CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Production Engineering) PROGRAMME

FIRST SEMESTER SUBJECTS

&

LIST OF ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015, TAMILNADU

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Passed in BOS meeting held on 20.08.2011

Department of Mechanical Engineering

Graduating Students of M.E. program of Production Engineering will be able to:

1. Plan the advanced manufacturing of given mechanical components and systems.
2. Analyze and design Production Engineering Systems.
3. Apply modern management methods to manufacturing of components and systems.
4. Work in a team using common tools and environments to achieve project objectives.

Passed in BOS meeting held on 20.08.2011

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Production Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses						Practical/Project
4th (12)							W41 Project Phase – II 0:12
3rd (16)	W31 Computer Integrated Manufacturing 4:0	WEX Elective - V 4:0	WEX Elective -VI 4:0				W34 Project Phase-I 0:4
2nd (24)	W21 Mechanics of Metal Cutting and Metal Forming 3:1	W22 Tool Design Engineering 3:0	WEX Elective -I 4:0	WEX Elective -II 4:0	WEX Elective - III 4:0	WEX Elective -IV 4:0	W27 Advanced Manufacturing Engineering Laboratory II 0:1
1st (24)	W11 Computational Methods in Engineering 3:1	W12 Optimisation Techniques 4:0	W13 Mechanical Behaviour of Materials 4:0	W14 Industrial Automation and Robotics 3:1	W15 CNC Machine Tool Technology 3:0	W16 Micro Electro Mechanical Systems and Nano Technology 3:1	W17 Advanced Manufacturing Engineering Laboratory I 0:1

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

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
W11	Computational Methods in Engineering	BS	3	1	-	4
W12	Optimisation Techniques	DC	4	-	-	4
W13	Mechanical Behaviour of Materials	DC	4	-	-	4
W14	Industrial Automation and Robotics	DC	3	1	-	4
W15	CNC Machine Tool Technology	DC	3	-	-	3
W16	Micro Electro Mechanical Systems and Nano Technology	DC	3	1	-	4
PRACTICAL						
W17	Advanced Manufacturing Engineering Laboratory I	DC	-	-	1	1
Total						**24**

BS : Basic Science

DC : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

Passed in BOS meeting held on 20.08.2011

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	W11	Computational Methods in Engineering	3	50	50	100	25	50
2	W12	Optimisation Techniques	3	50	50	100	25	50
3	W13	Mechanical Behaviour of Materials	3	50	50	100	25	50
4	W14	Industrial Automation and Robotics	3	50	50	100	25	50
5	W15	CNC Machine Tool Technology	3	50	50	100	25	50
6	W16	Micro Electro Mechanical Systems and Nano Technology	3	50	50	100	25	50
PRACTICAL								
7	W17	Advanced Manufacturing Engineering Laboratory I	3	50	50	100	25	50

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

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

LIST OF ELECTIVE SUBJECTS

S.No.	Sub. Code	Name of the Subjects	Credit
1.	WEA/LEA	Facilities Planning and Layout Design	4
2.	W EB/LEB	Sequencing and Scheduling	4
3.	W EC/LEC	Materials Management	4
4.	W ED/LED	Research Methodology	4
5.	WEE/LEE	Total Quality Management	4
6.	W EF/LEF	Maintenance Engineering and Management	4
7.	WEG/LEG	Machine Vision and its applications in manufacturing	4
8.	WEH/LEH	System Simulation	4
9.	W EI/LEI	Entrepreneurship Development	4
10.	WEJ/LEJ	Product Design and Development	4
11.	W EK/LEK	Design for Manufacture and Assembly	4
12.	WEL/LEL	Robust Design	4
13.	WEM/LEM	Six Sigma	4
14.	WEN/L13	Work Study and Cost Analysis	4
15.	WEO/L14	Quality and Reliability Engineering	4
16.	WEP/L21	Financial Management	4
17.	WEQ/L22	Operations Management	4
18.	WER/L31	Supply Chain Management	4
19.	WES	Computer Aided Design and Geometric Modeling	4
20.	WET	Metal Casting Engineering	4
21.	WEU	Metal Joining Engineering	4
22.	WEV	Fluid Power Automation	4
23.	WEW	Rapid Manufacturing	4
24.	WEY	Mechatronics in Manufacturing	4
25.	WEZ	Non-Traditional Manufacturing Processes	4

Passed in BOS meeting held on 20.08.2011

Sub Code	Lectures	Tutorial	Practical	Credit
W11	3	1	-	4

W11 Computational methods in Engineering 3:1

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.

Competencies

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

1. Express the theory of Boundary Value Problems arising in the study of engineering problems and their applications.
2. Determine Numeric / Approximate solutions for BVPs using several weighted residual methods.
3. Classify the PDEs and solve them numerically using the available familiar methods.
4. Solve the special type of PDEs using some methods involving implicit and explicit schemes.
5. Find the solution for the IVPs using finite element methods and grasp the advantages of them over the other traditional methods.

Assessment pattern

Sl.No	Bloom's category	Test 1	Test 2	Test 3 /End Semester Examinations
1	Remember	10	10	0
2	Understand	30	30	30
3	Apply	60	60	70
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define: Boundary value problems.
2. What are the different kinds of BVPs
3. Define: Residual
4. What are the various weighted residual methods?
5. What is the form of general second order partial differential equations?
6. Write different types of second order PDEs.

Understand:

1. Compare the different kinds of BVPs.
2. Explain perturbation method.
3. Describe the principle of finite difference method.
4. Distinguish between collocation method and moment method.
5. Classify the PDE : $f_{xx} + 2f_{xy} + f_{yy} = 0.$
6. Explain Bender Schmidt scheme.

Apply

1. Describe Hermitian method of solving a BVP.
2. Discuss in detail the process for solving a BVP using Galerkin method.
3. Explain Ritz finite element to solve a BVP.
4. Solve: $\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$ in the square region bounded by $x = 0$; $x = 4$; $y = 0$; $y = 4$

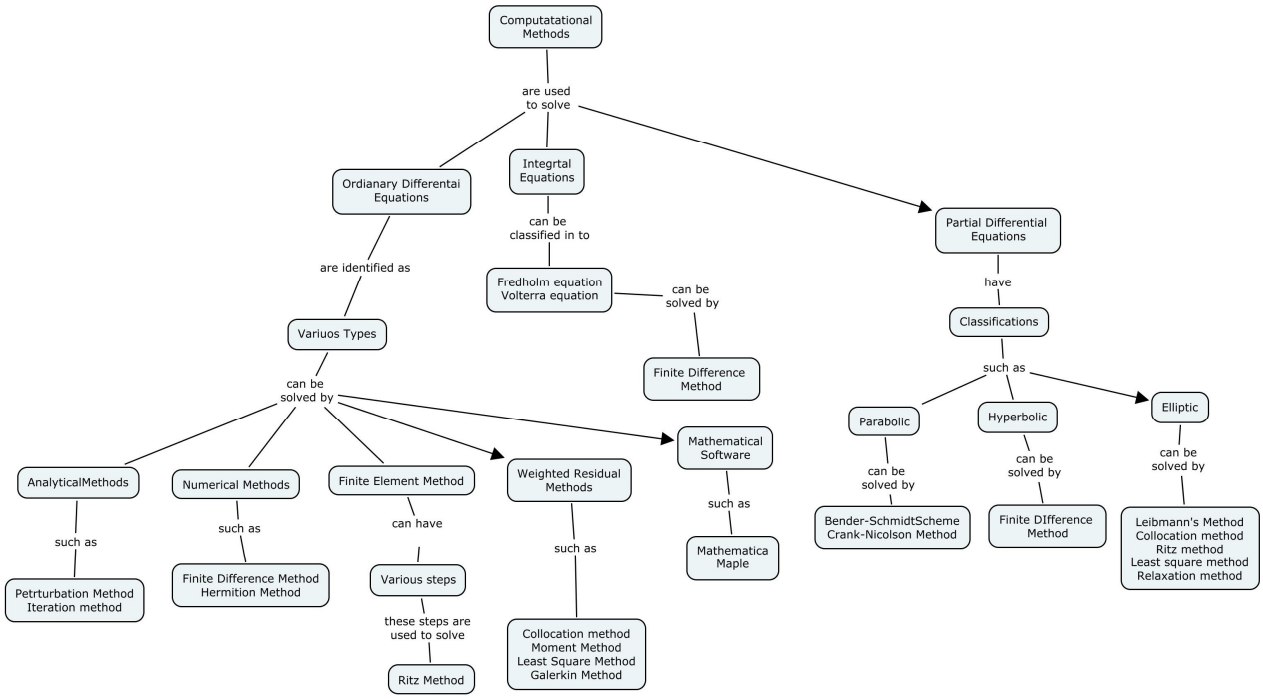
   with Boundary conditions

   $u(0, y) = 0$; $u(4, y) = 8 + 2y$; $u(x,0) = \frac{1}{2}x^2$; $u(x,4) = 2$ *taking* $h = k = 1$.
5. Solve $\frac{\partial^2 u}{\partial x^2} = \frac{\partial u}{\partial t}$ given that

   $u(0,t) = 0$; $u(4,t) = 0$; $u(x,0) = x(4 - x)$ *taking* $h = k = 1$.
6. 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 content and lecture schedule

No	Topic	No. of Lectures
1	**Boundary value problems -BVPs**	
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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Sub Code	Lectures	Tutorial	Practical	Credit
W12/L12	4	-	-	4

W12/L12 Optimisation Techniques 4:0

Preamble

Optimisation 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.

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

1. Formulate mathematical models of Linear Programming (LP), Integer Programming (IP), Dynamic Programming (DP), Networks and Non-linear Programming (NLPP) problems
2. Solve LP problems by graphical, simplex and dual-simplex methods
3. Solve IP problems using branch and bound, and cutting plane method
4. Solve deterministic DP problems using tabular approach
5. Select a suitable network model and apply appropriate technique for flow and project scheduling problems.
6. Solve unconstrained and constrained NLP problems using appropriate techniques.
7. Explain the concept and working of emerging intelligent search techniques such as GA, ACO, PSO, SAA and TS.

Assessment Pattern

Sl.No	Bloom's Category	Test 1	Test 2	Test 3 / End-semester examination
1	Remember	8	8	8
2	Understand	12	12	12
3	Apply	60	60	60
4	Analyze	20	20	20
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

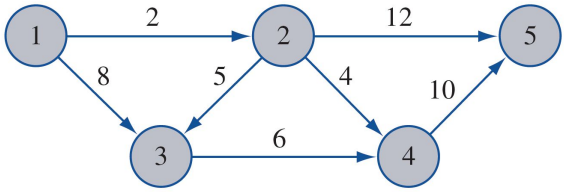
1. What are the characteristics of Linear Programming?
2. Define Bellman's Principle of Optimality?
3. What are the advantages of Dynamic Programming over LPP?
4. What do you mean by residuals in Maximal flow network?
5. Name any four applications of minimal spanning problems.
6. What is the importance of Lagrangian Multiplier?
7. When a problem is considered to be a Non-Linear Programming Problem (NLPP)?
8. What are the advantages of Genetic algorithm over conventional optimization?

Understand

1. What is the importance of the slack variables in simplex method?
2. How to find that a LPP has got an alternate optimal solution from the optimal simplex table?
3. How the condition for fathoming is evaluated in an Integer Programming Problem (IPP)?
4. Differentiate goal and constraint in Goal Programming.
5. Differentiate exploratory search and pattern move in Hooke-Jeeves search method?
6. In what types of problem intelligent heuristics are used?

Apply

1. Find the shortest path from node 1 to node 6 using Djikstra's algorithm.



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

	Tonnes of raw material per tonne of		
	Exterior Paint	Interior Paint	Maximum Daily Availability (Tonnes)
Raw Material, M_1	6	4	24
Raw Material, M_2	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.

3. 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.

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	-	-

4. Solve the following Non linear Programming Problem (NLPP),

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

Subject to constraints,

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

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

5. Solve the following NLP: $Minimise \quad Z = \quad x_1^{\,2} + x_2^{\,2}$

Subject to $x_1 + 2x_2 \le 15$

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

6. How to code a chromosome or string for representing a feasible solution with an accuracy four decimals for solving the following NLP problem:

$Minimise \quad Z = x_1^{\frac{3}{2}} - x_2^{\,2}$;Subject to $-10 \le x_1 \le 10 \qquad 1 \le x_2 \le 10$

Analyse

1. A project consists of 9 activities and the three time estimates are given below.

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?

2. An organization can produce a particular component for passenger cars, jeeps and trucks. The production of the component requires utilization of sheet metal working and painting facilities, the details of which are given below:

Resource	Consumption to produce a unit for			Availability
	Passenger Car	Jeep	Truck	
Sheet metal working	0.25 hr.	1 hr.	0.5 hr.	12
Painting	0.5 hr.	1 hr.	2 hr.	30

The profits that can be earned by the three categories of the components, i.e for passenger cars, jeeps and trucks are Rs. 600, Rs. 1400 and Rs. 1300, respectively.

a) What additional profit would be earned than the optimal product mix of the current scenario by increasing the availability of:

   i. Sheet metal working shop by an hour only

   ii. Painting shop by an hour only

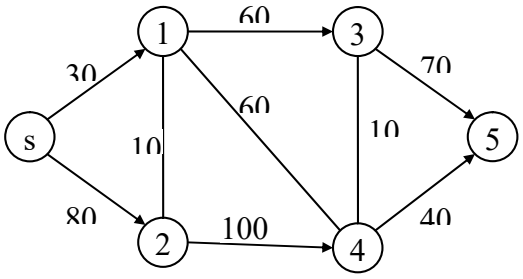
b) What would be the effect on the profit earned if at least one component for jeep had to be produced?

3. Minimise the following objective function using a Golden Section search. Use a resolution of $\varepsilon = 0.10$. $f(x) = 3x^4 + (x-1)^2$; $4 \geq x \geq 0$. Compare the results of this objective function, if it is carried out for 6 evaluations of Fibonacci method.

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. Consider a street network as shown below:



The numbers on the arcs represent the traffic flow capacities. The problem is to place one-way signs on streets not already oriented so as to maximize the traffic flow from the point 's' to the point 'n'. What will be the change in the flow if nodes 1-4 and 3-4 made into one-way flow and discuss the inference of the same.

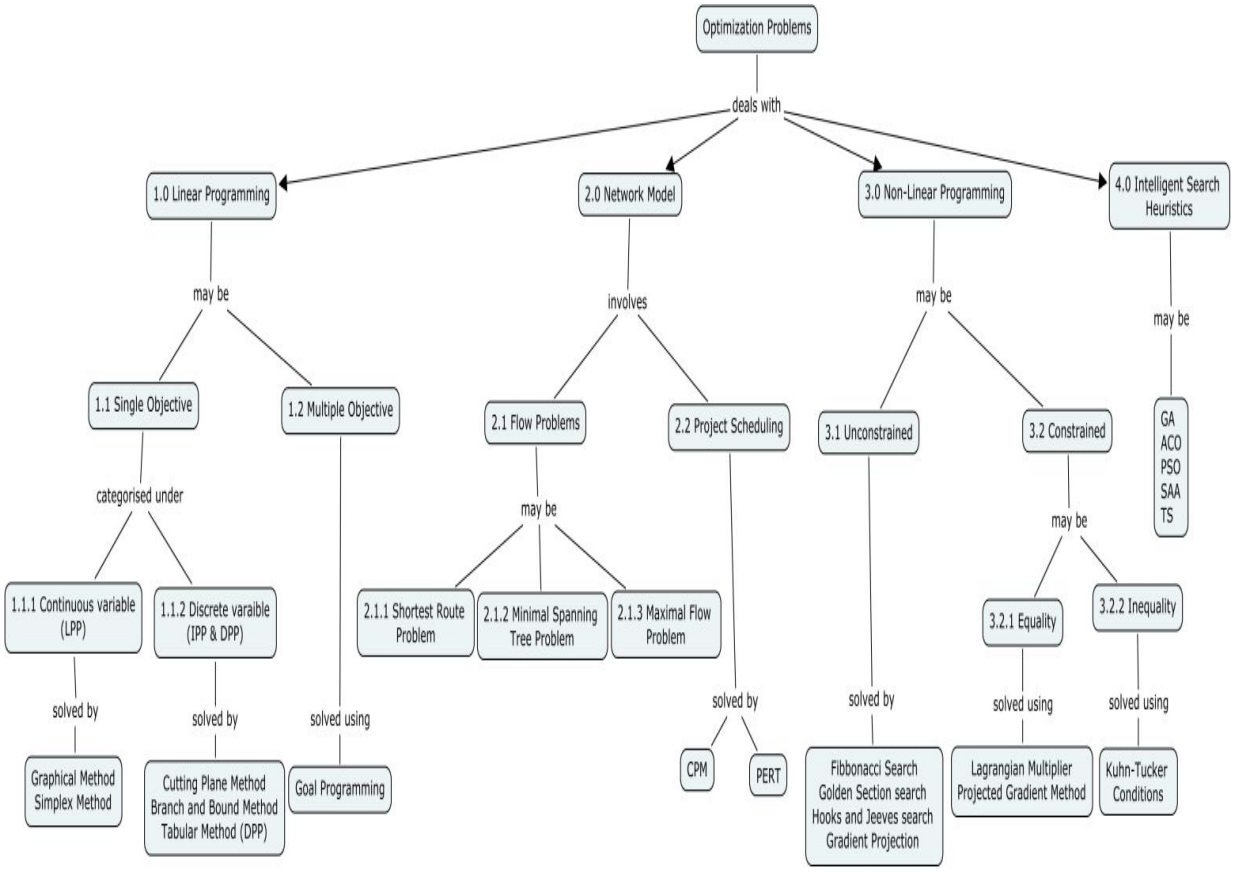
6. Solve the following NLP problem using projected gradient projection method.

$$Minimise \quad f(x) = (x_1 - 3)^2 + (x_2 - 4)^2$$

Subject to $2x_1 + x_2 = 15$

Is it possible to solve this NLP problem using Lagrangian multipliers? Discuss alternate methods to solve solving this problem**.**

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

1. Hamdy A. Taha, "Operations Research - An Introduction", MacMillan Co., Seventh Edition 2003.
2. A. Ravindran, Don. T. Phillips, and James J. Solberg, "Operations Research - Principles and Practice", John Wiley and Sons, Second Edition, Copy right 2000.
3. Srinath. L. S., "PERT and CPM Principles and Applications", Affiliated East West Press Pvt. Ltd., NewDelhi, 1975.
4. Hiller / Lieberman, " Introduction to Operations Research" Tata McGraw Hill, Seventh Edition, 2001
5. Ronald L Rardin, "Optimisation in Operations Research" Pearson Education Asia, First Indian reprint, 2002
6. Kalyanmoy Deb, "Optimisation for Engineering Design – Algorithms and Examples", Eastern Economy Edition, Prentice Hall of India Private Limited, New Delhi, 1995

Course Contents and Lecture schedule

S.No	Topics	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

S.No	Topics	No. of Lectures
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
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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Sub Code	Lectures	Tutorial	Practical	Credit
W13	4	-	-	4

W13 Mechanical Behaviour of Materials 4:0

Preamble

To impart knowledge in the fields of Strengthening Mechanisms, Fracture Mechanics, Fatigue, Creep, Fracture of metals.

Competencies

1. Explain the various Strengthening Mechanisms.
2. Explain the Fracture Mechanics.
3. Explain the Fatigue of Metals.
4. Explain the Creep Mechanisms.
5. Explain the various types of Fracture.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. List the various strengthening mechanisms in metals.
2. Define fracture toughness.
3. What are surface effects on fatigue?
4. Define creep.
5. What is superplasticity?
6. What is brittle fracture problem?

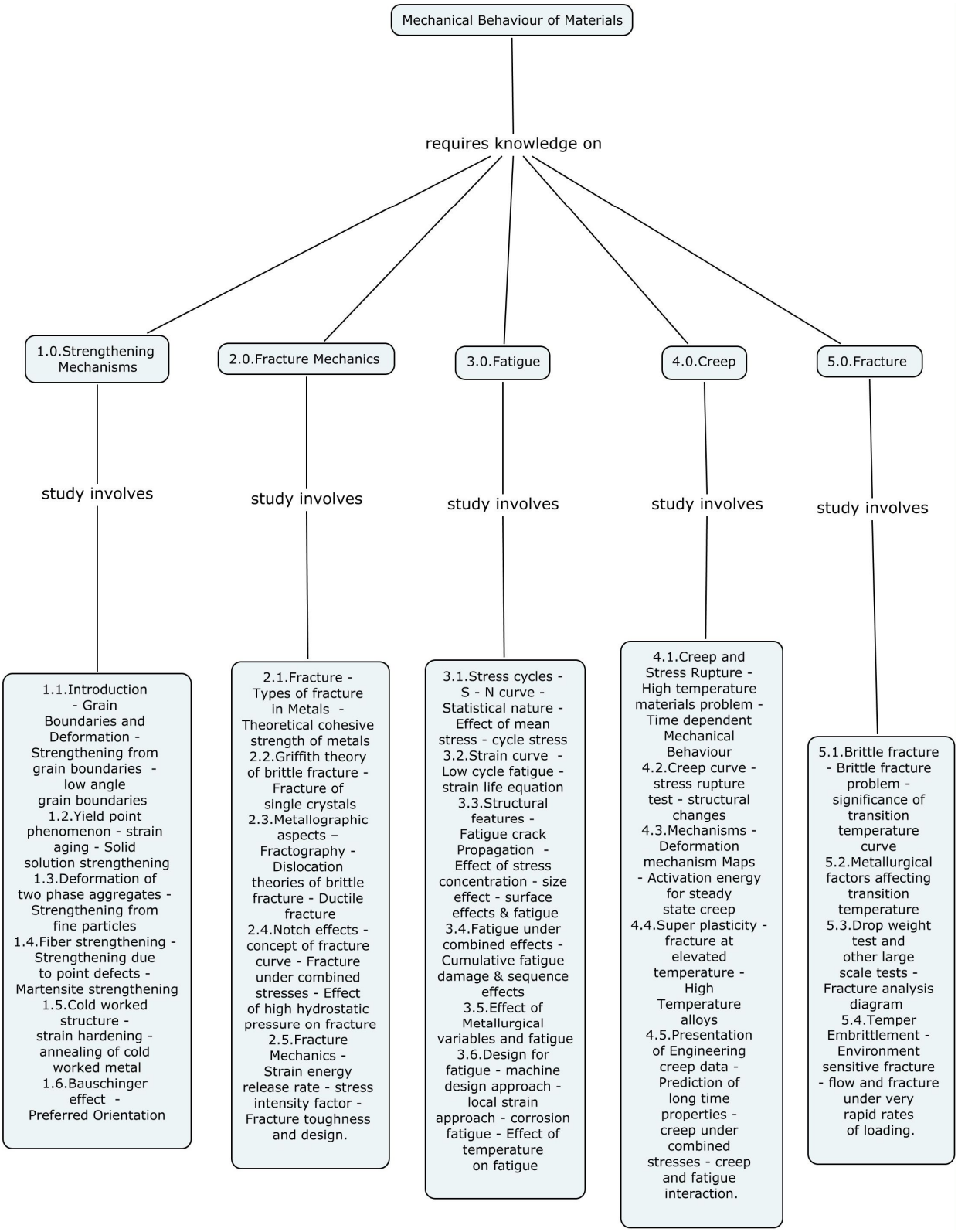
Understand

1. Discuss the theoretical cohesive strength of metals.
2. Describe the strengthening due to point defects.
3. Explain the effects of high hydrostatic pressure on fracture.
4. Describe the effects of metallurgical variables and fatigue.
5. Explain the mechanisms of creep.
6. Describe the metallurgical factors affecting transition temperature.

Apply

1. Explain the mechanisms of fiber strengthening with applications.
2. What is the significance of transition temperature curve?
3. Describe the machine design approach of fatigue.
4. Discuss the High Temperature alloys.
5. Describe the fracture toughness and design.
6. Explain the strengthening from fine particles with examples.

Concept Map


Mechanical Behaviour of Materials
requires knowledge on
1.0.Strengthening Mechanisms
2.0.Fracture Mechanics
3.0.Fatigue
4.0.Creep
5.0.Fracture
study involves
study involves
study involves
study involves
study involves
1.1.Introduction - Grain Boundaries and Deformation - Strengthening from grain boundaries - low angle grain boundaries 1.2.Yield point phenomenon - strain aging - Solid solution strengthening 1.3.Deformation of two phase aggregates - Strengthening from fine particles 1.4.Fiber strengthening - Strengthening due to point defects - Martensite strengthening 1.5.Cold worked structure - strain hardening - annealing of cold worked metal 1.6.Bauschinger effect - Preferred Orientation
2.1.Fracture - Types of fracture in Metals - Theoretical cohesive strength of metals 2.2.Griffith theory of brittle fracture - Fracture of single crystals 2.3.Metallographic aspects – Fractography - Dislocation theories of brittle fracture - Ductile fracture 2.4.Notch effects - concept of fracture curve - Fracture under combined stresses - Effect of high hydrostatic pressure on fracture 2.5.Fracture Mechanics - Strain energy release rate - stress intensity factor - Fracture toughness and design.
3.1.Stress cycles - S - N curve - Statistical nature - Effect of mean stress - cycle stress 3.2.Strain curve - Low cycle fatigue - strain life equation 3.3.Structural features - Fatigue crack Propagation - Effect of stress concentration - size effect - surface effects & fatigue 3.4.Fatigue under combined effects - Cumulative fatigue damage & sequence effects 3.5.Effect of Metallurgical variables and fatigue 3.6.Design for fatigue - machine design approach - local strain approach - corrosion fatigue - Effect of temperature on fatigue
4.1.Creep and Stress Rupture - High temperature materials problem - Time dependent Mechanical Behaviour 4.2.Creep curve - stress rupture test - structural changes 4.3.Mechanisms - Deformation mechanism Maps - Activation energy for steady state creep 4.4.Super plasticity - fracture at elevated temperature - High Temperature alloys 4.5.Presentation of Engineering creep data - Prediction of long time properties - creep under combined stresses - creep and fatigue interaction.
5.1.Brittle fracture - Brittle fracture problem - significance of transition temperature curve 5.2.Metallurgical factors affecting transition temperature 5.3.Drop weight test and other large scale tests - Fracture analysis diagram 5.4.Temper Embrittlement - Environment sensitive fracture - flow and fracture under very rapid rates of loading.

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", McGraw Hill, 1988.
2. Thomas H.Courtney, "Mechanical Behaviour of Materials", Mc Graw Hill, 1990.
3. Roy A. Lindberg, "Processes and Materials of Manufacture", Prentice Hall of India, 1995.

Passed in BOS meeting held on 20.08.2011

Course Contents and Lecture schedule

S.No	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	2
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	2
2.0	**Fracture Mechanics**	
2.1	Fracture - Types of fracture in Metals - Theoretical cohesive strength of metals	2
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
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

S.No	Topics	No. of Lectures
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	50

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
W14/L16	3	1	-	4

W14 / L16 INDUSTRIAL AUTOMATION AND ROBOTICS 3:1

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 learing the basics of Automation, Flexible Manufacturing Systems, Automated Materials Handling and Storage Systems, Robot Kinematics, Robot Programming and its industrial applications.

Program Outcomes Addressed

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

Competencies

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

1. Explain the basics of automation, automated production lines and automated assembly systems.
2. Explain the Automated Materials Handling and Storage Systems.
3. Explain the Flexible Manufacturing Systems.
4. Explain the Robot Kinematics and its industrial applications.

Assessment Pattern

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

Course Level Learning Objectives
Remember

1. What is a production system?
2. What is an automated production line?
3. Define flexibility.
4. Name three categories of AGVs.
5. Name the joint types used in Robotic arms and wrists.

6. What is an end effector?

Understand

1. Describe the automation migration strategy?
2. Name three reasons for including a storage buffer in an automated production line.
3. Discuss the hardware used in parts delivery system.
4. How do external sensors differ from internal sensors?
5. Discuss the Robot programming languages in brief.
6. What characteristics of industrial work situations that demand substitution of robots for human labour?

Apply

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. Illustrate the FMS in-line layouts with examples.
3. Identify the three application areas of AS/RS.
4. Select the suitable sensor for the following applications (a) to indicate distance (b) to indicate the presence (c) Inspection.
5. 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.
6. 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 o f (3, 7, and 9).

Analyse

1. 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.

2. 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.

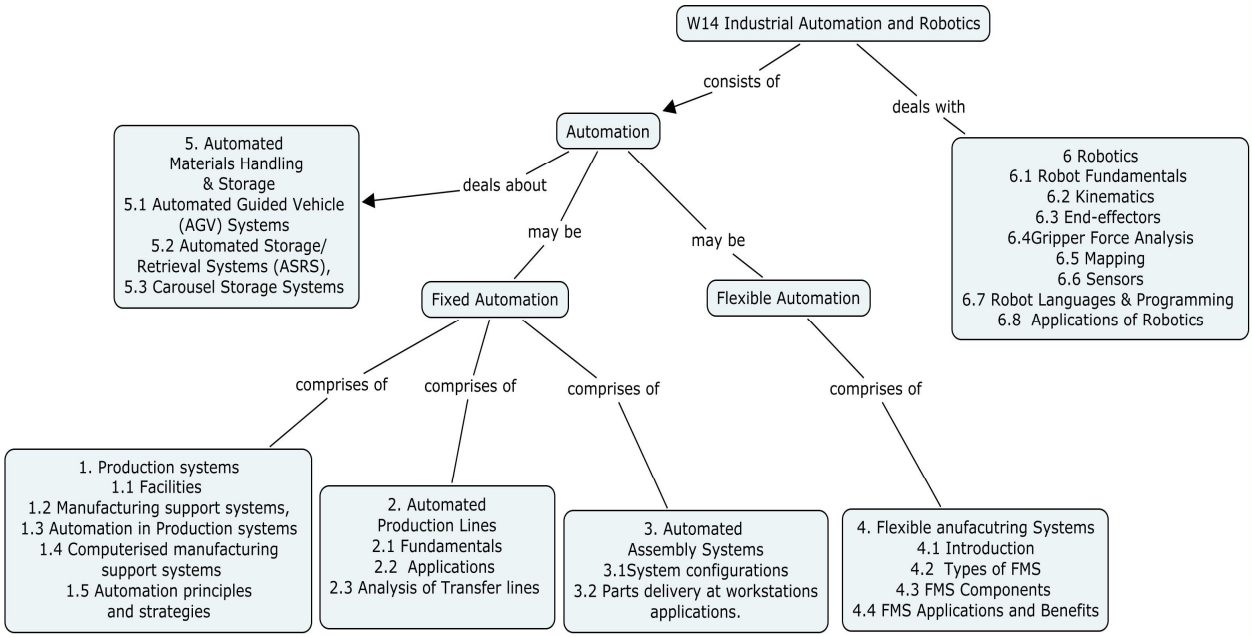
3. A ten-station transfer machine has an ideal cycle time of 30 sec. The frequency of line stops is 0.075 stops per cycle. When a line stop occurs, the average downtime is 4.0 min. Determine (a) average production rate in piece/hour, (b) line efficiency, and (c) proportion downtime.

4. Compare the several possible layouts of the segmented in-line configuration of an automated production line.

5. Distinguish between the first generation and second generation robot languages.

6. Analyse the functional aspects of various translation gripper mechanisms with illustrative sketches.

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", Prentice Hall of India Ltd., Third Edition, New Delhi, 2008.
2. D.M.Considine and G.D. Considine, "Standard Hand book of Industrial Automation", Chapman and Hall, New Jersey, 1986.
3. Radhakrishnan and S. Subramanyan, "CAD/CAM/CIM", New Age International (P) Limited, New Delhi, 1994.
4. Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi 2003.
5. Popov and E.I. Yurevih, "Robotics", MIR Publications, Moscow, 1987.
6. Yoram Koren, "Robotics for Engineers", Tata McGraw Hill - International Edition, 1987.

Course Contents and Lecture schedule

S.No	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

S.No	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	1
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)	1
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

S.No	Topics	No. of Lectures
6.3	Robot End-effectors - Classification - Types of Gripper	1
	Drive Systems for Grippers, Hooks, Scoops and other Miscellaneous Devices	2
6.4	Gripper Force Analysis	1
6.5	Mapping - General mapping and Compound mapping.	1
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	39

Course Designers

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Sub code	Lectures	Tutorial	Practical	Credit
W15	3	0	-	3

W15 CNC Machine Tool Technology 3:0

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.

Competencies

At the end of the course student will be able to

1. Understand the components of a CNC Machine Tools.
2. Select appropriate techniques for assembly of CNC machine tool elements.
3. Trouble shoots the problems that occur in the CNC machine.
4. Program the machine as per product geometry.
5. Select the testing and validation methods for CNC machine tool sub-assembly.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. What is the purpose of turcite?
2. What is solenoid?
3. Draw the axes diagram of turning centre.
4. Write the word address format for G71 finishing cycle.
5. Define oblique cutting.
6. What is idle running?

Understand

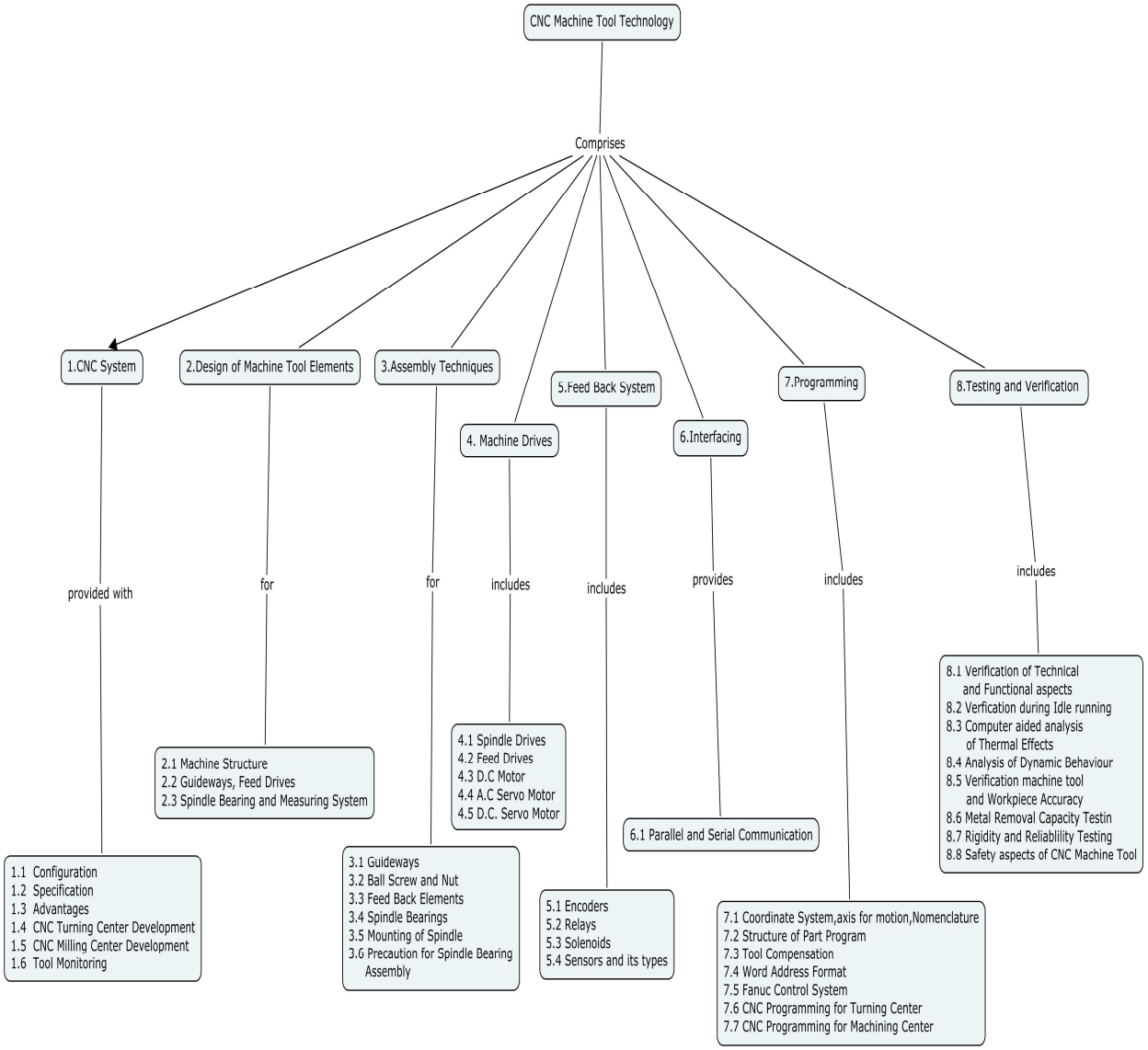
1. Compare the configuration of CNC machining centre and CNC turning centre.
2. Where the large capacity tool magazine is useful?
3. Describe the ballscrew and nut assembly with suitable diagram.
4. Explain the working principle of relay and solenoid with simple block diagram.
5. Why the tool compensation is more important?
6. Why the CNC machine tools are to be tested and validated?

Apply

1. Using manual part programming method, write a CNC part program for machining aluminum component using CNC turning centre for your assumed component. Also, give the detailed process plan and step-by-step descriptions of the CNC program you written.
2. Illustrate the procedure to for analyzing thermal effects on CNC main spindle with suitable diagram.
3. Suggest which type of communication is more suitable for 500 m distance data transfer and describe the principle in detail.
4. Illustrate the linear motion guide way assembly procedure generally followed while CNC machine assembly.
5. What are all the precautions need to be employed while assembling the spindle bearings?
6. Write down a CNC part program for milling operation using FANUC CNC milling machine for a suitable diagram as per you choice.

Passed in BOS meeting held on 20.08.2011

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, Ballscrew 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. Yusuf Altintas, "Manufacturing Automation", Cambridge universal Press, 2000.
3. Peter Smid, "CNC Programming Handbook", Industrial Press Inc., 2000.
4. Newton C. Braga, "Mechatronics Source book", Eswar Press, 2003.
5. Ken Evans, "Programming of CNC Machines", Industrial Press Inc., 2001.
6. PN.Rao, "CAD/CAM Principles and Applications", Tata McGraw hill, 2004.
7. N.Mathivanan, "Micro processors, PC Hardware and Interfacing", Prentice Hall of India, 2003.

Course content

No.	Topic	No. of Lectures
1.	**CNC Systems**	
1.1	Configuration of the CNC systems	1
1.2	Specifications of CNC Turning and Machining center	1
1.3	Advantages of the CNC machines	1
1.4	CNC Turning center development	1
1.5	CNC machining center development	1
1.6	Tool monitoring on CNC machines	1
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	Ballscrew and nut assembly	1
3.3	Feedback elements	2
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
5.3	Solenoids	1
5.4	Sensors and their types	1
6	**Interfacing**	
6.1	Parallel and Serial Communication	2
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	1
	Total	42

Course Designers

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Passed in BOS meeting held on 20.08.2011

Sub Code	Lectures	Tutorial	Practical	Credit
W16	3	1	-	4

W16 Micro Electro Mechanical Systems and Nano Technology 3:1

Preamble

To impart knowledge in manufacturing micro components and measuring systems to nano scale.

Competencies

1. To impart knowledge to the students on micro electromechanical systems, various fabrication techniques and micro actuators.
2. To impart knowledge to the students about nano materials and various nano measurements techniques.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. Define MEMS.
2. What is the function of photoresist?
3. What is diffusion process?
4. List the applications of scanning electron microscopy.
5. What is SLIGA Process?
6. What is the effect of nanoscale dimensions on biological systems?

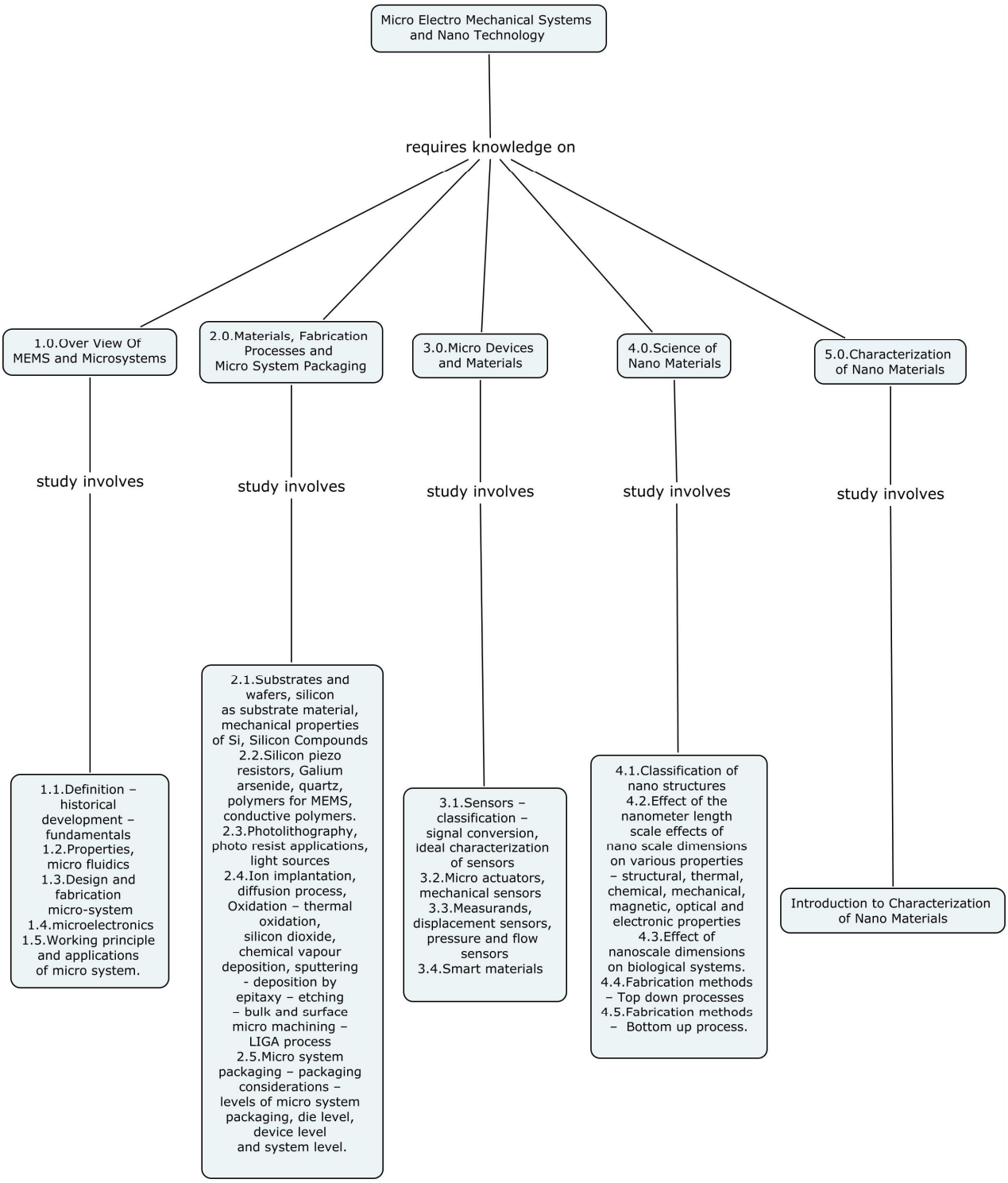
Understand

1. Explain the silicon as substrate material for MEMS applications.
2. Explain the LIGA process.
3. Describe the principle of working of pressure and flow sensors.
4. Explain the principle of working of the scanning electron microscopy
5. Describe in detail the micro actuators.
6. Describe the effects of the nano scale dimensions on various properties.

Apply

1. Discuss the design of a silicon die for pressure sensor.
2. Explain in detail the various CVD processes for MEMS applications.
3. Explain the various types of smart materials with applications.
4. Explain the scanning electron microscopy for different applications.
5. Describe the Top down processes and bottom up process fabrication methods of Nano Materials
6. Discuss the LIGA process with an example.

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, pressure and flow sensors, smart materials – applications. **Introduction to 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 Books

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, 1997.
3. Norio Taniguchi, Nano Technology, Oxford University Press, New York, 2003
4. The MEMS Hand book, Mohamed Gad-el-Hak, 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 1993.

Course Contents and Lecture schedule

S.No	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

S.No	Topics	No. of Lectures
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
3.4	Smart materials - applications.	2
4.0	**Science of Nano Materials**	
4.1	Classification of nano structures	1
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.	2
4.4	Fabrication methods – Top down processes	2
4.5	Fabrication methods – Bottom up process.	2
5.0	**Characterization of Nano Materials**	
5.1	Introduction to Characterization of Nano Materials	2
	Total	42

Course Designers

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2. T.Sornakumar tskmech@tce.edu

Passed in BOS meeting held on 20.08.2011

Sub. Code	Lectures	Tutorial	Practical	Credit
W17	0	0	1	1

W17 Advanced Manufacturing Engineering Laboratory - I 0:1

Objective

- To develop skill in 2D sketch, 3D Modeling and Assembly modeling.
- To develop skill in machining and inspection of surfaces/tools.

(At least 12 exercises are to be completed)

List of Exercises

I. Modeling using CAD software

1. Development of 2D Models – 2 Exercises
2. Development of 3D Models like Piston and Brackets – 2 Exercises
3. Assembly Modeling – 2 Exercises (like Screw Jack, Stop Valve)

II. Machining and Inspection

1. Influence of process parameter on surface quality (Turning / Milling / Grinding / EDM/ Lapping) – 2 Exercises
2. Grinding and inspection of single point cutting tool
3. Measurement of profile/dimensions (using CMM / Profile Projector / Tool makers microscope) – 2 Exercises
4. Testing of straightness of a straight edge/flatness of a surface

Facilities Required:

1. **Software**

   Pro/E and CATIA

2. **Hardware**

   Grinding machines – Surface, Cylindrical and Tool & Cutter

   Lapping machine / EDM/Universal Milling machine

   Profile Projector/Tool Maker's Microscope/CMM

   Surface roughness tester/Autocollimator

Course Designers

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Passed in BOS meeting held on 20.08.2011

CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Production Engineering) PROGRAMME

SECOND SEMESTER SUBJECTS

&

LIST OF ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015, TAMILNADU

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Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Production Engineering) PROGRAMME

Scheduling of Courses

Sem.	**Theory Courses**						**Practical/Project**
4th (12)							W41 Project Phase – II 0:12
3rd (16)	W31 Computer Integrated Manufacturing 4:0	WEX Elective - V 4:0	WEX Elective -VI 4:0				W34 Project Phase-I 0:4
2nd (24)	W21 Mechanics of Metal Cutting and Metal Forming 4:0	W22 Tool Design Engineering 3:0	WEX Elective -I 4:0	WEX Elective -II 4:0	WEX Elective -III 4:0	WEX Elective -IV 4:0	W27 Advanced Manufacturing Engineering Laboratory II 0:1
1st (24)	W11 Computational Methods in Engineering 3:1	W12 Optimisation Techniques 4:0	W13 Mechanical Behaviour of Materials 4:0	W14 Industrial Automation and Robotics 3:1	W15 CNC Machine Tool Technology 3:0	W16 Micro Electro Mechanical Systems and Nano Technology 3:1	W17 Advanced Manufacturing Engineering Laboratory I 0:1

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
W11	Computational Methods in Engineering	BS	3	1	-	4
W12	Optimisation Techniques	DC	4	-	-	4
W13	Mechanical Behaviour of Materials	DC	4	-	-	4
W14	Industrial Automation and Robotics	DC	3	1	-	4
W15	CNC Machine Tool Technology	DC	3	-	-	3
W16	Micro Electro Mechanical Systems and Nano Technology	DC	3	1	-	4
PRACTICAL						
W17	Advanced Manufacturing Engineering Laboratory I	DC	-	-	1	1
Total						**24**

BS : Basic Science

DC : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

FIRST SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	W11	Computational Methods in Engineering	3	50	50	100	25	50
2	W12	Optimisation Techniques	3	50	50	100	25	50
3	W13	Mechanical Behaviour of Materials	3	50	50	100	25	50
4	W14	Industrial Automation and Robotics	3	50	50	100	25	50
5	W15	CNC Machine Tool Technology	3	50	50	100	25	50
6	W16	Micro Electro Mechanical Systems and Nano Technology	3	50	50	100	25	50
PRACTICAL								
7	W17	Advanced Manufacturing Engineering Laboratory I	3	50	50	100	25	50

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

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
W21	Mechanics of Metal Cutting and Metal Forming	DC	4	-	-	4
W22	Tool Design Engineering	DC	3	-	-	3
WEX	Elective – I	DE				4
WEX	Elective – II	DE				4
WEX	Elective – III	DE				4
WEX	Elective – IV	DE				4
PRACTICAL						
W27	Advanced Manufacturing Engineering Laboratory II	DC	-	-	1	1
Total						**24**

BS : Basic Science

DC : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

SECOND SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	W21	Mechanics of Metal Cutting and Metal Forming	3	50	50	100	25	50
2	W22	Tool Design Engineering	3	50	50	100	25	50
3	WEX	Elective – I	3	50	50	100	25	50
4	WEX	Elective – II	3	50	50	100	25	50
5	WEX	Elective – III	3	50	50	100	25	50
6	WEX	Elective – IV	3	50	50	100	25	50
PRACTICAL								
7	W27	Advanced Manufacturing Engineering Laboratory II	3	50	50	100	25	50

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

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

LIST OF ELECTIVE SUBJECTS

S.No.	Sub. Code	Name of the Subjects	Credit
1.	WEA/LEA	Facilities Planning and Layout Design	4
2.	W EB/LEB	Sequencing and Scheduling	4
3.	W EC/LEC	Materials Management	4
4.	W ED/LED	Research Methodology	4
5.	WEE/LEE	Total Quality Management	4
6.	W EF/LEF	Maintenance Engineering and Management	4
7.	WEG/LEG	Machine Vision and its applications in manufacturing	4
8.	WEH/LEH	System Simulation	4
9.	W EI/LEI	Entrepreneurship Development	4
10.	WEJ/LEJ	Product Design and Development	4
11.	W EK/LEK	Design for Manufacture and Assembly	4
12.	WEL/LEL	Robust Design	4
13.	WEM/LEM	Six Sigma	4
14.	WEN/L13	Work Study and Cost Analysis	4
15.	WEO/L14	Quality and Reliability Engineering	4
16.	WEP/L21	Financial Management	4
17.	WEQ/L22	Operations Management	4
18.	WER/L31	Supply Chain Management	4
19.	WES	Geometric Modeling	4
20.	WET	Metal Casting Engineering	4
21.	WEU	Metal Joining Engineering	4
22.	WEV	Fluid Power Automation	4
23.	WEW	Rapid Manufacturing	4
24.	WEY	Mechatronics in Manufacturing	4
25.	WEZ	Non-Traditional Manufacturing Processes	4

Sub Code	Lectures	Tutorial	Practical	Credit
W21	4	-	-	4

W21 Mechanics of Metal Cutting and Metal Forming 4:0

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.

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

1. Calculate the forces, stresses acting on in a single point tool during machining
2. Explain the heat generation and its distribution in an orthogonal machining
3. Explain the effect of speed, feed and depth of cut in an orthogonal machining
4. Explain various tool wear and its process conditions
5. Explain the effect of cutting parameters on tool life
6. Choose appropriate tool material for specified machining process
7. Convert tool specifications between systems of nomenclature (American, German and ISO systems)
8. Explain the theory of plasticity
9. Explain the effect of combined stresses and anisotropy on forming processes
10. Determine the flow stresses in forming methods
11. Explain the effect of temperature, friction and strain rate in forming methods

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. What do you 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?
4. State the major characteristics of tool material?
5. What is Flow Curve?
6. How metal working processes are classified?
7. What is need of annealing after cold working?

Understand

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

Apply

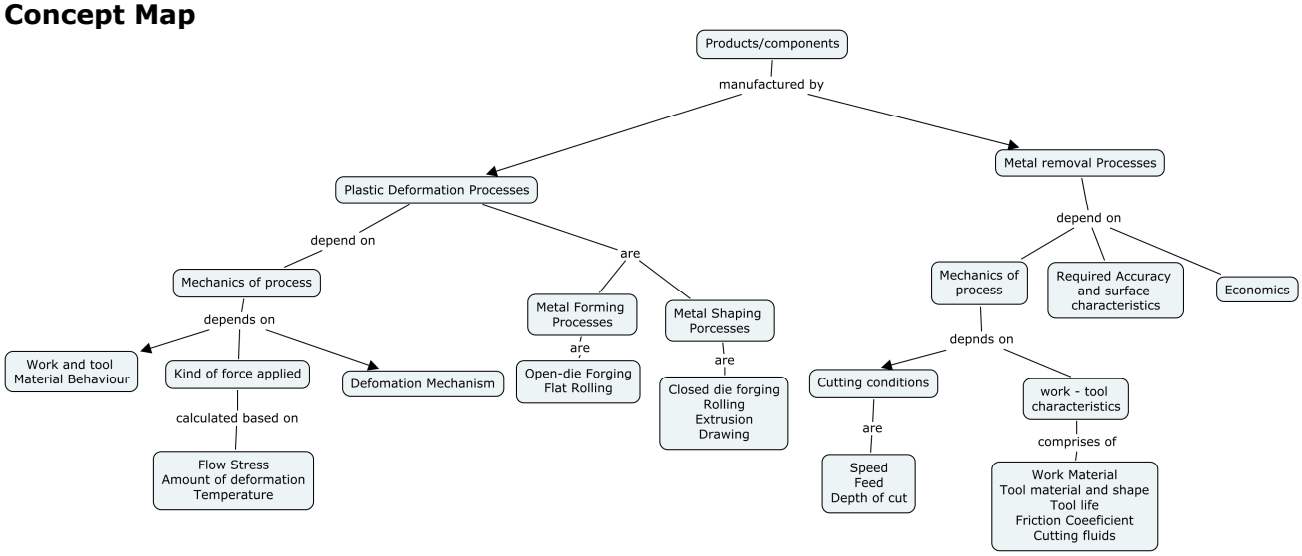
1. A large batch of steel shafts is to be rough turned to 76 mm diameter for 300 mm of their length at a feed of 0.25mm. A brazed type carbide tool is to be used, and the appropriate constants in Taylor's tool life equation for the conditions employed are as follows: n=0.25, and v_r = 4.064m/s when t_r = 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.
4. 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.
5. 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.

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, ISO System) – Interrelations between different systems of nomenclature – Setting System – Grinding of 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 1995.
2. George E. Dieter. "Mechanical Metallurgy", McGraw-Hill Book Company, London. 1988.
3. M.C. Shaw, "Metal Cutting Principles", CBS Publishers, New Delhi, 2003.
4. A. Bhattacharya, "Metal Cutting Theory and Practice", New Central Book Agency (P), Ltd., Edition. 1984.
5. G. Kuppusamy. "Principles of Metal Cutting", Universities Press (India) Ltd., 1996.
6. B.L.Juneja, G.S.Sekhon and N.Seth, "Fundamentals of Metal cutting and Machine Tools", 2nd Edition, Newage International (P) Ltd, New Delhi, 2001.
7. P.C. Pandey and C.K. Singh. "Production Engineering Sciences", Standard Publishers Distributors. New Delhi. 1992.
8. HMT, "Production Technology", Tata McGraw Hill Publishing Company Ltd., New Delhi. 1980.

Course Contents and Lecture schedule

S.No	Topics	No. of periods
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	2
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

S.No	Topics	No. of periods
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, ISO System)	2
19.	Interrelations between different systems of nomenclature	1
20.	Setting System – Grinding of 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 Hours	**45**

Course Designers

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2. S. Saravana Perumaal – sspmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
W22	3	0	-	3

W22 Tool Design Engineering 3:0

(Use of approved Data Books are permitted in the Terminal Examination)

Preamble

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, NC machine tooling and Design of gauges to meet the industrial needs.

Competencies

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

1. Design of sheet metal blanking and piercing dies
2. Design of bending, forming and drawing dies
3. Design of Jigs and Fixtures
4. Design of cutting tools
5. Explain NC machine tooling
6. Design of gauges

Assessment Pattern

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

Course Level Learning Objectives

Remember

1.What is the shut height of a press?

2.What is coining?

3.What problems are caused by burrs?

4.Differentiate Locating and Clamping.

5.What are the advantage of magnetic chucks?

6.What are the various methods of production milling?

Understand

1.Describe in detail the boring Fixtures.

2.Explain in detail the various types of drill jigs.

3.Discuss in detail the various locating methods and devices.

4.Explain in detail any one type of milling cutter.

5.Explain in detail the tool presetting in NC machine tools.

6.Discuss in detail the tool holding methods in NC machine tools.

Apply

1.Design a blanking die to blank the C15 steel washer of Outer diameter 20mm and Inner diameter 15 mm and of thickness 2 mm.

2.Discuss the general considerations in design of drill jigs.

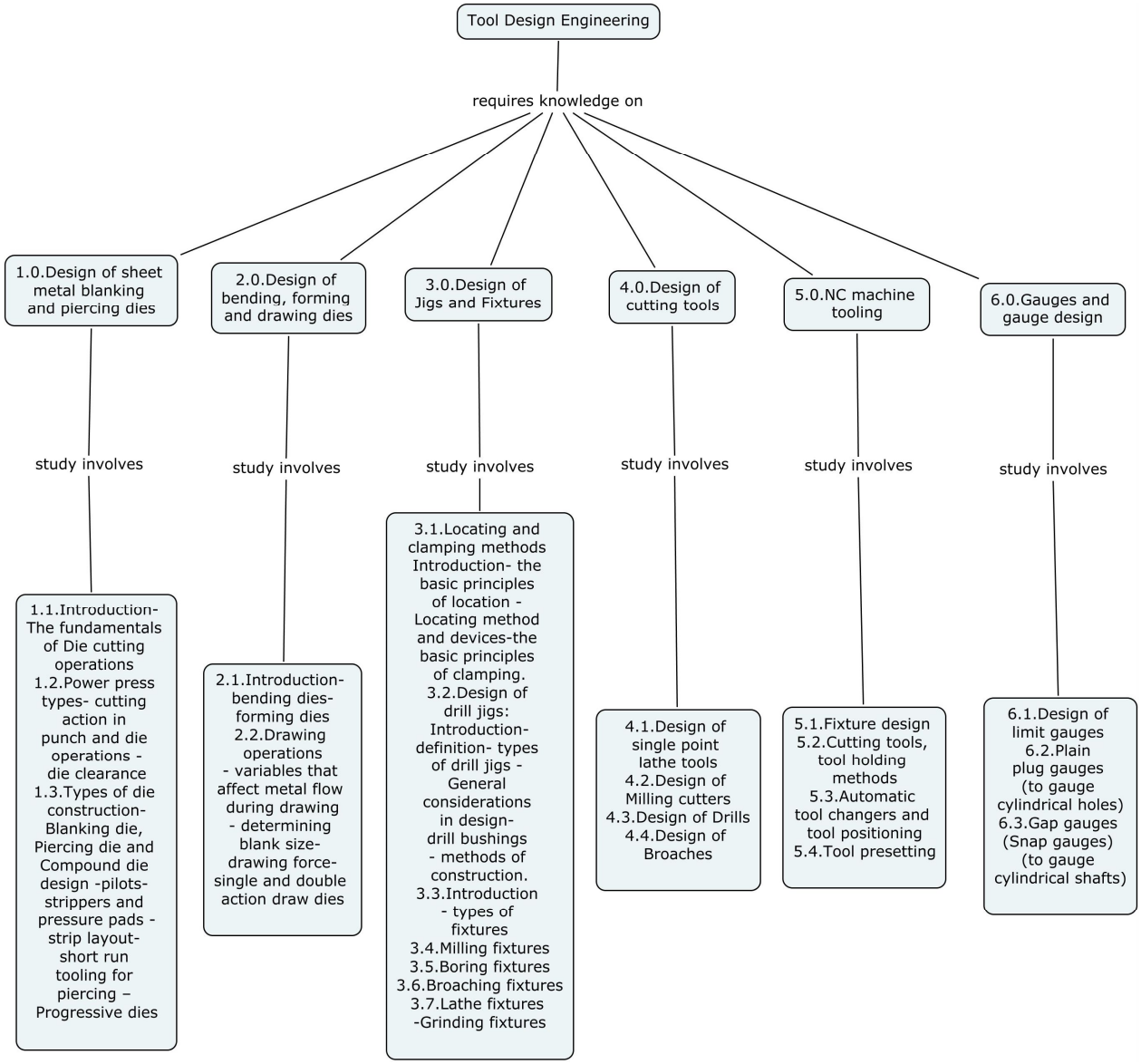
3.Draw and explain the box type drill jig.

4.Discuss in detail the design steps of any one type milling cutter.

5.Draw and explain the Tool presetting for a CNC Vertical machining center.

6.Design a plain plug limit gauge for measurement holes of 20 plus or minus 40 microns hole.

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. **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, 2003.
2. ASTME, "Fundamentals of Tool Design", Prentice Hall of India, 2003.
3. Edward G. Hoffman, "Jig and Fixture", Delmor Publishers, 1996.
4. M.H.A.Kempster, "An Introduction to Jig and Tool Design", Viva books, 1998.
5. V.Arshinov and G.Alekseev, "Metal Cutting Theory and Cutting Tool Design", Mir Publishers, 1976.
6. G.R.Nagpal, "Tool Engineering and Design", Khanna Publishers, New Delhi, 1998.
7. ASTME, Handbook of Industrial Metrology, Prentice Hall of India, 1988.
8. R. K. Jain, Engineering Metrology, Khanna Publishers, New Delhi, 2009.
9. William Boyes , Handbook of Jig and Fixture Design, SME, 1989.
10. P.S.G. Tech., "Design Data Book", Kalaikathir Achchagam, Coimbatore, 2003.

Course Contents and Lecture schedule

Sl. No	Topic	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	2
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	4
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.	3
3.0	**Design of Jigs and Fixtures**	
3.1	Locating and clamping methods : Introduction- the basic principles of	2

Sl. No	Topic	No. of Lectures
	location - Locating method and devices-the basic principles of clamping.	
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	2
3.7	Lathe fixtures -Grinding fixtures.	2
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
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	41

Course Designers

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

Sub Code	Lectures	Tutorial	Practical	Credit
W27	0	0	1	1

W27 Advanced Manufacturing Engineering Laboratory II 0:1

Objective

- To develop skill in analysing Geometric models.
- To develop skill in CNC code generation, Robot programming, Simulation of manufacturing, casting system and design of pneumatic & hydraulic circuit.

(At least 12 exercises need to be completed)

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 using MasterCAM.
2. Generate the CNC code for drilling and rectangular pocket using MasterCAM.
3. Do the pattern drilling operation using Traic Milling machine
4. Write a VAL off line Robot Programming for pick and place operation.

III. Manufacturing Simulation

1. Simulate a FMC using ProModel
2. Simulate an assembly line with 3 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 using HydroSIM software
2. Simulation of sequencing operation (A+B-B+A-) using FESTO pneumatic trainer

Facilities required:

Pro/E, ANSYS, MasterCAM, PSI robot programming, ProModel, SolidCAST, Industrial Robot

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
WEF/LEF	4	-	-	4

WEF/LEF Maintenance Engineering and Management 4:0

Preamble

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

Competencies

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

1. Understand the theory of maintenance system and their applications.
2. Predict the reliability of the system.
3. Decide the replacement schedules for the equipments.
4. Prepare maintenance budgets, training schedules.
5. Understand the importance computerization in maintenance management.
6. Evaluate the maintenance effectiveness and performance.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. List the objectives of maintenance.
2. What do you mean by corrective maintenance?
3. Define: Reliability.
4. What is codification and cataloguing?
5. What do you mean by systematic maintenance?
6. What is maintenance audit?
7. List the purpose of CMMS.
8. What do you understand by TPM?
9. What is 5 zero concepts?

Understand

1. Differentiate between break down maintenance and Preventive maintenance.
2. Explain different types of maintenance systems.

3. Explain the various components of maintenance costs.
4. Explain about planning and scheduling of maintenance.
5. Describe the procedure for the implementation of CMMS.
6. Explain about the maintenance performance indices and its usage.

Apply

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.
4. 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

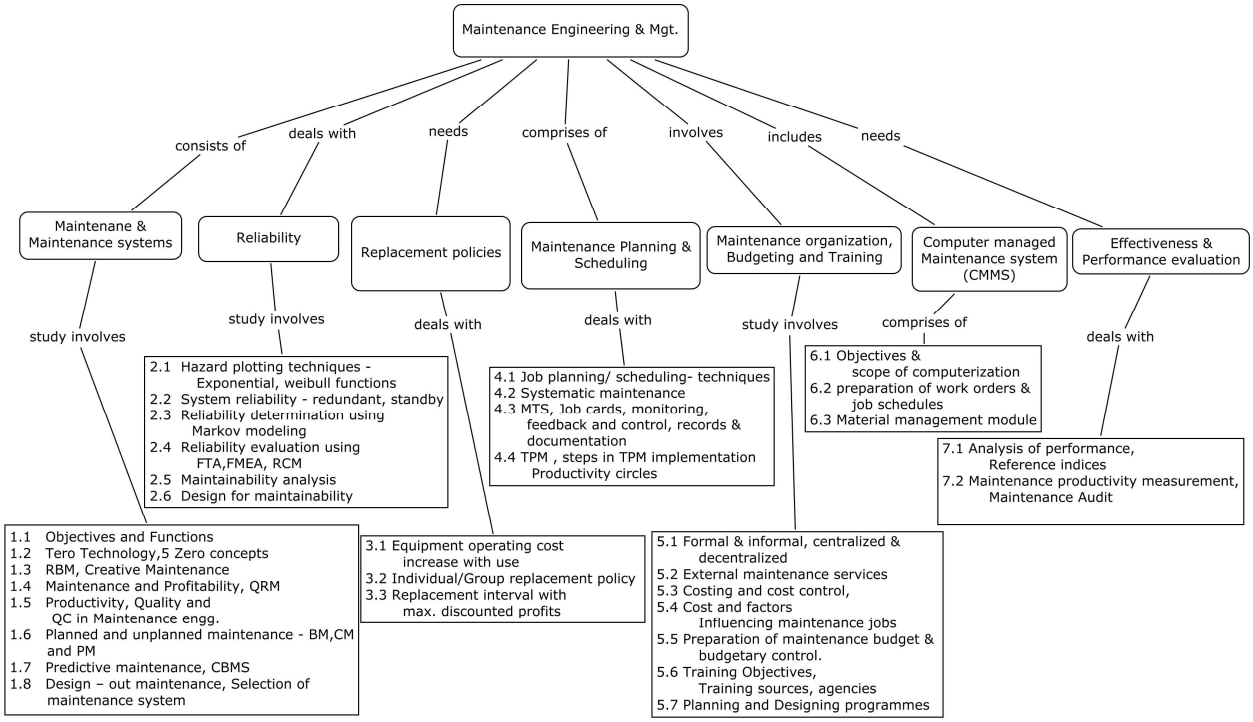
   Determine at what age is replacement due?

5. 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.
6. 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.

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 and Company Ltd., 2005.
2. Anteny Kelly , "Strategic Maintenance planning", Butterworth-Heinemann, 2006.
3. Gopalakrishnan, P. Banerji, A.K, "Maintenance and Spare Parts Management", Prentice Hall of India, 1991.
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

S.No	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

S.No	Topics	No. of Lectures
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, monitoring, feedback and control, Maintenance records and documentation.	2
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:	

S.No	Topics	No. of Lectures
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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Sub code	Lectures	Tutorial	Practical	Credit
WEG/LEG	4	0	-	4

WEG/LEG Machine Vision and its applications in manufacturing 4:0

Preamble

Machine Vision has become a key technology in the area of manufacturing and quality control. Increasing quality demands require inspection of every single part which in turn will lead to much more wide spread use of visual inspection systems. Furthermore the documentation requirements of ISO 9000 and similar quality control standards can only be met by fully automated networked inspection systems.

The Success of developing machine vision system depends on the understanding all parts of the imaging chain.

Hence this course discusses about image acquisition, lens and illumination systems, image preprocessing and processing, segmentation and classification techniques used in a typical machine vision application.

Competencies

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

1. Understand the components of a machine vision system
2. Select appropriate camera for a machine vision system
3. Select appropriate lens for a machine vision system
4. Select appropriate lighting system for a machine vision system
5. Apply suitable image processing and computer vision algorithms to solve applications and case studies
6. Build machine vision systems for automated inspection and assembly checking operations

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. What is a digital image?
2. What is meant by resolution?
3. Write the basic components of a machine vision system.
4. What are the two major categories of cameras used in image acquisition?
5. What is meant by dark current?
6. What is sensor format?

Understand

1. What is the need for frame grabber in image acquisition?
2. Explain the working principle of CCD sensor array
3. Describe in detail about various image acquisition modes.
4. Explain the advantages of CMOS sensors over CCD sensors.
5. Discuss the advantages of direct digital transmission
6. Differentiate between sensor format and lens format

Apply

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor. Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm.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.
4. A surveillance camera is embedded in one of the walls of a room as shown in figure. 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

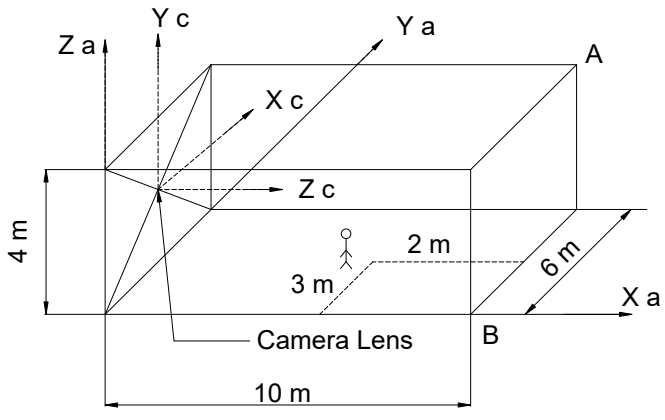
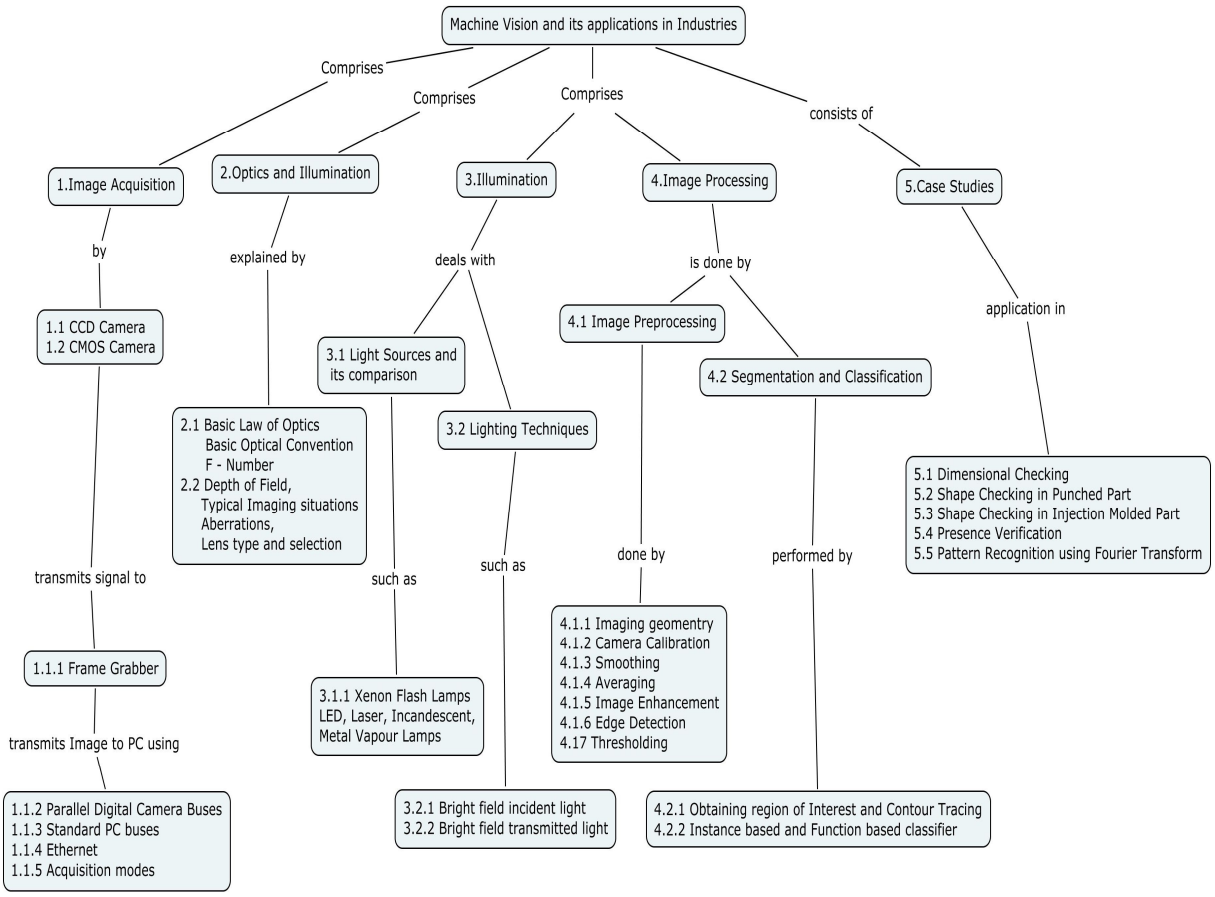


image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner as shown in Figure.

5. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.

Concept Map



Syllabus

IMAGE ACQUISITION: Photo Detection, CCD Array Operation, CCD Array Architecture, Charge Conversion,Dark Current, Types of CCD Camera. CMOS Camera; Camera Computer Interfaces: Introduction, Analog Camera Buses, Analog Camera Signal, Interlaced Video, Progressive Scan Video, Timing Signals, Analog Image Acquisition, S-Video, Analog connectors. Parallel Digital Camera Buses: Digital Video Transmission, Taps, Differential Signaling, Line Scan, Parallel Digital Connectors, camera link, camera link signals, Camera link connectors; Machine Vision Standard Interfaces: USB, IEEE 1394, Gigabit Ethernet. Choosing a Camera Bus. Basic Operation of Frame Grabber, Acquisition mode: Snap, Grab,

Sequence, Ring Image Representation, Image Representation in Memory; **OPTICS AND ILLUMINATION: Optics:** Basic Laws of Geometrical optics. Basic optical conventions. F-Number, Thin lens imaging equation, image resolution, Depth of field, Typical imaging situations, Aberrations, Lens types and selection; **Illumination Technology**Demands on Machine Vision Lighting. **Light Sources:** Incandescent Lamps, Metal vapour lamps, Xenon lamps, Fluorescent lamps, LEDs, Lasers. Light Source comparison. Light Filter-introduction Hand Book of Machine Vision PP 88-100**Lighting Techniques**: Diffuse Bright Field Incident Light, Directed Bright Field Incident Light, Telecentric Bright Field Incident Light, Structured bright field incident light, Diffuse/directed Dark field Incident Light, Limits of incident lighting, Diffuse Bright field Transmitted lighting, Directed Bright Field Transmitted Light, Telecentric Bright Field Transmitted Light, Diffuse/Directed Transmitted Dark field Light Hand Book of Machine Vision PP 160-185**IMAGE PRE PROCESSING:** Imaging geometry-Basic Transformations, Camera Model, Camera Calibration, Preprocessing-Spatial Domain Methods, Frequency Domain Methods, Smoothing-Neighborhood Averaging, Median Filtering, Image Averaging, Smoothing Binary Images Enhancement, Edge Detection, Thresholding.**SEGMENTATION AND CLASSIFICATION:**Segmentation-Regions of Interest, Thresholding, contour Tracing, Edge based methods, Template matching.Classification-Classification as function approximation, Instance based Classifiers, Function based Classifiers; **APPLICATIONS AND CASE STUDIES:** Dimensional Checking-Simple gauging, Shape checking on a punched part, shape checking on a injection molded part. Presence verification- Simple presence verification. Application of Fourier transform to pattern recognition applications.

Reference Books

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

Course contents and Lecture Schedule

S.No.	Topics	No. of Lectures
1	**IMAGE ACQUISITION**	
1	Photo Detection, CCD Array Operation	2
1.1	CCD Array Architecture, Charge Conversion, Dark Current. Types of	2

S.No.	Topics	No. of Lectures
	CCD Camera.	
1.2	CMOS Camera.	1
1.1	Camera Computer Interfaces: Introduction, Analog Camera Buses, Analog Camera Signal, Interlaced Video, Progressive Scan Video, Timing Signals, Analog Image Acquisition, S-Video, Analog connectors	1
1.1.1	Basic Operation of Frame Grabber.	1
1.1.1	Parallel Digital Camera Buses: Digital Video Transmission, Taps, Differential Signaling, Line Scan, Parallel Digital Connectors, camera link, camera link signals, Camera link connectors,	1
1.1.3,1.1.4 1.1.5	Standard PC Buses: USB, IEEE 1394 Gigabit Ethernet. Choosing a Camera Bus.	2
1.3	Acquisition mode: Snap, Grab, Sequence, Ring.	1
1.4	Image Representation, Image Representation in Memory.	1
2	**OPTICS AND ILLUMINATION**	
2.1	Basic Laws of Geometrical optics. Basic optical conventions. F-Number.	1
2.2	Depth of field, Typical imaging situations. Aberrations, Lens types and selection.	1
2.3	Thin lens imaging equation, image resolution.	1
3.0	**Illumination Technology:**Demands on Machine Vision Lighting. **Light Sources:** Incandescent Lamps, Metal vapour lamps.	1
3.1.3,3.1.4 ,3.1.5	Xenon lamps,Fluorescent lamps,LEDs,Lasers. Light Source comparison. Light Filter-introduction	1
3.2	**Lighting Techniques**: Diffuse Bright Field Incident Light, Directed Bright Field Incident Light.	1
3.2.1	Telecentric Bright Field Incident Light, Structured bright field incident light. Diffuse/directed Dark field Incident Light, Limits of incident lighting, Diffuse Bright field Transmitted lighting,	2
3.2.2	Directed Bright Field Transmitted Light, Tele centric Bright Field Transmitted Light. Diffuse/Directed Transmitted Dark field Light.	2
4.1	**IMAGE PRE PROCESSING**	
4.1.1	Imaging geometry-Basic Transformations, Camera Model.	1
4.2.3	Camera Calibration.	1

S.No.	Topics	No. of Lectures
4.1.2, 4.1.3, 4.1.4	Preprocessing-Spatial Domain Methods, Smoothing-Neighborhood Averaging, Median Filtering, Image Averaging,	2
4.1.5,4.1.6	Smoothing Binary Images Enhancement, Edge Detection, Thresholding.	2
4.1.7	Preprocessing-Frequency Domain Methods	1
4.2	**SEGMENTATION AND CLASSIFICATION**	
4.2.1	Segmentation-Regions of Interest, Thresholding.	2
4.2.1	contour Tracing, Edge based methods	1
4.2.1	Template matching.	1
4.2.2	Classification-Classification as function approximation	2
4.2.2	Instance based Classifiers.	2
4.2.2	Function based Classifiers.	1
5.0	**APPLICATIONS AND CASE STUDIES**	
5.1	Dimensional Checking-Simple gauging.	2
5.2	Shape checking on a punched part.	1
5.3	Shape checking on injection molded part.	2
5.4	Presence verification- Simple presence verification.	1
5.5	Fourier transform for pattern recognition applications	3
	Total	**46**

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Sub code	Lectures	Tutorial	Practical	Credit
WEH/LEH	4	0	-	4

WEH/LEH System Simulation 4 :0

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.

Competencies

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

a. understand the concepts, types and applications of simulation, steps in simulation study.
b. understand how computer simulation can be used to model complex systems and solve related decision problems.
c. understand the assumptions made in building a discrete event simulation.
d. understand and apply statistical methods used in simulation analysis.
e. learn the techniques of random number generator, testing of random numbers, evaluate generator in a given application, and how to use those generators to phenomena of interest.
f. learn to design a computer simulation, conduct input modeling validation, and output analysis.
g. run a simulation project from start to finish.

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	20	20	10
2	Understand	20	20	30
3	Apply	60	60	60
4	Analyze	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define 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
4. What is the purpose of Output analysis?
5. Give the Test statistic of Chi-square test of Goodness of fit.
6. List a few simulation languages.

Understand

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 $\alpha = 0.2$
3. Develop a random variate generator for exponential distribution.
4 Mention the factors that are to be considered in selecting a simulation language for a particular application.
5. Considering an Engineering educational system, identify the entities, attributes, and activities of the system.
6. Describe and explain the properties of linear models.
7. What are the steps in the development of a model of input data? Explain.
8. Mention the factors that are to be considered in selecting a simulation language for a particular application.

Apply

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.

3. Consider the 40 two digit values given below. Can the hypothesis that the numbers are independent be rejected on the basis of the length of runs above and below the mean, where $\alpha = 0.05$.

0.63	0.72	0.79	0.81	0.52	0.94	0.83	0.93	0.87	0.67
0.54	0.83	0.89	0.55	0.88	0.77	0.74	0.85	0.82	0.86
0.43	0.32	0.36	0.18	0.08	0.19	0.18	0.27	0.36	0.34
0.31	0.45	0.49	0.43	0.35	0.25	0.39	0.47	0.41	0.46

4. Give the correct value of the constant A that makes the following equation for y a probability density function. Derive formula for random variate generators and compute the first 5 values.

$$Y = \begin{cases} 0.5 + A(x + 1.5) & 1 < x < 2 \\ 0 & \text{otherwise} \end{cases}$$

5. Lead times have been found to be exponentially distributed with mean 3.7 days. Generate five random lead times from this distribution.

6. 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.

7. 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 $\alpha = 0.05$

8. 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?

9. 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.

10. 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.

10. 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 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 with out 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 Packages** – 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, 2008
2. Geoffrey Gordon, "System Simulation " Prentice Hall of India, New Delhi, 1996
3. Averill M Law, "Simulation Modeling and Analysis" Tata McGraw-Hill Publishing company Limited, New Delhi, Fourth edition,2008.
4. Narsingh Deo, "System Simulation with digital computer ", Prentice Hall of India, New Delhi, 1997

Course Contents and Lecture Schedule

No	Topic	No. of hours
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
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,	2

	sample variance, suggested estimators – Poisson, Exponential, Uniform, Normal, Gamma, and weibull distributions	
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 Packages	
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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Sub Code	Lectures	Tutorial	Practical	Credit
WEJ/LEJ	4	-	-	4

WEJ/LEJ Product Design and Development 4:0

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.

Competencies

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

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

Assessment pattern

Sl.No	Bloom's category	Test 1	Test 2	Test 3 /End Semester Examinations
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define product design.
2. Define the term concept scoring?
3. Define the term concept screening?
4. Define the term concept testing?
5. What is metrics?
6. What is pre project planning?
7. What is Intellectual Property?
8. Define proto type product.
9. What is industrial design?

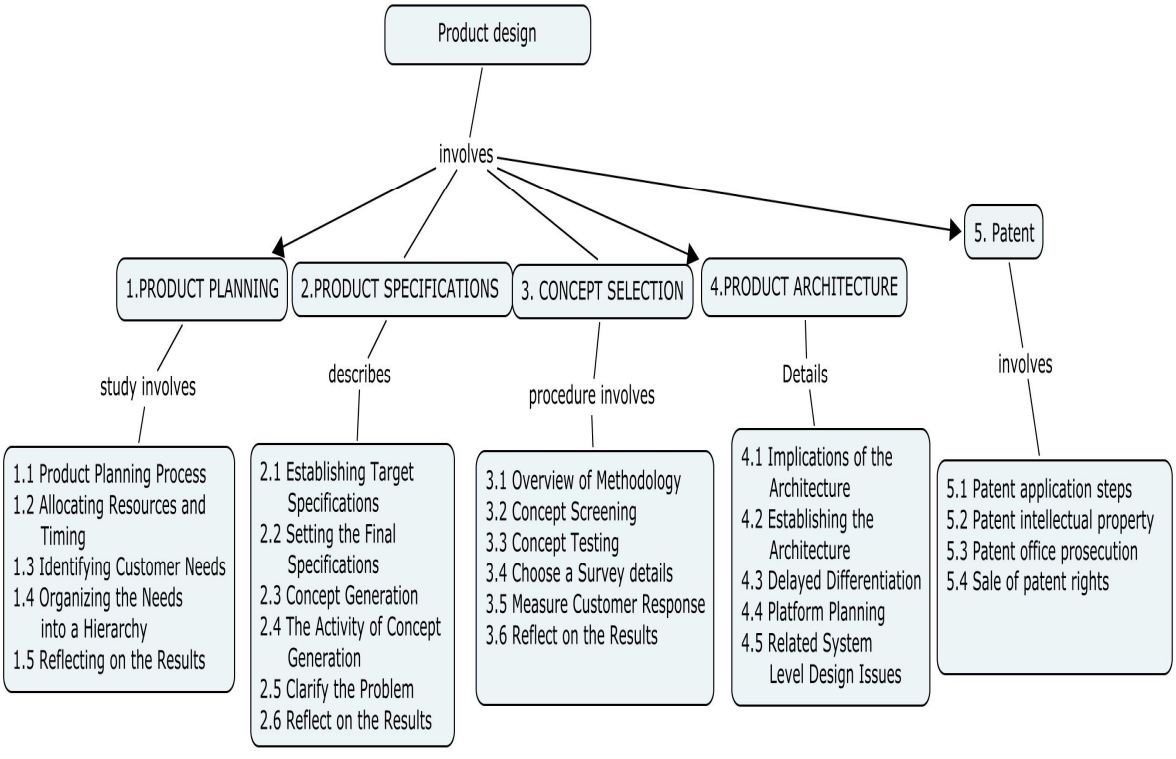
Understand

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

Apply

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

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** - What Are Specifications -When Are Specifications Established-Establishing Target Specifications–QFD-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation-Clarify the Problem- Search Externally-Search Internally-Explore Systematically- Case study for motor driven nailer -Reflect on the Results and the Process **CONCEPT SELECTION**-Concept Selection- Overview of Methodology-Concept Screening-Concept Testing-Define the Purpose of the Concept Test- Choose a Survey Population-Choose a Survey Format- Communicate the Concept- Measure Customer Response-Interpret the Results- Case study for motor driven nailer -Reflect on the Results and the Process **PRODUCT ARCHITECTURE**- Product Architecture-Implications of the Architecture-Establishing the Architecture-Delayed Differentiation-Platform Planning-Related System-Level Design Issues - Case study for motor driven nailer **DESIGN PATENTS** – Patent application steps – Patent intellectual property – Patent office prosecution – Sale of patent rights

Reference Books

1. Product Design and Development, Karl T.Ulrich and Steven D.Eppinger, McGraw –Hill International Edns.2007
2. Concurrent Engg./Integrated Product Development. Kemnneth Crow, DRM Associates, 26/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book
3. Effective Product Design and Development, Stephen Rosenthal, Business One Orwin, Homewood, 1992,ISBN, 1-55623-603-4
4. Tool Design – Integrated Methods for successful Product Engineering, Stuart Pugh, Addison Wesley Publishing,Neyourk,NY,1991, ISBN 0-202-41639-5
5. www.me.mit/2.7444

Course content and lecture schedule

No	Topic	No. of Lectures
1	**PRODUCT PLANNING**	
1.1	Product Planning Process- Identify Opportunities	1
1.1.1	Evaluating and Prioritizing Projects	1
1.2	Allocating Resources and Timing	2
1.2.1	Pre-Project Planning-Reflect on the Results and the Process	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	2
1.7	Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs	2
1.7.1	Case study for motor driven nailer	2
1.8	Reflecting on the Results and the Process	2
2	**PRODUCT SPECIFICATIONS**	
	What Are Specifications - When Are Specifications Established	1
2.1	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	2
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	2
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	1
4.2	Establishing the Architecture-	1
4.3	Delayed Differentiation	1
4.4	Platform Planning	1
4.5	Related System-Level Design Issues	1
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
		50

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
WEL/LEL	3	1	-	4

WEL/LEL Robust Design 3:1

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. The objective is to make the end-product immune to factors that could adversely affect performance. Robust Design requires that the following four factors be considered in the design process: signal, response, noise, and control. Noise factors are disturbances that cause the systems response to shift from specification. These factors are likely beyond the designer's control, such as manufacturing tolerances, aging, usage patterns, environmental conditions, etc. Noise factors must be identified and quantified so that accurate choices can be made about which effects require compensation. Control factors are used by the designer to compensate for noise factors that could significantly influence the system away from nominal performance. Once the critical noise factors are identified and the control factors selected, 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.

Competencies

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

1. Understand the concepts and applications of Robust Engineering, steps involved in Robust Engineering.
2. understand how Robust Engineering can be used to systems and solve related Problems.
3. understand the various measurement techniques in Robust Engineering.
4. understand and apply statistical methods used in productivity improvement and Optimum Process.

Assessment Pattern

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

Course level learning objectives

Remember

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?
8. When do we go for 3k factorial design?
9. What is effect of coding in one way ANOVA?
10. List out the nuisance factors in an experiment

Understand

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.
6. Explain about the system design, parameter design and Tolerance Design.

Apply

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
Bc	605	503
abc	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.

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

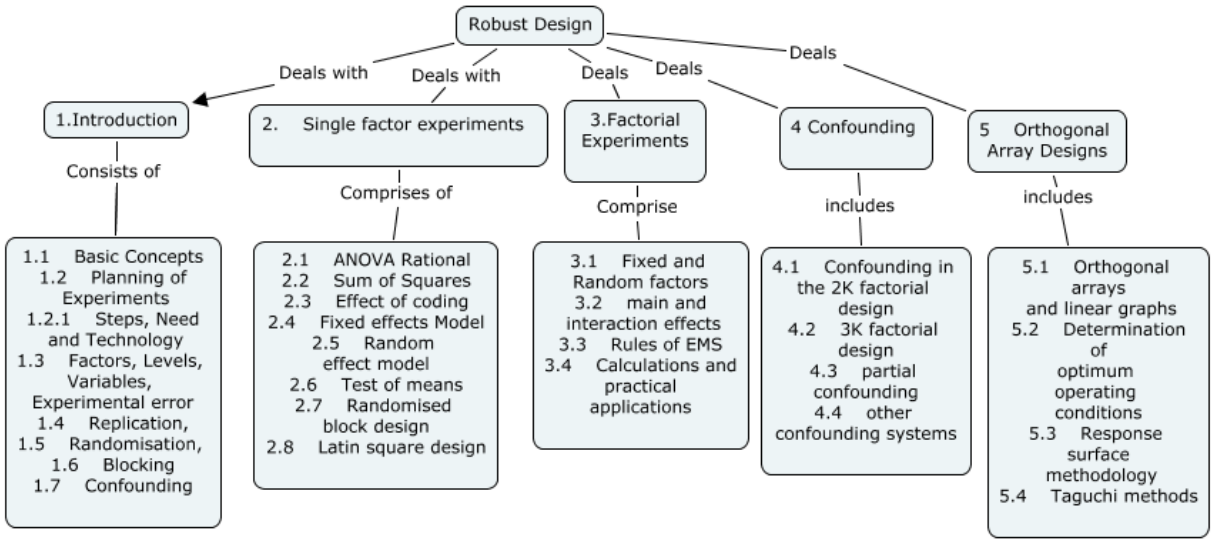
A	B	Replicate			
		I	Ii	III	IV
-	-	14.03	16.16	13.97	13.9
+	+	13.88	13.86	14.03	13.91
-	+	14.82	14.75	14.84	14.87
+	+	14.88	14.92	14.41	14.93

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

6. 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. Analyse the data and draw conclusions. [15]

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

Concept Map



Syllabus

Introduction: Basic Concepts - Planning of Experiments, Steps, Need, and Technology- Factors, Levels, Variables, Experimental error, Replication, Randomisation, Blocking, and Confounding. **Single factor experiments:** ANOVA Rational, Sum of Squares, Effect of coding, Fixed effects Model, Random effect model - Test of means - Randomised block design - Latin square design. **Factorial Experiments:** Fixed and Random factors main and interaction effects, rules of EMS, calculations and practical applications. **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. Charles R. Hicks, "Fundamental Concepts in the Design of Experiments", CBS College Publishing, New York, 1982.
2. Douglas C. Montgomery, "Design and Analysis of Experiments", Second Edition, John Wiley and Sons, New York, 1984.
3. Philips J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill, 1988.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
1.	**Introduction**	
1.1	Basic Concepts	1
1.2	Planning of Experiments	1
1.2.1	Steps, Need and Technology	1
1.3	Factors, Levels, Variables, Experimental error	1
1.4	Replication,	1
1.5	Randomisation,	1
1.6	Blocking	1
1.7	Confounding	1
2.	**Single factor experiments**	
2.1	ANOVA Rational	1
2.2	Sum of Squares	1
2.3	Effect of coding	1
2.4	Fixed effects Model	2
2.5	Random effect model	2
2.6	Test of means	1
2.7	Randomised block design	1
2.8	Latin square design	1
3.	**Factorial Experiments**	
3.1	Fixed and Random factors	2
3.2	main and interaction effects	2
3.3	Rules of EMS	1
3.4	Calculations and practical applications	2
4	**Confounding**	
4.1	Confounding in the 2^K factorial design	2
4.2	3^K factorial design	2

4.3	partial confounding	1
4.4	other confounding systems	1
5	**Orthogonal Array Designs**	
5.1	Orthogonal arrays and linear graphs	3
5.2	Determination of optimum operating conditions	2
5.3	Response surface methodology	2
5.4	Taguchi methods	2
	Total	**40**

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Sub Code	Lectures	Tutorial	Practical	Credit
WEP/L21	3	-	-	0

WEP/L21 FINANCIAL MANAGEMENT 3:0

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.

Competencies

At the end of the course the students will

1. Develop an understanding about Financial Management and its importance in decision making.
2. Understand the concepts of Financial Statement Analysis.
3. Interpret the Financial Statements of an organization.
4. Understand the concepts of Financial Planning.
5. Carry out various Investment Decision making.
6. Understand the meaning of financing and its functions and objectives.
7. Understand the various sources of finance.
8. Understand the nature and functions of Stock Market.
9. Get a brief idea about the various Financial Institutions and their role.
10. Understand the nature of Capital Structure and ides about the various dividend policies and models.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. What is the purpose of Balance Sheet?
2. What are the various types of Assets?
3. Define Working Capital?
4. What is Cost Volume Profit Analysis?
5. Define Risk.
6. Define capital Budgeting.
7. Define Cost of Capital.
8. Mention some financial institutions.
9. Define Working Capital.
10. Define Dividend.

Understand

1. Discuss how balance sheet is helping for corporate decision making.
2. Explain the factors influencing the working capital requirements.
3. What are the objectives of Capital Budgeting? Explain.
4. Discuss the non-traditional methods of investment decision making.
5. Explain the various sources of finance.
6. Discuss the legal and the procedural aspects of dividend policies

Apply

1.Journalize the following business transactions :

a).Rahul brings in cash Rs.10,000 as the capital and purchases land worth Rs.2000.

b). He purchases goods worth Rs.5000.

c).He sells goods for Rs.7000

d).He incurs travelling expenses for Rs.200

2. 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

3. 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

4. Prepare a balance sheet from the following information

Capital Turnover 2 times

Receivables turnover 3 times

Creditors velocity 2 months

Inventory turnover 6 times

Fixed Assets turnover 3 times

Gross Profit ratio 20%

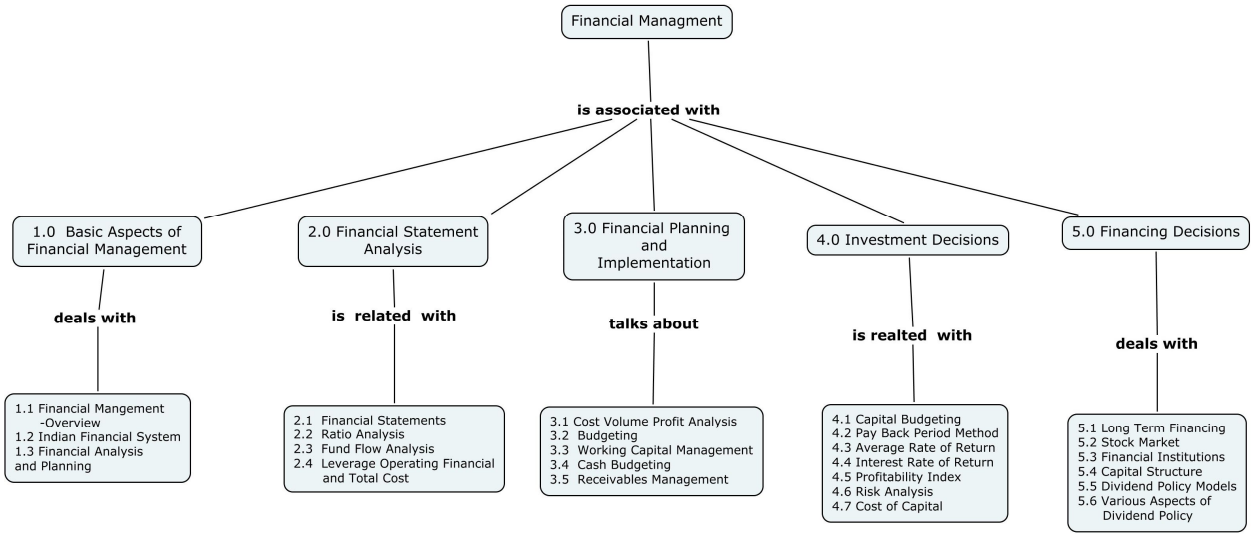
Gross profit during the year Rs.100000

Reserves and surplus Rs. 300000

Closing stock us Rs.4000 more than opening stock

5. "Ratios are predictors of Future" Comment on this statement to substantiate how financial status of an organization is studied and analyzed using Ratio Analysis considering a suitable example.

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** 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, Interest 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, 2002.
2. KY. Khan and P.K. Jain, " Financial Management", Tata McGraw Hill, 2003.
3. Khan and Jain, " Theory and Problems of Financial Management", Tata Mc Graw Hill Publishing Co, 1994
4. Pandey, "Financial Management" , Vikas Publishing House Pvt. Ltd., 2003.

Course Contents and Lecture schedule

S.No	Topics	No. of Lectures
1.0	**Basic Aspects of Financial Management**	
1.1	Financial Management Overview	2
1.2	Indian Financial System	1
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	Cost Volume Profit Analysis	2
3.2	Budgeting	2
3.3	Working capital Management	1
3.4	Cash Budgeting	1
3.5	Receivables Management	2
4.0	**Investment Decisions**	
4.1	Capital Budgeting	1
4.2	Pay Back Period Method	1
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

S.No	Topics	No. of Lectures
5.3	Financial Institutions	2
5.4	Capital Structure	1
5.5	Dividend Policy Models	2
5.6	Various Aspects of Dividend Policy	2
	Total	**40**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
WEQ/L22	4	-	-	4

WEQ/L22 Operations Management 4:0

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.

Competencies

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

7. Explain production and operation strategies for industries (Manufacturing / Service).
8. Explain the concept of JIT and Lean manufacturing
9. Propose a suitable forecasting method
10. Suggest methods for facility location and layout planning.
11. Develop inventory and MRP systems.
12. Apply production management techniques for aggregate planning and scheduling in manufacturing.

Assessment Pattern

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

Course Level Learning Objectives
Remember

1. Define Operation Management.
2. What are the inputs for MRP?
3. What is the principle behind JIT?
4. What are forecasting errors?

5. What are the objectives of scheduling?
6. State the most important factors used for selecting a location for a facility.

Understand

1. What is a production system? Explain.
2. Describe the Frame work for operations strategy in manufacturing.
3. Compare and contrast JIT and MRP, stating their main features.
4. Discuss the various Priority Dispatching Rules.
5. Discuss the Aggregate Production Planning Strategies and Techniques.
6. Describe the role of JIT in manufacturing and services.

Apply

1. Historical demand for a product is:

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. 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

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

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

4. 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.

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

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

i) State the order quantity and recorder point.
ii) Determine the annual holding and order costs.
iii) How many units per order cycle would you expect to the short?
iv) It a price break of $50 per order was offered for purchase quantities of over 2,000, would you take advantage of it? How much would you save on an annual basis?

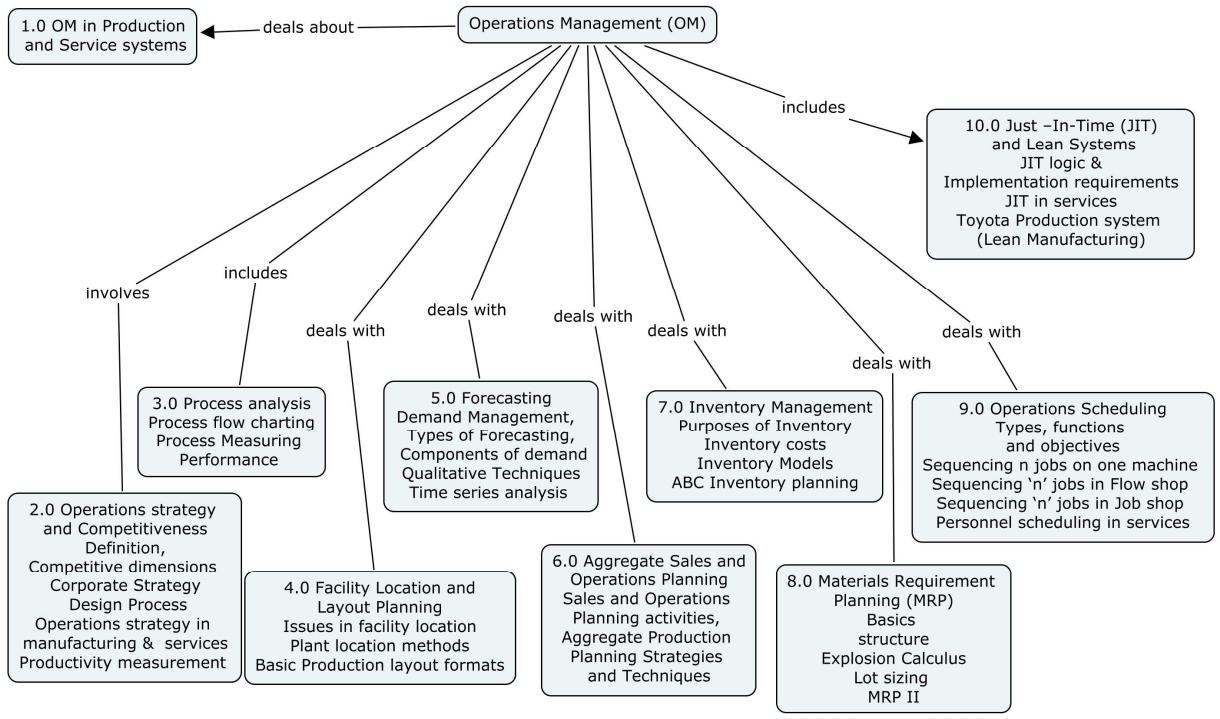
6. A new plant to be established will receive raw material from three suppliers P, Q, and R and supply finished products to three warehouses U, V, and W. The sources of raw material and the destination points may be considered as the existing facilities.

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.

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", Prentice-hall of India, 1999.
5. Chary, "Theory and Problems in Production and Operations Management", Second reprint, Tata McGraw Hill, 1996

6. Seetharama L.Narasimhan, Dennis W.McLeavy, Peter.J.Billington, "Production Planning and Inventory Control", PHI, 1997.

Course Contents and Lecture schedule

SL.NO	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
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	2
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.	1
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	1
5.0	**Forecasting**	
5.1	Demand Management, Types of Forecasting, Components of demand	1
5.2	Qualitative Techniques in Forecasting	1
5.3	Time series analysis in Forecasting	3
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	1
7.3	Fixed - order quantity Models, Establishing Safety stock levels	2
7.4	Fixed time period models	1
7.5	ABC Inventory planning	1

8.0	**Materials Requirement Planning (MRP)**	
8.1	MRP basics & MRP system structure	1
8.2	Explosion Calculus	1
8.3	Lot sizing in MRP systems: Lot-for-Lot, Economic Order Quantity, Silver Meal Heuristics, and Least Unit Cost.	3
8.4	MRP II	1
9.0	**Operations Scheduling**	
9.1	Scheduling – Types, functions and objectives.	1
9.2	Sequencing n jobs on one machine – Schedule using Priority dispatch rules (FCFS, SPT,EDD, LCFS, and Critical Ratio)	1
9.3	Sequencing 'n' jobs in Flow shop – Johnson, CDS and Palmer Algorithms.	2
9.4	Sequencing 'n' jobs in Job shop – Two jobs on M machines, Gantt chart.	2
9.5	Personnel scheduling in services.	1
10.0	**Just –In-Time (JIT) and Lean Systems**	
10.1	JIT logic	2
10.2	Toyota Production system (Lean Manufacturing)	
10.3	JIT Implementation requirements	2
10.4	JIT in services	
	Total	47

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
WES	4	0	-	4

WES Geometric Modeling 4:0

Preamble

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

Program outcomes addressed

a. An ability to apply knowledge of engineering, mathematics and science.
b. An ability to use CAD Systems for designing a system or component or process to meet stated specification.
c. An ability to identify, formulate and solve engineering problem using Computers.

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

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

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3 / End Semester Examination
1.	Remember	30	20	10
2.	Understand	40	40	40
3.	Apply	30	40	40
4.	Analyze	0	0	10
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course level learning objectives under each bloom's category

Remember

1. When the local coordinate system is useful?
2. List the desirable properties of curve modeling.
3. Write down the Euler equation.
4. List out the major area of computer graphics.
5. What is animation?
6. What is the function of graphics standard?

Understand

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

Apply

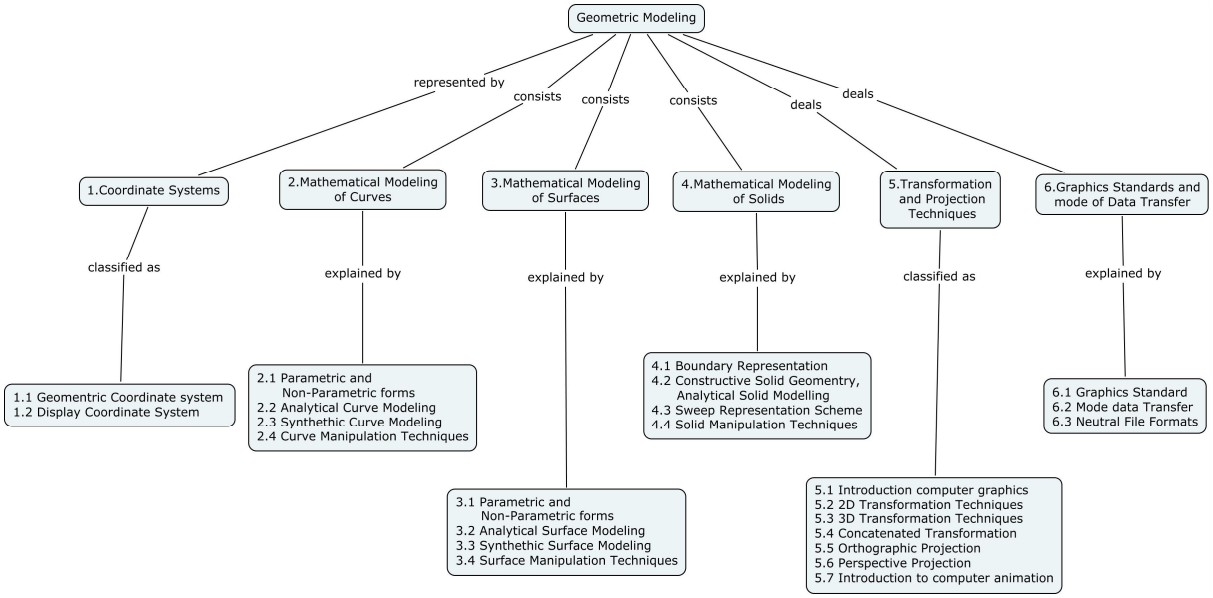
1. Generate a segment of Bezier curve using (0, 0), (15, 0), (10, 10) and (5, 10) using polynomial equation.
2. Obtain the IGES format for circle of diameter 30 mm located at (0, 0) and line segment of (10, 5) and (20, 0).
3. How can you combine the various surface entities provided by CAD systems to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

Analyze

1. Interpret the condition when a) $P_0 = P_1$, $P'_1 = P'_0$ and b) $P_0 = P_1$, $P'_1 = -P'_0$. Plot the resultant curve.
2. Suggest most suitable continuity at P_1 when the end conditions of two segments of hermite spline curves are P_0, $P'_{0,}$ $P_{1,}$ P'_{11} and P_1, $P'_{12,}$ $P_{2,}$ $P'_{12.}$ The second subscripts in the tangent vectors at P_1 refer to the segment number. If $P_{11} = R$ and $P_{12} = kR$, where 'k' is a constant.

3. A point P(2,5,10) is rotated 30^{o} 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?
4. When you introducing one new data point over the existing cubic Bezier curve, what will happen to the resultant shape of the curve and its degrees of freedom? Justify.
5. When you removing the two existing data point over the existing cubic Bezier curve, what will happen to the resultant shape of the curve? Justify your answer.
6. Suggest a suitable mathematical equation for introducing more control points without modifying the degree of curve and justify your answer.

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 Books:

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

Course contents and Lecture schedule

S.No	Topics	No. of Lectures
1	**Coordinate systems**	
1.1	Geometric co-ordinate systems – Cartesian, Cylindrical and Spherical coordinate systems	1
1.2	Display co-ordinate systems – Global, Local, View and Screen coordinate systems	1
2	**Mathematical modeling of Curves**	
2.1	Parametric and non-parametric forms of analytical and synthetic curves	2
2.2	Analytical Curve modeling – Line Segment, Circle, Ellipse.	2
2.3	Synthetic Curve modeling – Hermite cubic spline, Bezier curve	2
	Synthetic Curve modeling – B-spline and Rational Curves	2
2.4	Manipulation – Analytical and synthetic curve manipulation techniques	2
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 surface	2
	Analytical surface modeling – Cylindrical, Surface of revolution	1

3.3	Synthetic Surface modeling – Hermite bicubic spline, Bezier surface	2
	Synthetic Surface modeling – B-spline, Coon's, Triangular, Blending Surfaces	2
	Synthetic Surface modeling – triangular, blending Surfaces	1
3.4	Manipulation – Analytical and synthetic surface manipulation techniques	2
4	**Mathematical modeling of Solids**	
4.1	Boundary representation scheme	2
4.2	Constructive Solid Geometry, Analytical Solid Modeling	2
4.3	Sweep representation scheme	1
4.4	Manipulation – Solid Manipulation Techniques	1
5	**Transformation and Projection techniques**	
5.1	Introduction computer graphics – Non-interactive Vs Interactive computer graphics, applications, graphics system configuration	2
5.2	2D transformation techniques – Translation, Rotation	2
	2D transformation techniques – Scaling and Reflection	1
5.3	3D transformation techniques – Translation, Rotation	2
	3D transformation techniques – Scaling and Reflection	1
5.4	Principle of concatenated transformation	1
5.5	Orthographic Projections of Geometric Models	2
5.6	Perspective Projections of Geometric Models	1
5.7	Introduction to computer aided animation system	1
6	**Graphic Standards and mode of data transfer**	
6.1	Graphics standard	1
	Geometrical data	1
6.2	Mode of data transfer - Direct and indirect data transfer	1
6.3	Neutral file formats - Data Exchange Format (DXF) and Initial Graphics Exchange Specification (IGES)	2
	Total	**48**

NB: Students need to submit two programming assignments in the area of curve (like Line segment, Arc, Circle, Ellipse, Hermite cubic spline, Bezier and B-spline) modeling using C/C^{++}/Java programming language.

Course Designers

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2. M. Balamurali mbmmech@tce.edu

Sub Code	Lectures	Tutorial	Practical	Credit
WEV	3	1	-	4

WEV Fluid Power Automation 3:1

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.

Competencies

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

7. Express the theory related to Fluid power and arising in the study of engineering problems and their applications.
8. Classify the pumps and motors and selected them for the required applications.
9. Design the hydraulic and pneumatic circuits based on the required movement and sequence.
10. Provide speed, pressure, direction control for the hydraulic and pneumatic circuits.

Assessment pattern

Sl.No	Bloom's category	Test 1	Test 2	Test 3 /End Semester Examinations
1	Remember	20	20	20
2	Understand	20	20	20
3	Apply	60	60	60
4	Analyse	0	0	0
5	Evaluate	0	0	0
6	Create	0	0	0

Course level learning objectives

Remember

1. Define positive displacement pump
2. Name some positive displacement pump
3. List the parameters for selection a pump
4. What are the various type of hydraulic motors?
5. What is the control required for hydraulic circuits?
6. Name some pressure control valves
7. Why flow control is essential
8. What is FRL unit
9. State the importance of Hydro pneumatic circuits.

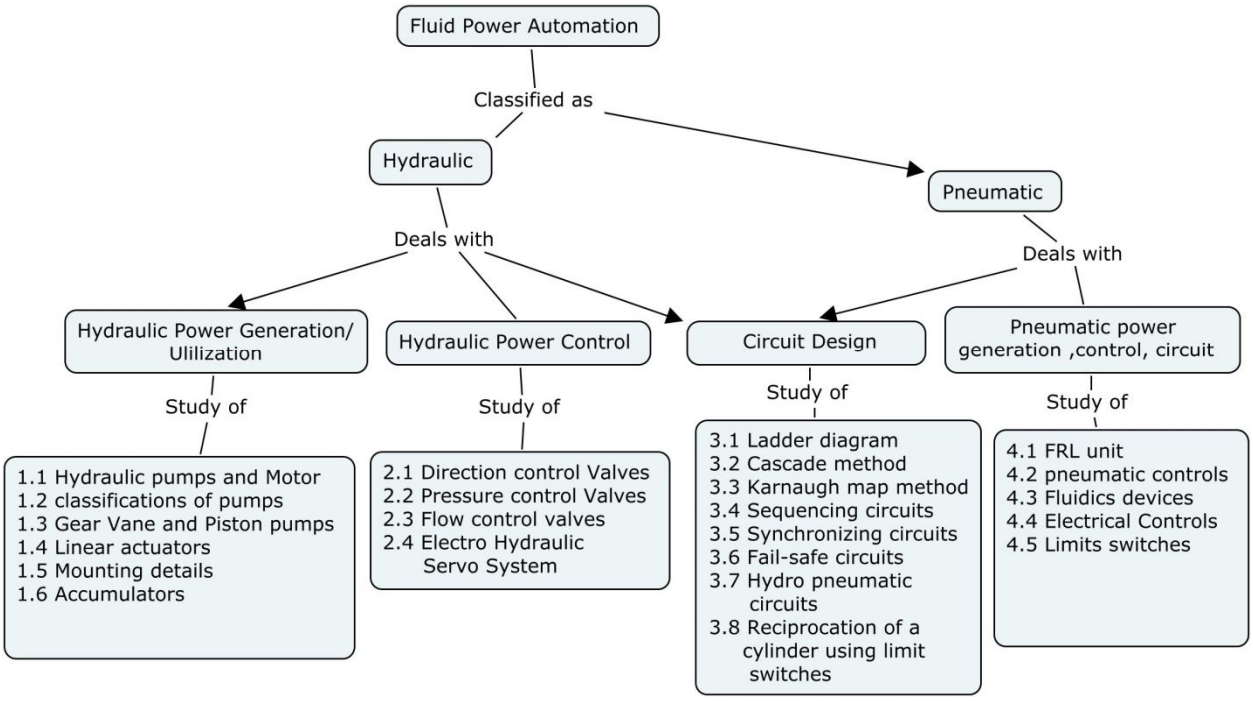
Understand

1. Compare the hydraulic and pneumatic
2. Distinguish between external and internal gear pump.
3. Describe the working principle cushioned cylinder
4. Distinguish between mechanical and Electro Hydraulic Servo Systems
5. Classify the pumps
6. Compare the meter-in and meter-out circuits

Apply

1. With neat sketch explain the working of the gear pump
2. Discuss in detail the 4/3 direction control valve with example.
3. Explain the cascade method of circuit design with example
4. Design a circuit for the A+B+A-B- using Karnaugh map method
5. Draw the ladder diagram for A+B+C-A-B-C+ and explain its operation
6. Explain the application of pressure Compensated flow control valve

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 1996.
6. E.F. Pictch and J.B. Suryaatmadyn, "Introduction to Fluid Power Logic", McGraw Hill, 1998.
7. Peter Rohner, "Fluid Power Logic Circuit Design", The Macmillan press, 1979.

Course content and lecture schedule

No	Topic	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	1
1.6.1	Types	1

1.6.2	Applications	1
2	**Control Components in Hydraulic Systems**	
2.1	Direction control Valves	1
2.1.1	check valves- two way	1
2.1.2	Three way and four way valves	1
2.1.3	Shuttle valves- Rotary shuttle	1
2.2	Pressure control Valves	1
2.2.1	primary and secondary type	1
2.3	Flow control valves	1
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	1
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	1
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	**40**

Course Designer

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CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Production Engineering) PROGRAM

THIRD SEMESTER

FOR THE STUDENTS ADMITTED FROM THE

ACADEMIC YEAR 2011-2012 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

MADURAI – 625 015, TAMILNADU

Phone: 0452 – 2482240, 41
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M.E. DEGREE (Production Engineering) PROGRAMME

Scheduling of Courses

Sem	Theory Courses						Practical/ Project
4th (12)							W41 Project Phase – II 0:12
3rd (16)	W31 Computer Integrated Manufacturing 4:0	WEX Elective - V 4:0	WEX Elective - VI 4:0				W34 Project Phase-I 0:4
2nd (24)	W21 Mechanics of Metal Cutting and Metal Forming 4:0	W22 Tool Design Engineering 3:0	WEX Elective -I 4:0	WEX Elective -II 4:0	WEX Elective -III 4:0	WEX Elective -IV 4:0	W27 Advanced Manufacturing Engineering Laboratory II 0:1
1st (24)	W11 Computational Methods in Engineering 3:1	W12 Optimisation Techniques 4:0	W13 Mechanical Behaviour of Materials 4:0	W14 Industrial Automation and Robotics 3:1	W15 CNC Machine Tool Technology 3:0	W16 Micro Electro Mechanical Systems and Nano Technology 3:1	W17 Advanced Manufacturing Engineering Laboratory I 0:1

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
W31	Computer Integrated Manufacturing	DC	4	0	-	4
WEX	Elective – V	DE	4	0	-	4
WEX	Elective - VI	DE	4	0	-	4
PRACTICAL						
W34	Project Phase I	DC	0	0	4	4
Total						**16**

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

THIRD SEMESTER

S. No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
THEORY								
1	W31	Computer Integrated Manufacturing	3	50	50	100	25	50
2	WEX	Elective – V	3	50	50	100	25	50
3	WEX	Elective - VI	3	50	50	100	25	50
PRACTICAL								
4	W34	Project Phase I	3	50	50	100	25	50

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

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

LIST OF ELECTIVE SUBJECTS – M.E Production Engineering

S.No.	Sub. Code	Name of the Subjects	Credit
1.	WEA/LEA	Facilities Planning and Layout Design	4
2.	W EB/LEB	Sequencing and Scheduling	4
3.	W EC/LEC	Materials Management	4
4.	W ED/LED	Research Methodology	4
5.	WEE/LEE	Total Quality Management	4
6.	W EF/LEF	Maintenance Engineering and Management	4
7.	WEG/LEG	Machine Vision and its applications in manufacturing	4
8.	WEH/LEH	System Simulation	4
9.	W EI/LEI	Entrepreneurship Development	4
10.	WEJ/LEJ	Product Design and Development	4
11.	W EK	Design for Manufacture and Assembly	4
12.	WEL/LEL	Robust Design	4
13.	WEM/LEM	Lean and Six Sigma	4
14.	WEN/L13	Work Study and Cost Analysis	4
15.	WEO/L14	Quality and Reliability Engineering	4
16.	WEP/L21	Financial Management	4
17.	WEQ/L22	Operations Management	4
18.	WER/L31	Supply Chain Management	4
19.	WES	Computer Aided Design and Geometric Modeling	4
20.	WET	Metal Casting Engineering	4
21.	WEU	Metal Joining Engineering	4
22.	WEV	Fluid Power Automation	4
23.	WEW	Rapid Manufacturing	4
24.	WEY	Mechatronics in Manufacturing	4
25.	WEZ	Computer Aided Metrology and Inspection	4

Sub Code	Lectures	Tutorial	Practical	Credit
W31/LEN	4	0	-	4

W31/LEN Computer Integrated Manufacturing 4:0

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.

Competencies:

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

1. Design and develop models using solid modeling techniques.
2. Develop APT code for machining a component.
3. Explain the concept of computer data communication and graphics standards.
4. Explain the formulation of computer aided process planning.
5. Convey the working of MRP and methods of factory data collection system.
6. Clarify the new developments in field of CIM.

Assessment Pattern

	Bloom's Category	**Test 1**	**Test 2**	**Test 3 / End Semester Examination**
1.	Remember	20	20	20
2.	Understand	60	60	60
3.	Apply	20	20	20
4.	Analyze	0	0	0
5.	Evaluate	0	0	0
6.	Create	0	0	0

Course level learning objectives under each bloom's category

Remember

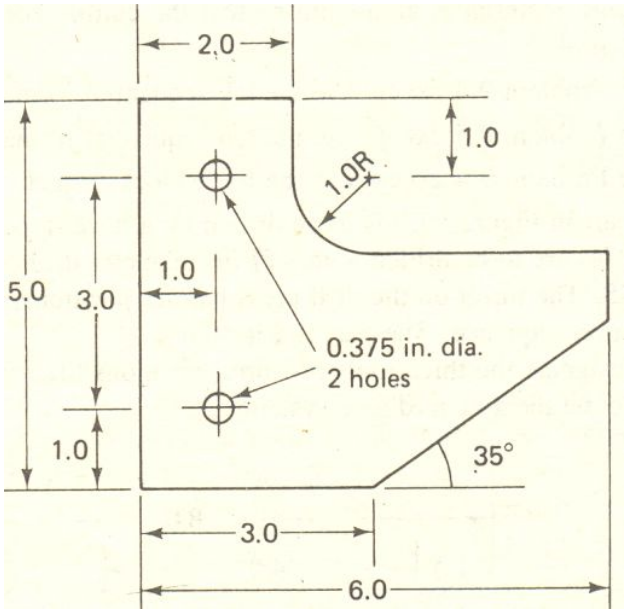
1. Identify the different elements of CIM.
2. List out the advantages of CNC machine tools.
3. Write down the implementation issues of CIM.
4. Quote the benefits of CAD process.
5. Write down the inputs of MRP.
6. What is capacity planning?

Understand

1. Describe the manufacturing automation protocol.
2. Describe the evolution of graphics standard.
3. Discuss about the different topologies of LAN.
4. Explain the concept of Generative type CAPP.
5. Describe the bar code technique briefly.
6. Describe the fundamentals of lean manufacturing.

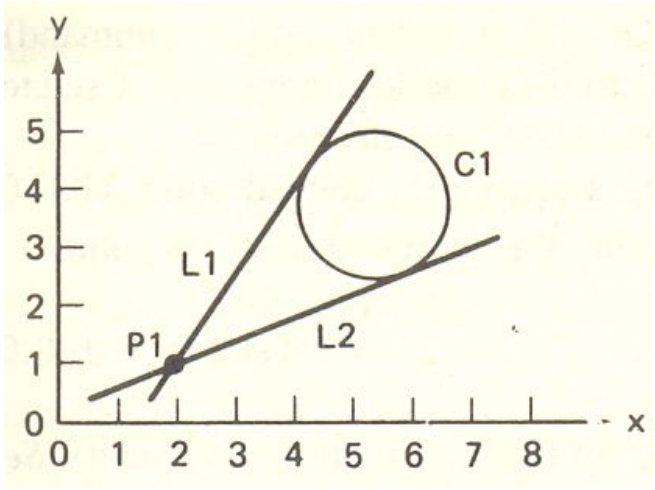
Apply

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



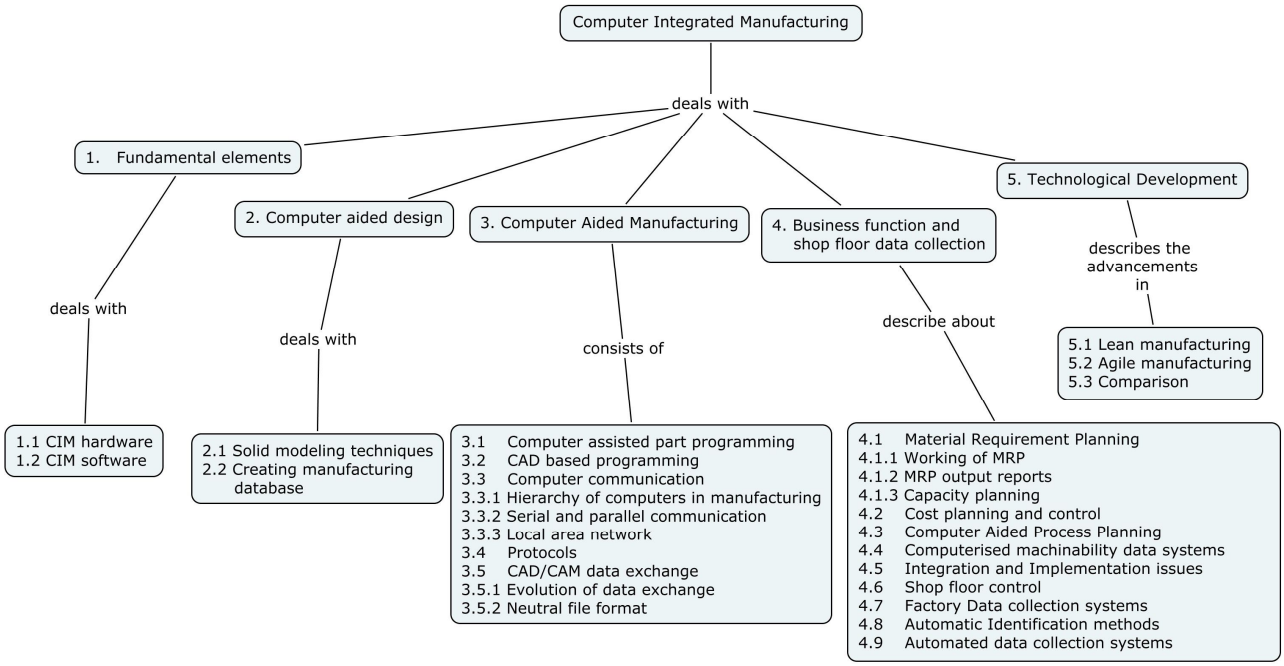
2. Develop IGES neutral format for circle of radius 20 mm with centre (10, 5, 0) and a straight line with two ends (0, 0) and (15, 25).
3. Develop DXF neutral format for a point located at (10, 2, 8) and circle of diameter 40 mm with (0, 0, 0) as centre.
4. Design and draw a bar code for representing 8 bit data of (1000 1010) based on AIM USD-2 standard.

5. Write an APT codes for describing lines 1 and 2 shown in the following figure.



6. 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.

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 of CAPP, 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, 2009.
4. Yorem Koren and Joseph Ben-Uri, "**Numerical Control of Machine Tools**", Khanna Publishers, 1988.
5. David Bedworth, "**Computer Integrated Design and Manufacturing**", Tata Mc Graw Hill publishing company Ltd, 1998.
6. Sureder Kumar and A.K.Jha, "**Technology of Computer Aided Design and Manufacturing**" Dhanpat rai and sons, Delhi, 1993.
7. P.Radhakrishnan, S.Subramanyan and V.Raju, CAD/CAM/CIM, New Age International (P) Ltd., New Delhi, 2008.

Course contents and Lecture schedule

No	Topics	No. of Lectures
1.	**Fundamentals Elements:** Nature of CIM, Evolution of CIM	1
1.1	CIM hardware	1
1.2	CIM software	1
2.	**Computer Aided Design:** Design process	2
2.1	Solid modeling techniques	2
2.2	Creating manufacturing database	2
3.	**Computer Aided Manufacturing:** Elements of CNC machine tools	2

No	Topics	No. of Lectures
3.1	Computer assisted part programming–APT language	2
3.2	CAD based programming	2
3.3	Computer Communication	1
3.3.1	Hierarchy of computers in manufacturing	1
3.3.2	Serial and parallel communication	2
3.3.3	Local area network	1
3.4	Protocols-Manufacturing Automation Protocol	1
	Technical Office Protocol	1
3.5	CAD/CAM data exchange-Method of data exchange	1
3.5.1	Evolution of data exchange	1
3.5.2	Neutral file format-DXF	1
	IGES and PDES	1
4.	**Business function and shop floor data collection:**	
4.1	Material Requirement Planning-Inputs to MRP	1
4.1.1	Working of MRP	2
4.1.2	MRP output reports	1
4.1.3	Capacity Planning	1
4.2	Cost planning and control	2
4.3	Computer Aided Process Planning-Retrieval type	2
	Generative type CAPP, Benefits of CAPP	1
4.4	Computerised machinability data systems	2
4.5	Integration and Implementation issues	1
4.6	Shop floor control-functions, information flow	2
4.7	Factory Data collection systems	2
4.8	Automatic Identification methods	2
4.9	Automated data collection systems	2
5.	**Technological Development:**	
5.1	Agile manufacturing	1
5.2	Lean manufacturing	1
5.3	Comparison of Agile and Lean manufacturing	1
	Total	**50**

Course designers:

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Sub Code	Lectures	Tutorial	Practical	Credit
WEE/LEE	4	0	-	4

WEE/LEE Total Quality Management 4:0

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.

Competencies:

At the end of the course students should be able to

1. Understand the principles of TQM.
2. Understand the concepts of Statistical process control.
3. Apply the tools and techniques of TQM in an organization.
4. Understand the need for Quality systems of international standards.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. Define 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'?

Understand

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.

Apply

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.

3.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.

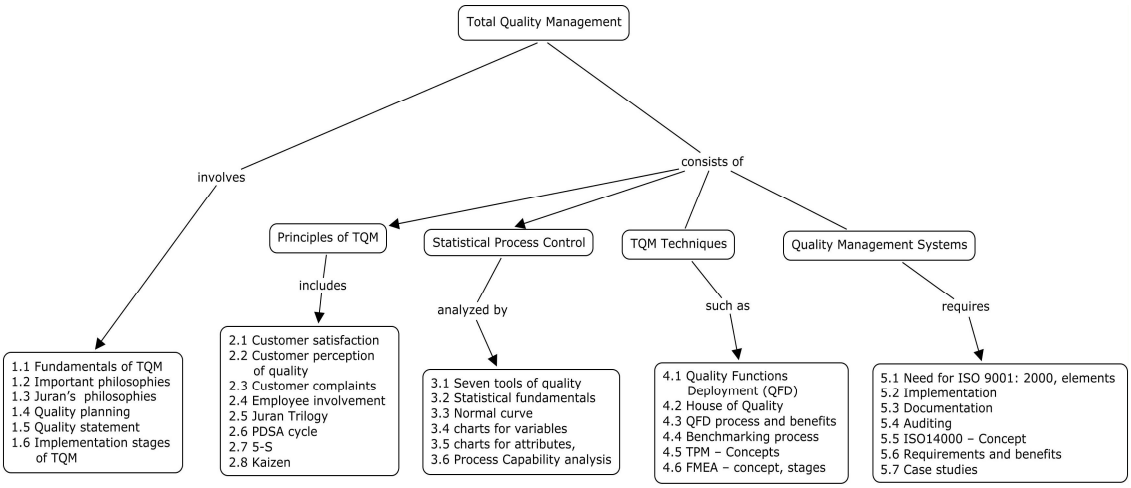
(b) Compute the control limits for the *np* chart

4.Build the house of quality matrix to show the inter relationship between the customer requirements and technical descriptors for a manufacturing system.

5.Discuss the mandatory items of ISO 14000.

6.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 & Cases**", Himalaya publishing House, 2002.
2. Berk, Joseph and Berk, S., "**The Essence of TQM**", Prentice Hall of India, 1998.
3. Narayana and Sreenivasan, "**Quality Management – Concepts & Tasks**", New Age International, 1996.
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, 2004.

Course contents and Lecture schedule

No.	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

No.	Topics	No. of Lectures
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	2
4.6	FMEA – concept, stages	2
5	**Quality Management Systems**	
5.1	Need for ISO 9001: 2008, Elements	1
5.2	Implementation	2
5.3	Documentation	1
5.4	Auditing	1
5.5	ISO14000 Concept	2
5.6	Requirements and benefits	1
5.7	Case studies	2
	Total	**50**

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Sub Code	Lectures	Tutorial	Practical	Credit
WEK	4	0	0	4

WEK Design for Manufacture and Assembly 4:0

Preamble: The term "design for manufacture" (or DFM) means the design for ease of manufacture of the collection of parts that will form the product after assembly and "design for assembly" (or 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.

Competencies:

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

1. Explain the elements and steps involved in concurrent engineering approach
2. Explain the importance of the Design for Manufacture and Assembly (DFMA)
3. Implement the tolerance requirements in the process of DFMA
4. Explain the of design guidelines for sand casting, die casting, machining, and sheet metal forming processes
5. Explain the principles and guidelines of design for assembly of components in manual, automated and robot assembly system
6. Redesign the component for ease of manufacturing and assembly

Assessment Pattern

Sl.No.	**Bloom's Category**	**Test 1**	**Test 2**	**Test 3 / End-semester examination**
1	Remember	20	20	10
2	Understand	40	40	30
3	Apply	40	40	60
4	Analyze	0	0	0
5	Evaluation	0	0	0
6	Create	0	0	0

Course Level Learning Objectives

Remember

1. Define Concurrent Engineering?
2. What is the importance of DFMA principles in product development?
3. What are the advantages of the Design for Manufacture (DFM)?
4. List out any four guidelines for Design for Assembly.
5. What are the factors to be considered in the selection of the component material?
6. What are the major factors that influence in the selection of the manufacturing process?

Understand

1. Explain the elements of concurrent engineering approach with block diageam.
2. Explain the guidelines of Design for Manufacture with suitable illustrations.
3. With suitable examples, explain the design guidelines for a assembly of less than six components.
4. Describe the step by step procedure for the selection of machining operations for the rotational and non rotational components.
5. Explain the effect of influencing parameters in designing of cast component.
6. Discuss the major considerations to be made during the assembly of components using automated system.

Apply

1. The shaft assembly of the intermediate transmission unit shown in Fig .1 is required to have an axial freedom in between 0.06 and 0.18 mm when assembled in the working condition. Using the nominal sizes specified for shaft, housing, and bearing bushes shown in Fig .2. State the appropriate limits to achieve the required axial freedom.

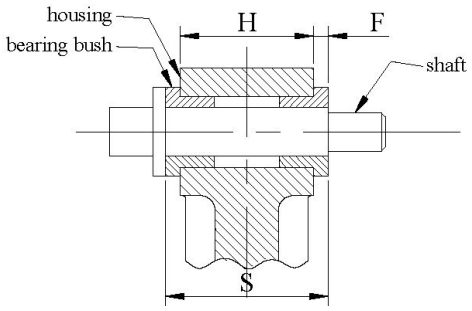


Figure 1

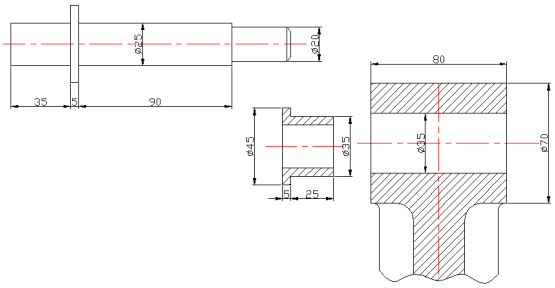
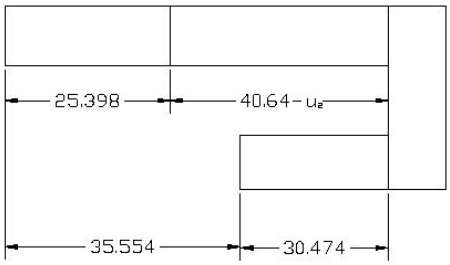
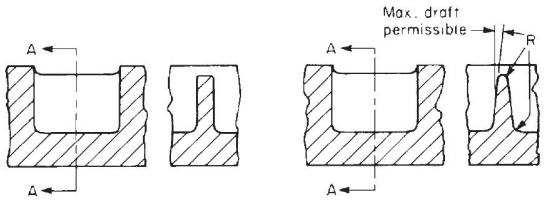


Figure 2

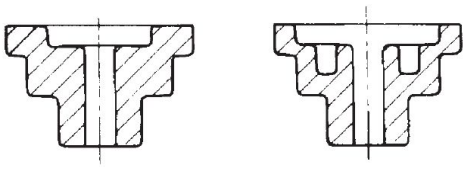
2. Find the value of tolerance u_2 if the tolerance of the resulting opening by the arithmetic rule is to be $\pm$0.4572 mm.



3. Observe the designs of following two cast components and suggest the better design for ease of casting.

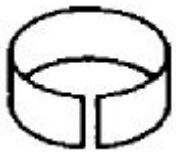


(a)

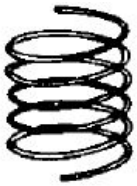


(b)

4. How will you avoid the tangling of following parts during feeding and orienting on automated assembly system and suggest suitable modification in the component design?



(a)

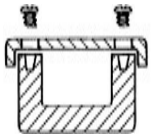


(b)

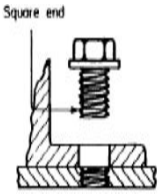
(c)

5. Suggest the suitable modifications needed for improving the assembly the following parts.

(a)

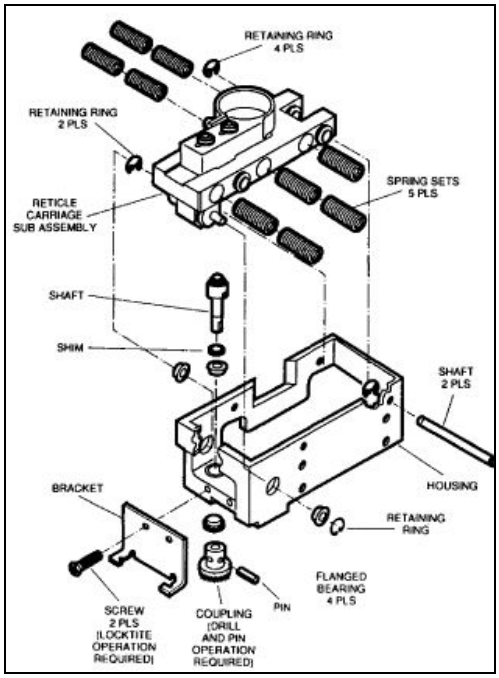


(b)

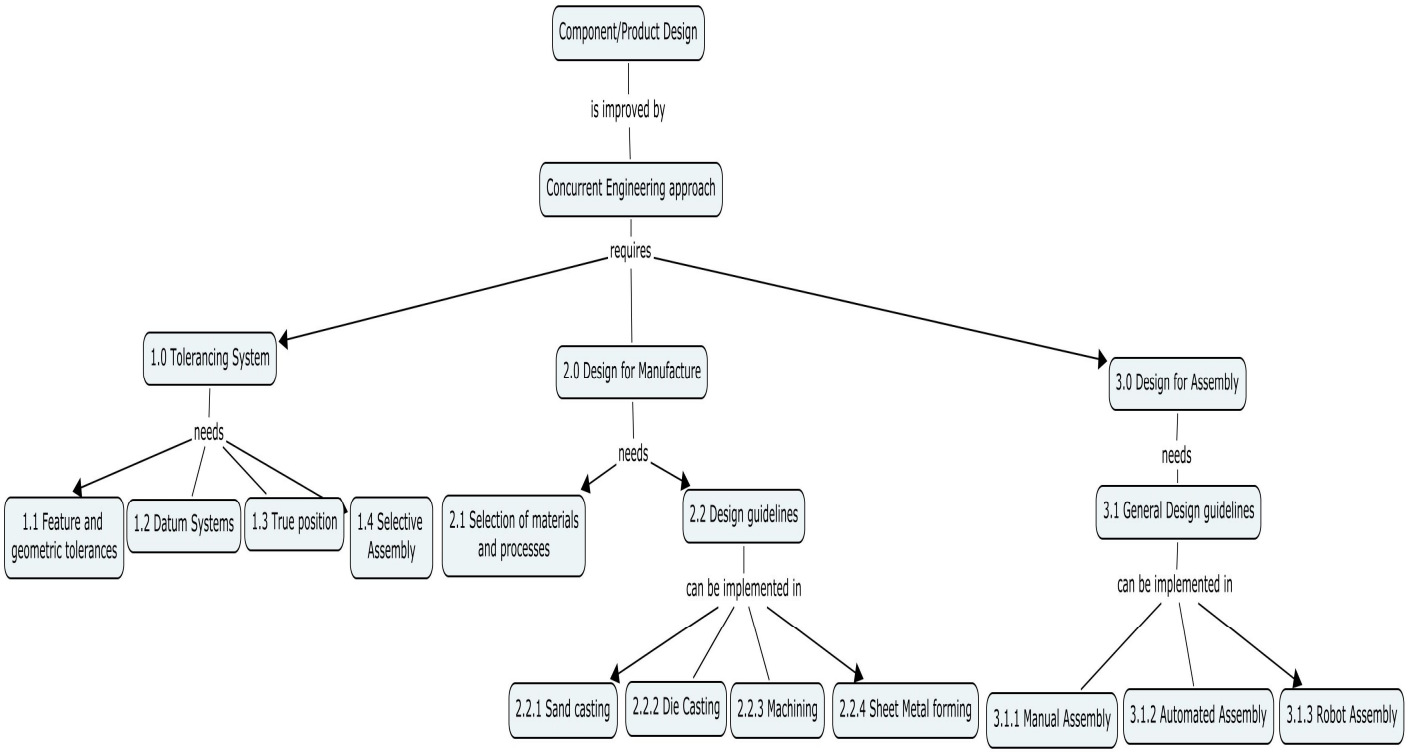


(c)

6. Suggest suitable modification in design of the following assembly.



Concept Map



Course Contents and Lecture schedule

No.	Topics	No. of Lectures
0	**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

No.	Topics	No. of Lectures
1.3	True position theory: Comparison between co-ordinate and convention method of feature location	1
1.3.1	Tolerancing and true position tolerancing -Virtual size concept - Projected tolerance zone	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**

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 - 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, 2004.
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.
6. Harry Peck, "**Designing for Manufacture**", Pitman Publications, 1983.

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Sub Code	Lectures	Tutorial	Practical	Credit
WER/L31	4	0	0	4

WER/L31 Supply Chain Management 4:0

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.

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

1. Explain issues important in the design of the logistics network.
2. Explain the interaction of various supply chain stages.
3. Explain various types of partnerships that can be used to manage SC more effectively.
4. Explain issues specific to global SCM.
5. Apply product design interaction with SCM. Develop inventory systems.
6. Suggest ways of improving customer value.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. Define SCM.
2. Give the issues important in the design of the logistics network.
3. What do we mean by cross-docking?
4. What are the types of Retailer-Supplier Partnerships?
5. What is mass customization?
6. What is Electronic Commerce?

Understand

1. Why SC integration is difficult? Explain.
2. Explain the data that are required for a typical network configuration problem.
3. Explain the three distinct outbound distribution strategies.
4. Explain the factors that are to be considered to determine whether a particular strategic alliance is appropriate or not.
5. Explain the requirements for global strategy implementation.
6. Explain the advantages of implementing a design for logistics strategy.

Apply

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

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

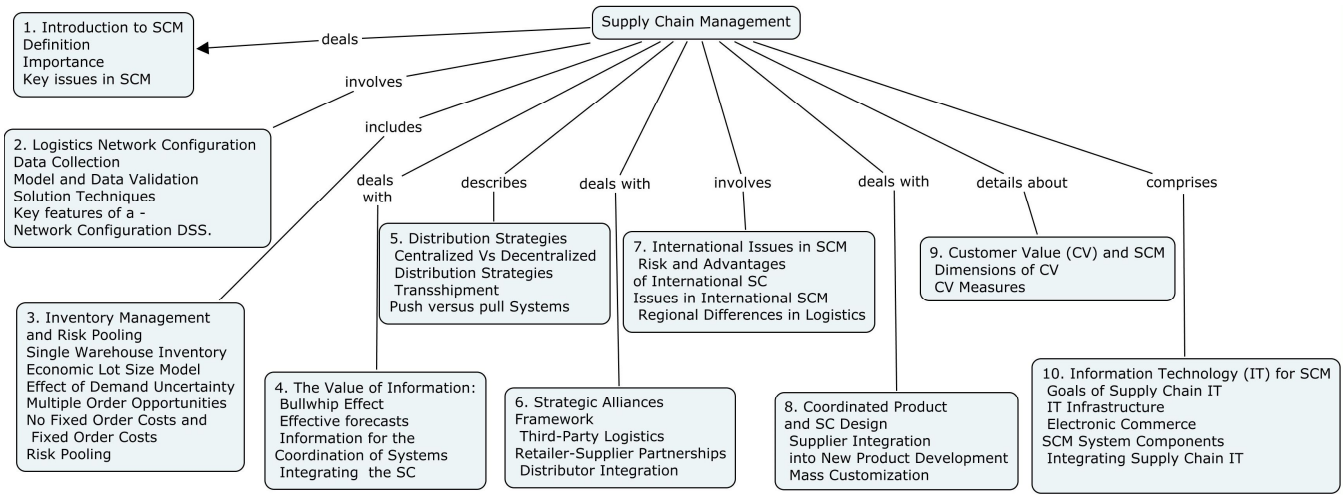
Parameter	Average Weekly demand	Safely stock	Reorder point

Value	44.58	86	176

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

3. Illustrate with an example how conflicting goals of different partners and facilities are achieved in a supply chain?
4. Explore the various methods for coping with the Bullwhip effect.
5. Classify the outbound distribution strategies and select a suitable distribution strategy for a grocery industry.
6. Summaraise the issues in International Supply Chain Management.
7. Demonstrate the functioning of Amazon's supply chain network.

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", Tata McGraw Hill Publishing Company Ltd, New Delhi, 2003.
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

No.	TOPICS	No. of Lectures
1.0	**Introduction to Supply Chain Management (SCM)**	
1.1	Definition, Importance	2
1.2	Key issues in SCM	1
2.0	**Logistics Network Configuration**	
2.1	Data Collection, Model and Data Validation	2
2.2	Solution Techniques and Problems	2
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	1
3.3	Risk Pooling	2
4.0	**The Value of Information**	
4.1	Bullwhip Effect	2
4.2	Effective forecasts	1
4.3	Information for the Coordination of Systems	1
4.4	Integrating the Supply Chain	1
5.0	**Distribution Strategies**	
5.1	Centralized versus Decentralized Control	1
5.2	Distribution Strategies, Transshipment	2
5.3	Push versus pull Systems	2
6.0	**Strategic Alliances**	
6.1	Framework for Strategic Alliances	2
6.2	Third-Party Logistics	2
6.3	Retailer-Supplier Partnerships	2
6.4	Distributor Integration	1
7.0	**International Issues in SCM**	
7.1	Risk and Advantages of International SC	2
7.2	Issues in International SCM	2
7.3	Regional Differences in Logistics	1
8.0	**Coordinated Product and SC Design**	
8.1	Supplier Integration into New Product Development	1

8.2	Mass Customization	2
9.0	**Customer Value (CV) and SCM**	
9.1	Dimensions of Customer Value	2
9.2	Customer Value Measures	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	**48**

Course Designers

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Sub Code	Lectures	Tutorial	Practical	Credit
WEU	4	0	0	4

WEU Metal Joining Engineering 4:0

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. 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.

Competencies:

At the end of the course students will be able to

1. Demonstrate the basic concepts of welding processes.
2. Understand the principles of various welding processes.
3. Understand the concepts of welding processes.
4. Apply the tool and techniques for welding process.
5. Analyze the applicability and limitations of the welding processes.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. State the applications of gas tungsten arc welding process.
2. What is resistance welding?
3. What is the need of computer welding process?
4. What are the inert gases used in the arc welding processes?
5. What gases are commonly used in the gas welding process?
6. What is brazing?

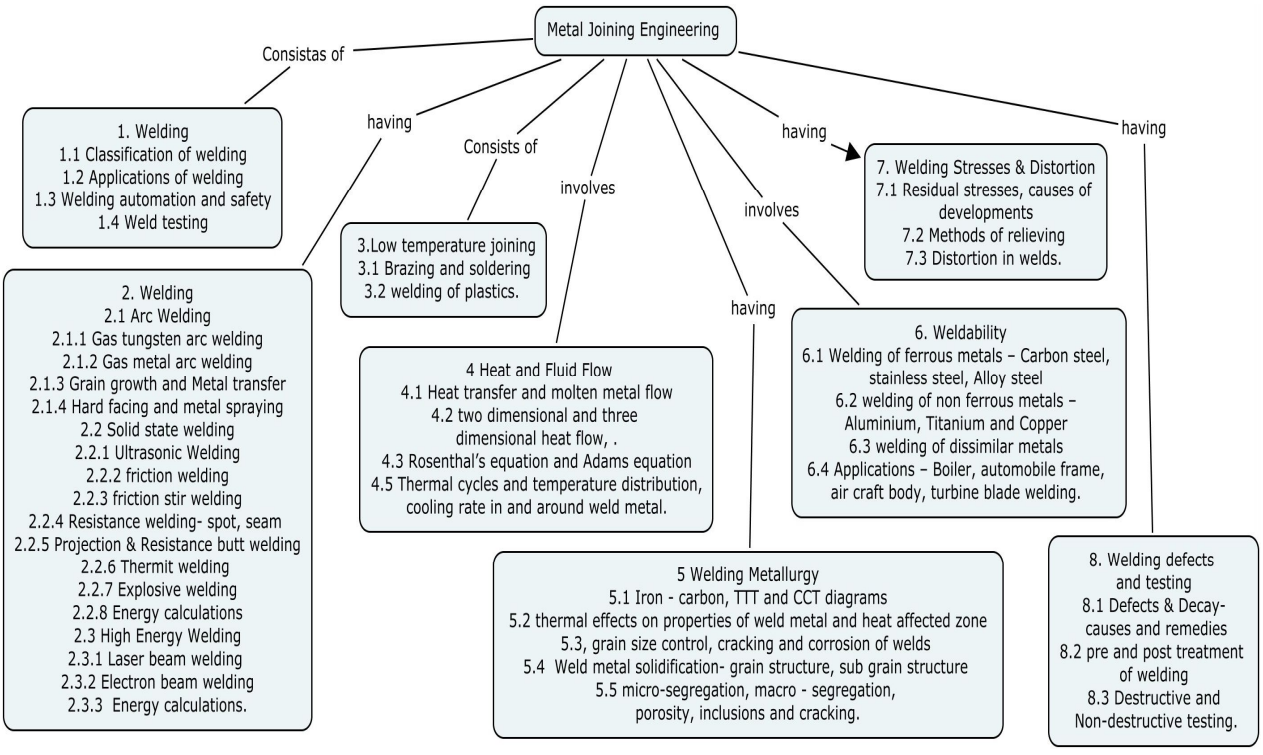
Understanding

1. Differentiate between TIG and MIG welding process.
2. Compare electron beam and laser welding processes.
3. Explain resistance seam welding process with neat sketches.
4. State the application of plasma arc welding process.
5. Differentiate between friction welding and friction stir welding processes.
6. Explain any two non-destructive testing of welded joints.

Apply

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. Discuss the welding processes which are used for automobile frame welding.
4. Select suitable welding processes to join medium carbon steels.
5. An aluminium name plate is to be fixed on a cast iron machine member, select a suitable welding process to fix the name plate and justify your selection with necessary illustrations.
6. Select a suitable inspection method to ensure the weld is not having any crack and other defects and justify your selection with necessary illustrations.

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 Welding:** 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, 1989.
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, 1979.
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

No	Topics	No. of Lectures
1	**Welding**	
1.1	Classification of welding	1
1.2	Applications of welding	1
1.3	Welding automation and safety	2
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	2
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	2
3.2	welding of plastics	1

No	Topics	No. of Lectures
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	2
4.4	Thermal cycles and temperature distribution, cooling rate in and around weld metal.	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	2
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 cracking.	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 welding.	2
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
	Total	**50**

Course Designers

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CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE Industrial Engineering & M.E Production Engineering PROGRAMME

FOURTH SEMESTER SUBJECT

&

ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2011-2012 ONWARDS

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

MADURAI – 625 015, TAMILNADU
Phone: 0452 – 2482240, 41
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Web: www.tce.edu

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Industrial Engineering) PROGRAMME

Scheduling of Courses
(For the candidates admitted from 2011-2012 onwards)

Sem.	**Theory Courses**						**Practical/Project**
4th (12)							L41 Project Phase – II 0:12
3rd (16)	L31 Supply Chain Management 4:0	LEX Elective -V 4:0	LEX Elective -VI 4:0				L34 Project Phase-I 0:4
2nd (24)	L21 Financial Management 3:0	L22 Operations Management 4:0	LEX Elective -I 4:0	LEX Elective -II 4:0	LEX Elective -III 4:0	LEX Elective -IV 4:0	L 27 Work System Engineering Laboratory 0:1
1st (24)	L11 Applied Probability and Statistics 3:1	L12 Optimisation Techniques 4:0	L13 Work Study and Cost Analysis 3:1	L14 Quality and Reliability Engineering 3:1	L15 Management Support Systems 3:0	L16 Industrial Automation and Robotics 3:1	L17 Industrial Engineering Laboratory 0:1

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
L41	Project Phase II	DC	0	0	36	12
Total						**12**

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

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

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

FOURTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	L41	Project Phase II	--	150	150	300	75	150

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

** L41 Project Phase II Terminal Examination will be conducted for maximum marks of 300 and subsequently be reduced to 150 marks for the award of terminal examination marks

*** The Duration of Terminal Examination for L34 Project Phase I (Third Semester) and L41 Project Phase II (Fourth Semester) is not specified and will be decided by the Department/ Examiners for the candidates admitted from 2011-2012 onwards.

REVISED LIST OF ELECTIVE SUBJECTS - M.E Industrial Engineering

(For the candidates admitted from 2011-2012 onwards)

S.No.	Sub. Code	Name of the Subjects	Credit
1.	LEA/WEA	Plant Layout and Material Handling	4
2.	L EB/WEB	Sequencing and Scheduling	4
3.	L EC/WEC	Materials Management	4
4.	L ED/WED	Research Methodology	4
5.	LEE/WEE	Total Quality Management	4
6.	L EF/WEF	Maintenance Engineering and Management	4
7.	LEG /WEG	Machine Vision and its applications in manufacturing	4
8.	LEH/WEH	System Simulation	4
9.	L EI/WEI	Entrepreneurship Development	4
10.	LEJ/WEJ	Product Design and Development	4
11.	L EK	Energy Systems	4
12.	LEL/WEL	Robust Design	4
13.	LEM/WEM	Lean Manufacturing and Six Sigma	4
14.	L EN/W31	Computer Integrated Manufacturing	4
15.	LEO	Modeling and Analysis of Manufacturing Systems	4
16.	L EP	Logistics and Distribution Management	4
17.	L EQ	Human Resource Management	4
18.	L ER	Value Engineering	4
19.	L ES	Industrial Instrumentation	4

M.E. DEGREE (Production Engineering) PROGRAMME

Scheduling of Courses

(For the candidates admitted from 2011-2012 onwards)

Sem.	Theory Courses						Practical/Project
4th (12)							W41 Project Phase – II 0:12
3rd (16)	W31 Computer Integrated Manufacturing 4:0	WEX Elective - V 4:0	WEX Elective - VI 4:0				W34 Project Phase-I 0:4
2nd (24)	W21 Mechanics of Metal Cutting and Metal Forming 4:0	W22 Tool Design Engineering 3:0	WEX Elective -I 4:0	WEX Elective -II 4:0	WEX Elective - III 4:0	WEX Elective -IV 4:0	W27 Advanced Manufacturing Engineering Laboratory II 0:1
1st (24)	W11 Computational Methods in Engineering 3:1	W12 Optimisation Techniques 4:0	W13 Mechanical Behaviour of Materials 4:0	W14 Industrial Automation and Robotics 3:1	W15 CNC Machine Tool Technology 3:0	W16 Micro Electro Mechanical Systems and Nano Technology 3:1	W17 Advanced Manufacturing Engineering Laboratory I 0:1

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Production Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2011-2012 onwards)

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
W41	Project Phase II	DC	0	0	36	12
Total						**12**

BS : Basic Science
DC : Department Core
DE : Departmental Elective

L : Lecture
T : Tutorial
P : Practical

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

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2011-2012 onwards)

FOURTH SEMESTER

S.No	Sub. code	Name of the subject	Duration of Terminal Exam. in Hrs.	Marks			Minimum Marks for Pass	
				Continuous Assessment *	Terminal Exam **	Max. Marks	Terminal Exam	Total
PRACTICAL								
1	W41	Project Phase II	--	150	150	300	75	150

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

** W41 Project Phase II Terminal Examination will be conducted for maximum marks of 300 and subsequently be reduced to 150 marks for the award of terminal examination marks

*** The Duration of Terminal Examination for W34 Project Phase I (Third Semester) and W41 Project Phase II (Fourth Semester) is not specified and will be decided by the Department/Examiners for the candidates admitted from 2011-2012 onwards.

REVISED LIST OF ELECTIVE SUBJECTS – M.E Production Engineering
(For the candidates admitted from 2011-2012 onwards)

S.No.	Sub. Code	Name of the Subjects	Credit
1.	WEA/LEA	Plant Layout and Material Handling	4
2.	W EB/LEB	Sequencing and Scheduling	4
3.	W EC/LEC	Materials Management	4
4.	W ED/LED	Research Methodology	4
5.	WEE/LEE	Total Quality Management	4
6.	W EF/LEF	Maintenance Engineering and Management	4
7.	WEG/LEG	Machine Vision and its applications in manufacturing	4
8.	WEH/LEH	System Simulation	4
9.	W EI/LEI	Entrepreneurship Development	4
10.	WEJ/LEJ	Product Design and Development	4
11.	W EK	Design for Manufacture and Assembly	4
12.	WEL/LEL	Robust Design	4
13.	WEM/LEM	Lean Manufacturing and Six Sigma	4
14.	WEN/L13	Work Study and Cost Analysis	4
15.	WEO/L14	Quality and Reliability Engineering	4
16.	WEP/L21	Financial Management	4
17.	WEQ/L22	Operations Management	4
18.	WER/L31	Supply Chain Management	4
19.	WES	Geometric Modeling	4
20.	WET	Metal Casting Engineering	4
21.	WEU	Metal Joining Engineering	4
22.	WEV	Fluid Power Automation	4
23.	WEW	Rapid Manufacturing	4
24.	WEY	Mechatronics in Manufacturing	4
25.	WEZ	Computer Aided Metrology and Inspection	4

Sub. code	Lecturers	Tutorial	Practical	Credit
LEA/WEA	4	0	-	4

LEA/WEA Plant Layout and Material Handling 4:0

(For the candidates admitted from 2011-2012 onwards)

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.

Competencies

At the end of the course students will be able to

1. Describe the concepts of plant location and layout.
2. Select a suitable plant location.
3. Design the layouts of manufacturing systems and service organizations.
4. Design the material handling system.

Assessment Pattern

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

Course Level Learning Objectives

Remember

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. What is REL chart?
5. List the classification of MH equipment.
6. Define Unit load.

Understand

1. Discuss the various techniques of locating a single facility.
2. Explain the procedure of systematic layout planning
3. Classify the basic material handling equipments with suitable example
4. Describe the criteria and guidelines for the design of Unit load system.
5. Discuss about the computerizing warehouse operations.
6. Discuss briefly the receiving principles in Warehousing.

Apply

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

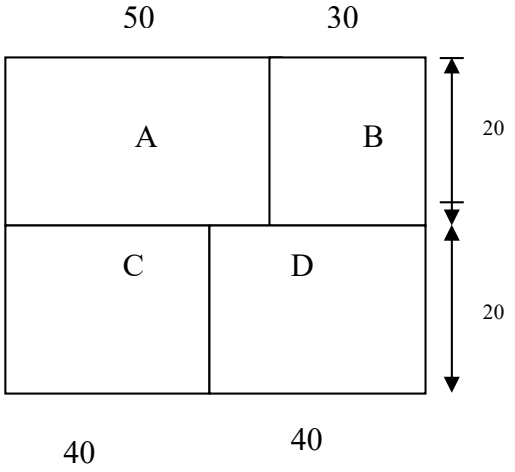
2. Identify the logical part families and machine groups by applying ROC technique. The part-machine incidence matrix is given in the table.

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

3. 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

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



Initial Layout

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

Flow Matrix

5. 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

6. Apply CORELAP to design a layout for the given details.

Dept.	Area
A	1280 Sq. feet
B	512
C	1280
D	1120
E	960
F	960
G	640

Analyze

1. A company produces 60 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. Analyze the issues when the number of workstations is increased.

Work Element	Immediate Predecessor	Estimated time (Sec)
A	-	30
B	-	10
C	-	15
D	B,C	10
E	D	25
F	E	10
G	F	30
H	G	30
I	A,H	20
J	I	35

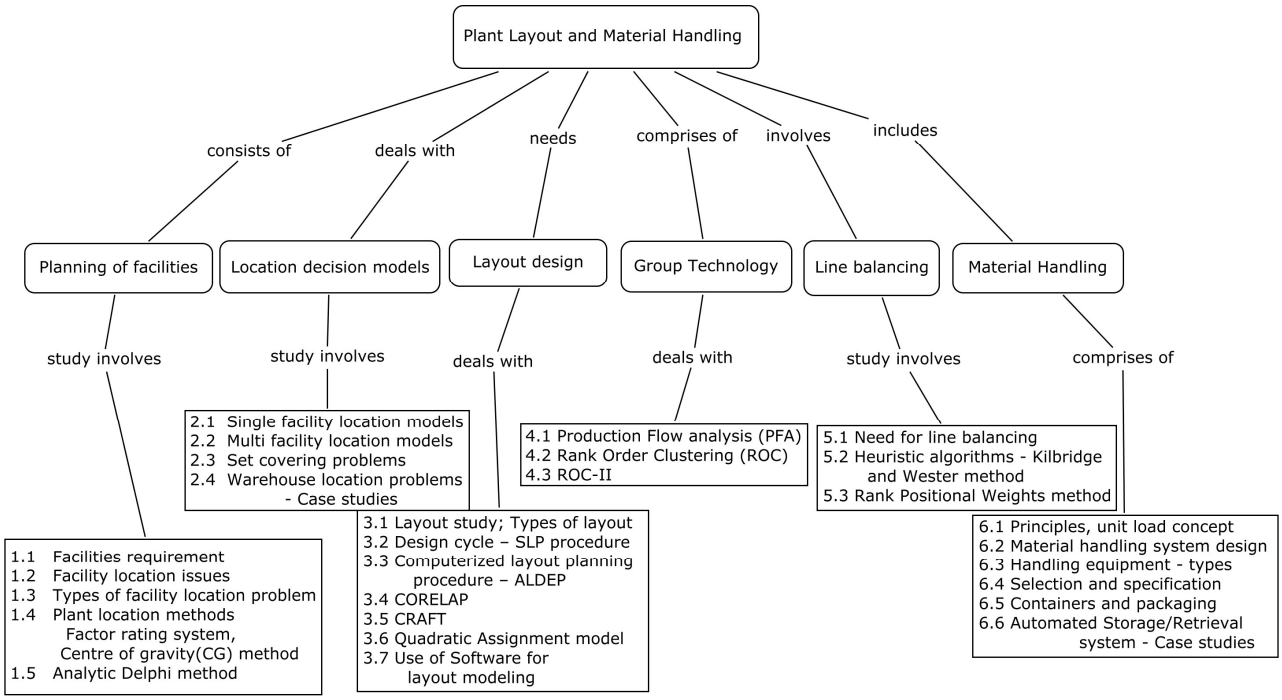
2. Analyze the choice of computerized layout planning procedure for the best layout plan with appropriate example.
3. Discuss about AS/AR system in comparison with the conventional warehousing system with an example.
4. Discuss about the choice of material handling system for a heavy manufacturing industry. Illustrate the pros and cons of the system under study.
5. Identify the logical part families and machine groups by applying ROC-2 technique. The part-machine incidence matrix is given in the table. Analyze the performance of the technique with ROC with respect to the exceptional elements.

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

6. 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

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. **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, 2003.
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,2007

Course contents and Lecture schedule

No	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	4
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	2
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.	2
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	**51**

Course Designer

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Sub Code	Lectures	Tutorial	Practical	Credit
LED/WED	4	0	-	4

LED/WED Research Methodology 4:0

(For the candidates admitted from 2011-2012 onwards)

Preamble This course aims at giving adequate exposure in research process, data analysis techniques, report writing.

Competencies

At the end of the course students will be able to

1. Identify and define the research problem.
2. Formulate the research process.
3. Determine sample size and sampling plans.
4. Identify sources of error in measurement.
5. Analyze data.
6. Write a research report.

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	30	30	30
4	Analyze	0	20	20	20
5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Level Learning Objectives

Remember

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.

Understand

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.

Apply

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

4. 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.

5. 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

6. 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?

Analyze

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.

4. 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?

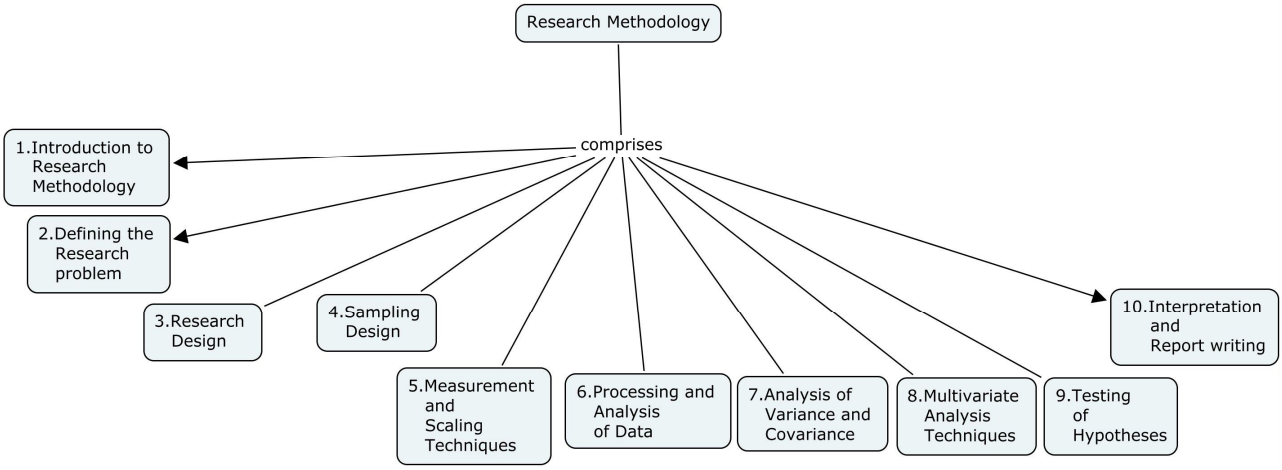
5. Sample of sales in similar shops in two towns are taken for a new product with the following results:

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?

6. "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. Kothari. C.R., "Research Methodology: Methods and Techniques", 2nd edition, New Age International, 2004
2. Khan Zode V.V., "Research Methodology and Trends", APH Publishing corporation 2004.
3. Best J.W., "Research in Education", Prentice Hall Inc, Newyork, USA, 1977.
4. William G. Zikmand, "Business Research Method", Dryden, 1992.
5. Panneerselvam R, "Research Methodology", Prentice Hall of India,2004

Course contents and Lecture schedule

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
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

No	Topics	No. of Lectures
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	

No	Topics	No. of Lectures
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**	
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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Sub Code	Lectures	Tutorial	Practical	Credit
LEM/WEM	4	0	-	4

LEM/WEM LEAN MANUFACTURING AND SIX SIGMA 4:0

(For the candidates admitted from 2011-2012 onwards)

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.

Competencies

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

1. Explain the concepts of Lean Manufacturing and Six Sigma.
2. Identify the wastes and suggest means for improving productivity.
3. Identify lean metrics and inspect it in the area of work.
4. Apply lean and six sigma tools for decision making problems.
5. Apply Six Sigma practices in quality problems.

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 Learning Objectives

Remember

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.

Understand

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.

Apply

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.

Analyze

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

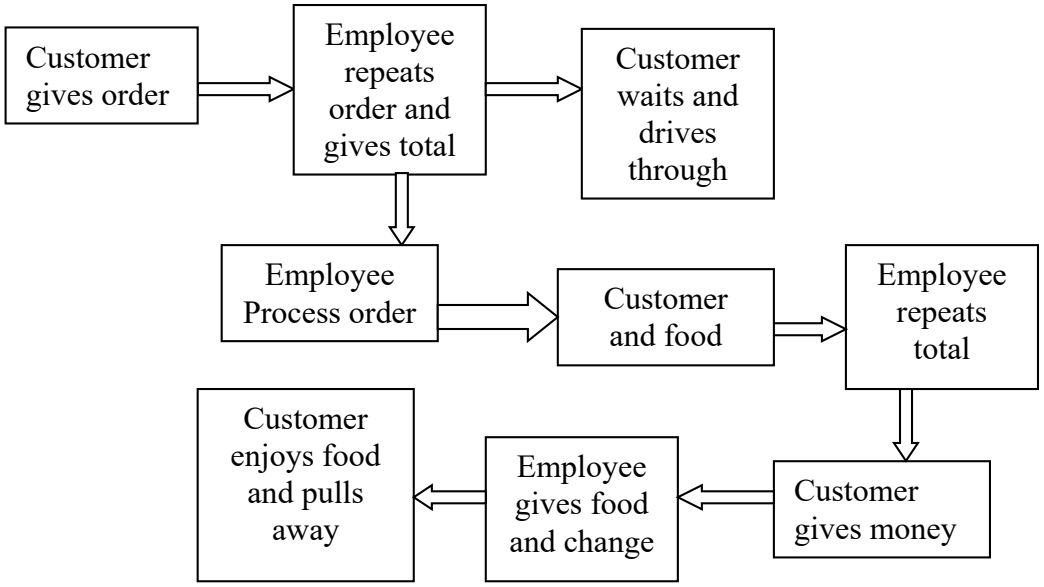
4. A Restaurant conducted consumer surveys and focus groups and identified the most important customer requirements as Healthy food, speedy service, an easy to read menu board, accurate order filling and perceived value. Develop of a set of technical requirements to incorporate into the design of a new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

5. Maintaining accuracy of books on shelves in a library is an important task. Consider the following problems that are often observed.

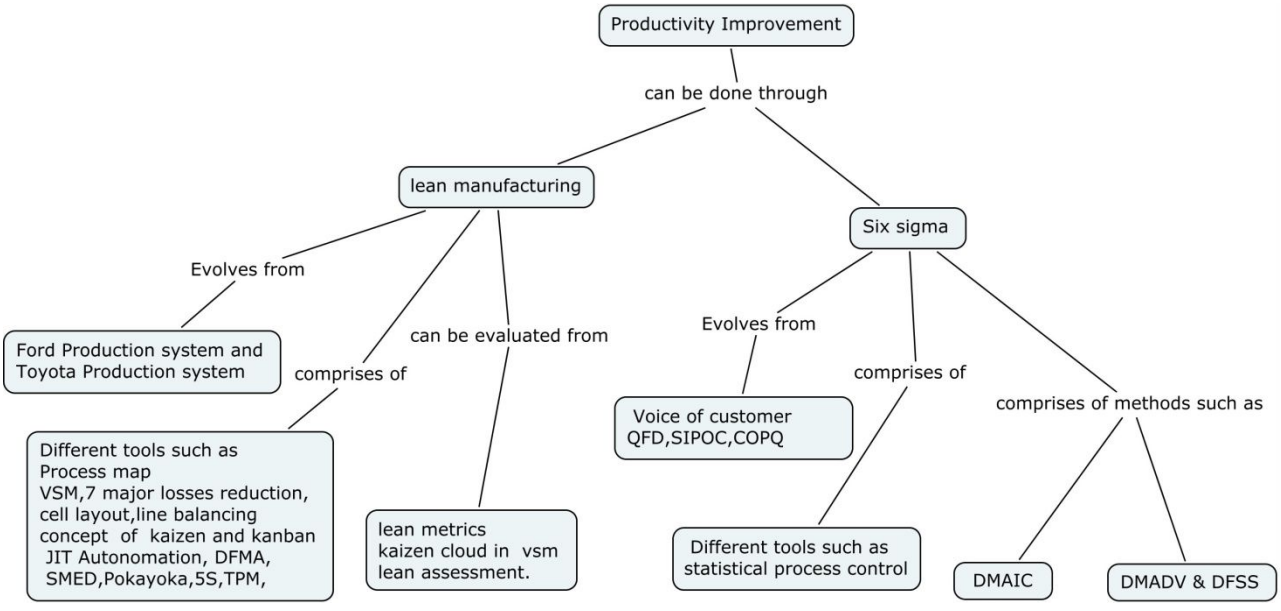
a. Books are not placed in the correct shelf, which include books that are checked out and returned and books taken off from shelves

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.

6. 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;

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, 2000
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, 2003.
5. N.Gopalakrishnan, simplified lean manufacture:Elements, rules, tools and implementation, Prentice Hall of India, NewDelhi 2010

Course Contents and Lecture schedule

S.No	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

S.No	Topics	No. of Lectures
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
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	1
	Total	**46**

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Sub Code	Lectures	Tutorial	Practical	Credit
LEG / WEG	4	0	-	4

LEG / WEG Machine Vision and its application in Manufacturing 4:0

(Revised Syllabus For the candidates admitted from 2012-2013 onwards)

Preamble

Machine Vision has become a key technology in the area of manufacturing and quality control. Increasing quality demands require inspection of every single part which in turn will lead to much more wide spread use of visual inspection systems. Furthermore the documentation requirements of ISO 9000 and similar quality control standards can only be met by fully automated networked inspection systems. The Success of developing machine vision system depends on the understanding all parts of the imaging chain. Hence this course discusses about image acquisition, lens and illumination systems, image preprocessing and processing, segmentation and classification techniques used in a typical machine vision application.

Competencies

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

1. Explain the components of a machine vision system.
2. Select appropriate camera, lens and lighting system for a machine vision system.
3. Apply image preprocessing, post processing algorithms like segmentation to solve Application and case studies.

Assessment Pattern

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

Course Level Learning Objectives

Remember

1. Define digital image.
2. List the types of Resolution used in Machine Vsion.
3. Write the basic components of a machine vision system.
4. Mention the types of cameras used in image acquisition.
5. What is meant by dark current?
6. Expand the acronym NTSC.

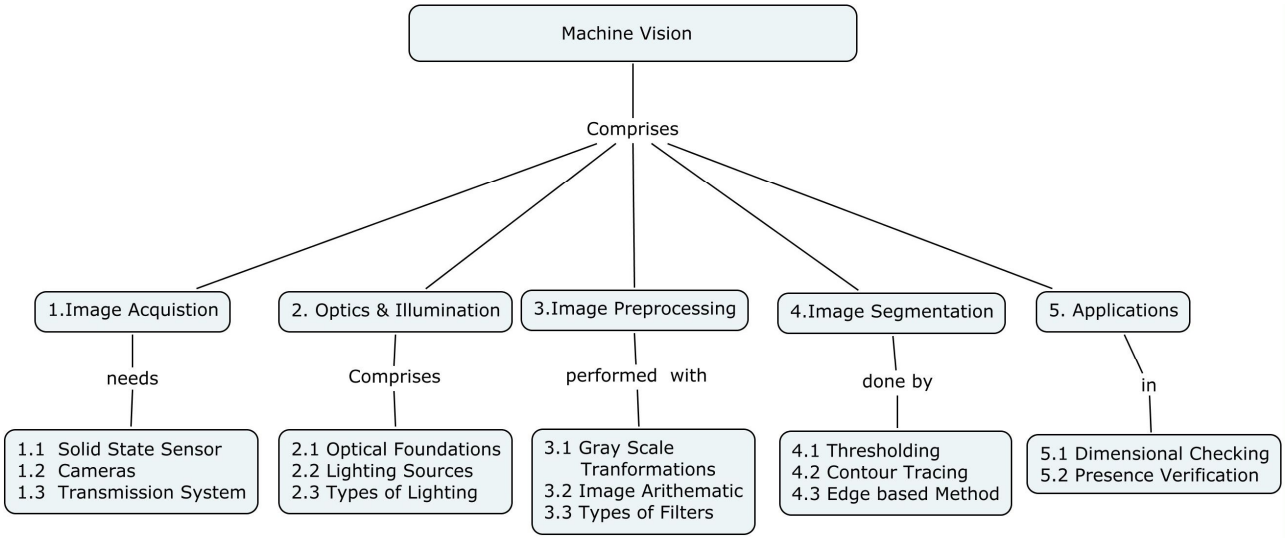
Understand

1. What is the need for frame grabber in image acquisition?
2. Explain the working principle of CCD sensor array
3. Describe in detail about various image acquisition modes.
4. Explain the advantages of CMOS sensors over CCD sensors.
5. Discuss the advantages of direct digital transmission
6. Differentiate between sensor format and lens format

Apply

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor. Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm.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.
4. A surveillance camera is embedded in one of the walls of a room . The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is .05m.The X-Z plane of the camera is parallel to the X-Y Plane of the world coordinate system. The image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner.
5. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.
6. Select and illustrate a suitable Machine Vision Technique used for Inspection of Threads in Nuts in a Batch Production Process.

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. R.C.Gonzalez, Richard E.Woods, "Digital Image Processing." Second Edition, Prentice Hall India, 2005.

Course contents and Lecture Schedule

S.No.	Topics	No. of Lectures
1	**Image Acquisition**	
1.1	Solid State Sensors:	
1.1.1	CCD Sensor Operation	1
1.1.2	CCD Properties, Image Degradation	1
1.1.3	CMOS Sensors Operation and its advantages	1
1.2	Standard Video Cameras:	
1.2.1	Basic Structure, Sampling of Line Signal	1
1.2.2	Extension of Video Standards, Image Quality	1
1.2.3	Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras and its Properties	2
1.3	Transmission to Computer:	
1.3.1	Basic operation of Frame Grabber	1
1.3.2	Direct Digital transmission	1
1.3.3	USB, IEEE1394, Firewire, Gigabit Ethernet, Choosing Computer Bus	2
2	**Optics and Illumination**	
2.1	Optical foundations	
2.1.1	Basic Laws of Optics, F number, Thin Lens Imaging Equation, Depth of Field	2
2.1.2	Typical Imaging Situations, Aberrations	1
2.1.3	Lens Selection, Special Optical devices	2
2.2	Lighting Sources	
2.2.1	Incandescent Lamps, Metal Vapour Lamps	1
	Xenon Lamps, Fluorescent, LED, Laser.	1

S.No.	Topics	No. of Lectures
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	1
2.3.3	Diffuse and Directed transmitted Lighting - Bright Field and Dark Field	1
3	**Image Preprocessing**	
3.1	Gray Scale Transformations:	
3.1.1	Look up tables, Linear Gray level scaling	1
3.1.2	Contrast enhancement, Histogram equalization, Local Contrast Enhancement.	2
3.1.3	Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images.	1
3.1.4	Types of Filters: Linear Filters, Median Filter	1
3.1.5	Morphological and Non Linear Filters	1
3.1.6	Fourier Transform Applications	2
4	**Image Segmentation**	
4.1	Thresholding:	
4.1.1	Threshold Determination from Histogram	1
4.1.2	Gray Level Histogram, Generalizations of Thresholding	2
4.2	Contour Tracing:	
4.2.1	Pixel Correctedness, Generating Object Contours, Contour representation	1
4.2.2	Edge based Methods: Edge probing and Edge Detection	1
4.2.3	Template matching: Basic Operation, Optimizing and Comments on Template Matching.	2
5	**Applications**	
5.1	Dimensional Checking:	
5.1.1	Simple gauging, Shape Checking	1
5.1.2	Angle Gauging, High accuracy Gauging	1
5.1.3	Calibration	2
5.2	Presence Verification:	
5.2.1	Simple Presence verification, Simple Gauging for assembly verification	2
5.2.2	Glue Check under UV Light	1

S.No.	Topics	No. of Lectures
5.2.3	Pin Type Verification	1
5.2.4	Alignment Checking	2
	Total	**48**

Course Designers

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