2015 onwards)

FOURTH SEMESTER

Sl. 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	14MG410	Project - II	-	150	150	300	75	150

LIST OF ELECTIVE SUBJECTS – M.E Manufacturing Engineering

(For the candidates admitted from 2014-2015 onwards)

Sl. No	Sub. Code	Name of the Subjects	Credit
1.	14MGPA0	Plant Layout and Material Handling	4
2.	14MGPB0	Research Methodology	4
3.	14MGPC0	Total Quality Management	4
4.	14MGPD0	Maintenance Engineering and Management	4
5.	14MGPE0	Machine Vision and its applications in manufacturing	4
6.	14MGPF0	System Simulation	4
7.	14MGPG0	Product Design and Development	4
8.	14MGPH0	Design for Manufacture and Assembly	4
9.	14MGPJ0	Robust Design	4
10.	14MGPK0	Lean Manufacturing and Six Sigma	4
11.	14MGPL0	Work Study and Cost Analysis	4
12.	14MGPM0	Quality and Reliability Engineering	4
13.	14MGPN0	Financial Management	4
14.	14MGPP0	Operations Management	4
15.	14MGPR0	Supply Chain Management	4
16.	14MGPS0	Geometric Modeling	4
17.	14MGPT0	Metal Joining Engineering	4
18.	14MGPU0	Fluid Power Automation	4
19.	14MGPV0	Rapid Prototyping	4
20.	14MGPW0	Composite Materials	4
21.	14MGPY0	Non Destructive Evaluation	4
22.	14MGPZ0*	Friction Stir Welding	4

14MG110	COMPUTATIONAL METHODS IN ENGINEERING	Category	L	T	P	Credit
		BS	3	1	0	4

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

Course Name: Numerical Methods

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.	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	L	L							
CO2	S	M	L	L							
CO3	S	M	L	L							
CO4	S	M	L	L							
CO5	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	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.

Course Outcome 2 (CO2):

1. Classify the PDE : $f_{xx} + 2f_{xy} + f_{yy} = 0.$

Course Outcome 3 (CO3):

1. Solve: $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ in the square region bounded by $x = 0$; $x = 4$; $y = 0$; $y = 4$ with Boundary conditions

Course Outcome 4 (CO4):

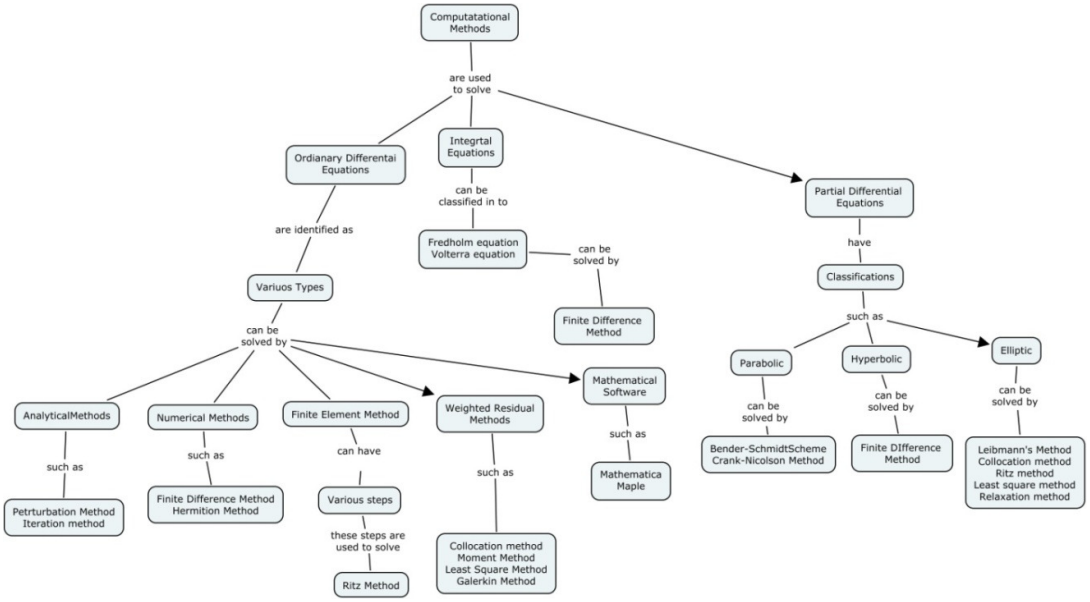
1. Explain Ritz finite element to solve a BVP Using Laplace transform solve the equation $y'+3y + 2 + \int_0^t y(t) = t..$ with y(0) = 0.

Course Outcome **5** (CO**5**)**:**

1.Solve:

$25\, u_{xx} - u_{tt} = 0$ *for u at the pivotal points given* $u(0,t) = u(5\,,\,t)$; $u_t(x,0) = 0:$

Concept Map



Syllabus

Boundary value problems: Boundary value problems in ODE - Different kinds of BVP, Analytical method - perturbation method - Hermitian method .Numerical Methods- Iteration method - Finite difference method - Ritz's 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. Elliptic equation- Leibmann's iterative scheme - collocation method - least square method - Relaxation method. Integral Equations: Classification – Solution to Integral equations by iteration and finite difference methods. Solution through software: Introduction to software - Solution of Boundary Value Problems from Ordinary Differential Equations through Mapple and Mathematica - Solution of Boundary Value Problems from Partial Differential Equations through Mapple and Mathematica.

Reference Books

1. M.K.Jain, S.R.K.Iyengar, R.K.Jain, "Numerical Methods for Scientific and Engineering Computations" New Age International publishers, 4th Edition 2003
2. Collatz , "The Numerical Treatment of Differential Equations " , Springer Verlog, 1966
3. Sastry ,"Introductory Methods of Numerical Analysis", 2nd Edition , Prentice Hall of India ,1998
4. Robert J.Schilling, Sandra.L Harris, "Applied Numerical Methods for Engineers using Matlab and C ", Thomson books / Cole , 1999

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1	**Boundary value problems -BVPs**	

Module Number	Topic	No. of Lectures
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	Ritz's finite element method	2
1.5	weighted residual methods	
1.5.1	Introduction	1
1.5.2	collocation method	1
1.5.3	moment method	2
1.5.4	least square method	2
1.5.5	Galerkin method.	2
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	1
2.3.3	Ritz method	1
2.3.4	least square method	1
2.3.5	Relaxation method.	2
2.4	Hyperbolic equations	1
2.4.1	Solution by finite difference scheme.	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 Mapple and Mathematica	1
4.3	Solution of BVPs from PDEs through Mapple and Mathematica	1
	Total	**40**

Course Designers

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14MG120 OPTIMIZATION TECHNIQUES

Category	L	T	P	Credit
PC	4	0	0	4

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. In this course, the practical aspects of optimization methodology, with a major focus on the techniques and stratagems relevant to manufacturing, design and operations applications. Attention is given primarily to techniques applicable to problems in linear, integer, dynamic and non-linear programming, and network models. Besides, intelligent search heuristics are introduced to understand the concepts so as to apply them in solving large-scale problems.

Prerequisite

. Matrix Manipulations

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	Compute mathematical models of Linear Programming (LP), Integer Programming (IP), Dynamic Programming (DP), Networks and Non-linear Programming (NLPP) problems	Apply	70	60
CO2	Evaluate the behaviour of Linear Programming Problems 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	Compare deterministic Dynamic Programming Problems using tabular approach and assess the performance under different conditions	Analyse	60	50
CO5	Decide on a suitable network model and apply appropriate technique for flow and project scheduling problems.	Analyse	60	50
CO6	Solve unconstrained and constrained Non-Linear Programming Problems (NLPP) using appropriate techniques.	Apply	70	60
CO7	Explain the concept and working of emerging intelligent search techniques	Understand	80	70

	such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), Simulated Annealing Algorithm (SAA) and Tabu Search (TS).			

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	L							
CO2	S	S	M	M							
CO3	S	M	L	L							
CO4	S	S	M	M							
CO5	S	S	M	M							
CO6	S	M	L	L							
CO7	M	L									

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	8	8	8	8
Understand	12	12	12	12
Apply	60	60	60	60
Analyse	20	20	20	20
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 revised 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.

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 2 provides the basic data of the problem:

Table 2

	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 1.

Table 1

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

Course Outcome 4 (CO4):

1. An organization is planning to diversify its business with a maximum outlay of Rs.5 crores. It has identified three different locations to install plants. The organization can invest in one or more of these plants subject to the availability of the fund. The different possible alternatives and their investment (in crores of rupees) and present worth of the return during the useful life (in crores of rupees) of each of these plants are summarized in the following table. The first row of Table has zero cost and zero return for all the plants. Hence, it is known as do-nothing alternative. Using dynamic programming, find the optimal allocation of the capital to different plants which will maximize the corresponding sum of the present worth of returns.

Table 2

Alternative	Plant 1		Plant 2		Plant 3	
	Cost	Return	Cost	Return	Cost	Return
1	0	0	0	0	0	0
2	1	15	2	14	1	3
3	2	18	3	18	2	7
4	4	28	4	21	-	-

2. An oil company has 8 units of money available for exploration of three sites. If oil is present at a site, the probability of finding it depends upon the amount allocated for exploiting the site as given in table 4:

Table 4

	0	1	2	3	4	5	6	7	8
Site 1	0.0	0.0	0.1	0.2	0.3	0.5	0.7	0.9	1.0
Site 2	0.0	0.1	0.2	0.3	0.4	0.6	0.7	0.8	1.0
Site 3	0.0	0.1	0.1	0.2	0.3	0.5	0.8	0.9	1.0

The probability that the oil exists at sites 1, 2 and 3 is 0.4, 0.3 and 0.2, respectively. Find the optimal allocation of money using dynamic programming.

3. A company has 6 salesmen and 3 market areas A, B, and C. It is desired to determine the number of salesmen to allocate to each market area to maximize profit. The following table gives the profit from each market areas as a function of the number of salesmen allotted:

Salesmen	0	1	2	3	4	5	6

Area							
A	38	41	48	58	66	72	83
B	40	42	50	60	66	75	82
C	60	64	68	78	90	102	109

Use dynamic programming technique to solve the above problem.

Course Outcome 5 (CO5):

1. A project consists of 9 activities and the three time estimates are given in table 5.

Table 5

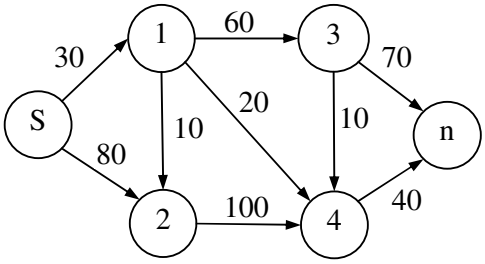
Activities		Activity Duration in Days		
I	j	Optimistic	Most likely	Pessimistic
1	2	3	6	15
2	3	6	12	30
3	5	5	11	17
7	8	4	19	28
5	8	1	4	7
6	7	3	9	27
4	5	3	6	15
1	6	2	5	14
2	4	2	5	8

a. Find the probability of completing the project before 31 weeks?
b. What is the chance of project duration exceeding 46 weeks?

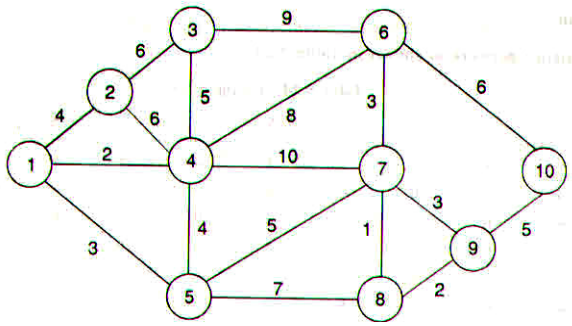
4. Consider the following project and discuss how the project schedule will be affected by events: a) Job H is delayed by 10 more days and b) Job F and G are completed 1 day ahead of schedule.

Job	A	B	C	D	E	F	G	H	I
Predecessor	-	-	A,B	A,B	B	D,E	C,F	D,E	G,H
Time (days)	15	10	10	10	5	5	20	10	15

5. 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.



6. 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.



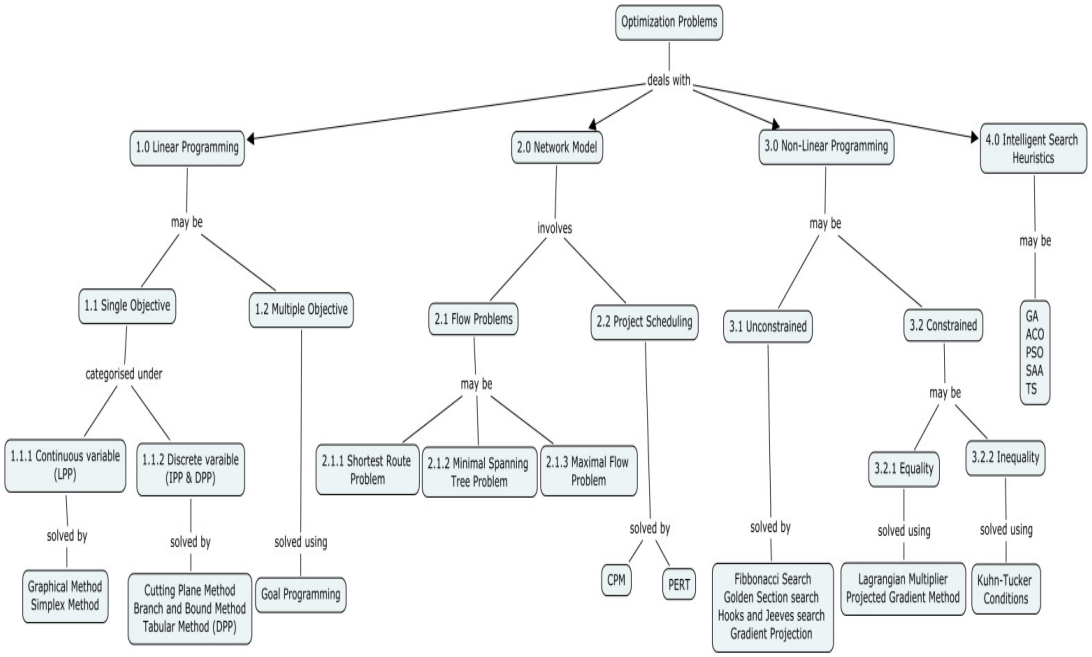
Course Outcome 6 (CO6):

1. Use Fibonacci search to: Maximize f(x) = $x^2 + \frac{54}{x}$; Subject to 0 ≤ x ≤ 5 with six evaluations and its final interval of uncertainty having a length less than 0.5.
2. Maximise $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ starting from the point X= (0, 0). Take $\Delta x_1 = \Delta x_2 = 0.8$. Perform four iterations using Hooke Jeeves search method.
3. Solve the following Non linear Programming Problem (NLPP),
   Minimise $z = x_1^2 + x_2^2 + x_3^2$
   Subject to, $4x_1 + x_2^2 + 2x_3 - 14 = 0$
4. Determine the value of x_1 & x_2 using Kuhn-Tucker's conditions
   Maximise $Z = 10\ x_1 - x_1^2 + 10x_2 - x_2^2$
   Subject to constraints, $x_1 + x_2 \leq 9$; $x_1 - x_2 \geq 6$

Course Outcome 7 (CO7):

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 - Dual Simplex Method; **Integer Programming**: Formulation - Branch and Bound Method - Cutting Plane Method; **Dynamic Programming -** Concepts - Mathematical description – Deterministic Dynamic Programming - Tabular approach; **Goal Programming** – Concepts – solution for multiple objective problems; **Network Model:** Network Construction – Terminologies - Shortest route problems, Minimal Spanning Tree problems, Maximal Flow problems; Critical Path Method (CPM) – crashing - Programme Evaluation and Review Technique (PERT); **Nonlinear Programming (Unconstrained Problem) -**Basic Concepts – Fibanocci and Golden Section search - Hooks and Jeeves search - Gradient Projection – **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 GA, ACO, PSO, SAA & TS.

Reference Books / Learning Resources

1. Hamdy A. Taha, “Operations Research - An Introduction”, 7th Edition, MacMillan Co., 2010.
2. Ravindran, Don. T. Phillips, and James J. Solberg, “Operations Research - Principles and Practice”, Second Edition, John Wiley and Sons, 2007
3. Srinath. L. S., “PERT and CPM Principles and Applications”, Affiliated East West Press Pvt. Ltd., New Delhi, 2001
4. Frederick Hillier, Gerald Lieberman, “Introduction to Operations Research” Seventh Edition, Tata McGraw Hill, 2010

5. Ronald L Rardin, "Optimisation in Operations Research" First Indian reprint, Pearson Education Asia, 2002
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
1	Introduction to Optimisation techniques - Classification	1
1.0	Linear Programming – Concept - Applications	1
1.1	Formulation – Single Objective problems	1
1.1.1	Solution Methods for continuous variable problems	1
1.1.1.1	Graphical Method	1
1.1.1.2	Simplex Method	2
1.1.1.3	Primal Vs. Dual relationships	1
1.1.1.4	Sensitivity Analysis	2
1.1.1.5	Dual Simplex Method	1
1.1.2	Solution Methods for Discrete variable problem	1
1.1.2.1	Integer Programming - Formulation	1
1.1.2.2	Cutting Plane Method	1
1.1.2.3	Branch and Bound Method	1
1.1.2.4	Dynamic Programming - Concepts - Mathematical description	1
1.1.2.5	Deterministic Dynamic Programming - Tabular approach	3
1.2	Solution Methods for Multi objective problem	1
1.2.1	Goal Programming (GP) – Concepts	1
1.2.2	Solution for multiple objective problems using GP	1
2.0	Network Model: Network Construction– Terminologies	1
2.1	Flow Problems – Concepts - Terminologies	1
2.1.1	Shortest route problems	1
2.1.2	Minimal Spanning Tree problems	
2.1.3	Maximal Flow problems	2
2.2	Project Scheduling – Concepts - Terminologies	1
2.2.1	Critical Path Method (CPM) – crashing	2
2.2.2	Programme Evaluation and Review Technique (PERT)	1
3.0	Nonlinear Programming (NLP) - Concepts – Terminologies - Classification	1
3.1	Unconstrained NLP Problems - Basic Concepts	
3.1.1	Fibanocci Search	1
3.1.2	Golden Section search	1
3.1.3	Hooks and Jeeves search	1
3.1.4	Gradient Projection	1
3.2	Constrained NLP Problems - Basic Concepts	1
3.2.1	NLP problems with Equality Constraints - Basic Concepts- Applications	
3.2.1.1	Lagrangian Multiplier Method	1

Module Number	Topic	No. of Lectures
3.2.1.2	Projected Gradient Methods	1
3.2.2	NLP problems with Inequality Constraints - Basic Concepts - Applications	1
3.2.2.1	Khun concept - Khun Tucker conditions	
4.0	Intelligent search heuristics: Concept	1
4.1	Principle and parameters of Genetic Algorithm (GA)	1
4.2	Principle and parameters of Ant Colony Optimisation (ACO)	1
4.3	Principle and parameters of Particle Swarm Optimisation (PSO)	1
4.4	Principle and parameters of Simulated Annealing Algorithm (SAA)	1
4.5	Principle and parameters of Tabu Search (TS)	1
Total		**46**

Course Designers:

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14MG130	MECHANICAL BEHAVIOUR OF MATERIALS	Category	L	T	P	Credit
		PC	4	0	0	4

Preamble

Plastic deformation occurs when large numbers of dislocations move and multiply so as to result in macroscopic deformation. In other words, it is the movement of dislocations in the material which allows for deformation. If we want to enhance a material's mechanical properties, we simply need to introduce a mechanism which prohibits the mobility of these dislocations. Fracture mechanics is the field of mechanics concerned with the study of the propagation of cracks in materials. It uses methods of analytical solid mechanics to calculate the driving force on a crack and those of experimental solid mechanics to characterize the material's resistance to fracture.

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

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 various Strengthening Mechanisms	Understand	80	70
CO2	Examine the Fracture and its mechanics	Apply	70	60
CO3	Choose the fatigue properties of Metals	Apply	70	60
CO4	Choose the creep mechanisms	Apply	70	60
CO5	Interpret various types of fracture failure	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	M	L									
CO 2	S	M	L	L							
CO 3	S	M	L	L							
CO 4	S	M	L	L							
CO 5	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	60	60	60	60
Apply	20	20	20	20
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 theoretical cohesive strength of metals.
3. Explain the mechanisms of fiber strengthening with applications.

Course Outcome 2 (CO2):

1. Define fracture toughness.
2. Explain the effects of high hydrostatic pressure on fracture.
3. Describe the fracture toughness and design.

Course Outcome 3 (CO3):

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

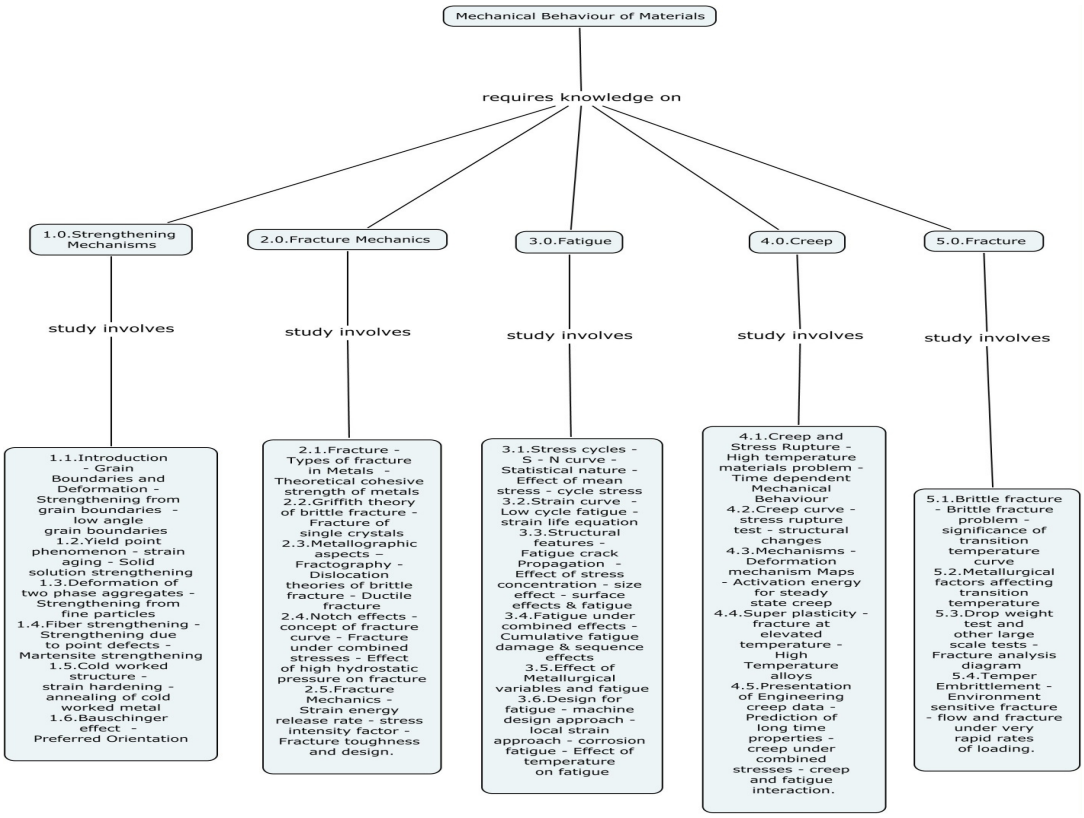
Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

1. What is brittle fracture problem?
2. Describe the metallurgical factors affecting transition temperature.
3. Discuss the drop weight test.

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. **Fracture Mechanics:** 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. **Fatigue:** Stress cycles - S - N curve - Statistical nature - Effect of mean stress - cycle 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 - creep under combined stresses - creep and fatigue interaction. **Fracture:** 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", Third Edition, McGraw Hill Education (India) Pvt Ltd, New Delhi, 2013.
2. Bhargava, A. K and Sharma, C. P. "Mechanical Behaviour and testing of Materials" PHI Learning Pvt. Ltd., 2014.
3. Thomas H. Courtney, "Mechanical Behaviour of Materials", 2nd Edition, Mc Graw Hill, 2005
4. Roy A. Lindberg, "Processes and Materials of Manufacture", 4th Edition, Prentice Hall of India, 1998.

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	2
1.2	Yield point phenomenon - strain aging - Solid solution strengthening	2
1.3	Deformation of two phase aggregates - Strengthening from fine particles	1
1.4	Fiber strengthening - Strengthening due to point defects - Martensite strengthening	2
1.5	Cold worked structure - strain hardening - annealing of cold worked metal	2
1.6	Bauschinger effect - Preferred Orientation	1
2.0	**Fracture Mechanics**	
2.1	Fracture - Types of fracture in Metals - Theoretical cohesive strength of metals	1
2.2	Griffith theory of brittle fracture - Fracture of single crystals	2
2.3	Metallographic aspects – Fractography - Dislocation theories of brittle fracture - Ductile fracture	2
2.4	Notch effects - concept of fracture curve - Fracture under combined stresses - Effect of high hydrostatic pressure on fracture	2
2.5	Fracture Mechanics - Strain energy release rate - stress intensity factor - Fracture toughness and design.	2
3.0	**Fatigue**	
3.1	Stress cycles - S - N curve - Statistical nature - Effect of mean stress - cycle stress	2
3.2	Strain curve - Low cycle fatigue - strain life equation	2

Module Number	Topics	No. of Lectures
3.3	Structural features - Fatigue crack Propagation - Effect of stress concentration - size effect - surface effects & fatigue	2
3.4	Fatigue under combined effects - Cumulative fatigue damage & sequence effects	2
3.5	Effect of Metallurgical variables and fatigue	1
3.6	Design for fatigue - machine design approach - local strain approach - corrosion fatigue - Effect of temperature on fatigue	2
4.0	**Creep**	
4.1	Creep and Stress Rupture - High temperature materials problem - Time dependent Mechanical Behaviour	2
4.2	Creep curve - stress rupture test - structural changes	2
4.3	Mechanisms - Deformation mechanism Maps - Activation energy for steady state creep	2
4.4	Super plasticity - fracture at elevated temperature - High Temperature alloys	2
4.5	Presentation of Engineering creep data - Prediction of long time properties - creep under combined stresses - creep and fatigue interaction.	2
5.0	**Fracture**	
5.1	Brittle fracture - Brittle fracture problem - significance of transition temperature curve	2
5.2	Metallurgical factors affecting transition temperature	1
5.3	Drop weight test and other large scale tests - Fracture analysis diagram	2
5.4	Temper Embrittlement - Environment sensitive fracture - flow and fracture under very rapid rates of loading.	2
	Total	47

Course Designers

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14MG140	INDUSTRIAL AUTOMATION AND ROBOTICS	Category	L	T	P	Credit
		PC	4	0	0	4

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, Flexible Manufacturing Systems, Automated Materials Handling and Storage Systems, Robot Kinematics, Robot Programming and its industrial applications.

Prerequisite

Knowledge on Mechanical engineering/ manufacturing 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	Explain the types of automation, types of machine tools and material handling equipments used for automation	Understand	80	70
CO2	Explain the principles of automation, types of production systems and management support systems involved in automation	Understand	80	70
CO3	Explain the basic components and their functions of automated production line, automated assembly system, FMS, AS/RS, AGV and Robot Kinematics and its industrial applications	Understand	80	70
CO4	Compute the cycle time, process time, indexing time of indexing devices, efficiency of the production line, production rate and production cost.	Apply	70	60
CO5	Compute the gripper force and Make path program of robots	Apply	70	60
CO6	Select the suitable layouts, material handling devices or 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	M	L									
CO2	M	L									
CO3	M	L									
CO4	S	M	L	L							

CO5	S	M	L	L							
CO6	S	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	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	0	0	0	0
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Course Outcome 1 (CO1):

1. What is a production system?
2. Define flexibility.
3. Name the joint types used in Robotic arms and wrists.
4. What is an end effector?

Course Outcome 2 (CO2):

1. Name three categories of AGVs.
2. What is an automated production line?
3. Describe the automation migration strategy?

Course Outcome 3 (CO3):

1. Name three reasons for including a storage buffer in an automated production line.
2. Discuss the hardware used in parts delivery system.
3. What characteristics of industrial work situations that demand substitution of robots for human labour?
4. Write a homogeneous transform matrix for a rotation of 90° about the z-axis, followed by a rotation of 90° about the x-axis followed by a translation of (3, 7 and 9)
5. Identify the three application areas of AS/RS.
6. Demonstrate the FMS in-line layouts with examples.

Course Outcome 4 (CO4):

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.

4. A ten-station transfer machine has an ideal cycle time of 30 sec. The frequency of line stops is 0.075 stops per cycle. When a line stop occurs, the average downtime is 4.0 min. Determine (a) average production rate in piece/hour, (b) line efficiency, and (c) proportion downtime.

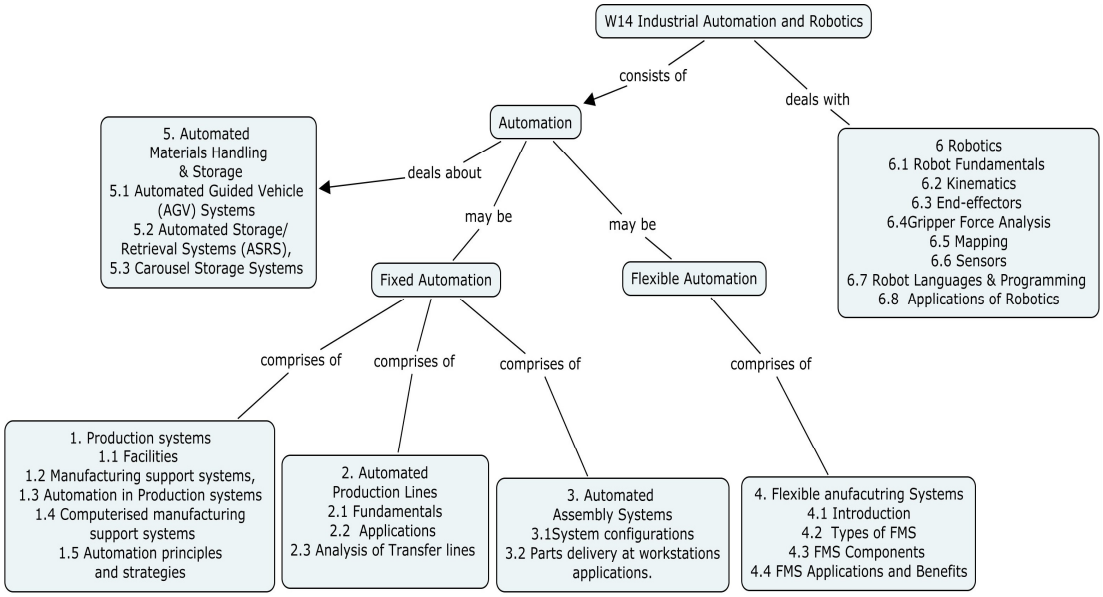
Course Outcome 5 (CO5):

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

Course Outcome 6 (CO6):

1. How do external sensors differ from internal sensors?
2. Select the suitable sensor for the following applications (a) to indicate distance (b) to indicate the presence (c) Inspection.
3. Compare 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, Computerised manufacturing support systems, Manual labour in Production systems, Automation principles and strategies.

Automated Production Lines: Fundamentals- System configurations, Workpants 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.

Flexible Manufacturing Systems: Introduction, Types of FMS, FMS Components, FMS Applications and Benefits.

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

Robotics : Robot Fundamentals - Definition - Anatomy – Specifications, Robot Kinematics - Forward and Reverse Kinematics (Transformation) of Two and Three Degrees of Freedom Robot Arm, Robot End-effectors - Classification - Types of Gripper, Drive Systems for Grippers, Hooks, Scoops and other Miscellaneous Devices, Gripper Force Analysis. Mapping - General mapping and Compound mapping. Sensors - Actuators - Types of Sensors, Robot Languages: Robot Languages and Programming, Classification of Robot languages and Robot Software. Applications of Robotics.

Reference Books

1. Mikell. P. Groover, “Automation Production Systems, and Computer Integrated Manufacturing”, Third Edition, PHI Learning Pvt. Ltd, New Delhi, 2008.
2. D.M.Considine and G.D. Considine, "Standard Hand book of Industrial Automation", Chapman and Hall, New Jersey, 1986.
3. P. Radhakrishnan, S. Subramanyan and V. Raju, ‘CAD/CAM/CIM’, New Age International (P) Ltd., New Delhi, 2009
4. Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi 2010
5. Popov and E.I. Yurevih, “Robotics", MIR Publications, Moscow, 1987.
6. 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

Module Number	Topics	No. of Lectures
1.3	Automation in Production systems – Automated Manufacturing system	1
1.4	Computerised manufacturing support systems, Manual labour in Production systems	2
1.5	Automation principles and strategies.	2
2	**Automated Production Lines**	
2.1	Fundamentals- System configurations	1
	Workpants transfer mechanisms, Storage buffers, and Control of the production line.	2
2.2	Applications – Machining systems and System Design Considerations.	2
2.3	Analysis of Transfer lines – Transfer lines with No internal parts storage,	2
	Transfer lines with internal storage buffers.	1
3	**Automated Assembly Systems**	
3.1	System configurations	1
3.2	Parts delivery at workstations, and applications.	2
4	**Flexible Manufacturing Systems**	
4.1	Flexible Manufacturing Systems – Introduction	1
4.2	Types of FMS	1
4.3	FMS Components	2
4.4	FMS Applications and Benefits	1
5	**Automated Material Transport systems**	
5.1	Types of vehicles, Automated Guided Vehicle (AGV) applications, Vehicle Guidance Technology, Vehicle Management and Vehicle safety.	2
5.2	Automated Storage systems: Automated Storage/Retrieval Systems (ASRS)	2
5.3	Carousel Storage Systems	1
6	**Robotics**	
6.1	Robot Fundamentals - Definition - Anatomy – Specifications	1
6.2	Robot Kinematics - Forward and Reverse Kinematics (Transformation) of Two and Three Degrees of Freedom Robot Arm	2
6.3	Robot End-effectors - Classification - Types of Gripper	2
	Drive Systems for Grippers, Hooks, Scoops and other Miscellaneous Devices	2
6.4	Gripper Force Analysis	2
6.5	Mapping - General mapping and Compound mapping.	2
6.6	Sensors - Actuators - Types of Sensors	2
6.7	Robot Languages: Robot Languages and Programming	1
	Classification of Robot languages and Robot Software	1
6.8	Applications of Robotics.	1
	Total	45

Course Designers

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14MG150 CNC MACHINE TOOL TECHNOLOGY

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

The introduction of lower cost CNC machines radically changed the manufacturing industry. 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 reduces the frequency of errors and provided the operators with more time to perform additional tasks. CNC also allows for more flexibility in the way parts are held in the manufacturing process and the time required changing the machine to produce different components.

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 different components of a CNC Machine tool	Understand	80	70
CO2	Summarize the appropriate techniques for assembly of CNC machine tool elements.	Understand	80	70
CO3	Explain the principle of different subsystems, feedback devices and interfacing of CNC machine tool	Understand	80	70
CO4	Write CNC program to perform the machining operations as per the product geometry given	Apply	70	60
CO5	Explain the testing and validation methods for the subassemblies of CNC machine tool	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	M	L									
CO4	S	M	L	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	20	20	20	20
Understand	80	80	60	60
Apply	0	0	20	20
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 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. Describe the process of identifying the problems in ballscrew assembly.
2. Explain the precautions to be followed while assembly of LM guides way.
3. Explain the different issues on CNC machine during assembly of electrical drives.

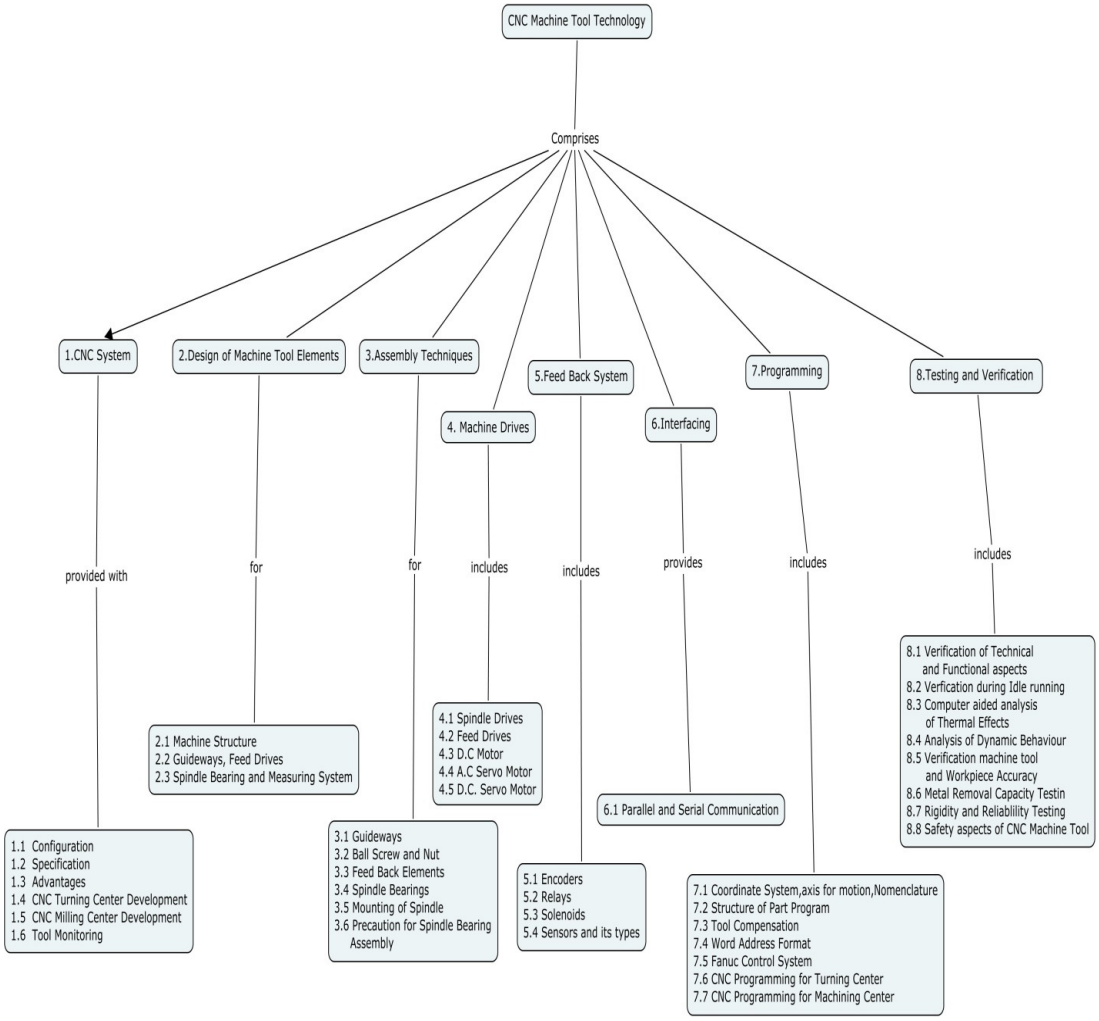
Course Outcome 4 (CO4):

1. Write a CNC program for turning operation to produce an aluminum component of your choice. 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.
3. Illustrate the concept of writing CNC program for turning and milling with suitable diagram.

Course Outcome 5 (CO5):

1. Describe the general procedure to be followed for verifying technical and functional specifications of a CNC machining center.
2. Explain the method of verification to ensure the accuracy of the machine tool and the work piece.
3. Describe the different safety aspects of a CNC turning and machine centers.

Concept Map



Syllabus

CNC Systems: Configuration of the CNC systems, Specifications of CNC Turning and Machining center, Advantages of the CNC machines, CNC Turning center development, CNC machining center development, Tool monitoring on CNC machines. **Design of 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, mounting accuracy of the spindles, Assembly precautions for assembling spindle bearings. **Machine Drives:** Spindle drives, Feed drives, DC motors, DC servomotors, AC servomotors. **Feedback devices:** Encoders, Relays, Solenoids, Sensors and their types. **Interfacing:** Parallel and Serial Communications. **Programming:** Coordinate systems, Axes motion and Nomenclature, Structure of part program, Tool compensation, Word address format, FANUC control system, CNC part programming for CNC Turning center, CNC part programming for CNC Machining center. **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, Safety aspects of CNC machine tools.

Reference Books

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.

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1.	**CNC Systems**	
1.1	Configuration of the CNC systems	1
1.2	Specifications of CNC Turning and Machining center	
1.3	Advantages of the CNC machines	1
1.4	CNC Turning center development	
1.5	CNC machining center development	1
1.6	Tool monitoring on CNC machines	
2	**Design of machine tool elements**	
2.1	Machine structure	1
2.2	Guide ways and feed drives	1
2.3	Spindle bearing and measuring systems	1
3	**CNC Machines Assembly Techniques**	
3.1	Guide ways	1
3.2	Ball screw and nut assembly	1
3.3	Feedback elements	1
3.4	spindle bearings	1
3.5	Mounting accuracy of the spindles	1
3.6	Assembly precautions for assembling spindle bearings	1
4	**Machine Drives**	
4.1	Spindle drives	1
4.2	Feed drives	1
4.3	DC motors	1
4.4	DC servomotors	1
4.5	AC servomotors	1
5	**Feedback devices**	
5.1	Encoders	1
5.2	Relays	1

Module Number	Topics	No. of Lectures
5.3	Solenoids	1
5.4	Sensors and their types	1
6	**Interfacing**	
6.1	Parallel and Serial Communication	1
7	**Programming**	
7.1	Coordinate systems, Axes motion and Nomenclature	1
7.2	Structure of part program	1
7.3	Tool compensation	1
7.4	Word address format	1
7.5	FANUC control system	1
7.6	CNC part programming for CNC Turning center	1
7.7	CNC part programming for CNC Machining center	1
8	**Testing and Verification**	
8.1	Verification of technical and functional aspects	1
8.2	Verification of CNC machine during idle running	1
8.3	Computer aided analysis of thermal effects	1
8.4	Analysis of dynamic behavior of CNC machine tools	1
8.5	Verification of machine tool accuracy and work piece accuracy	1
8.6	Metal removal capacity testing	1
8.7	Rigidity and reliability testing of CNC machines	1
8.8	Safety aspects of CNC machine tools	
	Total	36

Course Designers:

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14MG160	MICRO ELECTRO MECHANICAL SYSTEMS AND NANO TECHNOLOGY	Category	L	T	P	Credit
		PC	4	0	0	4

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. Nanotechnology is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced. In its original sense, 'nanotechnology' refers to the projected ability to construct items using techniques and tools being developed today to make complete, high performance products.

The objective of this course is to impart knowledge to the students on micro electromechanical systems, various fabrication techniques and micro actuators and to impart knowledge to the students about the science of nano materials and Characterization of Nano Materials.

Prerequisite

Nil

Course Outcomes

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 Materials, Fabrication Processes and Micro System Packaging	Apply	70	60
CO3	Use Micro Devices and Materials	Apply	70	60
CO4	Explain the Science of Nano Materials	Understand	80	70
CO5	Explain the Characterization of Nano Materials	Understand	80	70

Mapping with Programme Outcomes

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**
CO1	M	L									
CO2	S	M	L	L							
CO3	S	M	L	L							
CO4	M	L									
CO5	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	60	60	60	60
Apply	20	20	20	20
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. Explain in detail the micro fluidics.

Course Outcome 2 (CO2):

1. What is the function of a photoresist?
2. Explain in detail the various CVD processes for MEMS applications.
3. Illustrate the LIGA process with an example.

Course Outcome 3 (CO3):

1. What is a Micro actuator?
2. Describe the principle of working of flow sensors.
3. Design a silicon die for a pressure sensor.

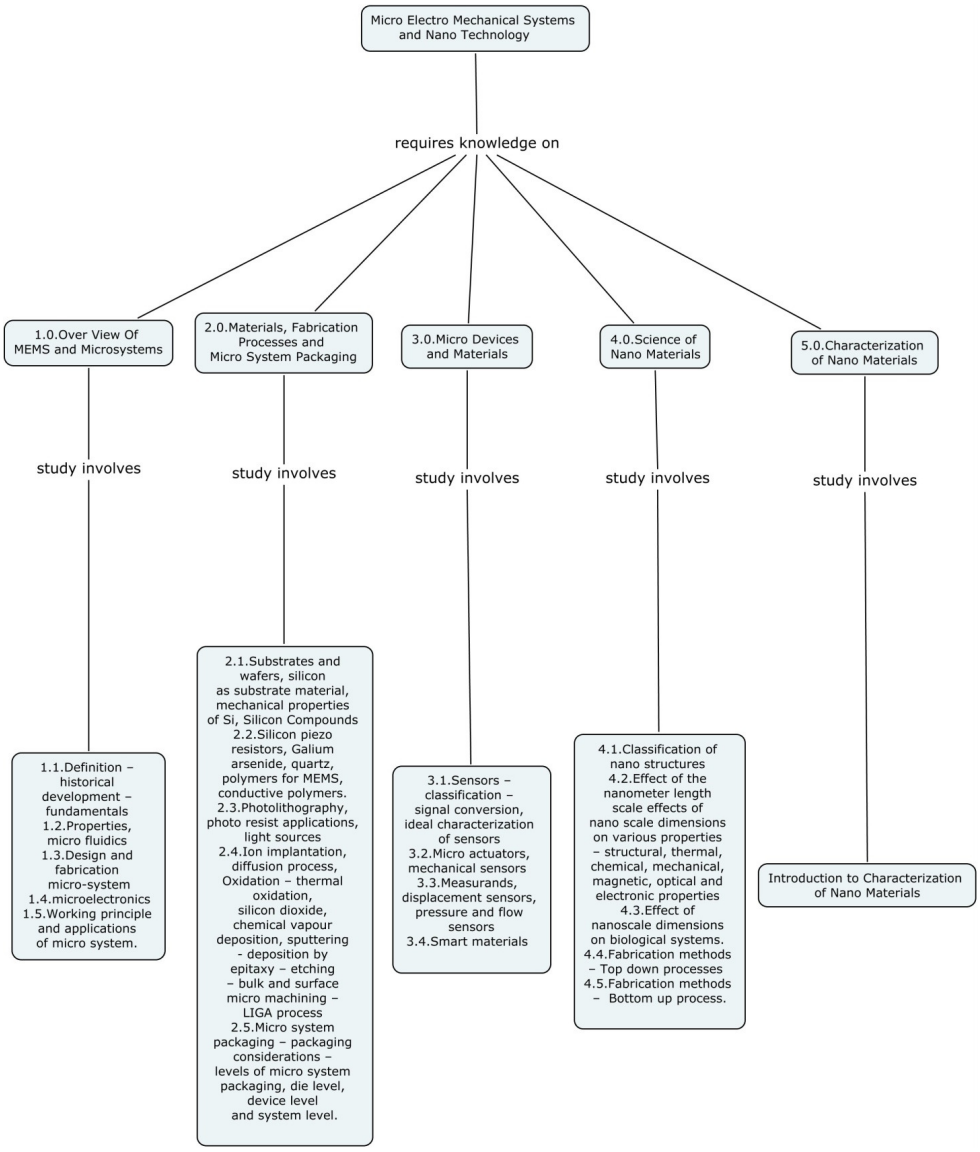
Course Outcome 4 (CO4):

1. What is the effect of nanoscale dimensions on biological systems?
2. Describe the effects of the nano scale dimensions on thermal properties.

Course Outcome 5 (CO5):

1. List the applications of scanning electron microscopy.
2. Explain in detail the principle of working of X-ray diffraction.

Concept Map



Syllabus

Over View of MEMS and Microsystems: Definition – historical development – fundamentals – properties, micro fluidics, design and fabrication micro-system, microelectronics, working principle and applications of micro system. **Materials, Fabrication Processes and Micro System Packaging:** Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds silicon piezo resistors, Galium arsenide, quartz, polymers for MEMS, conductive polymers. Photolithography, photo resist applications, light sources, ion implantation, diffusion process, oxidation – thermal oxidation, silicon dioxide, chemical vapour deposition, sputtering - deposition by epitaxy – etching – bulk and surface micro machining – LIGA process - Micro system packaging –packaging considerations – levels of micro system packaging, die level, device level and system level. **Micro Devices and Materials:** Sensors – classification – signal conversion ideal characterization of sensors - micro actuators, mechanical sensors – measurands, displacement sensors, and pressure and

flow sensors, smart materials. **Science of Nano Materials:** Classification of nano structures – effect of the nanometer length scale, effects of nano scale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties – effect of nanoscale dimensions on biological systems. Fabrication methods – Top down processes – bottom up process. **Characterization of Nano Materials:** Introduction to Characterization of Nano Materials.

Reference Book

1. Tai – Ran Hsu, "MEMS and Microsystems Design and Manufacture", Tata-McGraw Hill, New Delhi, 2002.
2. Mark Madou, "Fundamentals of Microfabrication", CRC Press, New York, 2002
3. Norio Taniguchi, "Nano Technology", Oxford University Press, New York, 2003
4. Mohamed Gad-el-Hak, "The MEMS Hand Book", CRC Press, New York, London.
5. Charles P Poole, Frank J Owens, "Introduction to Nano technology", John Wiley and Sons, 2003
6. Julian W. Hardner Micro Sensors, "Principles and Applications", CRC Press 1994
7. Choudhury, Prosenjit Rai, "MEMS and MOEMS Technology and Applications" PHI Learning Pvt. Ltd, New Delhi, 2009.

Course Content and Lecture Schedule

Module Number	Topics	No. of Lectures
1.0	Over View of MEMS and Microsystems	
1.1	Definition – historical development – fundamentals	1
1.2	Properties, micro fluidics	1
1.3	Design and fabrication micro-system	1
1.4	Microelectronics	1
1.5	Working principle and applications of micro system.	2
2.0	Materials, Fabrication Processes and Micro System Packaging	
2.1	Substrates and wafers, silicon as substrate material, mechanical properties of Si, Silicon Compounds	2
2.2	Silicon piezo resistors, Galium arsenide, quartz, polymers for MEMS, conductive polymers.	3
2.3	Photolithography, photo resist applications, light sources	2
2.4	Ion implantation, diffusion process, Oxidation – thermal oxidation, silicon dioxide, chemical vapour deposition, sputtering - deposition by epitaxy – etching – bulk and surface micro machining – LIGA process	4
2.5	Micro system packaging – packaging considerations – levels of micro system packaging, die level, device level and system level.	3
3.0	**Micro Devices and Materials**	
3.1	Sensors – classification – signal conversion, ideal characterization of sensors	2
3.2	Micro actuators, mechanical sensors	3
3.3	Measurands, displacement sensors, pressure and flow sensors.	3

Module Number	Topics	No. of Lectures
3.4	Smart materials	2
4.0	**Science of Nano Materials**	
4.1	Classification of nano structures	2
4.2	Effect of the nanometer length scale effects of nano scale dimensions on various properties – structural, thermal, chemical, mechanical, magnetic, optical and electronic properties	3
4.3	Effect of nanoscale dimensions on biological systems.	3
4.4	Fabrication methods – Top down processes	2
4.5	Fabrication methods – Bottom up process.	3
5.0	**Characterization of Nano Materials**	
5.1	Introduction to Characterization of Nano Materials	3
	Total	**46**

Course Designers

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14MG170	ADVANCED MANUFACTURING ENGINEERING LABORATORY - I	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

Manufacturing needs automation in the field of solid modeling, analysis and inspection. This practical is intended to have hands exercises in the area of creating solid models using third party design package and few aspects of inspection with various metrological instruments.

Prerequisite

- NIL

- **Course Outcomes**

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

(CO)	Course Outcome	Bloom's Level	Expected Proficiency	Expected Attainment Level
CO1	Draw 2D and 3D models of Engineering components	Apply	70	60
CO2	Develop assembly models of Engineering components	Apply	70	60
CO3	Infer the influence of process parameters on surface quality in Turning and Milling operations	Analyse	60	50
CO4	Produce a single point cutting tool using tool and cutter grinder and measure the tool signature	Apply	70	60
CO5	Operate CMM, Profile Projector, Auto Collimator and Tool makers microscope for linear and angular measurements	Apply	70	60

- **Mapping with Programme Outcomes**

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	M	L	L	M			M		L	L
CO2	S	M	L	L	M			M		L	L
CO3	S	S	M	M				M		L	L
CO4	S	M	L	L				M		L	L
CO5	S	M	L	L	M			M		L	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	0	0	0	0

Evaluate	0	0	0	0
Create	0	0	0	0

- For continuous assessment, totally 12 exercises need to be completed by the students from CAD modeling and machining practices.
- For final evaluation, TWO questions will be given with 50 marks each from CAD modeling and machining practices.

Syllabus

I. Modelling using CAD package

1. Development of 2D Sketches.
2. Development of 3D Models like Piston and Bracket.
3. Assembly Modeling like Screw Jack, Stop Valve.

II. Machining and Inspection

1. Working on any one of the machines –Lathe, CNC Lathe, and Milling Mahcines to identify the influence of process parameter on surface quality
2. Preparation of single point cutting tool using Tool and cutter Grinder and inspect the tool signature.
3. Profile and dimensional measurement using CMM, Profile Projector, Tool makers microscope, Autocollimator.

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14MG210	MECHANICS OF METAL CUTTING AND METAL FORMING	Category	L	T	P	Credit
		PC	4	0	0	4

Preamble

Metal cutting and forming processes are the core production processes and the economy of these processes depends on the proper selection and control of parameters. This requires the fundamental knowledge on the mechanisms involved in those processes. 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

- Principles of Metal Cutting and Metal Forming processes
- Working of machine tools and metal forming equipments

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	Discuss the forces, stresses acting on in a single point tool during machining	Understand	80	70
CO2	Explain the effect of temperature, speed, feed and depth of cut in an orthogonal machining	Understand	80	70
CO3	Explain characteristics of tool wears and their process conditions	Understand	80	70
CO4	Illustrate the effect of cutting parameters on tool life	Apply	70	60
CO5	Choose appropriate tool material for specified machining process	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	M	L									
CO4	S	M	L	L							
CO5	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. What do you mean by Apparent mean shear strength of work material?
2. How work-tool temperature is measured during metal cutting process?
3. List out the factors affecting the machinability of metals?

Course Outcome 2 (CO2):

1. Explain the various forms of tool wear in metal cutting?
2. Explain the effect of lubrication in metal cutting?
3. Derive the expression using Merchant's theory for the following
   i) Forces involved in Cutting ii) Stresses iii) Velocity relationship

Course Outcome 3 (CO3):

1. Discuss the various standards of nomenclature of a single point tool and indicate the relationship between the standards.
2. Discuss any two defects in rolling process due to variations in rolling load
3. Differentiate True Stress – Strain with conventional Stress-strain with a simple illustration.

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	$Vt^{0.16} = 90$

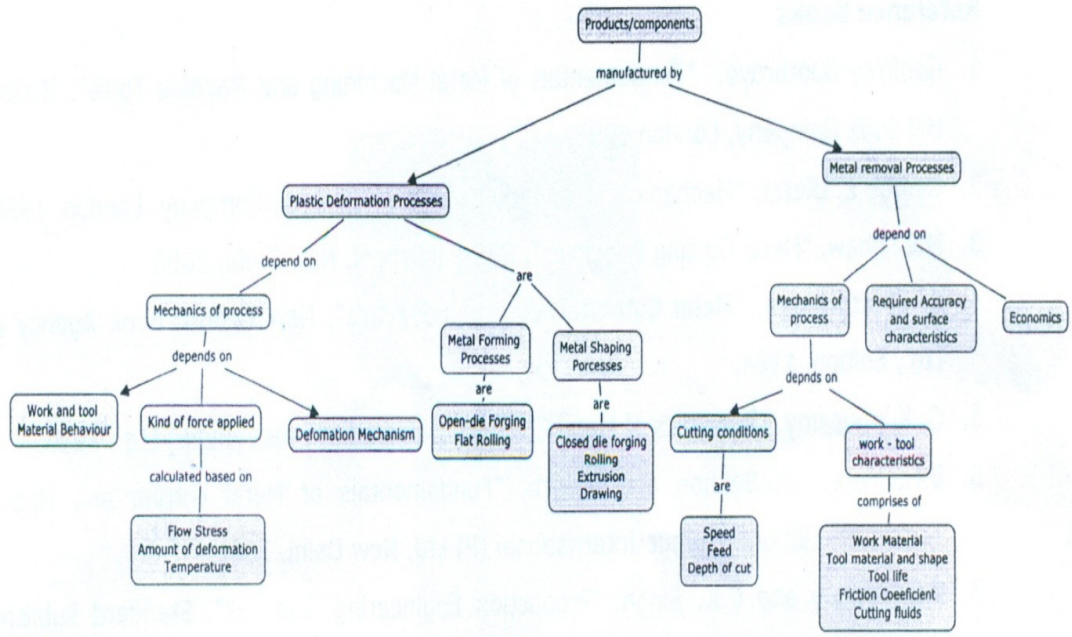
Calculate tool-life values and optimum cutting velocities for minimum cost with no consideration for material cost, and maximum production rate criteria for both workpiece materials. State which material should be chosen for total minimum cost.

3. In an orthogonal cutting, the cutting tool has a rake angle = 10º. The chip thickness before the cut =0.5 mm and the chip thickness after the cut = 2.8 mm. The cutting force and thrust force are measured during cutting operation: F_c=1559N and F_t=1271 N. The width of the orthogonal cutting operation = 3mm. Calculate the shear plane angle, shear strain and shear strength of work material.

Course Outcome 5 (CO5):

1. During the machining of mild steel with 0º-10º-6º-6º -8º-90º-1mm cutting tool the following observations have been obtained:
   Depth of cut = 2mm; Feed = 0.25 mm/rev; Cutting speed = 200 m/min; Chip thickness = 0.39 mm; Tangential force = 320 N; Axial force = 170 N. Calculate i) Shear force and normal force on shear plane, ii) Friction force and normal force on rake face, c) kinetic coefficient of friction and iv) specific cutting energy of cutting.
2. A 300 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 cost of the material is Rs.100/kg and its Tool life equation is $Vt^{0.10}$ = 67. Calculate tool-life values and optimum cutting velocities for minimum cost with no consideration for material cost, and maximum production rate criteria for workpiece material.
3. During the machining of mild steel with 0º-15º-6º-6º -8º-90º-1mm cutting tool the following observations have been obtained:
   Depth of cut = 4mm; Feed = 0.35 mm/rev; Cutting speed = 300 m/min; Chip thickness = 0.40 mm; Tangential force = 350 N; Axial force = 2000 N. Calculate i) Shear force and normal force on shear plane, ii) Friction force and normal force on rake face, c) kinetic coefficient of friction and iv) specific cutting energy of cutting.

Concept Map



Syllabus

Mechanics of Metal Cutting - Terms and Definitions – Chip Formation – Types of chips – Forces in orthogonal and oblique cutting – Specific Cutting Energy – Apparent Mean Shear Strength of the work material – Theories of Ernst and Merchant, Lee and Shaffler, Oxley and Palmer – 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 – Measurement of Cutting 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. Nomenclature of Cutting Tools -Systems of Cutting Tool Nomenclature (British Maximum Rake, American Standards Association, German System) – Coating of cutting tools, Setting System – Grinding tool angles.

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 – Strain-Rate Effects –Friction and Lubrication.

Reference Books

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

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 and oblique cutting – Specific Cutting Energy – Apparent Mean Shear Strength of the work material	2
3.	Theories of Ernst and Merchant, Lee and Shaffer, Oxley and Palmer	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	1
6.	Effect of Cutting parameters on Temperatures	1
7.	Measurement of Cutting Temperatures	1
8.	Tool Wear: Causes, Mechanisms and types – Tool life Criteria	2
9.	Effect of a Built-up Edge, Tool Angles, Speed and Feed on Tool life, Machinability	2
10.	Factors affecting the Machinability of Metals	1
11.	Tool materials – Classification and typical applications of tool Materials	2
12.	Types, selection and actions of cutting fluids - Coolants and lubricants – Causes of surface roughness	2
13.	Effect of nose radius on surface roughness.	1
14.	Choice of Feed and Cutting Speed	1
15.	Life for Minimum Cost and Minimum Production Time	1
16.	Estimation of factors that determine Optimum Conditions	1
17.	Machining at Maximum Efficiency	1
18.	Systems of Cutting Tool Nomenclature (British Maximum Rake, American Standards Association, German System) Coating of cutting tools	2

Module Number	Topic	No. of Lectures
19.	Interrelations between different systems of nomenclature	1
20.	Setting System – Grinding tool angles	1
21.	Elementary Theory of Plasticity - Flow Curve	2
22.	True Stress and True Strain – Yielding Criteria for Ductile Metals	2
23.	Combined Stress Tests – Yield Locus – Anisotropy in Yielding – Yield Surface and Normality	3
24.	Plastic Stress-Strain Relations	2
25.	Classification of Forming Process – Mechanics of Metal working	2
26.	Flow-Stress Determination	1
27.	Temperature in Metalworking – Strain-Rate Effects	2
28.	Friction and Lubrication	2
	Total	**45**

Course Designers:

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14MG220 TOOL DESIGN ENGINEERING

Category	L	T	P	Credit
PC	3	0	0	3

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

Preamble

Sheet metal blanking and piercing are shearing processes in which a punch and die are used to modify sheet metal. Sheet metal forming processes include the following: bending, forming and drawing. Press tools are commonly used in hydraulic, pneumatic, and mechanical presses to produce components at high volumes. Jigs and fixtures are production tools used to accurately manufacture duplicate and interchangeable parts.

Cutting tool is any tool that is used to remove material from the workpiece by means of shear deformation. Cutting may be accomplished by single-point or multipoint tools and used in turning, shaping, planning and remove material by means of one cutting edge. Milling and drilling tools and grinding tools are also multipoint tools. Each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip.

Limit Gauges are also called GO and NOGO gauges. One of the sides or ends of the gauge is made to correspond to maximum and the other end to the minimum permissible size. The function of limit gauges is to determine whether the actual dimensions of the work are within or outside the specified limits.

The objective of this course is to teach the students to the area design of sheet metal blanking and piercing dies; design of bending, forming and drawing dies; design of Jigs and Fixtures; design of cutting tools, design of NC machine tooling and design of limit gauges to meet the industrial needs.

Prerequisite

Nil

Course Outcomes

CO.No.	Course Outcome	Blooms Level	Expected proficiency	Expected attainment level
CO1	Illustrate the design of sheet metal blanking and piercing dies	Apply	70	60
CO2	Illustrate the design of bending, forming and drawing dies	Apply	70	60
CO3	Design of Jigs and Fixtures	Apply	70	60
CO4	Design of cutting tools	Apply	70	60
CO5	Design of NC machine tooling	Apply	70	60
CO6	Design of gauges	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	S	M	L	L							
CO3	S	M	L	L							
CO4	S	M	L	L							
CO5.	S	M	L	L							
CO6.	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):

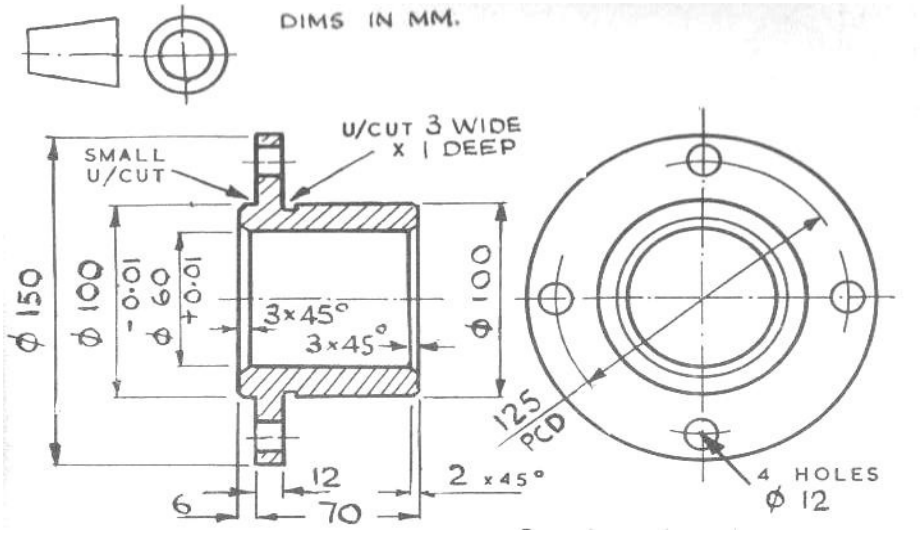
1. What is the shut height of a press?
2. Explain in detail the compound die.
3. Design a blanking die to blank the C15 steel washer of Outer diameter 20mm and Inner diameter 15 mm and of thickness 2 mm.

Course Outcome 2 (CO2):

1. What is coining?
2. Describe the variables that affect metal flow during drawing?
3. Discuss the design steps in drawing of 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 any plain milling cutter.

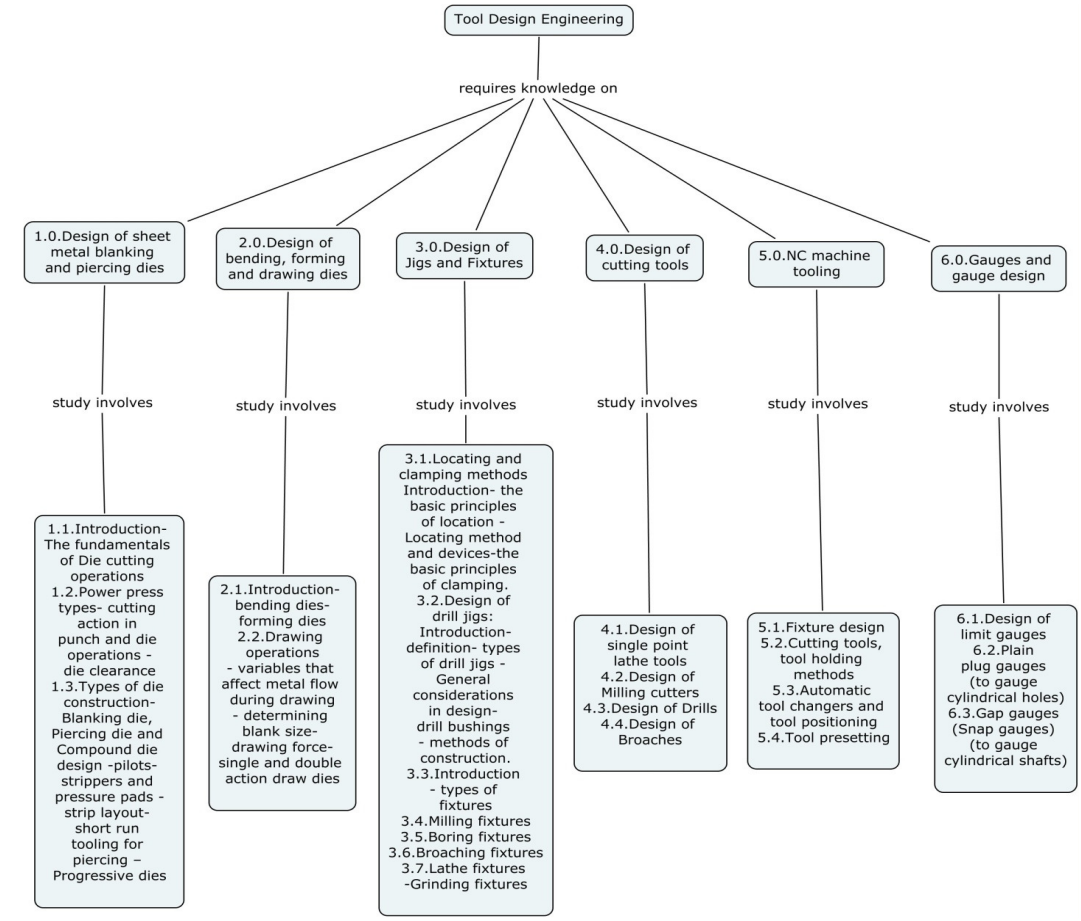
Course Outcome 5 (CO5):

1. What are the advantages of magnetic chucks?
2. Explain in detail the automatic tool changers in NC machine tools.
3. Illustrate the tool presetting for a CNC Vertical machining center.

Course Outcome 6 (CO6):

1. What are the types of limit gauges?
2. Describe the various types of plug gauges?
3. Design a plain plug limit gauge for measurement of hole of diameter 20 H7.

Concept Map



Syllabus

Design of sheet metal blanking and piercing dies: Introduction - The fundamentals of Die cutting operations - power press types - cutting action in punch and die operations-die clearance - Types of die construction-Blanking die, Piercing die and Compound die design-pilots - strippers and pressure pads - strip layout - short run tooling for piercing – Progressive dies. **Design of bending, forming and drawing dies:** Introduction-bending dies-forming dies- drawing operations- variables that affect metal flow during drawing- determining blank size- drawing force-single and double action draw dies. **Design of Jigs and Fixtures** Locating and clamping methods: Introduction- the basic principles of location-locating method and devices-the basic principles of clamping. Design of drill jigs: Introduction-definition- types of drill jigs -general considerations in design- drill bushings - methods of construction. Design of fixtures: Introduction - types of fixtures - Milling fixtures – Boring fixtures - Broaching fixtures - Lathe fixtures -Grinding fixtures. **Design of cutting tools:** Design of single point lathe tools – Design of Milling cutters – Design of Drills –Design of Broaches. **NC machine tooling:** Fixture design - cutting tools - tool holding methods - Automatic tool changers and tool positioning- Tool presetting. **Gauges and gauge design:** Design of limit gauges - plain plug gauges (to gauge cylindrical holes) - Gap gauges (Snap gauges) (to gauge cylindrical shafts).

Reference Books

1. Cyril Donaldson, George.H. Lecain and V.C.Goold, "**Tool Design**", Tata.McGraw Hill, 2012
2. ASTME, "**Fundamentals of Tool Design**", Prentice Hall of India, 2003.
3. Edward G. Hoffman, "**Jig and Fixture**", Delmor Publishers, 2003
4. M.H.A. Kempster, "**An Introduction to Jig and Tool Design**", ELBS, 2000.
5. G.R.Nagpal, "**Tool Engineering and Design**", Khanna Publishers, New Delhi, 1998.
6. R.K. Jain, "**Engineering Metrology**", Khanna Publishers, New Delhi, 2009.
7. William Boyes, "**Hand book of Jig and Fixture Design**", SME, 1989.
8. PSG Tech, "**Design Data Book**", Kalaikathir Achchagam, Coimbatore, 2012.

Course Content and lecture Schedule

Module number	Topics	No. of Lectures
1.0	**Design of sheet metal blanking and piercing dies**	
1.1	Introduction- The fundamentals of Die cutting operations	1
1.2	Power press types- cutting action in punch and die operations -die clearance	1
1.3	Types of die construction-Blanking die, Piercing die and Compound die design -pilots- strippers and pressure pads -strip layout- short run tooling for piercing – Progressive dies	3
2.0	**Design of bending, forming and drawing dies**	
2.1	Introduction- bending dies- forming dies	1
2.2	Drawing operations- variables that affect metal flow during drawing- determining blank size- drawing force-single and double action draw dies.	2
3.0	**Design of Jigs and Fixtures**	
3.1	Locating and clamping methods: Introduction- the basic principles of location - Locating method and devices-the basic principles of clamping.	2
3.2	Design of drill jigs: Introduction-definition- types of drill jigs - General considerations in design- drill bushings - methods of construction.	1
3.3	Introduction - types of fixtures	1
3.4	Milling fixtures	2
3.5	Boring fixtures	2
3.6	Broaching fixtures	1
3.7	Lathe fixtures -Grinding fixtures.	1
4.0	**Design of cutting tools**	
4.1	Design of single point lathe tools	2
4.2	Design of Milling cutters	2
4.3	Design of Drills	2
4.4	Design of Broaches	2
5.0	**NC machine tooling**	
5.1	Fixture design	1
5.2	Cutting tools, tool holding methods	1
5.3	Automatic tool changers and tool positioning	2

Module number	Topics	No. of Lectures
5.4	Tool presetting	1
6.0	**Gauges and gauge design**	
6.1	Design of limit gauges	1
6.2	Plain plug gauges (to gauge cylindrical holes)	2
6.3	Gap gauges (Snap gauges) (to gauge cylindrical shafts).	2
	Total	**36**

Course Designers

1. Dr. T.Sornakumar tskmech@tce.edu
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14MG270	ADVANCED MANUFACTURING ENGINEERING LABORATORY - II	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

Manufacturing needs automation in the field of generation of CNC codes for various machining operations, simulation of manufacturing systems, Robot programming, Simulation for casting validation, Simulation of pneumatic, hydraulic and, electro hydraulic circuits for operations like sequencing, cascading.

Prerequisite

Advanced Manufacturing Engineering Laboratory – I

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	Apprise the geometric models of Engineering components	Analyse	60	50
CO2	Generate CNC codes various machining operations and Operate CNC machines	Apply	70	60
CO3	Evaluate robot program through simulation	Analyse	60	50
CO4	Simulate manufacturing systems and casting processes	Analyse	60	50
CO5	Construct pneumatic, hydraulic and electro hydraulic circuits for various industrial operations	Apply	70	60

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

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

- For continuous assessment, totally 12 exercises need to be completed by the students.
- For final evaluation, TWO questions will be given with 50 marks from Analysis of geometric models and 50 marks from remaining exercises.

Syllabus

I. Analysis of Geometric Models

1. Static analysis of a loaded beam
2. Static analysis of a corner bracket
3. Temperature distribution of a hollow cylindrical pin-fin
4. Modal analysis of model airplane wing .

II. CAM / Robot Programming

1. Generate the CNC code for profile milling and circular pocket
2. Generate the CNC code for drilling and rectangular pocket
3. Perform pattern drilling operation on a CNC machine
4. Write an off-line Robot Programming for pick and place operation
5. Write an APT programme for profile and pocket milling operation

III. Simulation of Manufacturing systems and processes

1. Simulate a FMC
2. Simulate an assembly line with 'n' stations
3. Simulate the sand casting of valve
4. Validate the casting process for a brocket

IV. Design of Pneumatic/ Hydraulic circuit

1. Design of hydraulic circuit for cascading operation
2. Simulation of sequencing operation (A+B-B+A-) using pneumatic / hydraulic trainer

Course Designers:

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3. V. Balasubramani vbmech@tce.edu

14MG310	COMPUTER INTEGRATED MANUFACTURING	Category	L	T	P	Credit
		PC	4	0	0	4

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 processes to exchange information with each other 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), CAPP, computer aided process planning, computer numerical control machine tools, computer integrated production management system and a business system integrated by a common data base.

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	Develop the B-rep. scheme, CSG technique and sweep representation for the development of solid model	Apply	70	60
CO2	Write APT code for machining Engineering components	Apply	70	60
CO3	Explain the concept of computer data communication, Protocol and graphics standards	Understand	80	70
CO4	Explain the formulation of CAPP, factory data collection system, principles 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	L							
CO2	S	M	L	L							
CO3	M	L									
CO4	M	L									
CO5	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	60	60	60	40
Apply	20	20	20	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

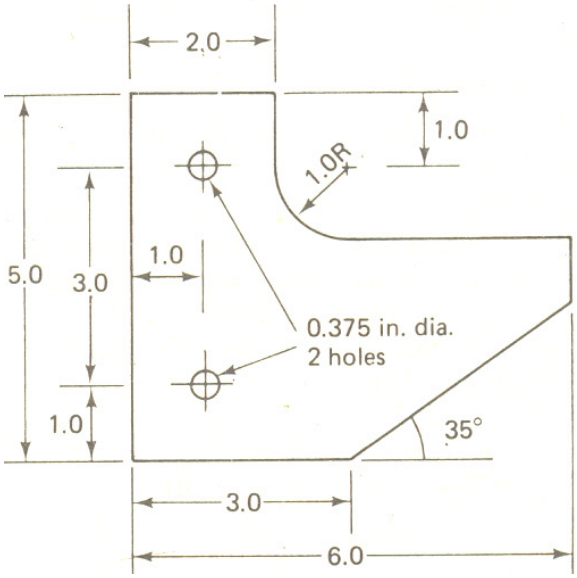
Course Level Assessment Questions

Course Outcome 1 (CO1):

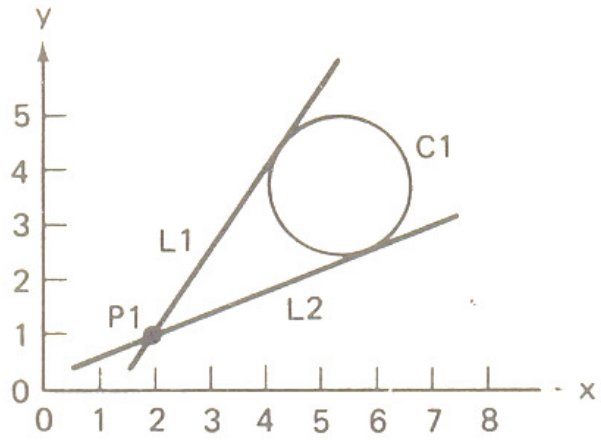
1. Develop a solid model of hollow cylinder of 15 mm thickness with inner diameter of 20 mm using sweep representation technique.
2. Suggest a suitable manipulation technique for joining two different solids.
3. Illustrate the Boundary representation and CSG technique with suitable solid model and compare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

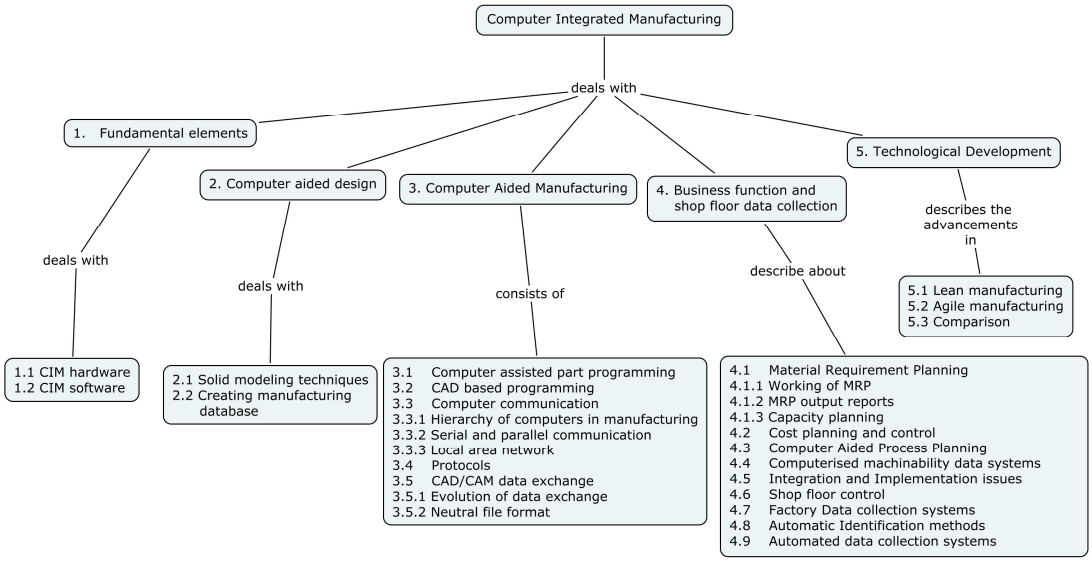
Course Outcome 4 (CO4):

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, Computer assisted part programming–APT language, 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”, Prentice Hall of India Learning, Third Edition, 2014.
4. David Bedworth, “Computer Integrated Design and Manufacturing”, Tata Mc Graw Hill publishing company Ltd, 1998.
5. Yorem Koren and Joseph Ben-Uri, “Numerical Control of Machine tools”, Khanna Publishers, 1988.
6. P. Radhakrishnan, S. Subramanyan and V. Raju, “CAD/CAM/CIM”, New Age International (P) Ltd., New Delhi, 2009.
7. Sureder Kumar and A.K.Jha, “Technology of Computer Aided Design and manufacturing” Dhanpat rai and sons, Delhi, 1993.

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

Module Number	Topics	No. of Lectures
3.1	Computer assisted part programming–APT language	2
3.2	CAD based programming	2
3.3	Computer Communication	2
3.3.1	Hierarchy of computers in manufacturing	2
3.3.2	Serial and parallel communication	1
3.3.3	Local area network	
3.4	Protocols-Manufacturing Automation Protocol	1
	Technical Office Protocol	
3.5	CAD/CAM data exchange-Method of data exchange	1
3.5.1	Evolution of data exchange	2
3.5.2	Neutral file format-DXF	
	IGES and PDES	
4.	**Business function and shop floor data collection**	
4.1	Material Requirement Planning-Inputs to MRP	2
4.1.1	Working of MRP	2
4.1.2	MRP output reports	2
4.1.3	Capacity Planning	
4.2	Cost planning and control	1
4.3	Computer Aided Process Planning-Retrieval type	2
	Generative type CAPP, Benefits of CAPP	2
4.4	Computerised machinability data systems	1
4.5	Integration and Implementation issues	2
4.6	Shop floor control-functions, information flow	1
4.7	Factory Data collection systems	2
4.8	Automatic Identification methods	3
4.9	Automated data collection systems	2
5.	**Technological Development**	
5.1	Agile manufacturing	2
5.2	Lean manufacturing	
5.3	Comparison of Agile and Lean manufacturing	2
	Total	46

Course Designers:

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14MGPA0	PLANT LAYOUT AND MATERIAL HANDLING	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

The workplace is one of the prime resources to deliver products/services with the expected level of quality at least cost. To achieve the organizational effectiveness, proper utilization of the workplace has to be ensured. This course has been designed to highlight 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	Blooms Level	Expected Proficiency	Expected attainment level
CO1	Describe the facility location determinants and methods	Understand	80	70
CO2	Solve different types of facility location models	Apply	70	60
CO3	Design the layouts of manufacturing systems and service organizations	Apply	70	60
CO4	Make clusters of machine and components using different techniques	Apply	70	60
CO5	Illustrate the activities for the work station in order to make balanced flow line using heuristic algorithms.	Apply	70	60
CO6	Describe about material handling system.	Understand	80	70

Mapping with Programme Outcomes

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

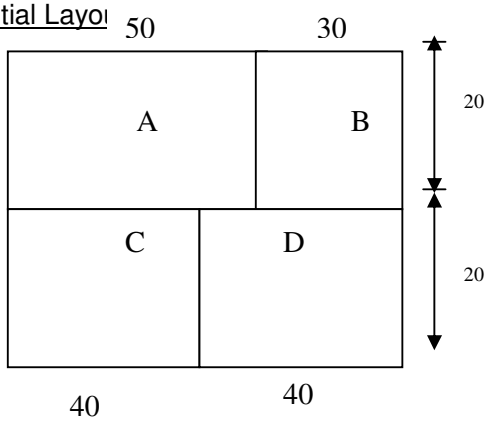
1. A company consists of the following functional areas. Design a layout using the construction algorithm ALDEP.

A – Wood cutting	1280 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 Layo



-	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.

Parts / Machine	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.

Parts / Machine	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 Element	Immediate Predecessor	Estimated 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 with suitable example
2. Describe the criteria and guidelines for the design of Unit load system.
3. Discuss about AS/AR system in comparison with the conventional warehousing system with an example.
4. Discuss about the choice of material handling system for a heavy manufacturing industry. Illustrate the pros and cons of the system under study.

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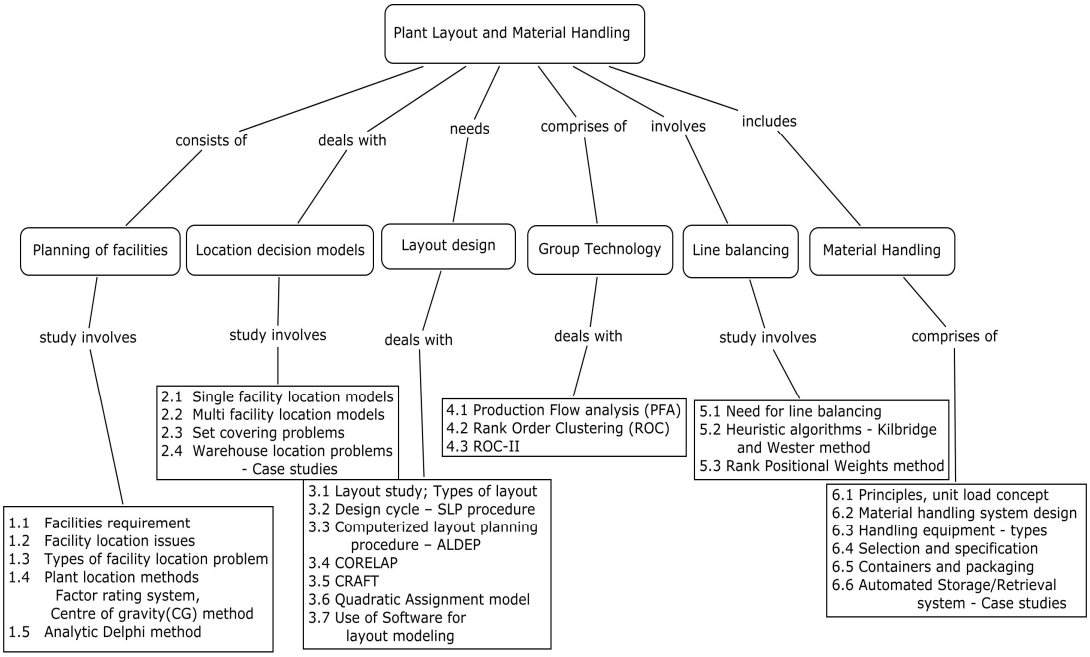
Concept Map



Syllabus

Planning of facilities: Facilities requirement; Facility location issues; Types of facility location problem; Plant location methods: Factor rating system, Centre of gravity (CG) method, Analytic Delphi method.

Location decision models: Single facility location models, Multi facility location models - Set covering problems – Warehouse location problems-case studies.

Layout design: Layout study; Types of layout; Design cycle – SLP procedure, computerized layout planning procedure – ALDEP, CORELAP, CRAFT; Quadratic Assignment model; 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).

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

Reference Books

1. Tompkins, J.A. and J.A.White, “Facilities planning”, John Wiley, 2010
2. Richard Francis.L. and John A.White, “Facilities Layout and location - an analytical approach”, Prentice Hall of India, 2002.
3. James Apple, M.Plant layout and “Material Handling”, John Wiley, 1977.
4. Pannerselvam,R, “Production and Operations Management”, Prentice Hall of India, 2012.

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1	**Planning of facilities**	
1.1	Facilities requirement	1
1.2	Facility location issues	1
1.3	Types of facility location problem	2
1.4	Plant location methods: Factor rating system, Centre of gravity(CG) method	2
1.5	Analytic Delphi method	1
2	**Location decision models**	
2.1	Single facility location models,	2
2.2	Multi facility location models	2
2.3	Set covering problems	2
2.4	Warehouse location problems-case studies	3
3	**Layout design**	
3.1	Layout study; Types of layout;	1
3.2	Design cycle – SLP procedure	2
3.3	Computerized layout planning procedure – ALDEP	1
3.4	CORELAP	2
3.5	CRAFT	2
3.6	Quadratic Assignment model	2
3.7	Use of Software for layout modeling	2
4	**Group Technology**	
4.1	Production Flow analysis (PFA)	2
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	2
5.3	Rank Positional Weights method	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	Selection and specification	1
6.5	Containers and packaging	2
6.6	Automated Storage/Retrieval system-case studies	3
	Total	**48**

Course Designers:

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14MGPB0 RESEARCH METHODOLOGY

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

Research Methodology will enable the Researchers to develop the most appropriate methodology for their Research Studies. The mission of the course is to impart research skills to the beginners and help improve the quality of Research by the existing researchers.

This course aims at giving adequate exposure in research process, data analysis techniques, report writing. Methodologies are often conflated with methods and techniques of data analyses, with limited understanding of the logic underlying the various techniques and methods. Further, engineering sciences also increasingly draw from developments in natural sciences and technology studies to enhance its explanatory domain. This has also strengthened the scope for trans-disciplinary research drawing upon perspectives from varied disciplines. Choice of methods is guided by the nature of the research questions posed. There is a scope for the researcher to learn from each other, and importantly understand the validity of the approaches that each study adopts.

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain the relationship between theory and research.	Remember
CO 2.	Describe and compare the major quantitative and qualitative research methods in engineering research.	Understand
CO 3.	Understand the importance of research ethics and integrate research ethics into the research process.	Understand
CO 4.	Propose a research study and justify the theory as well as the methodological decisions, including sampling and measurement.	Apply
CO 5.	Construct an effective questionnaire that employs several types of survey questions.	Apply
CO 6.	Assess and critique a published journal article that uses one of the primary research methods in the engineering field.	Apply

Mapping with Programme Outcomes

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1.	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO2.	**S**	**S**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO3.	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO4.	**S**	**S**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO5.	**S**	**S**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO6.	**S**	**S**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**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	20	20
Understand	80	40	60	40
Apply	0	40	20	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Outcome 1 (CO1):

1. Define Research.
2. What are the types of research?
3. List the steps of research process.
4. Define Data. Give examples of data.
5. Name the stages of report writing.
6. State the basic assumptions of the analysis of variance.

Course Outcome 2 (CO2):

1. Distinguish between fundamental research and applied research. Give examples.
2. List the types of chart and compare them.
3. Distinguish between Null hypothesis and alternative hypothesis.
4. What do you mean by multivariate techniques? Explain their significance in context of research studies.
5. Describe the technique of analysis of variance for one-way and two-way classifications.
6. Write short notes on characteristics of a good research report.

Course Outcome 3 (CO3):

1. A hotel management is interested in determining the percentage of the hotel guests who stay for more than 3 days. The reservation manager wants to be 95 percent confident that the percentage has been estimated to be within ±3% of the true value. What is the most conservative sample size needed for this problem?

2. In an international airport, the service time of a terminal follows exponential distribution. The service rate of a terminal serving the flights is 30 per day. Find the probability that the service time of the terminal in clearing a flight is :
   a. less than 0.5 hr.
   b. more than 0.75 hr.

3. In a Mainframe computer centre, execution time of programs follows exponential distribution. The average execution time of the programs is 5 minutes. Find the probability that the execution time of the programs is :
   a. less than 4 minutes
   b. more than 6 minutes

Course Outcome 4 (CO4):

1. A certain process produces 10 percent defective articles. A supplier of new raw material claims that the use of his material would reduce the proportion of defectives. A random sample of 400 units using this new material was taken out

of which 34 were defective units. Can the supplier's claim be accepted? Test at 1 percent level of significance.

2. Set up an analysis of variance table for the following per acre production data for three varieties of wheat, each grown on 4 plots and state if the variety differences are significant

Plot of land	Per acre production data		
	Variety of wheat		
	A	B	C
1	6	5	5
2	7	5	4
3	3	3	3
4	8	7	4

3. The following are the numbers of artifacts dug up by two archaeologists at an ancient cliff dwelling on 30 days.

By X	1 0 2 3 1 0 2 2 3 0 1 1 4 1 2 1 3 5 2 1 3 2 4 1 3 2 0 2 4 2
By Y	0 0 1 0 2 0 0 1 1 2 0 1 2 1 1 0 2 2 6 0 2 3 0 2 1 0 1 0 1 0

Use the sign test at 1% level of significance to test the null hypothesis that the two archaeologists, X and Y are equally good at finding artifacts against the alternative hypothesis that X is better?

Course Outcome 5 (CO5):

1. A Study compared the effects of four 1-month point of purchase promotion on sales. The unit sales for five stores using all four promotions in different months as follows.

Free sample	78	87	81	89	85
One pack gift	94	91	87	90	88
Cents off	73	78	69	83	76
Refund by mail	79	83	78	69	81

Do the promotions produce different effects on sales?

2. A research company has designed three different systems to cleanup oil spills. The following table contains the results, measured by how much surface area in (square meter) is cleared in 1 hour. The data were found by testing each method in several trials. Are the three systems equally effective? Use the 0.05 level of significance?

A	55	60	63	56	59	55
B	57	53	64	49	62	
C	66	52	61	57		

3. Determine the size of the sample for estimating the true weight of the cereal containers for the universe with N = 5000 on the basis of the following information:
   (1) The variance of weight = 4 ounces on the basis of past records.
   (2) Estimate should be within 0.8 ounces of the true average weight with 99% probability.
   Will there be a change in the size of the sample if we assume infinite population in the given case? If so, explain by how much.

Course Outcome 6 (CO6):

1. A simple random sampling survey in respect of monthly earnings of semi-skilled workers in two cities gives the following statistical information :

City	Mean monthly earnings (Rs)	Standard deviation of sample data of monthly earnings (Rs)	Size of sample
A	695	40	200
B	710	60	175

Test the hypothesis at 5 percent level that there is no difference between monthly earnings of workers in the two cities?

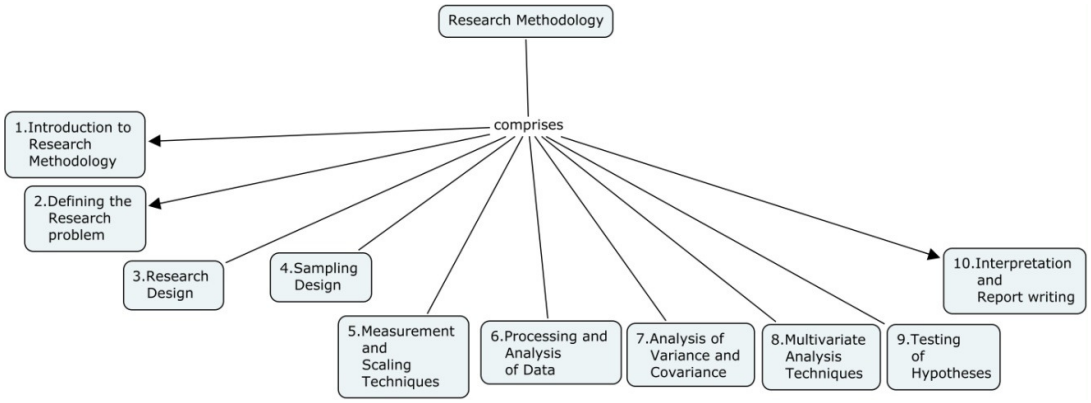
2. Sample of sales in similar shops in two towns are taken for a new product with the following results:

Town	Mean sales	Variance	Size of sample
A	57t	5.3	5
B	61	4.8	7

Is there any evidence of difference in sales in the two towns? Use 5 percent level of significance for testing this difference between the means of two samples?

3. “Report writing is more an art that hinges upon practice and experience”. Discuss.

Concept Map



Syllabus

Introduction to Research Methodology: Objectives of Research; Motivation in Research - Types of Research - Research Approaches - Significance of Research - Research Methods versus Methodology - Research Process - Criteria of Good

Research. **Defining the Research Problem:** Selecting the Problem - Necessity of Defining the Problem - Technique Involved in Defining a Problem. **Research Design:** Need for Research Design - Features of a Good Design - Important Concepts Relating to Research Design - Different Research Designs - Basic Principles of Experimental Designs. **Sampling Design:** Implications of a Sample Design - Steps in Sampling Design - Criteria for Selecting a Sampling Procedure - Characteristics of Good Sample Design- Different types of Sample Designs - Random Sample from an Indicate Universe- Complex Random Sampling Designs - Standard error. **Measurement and Scaling Techniques:** Measurement Scales - Sources of Error in Measurement - Tests of Sound Measurement - Technique of Developing Measurement Tools - Scaling - Meaning of Scaling - Scale Classification Bases - Important Scaling Techniques. **Processing and Analysis of Data:** Processing Operations - Elements/Types of Analysis - Statistics in Research - Measures of Central Tendency - Measures of Dispersion - Measures of Asymmetry (Skewness) - Measures of Relationship - Simple Regression Analysis - Multiple Correlation and Regression Partial Correlation - Association in Case of Attributes. **Analysis of Variance and Covariance:** Analysis of Variance (ANOVA) - The Basic Principle of ANOVA - ANOVA Technique - Setting up Analysis of Variance Table - Short-cut Method for One-way ANOVA - Coding Method - Two-way ANOVA - ANOVA in Latin-Square Design - Analysis of Co-variance (ANOCOVA) - ANOCOVA Technique - Assumptions in ANOCOVA. **Multivariate Analysis Techniques:** Classification of Multivariate techniques - Variables in multivariate analysis, important multivariate techniques - Rotation in factor analysis - R – type - Q – type factor analyses - Path analyses. **Testing of Hypotheses:** Non parametric or Distribution free test - Relationship between spear man's r's and Kendall's W - Characteristics of distribution – Free or non parametric tests. **Interpretation and Report Writing:** Technique of Interpretation - Precaution in Interpretation - Different Steps in Writing Report - Layout of the Research Report - Types of Reports - Oral Presentation- Mechanics of Writing a Research Report - Precautions for Writing Reports.

Reference Books

1. Dawson, Catherine,Practical Research Methods,New Delhi, UBS Publishers'Distributors 2002
2. Kothari, C.R.,2014, Second Edition, Research Methodology- Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for beginners,(2nd.ed.),Singapore, Pearson Education
4. Khan Zode V.V., "**Research Methodology and Trends**", APH Publishing corporation 2007.
5. Best J.W., "**Research in Education**", Prentice Hall Inc, Newyork, USA, 2005.
6. William G. Zikmand, "**Business Research Method**", Dryden, 2003
7. Panneerselvam R, "**Research Methodology**", Prentice Hall of India,2012

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1	**Introduction to Research Methodology**	
1.1	Objectives of Research; Motivation in Research	1
1.2	Types of Research	
1.3	Research Approaches	1
1.4	Significance of Research	1
1.5	Research Methods versus Methodology	1
1.6	Research Process	1
1.7	Criteria of Good Research	
2	**Defining the Research Problem**	
2.1	Selecting the Problem	2

S.No	Topics	No. of Lectures
2.2	Necessity of Defining the Problem	2
2.3	Technique Involved in Defining a Problem	1
3	**Research Design**	
3.1	Need for Research Design	1
3.2	Features of a Good Design	
3.3	Important Concepts Relating to Research Design	1
3.4	Different Research Designs	1
3.5	Basic Principles of Experimental Designs	1
4	**Sampling Design**	
4.1	Implications of a Sample Design	1
4.2	Steps in Sampling Design	
4.3	Criteria for Selecting a Sampling Procedure	1
4.4	Characteristics of Good Sample Design	
4.5	Different types of Sample Designs	1
4.6	Random Sample from an Indicate Universe	1
4.7	Complex Random Sampling Designs	2
4.8	Standard error	
5	**Measurement and Scaling Techniques**	
5.1	Measurement Scales	1
5.2	Sources of Error in Measurement	
5.3	Tests of Sound Measurement	1
5.4	Technique of Developing Measurement Tools	1
5.5	Scaling	1
5.6	Meaning of Scaling	
5.7	Scale Classification Bases	
5.8	Important Scaling Techniques	1
6	**Processing and Analysis of Data**	
6.1	Processing Operations	1
6.2	Elements/Types of Analysis	
6.3	Statistics in Research	
6.4	Measures of Central Tendency	1
6.5	Measures of Dispersion	
6.6	Measures of Asymmetry (Skewness)	
6.7	Measures of Relationship	1
6.8	Simple Regression Analysis	1
6.9	Multiple Correlation and Regression Partial Correlation	1
6.10	Association in Case of Attributes	1
7	**Analysis of Variance and Covariance**	
7.1	Analysis of Variance (ANOVA)	1
7.2	The Basic Principle of ANOVA	
7.3	ANOVA Technique	2
7.4	Setting up Analysis of Variance Table	
7.5	Short-cut Method for One-way ANOVA	
7.6	Coding Method	
7.7	Two-way ANOVA	1
7.8	ANOVA in Latin-Square Design	
7.9	Analysis of Co-variance (ANOCOVA)	2
7.10	ANOCOVA Technique	
7.11	Assumptions in ANOCOVA.	
8	**Multivariate Analysis Techniques**	

S.No	Topics	No. of Lectures
8.1	Classification of Multivariate techniques	1
8.2	Variables in multivariate analysis	
8.3	important multivariate techniques	1
8.4	Rotation in factor analysis	1
8.5	R – type - Q – type factor analyses	1
8.6	Path analyses	1
9	**Testing of Hypotheses**	
9.1	Non parametric or Distribution free test	1
9.2	Relationship between spear man's r's and Kendall's W - Characteristics of distribution	2
9.3	Free or non parametric tests	1
10	**Interpretation and Report Writing**	
10.1	Technique of Interpretation	1
10.2	Precaution in Interpretation	
10.3	Different Steps in Writing Report	1
10.4	Layout of the Research Report	1
10.5	Types of Reports	1
10.6	Oral Presentation	1
10.7	Mechanics of Writing a Research Report	1
10.8	Precautions for Writing Reports	
	Total	**52**

Course Designers:

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14MGPC0 TOTAL QUALITY MANAGEMENT

Category	L	T	P	Credit
PE	4	0	0	4

Preamble:

Quality is the mantra for success or even for the survival of any organization in this competitive global market. Total Quality Management (TQM) is an enhancement to the traditional way of doing business. It is a proven technique to guarantee survival in world-class competition. It integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach. At the end of the course the students are expected to recognize the quality issues in an organization and analyze the ways to solve those using TQM techniques, and demonstrate skills in using modern TQM tools and software to analyze problems.

Prerequisite

Probability and Statistics

Quality Engineering

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	Describe the principles of TQM	Understand	80	70
CO2	Describe the concepts of Statistical process control	Understand	80	70
CO3	Relate the tools and techniques of TQM in an organization	Apply	70	60
CO4	Show the need for Quality systems of international standards	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	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	Test 1	Test 2	Test 3	End Semester examination
1	Remember	20	20	20	20
2	Understand	30	30	30	30
3	Apply	50	50	50	50

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define TQM.
2. What is the need for quality planning?
3. What is a customer?
4. What are 5S?
5. List any four concepts under KAIZEN umbrella.
6. What is a 'defect' and 'defective'?

Course Outcome 2 (CO2):

1. Discuss in detail the role of senior management.
2. How can you retail your customer in the organization's business?
3. Explain about Juran's Trilogy.
4. Differentiate between specification limit and control limit.
5. How will you calculate process capability ratio?
6. Explain the six basic steps in bench marking process.

Course Outcome 3 (CO3):

1. In plastic moulding process, the results of the inspection of 10 lots of 125 items each are given in the following table.

Lot No.	1	2	3	4	5	6	7	8	9	10
No. of defectives	4	8	9	2	12	6	7	5	4	7

(i) Compute trial control limits
(ii) Plot the appropriate chart
(iii) Draw the conclusion

2. The following observations are made in a crankshaft machining process.

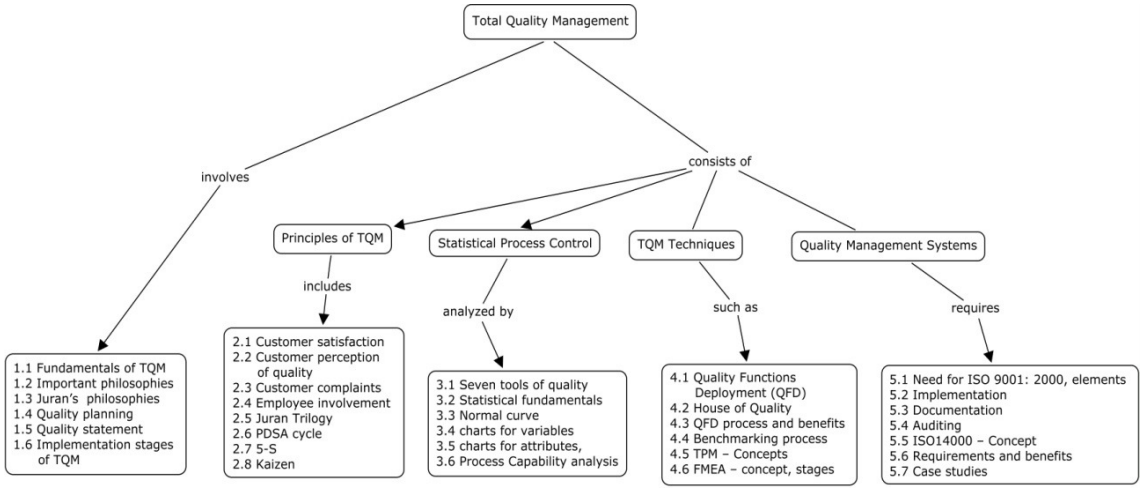
Sample No.	Observations			
	1	2	3	4
1	20.21	20.19	20.25	20.15
2	20.24	20.19	20.23	20.17
3	20.17	20.16	20.20	20.18
4	20.10	20.14	20.18	20.09
5	20.04	20.03	20.05	19.97
6	20.04	19.97	19.99	20.01
7	20.09	20.05	20.00	20.03
8	19.99	19.98	20.01	19.97

(i) Compute the trial control limits for X and R charts.
(ii) Construct and R chart
(iii) Comment of the process.
(iv) Calculate the process capability
(v) Compute percent defective if any

Course Outcome 4 (CO4):

1. The piston for a petrol engine is made in lots of 150 each. The lots are subjected to 100% inspection. 25 such lots are inspected and the number of defectives found was 125.
    a. Compute the control limits for a *p* charts.
    b. Compute the control limits for the *np* chart
2. Build the house of quality matrix to show the inter relationship between the customer requirements and technical descriptors for a manufacturing system.
3. Discuss the mandatory items of ISO 14000.
4. Explain the steps to be followed in implementing quality system ISO 9000:2000.

Concept Map



Syllabus

Introduction: Fundamentals of TQM – Historical developments – important philosophies- (Deming, Juran, Crossby) and their impact of quality – Quality planning, Quality statement – TQM implementation stages **Principles of TQM:** Customer satisfaction – customer perception of quality, customer complaints, Employee involvement – Juran Trilogy, PDSA cycle, 5S, Kaizen. **Process Monitoring:** Seven tools of quality, statistical fundamentals – Normal curve charts for variables and attributes, Process Capability analysis. **TQM Techniques:** Quality Functions Deployment (QFD) – house of Quality, QFD process and benefits, Benchmarking process, TPM – Concepts, FMEA – concept, stages. **Quality Management Systems:** Need for ISO 9001: 2008 – Elements, Implementation, Documentation and Auditing. ISO14000 – Concept requirements and benefits – Case studies.

Reference Books

1. Shridhara Bhat, "**TQM – Text and Cases**", Himalaya publishing House, 2010
2. Berk, Joseph and Berk, S., "**The Essence of TQM**", Prentice Hall of India, 1998.
3. Narayana and Sreenivasan, "**Quality Management – Concepts and Tasks**", New Age International, 2007
4. Sharma, D.D, "**Total Quality Management**", Sultan Chand & Sons, 2005.
5. Dale H.Besterfiled, Carol Besterfiled-Michna. Glen H. Beseterfiled and Mary Besterfield-Sacre., "**Total Quality Management**", Pearson Education Asia, 2013.

Course Contents and lecture Schedule

Module Number	Topics	No. of Lectures
1	**Introduction**	
1.1	Fundamentals of TQM – Historical developments	2
1.2	Important philosophies - (Deming, Crossby) & their impact of quality	2
1.3	Juran's philosophies and its impact of quality	2
1.4	Quality planning,	1
1.5	Quality statement	1
1.6	TQM implementation Stages	2
2	**Principles of TQM**	
2.1	Customer satisfaction	1
2.2	Customer perception of quality	1
2.3	Customer complaints	2
2.4	Employee involvement	1
2.5	Juran Trilogy	2
2.6	PDSA cycle	1
2.7	5S	1
2.8	Kaizen	1
3	**Process Monitoring**	
3.1	Seven tools of quality	2
3.2	Statistical fundamentals	1
3.3	Normal curve	1
3.4	Charts for variables	2
3.5	Charts for attributes	2
3.6	Process Capability analysis	2
4	**TQM Techniques**	
4.1	Quality Functions Deployment (QFD)	2
4.2	House of Quality	1
4.3	QFD process and benefits	1
4.4	Benchmarking process	2
4.5	TPM – Concepts	1
4.6	FMEA – concept, stages	2
5	**Quality Management Systems**	
5.1	Need for ISO 9001: 2008, Elements	1
5.2	Implementation	1
5.3	Documentation	1
5.4	Auditing	1
5.5	ISO14000 Concept	1
5.6	Requirements and benefits	1
5.7	Case studies	2
	Total	**47**

Course Designers

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14MGPD0	MAINTENANCE ENGINEERING AND MANAGEMENT	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

To impart knowledge in the fields of Maintenance engineering, reliability, maintainability, and maintenance budgeting

Prerequisite

Knowledge on mathematical distributions

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 principles of various types of Maintenance plans	Understand	80	70
CO2	Compute the system Reliability of different system configuration	Apply	70	60
CO3	Demonsrate suitable replacement interval of the system with an objective of optimum total cost	Apply	70	60
CO4	Explain the maintenance of job schedule using different techniques	Understand	80	70
CO5	Explain the principle of Total Productive Maintenance and its implementation	Understand	80	70
CO6	Describe the maintenance budget with various cost involved	Understand	80	70
CO7	Explain the process of Maintenance performance evaluation	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	S	M	L	L							
CO3	S	M	L	L							
CO4	M	L									
CO5	M	L									
CO6	M	L									
CO7	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	60	60	60	60
Apply	20	20	20	20
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 between break down maintenance and Preventive maintenance.
2. Explain different types of maintenance systems.

Course Outcome 2 (CO2):

1. An optical sensor has follow 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?
2. 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?
3. 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.

Course Outcome 3 (CO3):

1. A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000 are as given below:

Year	1	2	3	4	5	6
Maintenance Cost (Rs.)	1000	1200	1400	1800	2300	2800
Resale value	3000	1500	750	375	200	200

   Determine at what age is replacement due?
2. A manufacturer is offered two machines A and B. A is priced at Rs.5000 and running costs are estimated at Rs.800 for each of the first five years, increasing by Rs.200 per year in the sixth and subsequent years. Machine B, which has the same capacity as A, costs Rs.2500 but will have running costs of Rs.12000 per year for six years, increasing by Rs.200 per year thereafter. If money is worth 10% per year which machine should be purchased? Assume that the machines will eventually be sold for scrap at a negligible price.
3. The following failure rates have been observed for a certain type of light bulb.

End of week	1	2	3	4	5	6	7
Probability of failure	0.05	0.15	0.25	0.46	0.68	0.88	1.00

The cost of replacing an individual failed bulb is Rs.1.25. If the cost of group replacement is 80 paise per bulb, determine among individual and group replacement policies which one is better.

Course Outcome 4 (CO4):

1. Explain about planning and scheduling of maintenance
2. Illustrate the different techniques used in maintenance scheduling.

Course Outcome 5 (CO5):

1. Describe about the various components of TPM.
2. Discuss the steps in implementation of TPM.

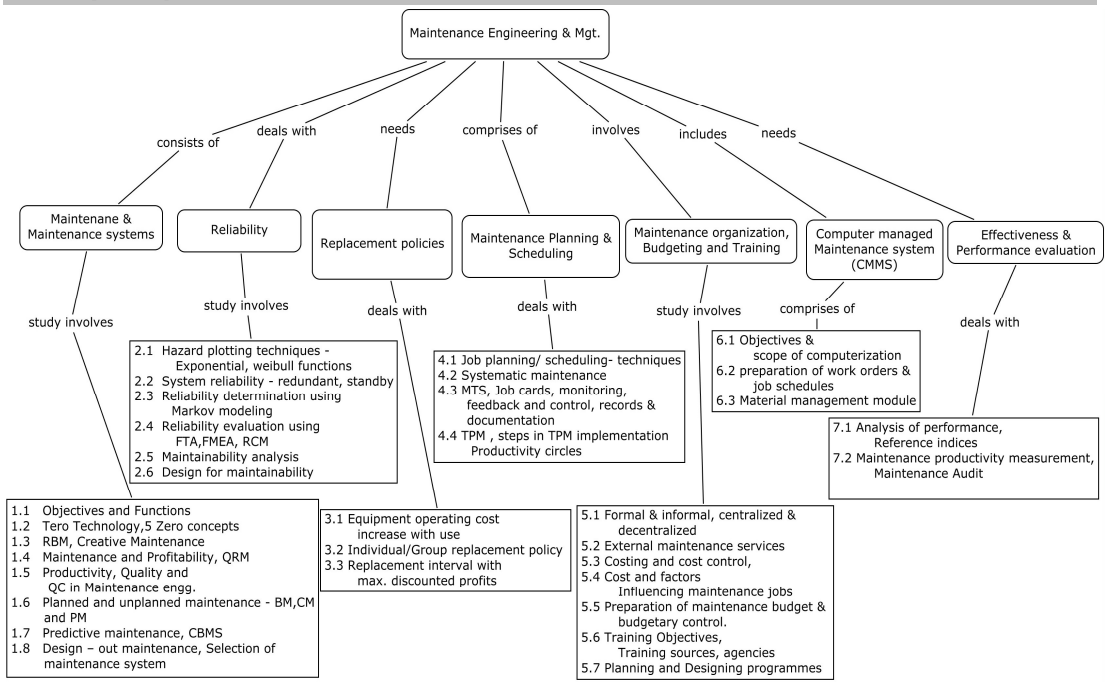
Course Outcome 6 (CO6):

1. Explain the various components of maintenance costs.
2. Describe about the preparation of Maintenance budget and its uses.

Course Outcome 7 (CO7):

1. Explain about the maintenance performance indices and its usage.
2. Discuss about the outcomes of maintenance audit.

Concept Map



Syllabus

Maintenance: Objectives and Functions, Concepts and Nature of Maintenance, Tero Technology, 5 Zero concepts, Reliability Based Maintenance (RBM), Creative Maintenance. Maintenance and Profitability – Quality, Reliability and Maintainability (QRM) – Productivity, Quality and quality circle in Maintenance Engineering. Maintenance systems: Planned and unplanned maintenance. Break down maintenance,

Corrective maintenance, Preventive maintenance, Predictive maintenance, Condition Based Maintenance Systems (CBMS), Design – out maintenance, Selection of maintenance system.

Reliability: Basic concepts – hazard plotting techniques, Exponential and Weibull reliability functions- Maximum likelihood estimation techniques – System reliability – redundancy – simple standby system – r out n configuration – reliability determination using Markov modeling – reliability evaluation using fault tree analysis, FMEA, RCM, Maintainability analysis, Design for maintainability.

Replacement Policies - Basic concepts – optimal replacement policy for equipment whose operating cost increase with use – optimal replacement of items subject to failure – individual/Group replacement policy – optimal replacement interval for capital equipment with maximization of discounted profits.

Maintenance Planning and Scheduling: Job planning – job scheduling – scheduling techniques – short term planning, Long term planning – Systematic maintenance – codification and cataloging, Manuals. Maintenance Time Standard (MTS), Job cards, Job execution, monitoring, feedback and control, Maintenance records and documentation. Total Productive Maintenance (TPM) – Basic systems, steps in TPM implementation - Productivity circles.

Maintenance organization: Formal and informal – centralized and decentralized – external maintenance services – captive shop facilities – working arrangements. Maintenance Budgeting: Costing and cost control – Behavior of maintenance costs – Types and components of maintenance costs. Cost and factors Influencing maintenance jobs. Budget and Budgeting of maintenance cost. Cost control – preparation of maintenance budget and budgetary control.

Training for maintenance personnel: Objectives, modes of training/development. Training sources, agencies, institutions - Planning and Designing programmes, Evaluation, Benefits.

Computer Managed Maintenance System (CMMS): Objectives, Approach towards computerization – scope of computerization – Equipment classification – codification for break downs – preparation of work orders and job schedules – follow up and documentation – material management module.

Maintenance Effectiveness and performance evaluation: Analysis of maintenance performance. Reference indices, Maintenance productivity measurement - Performance measuring parameters - Maintenance Audit.

Reference Books

1. Sushil Kumar Srivastava, “Industrial Maintenance Management”, S. Chand & Company Ltd., 2007
2. Anteny Kelly, “Strategic Maintenance planning”, Butterworth-Heinemann, 2006.
3. Gopalakrishnan, P. Banerji, A.K, “Maintenance and Spare Parts Management”, PHI, Learning Pvt. Ltd, New Delhi, 2013
4. A.K.S.Jardine and A.H.C. Tsang, “Maintenance, replacement, and reliability: theory and applications”, CRC/Taylor & Francis, 2006.
5. L.S.Srinath, “Reliability Engineering”, 4th Edition, Affiliated East West Press. New Delhi 2005.
6. C. Balagurusamy, “Reliability Engineering”, Tata McGraw Hill Pvt. Ltd. 2003.

7. A.K. Gupta, “Reliability & Tero Technology”, Macmillan India Ltd., 2004.

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1.0	Maintenance	
1.1	Objectives and Functions, Concepts and Nature of Maintenance	1
1.2	Tero Technology, 5 Zero concepts	1
1.3	Reliability Based Maintenance (RBM), Creative Maintenance(CM)	1
1.4	Maintenance and Profitability – Quality, Reliability and Maintainability (QRM)	1
1.5	Productivity, Quality and quality circle (QC) in Maintenance Engineering	1
1.6	Planned and unplanned maintenance-Break down maintenance (BM), Corrective maintenance(CM), Preventive maintenance (PM)	2
1.7	Predictive maintenance, Condition Based Maintenance Systems (CBMS)	1
1.8	Design – out maintenance, Selection of maintenance system	2
2.0	Reliability	
2.1	Basic concepts – hazard plotting techniques, Exponential and Weibull reliability functions- Maximum likelihood estimation techniques	2
2.2	System reliability – redundancy – simple standby system	2
2.3	r out n configuration – reliability determination using Markov modeling	1
2.4	Reliability evaluation using fault tree analysis, FMEA, RCM	1
2.5	Maintainability analysis	1
2.6	Design for maintainability	1
3.0	Replacement Policies	
3.1	Basic concepts – optimal replacement policy for equipment whose operating cost increase with use	2
3.2	Optimal replacement of items subject to failure – individual/Group replacement policy – optimal replacement interval for capital equipment with maximization of discounted profits	2
4.0	Maintenance Planning and Scheduling	
4.1	Job planning – job scheduling – scheduling techniques – short term planning, Long term planning	1
4.2	Systematic maintenance – codification and cataloging, Manuals.	1
4.3	Maintenance Time Standard (MTS), Job cards, Job execution,	2

Module Number	Topics	No. of Lectures
	monitoring, feedback and control, Maintenance records and documentation.	
4.4	Total Productive Maintenance (TPM) – Basic systems, steps in TPM implementation – Productivity circles	2
5.0	Maintenance organization	
5.1	Formal and informal – centralized and decentralized	1
5.2	External maintenance services – captive shop facilities – working arrangements.	1
	Maintenance Budgeting:	
5.3	Costing and cost control – Behavior of maintenance costs – Types and components of maintenance costs. budget and budgetary control	2
5.4	Cost and factors Influencing maintenance jobs	1
5.5	Budget and Budgeting of maintenance cost. Cost control – preparation of maintenance budget and budgetary control	2
	Training for maintenance personnel	
5.6	Objectives, modes of training/development. Training sources, agencies, institutions	2
5.7	Planning and Designing programmes, Evaluation, Benefits	2
6.0	Computer Managed Maintenance System (CMMS)	
6.1	Objectives, Approach towards computerization – scope of computerization	1
6.2	Equipment classification – codification for break downs – preparation of work orders and job schedules – follow up and documentation	1
6.3	Material management module	1
7.0	Maintenance Effectiveness and performance evaluation	
7.1	Analysis of maintenance performance. Reference indices	2
7.2	Maintenance productivity measurement - Performance measuring parameters - Maintenance Audit	2
	Total	46

Course Designers:

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14MGPE0	MACHINE VISION AND ITS APPLICATION IN MANUFACTURING	Category	L	T	P	Credit
		PE	4	0	0	4

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

Laplace Transforms

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 components of a machine vision system	Understand	80	70
CO2	Use appropriate camera, lens and lighting system for a machine vision system	Apply	70	60
CO3	Apply image preprocessing, post processing algorithms like segmentation to solve Application and case studies	Apply	70	60

Mapping with Programme Outcomes

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

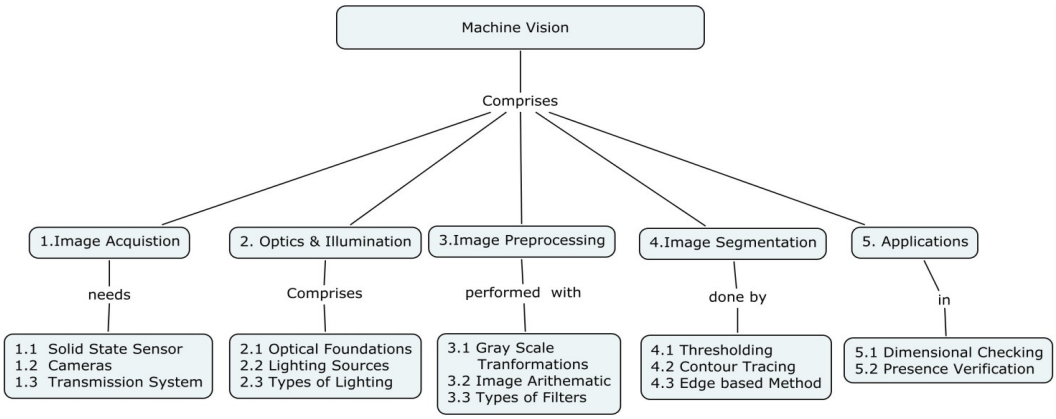
Course Outcome 2 (CO2):

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. **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, Fourier Transform Applications. **Image Segmentation** Threshold Determination from Histogram, Gray Level Histogram, Generalizations of Thresholding Contour Tracing: Pixel Correctedness, Generating Object Contours, Contour representation Edge based Methods: Edge probing and Edge Detection Template matching: Basic Operation, Optimizing and Comments on Template Matching. **Applications:** Dimensional Checking: Simple gauging, Shape Checking, Angle Gauging, High accuracy Gauging, Calibration. Presence Verification: Simple Presence verification, Simple Gauging for assembly verification, Glue Check under UV Light, Pin type Verification Alignment Checking.

Reference Books

1. C. Demant, B.Streicher Abel, P.Waszkewitz “Industrial Image Processing and Visual Quality control in manufacturing”. Springer, 1999.
2. Alexander Hornberg, “Handbook of Machine Vision”, Wiley VCH, 2006
3. Gerald C. Holst, “CCD Arrays Cameras and Displays” Second Edition, SPIE Optical Engineering Press, 1998.
4. K.S.Fu,R.C.Gonzalez,C.S.G.Lee “Robotics Control, Sensing, Vision and Intelligence.” Tata McgrawHill, 2008

5. Rafel C.Gonzalez, Richard E.Woods, “Digital Image Processing.” Third Edition, Prentice Hall India, 2007.
6. Nello Zeuch, “Understanding and Applying Machine Vision, Second Edition, Revised and Expanded (Manufacturing Engineering and Materials Processing)” Marcel Dekker Inc., 2000
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
1.1.3	CMOS Sensors Operation and its advantages	1
1.2	Standard Video Cameras:	
1.2.1	Basic Structure, Sampling of Line Signal	1
1.2.2	Extension of Video Standards, Image Quality	1
1.2.3	Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras and its Properties	2
1.3	Transmission to Computer:	
1.3.1	Basic operation of Frame Grabber	1
1.3.2	Direct Digital transmission	1
1.3.3	USB, IEEE1394, Firewire, Gigabit Ethernet, Choosing Computer Bus	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	2
2.1.3	Lens Selection, Special Optical devices	1
2.2	Lighting Sources	2
2.2.1	Incandescent Lamps, Metal Vapour Lamps Xenon Lamps, Fluorescent, LED, Laser.	2
2.2.2	Types of Light Filters – UV Filter, Day Light Filter, IR Filter Gray Filter, Polarization Filter, Color Filter and Combination.	2
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**	

Module Number	Topics	No. of Lectures
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.	2
3.1.4	Types of Filters: Linear Filters, Median Filter	1
3.1.5	Morphological and Non Linear Filters	1
3.1.6	Fourier Transform Applications	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.	2
5	**Applications**	
5.1	Dimensional Checking:	
5.1.1	Simple gauging, Shape Checking	1
5.1.2	Angle Gauging, High accuracy Gauging	1
5.1.3	Calibration	1
5.2	Presence Verification:	
5.2.1	Simple Presence verification, Simple Gauging for assembly verification	2
5.2.2	Glue Check under UV Light	
5.2.3	Pin Type Verification	2
5.2.4	Alignment Checking	
	Total	48

Course Designers:

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14MGPF0 SYSTEM SIMULATION

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

System Simulation is the imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviours of a selected physical or abstract system. Simulation is used in many contexts, such as simulation of technology for performance optimization, safety engineering, testing, training, education, and video games. Training simulators include flight simulators for training aircraft pilots in order to provide them with a lifelike experience. Simulation is also used for scientific modeling of natural systems or human systems in order to gain insight into their functioning. Simulation can be used to show the eventual real effects of alternative conditions and courses of action.

Prerequisite

- 14MG220 Tool Design Engineering
- 14MG150 CNC Machine Tool Technology

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 concepts, types and applications of simulation, steps in simulation study	Understand	80	70
CO2	Explain how computer simulation can be used to model complex systems	Understand	80	70
CO3	Solve related decision problems	Apply	70	60
CO4	Apply the statistical methods used in simulation analysis	Apply	70	60
CO5	Discuss the techniques of random number generator and testing of random numbers	Understand	80	70
CO6	Choose suitable generator for a given application	Apply	70	60
CO7	Design a computer simulation and conduct input modeling validation, output analysis	Apply	70	60
CO8	Compare simulation packages with programming language	Analyse	60	50

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	S	M	L	L							
CO4	S	M	L	L							
CO5	M	L									
CO6.	S	M	L	L							
CO7.	S	M	L	L							
CO8.	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	20	20	20	20
Apply	60	60	50	50
Analyse	0	0	10	10
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Endogenous and Exogenous events.
2. List the tests that are used to validate the properties of random numbers.
3. What are the parameters for the following distributions?
   a) Gamma distribution b) Normal distribution

Course Outcome 2 (CO2):

1. Describe and explain the properties of linear models.
2. What are the steps in the development of a model of input data? Explain.
3. Mention the factors that are to be considered in selecting a simulation Language.

Course Outcome 3 (CO3):

1. A new bus route is to be added to a city, and the traffic manager is to determine how many extra buses will be needed. What are the three key attributes of the passengers and buses that he should consider? If the company manager wants to asses the effect of the new route on the transit system as a whole, how would you suggest he aggregate the features of the new line to form part of a total system model? Would you suggest a continuous or discrete model for the traffic manager and the general manager?

2. The sequence of numbers 0.37, 0.59, 0.88, 0.48 and 0.21 has been generated. Use the Kolmogorov-Smirnov test with $\alpha = 0.05$ to determine if the hypothesis that the numbers are uniformly distributed on the interval (0,1) can be rejected.

Course Outcome 4 (CO4):

1. Draw a flow chart which represents the various steps involved in the simulation Process
2. Develop an Acceptance-Rejection technique for generating a Poisson random variable with mean $\alpha = 0.2$

Course Outcome 5 (CO5):

1. A robot is used to install the doors on automobiles along an assembly line. It was thought that the installation times followed a normal distribution. The robot is capable of accurately measuring installation times. A sample of 20 installation times was automatically taken by the robot with the following results, where the values are in seconds.

99.79	99.56	100.17	100.33
100.26	100.41	99.98	99.83
100.23	100.27	100.02	100.47
99.55	99.62	99.65	99.82
9.96	99.90	100.06	99.85

Determine the estimators for normal distribution.

2. Records pertaining to the monthly number of job related injuries at an underground coal mine were being studied by a federal agency The values for the past 100 months are as follows.

Injuries per month	0	1	2	3	4	5	6
Frequency of occurrence	35	40	13	6	4	1	1

Apply the Chi-square test to these data to test the hypothesis that the underlying distribution is Poisson. Use a level of significance of $\alpha = 0.05$

Course Outcome 6 (CO6):

1. Develop a random variate generator for exponential distribution.
2. Mention the factors that are to be considered in selecting a simulation language for a particular application.
3. Considering an Engineering educational system, identify the entities, attributes and activities of the system.

Course Outcome 7 (CO7):

1. The following data are randomly generated from a gamma Distribution

7.036	5.224	3.917	6.513
4.599	7.563	7.172	5.132
5.259	2.759	4.278	2.696

6.212	2.407	1.857	5.002
4.612	2.003	6.908	3.326

Determine the maximum likelihood estimators of the gamma distribution?

2.The following data represent the time to perform transactions in a bank, measured in minutes. 0.74, 1.28, 1.46, 2.36, 0.35, 0.78, 0.91, 4.44, 0.14, 3.08, 3.24, 1.10, 1.59, 1.47, 1.17, 1.27, 9.12, 11.5, 2.42, 1.77. Develop an input model for this data.

Course Outcome 8 (CO8)**:**

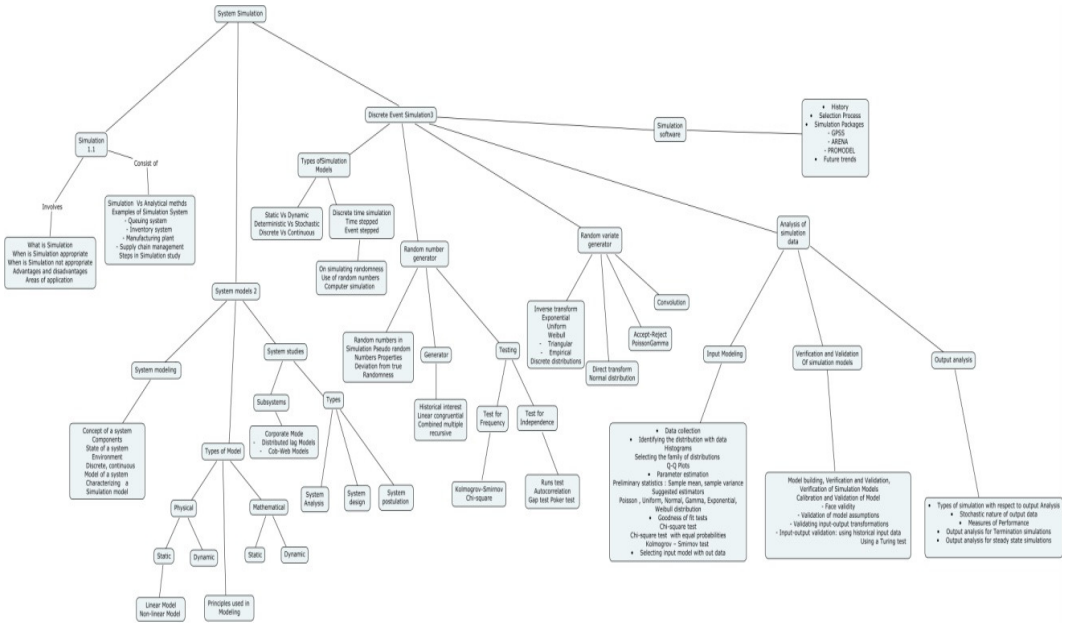
1. The following data are randomly generated from a gamma Distribution

7.036	5.224	3.917	6.513
4.599	7.563	7.172	5.132
5.259	2.759	4.278	2.696
6.212	2.407	1.857	5.002
4.612	2.003	6.908	3.326

2. Determine the maximum likelihood estimators of the gamma distribution?
    a. 19.The following data represent the time to perform transactions in a bank, measured in minutes. 0.74, 1.28, 1.46, 2.36, 0.35, 0.78, 0.91, 4.44, 0.14, 3.08, 3.24, 1.10, 1.59, 1.47, 1.17, 1.27, 9.12, 11.5, 2.42, 1.77. Develop an input model for this data.

3. Course Outcome 9 (CO9)**:**
    a. 20. Give GPSS block diagrams and write program. Parts are being made at the rate of one every 6 minutes. They are of two types, A and B, and are mixed randomly, with about 10% being type B. A separate inspector is assigned to examine each type of part. The inspection of A parts takes 4 ±2 minutes and B parts take 20 ± 10 minutes. Both inspectors reject about 10% of the parts they inspect. Simulate for a total of 1000 type A parts accepted.
    b. 21. A tool crib has exponential inter-arrival and service times and serves a very large group of mechanics. The mean time between arrivals is 4 minutes. It takes 3 minutes on the average for a tool crib attendant to serve a mechanic. The attendant is paid Rs. 40 per hour and the mechanic is paid Rs. 60 per hour. Would it be advisable to have a second tool crib attendant?

Concept Map



Syllabus

System simulation:

Simulation – Nature of simulation, Systems, Models and Simulation- Advantages and disadvantages, Areas of application – Simulation Vs Analytical methods- Monte Carlo simulation- Statistical models in simulation – discrete and continuous distributions - Examples of simulation systems – Queuing, Inventory, manufacturing plant – Steps in simulation study.

System Models –Concept of a system, Components, State of a system, System environment, Discrete and continuous systems- Model of a system – Characterizing a simulation model –**Types of model** – Physical, Mathematical –Static, Dynamic –Linear and Non-linear models – Principles used in Modeling – **System studies** – Sub-systems, Corporate Model – Distributed lag model, Cobweb Model –System analysis, system Design , System Postulation

Discrete Event Simulation –Types of Simulation Models – Discrete time simulation – Time stepped, Event stepped – Use of Random numbers – Computer simulation

Random number – Properties– Generator – Linear Congruential method, combined multiple recursive method – Tests for Frequency –Tests for independence

Random Variate generator – Inverse transform technique –Exponential, uniform, Weibull, Triangular distributions, Direct transform for normal distribution - Acceptance-Rejection technique - convolution method.

Input Modeling – Data collection, Selecting the family of distributions, Parameter estimation –Sample mean, sample variance, suggested estimators – Poisson, Uniform, Normal, Gamma, and Weibull distributions - Goodness of Fit Tests– Chisquare, Kolmogorov-Smirnov tests - Selecting input Model without data.

Verification and Validation – Model building, Verification of Simulation Models - Calibration and Validation of Models – Validation of existing systems, validation of hypothetical systems –Face validity, model assumptions, input-output transformations - Historical data, Turing test.

Output Analysis – Stochastic nature of output data – Checking for normality – Shapiro–Wilk Test, q-q plot - Types of simulation with respect to output Analysis, Stochastic

nature of output data, Measure of Performance, Output Analysis for Termination Simulations, Output Analysis for steady -state simulations.

Simulation package – History, Comparison of simulation packages with programming languages, Selection Process, Simulation Packages (GPSS, ARENA, PROMODEL)*- Simulation of queuing systems, Inventory systems and Manufacturing systems.

Reference Books

1. Jerry Banks, John S. Carson, Barry L. Nelson, David M. Nicol P. Shahabudeen " **Discrete – Event System Simulation**" Pearson Edition, 2011
2. Geoffrey Gordon, "**System Simulation"** Second Edition, PHI Learning Pvt. Ltd, New Delhi, 2009
3. Averill M Law, "**Simulation Modeling and Analysis**" Fourth edition, Tata McGraw-Hill Publishing company Limited, New Delhi, 2008.
4. Narsingh Deo, "**System Simulation with Digital Computer**", Second Edition, PHI Learning Pvt. Ltd., New Delhi, 2009

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1	Simulation	
1.1	Nature of Simulation, Systems, Models, and Simulation, When is simulation appropriate, not appropriate, Advantages and disadvantages, Areas of application, Simulation Vs analytical methods,	2
1.2	Monte-Carlo simulation-Examples of Simulation systems – Queuing System, Inventory System, Manufacturing Plant	2
1.3	Steps in Simulation study	1
2	System Models	
2.1.1	Concept of a System ,Components, State of a System, System Environment, Discrete and Continuous systems	1
2.1.2	Model of a system	1
2.1 3	Characterizing a simulation model	1
2.2.1	Types of Model –Physical, Mathematical – static, dynamic, linear and nonlinear	2
2.2.1	Principles used in modeling	1
2.3.1	System studies – Subsystems, Corporate Model, Distributed Lag Model, Cobweb Model	2
2.3.2	System Analysis, System Design, System Postulation	1
3	Discrete event Simulation	
3.1.1	Types of Simulation Models – Static Vs Dynamic, Deterministic Vs Stochastic, Discrete Vs Continuous	1
3.1.2	Discrete time Simulation – Time stepped, Event stepped	1
3.1.2.1	Use of Random numbers, Computer Simulation	1
3.2.1	Random number – Properties - generator	1

Module Number	Topics	No. of Lectures
3.2.2	Random number testing – Frequency. Independence	3
3.3.1	Random Variate generator – Inverse transform technique – Exponential, Uniform, Weibull, Triangular distributions	2
3.3.2	Direct transform for Normal distribution, Acceptance-Rejection technique, Convolution Method	2
3.4	Analysis of Simulation data	
3.4.1.1	Input modeling – Data collection, Selecting the family of distributions	2
3.4.1.2	Input modeling – Parameter estimation – sample mean, sample variance, suggested estimators – Poisson, Exponential, Uniform, Normal, Gamma, and weibull distributions	2
3.4.1.3	Goodness of Fit Tests – Chisquare and Kolmogorov tests	2
3.4.1.4	Selecting input model without data	1
3.4.2.1	Verification and Validation –Model building, Calibration and validation of Models –Validation of existing systems, Validation of hypothetical systems – Face validity	2
3.4.2.2	Model assumptions, Input-output transformations –Historical data, Turing Test	2
3.4.3.1	Output analysis – stochastic nature of output data – Checking for normality –Shapiro Wilk Test, q-q plot - Types of simulation with respect to output Analysis, Stochastic nature of output data, Measure of Performance, Output Analysis for Termination Simulations, Output Analysis for steady -state simulations.	4
3.5	Simulation Software	
3.5.1	History	1
3.5.2	Selection of Simulation software -example	1
3.5.3	Simulation in GPSS / ARENA / PROMODEL *– Queuing problem, Inventory Problem , Manufacturing Problem	5
	Total	47

Course Designers:

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14MGPG0	PRODUCT DESIGN AND DEVELOPMENT	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

The course aims at giving adequate exposure to design process and to solve the real time creative product design and development approach. The course also deals with various methods involved in product design and development. It also deals with patent rights, procedure sale of patent right.

Prerequisite

14MG120 : Optimisation Techniques

14MG130 : 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.	Explain the concept of product design and its applications	Understand	80	70
CO2.	Classify the product planning process based on the customer need	Understand	80	70
CO3.	Review the final specification of the product	Understand	80	70
CO4.	Identify the best concept based on concept selection process	Apply	70	60
CO5	Choose and implement the suitable product architecture	Apply	70	60
CO6	Use the successful product development strategies, product planning activities, specifications, various methods for concept selection and architecture planning	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	M	L									
CO4	S	M	L	L							
CO5	S	M	L	L							
CO6	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	20	20	20	20
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. Define product design.
2. Define the term concept scoring?
3. What is metrics?

Course Outcome 2 (CO2):

1. Distinguish between functional design and production design, with suitable examples.
2. Compare incidental interaction and fundamental interaction.
3. Draw proposed product architecture for a digital camera with chunks details.

Course Outcome 3 (CO3):

1. Convert need statement to metrics for ball pen.
2. Justify the final specification arrived from a metrics for a digital camera through QFD
3. Discuss the innovation criteria for product success in the life cycle of a product.

Course Outcome 4 (CO4):

1. Draw a schematic for a wrist watch using only functional element.
2. Evaluate concept selection methods for five automobiles you might consider for purchasing.
3. Discuss the innovation criteria for product success in the life cycle of a product.

Course Outcome 5 (CO5):

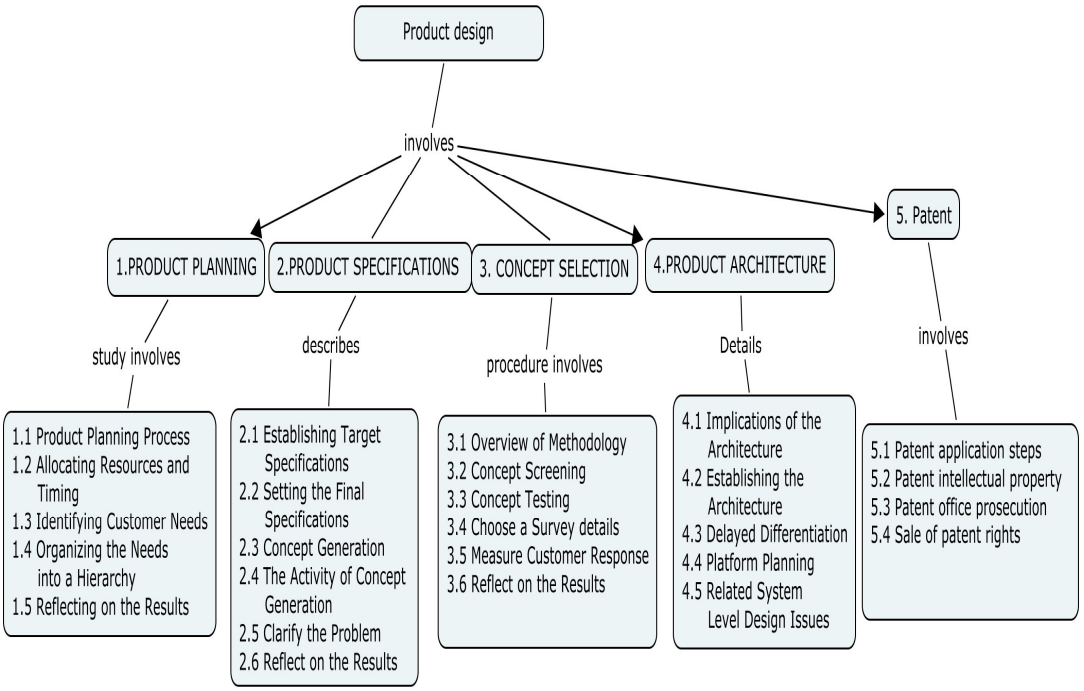
1. Draw proposed product architecture for a digital camera with chunks details.
2. What is industrial design?
3. Compare incidental interaction and fundamental interaction.

Course Outcome 6 (CO6):

1. What is pre project planning?
2. Draw the logic diagram for two claims for patterns with example.

3. Explain the procedure for applying pattern Perform concept screening for five pencil holder concept. Assume the pencil holders are for the member of product development team who is continually moving from site to site.

Concept Map



Syllabus

PRODUCT PLANNING- Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers-Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs- Case study for motor driven nailer -Reflecting on the Results and the Process -**PRODUCT SPECIFICATIONS** - Specification Establishment -Establishing Target Specifications-QFD-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation-Clarify the Problem- Search Externally-Search Internally-Explore Systematically-– Reflect on the Results and the Process - Case study for motor driven nailer **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-Reflect on the Results and the Process- Case study for motor driven nailer **PRODUCT ARCHITECTURE**- Product Architecture-Implications of the Architecture-Establishing the

Architecture-Delayed Differentiation-Platform Planning- Costing– Material – manufacturing –assembly – structure- Ergonomics and aesthetic aspects- Related System-Level Design Issues -Case study for motor driven nailer D**ESIGN PATENTS** – Patent application steps – Patent intellectual property – Patent office prosecution – Sale of patent rights.

Reference Books

1. Karl T. Ulrich and Steven D. Eppinger, "Product Design and Development", McGraw – Hill International Edns.2009.
2. Chitale and Guptha, "Product Design and manufacturing" PHI learning Pvt. Ltd, Delhi,
3. Product Design : Techniques in Reverse Engineering and New Product Development First Edition, Pearson India, 2003
4. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin, Homewood, 1992,
5. Stuart Pugh, "Tool Design – Integrated Methods for successful Product Engineering" Addison Wesley Publishing, Neyourk,NY,1991

Course Contents and Lecture Schedule

Module Number	Topics	No. of Lectures
1	**PRODUCT PLANNING**	
1.1	Product Planning Process- Identify Opportunities	1
1.1.1	Evaluating and Prioritizing Projects	1
1.2	Allocating Resources and Timing	1
1.2.1	Pre-Project Planning-Reflect on the Results and the Process	2
1.5	Identifying Customer Needs- Raw Data from Customers	2
1.6	Interpreting Raw Data in Terms of Customer Needs- Organizing the Needs into a Hierarchy	1
1.7	Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs	2
1.7.1	Case study for motor driven nailer	2
1.8	Reflecting on the Results and the Process	1
2	**PRODUCT SPECIFICATIONS**	
2.1	Specification Establishment -Establishing Target Specifications	2
2.1.1	QFD	1
2.2	Setting the Final Specifications	1
2.3	Concept Generation	1
2.4	The Activity of Concept Generation	1
2.5	Clarify the Problem- Search Externally –Search Internally Explore Systematically	1
2.5.1	Case study for motor driven nailer	2
2.6	Reflect on the Results and the Process Introduction and Classification	1
3	**CONCEPT SELECTION**	
3.1	Overview of Methodology	1

Module Number	Topics	No. of Lectures
3.2	Concept Screening	1
3.3	Concept Testing	1
3.3.1	Define the Purpose of the Concept Test	1
3.4	Choose a Survey details	1
3.4.1	Choose a Survey Format	1
3.4.2	Communicate the Concept	1
3.5	Measure Customer Response	1
3.5.1	Case study for motor driven nailer	2
3.6	Interpret the Results- Reflect on the Results and the Process	1
4	**PRODUCT ARCHITECTURE**	
4.1	Product Architecture-Implications of the Architecture	2
4.2	Establishing the Architecture	1
4.3	Delayed Differentiation	1
4.4	Platform Planning	1
4.4.1	Costing– Material – manufacturing –assembly – structure-Ergonomics and aesthetic aspects	2
4.5	Related System-Level Design Issues	1
4.5.1	Case study for motor driven nailer	2
5	**DESIGN PATENTS**	
5.1	Patent application steps	1
5.2	Patent intellectual property	1
5.3	Patent office prosecution	1
5.4	Sale of patent rights	1
	Total	47

Course Designers:

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14MGPH0	DESIGN FOR MANUFACTURE AND ASSEMBLY	Category	L	T	P	Credit
		PE	4	0	0	4

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

- Elements of Product Development
- Principles of Manufacturing Processes – Casting, Forming, Machining and Joining processes
- Assembly 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	Explain the elements and steps involved in concurrent engineering approach	Understand	80	70
CO2	Explain the importance of the Design for Manufacture and Assembly (DFMA)	Understand	80	70
CO3	Compute the tolerance requirements in the process of DFMA	Apply	70	60
CO4	Explain the of design guidelines for sand casting, die casting, machining, and sheet metal forming processes	Understand	80	70
CO5	Explain the principles and guidelines of design for assembly of components in manual, automated and robot assembly system	Understand	80	70
CO6	Apprise the redesign of component for ease of manufacturing and assembly	Analyse	60	50

- **Mapping with Programme Outcomes**

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

CO4:	M	L									
CO5:	M	L									
CO6:	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	10
Understand	40	40	40	30
Apply	40	40	30	50
Analyse	0	0	10	10
Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the elements of concurrent engineering approach with block diagram.
2. With an example, explain the step by step procedure of concurrent product development approach.
3. State the significance of concurrent engineering.

Course Outcome 2 (CO2):

1. List four advantages of implementing Design for Manufacture and Assembly.
2. With an example, explain the importance of the Design for Manufacture and Assembly (DFMA) over conventional process.

Course Outcome 3 (CO3):

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.

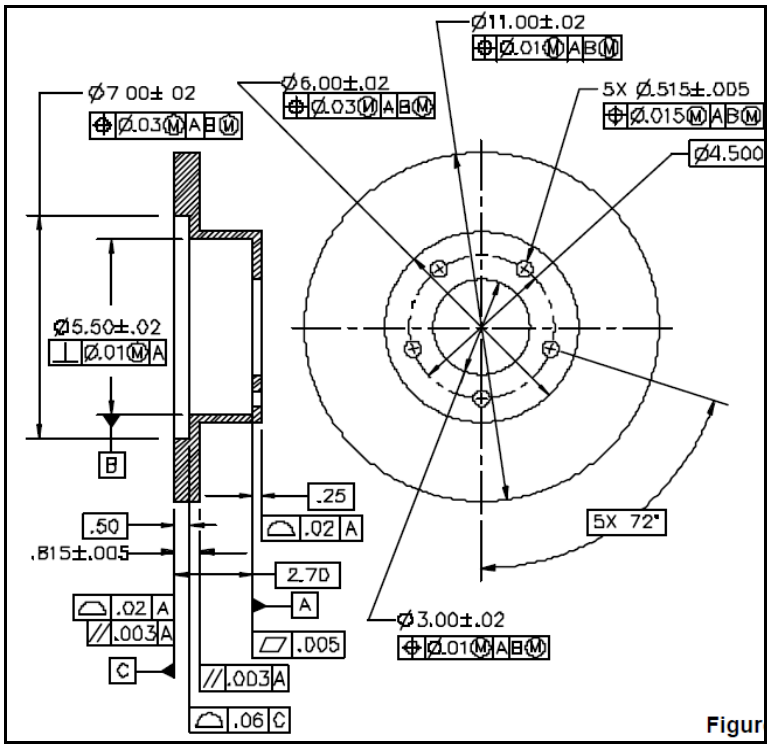
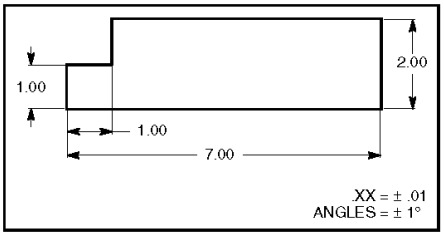
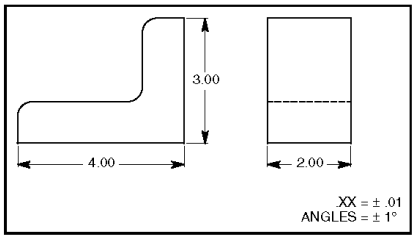


Figure 1

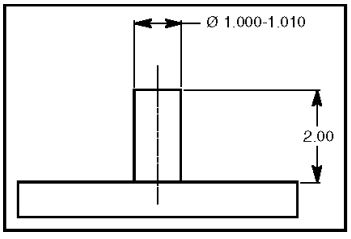
2. Specify the appropriate geometric tolerance on the drawing in Figure 2 and draw its tolerance zone for the following:
   i) to control the top surface of the part in Figure 2 (a) parallel to the bottom surface within .010.
   ii) to control the 3.000 units vertical surface of the part Figure 2 (b) 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.

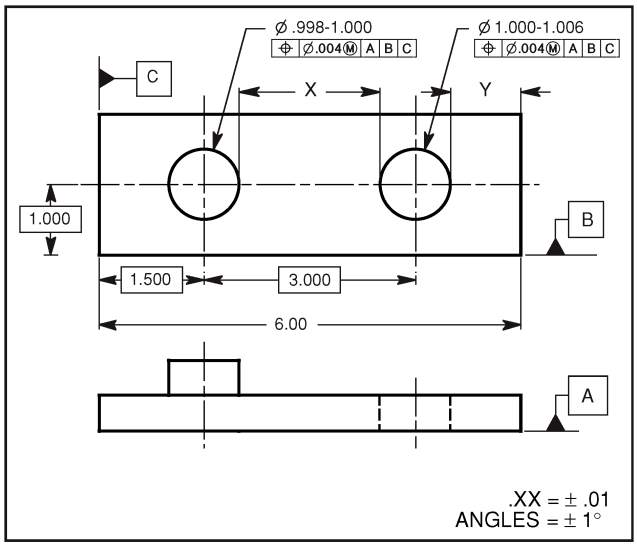


Figure 3

Course Outcome 4 (CO4):

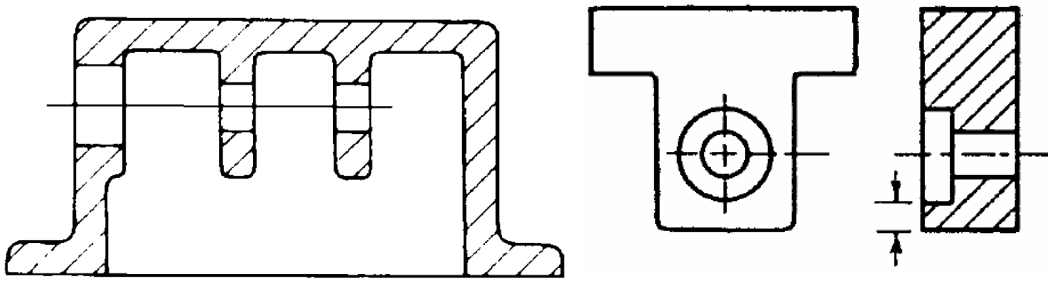
1. Explain any two guidelines for ease of sheet metal forming with examples.
2. With suitable sketches, explain the effect of chamfer design on insertion operations.
3. Prepare a check list for design guidelines of robot assembly system.

Course Outcome 5 (CO5):

1. Explain the principles and guidelines of design for assembly of components in manual assembly system
2. Prepare a check list for design guidelines of robot assembly system.
3. Explain the guidelines of design for automated assembly system with suitable examples.

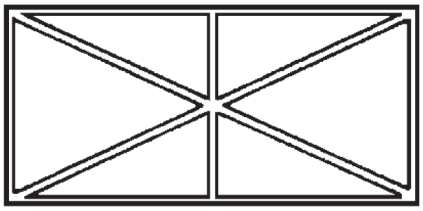
Course Outcome 6 (CO6):

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

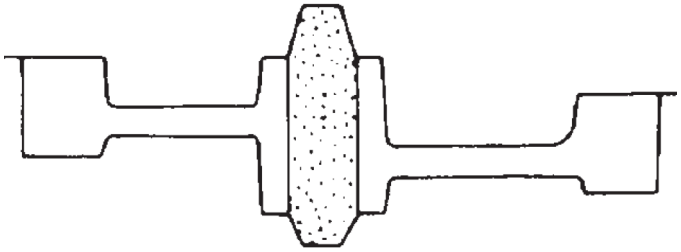


(i) (ii)

(iii)



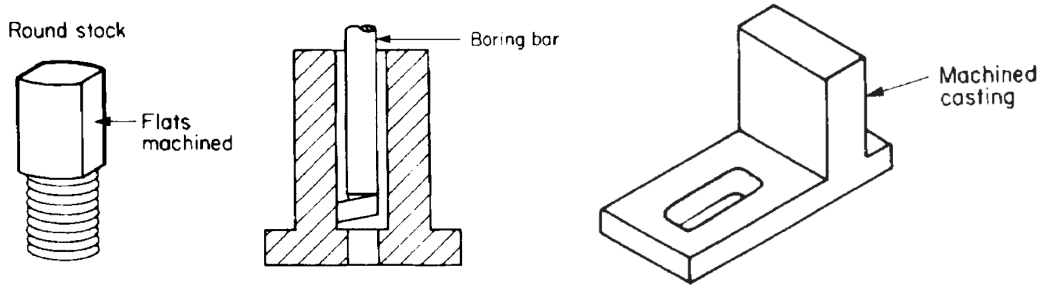
(iv)



(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.

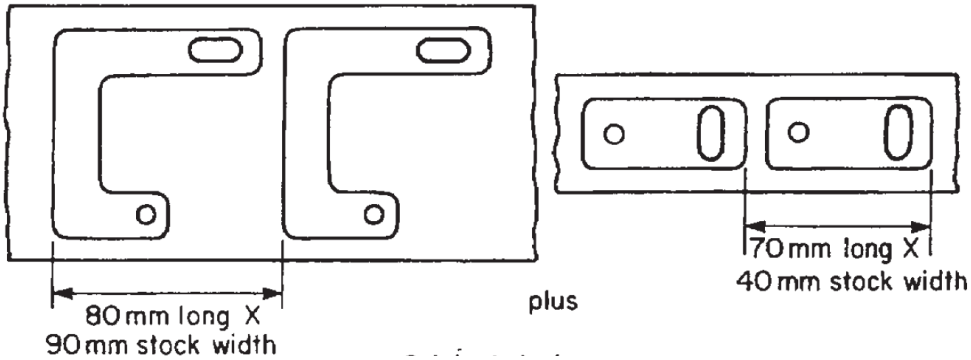


Figure 6

1. Recommend necessary modifications in part design of the following alternator assembly as shown in figure 7 and its assembly sequences in order to improve the efficiency of its automated assembly.

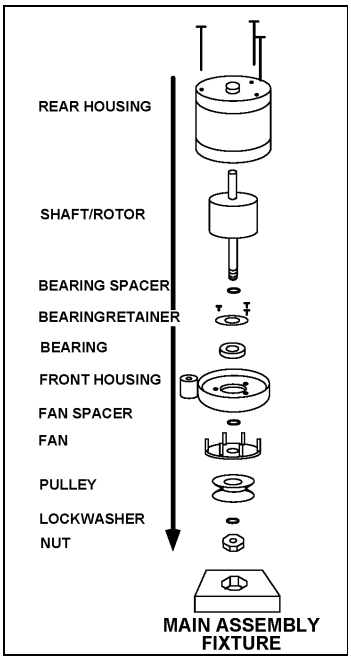
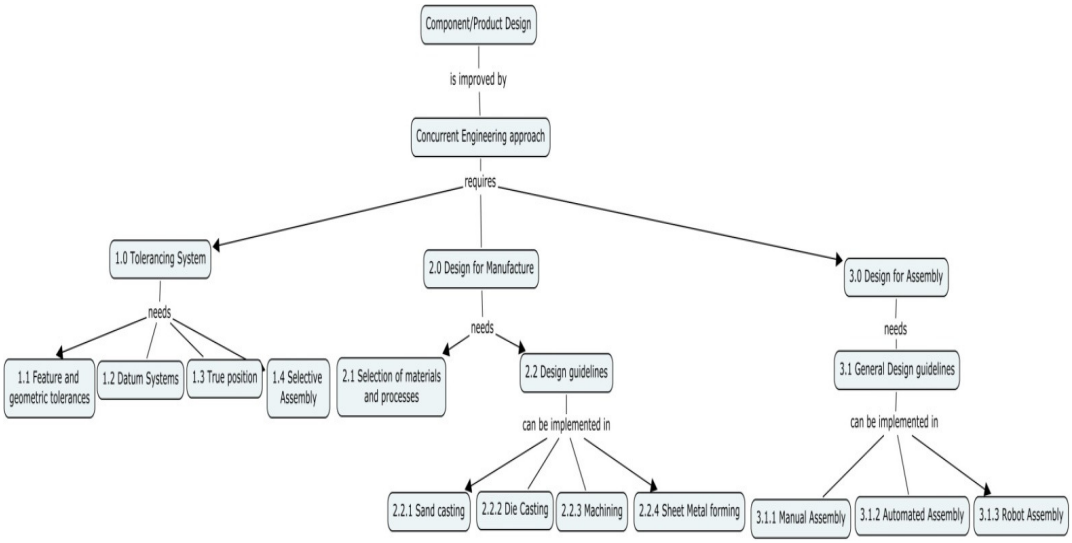


Figure 7

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 - Grouped datum systems - Different types, two and three mutually perpendicular grouped datum planes - Grouped datum system with spigot and recess, pin and hole - Grouped datum system with spigot and recess pair and tongue - Slot pair - Transnational and Rotational accuracy. True position theory: Comparison between co-

ordinate and convention method of feature location - Tolerancing and true position tolerancing -Virtual size concept - Projected tolerance zone - Assembly with gasket, zero true position tolerance. Selective Assembly: Interchangeable part manufacture and selective assembly - Deciding the number of groups - Group tolerances of mating parts equal - Total and group tolerances of shaft equal. **Design for Manufacture (DFM):** Selection of Materials and processes - General guidelines for design for manufacture – Applications - Design guidelines for Sand casting, Die casting, machining and Sheet metal forming - **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.

Reference Books

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, 2009
4. David M. Anderson, “Design for Manufacturability & Concurrent Engineering; How to Design for Low Cost, Design in High Quality, Design for Lean Manufacture, and Design Quickly for Fast Production”, CIM Press, 2010.
5. James G.Bralla, “Design for Manufacturability Handbook”, Second Edition, The McGraw-Hill Companies, Inc., 1999.

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	2
1.1.1	Relationship between attainable tolerance grades and different machining processes - Cumulative effect of tolerances.	2
1.2	Datum systems: Degrees of freedom - Grouped datum systems - Different types, two and three mutually perpendicular grouped datum planes	2
1.2.1	Grouped datum system with spigot and recess, pin and hole	1
1.2.2	Grouped datum system with spigot and recess pair and tongue - Slot pair - Transnational and Rotational accuracy.	1
1.3	True position theory: Comparison between co-ordinate and	1

Module No.	Topic	No. of Lectures
	convention method of feature location	
1.3.1	Tolerancing and true position tolerancing -Virtual size concept - Projected tolerance zone	2
1.3.2	Assembly with gasket, zero true position tolerance.	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	2
2.2	General guidelines for design for manufacture - Applications	2
2.2.1	Design guidelines for Sand casting	2
2.2.2	Design guidelines for Die 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
3.0	**Design for Assembly (DFA)**	
3.1	General guidelines of Design for Assembly	2
3.1.1	Design for manual assembly: guidelines for part handling, insertion and fastening	2
3.1.1.1	Effect of symmetry, part thickness and size and weight on handling time and on grasping and manipulation	2
3.1.1.2	Effect of chamfer design on insertion operations	1
3.1.2	Design for automated assembly: effect of feed rate on cost – high speed automatic insertion	2
3.1.2.1	Design for feeding and orienting	2
3.1.3	Design for Robot assembly: types of robot assembly system - design rules	2
	Case studies	3
	Total	**46**

Course Designers:

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14MGPJ0 ROBUST DESIGN

Category	L	T	P	Credit
PE	4	0	0	4

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 a 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

14MA110 :Statistics

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	CO1: Explain the need, importance and benefit of robust design over conventional design approach	Understand	80	70
CO2	CO 2: Identify DoE model and perform DoE	Understand	80	70
CO3	CO 3: Use and Interpret results of DoE using case studies	Apply	70	60
CO4	CO 4: Practice DoE on real time problems	Apply	70	60
CO5	CO 5: Examine when to use Branch of from Full to Fractional Factorial DoE	Analyse	60	50

Mapping with Programme Outcomes

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

CO5	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	80	40	60	20
Apply	0	40	20	40
Analyse	0	0	0	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Outcome 1 (CO1):

1. Cite the unbalanced data in DOE?
2. What is fixed effect model?
3. What do you mean by Hypothesis?
4. State the advantages of Confounding?
5. Plot a sample linear graph
6. Plot the taguchi's quality curve.
7. What is 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. Brief explain about the following with example, Response Surface Methodology, Partial Confounding and Fractional factorials
4. Write the Step by step procedure to optimize the manufacturing process by Taguchi Methods.
5. 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 =0.5

b) Use Tukeys test to make comparisons between pairs of means. Estimate the treatment effects.

2. An engineer is analyzing the effect of bottle types, (A, B, C, D) on the filling time for a soft drinks. Four workers are selected for the study and to account for this source of variability, the engineer uses the Latin Square shown below. Analyse the data from

this experiment (= 0.5) and draw appropriate conclusions.

Bottle type	**Workers**			
	1	**2**	**3**	**4**
1	C=11	B=10	D= 14	A=8
2	B=8	C=12	A =10	B=12
3	A=9	D=11	B=7	C-15
4	D=9	A=8	C=18	B=6

3. 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

4. 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 microamps to obtain a specified brightness level. The data are shown here. Analyze the data and draw conclusions.

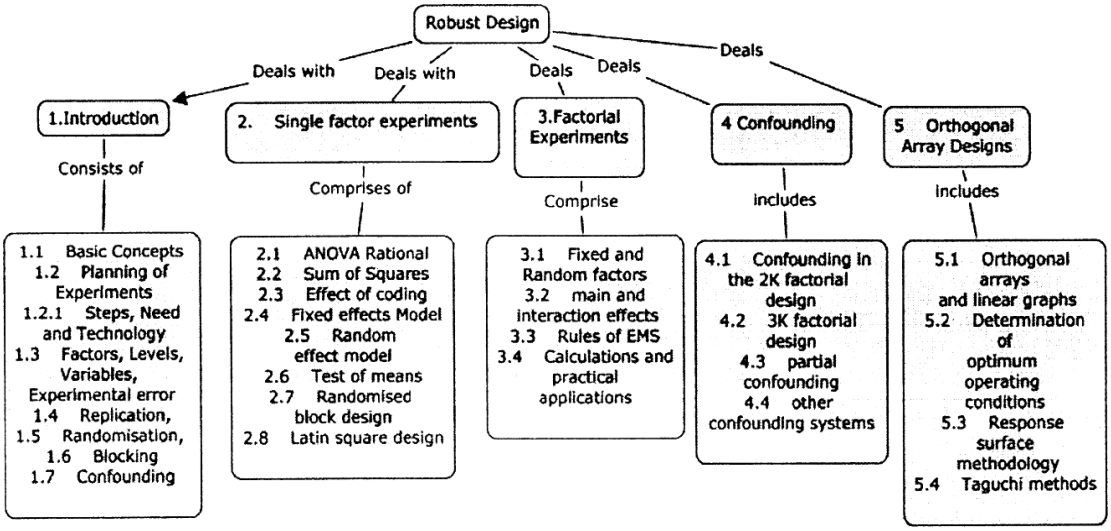
Glass Type	**Phosphor type**		
	1	**2**	**3**
1	280 290	300 310	290 285
2	230 235	260 240	220 225

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, Taguchi methods.

Reference Books

1. Douglas C. Montgomery, "**Design and Analysis of Experiments**", Fifth Edition, John Wiley and Sons, New York, 2013
2. Angela Dean and Daniel Voss," **Design and Analysis of Experiments**", First Indian reprint, Springer International edition,2006
3. Douglas C. Montgomery, " **Introduction to Statistical Quality Control**", Fourth Indian Edition, John Wiley and Sons, New York, 2004.
4. William W. Hines, Douglas C. Montgomery, David M.Goldsman and Connie M.Borror, "**Introduction to Statistical Quality Control**", Fourth Indian Edition, John Wiley and Sons, New York, 2003.
5. Philips J. Ross, "**Taguchi Techniques for Quality Engineering**", Second Edition, McGraw Hill Education (India) Pvt Ltd, 2005

Course Contents and Lecture Schedule

Module Number	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	2
2.2	Sum of Squares	1
2.3	Effect of coding	2
2.4	Fixed effects Model	2
2.5	Random effect model	2
2.6	Test of means	2
2.7	Randomized block design	2
2.8	Latin square design	2
3.	**Factorial Experiments**	
3.1	Fixed and Random factors	2
3.2	main and interaction effects	2
3.3	Rules of EMS	2
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	**46**

Course Designers:

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14MGPK0	LEAN MANUFACTURING AND SIX SIGMA	Category	L	T	P	Credit
		PE	4	0	0	4

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

Manufacturing Engineering
Probability and Statistics
Quality Engineering and TQM

Course Outcomes

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

CO.No.	Course Outcome	Blooms Level	Expected Proficiency	Expected Outcome level
CO1	Explain the concepts of Lean Manufacturing and Six Sigma	Understand	80	70
CO2	Identify the wastes and suggest means for improving productivity	Understand	80	70
CO3	Identify lean metrics and inspect it in the area of work	Understand	80	70
CO4	Apply lean and six sigma tools for decision making problems	Apply	70	60
CO5	Criticize Six Sigma practices in quality problems	Analyse	60	50

Mapping with Programme Outcomes

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

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	30	20	20
3	Apply	50	50	40	40
4	Analyze	0	0	20	20
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is the purpose of reducing waste?
2. What are the various types of lean metrics?
3. Define Process flow & Pitch.
4. What is Takt time?
5. What is six sigma?
6. Define DMAIC.

Course Outcome 2 (CO2):

1. Discuss how Lean concept is helping for corporate decision making.
2. Explain the factors influencing the current state map from Future state map.
3. Explain the objectives of SMED.
4. Discuss on Kano Model.
5. Explain the various steps in six sigma roadmap.
6. Discuss the capability and limitation of SPC six sigma tool.

Course Outcome 3 (CO3):

1. For a Textile Industry the following are main problems. How would you solve the following issues? which lean tool you would use, Justify it.
   A. High Inventory
   B. Frequent breakdown
   C. Process variability
2. Compare Push vs. Pull system. Demonstrate Pull system is suitable for Lean Manufacturing taking Dell Industry supply chain.
3. 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

4. Put in to practice the PFA chart for the products and machines given below and draw New cellular Layout

Product / Machines	1	2	3	4	5
A	X			X	X
B		X			
C			X	X	X
D	X				
E	X		X		X
x-indicates operation in that machine					

5. Use DMAIC principles to get best fit in to a Library Management system
6. Execute DMADV principles for organizing a student industrial tour.

Course Outcome 4 (CO4)

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

Sl. 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	62 ft
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. Analyze how kaizen can be used as a lean tool to solve the case study given below.

A company is mainly focused on manufacturing as per customer's design. HV Axle Ltd. currently has a capacity of about 3, 24,000axles per annum (inclusive of all varieties), total annual sales volume is US$50 Million-US$100Million and total employees are 1154, out of which 846 persons work in Axle division where the case study was taken up. In this division 510 employees are permanent as operator's level and 336 in supervisory. This work is on HVAL, Rear Axle (Assembly Line 1) in which target production is 300 Axles per shift but the current production is 210 Axles per shift (8 Hours). This is due to lack of multi-skilled development, lack of training to operators, no proper utilization of resources, and Noninvolvement of staff in Kaizen Program etc. Our main motto was to achieve the target production and find the factors which are responsible for lack of the production in the company. For completing a Rear Axle assemblies there are 35 work-stations corresponding 56 operators.

Problems faced in company are:

- Number of operators likely to exceed in assembly line.
- Low production efficiency.
- High product cost.
- Low Turnover of company.
- Maintaining the Quality.
- Lack of system simplification.

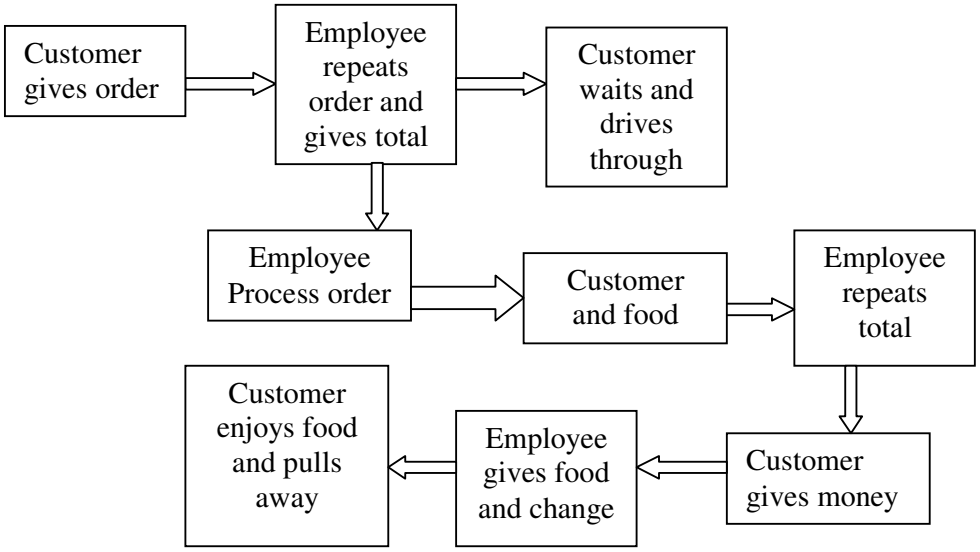
3. From the given information box, draw the current state map, identify the wastes, draw the future state map suitably. Justify your answers. Also compare the takt time in both cases.

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

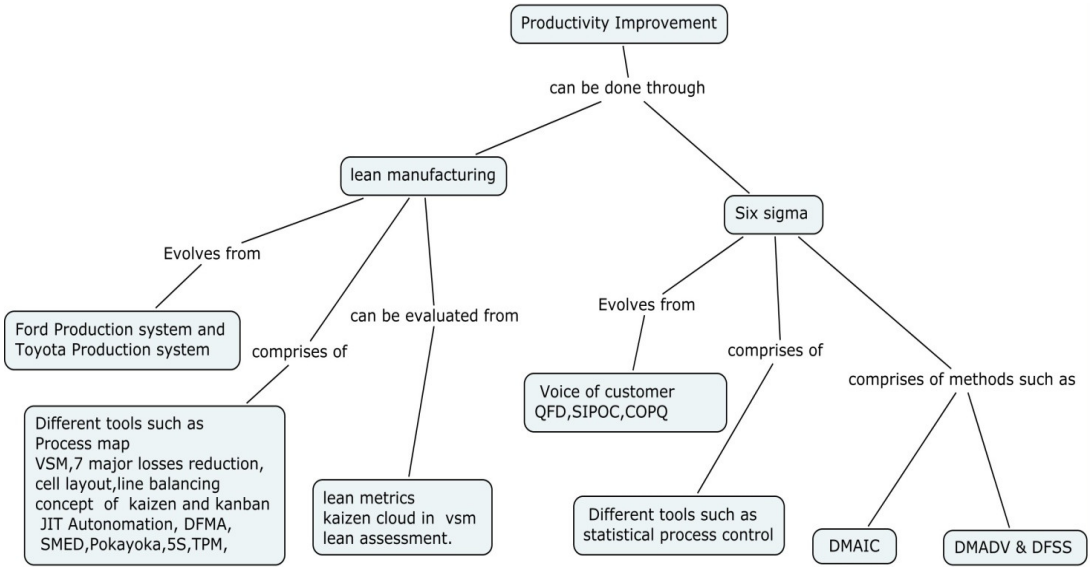
Course Outcome 5 (CO5)

1. A 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.
2. Maintaining accuracy of books on shelves in a library is an important task. Consider the following problems that are often observed.
   a. Books are not placed in the correct shelf, which include books that are checked out and returned and books taken off from shelves
   b. New or returned books are not checked out consequently, online catalog doesn't show availability. Organize a Poka-yoka system for mitigating above problems.

3. 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



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 VSM ; lean assessment. improving targets and benchmarks; **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 – introduction to statistical methods – sampling plan – data collection – choosing statistical software – measure tools – process maps, pareto charts, cause and effect diagrams, histograms, 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 and six sigma certificates.

Reference Books

1. Michael L. George, David Rowlands, Bill Kastle ,What is Lean Six Sigma, Tata McGraw-Hill,2003
2. Thomas Pyzdek, The Six Sigma Handbook , McGraw-Hill, 2010
3. James P. Womack , Daniel T. Jones, Lean Thinking, Free press business, 2003.
4. Kai Yang and Basemel-Haik, "Design for Six-Sigma: A Roadmap for Product Development", McGraw Hill, 2008
5. N. Gopalakrishnan, simplified lean manufacture: Elements, rules, tools and implementation, Prentice Hall of India, New Delhi 2013.

Course Contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Lean Manufacturing and Six sigma-Introduction**	
1.1	Introduction to lean manufacturing	2
1.2	Symptoms Indicating Requirement of Lean manufacturing	1
1.3	Evolution of lean, Types of Manufacturing	1
1.4	How to meet customer requirement, What Customer want?	2
1.5	Introduction to six sigma	2
1.6	Ford and Toyota Production systems	2
2.0	**Lean Tools**	
2.1	Process mapping-types and steps involved	1
2.2	What is Value, VSM,steps to be followed to prepare VSM	2
2.3	Problems and case studies	2
2.4	3 M;7 types of Muda; 7 major losses reduction.	1
2.5	cell layout; line balancing	2
2.6	concept of kaizen; steps involved in kaizen deployment;	1
2.7	kanban concepts ; types of kanbans ; and practical application; push vs pull	1
2.8	JIT	1
2.9	Autonomation, DFMA, various types of chart	2
2.10	SMED,Pokayoka,5S,TPM,Maintenance of all types	2
3.0	**Lean Metrics**	
3.1	identify lean metrics	2
3.2	kaizen cloud identification in vsm	1
3.3	lean assessment. improving targets and benchmarks	1
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	Define phase	2
5.2	Measure and Analyse phase	2
5.3	Improve and Control phase	2

Module Number	Topics	No. of Lectures
5.4	DMADV & DFSS	3
5.5	Case studies in manufacturing	2
5.6	Case studies in Service industries	2
5.7	Sustainability of Lean Manufacturing and Six sigma, six sigma certificates	1
	Total	**46**

Course Designers

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14MGPL0	WORK STUDY AND COST ANALYSIS	Category	L	T	P	Credit
		PE	3	1	0	4

Preamble

Work study is a business efficiency technique combining the Time Study work with the Motion Study work. It is a major part of scientific management. The two techniques became integrated and refined into a widely accepted method applicable to the improvement and upgrading of work systems. This integrated approach to work system improvement is known as methods engineering and it is applied today to industrial as well as service organizations, including banks, schools and hospitals. Time and motion study have to be used together in order to achieve rational and reasonable results. It is particularly important that effort be applied in motion study to ensure equitable results when time study is used. Motion study can be considered the foundation for time study. The time study measures the time required to perform a given task in accordance with a specified method and is valid only so long as the method is continued. Once a new work method is developed, the time study must be changed to agree with the new method.

Pre requisites

Production Planning and Control
Scheduling

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 concepts, types, applications and steps in work study	Understand	80	70
CO2	Explain how work study can be used to calculate man machine systems and solve related problems	Understand	80	70
CO3	Explain the various measurement techniques in time and motion study	Understand	80	70
CO4	Apply statistical methods for productivity measurement	Apply	70	60
CO5	Design ergonomics based structures for real life products	Apply	70	60

Mapping with Programme Outcomes

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

CO 4	S	M	L	L							
CO 5	S	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	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	0	0	0	0
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define Work Study.
2. State the objectives of work study.
3. Define Work Measurement.
4. State different types of data required to perform stop watch time study.
5. Define Ergonomics.
6. What is the purpose of cost estimating?

Course Outcome 2 (CO2):

1. What are the objectives and goals of ergonomic studies? Explain fatigue and its consequences in an industrial work.
2. Explain the various aspects of an ergonomic model of man-machine system.

Course Outcome 3 (CO3):

1. Give various symbols is flow process chart and explain their significance. Draw a typical flow process chart. How does it differ from an operation chart? What are its Uses?
2. Describe the Principles of Motion Economy. How they are related to work place layout?
3. What are the various charting techniques available foe recording a work method for analysis? Explain.
4. Describe the nature and uses of activity sampling.

Course Outcome 4 (CO4):

1. The observed times and the performance ratings for the five elements are given

Element	1	2	3	4	5
Observed time (min.)	0.2	0.08	0.50	0.12	0.10
Performance rating	85	80	90	85	80

Compute the standard time assuming rest and personal allowance as 15% and Contingency allowance as 2% of the basic time.

2. A work sampling study was conducted to establish the standard time for an operation.
   The observations of the study conducted are given below:
   Total number of observations = 160
   Manual (hand controlled work) = 14
   Machine controlled work = 106
   Machine idle time = 40
   Average performance rating = 80%
   No. of parts produced = 36
   Allowance for personal needs And fatigue = 10%
   Study conducted for 3 days Available working hours/day = 8 hrs.
   Calculate the standard time per piece.

3. In a Machine shop work sampling study was conducted for 160 hrs in order to estimate the standard time. Total numbers of observation recorded were 3500. There were 600 no working activities. Ratio between manual to machine element was 2:1 Average rating factor was 1:2 and total number of jobs produced during the study were 8000. Rest and personal allowances taken together will be 17% of normal time. Determine the standard time per job.

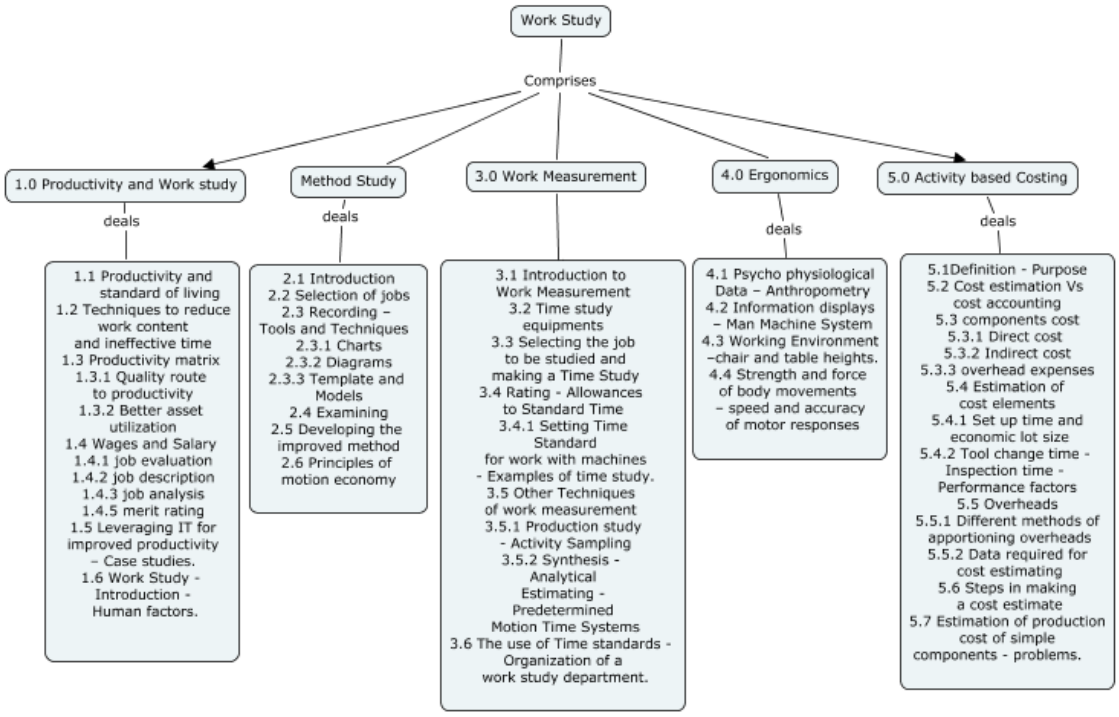
Course Outcome 5 (CO5):

1. A certain product is manufactured in batches of 100.The direct material cost is Rs 50,direct labour cost is Rs 80 and factory overhead charges are Rs. 65. If the selling expenses are 45 percent of factory cost, what should be selling price of each product so that the profit is 10 percent of the total cost?

2. A Cast iron foundry employs 30 people. It consumes material worth Rs. 25,000 pays workers @Rs 1 per hour and total overheads are Rs10, 000. In a particular month (25 day) workers had over time of 150 hrs and were paid at double their normal rate. Find i) Total cost ii) Man hour rate of overheads. Assume an 8 hours working day.

3. There are three car manufacturing industries A, B, and C and they are producing same types of cars. They are employing 1000, 2000and 3000 men and producing 10, 15 and 25 cars per month respectively. Find (i) the labour productivity of each firm and (ii) the production of each firm per year.

Concept Map



Syllabus:

Productivity and Work Study: Productivity and standard of living, Techniques to reduce work content and ineffective time. Productivity matrix, Quality route to productivity, better asset utilization, wages and salary, job evaluation, job description, job analysis and merit rating, Leveraging IT for improved productivity – Case studies. Work Study - Introduction - Human factors. **Method Study:** Introduction - Selection of jobs – Recording – Tools and Techniques - Charts, Diagrams, Template and Models - Examining - Developing the improved method - Principles of motion economy. **Work Measurement:** Introduction to Work Measurement - Time study equipments - Selecting the job to be studied and making a Time Study- Rating - Allowances to Standard Time - Setting Time Standard for work with machines - Examples of time study. Other Techniques of work measurement - Production study - Activity Sampling - Synthesis - Analytical Estimating - Predetermined Motion Time Systems. The use of Time standards - Organization of a work study department. **Ergonomics:** Psycho physiological Data – Anthropometry, information displays – Man Machine System - Working Environment – chair and table heights. Strength and force of body movements – speed and accuracy of motor responses. **Activity Based Costing:** Definition - Purpose - cost estimation Vs cost accounting - components cost - Direct cost - indirect cost - overhead expenses. Estimation of cost elements - set up time and economic lot size - tool change time - Inspection time - performance factors – overheads. different methods of apportioning overheads - Data required for cost estimating -Steps in making a cost estimate - estimation of production cost of simple components - problems.

Reference books

1. ILO, “Introduction to Work Study”, Universal Publishing Corporation, Bombay, 1992
2. Mundel, “Motion and Time Study”, Prentice Hall of India, 1998
3. Ralph M. Barnes, “Motion and Time Study”, John Wiley and Sons, 1990.
4. Niebel Benjamin. W., “Motion and Time Study”, Richard D. Irwin Inc., 1982.
5. Dalela. S,“Workstudy and Ergonomics”, Standard Publishers Distributors, New Delhi,1999.
6. Sunderesh Heragu “ Facilities Design” PWS publishing company, 2008
7. James M. Apple “Plant Layout and material Handling” The Ronald press company, 1991
8. Singh. C. K., “Mechanical Costing, Estimation and Project Planning”, Standard Publishers Distributors, New Delhi, 1996.

Course Contents and Lecture Schedule

Module Number	Topics	No. Of Periods
1.	**Productivity and Work Study**	
1.1	Productivity and standard of living	1
1.2	Techniques to reduce work content and ineffective time	1
1.3	Productivity matrix	1
1.3.1	Quality route to productivity	1
1.3.2	better asset utilization	
1.4	Wages and Salary	2
1.4.1	job evaluation	2
1.4.2	job description	
1.4.3	job analysis	
1.4.5	merit rating	1
1.5	Leveraging IT for improved productivity – Case studies.	1
1.6	Work Study - Introduction - Human factors.	1
2.	**Method Study**	
2.1	Introduction	1
2.2	Selection of jobs	1
2.3	Recording – Tools and Techniques	1
2.3.1	Charts	1
2.3.2	Diagrams	1
2.3.3	Template and Models	1
2.4	Examining	1
2.5	Developing the improved method	1
2.6	Principles of motion economy	1
3.	**Work Measurement**	

Module Number	Topics	No. Of Periods
3.1	Introduction to Work Measurement	1
3.2	Time study equipments	1
3.3	Selecting the job to be studied and making a Time Study	1
3.4	Rating - Allowances to Standard Time	1
3.4.1	Setting Time Standard for work with machines - Examples of time study.	1
3.5	Other Techniques of work measurement	1
3.5.1	Production study - Activity Sampling	1
3.5.2	Synthesis - Analytical Estimating - Predetermined Motion Time Systems	2
3.6	The use of Time standards - Organization of a work study department.	1
4.	**Ergonomics**	
4.1	Psycho physiological Data – Anthropometry	1
4.2	Information displays – Man Machine System	1
4.3	Working Environment –chair and table heights.	1
4.4	Strength and force of body movements – speed and accuracy of motor responses	2
5.	**Activity Based Costing**	
5.1	Definition - Purpose	1
5.2	cost estimation Vs cost accounting	1
5.3	components cost	
5.3.1	Direct cost	2
5.3.2	indirect cost	
5.3.3	overhead expenses	
5.4	Estimation of cost elements	
5.4.1	set up time and economic lot size	2
5.4.2	tool change time - Inspection time - Performance factors	1
5.5	overheads	
5.5.1	different methods of apportioning overheads	1
5.5.2	Data required for cost estimating	
5.6	Steps in making a cost estimate	1
5.7	Estimation of production cost of simple components - problems	2
	Total	**46**

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14MGPM0	QUALITY AND RELIABILITY ENGINEERING	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

It is a process by which entities review the quality of all factors involved in production. Quality control emphasizes testing of products to uncover defects, and reporting to management who make the decision to allow or deny the release, whereas quality assurance attempts to improve and stabilize production, and associated processes, to avoid, or at least minimize, issues that led to the defects in the first place.

Prerequisite

Knowledge on mathematical distributions

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	Construct the process control charts – variables, attributes	Apply	70	60
CO2	Examine the process control charts	Analyse	60	50
CO3	Illustrate Multivariate quality control	Understand	80	70
CO4	Prepare and comment the Sampling plans – single, double and multiple	Apply	70	60
CO5	Compute the system Reliability of different system configuration	Apply	70	60
CO6	Investigate the ways to improve the system reliability through redundancy and standby modes	Analyse	60	50
CO7	Describe the ways to implement the system certification	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	S	M	M							
CO3	M	L									
CO4	S	M	L	L							
CO5.	S	M	L	L							
CO6.	S	S	M	M							
CO7	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	20	20	20	20
Analyse	20	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course level Assessment Questions

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.

Course Outcome 2 (CO2):

1. What do you mean shift in process mean?
2. How will you implement SIX SIGMA approach to a Manufacturing Company?

Course Outcome 3 (CO3):

1. Explain about Hotelling T^2 control chart for multivariate analysis.
2. Describe about covariance matrix and its applications

Course Outcome 4 (CO4):

1. 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.

2. 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.

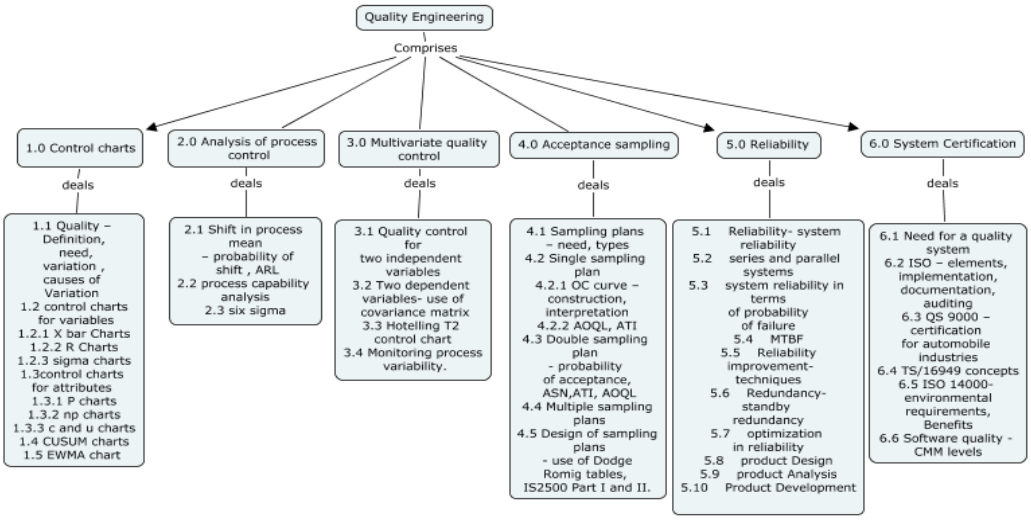
Course Outcome 6 (CO6):

1. Propose a system configuration in order to improve its reliability with the known component reliability.
2. 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.

Course Outcome 7 (CO7):

1. Discuss about the documentation process in ISO 9001: 2000 system.
2. Discuss about the design and implementation of quality management system for a higher learning education organization.

Concept Map



Syllabus

Control charts: Quality – Definition, need- variation – causes- 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.

System Certification: Need for a quality system, ISO – elements, implementation documentation, auditing, QS 9000 – certification for automobile industries- TS/16949 concepts ISO 14000- environmental requirements, Benefits – Software quality - CMM levels.

Reference Books

1. Dougles C. Montgomery, “Introduction to Statistical Quality Control”, John Wiley and Sons, Inc, Fifth Edition, 2008
2. Eugene L., Grant Richard S., Leven Worth, “Statistical Quality Control”, McGraw Hill, Seventh Edition, 1996.
3. Kannan SM, Jayabalan V, “Total Quality Management”, RKR Publications, 2005.
4. Mahajan, “Statistical Quality Control”, Dhanpat Rai and Co (P) Ltd, Third Edition, 2002.
5. Seiichi Nakajima, “Introduction to TPM”, Productivity press, Second Edition, 1997.

6. Sharma DD, “Total Quality Management”, Sultan Chand and Sons, 2002.
7. Connor, P.D.T.O., "Practical Reliability Engineering ", John Wiley (1993).
8. Green A.E., and Bourne A.J. "Reliability, Technology ", Wiley Inter science, 1991.

Course contents and Lecture Schedule

Module Number	Topics	No. Of Periods
	Control charts	
1.1	Quality – Definition, need, variation , causes of Variation	1
1.2	control charts for variables	
1.2.1	X Charts	2
1.2.2	R Charts	
1.2.3	σ charts	1
1.3	control charts for attributes	
1.3.1	P Chart	1
1.3.2	np Chart	1
1.3.3	C and u chart	2
1.4	CUSUM charts	
1.5	Exponential Weighted Moving Average (EWMA) chart.	1
2.	**Analysis of process control**	
2.1	Shift in process mean – probability of shift , ARL	1
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	2
4.2.1	OC curve – construction, interpretation	
4.2.2	AOQL, ATI	
4.3	Double sampling plan - probability of acceptance, ASN,ATI, AOQL	1
4.4	Multiple sampling plans	1
4.5	Design of sampling plans - use of Dodge Romig tables, IS2500 Part I and II.	2
5	**Reliability**	
5.1	Reliability- system reliability	2

Module Number	Topics	No. Of Periods
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	2
5.6	Redundancy-standby redundancy	2
5.7	optimization in reliability	1
5.8	product Design	2
5.9	product Analysis	
5.10	Product Development	2
5.11	product life	
6	**System Certification**	
6.1	Need for a quality system	1
6.2	ISO – elements, implementation, documentation, auditing	2
6.3	QS 9000 – certification for automobile industries	1
6.4	TS/16949 concepts	1
6.5	ISO 14000- environmental requirements, Benefits	1
6.6	Software quality - CMM levels	1
	Total	**45**

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	Category	L	T	P	Credit
14MGPN0 FINANCIAL MANAGEMENT	PE	4	0	0	4

Preamble

Financial Management is a science which deals with managing the monetary transactions in an organization. The field is related with relying on accounting and enables an engineer in taking useful financial and costing related decisions by providing scientific tools and techniques.

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 basic concepts of financial management, functions of finance and tools and techniques of finance	Understand	80	70
CO2	Prepare and interpret important financial statements like profit& Loss account ,Balance sheet, Budgets	Apply	70	60
CO3	Compute accurately working capital and fixed capital requirements of the organization	Apply	70	60
CO4	Evaluate appropriate sources of finance	Analyse	60	50
CO5	Evaluate investment decisions	Analyse	60	50
CO6	Prepare appropriate capital structure for an organization	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1	M	L									
CO 2	S	M	L	L							
CO 3	S	M	L	L							
CO 4	S	S	M	M							
CO 5	S	S	M	M							
CO 6	S	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	30	30	30
3	Apply	50	40	40	30
4	Analyze	0	10	10	20
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Outcome (CO)

Course outcome 1 (CO1):

1. What is financial management?
2. What are all the functions of finance?
3. What is a budget?
4. What is break even analysis?
5. List out some of the sources of long term finance

Course Outcome 2 (CO2):

1. Prepare Trading and Profit and Loss Account and Balance Sgeet on 31.12.96 from the following trial balance extracted from the books of Mr.Kumar as on 31.12.96

Debit Balances	Rs.	Credit Balances	Rs.
Buildings	30000	Capital	4000
Machinery	31400	Purchase Returns	2000
Furniture	2000	Sales	280000
Motor Car	16000	Sundry creditors	9600
Purchases	188000	Discounts received	1000
Sales return	1000	Provision for bad and doubtful debts	600
Sundry debtors	30000		
General expenses	1600		
Cash at bank	9400		
Rates and taxes	1200		
Bad debts	400		
Insurance premium	800		
Discount allowed	1400		
Opening stock	20000		
Total	333200	Total	333200

2. A chemical company is considering investing in a project that costs Rs.500000. The estimated salvage values is zero; tax rate is 55%. The company uses straight line depreciation and the proposed project ahs cash flows before tax (CFBT) as follows.

Year	CFBT (Rs.)

1	100000
2	100000
3	150000
4	150000
5	250000

Find the following a) Pay Back Period b) ARR

Course Outcome 3 (CO3):

1. What are all the factors that would influence working capital requirements of an organization?
2. From the following information estimate working capital requirement.
   a. Estimated output 96,000 units per year.
   b. Selling price per unit Rs.50/-
   c. Estimated cost to selling price.
      a) Materials 40% b) Labour 35% C) Overheads 15%
   d. Raw materials are expected to remain in stores for an average period of 3 months before issue to production.
   e. Materials will be in process for one month.
   f. Finished goods to remain in stock for one and half months (after production till it reaches the customer)
   g. Credit allowed to customers 2 months (25% sold for cash)
   h. Credit allowed by suppliers 2 months.
   i. Cash balance to be maintained Rs.10,000/-
   j. Advances paid-Rs.25,000.
   k. Delay in payment of wages Rs.5,000
   l. Allow 10% for contingencies.

Course Outcome 4 (CO4):

1. How will select the various sources of financing considering the fixed capital and working capital requirements of the organization?
2. Evaluate the various medium-term and long-term sources of financing.
3. Evaluate the various short-term sources of financing.

Course Outcome 5 (CO5):

1. Evaluate and critically analyse the various methods of appraising the capital budgeting decisions?
2. From the following information calculate (i) pay back period (ii)Net present value and profitability index @10% (iii)Internal rate of return and suggest which project can be selected?

Particulars	**Project x**	**Project y**
Initial investment	Rs.20,000	Rs.30,000
Estimated life	5years	5 years
Scrap value	Rs.1000	Rs.2000

Estimated profit before tax and after depreciation (cash flows)is as follows;

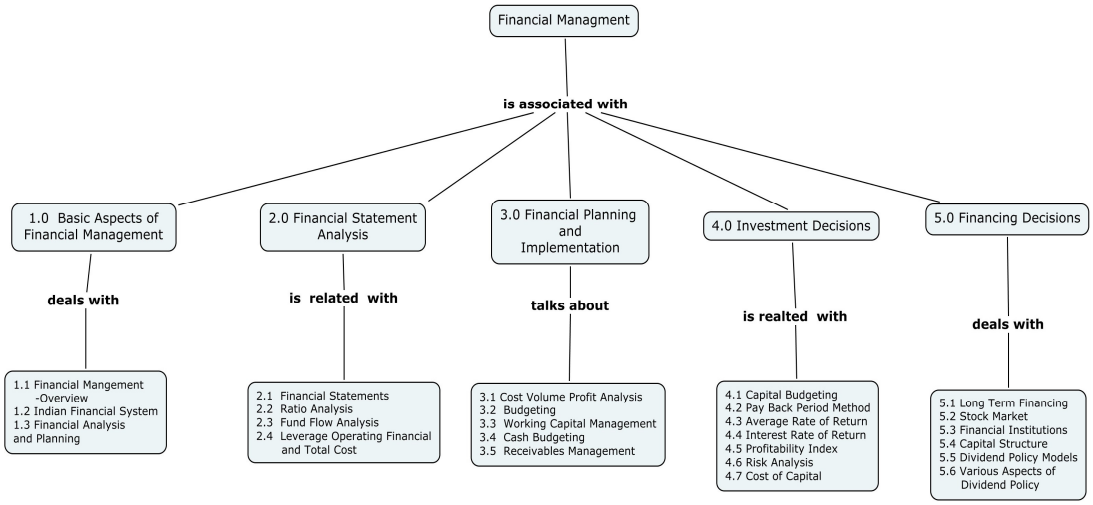
Year	1	2	3	4	5
Project "x" (Rs.)	5000	10000	10000	3000	2000

Project "y" (Rs.)	20,000	10,000	5,000	3,000	2,000

Course Outcome 6 (CO6)**:**

1. Devise a suitable capital structure for an organization which relies more on debt capital and less on equity capital.
2. The management of Samata Company, subscribing to the net operating income approach, believes that its cost of debt and overall cost of capital will remain at 8 per cent and 12 per cent, respectively. If the equity shareholders of the firm demand a return of 20 per cent, what should be the proportions of debt and equity in the firm's capital structure? Assume that there are no taxes.

Concept Map



Syllabus

Financial Management- An Overview - Indian Financial System - Financial Analysis and Planning - Financial Statements - Balance Sheet - Income Statement

Financial Statement Analysis - Types of Financial ratios - Predictive power of financial ratios-Funds Flow Analysis - Fund flow statement- Total resources basis - Working capital basis- cash basis- Leverage - Operating Financial and Total cost .

Financial Planning and Implementation

ABC analysis, Cost volume profit Analysis - Budgeting - Financial Forecasting-Working Capital Management - Factors influencing working capital requirements - Working capital policy- Cash Management -Cash budgeting - Long term cash forecasting- Receivables Management - Credit policy variables- Credit evaluation- Control of receivables.

Investment decisions -Capital Budgeting –Pay Back Period Method, Average Rate of Return, Internal Rate of Return, Profitability Index- Appraisal criteria - Risk Analysis of - Selection of a Project -Cost of Capital.

Financing Decisions -Long Term Financing - Sources of long term finance - Primary market for long term securities - Public issue - Rights issue- Private placement- Stock market - Function of the stock market - Regulation -Financial Institutions.

Capital Structure - Theory - Various approaches - Planning the capital structure -

Dividend policy and share valuation - Dividend policy models - Practical Aspects - Legal and procedural aspects.

Reference Books

1. Prasanna Chandra, "Fundamentals of Financial Management", Tata McGraw Hill, 2008
2. KY. Khan and P.K. Jain, " Financial Management", Tata McGraw Hill, 2007
3. Khan and Jain, " Theory and Problems of Financial Management", Tata Mc Graw Hill Publishing Co, 1999
4. Pandey, "Financial Management", Vikas Publishing House Pvt. Ltd., 2007

Course Contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Basic Aspects of Financial Management**	
1.1	Financial Management Overview	2
1.2	Indian Financial System	2
1.3	Financial Analysis and Planning	2
2.0	**Financial Statement Analysis**	
2.1	Financial Statements	2
2.2	Ratio Analysis	2
2.3	Fund Flow Analysis	2
2.4	Leverage Operating Financial and Total Cost	2
3.0	**Financial Planning and Implementation**	
3.1	ABC analysis, Cost Volume Profit Analysis	2
3.2	Budgeting	2
3.3	Working capital Management	2
3.4	Cash Budgeting	2
3.5	Receivables Management	2
4.0	**Investment Decisions**	
4.1	Capital Budgeting	2
4.2	Pay Back Period Method	2
4.3	Average Rate of Return	1
4.4	Interest Rate of Return	2
4.5	Profitability Index	1
4.6	Risk Analysis	2
4.7	Cost of Capital	2
5.0	**Financing Decisions**	
5.1	Long Term Financing	1
5.2	Stock Market	1
5.3	Financial Institutions	2
5.4	Capital Structure	3
5.5	Dividend Policy Models	2
5.6	Various Aspects of Dividend Policy	2
	Total	**46**

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	Category	L	T	P	Credit
14MGPP0 OPERATIONS MANAGEMENT	PE	4	0	0	4

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, Facility Location and Layout Planning, 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.

Prerequisite

Knowledge on Mathematics and Operation Research

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	CO 1: Explain strategies for operations, aggregate planning, forecasting, inventory, MRP and scheduling, and Concept of JIT and Lean manufacturing.	Understand	80	70
CO2	CO2: Select suitable aggregate plan, forecast model, and inventory model, MRP schedules and lot sizing methods	Analyse	60	50
CO3	CO3: Draw process flow chart and determine process performance and productivity measures	Apply	70	60
CO4	CO4: Compute forecast, order quantity, and safety stock levels	Apply	70	60
CO5	CO5: Criticize suitable facility location and layout plan	Analyse	60	50
CO6	CO6: Compute 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
CO 1.	M	L									

CO 2.	S	S	M	M							
CO 3.	S	M	L	L							
CO 4.	S	M	L	L							
CO 5.	S	S	M	M							
CO 6.	S	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	30	30	30
3	Apply	40	50	40	30
4	Analyze	10	0	10	20
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Course Outcome 1 (CO1):

1. Define Operation Management.
2. How does mixed strategy differ from pure strategy?
3. What are the major priorities associated with Operations Strategy?

Course Outcome 2 (CO2):

1. What are forecasting errors?
2. Discuss the Aggregate Production Planning Strategies and Techniques.
3. Describe the Frame work for operations strategy in manufacturing.
4. Compare and contrast JIT and MRP, stating their main features.

Course Outcome 3 (CO3):

1. 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

2. Consider 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.

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

Course Outcome 4 (CO4):

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. Tucson Machinery, Inc., manufactures numerically controlled machines, which sell for an average price of $0.5 million each. Sales for these NCMs for the past two years were as follows:

Quarter	Quantity (Units)	Quarter	Quantity (Units)
2005		**2006**	
I	12	I	16

II	18	II	24
III	26	III	28
IV	16	IV	18

(a) Hand fit a line.

(b) Find the trend and seasonal factors

(c) Forecast sales for 2007.

3. Give the following information, analyse and suggest suitable inventory management system by answering the following questions. The item is demanded 50 weeks a year.

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

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?

Course Outcome 5 (CO5):

1. A new plant to be established will receive raw material from three suppliers P, Q, and R and supply finished products to three warehouses U, V, and W. The sources of raw material and the destination points may be considered as the existing facilities. The coordinates of the existing facilities and the amount of material movement between the existing facilities and the new facility are as follows:

Serial No.	Existing facility	Coordinates		Material movement to and from new facility w_i
		X	Y	
1	P	300	300	400
2	Q	350	500	600

3	R	280	180	700
4	U	100	500	300
5	V	500	600	500
6	W	350	700	450

Find the optimal location for the new plant.

2. A medical consortium wishes to establish two clinics to provide medical care for people living in four communities. Assume that the sites under study are in each community and that the population of each community is evenly distributed within the community's boundaries. Further, assume that the potential use of the clinics by members of the various communities has been determined and weighting factors reflecting the relative importance of serving members of the population of each community have been developed. The objective of the problem is to find the two clinics that can serve all communities at the lowest weighted travel-distance cost. Given the weighted population distance, determine the two communities where the two clinics are to be established.

Weighted Population Distance

From Community	To Clinic			
	A	B	C	D
A	0	121	88	132
B	123.2	0	112	78.4
C	112	140	0	126
D	114	84	108	0

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 6 (CO6):

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 make span?

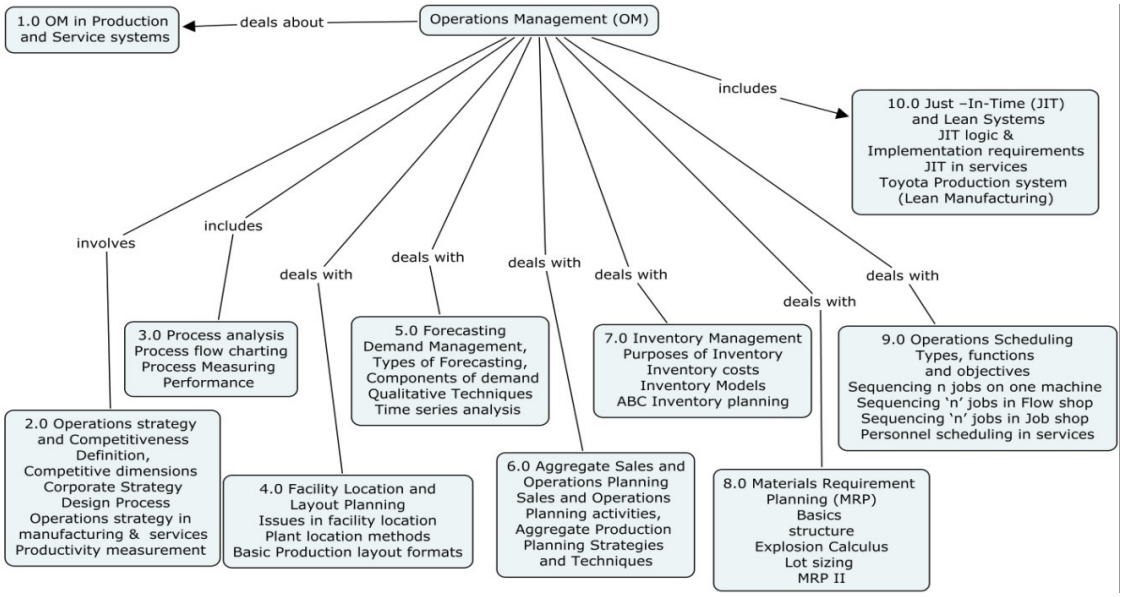
Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

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 and Process Measuring Performance. **Facility Location and Layout Planning:** Issues in facility location, Plant location methods: Factor rating method and Gravity location method, Basic Production layout formats, Process layout– Craft and Systematic layout Planning, Product layout – Assembly line balancing, and Other layouts- Group Technology layout, Fixed Position layout, Retail service layout and office layout. **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. Personnel scheduling in services. **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., 2004.
2. Everette. Adam. Jr.Ronald J.Ebert, "**Production and Operations Management**", Eight Indian Reprinting, PHI 1997.
3. Steven Nahmias, "**Production and Operations Analysis**", Third Edition, Irwin McGraw Hill Companies Inc., 1997.
4. Paneer Selvam.R, "**Production and Operations Management**", Third Edition, Prentice-hall of India, 2012.
5. Mahabatra, "**Computer Aided Production Management**", Prentice-hall Of India Pvt.ltd, 2004.
6. Chary, "**Theory and Problems in Production and Operations Management**", Second reprint, Tata McGraw Hill, 1996
7. Seetharama L.Narasimhan, Dennis W.McLeavy, Peter.J.Billington, "**Production Planning and Inventory Control**", PHI, 1997.

Course Contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Introduction to Operations Management (OM)**	
1.1	Definition, OM in organisation chart	2
1.2	OM in Production and Service systems	
2.0	**Operations strategy and Competitiveness:**	
2.1	Definition, Competitive dimensions and Corporate Strategy Design Process	1

Module Number	Topics	No. of Lectures
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	1
3.2	Process Measuring Performance	1
4.0	**Facility Location and Layout Planning**	
4.1	Issues in facility location	1
4.2	Plant location methods: Factor rating method and Gravity location method.	2
4.3	Basic Production layout formats	1
4.4	Process layout– Craft and Systematic layout Planning	2
4.5	Product layout – Assembly line balancing	1
4.6	Other layouts- Group Technology layout, Fixed Position layout, Retail service layout and office layout	2
5.0	**Forecasting**	
5.1	Demand Management, Types of Forecasting, Components of demand	2
5.2	Qualitative Techniques in Forecasting	1
5.3	Time series analysis in Forecasting	2
6.0	**Aggregate Sales and Operations Planning**	
6.1	Sales and Operations Planning activities	1
6.2	Aggregate Production Planning Strategies and Techniques	2
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	2
7.3	Fixed - order quantity Models, Establishing Safety stock	1

Module Number	Topics	No. of Lectures
	levels	
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	2
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)	2
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.	1
9.5	Personnel scheduling in services.	1
10.0	**Just –In-Time (JIT) and Lean Systems**	
10.1	JIT logic	1
10.2	Toyota Production system (Lean Manufacturing)	
10.3	JIT Implementation requirements	1
10.4	JIT in services	
	Total	**46**

Course Designers

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14MGPR0 SUPPLY CHAIN MANAGEMENT

Category	L	T	P	Credit
PE	4	0	0	4

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

Knowledge on Mathematics

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 issues important in the design of the logistics network, inventory management and risk pooling	Understand	80	70
CO2	Explain the value of information, Distribution strategies, and strategic alliances	Understand	80	70
CO3	Explain the International Supply Chain Management, supplier integration, customer value and Information Technology	Understand	80	70
CO4	Calculate the distribution cost, bullwhip effect, order quantity, and safety stock levels	Apply	70	60
CO5	Demonstrate case studies about distribution strategies, strategic alliances, and coordinated product design	Apply	70	60
CO6	Show 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
CO 1.	M	L									
CO 2.	M	L									
CO 3.	M	L									
CO 4.	S	M	L	L							
CO 5.	S	M	L	L							
CO 6.	S	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	40	40	40	40
3	Apply	40	40	40	40
4	Analyze	0	0	0	0
5	Evaluation	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

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

   a. 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?

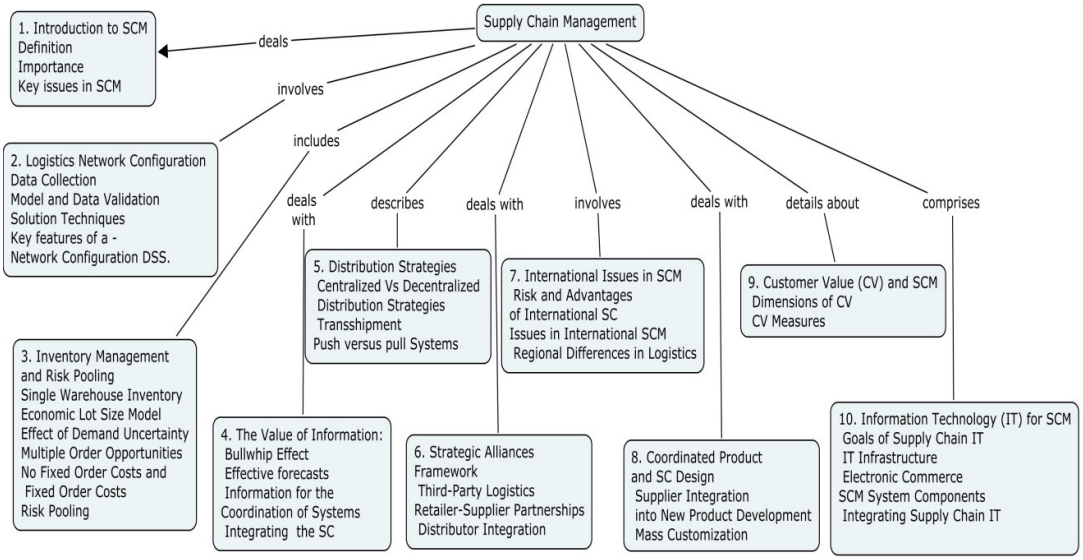
Course Outcome 5 (CO5):

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, Key features of a Network Configuration DSS. **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, Effective forecasts, Information for the Coordination of Systems, Integrating the SC. **Distribution Strategies:** Centralized versus Decentralized Control, Distribution Strategies, Transshipment, Push versus pull Systems. **Strategic Alliances**: A Framework for Strategic Alliances, Third-Party Logistics, 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 CV, CV Measures. **Information Technology (IT) for SCM**: Goals of Supply Chain IT, IT Infrastructure, Electronic Commerce, 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”, McGraw Hill Education India Pvt. Ltd, New Delhi, 2007.
2. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Second Edition, Prentice Hall India Pvt. Ltd, New Delhi, 2007.
3. Robert B Handfield and Ernest L Nichols, “Introduction to Supply Chain Management”, Prentice Hall, Inc. New Delhi, 1999.
4. Sahay B S, “Supply Chain Management”, Macmillan Company, 2000.
5. David Brunt and David Taylor, “Manufacturing Operations and Supply Chain Management : The Lean Approach”, Vikas Publishing House, New Delhi, 2001.

Course Contents and Lecture schedule

Module number	Topics	No. of Lectures

Module number	Topics	No. of Lectures
1.0	Introduction to Supply Chain Management (SCM)	
1.1	Definition, Importance	1
1.2	Key issues in SCM	2
2.0	Logistics Network Configuration	
2.1	Data Collection, Model and Data Validation	2
2.2	Solution Techniques and Problems	2
2.3	Key features of a Network Configuration DSS	1
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.	2
3.3	Risk Pooling	1
4.0	The Value of Information	
4.1	Bullwhip Effect	1
4.2	Effective forecasts	1
4.3	Information for the Coordination of Systems	1
4.4	Integrating the Supply Chain	2
5.0	Distribution Strategies	
5.1	Centralized versus Decentralized Control	1
5.2	Distribution Strategies, Transshipment	2
5.3	Push versus pull Systems	1
6.0	Strategic Alliances	
6.1	Framework for Strategic Alliances	2

Module number	Topics	No. of Lectures
6.2	Third-Party Logistics	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	1
7.2	Issues in International SCM	2
7.3	Regional Differences in Logistics	1
8.0	Coordinated Product and SC Design	
8.1	Supplier Integration into New Product Development	2
8.2	Mass Customization	2
9.0	Customer Value (CV) and SCM	
9.1	Dimensions of Customer Value	2
9.2	Customer Value Measures	2
10.0	Information Technology (IT) for SCM	
10.1	Goals of Supply Chain IT	2
10.2	IT Infrastructure, Electronic Commerce	2
10.3	SCM System Components, Integrating Supply Chain IT	2
	Total	46

Course Designers

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14MGPS0 GEOMETRIC MODELING

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

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

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 coordinate system for the development of geometric models	Understand	80	70
CO2	Draw and manipulate the curves and surfaces using parametric equations	Apply	70	60
CO3	Draw and manipulate the solid models using modeling techniques	Apply	70	60
CO4	Compute the transformation and projection over the geometric model	Apply	70	60
CO5	Apply the DXF and IGES neutral file formats over the given 2D wireframe model	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	S	M	L	L							
CO3	S	M	L	L							
CO4	S	M	L	L							
CO5	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	20	20	10
Understand	50	40	50	30
Apply	40	40	30	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):

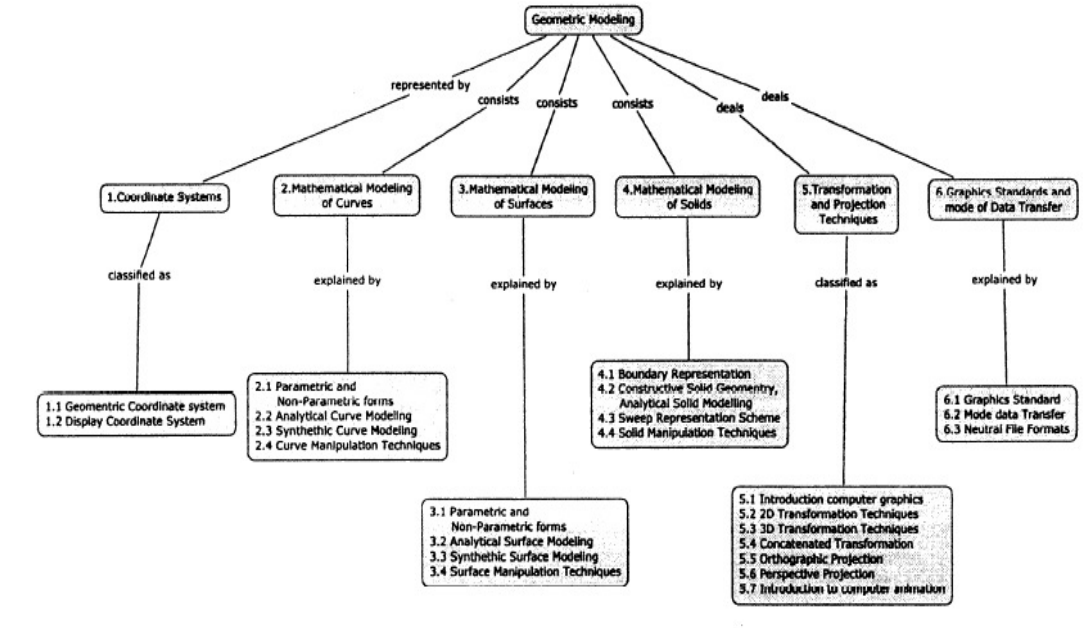
1. Consider a line with (5,5) and (5,0) points. Rotate the line with respect to another point (0, 2.5) by 45 degrees in CW direction and get the transformed position.
2. A point P(2,5,10) is rotated 30° in CCW about z-axis then followed by scaling 200% and refection about Y=0 plane. What happens if this 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

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.

Course Contents and Lecture Schedule

Module Number	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.	2
2.3	Synthetic Curve modeling - Hermite cubic spline, Bezier curve	2
	Synthetic Curve modeling - B-spline and Rational Curves	2
2.4	Manipulation - Analytical and synthetic curve manipulation techniques	1
3	**Mathematical modeling of Surfaces**	
3.1	Parametric and non-parametric forms of analytical and synthetic surfaces	2
3.2	Analytical surface modeling - Parametric form of plane, loft	2
	Analytical surface modeling - Cylindrical, Surface of revolution	1
3.3	Synthetic Surface modeling - Hermite bicubic spline, Bezier	2
	Synthetic Surface modeling - B-spline, Coon's, Triangular, Blending Surfaces	2
	Synthetic Surface modeling - triangular, blending Surfaces	1

3.4	Manipulation - Analytical and synthetic surface manipulation techniques	2
4	**Mathematical modeling of Solids**	
4.1	Boundary representation scheme	1
4.2	Constructive Solid Geometry, Analytical Solid Modeling	1
4.3	Sweep representation scheme	1
4.4	Manipulation - Solid Manipulation Techniques	1
5	**Transformation and Projection techniques**	
5.1	Introduction computer graphics - Non-interactive Vs Interactive computer graphics, applications, graphics system configuration	2
5.2	2D transformation techniques - Translation, Rotation	1
	2D transformation techniques - Scaling and Reflection	1
5.3	3D transformation techniques - Translation, Rotation	2
	3D transformation techniques - Scaling and Reflection	2
5.4	Principle of concatenated transformation	1
5.5	Orthographic Projections of Geometric Models	
5.6	Perspective Projections of Geometric Models	1
5.7	Introduction to computer aided animation system	2
6	**Graphic Standards and mode of data transfer**	
6.1	Graphics standard	1
	Geometrical data	2
6.2	Mode of data transfer - Direct and indirect data transfer	2
6.3	Neutral file formats - Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES)	2
	Total	45

Course Designers:

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14MGPT0 METAL JOINING ENGINEERING

Category	L	T	P	Credit
PE	4	0	0	4

Preamble: Metal joining is one among the manufacturing processes for joining the components by welding processes. Welding is required in the manufacture of various parts of boiler, air craft, automobiles, ships, nuclear reactor etc. Metal joining is a controlled process used to fuse metals. There are several techniques of metal joining of which welding is one of the more basic forms. Welding is a fabrication process that joins materials, usually metals or thermoplastics, by causing coalescence . This is often done by melting the workpieces and adding a filler material to form a pool of molten material that cools to become a strong joint, but sometimes pressure is used in conjunction with heat , or by itself, to produce the weld. Many different energy sources can be used for welding, including a gas flame, an electric arc, a laser, an electron beam, friction, and ultrasound. While often an industrial process, welding can be done in many different environments, including open air, underwater and in space. The end product is obtained by joining the two similar or dissimilar materials by selecting suitable welding process. Advanced welding processes are developed to improve the quality of the product, reduce the cost and preserve the environment.

Prerequisite

14MG130 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	Explain the principles and process capabilities of various fusion and solid state joining processes	Understand	80	70
CO2	Choose the suitable process parameters of various types of welding techniques	Apply	70	60
CO3	Describe heat transfer and molten metal flow in various metal joining processes	Understand	80	70
CO4	Describe the metallurgical changes during the joining processes in the weld zone.	Understand	80	70
CO5	Interpret the weldability of various ferrous and non ferrous metals	Apply	70	60
CO6	Identify the stress distortion and relieving techniques in the metal joining process	Understand	80	70
C07	Identify the defects and causes in metal joining processes	Understand	80	70

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	S	M	L	L							
CO3	M	L									
CO4	M	L									
CO5.	S	M	L	L							
CO6.	M	L									
CO7	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	50	50	50	50
Apply	30	30	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. What is resistance welding?
2. State the applications of gas tungsten arc welding process.
3. Explain resistance seam welding process with neat sketches.

Course Outcome 2 (CO2):

1. Select a suitable process to weld boiler shell and explain with necessary sketches.
2. How will you weld a dissimilar metal? Justify your selection.
3. 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 3 (CO3):

1. Explain the one dimensional heat transfer rate with necessary diagram
2. Discuss the Rosenthal' s Equation for heat flow in welding.
3. Discuss the cooling rate of welding in and around the welding

Course Outcome 4 (CO4):

1. Define weld metallurgy.
2. How to control the grain size in the welding
3. Explain the weld metal solidification technique

Course Outcome 5 (CO5):

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.

Course Outcome 6 (CO6):

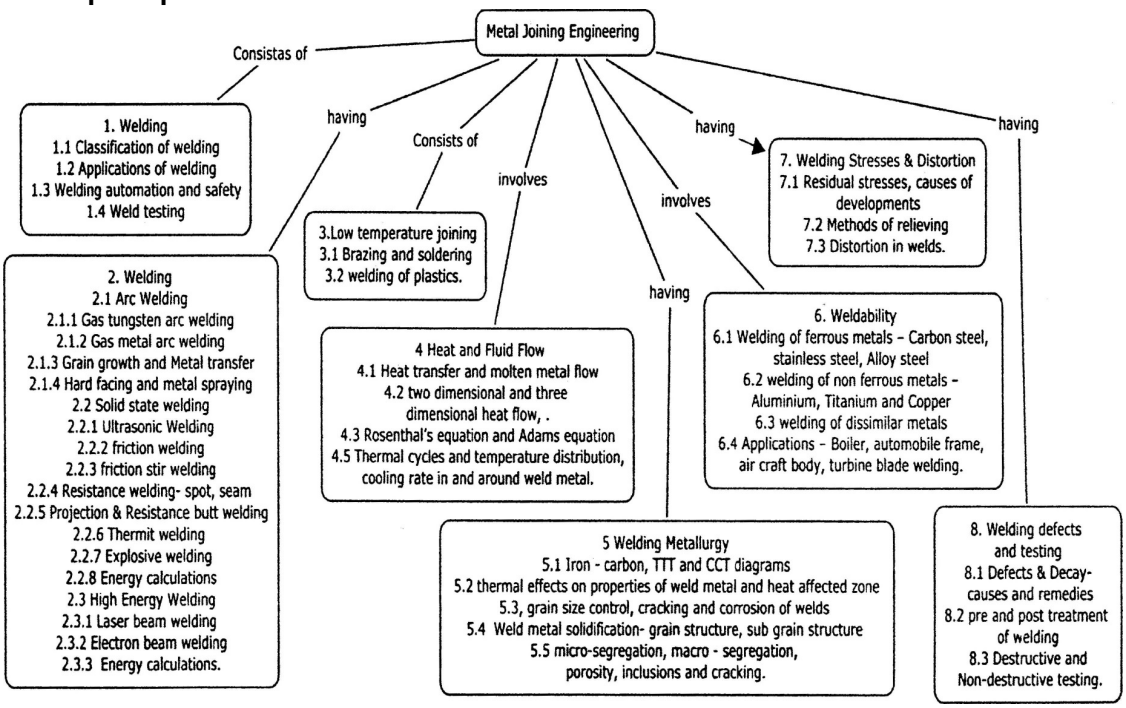
1. What is weld distortion?

2. Name the various stresses developed during welding process
3. Discuss how the stresses are relived from the weld surface

Course Outcome 7 (CO7):

1. Name the various weld crack identification techniques
2. Explain the dye penetrants technique with necessary sketches
3. Explain the various pre treatment techniques used in the welding process

Concept Map



Syllabus

Welding: Classification of welding, Applications of welding, Welding automation and safety, Weld testing. **Arc welding:** Gas tungsten arc welding, Gas metal arc welding - Grain growth and Metal transfer- 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 - energy calculations. **High Energy We!ding:** Laser and Electron beam welding - energy calculations. **Low temperature joining:** Brazing and soldering, welding of plastics. **Heat and Fluid Flow:** Heat transfer and molten metal flow, two dimensional and three dimensional heat flow, Rosenthal's equation and Adams equation - Thermal cycles and temperature distribution, cooling rate in and around weld metal. **Welding Metallurgy,** 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- grain structure, sub grain structure, micro-segregation, macro - segregation, porosity, inclusions and cracking. **Weldability:** welding of ferrous metals - Carbon steel, stainless steel, Alloy steel - welding of non ferrous metals - Aluminium, Titanium and Copper - welding of

dissimilar metals - Applications - Boiler, automobile frame, air craft body, turbine blade welding. **Welding Stresses & Distortion:** Residual stresses, causes of developments, methods of relieving - Distortion in welds. **Welding defects and testing:** Defects and decay - causes and remedies, pre and post treatment of welding, Destructive and Non-destructive testing.

Reference Books

1. Little R.L, **"Welding and Welding Technology"** - Tata McGraw Hill Publishing Ltd, New Delhi, 2001
2. Parmer R.S, **"Welding Engineering and Technology",** 2nd Edition Khanna publishers, Delhi, 2010.
3. Sindo Kou, **"Welding Metallurgy",** Wiley Interscience, USA, 2003.
4. Davies, A.C, **"Welding",** 10th Edition, Cambridge University press, 1996.
5. Howard B. Cary, **"Modern Welding Technology",** Prentice Hall Inc, New Jersey, 2001
6. Khanna, O.P, **"A Text Book of Welding Technology",** - Dhanpat Rai Publications (P) Ltd., New Delhi, 1998.
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.

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures
1	**Welding**	
1.1	Classification of welding	1
1.2	Applications of welding	1
1.3	Welding automation and safety	
1.4	Weld testing	1
2	**Welding**	
2.1	Arc welding	
2.1.1	Gas Tungsten Arc Welding	1
2.1.2	Gas Metal Arc Welding	1
2.1.3	Grain Growth and Metal transfer	1
2.1.4	Hard facing and metal spraying	1
2.2	Solid state welding	
2.2.1	Ultrasonic welding	1
2.2.2	Friction welding	1
2.2.3	Friction stir welding	1
2.2.4	Resistance welding, Spot, seam welding processes	

Module Number	Topics	No. of Lectures
2.2.5	Projection and Resistance butt welding processes	1
2.2.6	Thermit welding	1
2.2.7	Explosive welding	
2.2.8	Energy calculations	1
2.3	High Energy Welding	
2.3.1	Laser beam welding	1
2.3.2	Electron beam welding	1
2.3.3	Energy calculations.	1
3	**Low temperature joining**	
3.1	Brazing and soldering	1
3.2	welding of plastics	1
4.	**Heat and Fluid Flow**	
4.1	Heat transfer and molten metal flow,	1
4.2	two dimensional and three dimensional heat flow,	2
4.3	Rosenthal's equation and Adams equation	1
4.4	Thermal cycles and temperature distribution, cooling rate in and	2
5	**Metallurgy of welding**	
5.1	Iron-carbon, TTT and CCT diagrams	1
5.2	Thermal effects on properties of weld metal and heat affected zone	1
5.3	grain size control, cracking and corrosion of welds	1
5.4	Weld metal solidification-grain structure, sub grain structure	1
5.5	Micro - segregation, macro-segregation, porosity, inclusions and	1
6	**Weldability**	
6.1	welding of ferrous metals - Carbon steel, stainless steel, Alloy steel	2
6.2	welding of non ferrous metals - Aluminium, Titanium and Copper	2
6.3	welding of dissimilar metals	1
6.4	Applications - Boiler, automobile frame, air craft body, turbine blade	1
7	**Welding Stresses & Distortion**	
7.1	Residual stresses, causes of developments,	1
7.2	methods of relieving	1
7.3	Distortion in welds.	1
8	**Welding defects and testing**	
8.1	Defects and Decay- causes and remedies	1
8.2	Pre and post treatment	1
8.3	Destructive testing and Non-destructive testing	2

Module Number	Topics	No. of Lectures
	Total	46

Course Designers:

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14MGPU0 FLUID POWER AUTOMATION

Category	L	T	P	Credit
PE	3	1	0	4

Preamble

The course aims at giving adequate exposure to hydraulic and pneumatic systems and Design of hydraulic and pneumatic circuits. The course gives various circuit design methods needed for the industrial automation

Prerequisite

14MG140 : Industrial Automation and Robotics

14MG150 : CNC Machine Tool Technology

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 theory related to Fluid power and arising in the study of engineering problems and their applications	Understand	80	70
CO2	Choose the pumps and motors for the given applications	Apply	70	60
CO3	Design the hydraulic and pneumatic circuits based on the required movement and sequence	Apply	70	60
CO4	Calculate speed, pressure, direction control for the hydraulic and pneumatic circuits	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	S	M	L	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	20	20	20	20
Understand	20	20	20	20
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. 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.

Course Outcome 2 (CO2):

1. Explain the cascade method of circuit design with example.
2. Distinguish between mechanical and Electro Hydraulic Servo Systems
3. List the selection parameters for a pump.

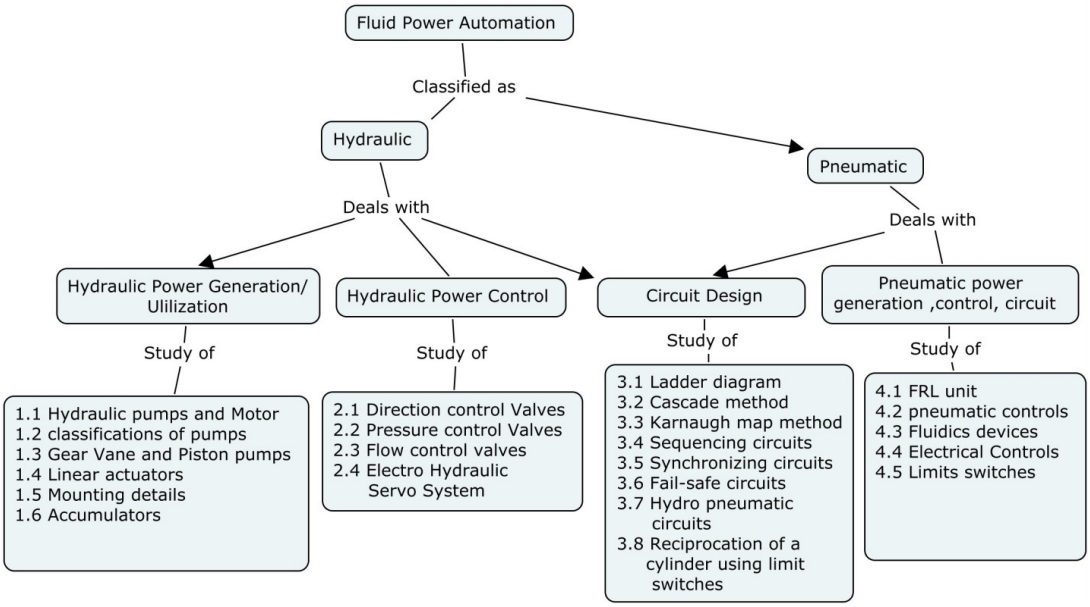
Course Outcome 3 (CO3):

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 circuits for a material handling in heat treatment plant

Course Outcome 4 (CO4):

1. Explain the application of pressure Compensated flow control valve.
2. Distinguish between mechanical and Electro Hydraulic Servo Systems
3. Discuss in detail the 4/3 direction control valve with example.
4. Compare the meter-in and meter-out circuits

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 - primary and secondary type - Flow control valves - types - Compensated and non-compensated valves. Circuit Design- Typical industrial hydraulic circuits design methodology – Ladder diagram – Cascade method – Truth table – Karnaugh map method – Sequencing circuits – Synchronizing circuits – Fail-safe circuits – Design of hydraulic circuits. Control and Use of Pneumatic Power- Use of pneumatics for LCA - pneumatic controls FRL unit - Design of pneumatic circuits - Fluidics devices and their application - Hydro pneumatic circuits. -Electrical Controls for Fluid Power systems Electrical components - Limits switches - Hydraulic cylinder - Reciprocation of a cylinder using limit switches - Dual-cylinder sequence circuits - Box sorting systems - Electro Hydraulic Servo System.

Reference Books

1. Anthony Esposito, “Fluid Power with application”, Sixth edition, Prentice Hall of India Private limited, 2005
2. James L. Johnson “Introduction to Fluid Power” Delmar Thomson Learning Publishers 2003
3. CMTI, “Machine Tool Design Hand Book”, Tata McGraw Hill, 2000.
4. Dudley A. Pease, “Basic Fluid Power”, Prentice Hall, 2000.
5. William W. Reeves, “Technology of Fluid Power” Delmar Publishers 1997
6. Peter Rohner, “Fluid Power Logic Circuit Design”, The Macmillan press, 1979.

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	Classification- positive displacement pumps	1
1.4	Linear actuators	1
1.4.1	Single, Double acting and Cushion telescopic cylinder	2
1.4.2	Working principles of cylinders	1
1.5	Mounting details	1
1.6	Accumulators	2
1.6.1	Types	1
1.6.2	Applications	1
2	**Control Components in Hydraulic Systems**	
2.1	Direction control Valves	2
2.1.1	check valves- two way	2
2.1.2	Three way and four way valves	1
2.1.3	Shuttle valves- Rotary shuttle	1

Module Number	Topics	No. of Lectures
2.2	Pressure control Valves	1
2.2.1	primary and secondary type	1
2.3	Flow control valves	2
2.3.1	Flow control valves - types	2
2.3.2	Non-compensated valves	1
2.3.3	Compensated valves.	1
2.4	Electro Hydraulic Servo System	1
3	**Circuit Design**	
3.1	Typical industrial hydraulic circuits design methodology	1
3.2	Ladder diagram	2
3.3	Cascade method Truth table	1
3.4	Karnaugh map method	1
3.5	Sequencing circuits	1
3.6	Fail-safe circuits	1
3.7	Synchronizing circuits	1
3.8	Reciprocation of a cylinder using limit switches	1
4	**Control and Use of Pneumatic Power**	
4.1	Use of pneumatics for LCA	2
4.2	Design of pneumatic circuits	1
4.3	pneumatic controls FRL unit	1
4.4	Fluidics devices and their application Hydro pneumatic circuits	2
4.5	Electrical components Limits switches Dual-cylinder sequence circuits - Box sorting systems	2
	Total	46

Course Designers:

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14MGPV0 RAPID PROTOTYPING

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

Rapid prototyping 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. Rapid Prototyping improves product development by enabling better communication in a concurrent engineering environment. This course aims to provide knowledge on the rapid prototyping technologies 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	Blooms Level	Expected Proficiency	Expected attainment level
CO1	Explain the principles of rapid prototyping processes and rapid tooling	Understand	80	70
CO2	Explain the process capabilities of rapid prototyping methods and tooling	Understand	80	70
CO3	Explain the process parameters of rapid prototyping technologies and its influences on part quality	Understand	80	70
CO4	Interpret cloud point data from reverse engineering	Apply	70	60
CO5	Modify cloud point data for generation of RP model	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	M	L									
CO4	S	M	L	L							
CO5.	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. Explain the principle of Stereolithography (SLA) processes.
2. Discuss the working principle of Fusion Deposition Modelling (FDM).
3. Discuss the solid ground process steps in details with suitable diagrams.

Course Outcome 2 (CO2):

1. Differentiate direct and indirect tooling process.
2. Explain silicon rubber tooling processes in detail.
3. Explain laminate tooling and discuss its limitations.

Course Outcome 3 (CO3):

1. Explain the process parameters of solid ground curing.
2. Discuss the process parameters to be considered in selective laser sintering
3. Identify the process parameters considered for laminated object manufacturing.

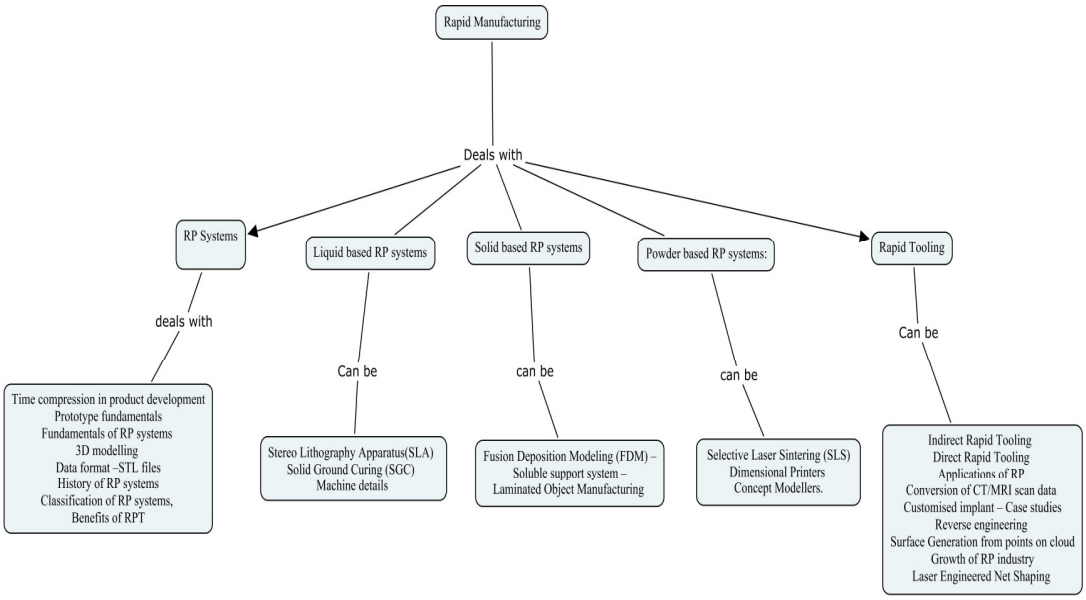
Course Outcome 4 (CO4):

1. How the conversion of CT/MRI scan data can be done.
2. How was the surface Generation from points on cloud are done and explain in detail.
3. Differentiate soft tooling with hard tooling.

Course Outcome 5 (CO5):

1. Discuss the applications and limitations of SGC process.
2. Suggest few application of RP in product design, automotive industry and medical field.
3. Explain in details about the application of cloud point data for generation of RP model.

Concept Map



Syllabus

Introduction and Liquid Based RP Processes: Introduction: Need for time compression in product development, Prototype fundamentals, Fundamentals of RP systems – 3D modelling – Data format – STL files, History of RP systems, classification of RP systems, benefits of RPT, Liquid based RP systems: Stereo Lithography Apparatus(SLA) – Principle – Photo polymers – Post processes – process parameters – Machine details – Advantages, Solid Ground Curing (SGC) – Principle – processes parameters – Process details - Machine details – Limitations.

Solid and Powder Based RP Processes: Solid based RP systems: Fusion Deposition Modeling (FDM) – Principle – Raw materials – BASS – Water soluble support system – Process parameters – Machine details – Advantages and limitations, Laminated Object Manufacturing – Principle – Processes parameters = Process details – Advantages and limitations.

Powder based RP systems: Selective Laser Sintering (SLS) – Principle – process parameters – Process details –Machine details, -Dimensional Printers – Principle – Process parameters - Process details – Machine details, Concept Modellers.

Rapid Tooling and Applications of RP: Indirect Rapid Tooling – Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling, Direct Rapid Tooling – Direct AIM. Quick cast process, Copper polyamide, Rapid Tool, DMLS, ProMetal, Sand casting tooling, soft tooling Vs hard tooling, Applications of RP in product design, automotive industry, medical field – Conversion of CT/MRI scan data – Customised implant – Case studies, reverse engineering – Surface Generation from points on cloud, Growth of RP industry, Laser Engineered Net Shaping – Principle – Process details,

Reference Books

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. www.utah.edu/~asn8200/rapid.html
7. http://www.cheshirehenbury,com/rapid/index.html

Course Contents and Lecture Schedule

Module Number	Topic	No. of Lectures
1	**Introduction and Liquid Based RP Processes:**	
1.1	Introduction: Need for time compression in product development, Prototype fundamentals	2
1.2	Fundamentals of RP systems – 3D modelling – Data format – STL files, History of RP systems	2
1.3	classification of RP systems, benefits of RPT, Liquid based RP systems	2
1.4	Stereo Lithography Apparatus(SLA) – Principle – Photo polymers – Post processes –	2
1.5	process parameters -Machine details – Advantages,	3
1.6	Solid Ground Curing (SGC) – Principle – processes parameters	3
1.7	Process details - Machine details – Limitations	2
2	**Solid and Powder Based RP Processes:**	
2.1	Solid based RP systems: Fusion Deposition Modeling (FDM) – Principle – Raw materials – BASS	2
2.2	Water soluble support system – Process parameters – Machine details – Advantages and limitations	3
2.3	Laminated Object Manufacturing – Principle – Processes parameters = Process details – Advantages and limitations	2
2.4	Powder based RP systems: Selective Laser Sintering (SLS) – Principle – process parameters	3
2.5	Process details –Machine details, -Dimensional Printers – Principle – Process parameters	3
2.6	Process details – Machine details, Concept Modellers	2
3	**Rapid Tooling and Applications of RP:**	
3.1	Indirect Rapid Tooling – Silicone rubber tooling, Aluminium filled epoxy tooling, Spray metal tooling	2
3.2	Direct Rapid Tooling – Direct AIM. Quick cast process, Copper polyamide, Rapid Tool, DMLS	3
3.3	ProMetal, Sand casting tooling, soft tooling Vs hard tooling	2
	Applications of RP in product design, automotive industry, medical field	3
3.4	Conversion of CT/MRI scan data – Customised implant – Case studies, reverse engineering –	3
3.5	Surface Generation from points on cloud, Growth of RP industry	2
3.6	Laser Engineered Net Shaping – Principle – Process details	2
	Total	46

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	Category	L	T	P	Credit
14MGPW0 COMPOSITE MATERIALS	PE	4	0	0	4

Preamble

Composite materials (also called composition materials or shortened to composites) 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. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter or less expensive when compared to traditional materials. This course covers the fundamentals of composite material and manufacturing of various composite materials

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	Explain the various Fibers and Matrix Materials	Understand	80	70
CO2	Illustrate the various polymer matrix composites processing methods	Apply	70	60
CO3	Explain the Lamina Constitutive Equations	Understand	80	70
CO4	Choose the various processing methods of metal matrix composites	Apply	70	60
CO5	Examine the processing of ceramic matrix composites and carbon - carbon Composites	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	S	M	L	L							
CO3	M	L									
CO4	S	M	L	L							
CO5	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	60	60	60	60
Apply	20	20	20	20
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 composite material
2. List the properties of glass fibre
3. Explain the various types of matrix materials

Course Outcome 2 (CO2):

1. Differentiate between thermosetting and thermo plastics
2. List the components manufactured using filament winding technique
3. Discuss the compression moulding technique for the fabrication of PMC.

Course Outcome 3 (CO3):

1. Write the transformation matrix for a lamina
2. List the lamina assumptions used in classic laminate theory.
3. Derive the rule of mixture equation.

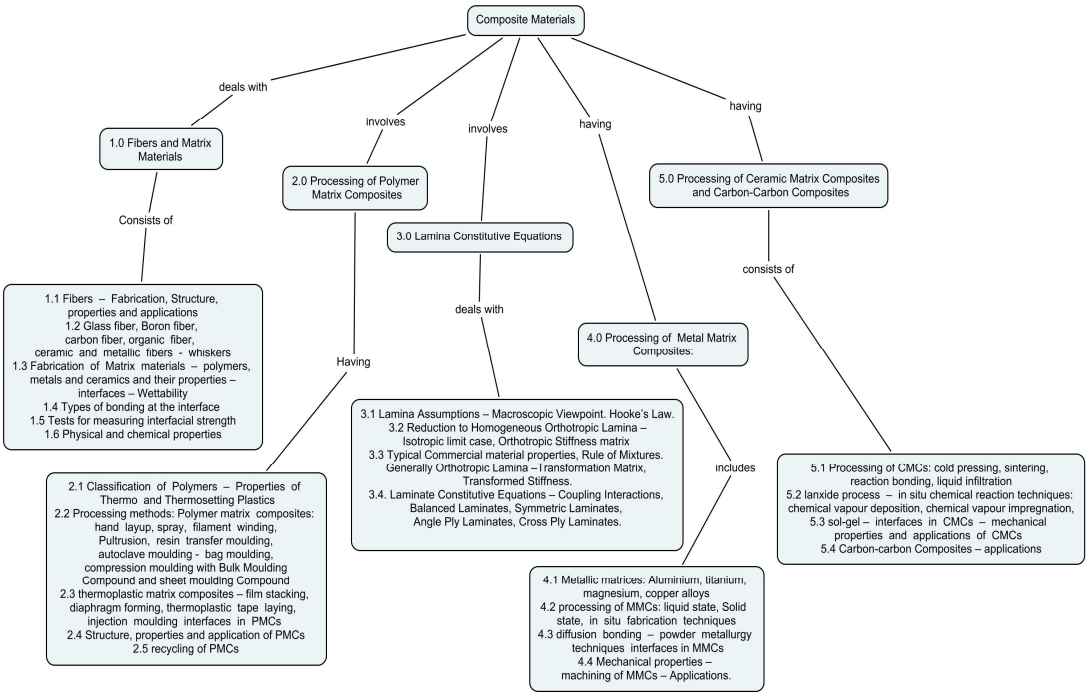
Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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.

Concept Map



Syllabus

Fibers and Matrix Materials : Fibers – Fabrication, Structure, properties and applications – Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - whiskers–Fabrication of Matrix materials – polymers, metals and ceramics and their properties – interfaces – Wettability – Types of bonding at the interface – Tests for measuring interfacial strength - Physical and chemical properties.

Processing of Polymer Matrix Composites: Classification of Polymers – Properties of Thermo and Thermosetting Plastics – Extrusion, Polymer matrix composites: 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.

Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix (Q_{ij}), Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates.

Processing of Metal Matrix Composites: Metallic matrices: Aluminium, titanium, magnesium, copper alloys – processing of MMCs: liquid state, Solid state, in situ fabrication techniques – diffusion bonding – powder metallurgy techniques interfaces in MMCs – mechanical properties – machining of MMCs – Applications.

Processing of Ceramic Matrix Composites and Carbon-Carbon Composites: Processing of CMCs: cold pressing, sintering, reaction bonding, liquid infiltration, lanxide process – in situ chemical reaction techniques: chemical vapour deposition, chemical vapour impregnation, sol-gel – interfaces in CMCs – mechanical properties and applications of CMCs – Carbon-carbon Composites – applications.

Reference Books

1. Krishnan K Chawla, Composite Materials: Science and Engineering, International Edition, Springer, 2012
2. Mallick P.K., Fiber Reinforced Composites: Materials, Manufacturing and Design, CRC press, New Delhi, 2010
3. Jamal Y. Sheikh-Ahmad, Machining of Polymer Composites, Springer, USA, 2009.
4. Mallick, P.K. and Newman.S., Composite Materials Technology, Hanser Publishers, 2003.
5. Said Jahanmir, Ramulu M. and Philp Koshy, Machining of Ceramics and Composites, Marcel Dekker Inc., New York, 1999

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Fibers and Matrix Materials**	
1.1	Fibers – Fabrication, Structure, properties and applications	2
1.2	Glass fiber, Boron fiber, carbon fiber, organic fiber, ceramic and metallic fibers - whiskers	2
1.3	Fabrication of Matrix materials – polymers, metals and ceramics and their properties – interfaces – Wettability	2
1.4	Types of bonding at the interface	2
1.5	Tests for measuring interfacial strength	2
1.6	Physical and chemical properties	1
2.0	**Processing of Polymer Matrix Composites**	
2.1	Classification of Polymers – Properties of Thermo and Thermosetting Plastics	2
2.2	Processing methods: Polymer matrix composites: hand layup, spray, filament winding, Pultrusion, resin transfer moulding, autoclave moulding - bag moulding, compression moulding with Bulk Moulding Compound and sheet moulding Compound	3
2.3	thermoplastic matrix composites – film stacking, diaphragm forming, thermoplastic tape laying, injection moulding interfaces in PMCs	3
2.4	Structure, properties and application of PMCs	2
2.5	recycling of PMCs	1
3.0	**Lamina Constitutive Equations**	
3.1	Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law.	2
3.2	Reduction to Homogeneous Orthotropic Lamina – Isotropic limit	2

Module Number	Topics	No. of Lectures
	case, Orthotropic Stiffness matrix	
3.3	Typical Commercial material properties, Rule of Mixtures. Generally Orthotropic Lamina –Transformation Matrix, Transformed Stiffness.	3
3.4	Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates.	3
4.0	**Processing of Metal Matrix Composites:**	
4.1	Metallic matrices: Aluminium, titanium, magnesium, copper alloys	3
4.2	processing of MMCs: liquid state, Solid state, in situ fabrication techniques	3
4.3	diffusion bonding – powder metallurgy techniques interfaces in MMCs	2
4.4	Mechanical properties – machining of MMCs – Applications.	2
5.0	**Processing of Ceramic Matrix Composites and Carbon-Carbon Composites**	
5.1	Processing of CMCs: cold pressing, sintering, reaction bonding, liquid infiltration	2
5.2	lanxide process – in situ chemical reaction techniques: chemical vapour deposition, chemical vapour impregnation,	1
5.3	sol-gel – interfaces in CMCs – mechanical properties and applications of CMCs	2
5.4	Carbon-carbon Composites – applications.	2
	Total	47

Course Designers

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14MGPY0 NON DESTRUCTIVE EVALUATION

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

Inspection is one of the prime factor to use the component for a specific application where the safety is to be ensured. Non Destructive testing is the use of noninvasive techniques to determine the integrity of a material, component or structure or quantitatively measure some characteristic of an object. This course covers the various non destructive techniques used for various engineering applications

Prerequisite

14MG130 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	Explain the various Non-Destructive tests	Understand	80	70
CO2	Explain the Eddy Current Testing and Acoustic Emission Test	Understand	80	70
CO3	Interpret the Magnetic Particle Testing and Thermography	Apply	70	60
CO4	Employ the Ultrasonic Testing for engineering applications	Apply	70	60
CO5	Employ the Radiography testing for engineering applications	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	L									
CO2	M	L									
CO3	S	M	L	L							
CO4	S	M	L	L							
CO5	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	50	50	50	50
Apply	30	30	30	30
Analyse	0	0	0	0

Board of studies meeting on 07.11.14 Approved in 49th Academic Council meeting on 04.12.2014

Evaluate	0	0	0	0
Create	0	0	0	0

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define NDT.
2. Discuss the Liquid Penetrant Testing with necessary illustrations.
3. State the benefits of using visual inspection.

Course Outcome 2 (CO2):

1. State the principle of ECT.
2. Describe the Acoustic emission testing process with necessary illustrations.
3. Discuss how to detect the fatigue crack by using AET.

Course Outcome 3 (CO3):

1. Mention the principle of MPT.
2. Discuss how thermography is used to find the cracks on a coated surface.
3. Explain the various equipments used in the magnetic particle testing

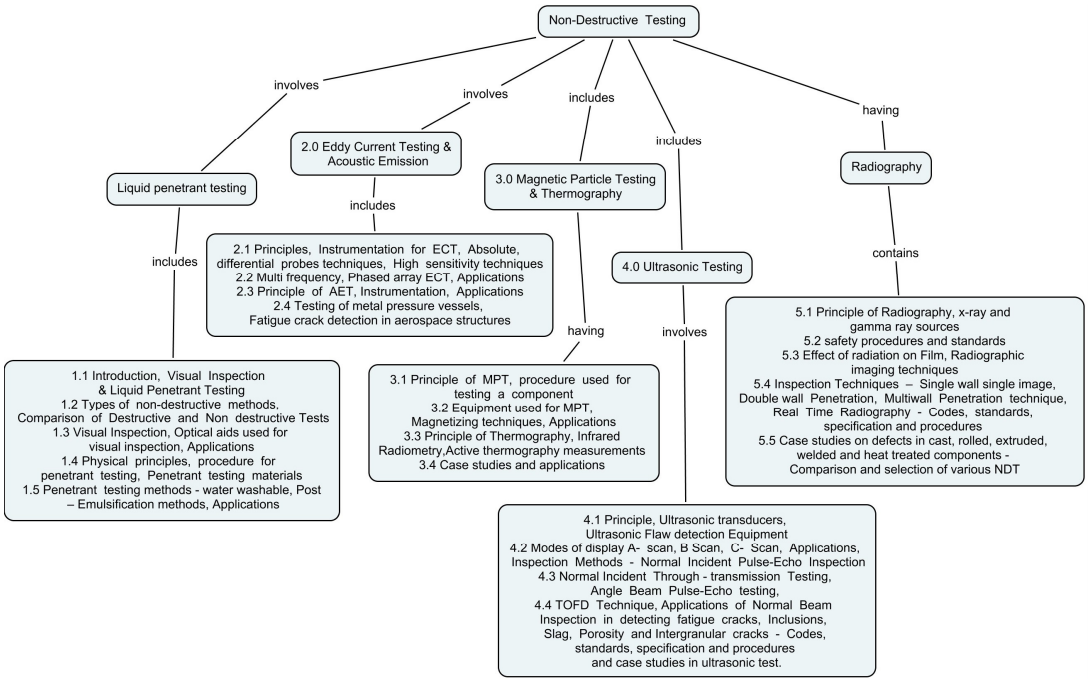
Course Outcome 4 (CO4):

1. What is the principle of ultrasonic testing?
2. Explain the transmission testing process with necessary illustrations.
3. Suggest a suitable process to find the porosity and intergranular cracks and also explain the process.

Course Outcome 5 (CO5):

1. State the principle of radiography?
2. Discuss the effect of radiation on thin film.
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 & Liquid Penetrant Testing Types of non-destructive methods, Comparison of Destructive and Non destructive Tests, Visual Inspection, Optical aids used for visual inspection, Applications. Physical principles, procedure for penetrant testing, Penetrant testing materials, Penetrant testing methods-water washable, Post – Emulsification methods, Applications

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

Magnetic Particle Testing & Thermography : Principle of MPT, procedure used for testing a component, Equipment used for MPT, Magnetizing techniques, Applications. Principle of Thermography, 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, 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

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.

Course contents and Lecture schedule

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	2
1.3	Visual Inspection, Optical aids used for visual inspection, Applications	2
1.4	Physical principles, procedure for penetrant testing, Penetrant testing materials	2
1.5	Penetrant testing methods - water washable, Post – Emulsification methods, Applications	3
2.0	**Eddy Current Testing & Acoustic Emission**	
2.1	Principles, Instrumentation for ECT, Absolute, differential probes techniques, High sensitivity techniques	3
2.2	Multi frequency, Phased array ECT, Applications	
2.3	Principle of AET, Instrumentation, Applications	3
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,	2
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, Applications, Inspection Methods - Normal Incident Pulse-Echo Inspection,	2
4.3	Normal Incident Through - transmission Testing, Angle Beam Pulse-Echo testing	2
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.	3
5.0	**Radiography**	
5.1	Principle of Radiography, x-ray and gamma ray sources	2
5.2	safety procedures and standards,	1
5.3	Effect of radiation on Film, Radiographic imaging techniques	2
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	2

Module Number	Topics	No. of Lectures
	NDT	
	Total	**46**

Course Designer:

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14MGPZ0 **FRICTION STIR WELDING** (2016-17)

Category	L	T	P	Credit
PE	4	0	0	4

Preamble

Friction-stir welding (FSW) is a solid-state joining process (the metal is not melted) that uses a third body tool to join two facing surfaces. Heat is generated between the tool and material which leads to a very soft region near the FSW tool. It then mechanically intermixes the two pieces of metal at the place of the joint, then the softened metal (due to the elevated temperature) can be joined using mechanical pressure (which is applied by the tool), much like joining clay, or dough. It is primarily used on aluminium, and most often on extruded aluminium (non-heat treatable alloys), and on structures which need superior weld strength without a post weld heat treatment. This course aims to provide working principle of FSW, Material deformation, joint formation, equipment and Industrial applications of FSW.

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 working principle of friction stir welding process	Understand	80	70
CO2	Explain the working principles of machines/equipments used for friction stir welding process	Understand	80	70
CO3	Choose the process parameters involved in friction stir welding process	Apply	70	60
CO4	Examine the suitable conditions or joining methods for fabrication/assembly of products	Apply	70	60

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	M	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	20	20	20	20
Understand	60	50	50	50
Apply	20	30	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):

4. State the principle of working of friction stir welding.
5. Mention some materials used with friction stir welding.
6. List the industrial applications of friction stir welding.

Course Outcome 2 (CO2):

4. Explain the material deformation and joint formation in friction stir welding process.
5. Why friction stir welding process is called thermo-mechanical joining process?
6. Explain in details about the various equipment used in friction stir welding process.

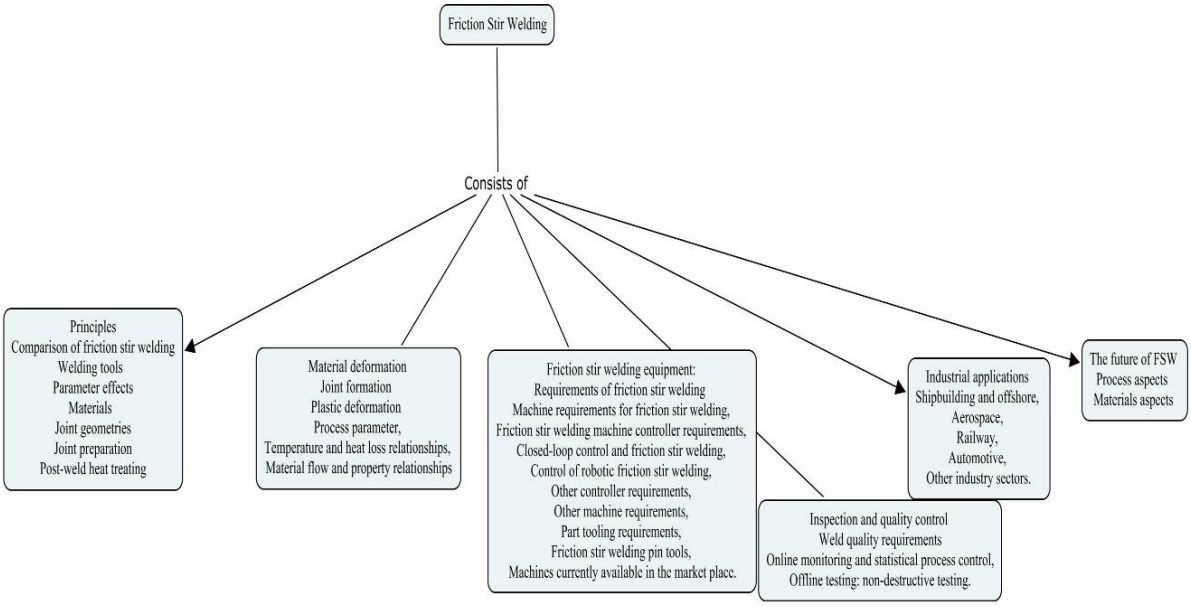
Course Outcome 3 (CO3):

4. Suggest the suitable process parameter need to weld two dissimilar metal matrix composites.
5. Suggest the suitable design of friction stir welding pin tools for welding of dissimilar aluminium alloys.
6. Discuss about the process parameters involved in friction stir welding process.

Course Outcome 4 (CO4):

4. Explain the process of post-weld heat treatment in FSW.
5. Suggest few techniques to inspect welding defects in friction stir welding process.
6. Suggest a suitable industry in which friction stir welding can be used.

Concept Map



Syllabus

Introduction to Friction stir welding (FSW) process: an overview, principles, Comparison of friction stir welding to other welding processes, Welding tools used for friction stir welding , Parameter effects, Materials used with friction stir welding , Joint geometries, Joint preparation, Post-weld heat treating,

Material deformation and joint formation in friction stir welding: A thermo-mechanical joining process, Plastic deformation in relation to material properties, Process parameter, temperature and heat loss relationships, Material flow and property relationships of the resultant friction stir welded joint

Friction stir welding equipment: Requirements of friction stir welding coming from the process and applications, Overview of the machine requirements for friction stir welding, Friction stir welding machine controller requirements, Closed-loop control and friction stir welding, Control of robotic friction stir welding, Other controller requirements, Other machine requirements, Part tooling requirements, Friction stir welding pin tools, Machines currently available in the market place.

Inspection and quality control in friction stir welding: Weld quality requirements, online monitoring and statistical process control, Destructive testing-Offline testing: non-destructive testing.

Industrial applications of friction stir welding: Introduction- Shipbuilding and offshore, Aerospace, Railway, Automotive, Other industry sectors.

The future of friction stir welding: Process aspects of friction stir welding, Materials aspects of friction stir welding.

Reference Books

1. Rajiv Sharan Mishra, Partha Sarathi De, Nilesh Kumar “Friction Stir Welding and Processing” Springer International Publishing Switzerland, 2014.

2. Daniela Lohwasser and Zhan Chen M. “Friction stir welding from basics to applications”, Woodhead Publishing India Private Limited, New Delhi, 2010.

3. Mohammad Kazem Besharati Givi and Parviz Asadi “Advances in Friction Stir Welding and Processing” Woodhead Publishing Limited, UK, 2014.

4. Nilesh Kumar, Rajiv S. Mishra, John A. Baumann “Residual Stresses in Friction Stir Welding”, Butterworth-Heinemann publications , USA, 2014.

Course contents and Lecture schedule

Module Number	Topics	No. of Lectures
1.0	**Introduction to Friction stir welding (FSW) process**	
1.1	Introduction, an overview, principles, Comparison of friction stir welding to other welding processes,	2
1.2	Welding tools used for friction stir welding , Parameter effects	2
1.3	Materials used with friction stir welding , Joint geometries,	2
1.4	Joint preparation, Post-weld heat treating	2
2.0	**Material deformation and joint formation in friction stir welding**	
2.1	A thermo-mechanical joining process, Plastic deformation in relation to material properties	2
2.2	Process parameter, temperature and heat loss relationships	3
2.3	Material flow and property relationships of the resultant friction stir welded joint	3
3.0	**Friction stir welding equipment**	
3.1	Requirements of friction stir welding coming from the process and applications, Overview of the machine requirements for friction stir welding	2
3.2	Friction stir welding machine controller requirements, Closed-loop control and friction stir welding	2
3.3	Control of robotic friction stir welding, Other controller requirements	2
3.4	Other machine requirements, Part tooling requirements	2
3.5	Friction stir welding pin tools, Machines currently available in the market place	2
4.0	**Inspection and quality control in friction stir welding**	
4.1	Weld quality requirements, online monitoring and statistical process control	2
4.2	Offline testing: non-destructive testing	2
5.0	**Industrial applications of friction stir welding**	

Module Number	Topics	No. of Lectures
5.1	Shipbuilding and offshore	2
5.2	Aerospace, Railway	2
5.3	Automotive, Other industry sectors.	2
6.0	**The future of friction stir welding**	
6.1	Process aspects of friction stir welding	2
6.2	Materials aspects of friction stir welding.	2
	Total	**40**

Course Designers:

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