CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Industrial Engineering) PROGRAMME

FIRST SEMESTER SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2014-2015 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

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DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

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

Mission:

As a department, we are committed to

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

Programme Educational Objectives: (PEO's) of M.E (Industrial Engineering)

PEO 1

Graduates will assume lead roles in the practice of Industrial Engineering and its allied disciplines in manufacturing, services, and government.

PEO2

Graduates will continue to engage in life-long learning, understanding and applying knowledge and ideas of Industrial Engineering and allied disciplines.

PEO3

Graduates will associate themselves and become a part of IE professional societies or other professional organizations as well as in community-based organizations.

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

Graduating Students of M.E. Industrial Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	An ability to apply knowledge of mathematics and science in solving problems	**Scholarship of Knowledge**
PO2.	An ability to design and conduct experiments, as well as to analyze and interpret data	**Critical Thinking**
PO3.	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Problem Solving**
PO4.	An ability to have the broad education necessary to understand the impact of engineering solutions in a global and societal context	**Research Skill**
PO5.	An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice	**Usage of modern tools**
PO6.	An ability to function effectively as an individual and as a member or a leader in diverse teams, and in multidisciplinary activities	**Collaborative and Multidisciplinary work**
PO7.	An ability to apply project, financial management principles and techniques individually/collaboratively in project planning, implementation and control	**Project Management and Finance**
PO8.	An ability to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**Communication**
PO9.	An ability to engage in independent and life-long learning for personal and societal development	**Life-long Learning**
PO10.	An ability to understand the professional and ethical responsibility	**Ethical Practices and Social Responsibility**
PO11.	An Ability to make corrective measures and learn from the mistakes without depending on external feed back	**Independent and Reflective Learning**

PEO – PO Matrix

POs / PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	S	S	S	S	S	S	S	S	M	S	M
PEO2	S	S	S	S	S	M	M	S	S	L	S
PEO3	S	S	M	M	M	M	L	S	S	S	S

Correlation: S – Strong; M-Medium; L-Low

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Industrial Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses						Practical/Project
4th (12)							14IE410 Project Phase – II 0:12
3rd (16)	14IE310 Supply Chain Management 4:0	14IEPX0 Elective -V 4:0	14IEPX0 Elective -VI 4:0				14IE340 Project Phase-I 0:4
2nd (24)	14IE210 Financial Management 3:0	14IE220 Operations Management 4:0	14IEPX0 Elective -I 4:0	14IEPX0 Elective -II 4:0	14IEPX0 Elective -III 4:0	14IEPX0 Elective -IV 4:0	14IE 270 Work System Engineering Laboratory 0:1
1st (24)	14IE110 Applied Probability and Statistics 4:0	14IE120 Optimisation Techniques 4:0	14IE130 Work Study and Cost Analysis 4:0	14IE140 Quality and Reliability Engineering 4:0	14IE150 Management Support Systems 3:0	14IE160 Industrial Automation and Robotics 4:0	14IE170 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 2014-2015 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE110	Applied Probability and Statistics	BS	4	0	-	4
14IE120	Optimization Techniques	PC	4	0	-	4
14IE130	Work Study and Cost Analysis	PC	4	0	-	4
14IE140	Quality and Reliability Engineering	PC	4	0	-	4
14IE150	Management Support Systems	PC	3	0	-	3
14IE160	Industrial Automation and Robotics	PC	4	0	-	4
PRACTICAL						
14IE170	Industrial Engineering Laboratory	PC	-	-	2	1
Total						**24**

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

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE110	Applied Probability and Statistics	3	50	50	100	25	50
2	14IE120	Optimization Techniques	3	50	50	100	25	50
3	14IE130	Work Study and Cost Analysis	3	50	50	100	25	50
4	14IE140	Quality and Reliability Engineering	3	50	50	100	25	50
5	14IE150	Management Support Systems	3	50	50	100	25	50
6	14IE160	Industrial Automation and Robotics	3	50	50	100	25	50
PRACTICAL								
7	14IE170	Industrial Engineering Laboratory	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.	14IEPA0	Plant Layout and Material Handling	4
2.	14IEPB0	Total Quality Management	4
3.	14IEPC0	Maintenance Engineering and Management	4
4.	14IEPD0	Machine Vision and its applications in manufacturing	4
5.	14IEPE0	System Simulation	4
6.	14IEPF0	Product Design and Development	4
7.	14IEPG0	Energy Management Systems	4
8.	14IEPH0	Robust Design	4
9.	14IEPJ0	Lean Manufacturing and Six Sigma	4
10.	14IEPK0	Computer Integrated Manufacturing	4
11.	14IEPL0	Value Engineering	4
12.	14IEPM0	Human Resource Management	4
13.	14IEPN0	Industrial Instrumentation	4
14.	14IEPP0	Research Methodology	4

14IE110	Applied Probability and Statistics	Category	L	T	P	Credit
		BS	4	0	0	4

Preamble

An engineering PG student needs to have some basic mathematical tools and techniques to apply in diverse applications in Engineering. This emphasizes the development of rigorous logical thinking and analytical skills of the student and appraises him the complete procedure for solving different kinds of problems that occur in engineering. Based on this, the course aims at giving adequate exposure in random variables, functions of random variables, regression and correlation, test of hypothesis and multivariate analysis technique

Prerequisite

NIL

Course Outcomes

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

(CO1):	remember various statistical and probabilistic mehods for different types of random variables	Remember
(CO 2):	Calculate expectation, variance, standard deviation moments and moment generating function for discrete and continuous random variables	Understand
(CO 3):	apply the concept of expectation and moment generating function to discrete and continuous distributions and to find the probability values for the defined distributions	Apply
(CO 4):	Understand the concept of functions of random variables to estimate the probability density functions	Understand
(CO 5):	Remember the idea of order statistics through the cumulative distribution function	Remember
(CO6):	Interpret the marginal density functions by transforming the random variables by using the jacobians	Apply
(CO 7):	Apply moment generating function technique to find higher order moments	Apply
(CO 8):	Understand the concept of linear and non linear correlation, linear and non linear regressions, rank correlation	Understand
(CO 9):	Apply least square method in fitting linear and non linear regressions	Apply
(CO 10):	Determine the equation of plane of partial and multiple regression	Understand
CO11	Understand the concept of testing of hypothesis for small and large samples by using various tests like t-test, F-test, z-test and chi-square test	Understand
(CO12):	Demonstrate whether two samples came from same population or from different population for set of collected sample data	Apply
(CO 13):	Understand the concept of multivariate analysis, its classification and important techniques	Understand
(CO 14):	Predict the shares in the market for future periods by using markov process in marketing strategy	Understand

Mapping with Programme Outcomes

POs / COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	S	S	L	M	S	L	L	L	M	S	M
CO2	S	S	M	M	L	L	L	L	L	M	M
CO3	S	S	S	S	M	S	S	S	L	S	S
CO4	S	S	S	M	M	M	L	L	S	S	M
CO5	S	S	L	M	M	M	S	S	L	L	M
CO6	S	S	S	M	S	M	S	M	S	L	M
CO7	S	S	M	M	S	S	S	S	M	M	M
CO8	S	S	L	L	L	M	M	S	S	S	S
CO9	S	S	M	M	L	L	S	S	S	L	M
CO10	S	S	L	L	L	L	L	M	M	L	M
CO11	S	S	L	L	L	L	L	L	M	L	M
CO12	S	S	S	L	L	M	M	M	L	L	M
CO13	S	S	L	L	M	M	L	L	M	M	M
CO14	S	S	L	L	M	S	S	L	L	L	M

Correlation: S-Strong; M-Medium; - L- Low

Assessment Pattern

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

Course Level Assessment Questions

(CO1):

1. Describe Continuous random variable with an example.
2. Define probability mass function of hyper geometric distribution

(CO2):

1. Identify the expectation where X is the outcome when we roll a die
2. Estimate the moment generating function of the random variable X given pdf

   $f(x) = 2e^{-2x}$; $x > 0$

(CO3):

1. A R V X has the following prob. Distribution

x	-2	-1	0	1	2	3
p (x)	0.1	K	0.2	2k	0.3	3k

Find a) k b) P (X< 2) c) P (-2 < X < 2) d) Cdf e) Mean of X.

2.Predict the value of 'a' if $P(X = x) = c\,(2/3)^x$; x = 1,2,3……

(CO4):

1.If X is uniformly distributed in (-1,1), then find the probability density function of

$y = \sin\frac{\pi x}{2}$

2.Define a function of a random variable with jacobian

(CO5):

1. Define distribution of order statistics
2. Identify the cumulative distribution function of largest order statistics

(CO6):

1. If X and Y each follow an exponential distribution with parameter 1 and are independent, find the pdf of U = X-Y

2.If the joint pdf of the random variable X & Y is given by f(x,y)=2; 0<X<Y<1.Find the marginal density of W=X/Y

(CO7):

1. The distribution function of a R V X is given by $F(x) = 1 - (1+ x)\,e^{-x}$; $x \geq 0$. Find the density function, mean.
2. Interpret moments in terms of moment generating functions

(CO8):

1. Compute $R_{1.23}$ if r_{12}=0.77; r_{13}=0.72; r_{23}=0.52.
2. Differentiate between correlation and regression of variables

(CO9):

1. Fit a parabola for a following data

X:	1	2	3	4	5	6	7	8	9	10
Y:	2	6	7	8	10	11	11	10	9	7

2. Interpret least square method to fit a linear and non linear regression

(CO 10):

1.Determine the plan of regression of Y on X1 and X2 for the following data

Y :	90	72	54	42	30	12
X1:	3	5	6	8	12	14
X2:	16	10	7	4	3	2

2. In a distribution $\sigma_1 = 2, \sigma_2 = 3, \sigma_3 = 3, r_{12} = 0.7, r_{23} = 0.5, r_{31} = 0.5$ Find

(i) $r_{23.1}\,(ii) R_{1.23}\,(iii) b_{12.3}, b_{13.2}\,(iv)\sigma_{1.23}$

(CO 11):

1. Distinguish between consumer's risk and producer's risk.
2. In a random sample of size 500 the mean is found to be 20 . In another sample of size 400 the mean is 15. Could the samples have been drawn from the same population with SD 4?

(CO 12):

The nicotine contents in two samples of tobacco are given below:

Sample 1:	21	24	25	26	27	-
Sample 2:	22	27	28	30	31	36

Can you say that the two samples came from the same normal population.

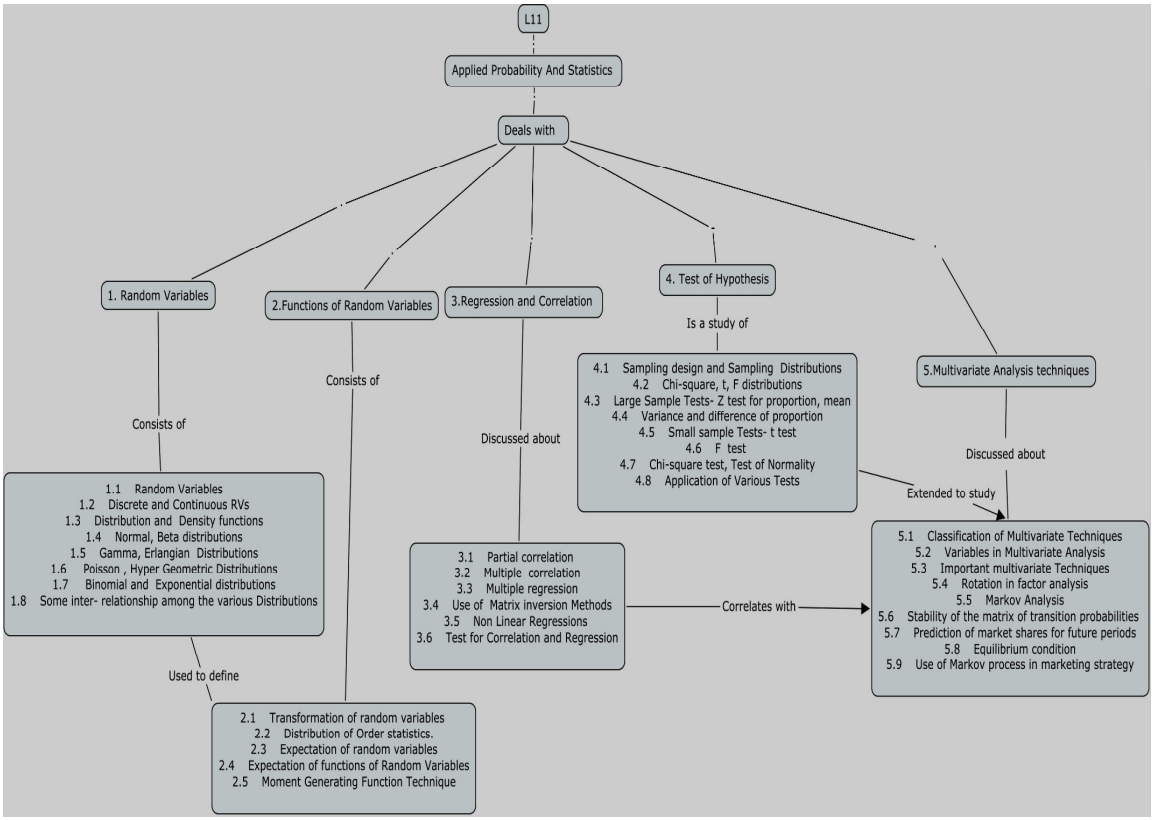
(CO 13):

1. Classify the various multivariate analysis techniques
2. Discuss about rotation in factor analysis

(CO 14):

1. Define Markov analysis
2. Predict the market shares by using markov analysis for future periods

Concept Map



Syllabus

Random variables: Random variables, Discrete, continuous Random variables, Distribution and density functions, Normal, Beta, Gamma, Erlangian, Poisson, Hypergeometric, Binomial and Exponential distributions, some inter-relationships among the various distributions. **Functions of random variables**: Transformation of variables, distribution of order statistics, expectation of random variables, expectation of functions of random variables, moment generating function techniques. **Regression and Correlation:** Partial Correlation and multiple correlation, Multiple regression, Use of matrix inversion methods, Non-linear regressions, Test for correlation and regression. **Test of Hypothesis:** Sampling design, sampling distributions, chi-square, 't', 'F' distribution, Large and small sample tests, Test for (1)Proportion (2) Mean (3)Variance and (4) Difference between two proportions, Means and variances in large and small samples, Tests of normality, Applications of chi-square, 't', 'F' distributions for test of hypothesis. **Multivariate Analysis Techniques:** Classifications of Multivariate techniques, Variables in multivariate analysis, important multivariate techniques, Rotation in factor analysis, Markov Analysis, Stability of the matrix of transition probabilities, prediction of market shares for future periods, Equilibrium condition, Use of Markov process in marketing strategy. Statistical analysis using SPSS software.

Reference Books

1. S.C.Gupta, V.K.Kapoor, " Fundamentals of Mathematical Statistics", Eleventh Edition, Sultan Chand and Sons, New Delhi, 2014
2. Damodar N. Gujarati, "Basic Econometrics", McGraw Hill, New Delhi,2003
3. R.C. Saxena, J.N. Kapoor, "Mathematical Statistics", S.Chand and Co, 2010.
4. J.N.Sharma, J.K.Goel, "Mathematical Statistics", Twenty Eighth Edition, Krishna Prakasham Mandir, Meerut, 2014.
5. Miller, Fan, " Probability and Statistics for Engineers", Prentice Hall of India, 2010.
6. Veerarajan.T, " Probablility and Statistics" Tata McGraw-Hill Limited, New Delhi, 2008

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1	**Random variables**	
1.1	Random Variables	1
1.2	Discrete and Continuous RVs	1
1.3	Distribution and Density functions	1
1.4	Normal, Beta distributions	1
1.5	Gamma, Erlangian Distributions	1
1.6	Poisson , Hyper Geometric Distributions	1
1.7	Binomial and Exponential distributions	1
1.8	Some inter- relationship among the various Distributions	1
2	**Functions of Random variables**	
2.1	Transformation of random variables	2
2.2	Distribution of Order statistics.	2
2.3	Expectation of random variables	2
2.4	Expectation of functions of Random Variables	1
2.5	Moment Generating Function Technique	1
3	**Regression and Correlation**	
3.1	Partial correlation	1
3.2	Multiple correlation	1
3.3	Multiple regression	1
3.4	Use of Matrix inversion Methods	2
3.5	Non Linear Regressions	2
3.6	Test for Correlation and Regression	1
4	**Test of Hypothesis**	

4.1	Sampling design and Sampling Distributions	1
4.2	Chi-square, t, F distributions	1
4.3	Large Sample Tests- Z test for proportion, mean	1
4.4	Variance and difference of proportion	1
4.5	Small sample Tests- t test	1
4.6	F test	1
4.7	Chi-square test, Test of Normality	1
4.8	Application of Various Tests	1
5	**Multivariate Analysis techniques**	
5.1	Classification of Multivariate Techniques	1
5.2	Variables in Multivariate Analysis	1
5.3	Important multivariate Techniques	1
5.4	Rotation in factor analysis	1
5.5	Markov Analysis	1
5.6	Stability of the matrix of transition probabilities	1
5.7	Prediction of market shares for future periods,	1
5.8	Equilibrium condition	1
5.9	Use of Markov process in marketing strategy - Statistical analysis using SPSS software.	1

Course Designers:

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		Category	L	T	P	Credit
14IE120	**OPTIMIZATION TECHNIQUES**	PC	4	0	0	4

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.

Prerequisite

- NIL

Course Outcomes

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

CO1:	Formulate mathematical models of Linear Programming (LP), Integer Programming (IP), Dynamic Programming (DP), Networks and Non-linear Programming (NLPP) problems	Apply
CO2:	Solve Linear Programming Problems (LPP) by graphical, simplex and dual-simplex methods	Analyse
CO3:	Solve Integer Programming Problems (IPP) using branch and bound, and cutting plane method	Apply
CO4:	Solve deterministic Dynamic Programming Problems using tabular approach	Analyse
CO5:	Select a suitable network model and apply appropriate technique for flow and project scheduling problems.	Analyse
CO6:	Solve unconstrained and constrained Non-Linear Programming Problems (NLPP) using appropriate techniques.	Apply
CO7:	Explain the concept and working of emerging intelligent search techniques such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particel Swarm Optimization (PSO), Simulated Annealing Algorithm (SAA) and Tabu Search (TS).	Understand

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	8	8	8	8
Understand	12	12	12	12
Apply	60	60	60	60
Analyse	20	20	20	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Table 2

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

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

2. The problem of maximising the overall profits for product mix with given the resource constraints is formulated as linear program given as: Maximise $Z = 3x_1 + 5x_2$; Subject to: $x_1 \leq 4$; $3x_1 + 2x_2 \leq 0$; $x_1, x_2 \geq 0$. The optimal table is given in Table 1.

Table 1

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

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

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

Maximise $Z = 3x_1 + 2x_2$

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

$x_1 + x_2 \leq 7$

$x_1 + 2x_2 \leq 10$

$x_1, x_2 \geq 0$

Course Outcome 3 (CO3):

1. A company manufacturer two types of products, P1 and P2. Each product uses lathe and milling machine. The processing time per unit of P1 on the lathe is 5 hours and on the milling machine is 4 hours. The processing time per unit of P2 on the lathe is 10 hours and on the milling machine is 4 hours. The maximum number of hours available per week on the lathe and milling machine are 60 hours and 40 hours, respectively. Also, profit per unit of selling P1 and P2 are Rs.6 and Rs.8, respectively. Formulate as

integer programming model and determine the production volume of each of product such that the total profit is maximized.

2. Solve the following:

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

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

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

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

Course Outcome 4 (CO4):

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

Table 2

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

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

Table 4

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

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

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

Salesmen Area	0	1	2	3	4	5	6

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

Use dynamic programming technique to solve the above problem.

Course Outcome 5 (CO5):

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

Table 5

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

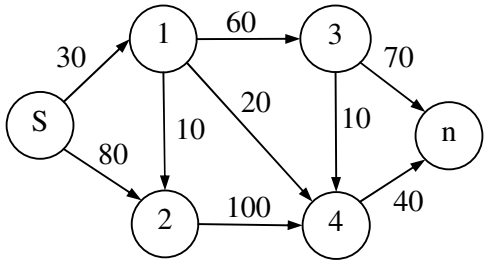
   a. Find the probability of completing the project before 31 weeks?

   b. What is the chance of project duration exceeding 46 weeks?

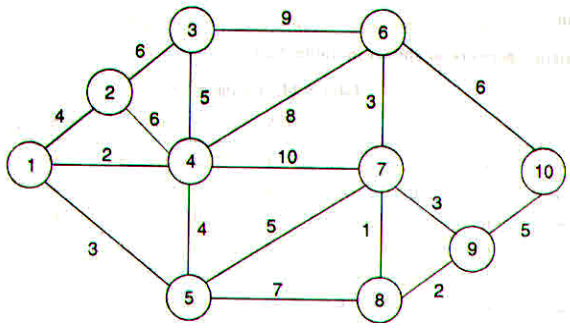
2. Consider the following project and discuss how the project schedule will be affected by events: a) Job H is delayed by 10 more days and b) Job F and G are completed 1 day ahead of schedule.

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

3. A network as shown in figure 3, has the maximum flow of 70 units between 'S' and 'n'. If the direction of the arc between nodes 1 and 4, has been reversed, is there any changes in the flow? If so, determine the revised maximum flow between the source, *S* to sink, *n* and justify the same. (10)



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



Course Outcome 6 (CO6):

1. Use Fibonacci search to: Maximize f(x) = $x^2 + \frac{54}{x}$; Subject to 0 ≤ x ≤ 5 with six evaluations and its final interval of uncertainty having a length less than 0.5.
2. Maximise $f(x_1, x_2) = x_1 - x_2 + 2x_1^2 + 2x_1x_2 + x_2^2$ starting from the point X= (0, 0). Take $\Delta x_1 = \Delta x_2 = 0.8$. Perform four iterations using Hooke Jeeves search method.
3. Solve the following Non linear Programming Problem (NLPP),

   Minimise $z = x_1^2 + x_2^2 + x_3^2$

   Subject to, $4x_1 + x_2^2 + 2x_3 - 14 = 0$
4. Determine the value of x_1 & x_2 using Kuhn-Tucker's conditions

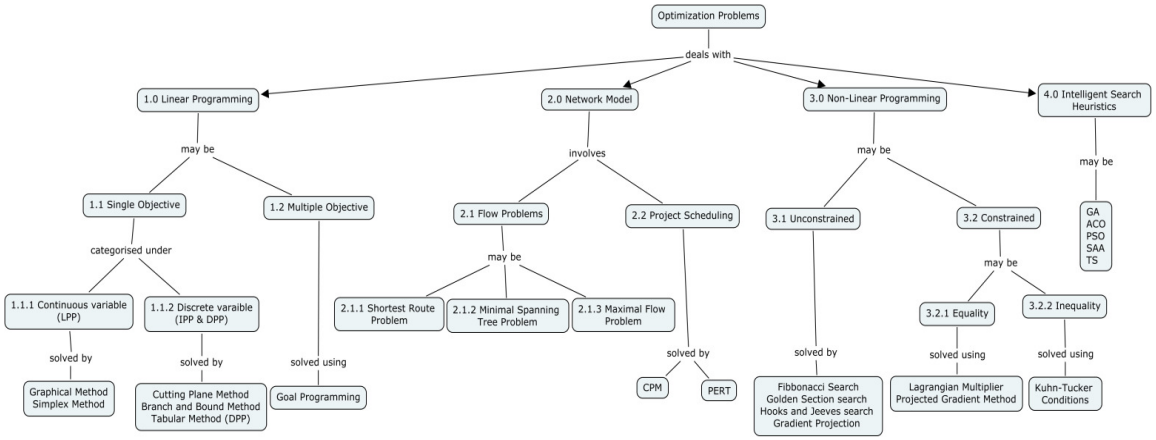
   Maximise $Z = 10\,x_1 - x_1^2 + 10x_2 - x_2^2$

   Subject to constraints, $x_1 + x_2 \leq 9$; $x_1 - x_2 \geq 6$

Course Outcome 7 (CO7):

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

Concept Map



Syllabus

Linear Programming: Formulation - Graphical Method and Simplex Method – Primal Vs. Dual relationships - Sensitivity Analysis-Dual Simplex Method; **Integer Programming**: Formulation - Branch and Bound Method - Cutting Plane Method; **Dynamic Programming -** Concepts - Mathematical description – Deterministic Dynamic Programming - Tabular approach; **Goal Programming** – Concepts – solution for multiple objective problems; **Network Model:** Network Construction – Terminologies - Shortest route problems, Minimal Spanning Tree problems, Maximal Flow problems; Critical Path Method (CPM) – crashing - Programme Evaluation and Review Technique (PERT); **Nonlinear Programming (Unconstrained Problem) -**Basic Concepts – Fibanocci and Golden Section search - Hooks and Jeeves search - Gradient Projection – **Nonlinear Programming (with Equality Constraints)** Lagrangian Multiplier - Equality constrained optimization -Projected Gradient Methods with equality constraints; **Nonlinear Programming (Inequality Constraints):** Khun concept - Khun Tucker conditions; **Intelligent search heuristics**: Concept – principle and parameters of GA, ACO, PSO, SAA & TS.

Reference Books/Learning Resources

1. Hamdy A. Taha, “Operations Research - An Introduction”, MacMillan Co., Eighth Edition 2010.
2. A. Ravindran, Don. T. Phillips, and James J. Solberg, “Operations Research - Principles and Practice”, John Wiley and Sons, Second Edition, Copy right 2007.
3. Srinath. L. S., “PERT and CPM Principles and Applications”, Third Edition, Affiliated East West Press Pvt. Ltd., NewDelhi, 2001.
4. Hiller / Lieberman, “ Introduction to Operations Research” Tata McGraw Hill, Eighth Edition, 2005

5. Ronald L Rardin, “Optimisation in Operations Research” Pearson Education Asia, First Indian reprint, 2013
6. Kalyanmoy Deb, “Optimisation for Engineering Design – Algorithms and Examples”, Eastern Economy Edition, Prentice Hall of India Private Limited, New Delhi, 2013

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	Introduction to Optimisation techniques - Classification	1
1.0	Linear Programming – Concept - Applications	1
1.1	Formulation – Single Objective problems	1
1.1.1	Solution Methods for continuous variable problems	1
1.1.1.1	Graphical Method	1
1.1.1.2	Simplex Method	2
1.1.1.3	Primal Vs. Dual relationships	1
1.1.1.4	Sensitivity Analysis	2
1.1.1.5	Dual Simplex Method	1
1.1.2	Solution Methods for Discrete variable problem	1
1.1.2.1	Integer Programming - Formulation	1
1.1.2.2	Cutting Plane Method	1
1.1.2.3	Branch and Bound Method	1
1.1.2.4	Dynamic Programming - Concepts - Mathematical description	1
1.1.2.5	Deterministic Dynamic Programming - Tabular approach	3
1.2	Solution Methods for Multi objective problem	1
1.2.1	Goal Programming (GP) – Concepts	1
1.2.2	Solution for multiple objective problems using GP	1
2.0	Network Model: Network Construction– Terminologies	1
2.1	Flow Problems – Concepts - Terminologies	1
2.1.1	Shortest route problems	1
2.1.2	Minimal Spanning Tree problems	
2.1.3	Maximal Flow problems	2
2.2	Project Scheduling – Concepts - Terminologies	1
2.2.1	Critical Path Method (CPM) – crashing	2
2.2.2	Programme Evaluation and Review Technique (PERT)	1
3.0	Nonlinear Programming (NLP) - Concepts – Terminologies - Classification	1
3.1	Unconstrained NLP Problems - Basic Concepts	
3.1.1	Fibanocci Search	1
3.1.2	Golden Section search	1
3.1.3	Hooks and Jeeves search	1
3.1.4	Gradient Projection	1
3.2	Constrained NLP Problems - Basic Concepts	1
3.2.1	NLP problems with Equality Constraints - Basic Concepts- Applications	
3.2.1.1	Lagrangian Multiplier Method	1
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

Module No.	Topic	No. of Lectures
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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14IE130 WORK STUDY AND COST ANALYSIS

Category	L	T	P	Credit
PC**	4	0	0	4

Preamble

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

Pre requisites

NIL

Course Outcomes

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

CO 1.	Explain the concepts, types, applications and steps in work study.	Remember
CO 2.	Explain how work study can be used to calculate man machine systems and solve related problems.	Understand
CO 3.	Explain the various measurement techniques in time and motion study.	Understand
CO 4.	Explain and apply statistical methods used in productivity measurement.	Apply
CO 5.	Design ergonomics based structures of real life product.	Apply
CO 6.	Estimate the Production cost of simple components.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	L	M	S	L	M	L	L	L	L	L	L
CO 2.	S	M	S	M	M	L	M	L	L	L	L
CO 3.	L	M	S	M	S	M	L	L	M	L	L
CO 4.	L	M	S	M	S	M	M	L	M	L	L
CO 5.	L	S	S	M	M	M	L	M	M	L	L
CO 6.	S	M	S	M	M	L	M	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's	Test 1	Test 2	Test 3 / End

	category			**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 Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

Course Outcome 4 (CO4):

Element	1	2	3	4	5

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

Observed time (min.)	0.2	0.08	0.50	0.12	0.10
Performance rating	85	80	90	85	80

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

2. A work sampling study was conducted to establish the standard time for an operation.

The observations of the study conducted are given below:

Total number of observations = 160
Manual (hand controlled work) = 14
Machine controlled work = 106
Machine idle time = 40
Average performance rating = 80%
No. of parts produced = 36
Allowance for personal needs And fatigue = 10%
Study conducted for 3 days Available working hours/day = 8 hrs.
Calculate the standard time per piece.

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

Course Outcome 5(CO5) and (CO6)

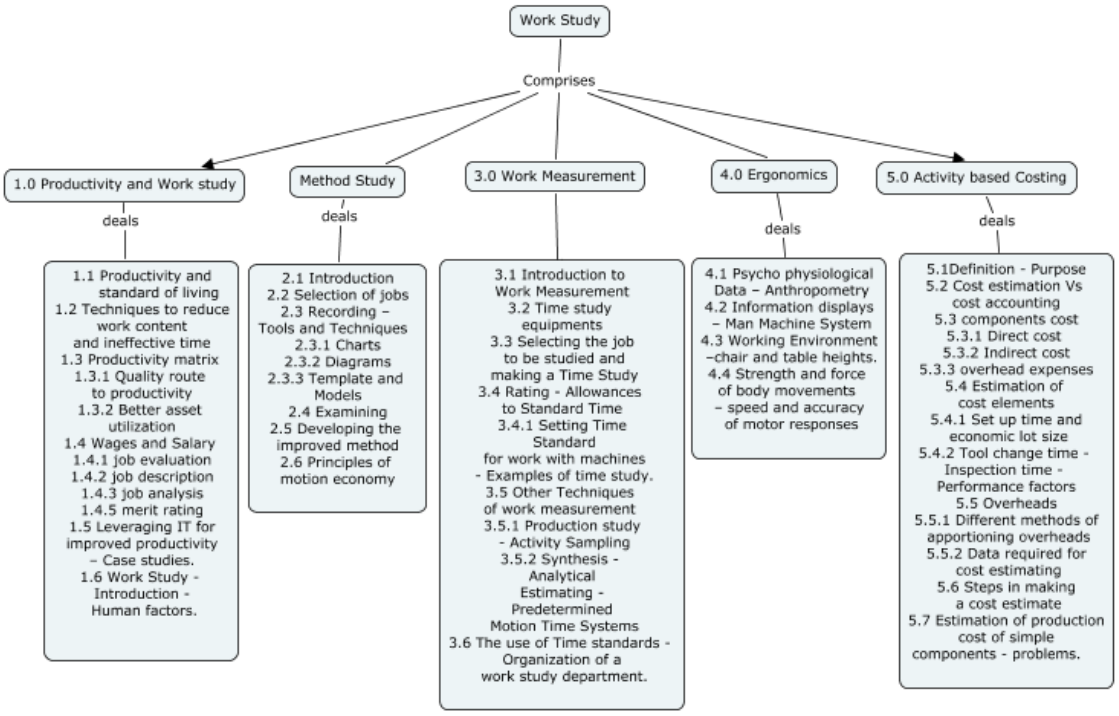
1. A certain product is manufactured in batches of 100.The direct material cost is Rs 50,direct labour cost is Rs 80 and factory overhead charges are Rs. 65. If the selling expenses are 45 percent of factory cost, what should be selling price of each product so that the profit is 10 percent of the total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

2. A Cast iron foundry employs 30 people. It consumes material worth Rs. 25,000 pays workers @Rs 1 per hour and total overheads are Rs10, 000. In a particular month (25

day) workers had over time of 150 hrs and were paid at double their normal rate. Find i) Total cost ii) Man hour rate of overheads. Assume an 8 hours working day.

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

Concept Map



Syllabus:

Productivity and Work Study: Productivity and standard of living, Techniques to reduce work content and ineffective time. Productivity matrix, Quality route to productivity, better asset utilization, wages and salary, job evaluation, job description, job analysis and merit rating, Leveraging IT for improved productivity – Case studies. Work Study - Introduction - Human factors. **Method Study:** Introduction - Selection of jobs – Recording – Tools and Techniques - Charts, Diagrams, Template and Models - Examining - Developing the improved method - Principles of motion economy. **Work Measurement:** Introduction to Work Measurement - Time study equipments - Selecting the job to be studied and making a Time Study- Rating - Allowances to Standard Time - Setting Time Standard for work with machines - Examples of time study. Other Techniques of work measurement - Production study - Activity Sampling - Synthesis - Analytical Estimating - Predetermined Motion Time Systems. The use of Time

standards - Organization of a work study department. **Ergonomics:** Psycho physiological Data – Anthropometry, information displays – Man Machine System - Working Environment –chair and table heights. Strength and force of body movements – speed and accuracy of motor responses. **Activity Based Costing:** Definition - Purpose - cost estimation Vs cost accounting - components cost - Direct cost - indirect cost - overhead expenses. Estimation of cost elements - set up time and economic lot size - tool change time - Inspection time - performance factors – overheads. different methods of apportioning overheads - Data required for cost estimating -Steps in making a cost estimate - estimation of production cost of simple components - problems.

Reference books

1. ILO, "Introduction to Work Study", Universal Publishing Corporation, Bombay, 1986.
2. Mundel, "Motion and Time Study", Prentice Hall of India, 1995.
3. Ralph M. Barnes, "Motion and Time Study", John Wiley and Sons, 1990.
4. Niebel Benjamin. W., "Motion and Time Study", Richard D. Irwin Inc., 1982.
5. Dalela. S,"Workstudy and Ergonomics", Standard Publishers Distributors, New Delhi,1999.
6. Sunderesh Heragu " Facilities Design" PWS publishing company., 1997
7. James M. Apple "Plant Layout and material Handling" The Ronald press company, 1972.
8. Singh. C. K., "Mechanical Costing, Estimation and Project Planning", Standard Publishers Distributors, New Delhi, 1996.
9. GBS Narangh , V. Kumar, "Production and Costing", Khanna Publishers, 1980.
10. Banga , Sharma, "Mechanical Estimating and Costing", Khanna Publishers, 1976.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
1.	**Productivity and Work Study**	
1.1	Productivity and standard of living	1
1.2	Techniques to reduce work content and ineffective time	1
1.3	Productivity matrix	1
1.3.1	Quality route to productivity	1
1.3.2	better asset utilization	
1.4	Wages and Salary	2
1.4.1	job evaluation	2
1.4.2	job description	
1.4.3	job analysis	
1.4.5	merit rating	1

1.5	Leveraging IT for improved productivity – Case studies.	1
1.6	Work Study - Introduction - Human factors.	1
2.	**Method Study**	
2.1	Introduction	1
2.2	Selection of jobs	1
2.3	Recording – Tools and Techniques	1
2.3.1	Charts	1
2.3.2	Diagrams	1
2.3.3	Template and Models	1
2.4	Examining	1
2.5	Developing the improved method	1
2.6	Principles of motion economy	1
3.	**Work Measurement**	
3.1	Introduction to Work Measurement	1
3.2	Time study equipments	1
3.3	Selecting the job to be studied and making a Time Study	1
3.4	Rating - Allowances to Standard Time	1
3.4.1	Setting Time Standard for work with machines - Examples of time study.	1
3.5	Other Techniques of work measurement	1
3.5.1	Production study - Activity Sampling	1
3.5.2	Synthesis - Analytical Estimating - Predetermined Motion Time Systems	1
3.6	The use of Time standards - Organization of a work study department.	1
4.	**Ergonomics**	
4.1	Psycho physiological Data – Anthropometry	1
4.2	Information displays – Man Machine System	1
4.3	Working Environment –chair and table heights.	1
4.4	Strength and force of body movements – speed and accuracy of motor responses	1
5.	**Activity Based Costing**	
5.1	Definition - Purpose	1
5.2	cost estimation Vs cost accounting	1
5.3	components cost	

5.3.1	Direct cost	2
5.3.2	indirect cost	
5.3.3	overhead expenses	
5.4	Estimation of cost elements	
5.4.1	set up time and economic lot size	1
5.4.2	tool change time - Inspection time - Performance factors	1
5.5	overheads	
5.5.1	different methods of apportioning overheads	1
5.5.2	Data required for cost estimating	
5.6	Steps in making a cost estimate	1
5.7	Estimation of production cost of simple components - problems.	1
	Total	**42**

Course Designers:

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14IE140	QUALITY AND RELIABILITY ENGINEERING	Category	L	T	P	Credit
		PC**	4	0	0	4

Preamble

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

Prerequisite

- Knowledge on mathematical distributions

Course Outcomes

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

CO 1.	Develop the process control charts – variables, attributes.	**Apply**
CO 2.	Analyse the process control charts.	**Analyse**
CO 3.	Illustrate about Multivariate quality control.	**Understand**
CO 4.	Develop and comment the Sampling plans – single, double and multiple.	**Apply**
CO 5.	Compute the system Reliability of different system configuration	**Apply**
CO 6.	Identify the ways to improve the system reliability through redundancy and standby modes	**Analyse**
CO7	Describe the ways to implement the system certification.	**Understand**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO8.	S	S	M	M	M	M	S	M	M	M	S
CO9.	S	S	M	M	S	M	M	M	M	M	S
CO10.	S	S	M	M	S	M	M	M	M	M	M
CO11.	S	S	M	M	M	L	S	M	M	S	M
CO5.	S	S	L	L	M	L	M	L	M	M	L
CO6.	M	S	M	M	M	L	M	M	M	M	L
CO7	L	L	L	M	S	M	M	S	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Outcome 1 (CO1):

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

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

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

Course Outcome 4 (CO4):

1. Compute the probability of acceptance for the following double sampling plan with an incoming fraction defective 0.02

   $n_1 = 65$ $c_1 = 1$ $R_1 = 3$

   $n_2 = 90$ $c_2 = 2$ $R_2 = 3$

   Also compute ATI, ASN for N = 750.
2. Write the Step by step procedure to construct OC curve for double sampling plan with an incoming fraction defective 0.02

   $n_1 = 65$ $c_1 = 1$ $R_1 = 3$

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

Course Outcome 5 (CO5):

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

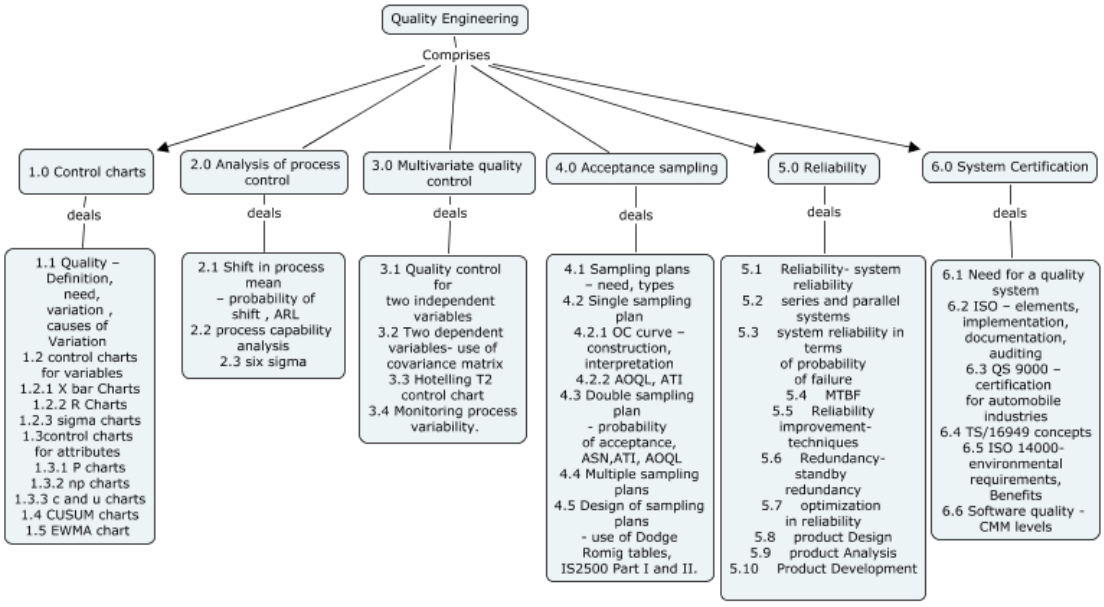
Course Outcome 6 (CO6):

1. Propose a system configuration in order to improve its reliability with the known component reliability.
2. A standby system has a basic unit with two standby components. The time to failure of each component has an exponential distribution with a failure rate of 0.004 per h. For a 600h operation period, compute the reliability of the standby system. Develop ways to improve the standby system reliability.

Course Outcome 7 (CO7):

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

Concept Map



Syllabus

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

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

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

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

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

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

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1. Dougles C. Montgomery, “Introduction to Statistical Quality Control”, John Wiley and Sons, Inc, Seventh Edition, 2012.

2. Eugene L., Grant Richard S., Leven Worth, “Statistical Quality Control”, McGraw Hill, Seventh Edition, 1996.
3. Kannan SM, Jayabalan V, “Total Quality Management”, RKR Publications, 2005.
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5. Seiichi Nakajima, “Introduction to TPM”, Productivity press, Second Edition, 1997.
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7. Connor, P.D.T.O., "Practical Reliability Engineering ", John Wiley, 2012.
8. Green A.E., and Bourne A.J. "Reliability, Technology ", Wiley Inter science, 1991.

Course Contents and Lecture Schedule

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

4.2	Single sampling plan	1
4.2.1	OC curve – construction, interpretation	
4.2.2	AOQL, ATI	
4.3	Double sampling plan - probability of acceptance, ASN,ATI, AOQL	1
4.4	Multiple sampling plans	1
4.5	Design of sampling plans - use of Dodge Romig tables, IS2500 Part I and II.	1
5	**Reliability**	
5.1	Reliability- system reliability	1
5.2	series and parallel systems	
5.3	system reliability in terms of probability of failure	2
5.4	MTBF	2
5.5	Reliability improvement-techniques	1
5.6	Redundancy-standby redundancy	2
5.7	optimization in reliability	1
5.8	product Design	1
5.9	product Analysis	
5.10	Product Development	1
5.11	product life	
6	**System Certification**	
6.1	Need for a quality system	1
6.2	ISO – elements, implementation, documentation, auditing	2
6.3	QS 9000 – certification for automobile industries	1
6.4	TS/16949 concepts	1
6.5	ISO 14000- environmental requirements, Benefits	1
6.6	Software quality - CMM levels	1
	Total	**36**

Course Designers:

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14IE150 MANAGEMENT SUPPORT SYSTEMS

Category	L	T	P	Credit
PC**	3	0	0	3

Preamble

Management support system (MSS) is a computer-based information system that supports business or organizational decision-making activities. MSSs serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance. MSSs include knowledge-based systems. A properly designed MSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents, personal knowledge, or business models to identify and solve problems and make decisions.

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain the concepts, types and applications of MSS, steps in MSS	Remember
CO 2.	Explain how MSS can be used to create a model for complex systems	Understand
CO 3.	Explain the various techniques in Decision Support Systems.	Understand
CO 4.	Explain and apply DSS methods used in Management environment.	Apply
CO 5.	design a DSS Model based structures of real life product.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's category	Test 1	Test 2	Test 3 / End Semester Examination
1	Remember	20	20	20
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 Outcome 1 (CO1):

1. Compare Management Support System and Management Information Systems.
2. Differentiate the efficiency and effectiveness of the system.
3. List the major components of a mathematical model.
4. List several measures for evaluating the success of expert systems.
5. What is the difference between functional and physical integration?
6. List three reasons why intelligent systems could result in massive unemployment.
7. What is DSS hardware? How it is used for MSS?

Course Outcome 2 (CO2):

1. What are the classifications of models? What is the purpose of such a classification? Give an example of each.
2. Describe the various criteria for measuring the success of an implemented information system.

Course Outcome 3 (CO3):

1. What are the tools or technologies of MSS?
2. Draw the Decision Support framework? Explain the each.
3. Discuss the importance of Knowledge Management.

Course Outcome 4 (CO4) and Course Outcome 5 (CO5):

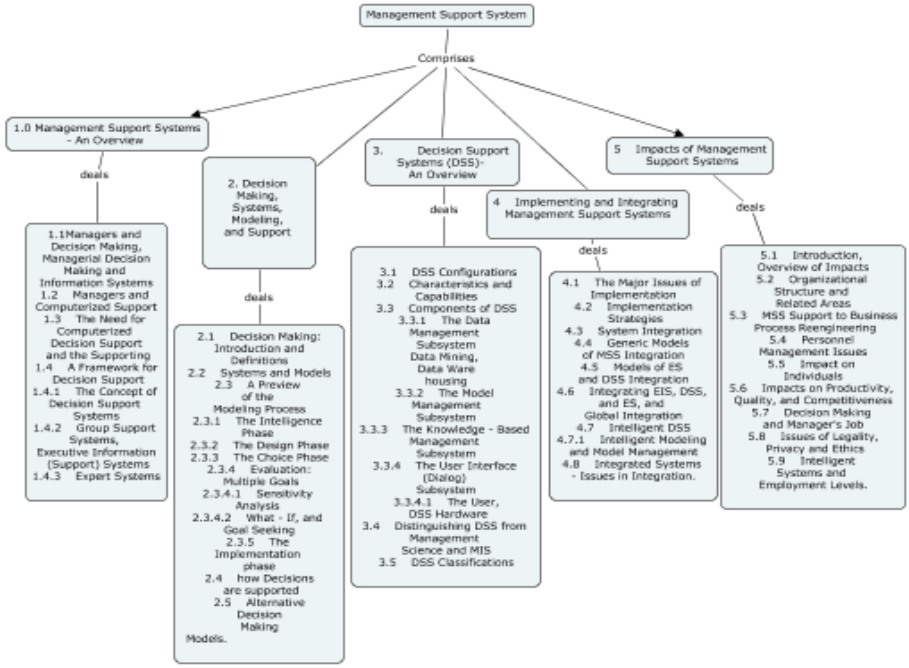
1. Several hospitals are considering the introduction of an intelligent bedside assistant that will provide physicians and staff with a patient record database for diagnosis and prognosis. The system will supply any information required from the patient's medical records, make diagnosis based on symptoms, and prescribe medications and other treatment. The system includes an expert system as well as a DSS. The system is expected to eliminate some human error and improve patient care.

   You are hospital administrator and you are very excited about the benefits for the patients. However, when you called a staff meeting, the following questions were raised: What if the system malfunctions? What if there is an undetected error in the program or the rules? The

system once implemented, will take full responsibility for patient care because physicians will rely on it. A loss of data or error in the program may result in disaster. For example, suppose there is a bug in the database program and as a result a critical piece of information is missing from the patient's record. A physician who relies on the system could prescribe a drug on the basis of incomplete data. The consequence of this mistake may be life threatening. Another possibility is that some of the rules in the knowledge base may not be accurate for all patients. Would you implement such a system? Why or Why not?

2. You are about to buy a car. Follow simon's four phase model and describe your activities at each step.
3. Your company is considering opening a branch in Italy. List typical activities in each phase of the decision to open or not to open.
4. What are the classifications of models? What is the purpose of such a classification? Give an example of each in to industrial environment.
5. How do you list the issues in integration systems after implementation of DSS ? Explain the same.
6. Compare an Individual DSS to a Group DSS. Explain User Interface Management System? Give an example of each.

Concept Map



Syllabus

Management Support Systems: An Overview. Managers and Decision Making, Managerial Decision Making and Information Systems, Managers and Computerized Support, The Need for Computerized Decision Support and the Supporting, Technologies, A Framework for

Decision Support, The Concept of Decision Support Systems, Group Support Systems, Executive Information (Support) Systems, Expert Systems. **Decision Making, Systems, Modeling, and Support:** Decision Making: Introduction and Definitions, Systems, Models, A Preview of the Modeling Process, The Intelligence Phase, The Design Phase, The Choice Phase, Evaluation: Multiple Goals, Sensitivity Analysis, What - If, and Goal Seeking, The Implementation phase, how Decisions are supported, Alternative Decision Making Models. **Decision Support Systems (DSS):** An Overview, DSS Configurations- Characteristics and Capabilities and Components of DSS, The Data Management Subsystem, Data Mining, Data Ware housing - The Model Management Subsystem, The Knowledge - Based Management Subsystem, The User Interface (Dialog) Subsystem, The User, DSS Hardware, Distinguishing DSS from Management Science and MIS, DSS Classifications. **Implementing and Integrating Management Support Systems:** An Overview, The Major Issues of Implementation, Implementation Strategies, System Integration, Generic Models of MSS Integration, Models of ES and DSS Integration, Integrating EIS, DSS, and ES, and Global Integration, Intelligent DSS, Intelligent Modeling and Model Management, Integrated Systems - Issues in Integration. **Impacts of Management Support Systems:** Introduction, Overview of Impacts, Organizational Structure and Related Areas, MSS Support to Business Process Reengineering, Personnel Management Issues, Impact on Individuals, Impacts on Productivity, Quality, and Competitiveness, Decision Making and Manager's Job, Issues of Legality, Privacy and Ethics. Intelligent Systems and Employment Levels.

Reference Books:

1. Efraim Turban, Jay E. Aronson, “Decision Support Systems and Intelligent Systems”, Tenth Edition, Prentice Hall, 2014.
2. G.M Marakas, “Decision Support Systems in the 21th century”, Second Edition, Prentice Hall, 2002.
3. C.Holsapple, A.Whinston, “Decision Support Systems: A Knowledge based Approach”, Prentice Hall, 2001.
4. Elamsri, Navathe, “Fundamentals of Data base systems”, Sixth Edition, Addison Wesley, 2010.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
1.0	**Management Support Systems** - An Overview	

1.1	Managers and Decision Making, Managerial Decision Making and Information Systems	1
1.2	Managers and Computerized Support	
1.3	The Need for Computerized Decision Support and the Supporting	1
1.4	A Framework for Decision Support	1
1.4.1	The Concept of Decision Support Systems	1
1.4.2	Group Support Systems, Executive Information (Support) Systems	1
1.4.3	Expert Systems	1
2.	**Decision Making, Systems, Modeling, and Support**	
2.1	Decision Making: Introduction and Definitions	1
2.2	Systems and Models	
2.3	A Preview of the Modeling Process	
2.3.1	The Intelligence Phase	1
2.3.2	The Design Phase	1
2.3.3	The Choice Phase	1
2.3.4	Evaluation: Multiple Goals	1
2.3.4.1	Sensitivity Analysis	1
2.3.4.2	What - If, and Goal Seeking	1
2.3.5	The Implementation phase	1
2.4	how Decisions are supported	1
2.5	Alternative Decision Making Models.	
3.	**Decision Support Systems (DSS)-** An Overview	
3.1	DSS Configurations	1
3.2	Characteristics and Capabilities	1
3.3	Components of DSS	1
3.3.1	The Data Management Subsystem - Data Mining, Data Ware housing	2
3.3.2	The Model Management Subsystem	1
3.3.3	The Knowledge - Based Management Subsystem	1
3.3.4	The User Interface (Dialog) Subsystem	1
3.3.4.1	The User, DSS Hardware	
3.4	Distinguishing DSS from Management Science and MIS	1
3.5	DSS Classifications	1
4	**Implementing and Integrating Management Support Systems -** Implementation: An Overview	
4.1	The Major Issues of Implementation	1
4.2	Implementation Strategies	1

4.3	System Integration	1
4.4	Generic Models of MSS Integration	1
4.5	Models of ES and DSS Integration	1
4.6	Integrating EIS, DSS, and ES, and Global Integration	1
4.7	Intelligent DSS	1
4.7.1	Intelligent Modeling and Model Management	
4.8	Integrated Systems - Issues in Integration.	1
5	**Impacts of Management Support Systems**	
5.1	Introduction, Overview of Impacts	1
5.2	Organizational Structure and Related Areas	1
5.3	MSS Support to Business Process Reengineering	1
5.4	Personnel Management Issues	1
5.5	Impact on Individuals	1
5.6	Impacts on Productivity, Quality, and Competitiveness	1
5.7	Decision Making and Manager's Job	1
5.8	Issues of Legality, Privacy and Ethics	1
5.9	Intelligent Systems and Employment Levels.	1
Total		42

Course Designers

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14IE160	INDUSTRIAL AUTOMATION AND ROBOTICS	Category	L	T	P	Credit
		PC**	4	0	0	4

Preamble

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

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain the types of automation, types of machine tools and material handling equipments used for automation	Remember
CO 2.	Explain the principles of automation, types of production systems and management support systems involved in automation	Understand
CO 3.	Explain the basic components and their functions of automated production line, automated assembly system, FMS, AS/RS, AGV and Robot Kinematics and its industrial applications	Understand
CO 4.	Determine the cycle time, process time, indexing time of indexing devices, efficiency of the production line, production rate and production cost.	Apply
CO 5.	Determine the gripper force, and path program of robots	Apply
CO 6.	Select the suitable layouts, material handling devices or sensors for various industrial applications	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	S	M	L	M	M	L	L	L	L	L	L
CO 2.	S	M	M	M	M	L	L	L	L	L	L
CO 3.	S	M	S	M	M	L	L	L	L	L	L
CO 4.	S	S	S	M	M	L	L	L	L	L	L
CO 5.	S	S	M	M	M	L	L	L	L	L	L
CO 6.	S	M	M	M	M	L	L	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Outcome 1 (CO1)**:**

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

Course Outcome 2 (CO2)**:**

5. Name three categories of AGVs.
6. What is an automated production line?
7. Describe the automation migration strategy?

Course Outcome 3 (CO3)**:**

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

Course Outcome 4 (CO4)**:**

14. 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.
15. 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.
16. 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.

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

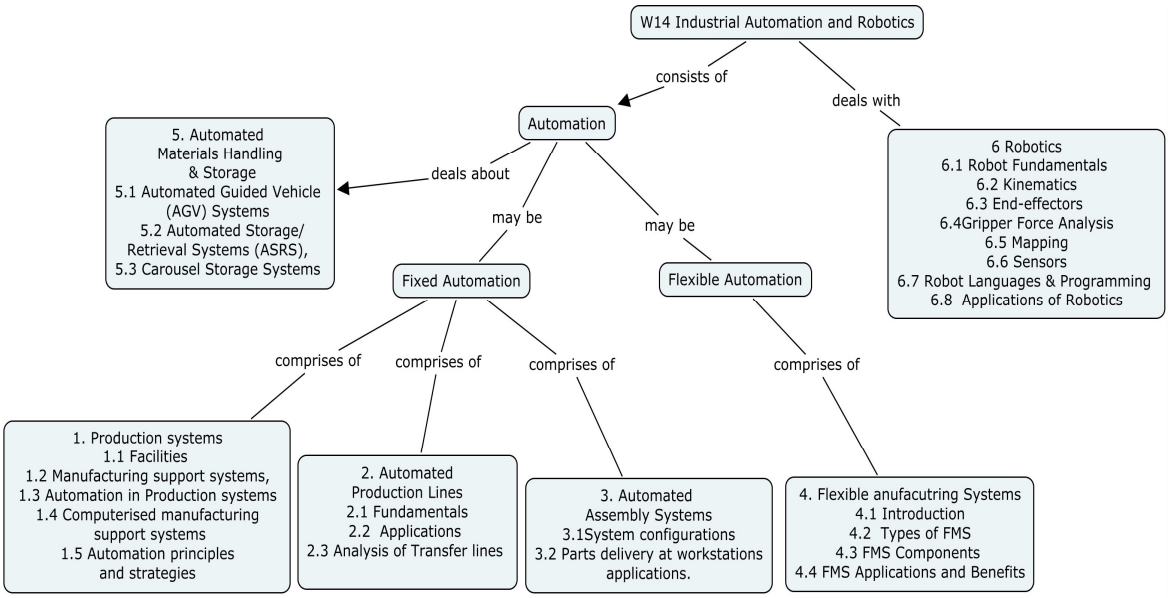
Course Outcome 5 (CO5)**:**

18. 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.
19. Discuss the Robot programming languages in brief.
20. Distinguish between the first generation and second generation robot languages.

Course Outcome 6 (CO6)**:**

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

Concept Map



Syllabus

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

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

Automated Assembly Systems: System configurations, Parts delivery at workstations, and applications.

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

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

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

Languages: Robot Languages and Programming, Classification of Robot languages and Robot Software. Applications of Robotics.

Reference Books

1. Mikell. P. Groover, “Automation Production Systems, and Computer Integrated Manufacturing”, 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, 2008.
4. Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi 2009.
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
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

S.No	Topics	No. of Lectures
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
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

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14IE170	INDUSTRIAL ENGINEERING LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

'**Industrial Engineer**' is synonymous with **Systems Integrator** - a big-picture thinker, in other words. It's an employee who takes what exists today and conceptualizes what should exist in the future. Many people are misled by the term "Industrial Engineer." The word 'Industrial" does not mean just manufacturing. It encompasses wide span of industries ranging from FMCG, IT & System, Consultancy, Banking & Financial Institution and to Telecom. With era of management growing from Scientific Principles to Strategic Concept companies adopt management philosophies of continuous productivity and quality improvement to survive in the increasingly competitive world market, the need for Industrial Engineers is growing.

Prerequisite

NIL

Course Outcomes

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

CO 1.	Develop and solve optimization problem using commercial packages	Apply
CO 2.	Generate and test simulation models using commercial packages	Analyze
CO 3.	Usage of spreadsheets for quality control charts and simple problems	Analyze

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Syllabus

List of Experiments

Optimization problems modeling

1. Quadratic assignment problem
2. Capacitated Plant Location Problem
3. Traveling Salesman Problem
4. Vehicle routing problem
5. One machine job selection

Generation of simulation models

1. Development of random number generator.
2. Uniform Random varieties generation and testing
3. Simulation of single server queuing system
4. Simulation of multi server queuing system

5. Flexible manufacturing system simulation

Spreadsheet exercises

1. Simplex models
2. Linear regression equations
3. P-chart
4. np-chart
5. Chi-Square test of independence

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CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Industrial Engineering) PROGRAMME

SECOND SEMESTER SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2014-2015 ONWARDS

THIAGARAJAR COLLEGE OF ENGINEERING

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

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DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

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

Mission:

As a department, we are committed to

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

Programme Educational Objectives: (PEO's) of M.E (Industrial Engineering)

PEO1

Graduates will assume lead roles in the practice of Industrial Engineering and its allied disciplines in manufacturing, services, and government.

PEO2

Graduates will continue to engage in life-long learning, understanding and applying knowledge and ideas of Industrial Engineering and allied disciplines.

PEO3

Graduates will associate themselves and become a part of IE professional societies or other professional organizations as well as in community-based organizations.

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

Graduating Students of M.E. Industrial Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	An ability to apply knowledge of mathematics and science in solving problems	**Scholarship of Knowledge**
PO2.	An ability to design and conduct experiments, as well as to analyze and interpret data	**Critical Thinking**
PO3.	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Problem Solving**
PO4.	An ability to have the broad education necessary to understand the impact of engineering solutions in a global and societal context	**Research Skill**
PO5.	An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice	**Usage of modern tools**
PO6.	An ability to function effectively as an individual and as a member or a leader in diverse teams, and in multidisciplinary activities	**Collaborative and Multidisciplinary work**
PO7.	An ability to apply project, financial management principles and techniques individually/collaboratively in project planning, implementation and control	**Project Management and Finance**
PO8.	An ability to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**Communication**
PO9.	An ability to engage in independent and life-long learning for personal and societal development	**Life-long Learning**
PO10.	An ability to understand the professional and ethical responsibility	**Ethical Practices and Social Responsibility**
PO11.	An Ability to make corrective measures and learn from the mistakes without depending on external feed back	**Independent and Reflective Learning**

PEO – PO Matrix

POs / PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	S	S	S	S	S	S	S	S	M	S	M
PEO2	S	S	S	S	S	M	M	S	S	L	S
PEO3	S	S	M	M	M	M	L	S	S	S	S

Correlation: S – Strong; M-Medium; L-Low

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Industrial Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses						Practical/Project
4th (12)							14IE410 Project Phase – II 0:12
3rd (16)	14IE310 Supply Chain Management 4:0	14IEPX0 Elective -V 4:0	14IEPX0 Elective -VI 4:0				14IE340 Project Phase-I 0:4
2nd (24)	14IE210 Financial Management 3:0	14IE220 Operations Management 4:0	14IEPX0 Elective -I 4:0	14IEPX0 Elective -II 4:0	14IEPX0 Elective -III 4:0	14IEPX0 Elective -IV 4:0	14IE 270 Work System Engineering Laboratory 0:1
1st (24)	14IE110 Applied Probability and Statistics 4:0	14IE120 Optimisation Techniques 4:0	14IE130 Work Study and Cost Analysis 4:0	14IE140 Quality and Reliability Engineering 4:0	14IE150 Management Support Systems 3:0	14IE160 Industrial Automation and Robotics 4:0	14IE170 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 2014-2015 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE110	Applied Probability and Statistics	BS	4	0	-	4
14IE120	Optimization Techniques	PC	4	0	-	4
14IE130	Work Study and Cost Analysis	PC	4	0	-	4
14IE140	Quality and Reliability Engineering	PC	4	0	-	4
14IE150	Management Support Systems	PC	3	0	-	3
14IE160	Industrial Automation and Robotics	PC	4	0	-	4
PRACTICAL						
14IE170	Industrial Engineering Laboratory	PC	-	-	2	1
Total						**24**

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

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

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M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE210	Financial Management	DC	3	0	-	3
14IE220	Operations Management	DC	4	0	-	4
14IEPX0	Elective - I	DE				4
14IEPX0	Elective - II	DE				4
14IEPX0	Elective - III	DE				4
14IEPX0	Elective - IV	DE				4
PRACTICAL						
14IE270	Work Systems Engineering Laboratory	DC	-	-	2	1
Total						**24**

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

BS : Basic Science

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1 Hour Lecture/Tutorial is equivalent to 1 credit

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE110	Applied Probability and Statistics	3	50	50	100	25	50
2	14IE120	Optimization Techniques	3	50	50	100	25	50
3	14IE130	Work Study and Cost Analysis	3	50	50	100	25	50
4	14IE140	Quality and Reliability Engineering	3	50	50	100	25	50
5	14IE150	Management Support Systems	3	50	50	100	25	50
6	14IE160	Industrial Automation and Robotics	3	50	50	100	25	50
PRACTICAL								
7	14IE170	Industrial Engineering Laboratory	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 (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE210	Financial Management	3	50	50	100	25	50
2	14IE220	Operations Management	3	50	50	100	25	50
3	14IEPX0	Elective - I	3	50	50	100	25	50
4	14IEPX0	Elective - II	3	50	50	100	25	50
5	14IEPX0	Elective - III	3	50	50	100	25	50
6	14IEPX0	Elective - IV	3	50	50	100	25	50
PRACTICAL								
7	14IE270	Work Systems Engineering Laboratory	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.	14IEPA0	Plant Layout and Material Handling	4
2.	14IEPB0	Total Quality Management	4
3.	14IEPC0	Maintenance Engineering and Management	4
4.	14IEPD0	Machine Vision and its applications in manufacturing	4
5.	14IEPE0	System Simulation	4
6.	14IEPF0	Product Design and Development	4
7.	14IEPG0	Energy Management Systems	4
8.	14IEPH0	Robust Design	4
9.	14IEPJ0	Lean Manufacturing and Six Sigma	4
10.	14IEPK0	Computer Integrated Manufacturing	4
11.	14IEPL0	Value Engineering	4
12.	14IEPM0	Human Resource Management	4
13.	14IEPN0	Industrial Instrumentation	4
14.	14IEPP0	Research Methodology	4

14IE210 FINANCIAL MANAGEMENT

Category	L	T	P	Credit
PC	3	0	0	3

Preamble

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

Prerequisite

NIL

Course outcomes

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

CO 1.	Understand and Explain basic concepts of financial management, functions of finance and tools and techniques of finance.	Understand
CO 2.	Prepare, analyze and interpret important financial statements like profit& Loss account ,Balance sheet, Budgets etc.,	Understand& Apply
CO 3.	Determine accurately working capital and fixed capital requirements of the organization.	Apply
CO 4.	Identify, Evaluate and choose appropriate sources of finance.	
CO 5.	Evaluate and choose most profitable investment decisions.	Apply
CO 6.	Plan and implement appropriate capital structure for an organization.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course outcome 1 (co1):

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

Course Outcome 2 (CO2):

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

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

Opening stock	20000		
Total	333200	Total	333200

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

Year	CFBT (Rs.)
1	100000
2	100000
3	150000
4	150000
5	250000

Find the following a) Pay Back Period b) ARR

Course Outcome 3 (CO3):

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

Course Outcome 4 (CO4):

1. How will select the various sources of financing considering the fixed capital and working capital requirements of the organization?

2. Evaluate the various medium-term and long-term sources of financing.

3.Evaluate the various short-term sources of financing.

Course Outcome 5 (CO5):

1.Evaluate and critically analyse the various methods of appraising the capital budgeting decisions?

2.From the following information calculate (i) pay back period (ii)Net present value and profitability index @10% (iii)Internal rate of return and suggest which project can be selected?

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

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

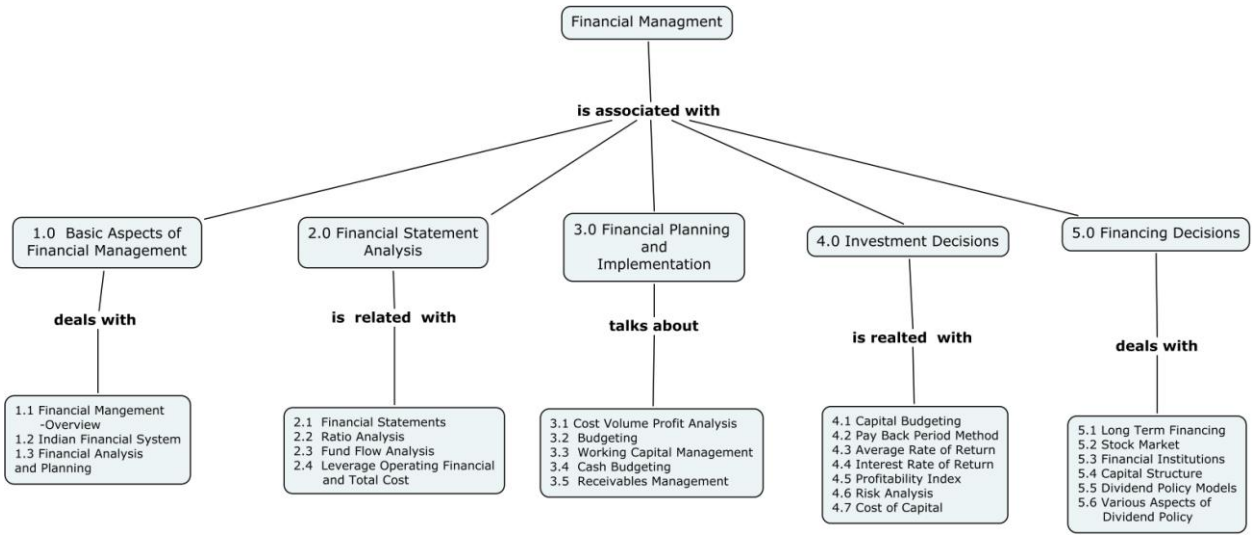
Year	1	2	3	4	5
Project "x" (Rs.)	5000	10000	10000	3000	2000
Project "y" (Rs.)	20,000	10,000	5,000	3,000	2,000

Course Outcome 6 (CO6):

1. Devise a suitable capital structure for an organization which relies more on debt capital and less on equity capital.

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

Concept Map



Syllabus

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

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

Financial Planning and Implementation

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

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

Financing Decisions -Long Term Financing - Sources of long term finance - Primary market for long term securities - Public issue - Rights issue- Private placement- Stock market - Function of the stock market - Regulation -Financial Institutions. **Capital Structure** - Theory - Various approaches - Planning the capital structure - Dividend policy and share valuation - Dividend policy models - Practical Aspects - Legal and procedural aspects.

Reference Books

1. Prasanna Chandra, “Fundamentals of Financial Management”, Tata McGraw Hill, 2014.
2. KY. Khan and P.K. Jain, “ Financial Management”, Tata McGraw Hill, 2007.
3. Khan and Jain, “ Theory and Problems of Financial Management”, Tata Mc Graw Hill Publishing Co, 2009
4. Pandey, “Financial Management” , Vikas Publishing House Pvt. Ltd., 2010.

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	Internal 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

S.No	Topics	No. of Lectures
5.2	Stock Market	1
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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14IE220 OPERATIONS MANAGEMENT

Category	L	T	P	Credit
PC	4	0	0	4

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

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain production and operation strategies for industries (Manufacturing / Service), and facility location and layout planning methods.	Understand
CO 2.	Explain Aggregate Production Planning Strategies and Techniques, Forecasting methods, Inventory Management models and costs, MRP structure, and Concept of JIT and Lean manufacturing.	Understand
CO 3.	Draw process flow chart and determine process performance and productivity measures.	Apply
CO 4.	Determine forecast, order quantity, and safety stock levels.	Apply
CO 5.	Suggest suitable facility location, layout planning, inventory models and lot sizing method and develop MRP schedules.	Apply
CO 6.	Determine optimal sequence and Schedule the jobs in single machine, flow shop and job shop environments.	Apply

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	S	M	M	M	M	L	L	L	L	L	L
CO 2.	S	M	M	M	M	L	L	L	L	L	L
CO 3.	S	S	S	M	M	L	L	L	L	L	L
CO 4.	S	S	S	M	M	L	L	L	L	L	L
CO 5.	S	S	S	M	M	L	L	L	L	L	L
CO 6.	S	S	S	M	M	L	L	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

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

9. Consider the construction of a simple 8" X 10" wood picture frame. The picture frame consists of four wood pieces that are cut from the wood molding, four staples to hold the frame together, a piece of glass, a backing board made of cardboard, six

points to hold the glass and backing board to the frame, and a clip for hanging the picture frame from the wall.

i) Construct an assembly chart for the picture frame.

ii) Construct a flow process chart for the entire process from receiving materials to final inspection.

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

Course Outcome 4 (CO4):

11. Historical demand for a product is:

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

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

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

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

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

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

Quarter	**Quantity (Units)**	**Quarter**	**Quantity (Units)**
2005		**2006**	
I	12	I	16
II	18	II	24
III	26	III	28
IV	16	IV	18

(a) Hand fit a line.

(b) Find the trend and seasonal factors

(c) Forecast sales for 2007.

13. 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?

Course Outcome 5 (CO5):

14. 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.

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

Weighted Population Distance

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

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

Course Outcome 6 (CO6):

17. 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

18. 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?

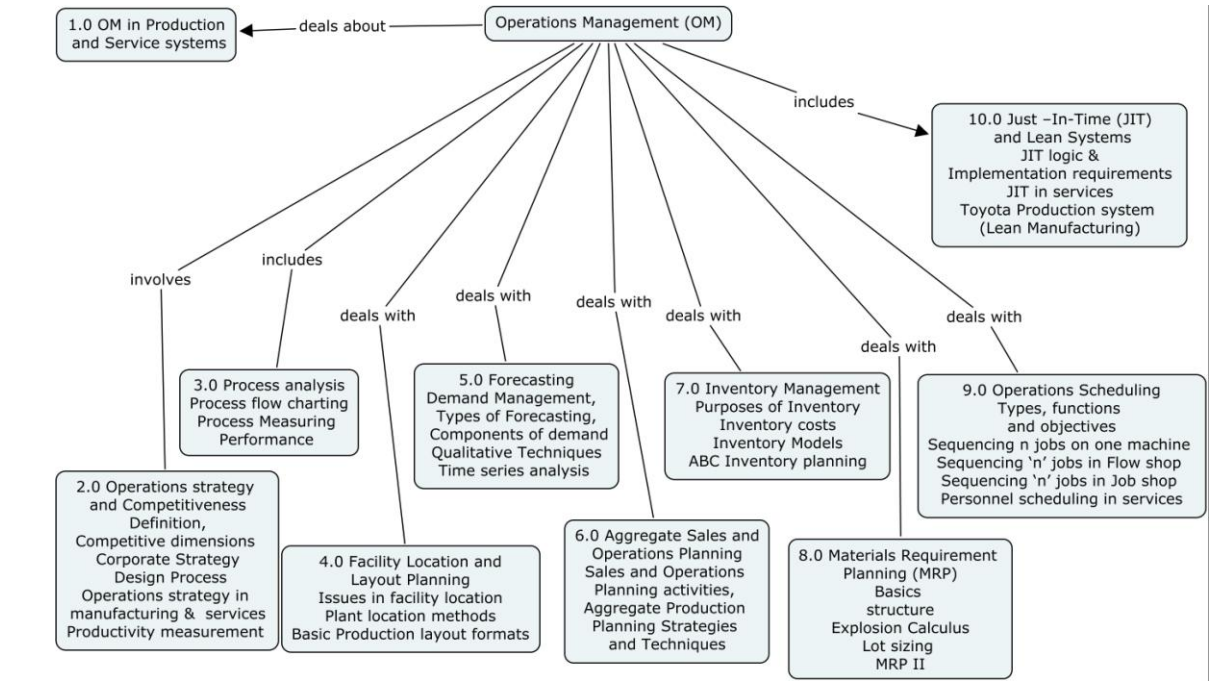
Job	Machine 1	Machine 2	Machine 3
1	11	10	12
2	13	8	20
3	15	6	15
4	12	7	19
5	20	9	7

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

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

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

Concept Map



Syllabus

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

Process analysis: Process flow charting and Process Measuring Performance. **Facility Location and Layout Planning:** Issues in facility location, Plant location methods: Factor rating method and Gravity location method, Basic Production layout formats, Process layout– Craft and Systematic layout Planning, Product layout – Assembly line balancing, and Other layouts- Group Technology layout, Fixed Position layout, Retail service layout and office layout. **Forecasting:** Demand Management, Types of Forecasting, Components of demand, Qualitative Techniques, and Time series analysis in Forecasting.

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

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

Reference Books

1. Chase, Jacobs, Aquilano, "**Production and Operations Management**", Tenth Edition, Irwin McGraw Hill Companies Inc., 2004.
2. Everette. Adam. Jr.Ronald J.Ebert, "**Production and Operations Management**", Eight Indian Reprinting, PHI 1997.
3. Steven Nahmias, "**Production and Operations Analysis**", Third Edition, Irwin McGraw Hill Companies Inc., 2008.
4. Paneer Selvam.R, "**Production and Operations Management**", Prentice-hall of India, 2012.
5. Mahabatra, "**Computer Aided Production Management**", Prentice-hall Of India Pvt.ltd, 2004.

5. Chary, "**Theory and Problems in Production and Operations Management**", Second reprint, Tata McGraw Hill, 2013
6. Seetharama L.Narasimhan, Dennis W.McLeavy, Peter.J.Billington, "**Production Planning and Inventory Control**", PHI, 1997.

Course Contents and Lecture schedule

S.NO	Topics	No. of Lectures
1.0	**Introduction to Operations Management (OM)**	
1.1	Definition, OM in organisation chart	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

S.NO	Topics	No. of Lectures
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**	

S.NO	Topics	No. of Lectures
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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14IE270	WORK SYSTEM ENGINEERING LABORATORY	Category	L	T	P	Credit
		PC	0	0	2	1

Preamble

Work system engineering is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals.

Prerequisite

NIL

Course Outcomes

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

CO 1.	Develop practical awareness of conducting Time Study.	Understand
CO 2.	Enhance practical exposure of conducting Method Study.	Apply
CO 3.	Get exposure in Therapeutic techniques.	Apply
CO 4.	Know how to conduct physical fitness testing.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Syllabus

List of Experiments

1. Peg board experiment
2. Stop watch time study
3. Performance rating exercise
4. Graphic tools for method study
5. Work sampling
6. MTM practice
7. Study of physical performance using tread mill and Ergo cycle
8. Physical fitness testing of individuals
9. Experiments using sound level and lux meter

Course Designers

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CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Industrial Engineering) PROGRAMME

THIRD SEMESTER SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2014-2015 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
Fax: 0452 2483427
Web: www.tce.edu

DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

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

Mission:

As a department, we are committed to

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

Programme Educational Objectives: (PEO's) of M.E (Industrial Engineering)

PEO1

Graduates will assume lead roles in the practice of Industrial Engineering and its allied disciplines in manufacturing, services, and government.

PEO2

Graduates will continue to engage in life-long learning, understanding and applying knowledge and ideas of Industrial Engineering and allied disciplines.

PEO3

Graduates will associate themselves and become a part of IE professional societies or other professional organizations as well as in community-based organizations.

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

Graduating Students of M.E. Industrial Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	An ability to apply knowledge of mathematics and science in solving problems	**Scholarship of Knowledge**
PO2.	An ability to design and conduct experiments, as well as to analyze and interpret data	**Critical Thinking**
PO3.	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Problem Solving**
PO4.	An ability to have the broad education necessary to understand the impact of engineering solutions in a global and societal context	**Research Skill**
PO5.	An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice	**Usage of modern tools**
PO6.	An ability to function effectively as an individual and as a member or a leader in diverse teams, and in multidisciplinary activities	**Collaborative and Multidisciplinary work**
PO7.	An ability to apply project, financial management principles and techniques individually/collaboratively in project planning, implementation and control	**Project Management and Finance**
PO8.	An ability to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**Communication**
PO9.	An ability to engage in independent and life-long learning for personal and societal development	**Life-long Learning**
PO10.	An ability to understand the professional and ethical responsibility	**Ethical Practices and Social Responsibility**
PO11.	An Ability to make corrective measures and learn from the mistakes without depending on external feed back	**Independent and Reflective Learning**

PEO – PO Matrix

POs / PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	S	S	S	S	S	S	S	S	M	S	M
PEO2	S	S	S	S	S	M	M	S	S	L	S
PEO3	S	S	M	M	M	M	L	S	S	S	S

Correlation: S – Strong; M-Medium; L-Low

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Industrial Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses						Practical/Project
4th (12)							14IE410 Project Phase – II 0:12
3rd (16)	14IE310 Supply Chain Management 4:0	14IEPX0 Elective -V 4:0	14IEPX0 Elective -VI 4:0				14IE340 Project Phase-I 0:4
2nd (24)	14IE210 Financial Management 3:0	14IE220 Operations Management 4:0	14IEPX0 Elective -I 4:0	14IEPX0 Elective -II 4:0	14IEPX0 Elective -III 4:0	14IEPX0 Elective -IV 4:0	14IE 270 Work System Engineering Laboratory 0:1
1st (24)	14IE110 Applied Probability and Statistics 4:0	14IE120 Optimisation Techniques 4:0	14IE130 Work Study and Cost Analysis 4:0	14IE140 Quality and Reliability Engineering 4:0	14IE150 Management Support Systems 3:0	14IE160 Industrial Automation and Robotics 4:0	14IE170 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 2014-2015 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE110	Applied Probability and Statistics	BS	4	0	-	4
14IE120	Optimization Techniques	PC	4	0	-	4
14IE130	Work Study and Cost Analysis	PC	4	0	-	4
14IE140	Quality and Reliability Engineering	PC	4	0	-	4
14IE150	Management Support Systems	PC	3	0	-	3
14IE160	Industrial Automation and Robotics	PC	4	0	-	4
PRACTICAL						
14IE170	Industrial Engineering Laboratory	PC	-	-	2	1
Total						**24**

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

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE210	Financial Management	PC	3	0	-	3
14IE220	Operations Management	PC	4	0	-	4
14IEPX0	Elective - I	PE				4
14IEPX0	Elective - II	PE				4
14IEPX0	Elective - III	PE				4
14IEPX0	Elective - IV	PE				4
PRACTICAL						
14IE270	Work Systems Engineering Laboratory	PC	-	-	2	1
Total						**24**

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE310	Supply Chain Management	PC	4	0	-	4
14IEPX0	Elective – V	PE	4	0	-	4
14IEPX0	Elective - VI	PE	4	0	-	4
PRACTICAL						
14IE340	Project Phase I	PC	0	0	8	4
Total						**16**

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture
T : Tutorial
P : Practical

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE110	Applied Probability and Statistics	3	50	50	100	25	50
2	14IE120	Optimization Techniques	3	50	50	100	25	50
3	14IE130	Work Study and Cost Analysis	3	50	50	100	25	50
4	14IE140	Quality and Reliability Engineering	3	50	50	100	25	50
5	14IE150	Management Support Systems	3	50	50	100	25	50
6	14IE160	Industrial Automation and Robotics	3	50	50	100	25	50
PRACTICAL								
7	14IE170	Industrial Engineering Laboratory	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 (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE210	Financial Management	3	50	50	100	25	50
2	14IE220	Operations Management	3	50	50	100	25	50
3	14IEPX0	Elective - I	3	50	50	100	25	50
4	14IEPX0	Elective - II	3	50	50	100	25	50
5	14IEPX0	Elective - III	3	50	50	100	25	50
6	14IEPX0	Elective - IV	3	50	50	100	25	50
PRACTICAL								
7	14IE270	Work Systems Engineering Laboratory	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.

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE310	Supply Chain Management	3	50	50	100	25	50
2	14IEPX0	Elective – V	3	50	50	100	25	50
3	14IEPX0	Elective - VI	3	50	50	100	25	50
PRACTICAL								
4	14IE340	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 Industrial Engineering

S.No.	Sub. Code	Name of the Subjects	Credit
1.	14IEPA0	Plant Layout and Material Handling	4
2.	14IEPB0	Total Quality Management	4
3.	14IEPC0	Maintenance Engineering and Management	4
4.	14IEPD0	Machine Vision and its applications in manufacturing	4
5.	14IEPE0	System Simulation	4
6.	14IEPF0	Product Design and Development	4
7.	14IEPG0	Energy Management Systems	4
8.	14IEPH0	Robust Design	4
9.	14IEPJ0	Lean Manufacturing and Six Sigma	4
10.	14IEPK0	Computer Integrated Manufacturing	4
11.	14IEPL0	Value Engineering	4
12.	14IEPM0	Human Resource Management	4
13.	14IEPN0	Industrial Instrumentation	4
14.	14IEPP0	Research Methodology	4

		Category	L	T	P	Credit
14IE310	**SUPPLY CHAIN MANAGEMENT**	PC	4	0	0	4

Preamble

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

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain issues important in the design of the logistics network, inventory management and risk pooling	Understand
CO 2.	Explain the value of information, Distribution strategies, and strategic alliances	Understand
CO 3.	Explain the International Supply Chain Management, supplier integration, customer value and Information Technology.	Understand
CO 4.	Determine distribution cost, bullwhip effect, order quantity, and safety stock levels	Apply
CO 5.	Demonstrate / Review case studies about distribution strategies, strategic alliances, and coordinated product design	Apply
CO 6.	Suggest ways of improving customer value, supplier integration, mass customization and integrating SC and IT.	Apply

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

7. Why SC integration is difficult? Explain.
8. What is Electronic Commerce?
9. Explain the requirements for global strategy implementation.

Course Outcome 4 (CO4):

10. 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'.
11. 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.

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

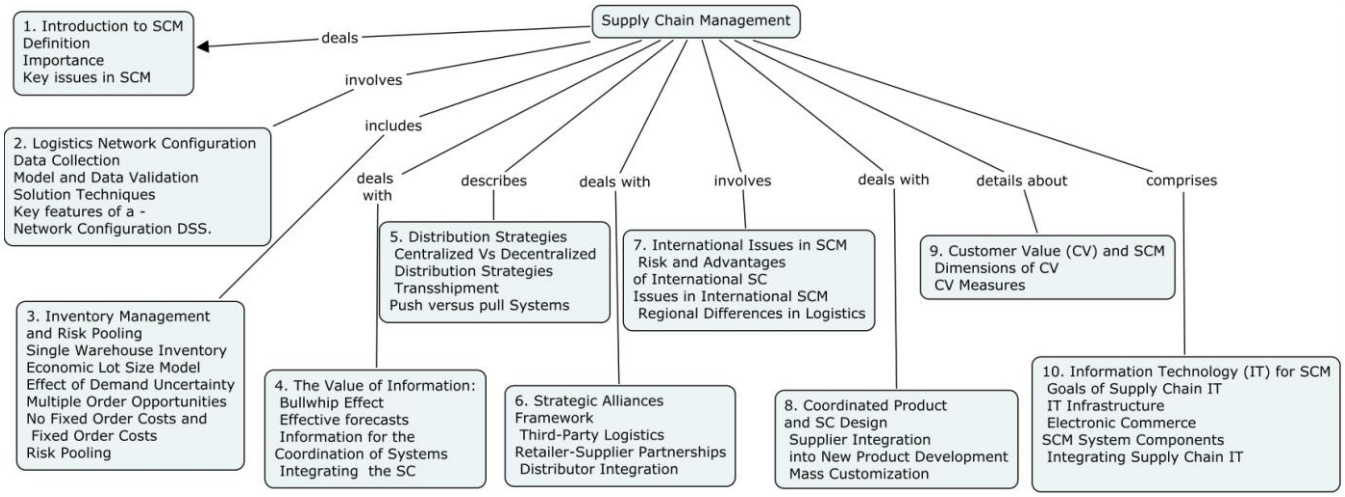
Course Outcome 5 (CO5):

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

Course Outcome 6 (CO6):

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

Concept Map



Syllabus

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

Reference Books

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi Edith, “Designing and Managing the Supply Chain”, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2007.
2. Chopra S and Meindl P, “Supply Chain Management: Strategy, Planning, and Operation”, Second Edition, Prentice Hall India Pvt. Ltd, New Delhi, 2012.
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, 2002.

Course Contents and Lecture schedule

Sl.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 Costs.	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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CURRICULUM AND DETAILED SYLLABI

FOR

M.E. DEGREE (Industrial Engineering) PROGRAMME

FOURTH SEMESTER SUBJECTS

&

ELECTIVE SUBJECTS

FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2014-2015 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
Fax: 0452 2483427
Web: www.tce.edu

DEPARTMENT OF MECHANICAL ENGINEERING

Vision:

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

Mission:

As a department, we are committed to

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

Programme Educational Objectives: (PEO's) of M.E (Industrial Engineering)

PEO 1

Graduates will assume lead roles in the practice of Industrial Engineering and its allied disciplines in manufacturing, services, and government.

PEO2

Graduates will continue to engage in life-long learning, understanding and applying knowledge and ideas of Industrial Engineering and allied disciplines.

PEO3

Graduates will associate themselves and become a part of IE professional societies or other professional organizations as well as in community-based organizations.

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Graduating Students of M.E. Industrial Engineering programme will have

Programme Outcomes (POs)		Graduate Attributes (GAs)
PO1.	An ability to apply knowledge of mathematics and science in solving problems	**Scholarship of Knowledge**
PO2.	An ability to design and conduct experiments, as well as to analyze and interpret data	**Critical Thinking**
PO3.	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	**Problem Solving**
PO4.	An ability to have the broad education necessary to understand the impact of engineering solutions in a global and societal context	**Research Skill**
PO5.	An ability to use the techniques, skills, and modern engineering tools necessary for industrial engineering practice	**Usage of modern tools**
PO6.	An ability to function effectively as an individual and as a member or a leader in diverse teams, and in multidisciplinary activities	**Collaborative and Multidisciplinary work**
PO7.	An ability to apply project, financial management principles and techniques individually/collaboratively in project planning, implementation and control	**Project Management and Finance**
PO8.	An ability to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions	**Communication**
PO9.	An ability to engage in independent and life-long learning for personal and societal development	**Life-long Learning**
PO10.	An ability to understand the professional and ethical responsibility	**Ethical Practices and Social Responsibility**
PO11.	An Ability to make corrective measures and learn from the mistakes without depending on external feed back	**Independent and Reflective Learning**

PEO – PO Matrix

POs / PEOs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
PEO1	S	S	S	S	S	S	S	S	M	S	M
PEO2	S	S	S	S	S	M	M	S	S	L	S
PEO3	S	S	M	M	M	M	L	S	S	S	S

Correlation: S – Strong; M-Medium; L-Low

Thiagarajar College of Engineering: Madurai-625015.

Department of Mechanical Engineering

M.E. DEGREE (Industrial Engineering) PROGRAMME

Scheduling of Courses

Sem.	Theory Courses						Practical/Project
4th (12)							14IE410 Project Phase – II 0:12
3rd (16)	14IE310 Supply Chain Management 4:0	14IEPX0 Elective -V 4:0	14IEPX0 Elective -VI 4:0				14IE340 Project Phase-I 0:4
2nd (24)	14IE210 Financial Management 3:0	14IE220 Operations Management 4:0	14IEPX0 Elective -I 4:0	14IEPX0 Elective -II 4:0	14IEPX0 Elective -III 4:0	14IEPX0 Elective -IV 4:0	14IE 270 Work System Engineering Laboratory 0:1
1st (24)	14IE110 Applied Probability and Statistics 4:0	14IE120 Optimisation Techniques 4:0	14IE130 Work Study and Cost Analysis 4:0	14IE140 Quality and Reliability Engineering 4:0	14IE150 Management Support Systems 3:0	14IE160 Industrial Automation and Robotics 4:0	14IE170 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 2014-2015 onwards)

FIRST SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE110	Applied Probability and Statistics	BS	4	0	-	4
14IE120	Optimization Techniques	PC	4	0	-	4
14IE130	Work Study and Cost Analysis	PC	4	0	-	4
14IE140	Quality and Reliability Engineering	PC	4	0	-	4
14IE150	Management Support Systems	PC	3	0	-	3
14IE160	Industrial Automation and Robotics	PC	4	0	-	4
PRACTICAL						
14IE170	Industrial Engineering Laboratory	PC	-	-	2	1
Total						**24**

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

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

T : Tutorial

P : Practical

Note:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2 Hours Practical is equivalent to 1 credit

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

SECOND SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE210	Financial Management	DC	3	0	-	3
14IE220	Operations Management	DC	4	0	-	4
14IEPX0	Elective - I	PE				4
14IEPX0	Elective - II	PE				4
14IEPX0	Elective - III	PE				4
14IEPX0	Elective - IV	PE				4
PRACTICAL						
14IE270	Work Systems Engineering Laboratory	PC	-	-	2	1
Total						**24**

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

BS : Basic Science

PC : Programme Core

PE : Programme Elective

L : Lecture

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THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SUBJECTS OF STUDY

(For the candidates admitted from 2014-2015 onwards)

THIRD SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
THEORY						
14IE310	Supply Chain Management	PC	4	0	-	4
14IEPX0	Elective – V	PE	4	0	-	4
14IEPX0	Elective - VI	PE	4	0	-	4
PRACTICAL						
14IE340	Project Phase I	PC	0	0	8	4
Total						**16**

FOURTH SEMESTER

Subject code	Name of the subject	Category	No. of Hours / Week			credits
			L	T	P	
PRACTICAL						
14IE410	Project Phase II	PC	0	0	24	12
Total						**12**

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

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

L : Lecture
T : Tutorial
P : Practical

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

THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.

M.E. DEGREE (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE110	Applied Probability and Statistics	3	50	50	100	25	50
2	14IE120	Optimization Techniques	3	50	50	100	25	50
3	14IE130	Work Study and Cost Analysis	3	50	50	100	25	50
4	14IE140	Quality and Reliability Engineering	3	50	50	100	25	50
5	14IE150	Management Support Systems	3	50	50	100	25	50
6	14IE160	Industrial Automation and Robotics	3	50	50	100	25	50
PRACTICAL								
7	14IE170	Industrial Engineering Laboratory	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 (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE210	Financial Management	3	50	50	100	25	50
2	14IE220	Operations Management	3	50	50	100	25	50
3	14IEPX0	Elective - I	3	50	50	100	25	50
4	14IEPX0	Elective - II	3	50	50	100	25	50
5	14IEPX0	Elective - III	3	50	50	100	25	50
6	14IEPX0	Elective - IV	3	50	50	100	25	50
PRACTICAL								
7	14IE270	Work Systems Engineering Laboratory	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 (Industrial Engineering) PROGRAMME

SCHEME OF EXAMINATIONS

(For the candidates admitted from 2014-2015 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	14IE310	Supply Chain Management	3	50	50	100	25	50
2	14IEPX0	Elective – V	3	50	50	100	25	50
3	14IEPX0	Elective - VI	3	50	50	100	25	50
PRACTICAL								
4	14IE340	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

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	14IE410	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.

** 14IE410 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 14IE340 Project Phase I (Third Semester) and 14IE410 Project Phase II (Fourth Semester) is not specified and will be decided by the Department/ Examiners for the candidates admitted from 2014-2015 onwards.

LIST OF ELECTIVE SUBJECTS - M.E Industrial Engineering

S.No.	Sub. Code	Name of the Subjects	Credit
1.	14IEPA0	Plant Layout and Material Handling	4
2.	14IEPB0	Total Quality Management	4
3.	14IEPC0	Maintenance Engineering and Management	4
4.	14IEPD0	Machine Vision and its applications in manufacturing	4
5.	14IEPE0	System Simulation	4
6.	14IEPF0	Product Design and Development	4
7.	14IEPG0	Energy Management Systems	4
8.	14IEPH0	Robust Design	4
9.	14IEPJ0	Lean Manufacturing and Six Sigma	4
10.	14IEPK0	Computer Integrated Manufacturing	4
11.	14IEPL0	Value Engineering	4
12.	14IEPM0	Human Resource Management	4
13.	14IEPN0	Industrial Instrumentation	4
14.	14IEPP0	Research Methodology	4

14IEPA0	PLANT LAYOUT AND MATERIAL HANDLING	Category	L	T	P	Credit
		PE**	4	0	0	4

Preamble

The workplace is one of the prime resources to deliver products/services with the expected level of quality at least cost. To achieve the organizational effectiveness, proper utilization of the workplace has to be ensured. This course has been designed to highlight the fundamental issues, concepts and the methodologies related to Plant layout and material handling

Prerequisite

NIL

Course Outcomes

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

CO 1.	Describe the facility location determinants and methods	**Understand**
CO 2.	Solve different types of facility location models	**Apply**
CO 3.	Design the layouts of manufacturing systems and service organizations	**Apply**
CO 4.	Make clusters of machine and components using different techniques	**Apply**
CO 5.	Group the activities for the work station in order to make balanced flow line using heuristic algorithms.	Apply
CO 6.	Describe about material handling system.	**Understand**

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. List the issues of facility location.
2. Identify the factors to be considered for location selection.
3. Write the equation to compute the Euclidian distance.
4. Discuss about different types of facility location problem.

Course Outcome 2 (CO2):

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

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

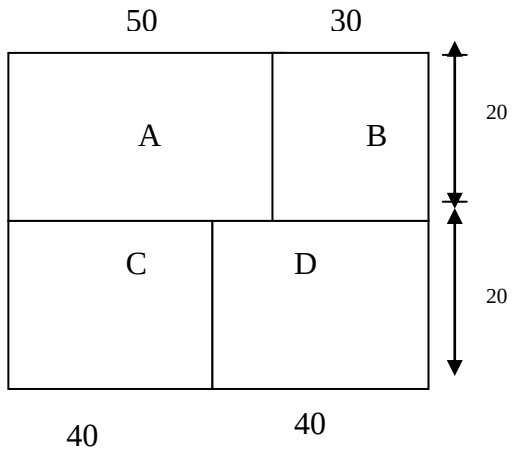
2. Discuss the various techniques of locating a single facility

Course Outcome 3 (CO3):

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

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

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



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

Course Outcome 4 (CO4):

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

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

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

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

Course Outcome 5 (CO5):

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

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

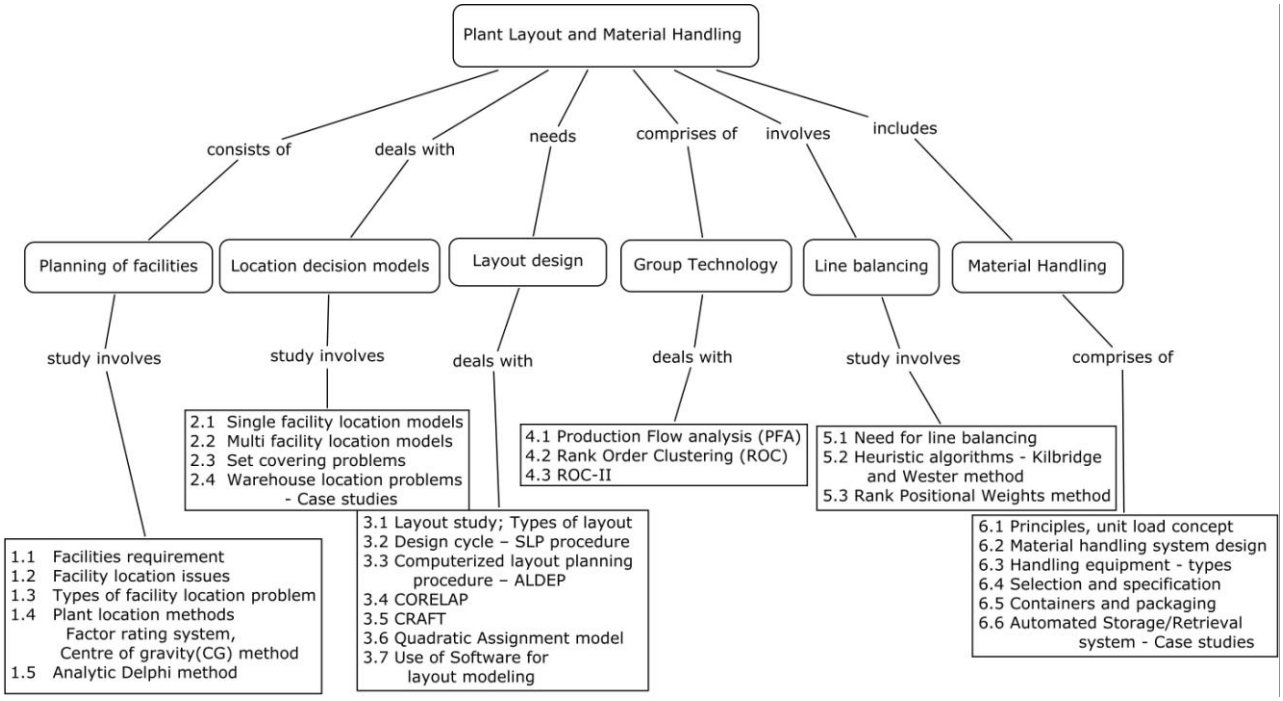
2. The operations involved in an organization are given below. Balance the line using Kilbridge and Wester method. Determine the balance delay. Assume that number of workstations is Three.

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

Course Outcome 6 (CO6):

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

Concept Map



Syllabus

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

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

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

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

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

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

Reference Books

1. Tompkins, J.A. and J.A.White, "Facilities planning", Fourth Edition, John Wiley, 2010.
2. Richard Francis.L. and John A.White, "Facilities Layout and location - an analytical approach", Prentice Hall of India, 2012.

3. James Apple, M.Plant layout and "Material Handling", John Wiley, 1991.
4. Pannerselvam,R, "Production and Operations Management", Third Edition, Prentice Hall of India,2012

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 Designers:

1. ML.MAHADEVAN mlmmech@tce.edu

14IEPB0 TOTAL QUALITY MANAGEMENT

Category	L	T	P	Credit
PE**	4	0	0	4

Preamble:

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

Prerequisite

- NIL

Course Outcomes

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

CO 1.	Understand the principles of TQM.	**Remember**
CO 2.	Understand the concepts of Statistical process control	**Understand**
CO 3.	Apply the tools and techniques of TQM in an organization.	**Apply**
CO 4.	Understand the need for Quality systems of international standards.	**Apply**
CO 5.	Implement the Quality Management Systems in a different organization environment.	**Apply**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	L	L	L	L	L	L	L	L	M	L	L
CO 2.	S	S	M	L	M	L	L	M	M	L	L
CO 3.	S	S	S	M	S	M	L	M	M	L	L
CO 4.	M	S	S	L	M	L	L	M	M	L	L
CO 5.	S	S	S	L	S	L	L	M	M	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

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

5	Evaluate	0	0	0	0
6	Create	0	0	0	0

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

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

(i) Compute trial control limits

(ii) Plot the appropriate chart

(iii) Draw the conclusion

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

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

7	20.09	20.05	20.00	20.03
8	19.99	19.98	20.01	19.97

(i) Compute the trial control limits for X and R charts.

(ii) Construct and R chart

(iii) Comment of the process.

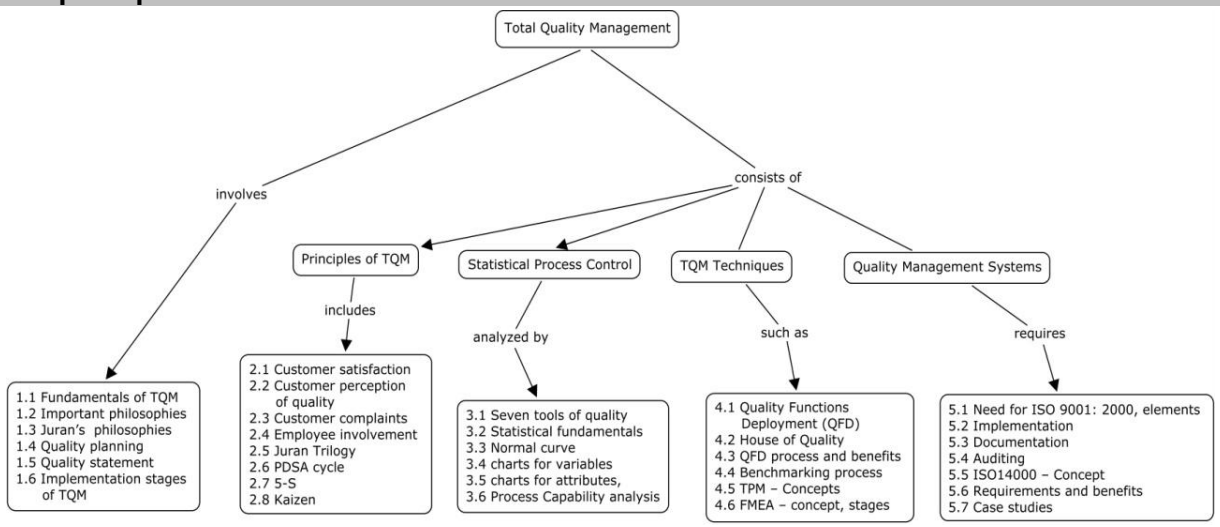
(iv) Calculate the process capability

(v) Compute percent defective if any

Course Outcome 4 and 5 (CO4&5):

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

Concept Map



Syllabus

Introduction: Fundamentals of TQM – Historical developments – important philosophies- (Deming, Juran, Crossby) and their impact of quality – Quality planning, Quality statement – TQM implementation stages **Principles of TQM:** Customer satisfaction – customer perception of quality, customer complaints, Employee involvement – Juran Trilogy, PDSA cycle, 5S, Kaizen. **Process Monitoring:** Seven tools of quality, statistical fundamentals – Normal curve charts for

variables and attributes, Process Capability analysis. **TQM Techniques:** Quality Functions Deployment (QFD) – house of Quality, QFD process and benefits, Benchmarking process, TPM – Concepts, FMEA – concept, stages. **Quality Management Systems:** Need for ISO 9001: 2008 – Elements, Implementation, Documentation and Auditing. ISO14000 – Concept requirements and benefits – Case studies.

Reference Books

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

S.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

S.No	Topics	No. of Lectures
3.2	Statistical fundamentals	1
3.3	Normal curve	1
3.4	Charts for variables	2
3.5	Charts for attributes	2
3.6	Process Capability analysis	2
4	**TQM Techniques**	
4.1	Quality Functions Deployment (QFD)	2
4.2	House of Quality	1
4.3	QFD process and benefits	1
4.4	Benchmarking process	2
4.5	TPM – Concepts	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**

Course Designers

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

Preamble

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

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain the principles of various types of Maintenance plans.	**Understand**
CO 2.	Compute the system Reliability of different system configuration	**Apply**
CO 3.	Determination of suitable replacement interval of the system with an objective of optimum total cost.	**Apply**
CO 4.	Preparation of maintenance job schedule using different techniques	**Understand**
CO 5.	Express the principle of Total Productive Maintenance and its implementation	**Understand**
CO 6.	Preparation of maintenance budget with understanding of various cost involved.	**Understand**
CO 7.	Explain the process of Maintenance performance evaluation	**Understand**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	L	M	S	L	M	M	S	L	M	M	M
CO 2.	S	S	S	M	M	M	M	L	M	L	L
CO 3.	M	M	M	M	M	L	S	M	M	M	M
CO 4.	S	S	M	M	M	L	S	L	L	M	M
CO 5.	L	M	M	L	L	M	S	L	M	M	M
CO 6.	M	M	M	M	M	L	S	M	M	M	M
CO 7.	L	M	M	L	L	M	S	L	M	M	M

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

1. An optical sensor has follow the Weibull time to failure distribution with scale parameter of 300 h and shape parameter of 0.6. What is the reliability of the sensor after 500 h of operation?
2. Consider a system with three components A, B and C in parallel. Determine the system reliability for 2000 h of operation, and find the mean time to failure. Assume all the three components have an identical time-to failure distribution that is exponential, with a constant failure rate of 0.0006 per hour. What is the mean time failure of each component?
3. A standby system has a basic unit with four standby components. The time to failure of each component has an exponential distribution with a failure rate of 0.007 per h. For a 400h operation period, find the reliability of the standby system.

Course Outcome 3 (CO3):

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

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

   Determine at what age is replacement due?

2. A manufacturer is offered two machines A and B. A is priced at Rs.5000 and running costs are estimated at Rs.800 for each of the first five years, increasing by Rs.200 per year in the sixth and subsequent years. Machine B, which has the same capacity as A, costs Rs.2500 but will have running costs of Rs.12000 per year for six years, increasing by Rs.200 per year thereafter. If money is worth 10% per year which machine should be

purchased? Assume that the machines will eventually be sold for scrap at a negligible price.

3. The following failure rates have been observed for a certain type of light bulb.

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

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

Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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

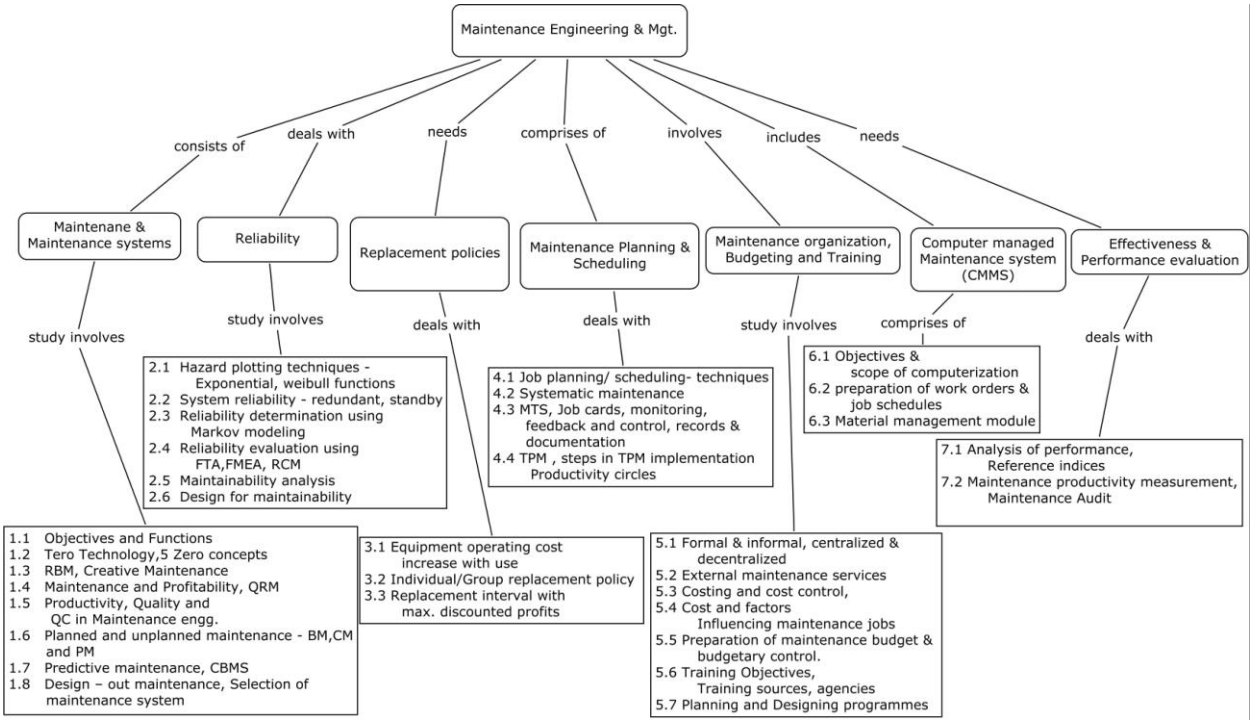
Course Outcome 6 (CO6):

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

Course Outcome 7 (CO7):

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

Concept Map



Syllabus

Maintenance: Objectives and Functions, Concepts and Nature of Maintenance, Tero Technology, 5 Zero concepts, Reliability Based Maintenance (RBM), Creative Maintenance. Maintenance and Profitability – Quality, Reliability and Maintainability (QRM) – Productivity, Quality and quality circle in Maintenance Engineering. Maintenance systems: Planned and unplanned maintenance. Break down maintenance, Corrective maintenance, Preventive maintenance, Predictive maintenance, Condition Based Maintenance Systems (CBMS), Design – out maintenance, Selection of maintenance system.

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

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

Maintenance Planning and Scheduling: Job planning – job scheduling – scheduling techniques – short term planning, Long term planning – Systematic maintenance – codification and cataloging, Manuals. Maintenance Time Standard (MTS), Job cards, Job execution, monitoring,

feedback and control, Maintenance records and documentation. Total Productive Maintenance (TPM) – Basic systems, steps in TPM implementation - Productivity circles.

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

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

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

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

Reference Books

1. Sushil Kumar Srivastava, “Industrial Maintenance Management”, S.Chand 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, 2011.
4. A.K.S.Jardine and A.H.C. Tsang, “Maintenance, replacement, and reliability: theory and applications”, CRC/Taylor & Francis, 2013.
5. L.S.Srinath, “Reliability Engineering”, 4th Edition, Affiliated East West Press. New Delhi 2005.
6. C. Balagurusamy, “Reliability Engineering”, Tenth Reprint, Tata McGraw Hill Pvt. Ltd. 2010.
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	1

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

S.No	Topics	No. of Lectures
	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**

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14IEPD0	MACHINE VISION AND ITS APPLICATION IN MANUFACTURING	Category	L	T	P	Credit
		PE	4	0	0	4

Preamble

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

Prerequisite

NIL

Course Outcomes

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

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

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Outcome 1 (CO1)**:**

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

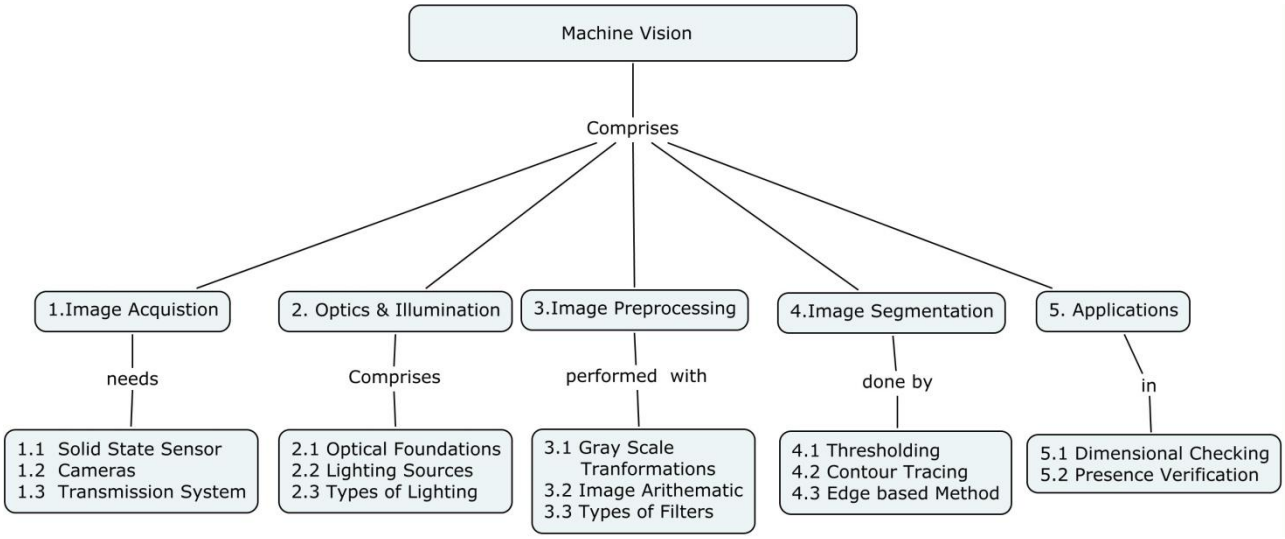
Course Outcome 2 (CO2)**:**

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

Course Outcome 3 (CO3)**:**

4. Select and illustrate a suitable Machine Vision Technique used for Inspection of Threads in Nuts in a Batch Production Process.
5. 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
6. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.

Concept Map



Syllabus

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

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

Reference Books

1. C.Demant, B.Streicher Abel, P.Waszkewitz “Industrial Image Processing and Visual Quality control in manufacturing”. Springer, 2012.
2. Alexander Hornberg, “Handbook of Machine Vision”, Wiley VCH, 2008
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.” Third Edition, Prentice Hall India, 2007.
6. http://www.cse.usf.edu/~r1k/MachineVisionBook/MachineVision.pdf
7. http://www.machinevision.co.uk/
8. nptel.ac.in/courses/117105079

Course Contents and Lecture Schedule

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

S.No.	Topics	No. of Lectures
	Enhancement.	
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	1
4	**Image Segmentation**	
4.1	Thresholding:	
4.1.1	Threshold Determination from Histogram	1
4.1.2	Gray Level Histogram, Generalizations of Thresholding	1
4.2	Contour Tracing:	
4.2.1	Pixel Correctedness, Generating Object Contours, Contour representation	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.	1
5	**Applications**	
5.1	Dimensional Checking:	
5.1.1	Simple gauging, Shape Checking	1
5.1.2	Angle Gauging, High accuracy Gauging	1
5.1.3	Calibration	1
5.2	Presence Verification:	
5.2.1	Simple Presence verification, Simple Gauging for assembly verification	1
5.2.2	Glue Check under UV Light	
5.2.3	Pin Type Verification	1
5.2.4	Alignment Checking	
	Total	36 Hours

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		Category	L	T	P	Credit
14IEPE0	**SYSTEM SIMULATION**	PE**	4	0	0	4

Preamble

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

Prerequisite

NIL

Course Outcomes

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

CO 1.	Explain the concepts, types and applications of simulation, steps in simulation study.	**Remember**
CO 2.	Explain how computer simulation can be used to model complex systems	**Understand**
CO 3.	Solve related decision problems.	**Apply**
CO 4.	Explain the assumptions made in building a discrete event simulation.	**Understand**
CO 5.	Explain and to apply the statistical methods used in simulation analysis.	**Apply**
CO 6.	Examine the techniques of random number generator, testing of random numbers	**Understand**
CO 7.	Evaluate generator in a given application, and how to use those generators to phenomena of interest	**Apply**
CO 8.	Explain how to design a computer simulation, conduct input modeling validation, and output analysis.	**Apply**
CO 9.	Run a simulation project from start to finish.	**Apply**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	M	M	S	L	L	M	L	M	S	L	L
CO 2.	S	M	L	M	M	M	L	M	L	L	L
CO 3.	M	M	L	L	M	M	L	M	M	L	L
CO 4.	M	S	M	M	M	L	M	L	L	M	M
CO 5.	S	M	M	M	M	L	L	M	M	L	L
CO 6.	M	M	M	L	L	L	M	L	L	M	L
CO 7.	M	S	M	M	M	M	L	M	L	M	L
CO 8.	M	M	M	L	M	M	M	L	M	L	L
CO 9.	M	M	L	L	M	M	L	M	L	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1)**:**

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

   a) Gamma distribution b) Normal distribution

Course Outcome 2 (CO2)**:**

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

Course Outcome 3 (CO3)**:**

7. 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?

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

Course Outcome 4 (CO4)**:**

9.Draw a flow chart which represents the various steps involved in the simulation process

10.Develop an Acceptance-Rejection technique for generating a Poisson random variable with mean $\alpha = 0.2$

Course Outcome 5 (CO5)**:**

11. 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.

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

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

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

Course Outcome 6 (CO6)**:**

13. Develop a random variate generator for exponential distribution.

14. Mention the factors that are to be considered in selecting a simulation language for a particular application.

15. Considering an Engineering educational system, identify the entities, attributes and activities of the system.

Course Outcome 7 (CO7):

16. 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?

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

Course Outcome 8 (CO8):

18. 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?

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

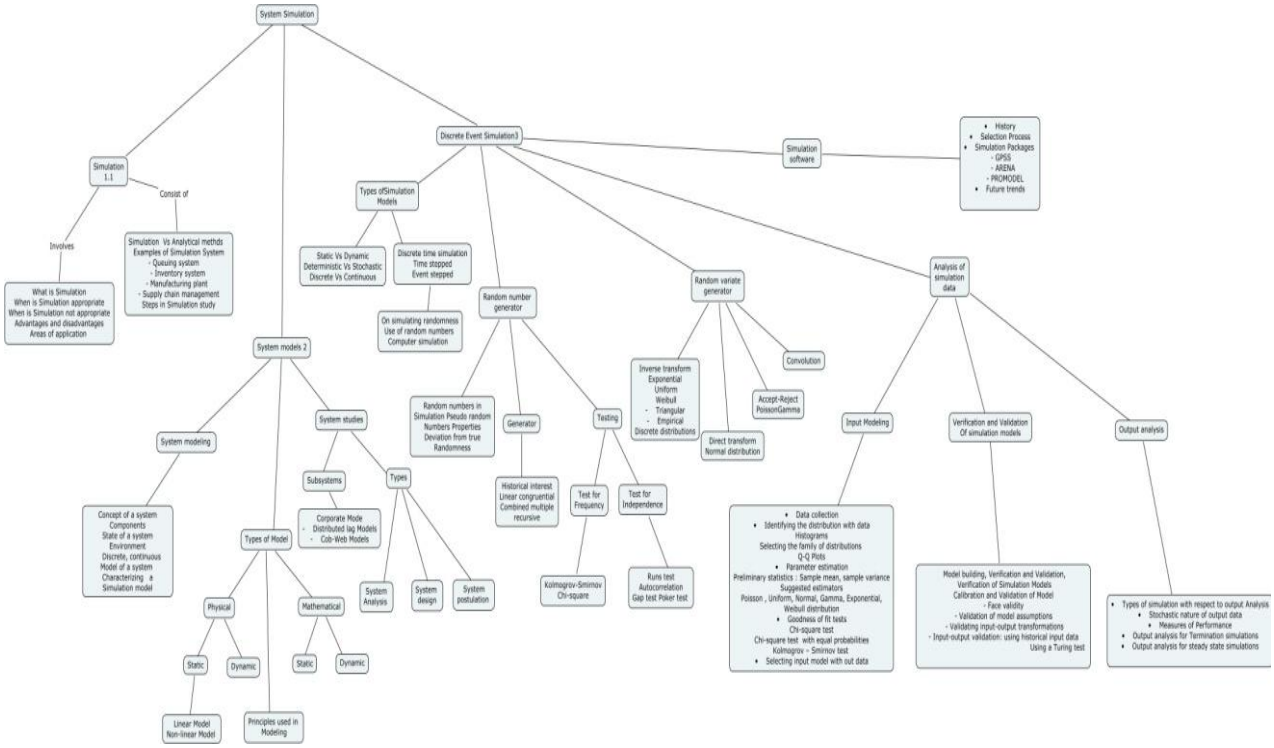
Course Outcome 9 (CO9):

20. Give GPSS block diagrams and write program. Parts are being made at the rate of one every 6 minutes. They are of two types, A and B, and are mixed randomly, with about 10% being type B. A separate inspector is assigned to examine each type of part. The inspection of A parts takes 4 ±2 minutes and B parts take 20 ± 10 minutes. Both inspectors reject about 10% of the parts they inspect. Simulate for a total of 1000 type A parts accepted.

21. A tool crib has exponential inter-arrival and service times and serves a very large group of mechanics. The mean time between arrivals is 4 minutes. It takes 3 minutes on the average for

a tool crib attendant to serve a mechanic. The attendant is paid Rs. 40 per hour and the mechanic is paid Rs. 60 per hour. Would it be advisable to have a second tool crib attendant?

Concept Map



Syllabus

System simulation:

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

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

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

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

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

Input Modeling – Data collection, Selecting the family of distributions, Parameter estimation – Sample mean, sample variance, suggested estimators – Poisson, Uniform, Normal, Gamma, and Weibull distributions - Goodness of Fit Tests– Chisquare, Kolmogorov-Smirnov tests - Selecting input Model 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 package – History, Comparison of simulation packages with programming languages, Selection Process, Simulation Packages (GPSS, ARENA, PROMODEL)*- Simulation of queuing systems, Inventory systems and Manufacturing systems.

Reference Books

1. Jerry Banks, John S.Carson, Barry L.Nelson, David M. Nicol P.Shahabudeen " **Discrete – Event System Simulation**" Pearson Edition, 2009
2. Geoffrey Gordon, "**System Simulation** " Prentice Hall of India, New Delhi, 2003
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, 2004

Course Contents and Lecture Schedule

S. No	Topics	No. of Lectures
1	Simulation	
1.1	Nature of Simulation, Systems, Models, and Simulation, When is simulation appropriate, not appropriate, Advantages and disadvantages, Areas of application, Simulation Vs analytical methods,	2
1.2	Monte-Carlo simulation-Examples of Simulation systems –	2

S. No	Topics	No. of Lectures
	Queuing System, Inventory System, Manufacturing Plant	
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, sample variance, suggested estimators – Poisson, Exponential, Uniform, Normal, Gamma, and weibull distributions	2
3.4.1.3	Goodness of Fit Tests – Chisquare and Kolmogorov tests	2
3.4.1.4	Selecting input model without data	1
3.4.2.1	Verification and Validation –Model building, Calibration and	2

S. No	Topics	No. of Lectures
	validation of Models –Validation of existing systems, Validation of hypothetical systems – Face validity	
3.4.2.2	Model assumptions, Input-output transformations –Historical data, Turing Test	2
3.4.3.1	Output analysis – stochastic nature of output data – Checking for normality –Shapiro Wilk Test, q-q plot - Types of simulation with respect to output Analysis, Stochastic nature of output data, Measure of Performance, Output Analysis for Termination Simulations, Output Analysis for steady -state simulations.	4
3.5	Simulation Software	
3.5.1	History	1
3.5.2	Selection of Simulation software -example	1
3.5.3	Simulation in GPSS / ARENA / PROMODEL *– Queuing problem, Inventory Problem , Manufacturing Problem	5

Total 47 Hours

Course Designers:

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14IEPF0	PRODUCT DESIGN AND DEVELOPMENT	Category	L	T	P	Credit
		PE**	4	0	0	4

Preamble

The course aims at giving adequate exposure to design process and to solve the real time creative product design and development approach. The course also deals with various methods involved in product design and development.

Prerequisite

- 14IE120 : Optimisation Techniques

Course Outcomes

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

CO1	Express the concept of product design and its applications.	**Remember**
CO2	Classify the product planning process based on the customer need.	**Understand**
CO3	Justify the final specification of the product.	**Understand**
CO4	Identify the best concept based on concept selection process	**Apply**
CO5	Suggest and implement the suitable product architecture	**Apply**
CO6	Apply the successful product development strategies, product planning activities, specifications, various methods for concept selection and architecture planning.	**Apply**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	S	M	M	L	S	L	L	S	L	S	S
CO 2.	S	S	L	L	L	L	M	S	S	S	S
CO 3.	S	M	M	L	L	L	L	L	L	L	L
CO 4.	S	S	L	L	L	L	L	L	L	L	L
CO 5.	S	M	L	M	M	L	M	S	S	S	M
CO 6.	M	M	L	L	L	L	M	S	S	S	S

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Define product design.
2. Define the term concept scoring?
3. What is metrics?

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

Course Outcome 4 (CO4):

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

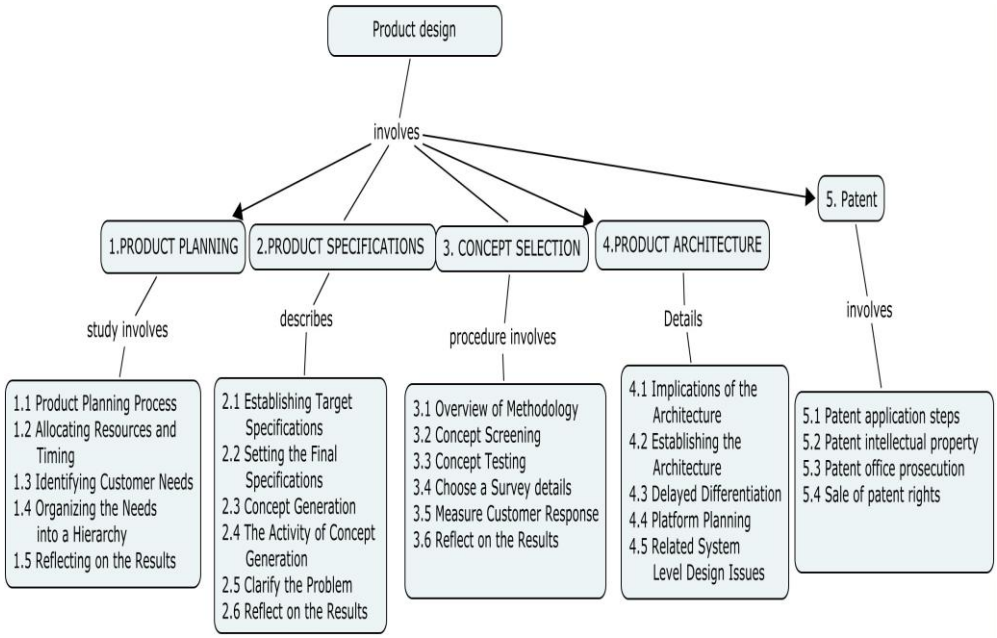
Course Outcome 5 (CO5):

13. Draw proposed product architecture for a digital camera with chunks details.
14. What is industrial design?
15. Compare incidental interaction and fundamental interaction.

Course Outcome 6 (CO6):

16. What is pre project planning?
17. Draw the logic diagram for two claims for patterns with example.
18. Explain the procedure for applying pattern Perform concept screening for five pencil holder concept. Assume the pencil holders are for the member of product development team who is continually moving from site to site.

Concept Map



Syllabus

PRODUCT PLANNING- Product Planning Process- Identify Opportunities- Evaluating and Prioritizing Projects- Allocating Resources and Timing- Pre-Project Planning-Reflect on the Results and the Process-Identifying Customer Needs- Raw Data from Customers- Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy-Establishing the Relative Importance of the Needs- Case study for motor driven nailer -Reflecting on the Results and the Process -**PRODUCT SPECIFICATIONS** - Specification Establishment -Establishing Target Specifications-QFD-Setting the Final Specifications-Concept Generation-The Activity of Concept Generation-Clarify the Problem- Search Externally-Search Internally-Explore Systematically-– Reflect on the Results and the Process - Case study for motor driven nailer **CONCEPT SELECTION**- Overview of Methodology-Concept Screening-Concept Testing-Define the Purpose of the Concept Test- Choose a Survey Population- Choose a Survey Format-Communicate the Concept- Measure Customer Response-– Interpret the Results- Reflect on the Results and the Process- Case study for motor driven nailer **PRODUCT ARCHITECTURE**-Product Architecture-Implications of the Architecture-Establishing the Architecture-Delayed Differentiation-Platform Planning- Costing– Material – manufacturing –assembly – structure-Ergonomics and aesthetic aspects- Related System-Level Design Issues -Case study for motor driven nailer D**ESIGN PATENTS** – Patent application steps – Patent intellectual property – Patent office prosecution – Sale of patent rights.

Reference Books

1. Karl T.Ulrich and Steven D.Eppinger, “Product Design and Development”, McGraw –Hill International Edns.2011
2. Kemnneth Crow, DRM Associates, “Concurrent Engg./Integrated Product Development” 26/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book

3. Stephen Rosenthal, “Effective Product Design and Development”, Business One Orwin, Homewood, 1992,ISBN, 1-55623-603-4
4. Stuart Pugh, “Tool Design – Integrated Methods for successful Product Engineering” Addison Wesley Publishing,Neyourk,NY,1991, ISBN 0-202-41639-5

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1	**PRODUCT PLANNING**	
1.1	Product Planning Process- Identify Opportunities	1
1.1.1	Evaluating and Prioritizing Projects	1
1.2	Allocating Resources and Timing	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**	
2.1	Specification Establishment -Establishing Target Specifications	2
2.1.1	QFD	1
2.2	Setting the Final Specifications	1
2.3	Concept Generation	1
2.4	The Activity of Concept Generation	1
2.5	Clarify the Problem- Search Externally –Search Internally Explore Systematically	1
2.5.1	Case study for motor driven nailer	2
2.6	Reflect on the Results and the Process Introduction and Classification	1
3	**CONCEPT SELECTION**	
3.1	Overview of Methodology	1
3.2	Concept Screening	1
3.3	Concept Testing	1

S.No	Topics	No. of Lectures
3.3.1	Define the Purpose of the Concept Test	1
3.4	Choose a Survey details	1
3.4.1	Choose a Survey Format	1
3.4.2	Communicate the Concept	1
3.5	Measure Customer Response	1
3.5.1	Case study for motor driven nailer	2
3.6	Interpret the Results- Reflect on the Results and the Process	1
4	**PRODUCT ARCHITECTURE**	
4.1	Product Architecture-Implications of the Architecture	2
4.2	Establishing the Architecture	1
4.3	Delayed Differentiation	1
4.4	Platform Planning	1
4.4.1	Costing– Material – manufacturing –assembly – structure-Ergonomics and aesthetic aspects	2
4.5	Related System-Level Design Issues	1
4.5.1	Case study for motor driven nailer	2
5	**DESIGN PATENTS**	
5.1	Patent application steps	1
5.2	Patent intellectual property	1
5.3	Patent office prosecution	1
5.4	Sale of patent rights	1
	Total	50

Course Designers:

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14IEPG0	ENERGY MANAGEMENT SYSTEMS	Category	L	T	P	Credit
		PE**	4	0	0	4

Preamble

In the global scenario, the management of energy resources plays an important role. The knowledge on various forms of energy, efficient usage of the available energy and the potential areas of improvement in application is the need of the hour. For any industry or organization, the economical aspects like investment, maintenance cost and pay-back period of energy conversion machines are very important. It is essential for a post graduate industrial engineering student to understand the basics of energy conservation techniques, energy auditing in industries and the associated economical benefits.

Prerequisite

NIL

Course Outcomes

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

CO 1.	Demonstrate the basic concepts of energy planning, energy management and energy conservation opportunities in various energy sectors.	**Apply**
CO 2.	Apply thermal engineering basics in energy conversion systems.	**Apply**
CO 3.	**Demonstrate the importance of energy awareness programmes.**	**Apply**
CO 4.	Demonstrate the opportunities of energy saving and conservation methods in various types of industries.	**Apply**

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the various energy management techniques in detail.
2. Describe the various non-conventional energy sources and their potential in meeting energy demands in India.
3. Illustrate the possible ways of energy conservation and energy saving in domestic energy consumption.

Course Outcome 2 (CO2):

1. Explain the benefits of fluidized bed combustion in energy point of view.
2. What is a combined cycle? Demonstrate with an example how does it help to conserve energy.
3. With neat sketches, explain the different methods of co-generation in power plants.

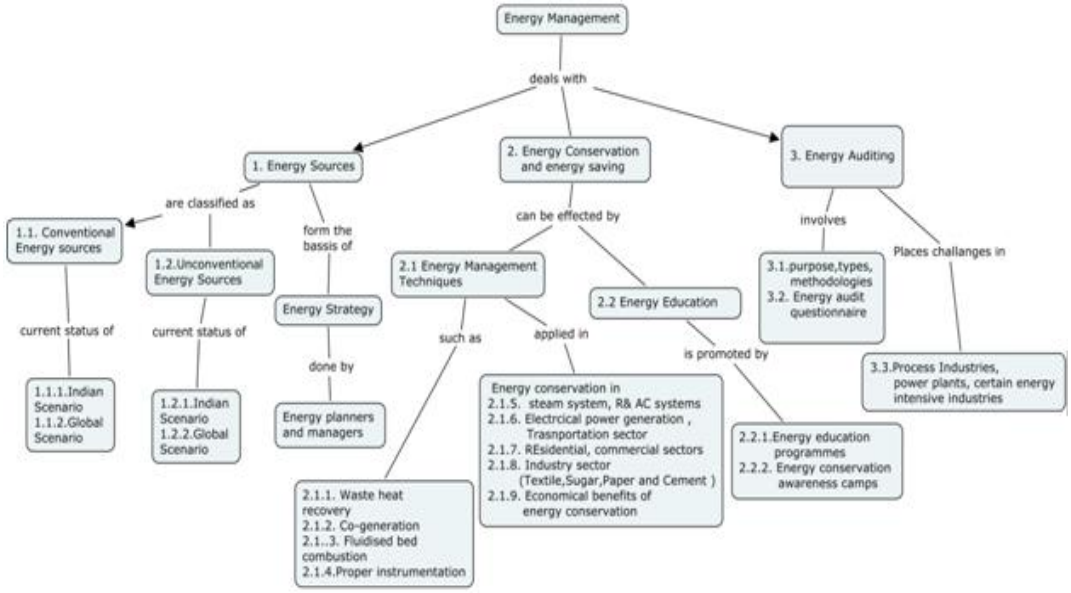
Course Outcome 3 (CO3):

1. Schedule an energy awareness programme or camp on energy conservation for schools and rural people. Demonstrate the possible outcomes and difficulties you may encounter.
2. Differentiate energy saving and energy conservation.
3. Explain "Per capita energy consumption" and "energy strategy".

Course Outcome 4 (CO4):

1. Explain the steps involved in energy auditing of an organization.
2. Explain the energy conservation possibilities in sugar industry.
3. Demonstrate how instruments can play in the energy conservation in industries.

Concept Map



Syllabus

Introduction - Energy Scenario in India and World, Energy Resources in India, Energy consumption Pattern, Energy Conservation and Energy Efficiency. **Energy strategy** – National energy strategy of India, Energy planning and role of energy manager. **Energy management** - Techniques - Co-generation, Combined cycle, Fluidized bed combustion. **Non-conventional energy sources -** solar thermal, photovoltaic and wind mill. **Waste Heat recovery systems** - Heat pipe, waste heat boiler and heat pump. **Energy Conservation** in Steam Systems, Refrigeration and Air-conditioning Systems, Electrical power generation sector, transportation, residential, commercial sector, and industry sector (Textile, Sugar, Paper and cement Industries), Role of instrumentation in energy conservation, economical benefits of energy conservation efforts. **Energy Audit**–Purpose, Types, Methodologies, Challenges with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries, Energy Audit Questionnaire.

Reference Books

1. Murphy W.R., Mckay G., "**Energy Management"**, Butterworth and Co. Publishers Ltd., 2003.
2. Rao S., Parulekar B.B., "**Energy Technology"**, Khanna Publishers, Delhi, 2009.
3. Arora, and Domkundwar,"**A Course in Power Plant Engineering"**, Dhanpat Rai & Co., Delhi, 1998
4. Confederation of Indian Industry, **"Energy Conservation Case Study Booklet"**, , Chennai, 1998.

Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1	**Introduction**	
1.1	**Conventional Energy Sources**	
1.1.1	Conventional energy sources - Indian Scenario	2
1.1.2	Conventional energy sources - Global Scenario	2

S.No	Topics	No. of Lectures
1.2	**Unconventional Energy Sources**	
1.2.1	unconventional energy sources (solar thermal, photovoltaic and wind mill, etc)- Indian Scenario	2
1.2.2	unconventional energy sources (solar thermal, photovoltaic and wind mill, etc)- Global Scenario	2
1.3	Energy strategy	
1.3.1	National energy strategy of India	2
1.3.2	Energy planning and role of energy manager	2
2	**Energy Conservation and energy saving**	
2.1	Energy Management Techniques	
2.1.1	Waste heat recovery systems	3
2.1.2	Co-generation, Combined cycle – Types, Merits and Demerits	3
2.1.3	Fluidized bed combustion, Heat pipe	3
2.1.4	Role of instrumentation in energy conservation	2
2.1.5	Energy Conservation in Steam Systems, Refrigeration and Air-conditioning Systems	2
2.1.6	Energy Conservation in Electrical power generation sector, transportation sector	2
2.1.7	Energy Conservation in residential, commercial sector	2
2.1.8	Energy Conservation in industry sector (Textile, Sugar, Paper and cement Industries)	4
2.1.9	Economical benefits of energy conservation efforts	2
2.2	Energy Education	
2.2.1	Energy education programmes	2
2.2.2	Energy conservation awareness camps	2
3	**Energy Audit**	
3.1	Purpose of energy audit, Types, Methodologies	2
3.2	Energy Audit Questionnaire	2
3.3	Challenges with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries,	2
	Total Hours	45

Course Designer:

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14IEPH0 ROBUST DESIGN

Category	L	T	P	Credit
PE**	4	0	0	4

Preamble

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

Prerequisite

- Applied Probability and Statistics

Course Outcomes

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

CO 1.	Explain the need, importance and benefit of robust design over conventional design approach	**Remember**
CO 2.	Set up DoE model and perform DoE	**Understand**
CO 3.	Analyse and Interpret results of DoE using case studies	**Apply**
CO 4.	Do hands-on solving DoE on actual problems.	**Apply**
CO 5.	Decide When to Branch of - from Full Factorial to Fractional Factorial DoE - Trade-Off and Benefits	**Analyse**

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	S	M	M	L	L	L	L	L	L	L	L
CO 2.	S	S	L	L	L	L	L	L	L	L	L
CO 3.	S	M	M	L	L	L	L	L	L	L	L
CO 4.	S	S	L	L	L	L	L	L	L	L	L
CO 5.	S	S	M	L	L	L	L	L	L	L	L
CO6.	S	S	M	L	L	L	L	L	L	L	L

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	40	60	20
Apply	0	40	20	40
Analyse	0	0	0	20
Evaluate	0	0	0	0
Create	0	0	0	0

Course Outcome 1 (CO1):

1. Cite the unbalanced data in DOE?
2. What is fixed effect model?
3. What do you mean by Hypothesis?
4. State the advantages of Confounding?
5. Plot a sample linear graph
6. Plot the taguchi's quality curve.
7. What is Random effect model?

Course Outcome 2 (CO2):

1. Describe the guidelines for designing experiments and elaborate the key points.
2. Briefly explain about the Blocking in experimental design with suitable examples.
3. Brief explain about the following with example, Response Surface Methodology, Partial Confounding and Fractional factorials
4. Write the Step by step procedure to optimize the manufacturing process by Taguchi Methods.
5. State and explain the robust design concepts through quality Loss function.

Course Outcome 3 (CO3):

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

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

a) Test the hypothesis that mixing us techniques affect the strength of the concrete. Use =0.5

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

2. An engineer is analyzing the effect of bottle types, (A, B, C, D) on the filling time for a soft drinks. Four workers are selected for the study and to account for this source of variability, the engineer uses the Latin Square shown below. Analyse the data from this experiment (= 0.5) and draw appropriate conclusions.

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

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

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

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

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

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

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

Course Outcome 4 (CO4):

1. An annealed copper strip 228 mm wide and 25 mm thick, is rolled to a thickness of 20 mm. The roll radius is 300 mm and rotates at 100 rpm. Calculate the roll force and the power in this operation.
2. A solid cylindrical work piece made of 304 stainless steel is 150 mm in diameter and 100 mm high. It is forged by open die forging at room temperature with flat dies to a 50 % reduction in height. Assuming that the coefficient of friction is 0.2, calculate the forging force at the end of the stroke.
3. A round billet made of 70-30 brass is extruded at a temperature of 675° C. The billet diameter is 125 mm and the diameter of the extrusion is 50 mm. Calculate the extrusion force required.

Course Outcome 5 (CO5):

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

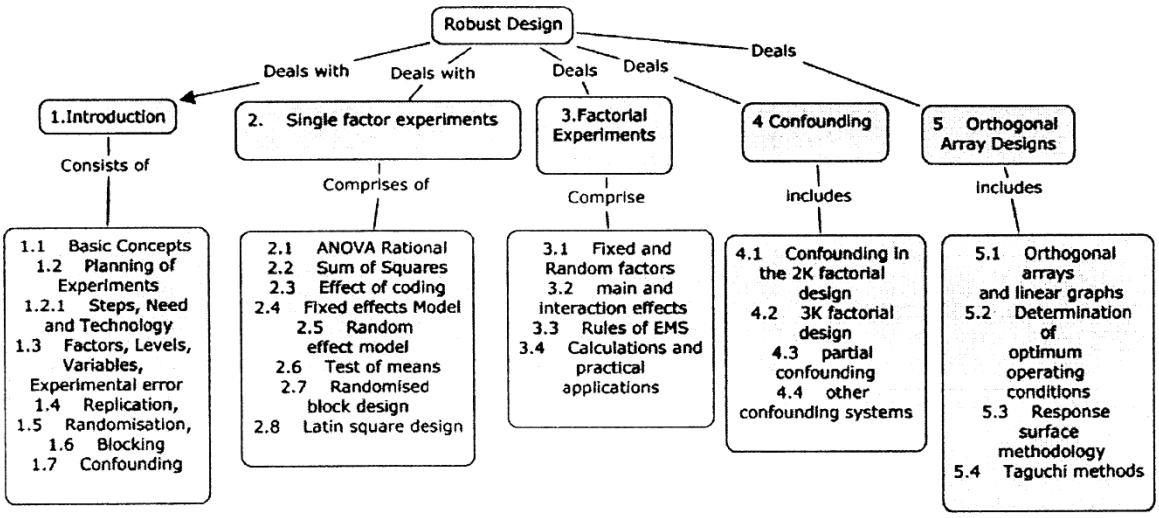
Glass	**Phosphor type**		
Type	**1**	**2**	**3**
1	280 290	300 310	290 285
2	230 235	260 240	220 225

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

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

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

Concept Map



Syllabus

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

Reference Books

1. Douglas C. Montgomery, "**Design and Analysis of Experiments**", Fifth Edition, John Wiley and Sons, New York, 2013.
2. Angela Dean and Daniel Voss," **Design and Analysis of Experiments**", First Indian reprint, Springer International edition,2013
3. Douglas C. Montgomery, " **Introduction to Statistical Quality Control**", Fourth Indian Edition, John Wiley and Sons, New York, 2012.
4. William W. Hines, Douglas C. Montgomery, David M.Goldsman and Connie M.Borror, "**Introduction to Statistical Quality Control**", Fourth Indian Edition, John Wiley and Sons, New York, 2012.
5. Philips J. Ross, "**Taguchi Techniques for Quality Engineering**", McGraw Hill, 1995.

Course Contents and Lecture Schedule

Sl.No.	Topics	No. Of Periods
1.	**Introduction**	
1.1	Basic Concepts	1
1.2	Planning of Experiments	1
1.2.1	Steps, Need and Technology	1
1.3	Factors, Levels, Variables, Experimental error	1
1.4	Replication,	1
1.5	Randomization,	1
1.6	Blocking	1
1.7	Confounding	1
2.	**Single factor experiments**	
2.1	ANOVA Rational	1
2.2	Sum of Squares	1
2.3	Effect of coding	1
2.4	Fixed effects Model	2
2.5	Random effect model	2
2.6	Test of means	1
2.7	Randomized block design	1
2.8	Latin square design	1
3.	**Factorial Experiments**	
3.1	Fixed and Random factors	2
3.2	main and interaction effects	2
3.3	Rules of EMS	1
3.4	Calculations and practical applications	2
3.5	Fractional Factorials	2
4	**Confounding**	
4.1	Confounding in the 2^K factorial design	2
4.2	3^k factorial design	2
5	**Orthogonal Array Designs**	
5.1	Orthogonal arrays and linear graphs	2
5.2	Determination of optimum operating conditions	2
5.3	Response surface methodology	2

5.4	Taguchi methods	2
	Total	**40**

Course Designers:

1. M. Palaninatharaja pnatharaja@tce.edu
2. S. Karthikeyan skarthikeyanlme@tce.edu

14IEPJ0	LEAN MANUFACTURING AND SIX SIGMA	Category	L	T	P	Credit
		PE**	4	0	0	4

Preamble

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

Prerequisite

- NIL

Course Outcomes

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

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

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO 1.	L	L	L	M	L	L	M	L	M	M	L
CO 2.	L	M	L	L	L	M	M	M	M	M	L
CO 3.	S	M	M	M	M	L	L	L	M	L	L
CO 4.	S	S	S	M	S	M	M	L	M	M	L
CO 5.	S	S	S	M	M	M	M	L	M	M	L

S- Strong; M-Medium; L-Low

Assessment Pattern

	Bloom's Category	Test 1	Test 2	Test 3	End-semester examination
1	Remember	20	20	20	20
2	Understand	30	30	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 Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

3. In a Copper smelter Maintenance the following are problems

   A. Frequent Breakdowns

   B.All Planned Maintenance activities are rescheduled

   C. No Preventive maintence available

   Execute the Total Productive Maintenance for solving above said problems

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

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

5. Use DMAIC principles to get best fit in to a Library Management system

6. Execute DMADV principles for organizing a student industrial tour.

Course Outcome 4 (CO4) and Course Outcome 5 (CO5):

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

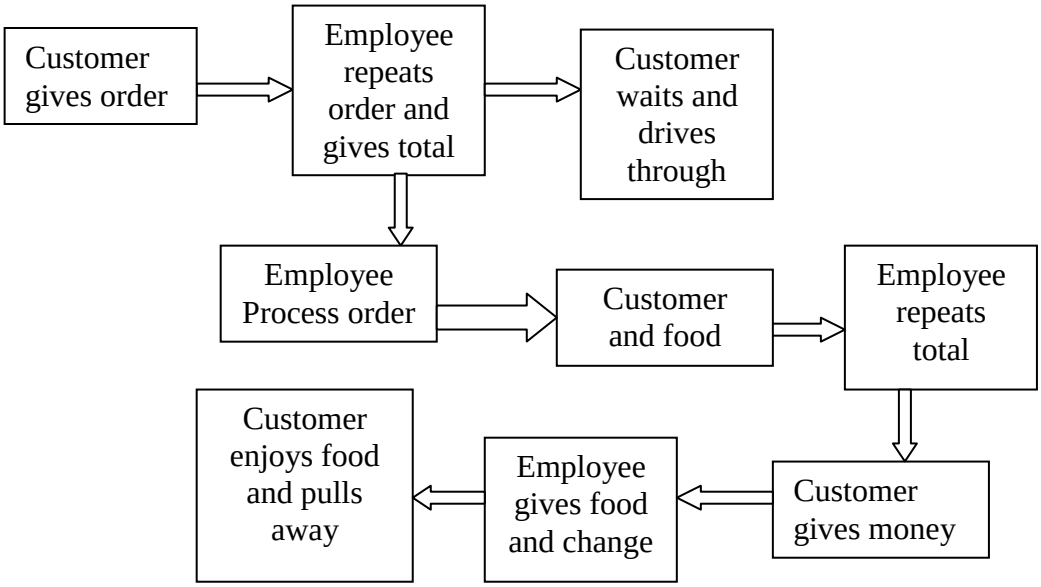
4. A Restaurant conducted consumer surveys and focus groups and identified the most important customer requirements as Healthy food, speedy service, an easy to read menu board, accurate order filling and perceived value. Develop of a set of technical requirements to incorporate into the design of a new 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.

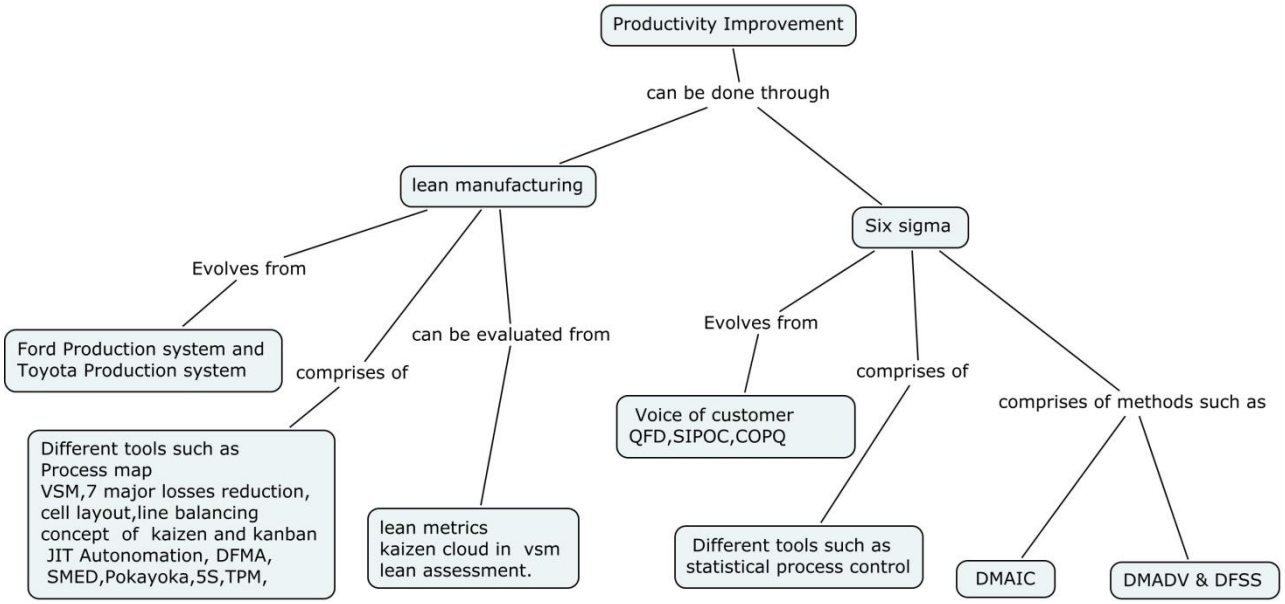
a. Books are not placed in the correct shelf, which include books that are checked out and returned and books taken off from shelves

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, 2014
3. James P. Womack , Daniel T. Jones ,Lean Thinking, Free press business,2013.
4. Kai Yang and Basemel-Haik, “Design for Six-Sigma: A Roadmap for Product Development”, McGraw Hill, 2009.
5. N.Gopalakrishnan, simplified lean manufacture:Elements, rules, tools and implementation, Prentice Hall of India, NewDelhi 2013

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
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

S.No	Topics	No. of Lectures
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**

Course Designers

1. S. Muralidharan murali@tce.edu

14IEPK0	COMPUTER INTEGRATED MANUFACTURING	Category	L	T	P	Credit
		PE**	4	0	0	4

Preamble

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

Prerequisite

NIL

Course Outcomes

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

CO1	Develop models using solid modeling techniques	**Apply**
CO2	Develop an APT code for machining a component	**Apply**
CO3	Explain the concept of computer data communication and graphics standards	**Understand**
CO4	Explain the formulation of computer aided process planning	**Understand**
CO5	Convey the working of MRP and methods of factory data collection system	**Apply**

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

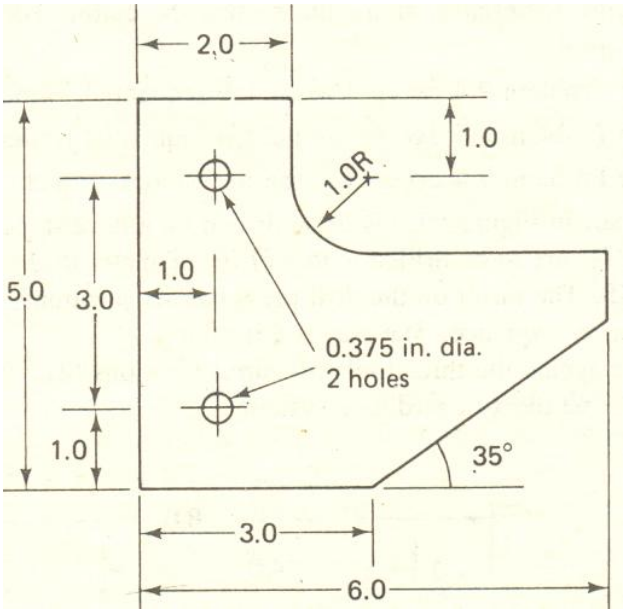
Course Level Assessment Questions

Course Outcome 1 (CO1):

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

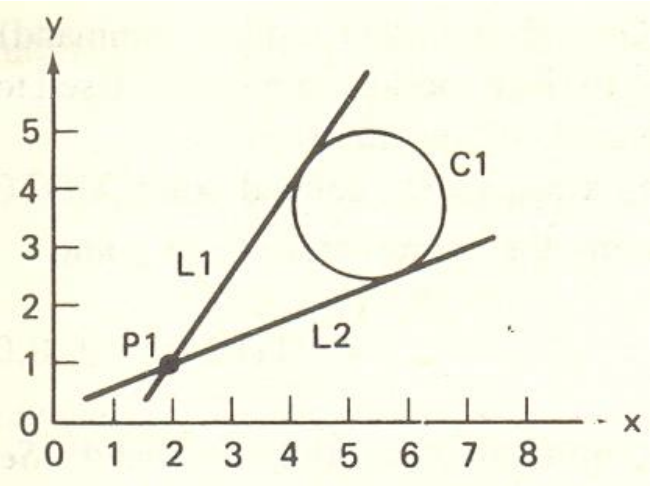
Course Outcome 2 (CO2):

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



2. Develop an APT code for 12 mm diameter drill at centre of a MS plate of size 20 x 40 mm with 3 mm thickness.

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



Course Outcome 3 (CO3):

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

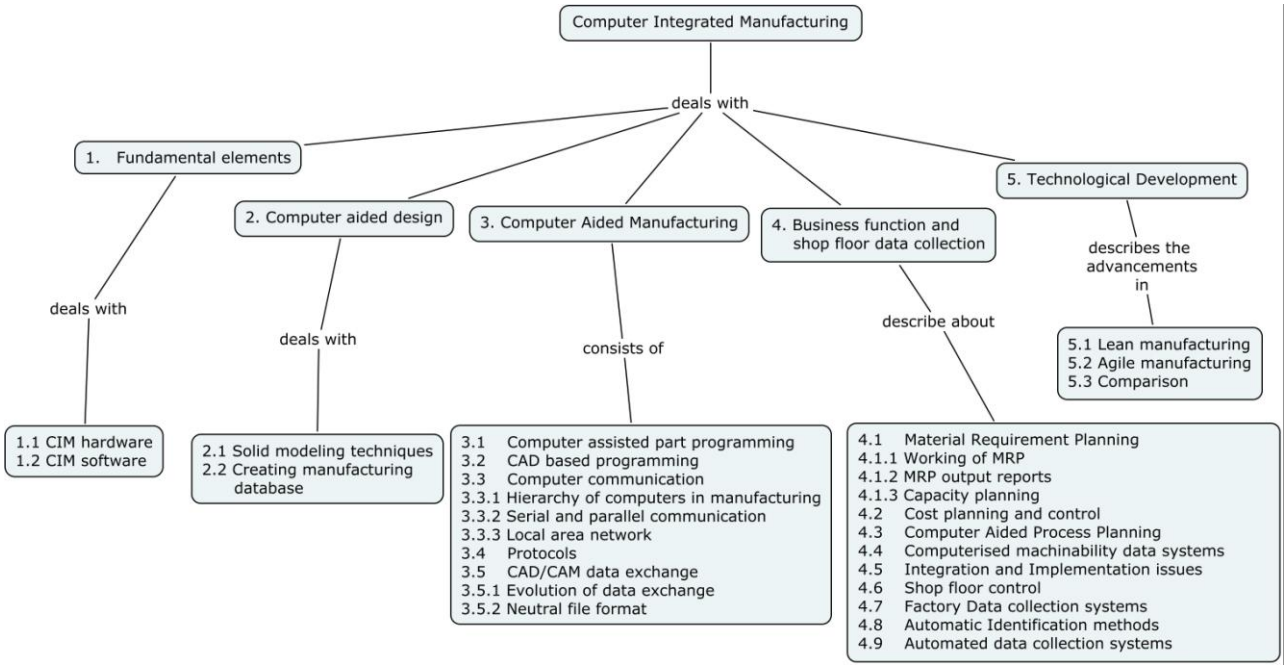
Course Outcome 4 (CO4):

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

Course Outcome 5 (CO5):

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

Concept Map



Syllabus

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

Reference Books

1. Vajpayee S. Kant, “Principles of Computer Integrated Manufacturing”, Prentice Hall of India Learning, 2009.
2. Ibrahim Zeid, “Mastering CAD/CAM”, Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2008.
3. Mikell P.Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Learning, Third Edition, 2014.

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

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Course Contents and Lecture Schedule

S.No	Topics	No. of Lectures
1.	**Fundamentals Elements:** Nature of CIM, Evolution of CIM	1
1.1	CIM hardware	1
1.2	CIM software	
2.	**Computer Aided Design:** Design process	1
2.1	Solid modeling techniques	2
2.2	Creating manufacturing database	1
3.	**Computer Aided Manufacturing:** Elements of CNC machine tools	1
3.1	Computer assisted part programming–APT language	2
3.2	CAD based programming	1
3.3	Computer Communication	1
3.3.1	Hierarchy of computers in manufacturing	1
3.3.2	Serial and parallel communication	1
3.3.3	Local area network	
3.4	Protocols-Manufacturing Automation Protocol	1
	Technical Office Protocol	
3.5	CAD/CAM data exchange-Method of data exchange	1
3.5.1	Evolution of data exchange	2
3.5.2	Neutral file format-DXF	
	IGES and PDES	
4.	**Business function and shop floor data collection**	
4.1	Material Requirement Planning-Inputs to MRP	1
4.1.1	Working of MRP	2
4.1.2	MRP output reports	1
4.1.3	Capacity Planning	
4.2	Cost planning and control	1

4.3	Computer Aided Process Planning-Retrieval type	1
	Generative type CAPP, Benefits of CAPP	1
4.4	Computerised machinability data systems	1
4.5	Integration and Implementation issues	2
4.6	Shop floor control-functions, information flow	1
4.7	Factory Data collection systems	2
4.8	Automatic Identification methods	2
4.9	Automated data collection systems	2
5.	**Technological Development**	
5.1	Agile manufacturing	1
5.2	Lean manufacturing	
5.3	Comparison of Agile and Lean manufacturing	1

Total 36 Hours

Course Designers:

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14IEPL0 VALUE ENGINEERING

Category	L	T	P	Credit
PE**	4	0	0	4

Preamble

New Product development is on rise and developing these products without compromising quality and cost is a challenge. In such development, it has become necessary to reduce the cost or eliminating the unnecessary cost, while improving the product performance or otherwise quality. This course deals with improving the quality in terms of the requirements of customer at the same or reduced cost by ensuring adequate system performance. Value engineering is a systematic approach for value improvement and contains seven broader phases. Hence, for product development, both cost and quality related issues need to be tackled concurrently.

Prerequisite

- NIL

Course Outcomes

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

CO 1.	Establish the Value engineering methodology	**Remember**
CO 2.	Recognize the various phases of value engineering	**Understand**
CO 3.	Perform function cost worth analysis	**Apply**
CO 4.	Create the ideas for solving the problems	**Create**
CO 5.	Analyse the functional importance and functional cost	**Analyse**
CO 6.	Recommend the present facts and present costs	**Apply**

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

CAT3 : MINI PROJECT (50 MARKS)

Course Outcome 1 (CO1):

1. What are the objectives of value engineering?
2. Name the types of value
3. Define : Function
4. What do you meant by functional worth?

Course Outcome 2 (CO2):

1. Outline the techniques of value engineering plan
2. Differentiate between ex-factory selling price and life cycle cost of a product
3. Compare real savings and false savings

Course Outcome 3 (CO3):

1. How would you determine the costs required to accomplish various functions of a product? Explain with an example.

2. Explain how the low cost promising ideas for various customer desired functions combined together to develop a number of workable solutions.

3. A product is manufactured at the break-even point. The management is considering a change in the product design in spite of the fact that the fixed costs will increase 50%. The sale of the new product is expected to shoot up by 100%. What should be the profitability of the new design (as compared to the present design) so that the company realizes a profit equal to the initial fixed cost per year?

Course Outcome 4 (CO4):

1. Consider the following decision making situation involving alternatives A & B

	A (RS.)	**B(RS.)**
Investment	20000	30000
Salvage Value	4000	0
Annual receipts	10000	14000
Annual costs	4400	8600
Life (years)	5	10

If minimum acceptable rate of return (MARR) is 15% and period of analysis is 10 years, alternative is to be chosen (use NPW method)

2. Consider the following three alternatives

	ALT A	ALTB	ALTC
Investment cost	28000	16000	23500
Net cash flow per year	5500	3300	4800
Salvage value	1500	0	500
Life (Years)	10	10	10

Assuming MARR = 15% and using IRR method, chosse the best alternative of the above.

3. Assume an initial investment of an asset as Rs.100000 and salvage value of Rs.10000 with the life of the assets as 10 years
Consider the following three methods of depreciation:
i) Straight line (ii) SYD (iii) Declining balance method (with 10% rate)
For these methods, plot the profile of book value as a function of life. Assuming interest rate of 15%, Compute the net present worth of cash flows if above methods are to be used. Incremental tax rate is 50%. Also rank the depreciation methods.

Course Outcome 5 (CO5):

4. An equipment is purchased for Rs.50000 that will reduce materials and labour cost by Rs.14000 each year for N years. After N years, there will be no need for the equipment and since it is specially designed, it will have no salvage value at any time. However, according to the company tax procedure, this equipment must be depreciated on a straight line basis for the tax life of 5 years. If the tax rate is 50%, what is the minimum number of years (that is N) that the company must operate the equipment to earn a minimum 10% after tax return/

5. Consider the following data for two machines X & Y

Machine	Initial Cost	Annual costs	Salvage value
X	25000	4000	0
Y	15000	8000	0

The machines can be used fir 5 years or they can be retained for use after the 5th year. If so, the total useful life will be 20 years. The company is permitted to write off the machine in 5 years for tax purpose, or it can write off the machine in 20 years.
Compare the results of using the long (20 years) or short (5 years) write off periods of the tax rate is 50% and sum of year's digits (SYD) method is used for depreciation. Assume interest rate of 10%.

6. A plant manager is attempting to determine whether his firm should purchase a component part or make it at its own facilities. If he purchases the item, it will cost the company Rs.10 per unit. The company can make the item on an assembly line at a variable cost of RS.2.50 per unit with a fixed cost of Rs.20000/- per year, or it can make it at individual stations at a variable cost of Rs.5.00 per unit with a fixed cost of Rs.10000 per year. Assuming that the annual demand is expected to be 3500 units, determine which alternative the plant manager should select. Also, frame decision rules for MAKE/BUY for various levels of annual demand

Course Outcome 6 (CO6):

1. A company proposes to invest Rs.40000 in a new machine. The service life of machine is 10 years.

a) What should be the annual savings if the minimum acceptable rate of return is 20%?
b) If the actual savings over this period are Rs.8000/- per year. What is the actual rate of return (internal) on investment?

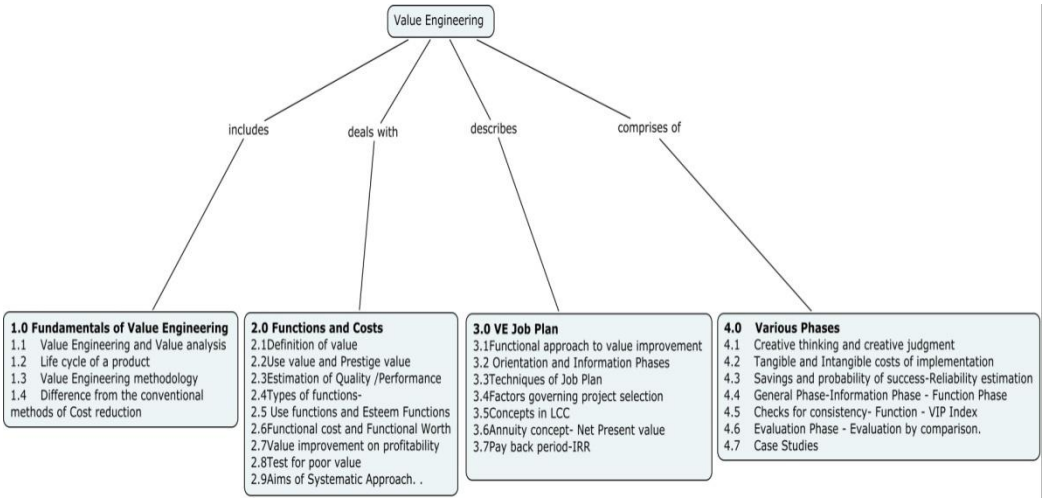
2. A man needs Rs.300000immediately for the purchase of a house. He will be required to repay the loan in equal six monthly installments over the next 10 years. What are the required payments at

a) 6% interest compounded semi annually
b) 10% interest compounded semi annually.

3. A new office copying machine costing $5600 will enable a company to save $0.03 per sheet on some duplicating work. The present usage is approximately 9000 sheets per month. Calculate the after tax IRR

Economic life	8 years
Depreciation term	10 Years
Depreciation method	Straight line
Incremental tax rate	50 percent
Interest rate	10 percent

Concept Map



Syllabus

Value Engineering (VE) and Value Analysis(VA) - Life Cycle of a product-Methodology of value engineering – Difference from the conventional methods of cost reduction- Unnecessary costs reasons- Quantitative definition of value- Use value and Prestige value. Estimation of product Quality/performance-Types of functions- Relationship between Use functions and Esteem Functions in product design – Functional cost and Functional Worth –Effect of Value improvement on profitability-Test for poor value –Aims of Systematic Approach. Functional approach to value improvement-various phases and techniques of Job Plan – Factors governing project selection – Types of Projects-Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC – Present value concept-Annuity concept- Net Present value-Pay back period-Internal rate of return on Investment (IRR)-Examples and Illustrations.

Creative thinking and creative judgment- positive or constructive discontent-Tangible and Intangible costs of implementation-False material-labour and overhead saving – Relationship between savings and probability of success-Reliability estimation-System reliability- Reliability

elements in series and parallel. General Phase-Information Phase – Type of costs- Function Phase – Evaluation of Functional Relationships- Checks for consistency-Function –cost-weight-matrix-VIP Index – High cost and Poor value areas- Creativity/Speculation Phase – Rules of creativity-Brainstorming- Idea activators- Result accelerators – Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison – FAST Diagram.

Reference Books

1. Value engineering, Mukhopadhyaya, Anil Kumar, Response Books, New Delhi ,2009, ISBN: 0-7619-9788-1
2. Value Engineering – A How to Manual by S S Iyer, 3rd edition, New Age Publishers, Chennai, 2009, ISBN: 978-81-224-2405-8
3. Richard J Park, "Value Engineering – A Plan for Inventions", St.Lucie Press, London, 1999.
4. Profit Improvement through Value Analysis, value Engineering and Purchase Price Analysis, A.D.Raven, (1971),Cassell and Co. London.
5. Arthur E Mudge, "Value Engineering", McGraw Hill Book Company, 1989.
6. NPTEL Value Engineering course videos

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Introduction**	
1.1	Value Engineering and Value analysis	2
1.2	Life cycle of a product	2
1.3	Value Engineering methodology	2
1.4	Difference from the conventional methods of Cost reduction	1
2	**Reasons for unnecessary costs**	
2.1	Definition of value	1
2.2	Use value and Prestige value	1
2.3	Estimation of Quality /Performance	1
2.4	Types of functions-	1
2.5	Relationship between Use functions and Esteem Functions in product design	2
2.6	Functional cost and Functional Worth	2
2.7	Effect of Value improvement on profitability	1
2.8	Test for poor value	1
2.9	Aims of Systematic Approach. Functional approach to value improvement	1
3	**VE Job Plan**	
3.1	Functional approach to value improvement	1
3.2	Orientation and Information Phases	2
3.3	Techniques of Job Plan	2
3.4	Factors governing project selection – Types of Projects	2
3.5	Life Cycle Costing (LCC) for managing the Total Value- Concepts in LCC –	2
3.6	Present value concept-Annuity concept- Net Present value	2
3.7	Pay back period-Internal rate of return on Investment (IRR)-Examples and Illustrations	2
4	**Various phases**	
4.1	Creative thinking and creative judgment- positive or constructive discontent	2
4.2	Tangible and Intangible costs of implementation-False material-labour and overhead saving	2

4.3	Relationship between savings and probability of success-Reliability estimation-System reliability- Reliability elements in series and parallel.	2
4.4	General Phase-Information Phase – Type of costs - Function Phase	1
4.5	Evaluation of Functional Relationships - Checks for consistency-Function – cost-weight-matrix - VIP Index – High cost and Poor value areas-	2
4.6	Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison.	1
4.7	FAST Diagram	2
4.7	Mini Project presentation and Case Studies	4
Total		**48**

Course Designers:

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		Category	L	T	P	Credit
14IEPM0	**HUMAN RESOURCES MANAGEMENT**	PC**	4	0	0	4

Preamble

Human Resource Management (HRM) is fundamentally based on the assumption that employees are individuals with varying goals and needs. It is the management of an organization's employees. HR is sometimes referred as a "soft" management skill. Effective practice within an organization requires a strategic focus to ensure that people resources can facilitate the achievement of organizational goals.HRM is seen by practitioners as a more innovative view of workplace management than the traditional approach. Its techniques force the managers of an enterprise to express their goals with specificity so that they can be understood and undertaken by the workforce and to provide the resources needed for them to successfully accomplish their assignments. Practicing good human resource management (HRM) enables managers of an enterprise to express their goals with specificity, increasing worker comprehension of goals and provide the necessary resources to promote successful accomplishment of said goals. While HRM is properly employed, members of the workforce are expressive of the goals and operating practices of the firm.

Prerequisite

Nil

Course Outcomes

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

CO 1.	Describe the field of HRM and its potential for creating and sustaining competitive advantage.	**Remember**
CO 2.	Understand the importance of HR planning to the organization.	**Understand**
CO 3.	Understand the values and uses of performance appraisals and the prescriptions for effective appraisal.	**Apply**
CO 4.	Know the basic approaches to job evaluation.	**Apply**
CO 5.	Understand the concept of organizational justice and how it relates of all aspects of relationship building with employees.	**Apply**
CO 6.	Understand the importance of employee health and safety.	**Apply**

Mapping with Programme Outcomes

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**
CO1	M	L	S	M	S	S	M	M	S	S	S
CO2	L	L	S	M	M	M	S	M	M	M	S
CO3	L	S	S	M	S	M	L	S	M	L	L
CO4	M	S	S	S	M	M	S	M	ML	L	S
CO5	L	L	L	M	L	L	M	M	L	S	L
CO6	L	L	L	M	L	S	L	L	L	S	M

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	**20**	**20**	**20**	**20**
Understand	**80**	**40**	**40**	**40**
Apply	**0**	**40**	**40**	**40**
Analyse	**0**	**0**	**0**	**0**
Evaluate	**0**	**0**	**0**	**0**
Create	**0**	**0**	**0**	**0**

Course Outcome 1 (CO1):

1. What is HRM?
2. Define work analysis?
3. What do we mean by clerical ability?

Course Outcome 2 (CO2):

4. Why is HR planning an important activity? What are the advantages of effective planning?
5. Why should a training department develop a mission and goals?

Course Outcome 3(CO3):

6. Bring out the challenges in executing the Performance Appraisal System
7. Suggest and design a suitable performance appraisal system for a manufacturing industry
8. Analyze the challenges in implementing Performance Appraisal System for an educational institution

Course Outcome 4(CO4):

9. Illustrate the process of Job Evaluation for a service industry
10. Bring all the relevant advantages of Job Evaluation for a 100% EOU with examples

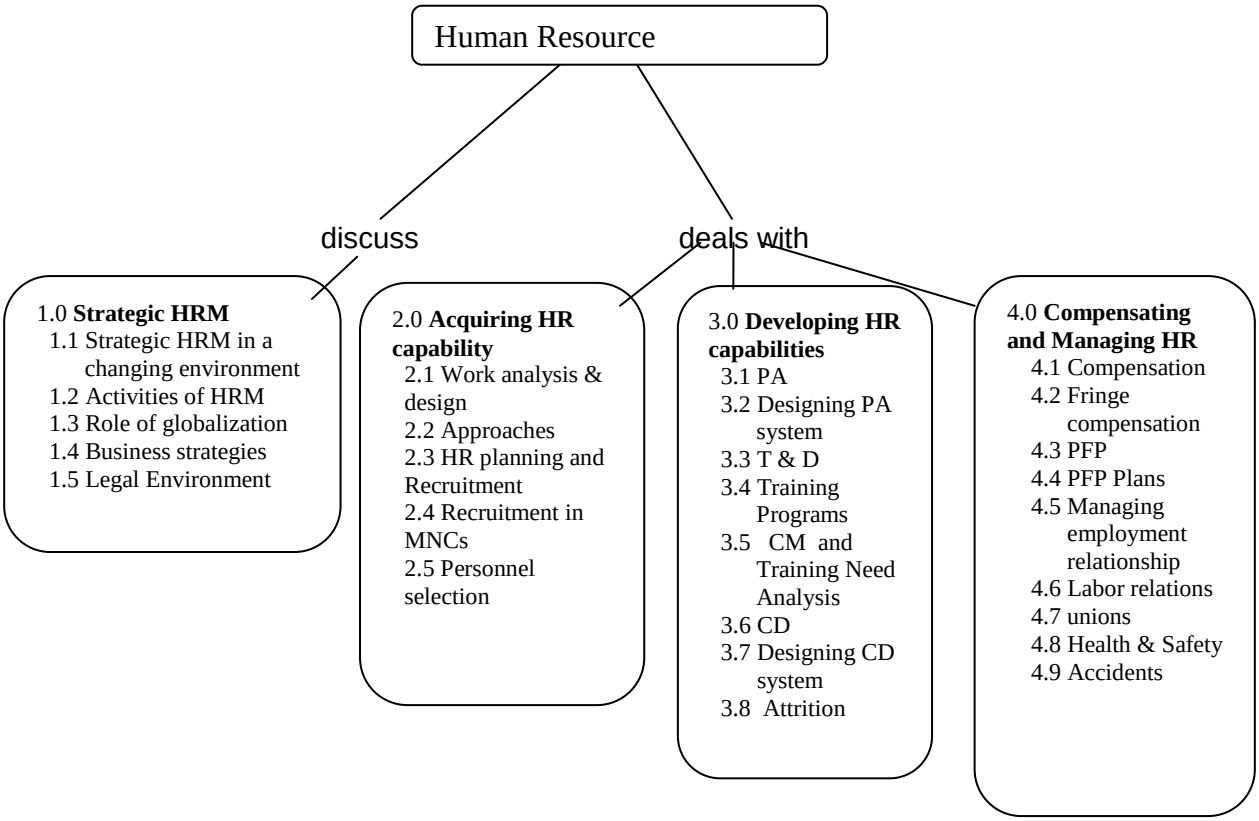
Course Outcome 5(CO5):

11. Bring out the outcomes of a healthy employer-employee relationship in an organization
12. Prepare a strategic plan to enhance employee productivity in a manufacturing industry

Course Outcome 6(CO6):

13. Justify with examples that employees safety is contributing for overall productivity of an organization

Concept Map:



Syllabus

HRM and the environment: Strategic HRM in a changing environment- HRM- Academic Research and HRM practice- Activities of HRM- Trends and importance of HRM. Role of globalization in HR policy and practice- International Commerce- Business strategies- Domestic Vs International HR- International HR strategies. Legal Environment of HRM- Equal Employment Opportunity Law (EEO)- Future trends in EEO. **Acquiring HR Capability:** Work analysis and design- Work analysis- Need, importance and methods- Formal approaches to work analysis methods- Autonomous Work Groups (AWG) – HR planning and recruitment- HR planning- Recruitment- Methods of recruitment in MNCs Personnel selection- Selection methods-Tests-Interviews-Selection for overseas assignment. **Developing HR capability:** Performance Appraisal (PA)- Need- Legal issues associated with PA- Designing an appraisal system. Training and development (TD)- Extend of TD- A systems view of training- Development of Training Programs- Evaluation- Planning for training effectiveness-Special training programs- Competency Mapping and Training Need Analysis. Career development (CD)- Implications of work place changes- Importance- Designing CD system- Components of CD system- Career programs for special target groups- Attrition- Employee Retaining strategies in the current scenario. **Compensating and Managing HR:** Compensation- Cash compensation- Traditional Approach to compensation- Fringe compensation- Communicating the benefits program- International compensation. Pay for performance (PFP)- Determinants of effective PFP system- Main problems with PFP- Legal implications of PFP- selecting a PFP- Individual PFP plans- Group incentive plans- Managerial and executive incentive pay- Managerial implications for PFP. Managing the employment relationship- Organizational entry-

Ongoing relationship- Organizational exit- Labor relations and collective Bargaining- Reasons for joining unions- Legal environment of legal relations- Effects of unions- Collective bargaining- Current and future trends- International issues- Employee health and safety- Work place injuries and diseases- Legal issues related to health and safety- Programs to reduce accidents at work- Contemporary issues related to health and safety.

Reference Books

1. H John Bernardin, "Human Resource Management- An Experimental Approach" – TMH, New Delhi- Fifth Reprint 2011
2. Edwin B Flippo, "Principles of Personnel Management"- McGraw Hill International Editions: Management series- Fourth Edition 2004
3. Kandula, Srinivas R. "Human Resource Management in practice with 300 models, techniques and tools"- PHI- Third edition 2009

Course contents and lecture schedule

No.	Topic	No of Lectures
1.0	**HRM and the environment:**	
1.1	Strategic HRM in a changing environment- HRM-Academic research and HRM Practice	2
1.2	Activities of HRM- Trends and importance of HRM	1
1.3	Role of Globalization in HR policy and practice- International Commerce	2
1.4	Business strategies- Domestic Vs International HR- International HR strategies	1
1.5	Legal Environment of HRM- Equal Employment opportunity law- Future trends in EEO	2
2.0	**Acquiring HR capability**	
2.1	Work analysis and design- Work analysis- Need, importance and methods	2
2.2	Formal Approaches to work analysis methods- Autonomous work groups (AWG)	2
2.3	HR planning and Recruitment- HR planning- Recruitment	2
2.4	Methods of recruitment in MNCs	2
2.5	Personnel selection- Selection methods- Tests- Interviews- Selection for overseas assignment	2
3.0	**Developing HR capability**	
3.1	Performance Appraisal (PA)- Need- Issues associated with PA	2
3.2	Designing and Appraisal system	2
3.3	Training and Development (TD) – extend of TD- A systems view of training	1
3.4	Development of Training Programs- Evaluation- Planning for training effectiveness- Special training programs	1
3.5	Competency Mapping and Training Need Analysis	2
3.6	Career Development (CD)- Implications of work place changes- Importance	2
3.7	Designing CD system- Components of CD system- career programs for special target groups	2
3.8	Attrition- Employee Retaining strategies in the current scenario	2

4.0	**Compensating and Managing HR**	
4.1	Compensation- Cash compensation- Traditional Approach to Compensation	2
4.2	Fringe compensation- Communicating the benefits program- International compensation	2
4.3	Pay for Performance (PFP)- Determinants of effective PFP system- Main Problems with PFP- Legal implications of PFP- Selecting PFP	2
4.4	Individual PFP plans- Group incentive plans- Managerial and executive pay- Managerial implications exit	2
4.5	Managing the employment relationship- Organizational entry- Ongoing relationship- Organizational exit	2
4.6	Labor relations and collective Bargaining- Reasons for joining unions- Legal environments of legal relations	2
4.7	Effects of unions- Collective Bargaining- Current and future trends- International issues	2
4.8	Employee health and safety- Work place injuries and diseases- legal issues related to health and safety	2
4.9	Programs to reduce accidents at work- Contemporary issues related to health and safety	2
	Total	**50**

Course Designers

1. P.S. Boopathi Manickam psbmeco@tce.edu
2. J.L.Sugumar jlsugumar@tce.edu

		Category	L	T	P	Credit
14IEPN0	**INDUSTRIAL INSTRUMENTATION**	PE**	4	0	0	4

Preamble

The advancement of science and technology in an industrial sector dependent upon a parallel progress in measurement techniques. As technology move ahead, new phenomena and relationship are discovered and these advances make new types of measurements imperative. The measurements, no doubt, confirm the validity of a hypothesis but also add to its understanding.

Prerequisite

- NIL

Course Outcomes

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

CO1	Determine the static and dynamic responses of the instruments.	Apply
CO2	Understand the basic working principle measurement of motion, strain, force, torque.	Understand
CO3	Understand the basic working principle measurement of temperature.	Apply
CO4	Understand the basic working principle measurement of pressure, flow and level.	Apply
CO5	Understand working principles of data acquisition system.	Understand

Mapping with Programme Outcomes

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

S- Strong; M-Medium; L-Low

Assessment Pattern

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

Course Level Assessment Questions

Course Outcome 1 (CO1)**:**

1. Define time constant. (remember)
2. Explain briefly the various errors in a measurement.(understand)
3. Describe the step response of a first order thermal system. (understand)
4. Ten measurements are made of the thickness of a metal plate which gives 3.61, 3.62, 3.60, 3.63, 3.61, 3.62,3.60,3.62, 3.64 and 3.62 mm. Determine the mean value and the tolerance limits for a 90 percent confidence level. Take t_{90} for 9 degrees of freedom as 1.833. (Apply)
5. A set of independent length measurements were taken by six observers and were recorded as 12.8 m, 12.2 m, 12.5 m, 13.1 m and 12.4 m. Calculate: the arithmetic mean; the deviations from the mean; the average deviation; the standard deviation and variance. (Apply)

Course Outcome 2 (CO2)**:**

6. Distinguish between linear motion and angular motion. Give the name of any one instruments to measure the same. (remember)
7. Explain with neat sketches any one method for force measurement and acceleration measurement. (Understand)
8. Describe the basin working feature of a torque meter. (Understand)
9. Describe the seismic pickup method for velocity and displacement with neat sketches. (Understand)

Course Outcome 3 (CO3):

10. Explain working of resistance thermometer. (Understand)
11. Why is emissivity important in radiation temperature measurement? (Remember)
12. Two resistors R_1 and R_2 are connected in series and then parallel. The values of resistances are: $R_1 = 100 \pm 0.1\Omega$ and $R_2 = 50 \pm 0.03$. Calculate the uncertainty in the resistance for both the connections. (Apply)

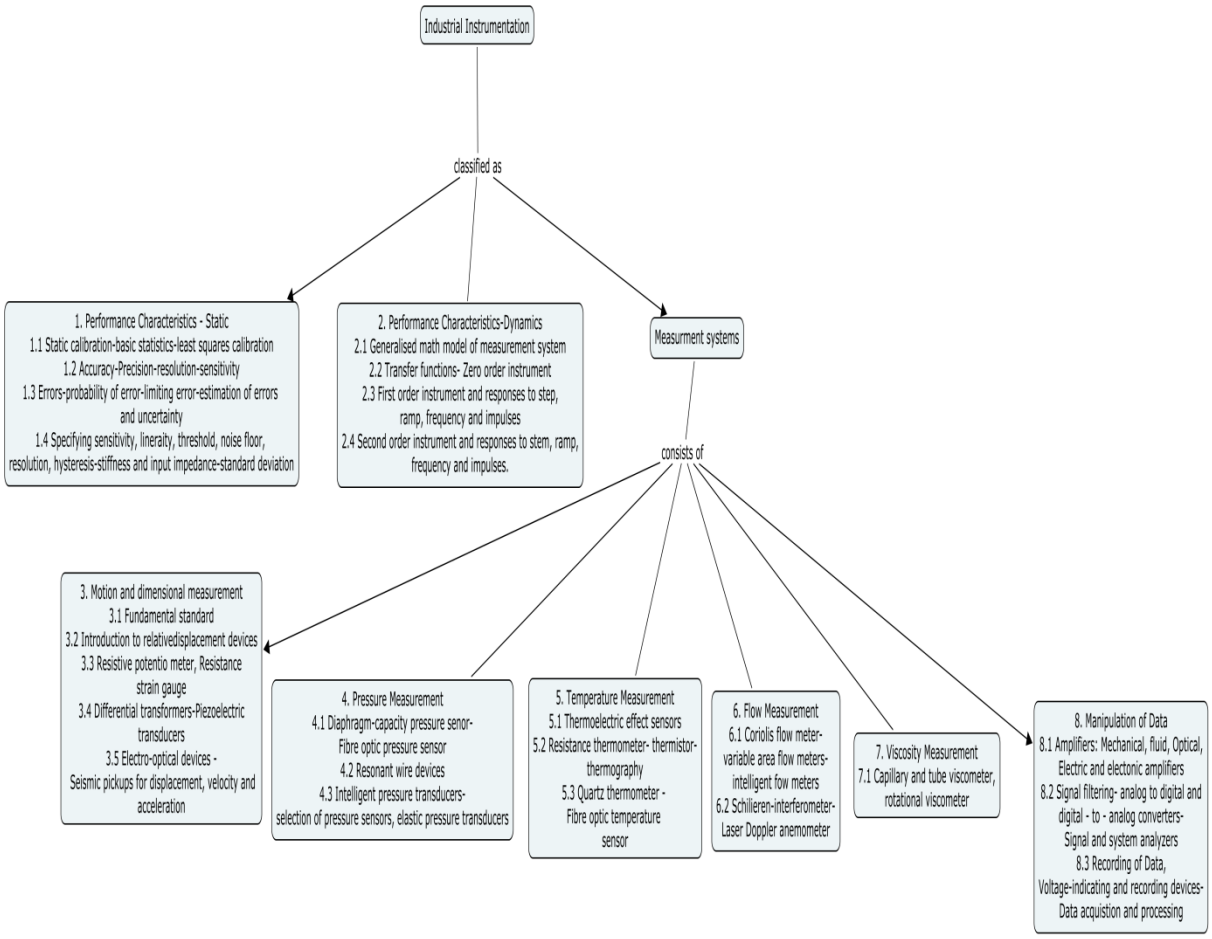
Course Outcome 4 (CO4):

1. Differentiate between kinematic viscosity and dynamic viscosity. (Remember)
2. Explain construction, working, merits and demerits of ultrasonic type flow meters. (Understand)
3. A pilot-static tube is used to measure the speed of air plane. If the pressure difference indicated by a U-tube differential manometer is equivalent to x mm of water, establish an equation relating the manometer deflection x in mm and the velocity V in m/s. Take air density equal to 1.22 kg/m^3 and water density equal to 1000 kg/m^3. (Apply)
4. Explain with a neat sketch the constructional features and basic working principle of McLeod gauge used for the measurement of pressure. (Understand)

Course Outcome 5 (CO5):

1. Give any two examples for the requirement of data acquisition system in thermal field. (Remember)
2. Sketch the block diagram of a digital to analog convertors and explain the various elements. (Understand)
3. Write short notes on: Signal and system analyzers. (Understand)

Concept Map



Syllabus

Performance Characteristics - Static

Static calibration -Basic statistics - Least squares calibration - Accuracy – Precision – Resolution – Sensitivity – Errors - probability of error - Limiting error-Estimation of errors and uncertainty- Specifying sensitivity, linearity, threshold, noise floor, resolution, hysteresis.- Stiffness and input impedance- standard deviation.

Performance Characteristics - Dynamic

Generalized math model of measurement system - Transfer functions- Zero-order instrument - First-order instrument and responses to step, ramp, frequency and impulses- Second-order instrument and responses to step, ramp, frequency and impulses.

Motion and dimensional measurement

Fundamental standards -Introduction to relative displacement devices - Resistive potentiometers, Resistance strain gage - Differential transformers- Piezoelectric transducers - Electro-optical devices- Seismic pickups for displacement, velocity, and acceleration.

Pressure measurement

Diaphragm – capacity pressure sensor – Fibre optic pressure sensor – Resonant wire devices – Intelligent pressure transducers – selection of pressure sensors, Elastic pressure transducers.

Temperature Measurement

Thermoelectric effect sensors – resistance thermometer – thermistor – thermography (thermal imaging) – Quartz thermometer – Fibre optic temperature sensor.

Flow Measurement
Coriolis flow meter – variable area flow meters– intelligent flow meters – Schlieren interferometer - Laser Doppler anemometer.
Viscosity measurement
Capillary and tube viscometer, rotational viscometer.
Manipulation of Data
Amplifiers: Mechanical, Fluid, Optical, Electric and Electronic amplifiers – Signal filtering -Analog-to-Digital and Digital-to-Analog converters - Signal and system analyzers, Recording of Data, Voltage-indicating and recording devices - Data acquisition and processing.

Reference Books

1. Holman. J.P., "**Experimental methods for Engineers**", 7th edition, McGraw Hill, 2011.
2. Doebelin. E. O, "**Measurement Systems, Application and Design***"*, 5th edition, McGraw Hill, New York, 2004
3. Norman A. Anderson, "**Instrumentation for process measurement and control**", 3rd edition, McGraw Hill, 2004.
4. Venkatesahan, S.P., "**Mechanical Measurements**", Ane's student edition, 2009.
5. Allan S. Morris, "**Measurement and instrumentation principles**", Butterworth - Heinermann publication, Oxford, 2001.
6. Richard S. Figliola, Donald E. Beasley, "**Theory and Design for Mechanical Measurements**", Wiley Student Edition, 2004.
7. Ramsay. D.C., "**Principles of Engineering Instrumentation**", Butterworth Heinermann publication, Oxford, 1996
8. Singh. S.K., "**Industrial Instrumentation and control**", Tata McGraw Hill, 2010.
9. James W. Dally, William F. Riley, Kenneth G. Mcconnel, "**Instrumentation for Engineering Measurement**", 2nd Edition, Wiley publications, 2005.
10. Kumar, D.S, "**Mechanical Measurements and Control**" 3rd Edition, Metropolitan Book Co. Pvt. Ltd, 2004.

Course Contents and Lecture Schedule

Module No.	Topic	No. of Lectures
1	**Performance Characteristics - Static**	
1.1	Static calibration -Basic statistics - Least squares calibration	2
1.2	Accuracy – Precision – Resolution – Sensitivity	2
1.3	Errors - probability of error - Limiting error-Estimation of errors and uncertainty	2
1.4	Specifying sensitivity, linearity, threshold, noise floor, resolution, hysteresis.- Stiffness and input impedance- standard deviation	2
2	**Performance Characteristics - Dynamic**	
2.1	Generalized math model of measurement system	2
2.2	Transfer functions- Zero-order instrument	2
2.3	First-order instrument and responses to step, ramp, frequency and impulses	2
2.4	Second-order instrument and responses to step, ramp, frequency and impulses.	2
3	**Motion and dimensional measurement**	
3.1	Fundamental standards	1
3.2	Introduction to relative displacement devices	1
3.3	Resistive potentiometers, Resistance strain gage	2

Module No.	Topic	No. of Lectures
3.4	Differential transformers- Piezoelectric transducers	1
3.5	Electro-optical devices- Seismic pickups for displacement, velocity, and acceleration	2
4	**Pressure measurement**	
4.1	Diaphragm – capacity pressure sensor – Fibre optic pressure sensor	2
4.2	Resonant wire devices	1
4.3	Intelligent pressure transducers – selection of pressure sensors, Elastic pressure transducers	2
5	**Temperature Measurement**	
5.1	Thermoelectric effect sensors	1
5.2	Resistance thermometer – thermistor – thermography (thermal imaging)	2
5.3	Quartz thermometer – Fibre optic temperature sensor	1
6	**Flow Measurement**	
6.1	Coriolis flow meter – variable area flow meters– intelligent flow meters	1
6.2	Schlieren interferometer - Laser Doppler anemometer.	2
7	**Viscosity measurement**	
7.1	Capillary and tube viscometer, rotational viscometer	2
8	**Manipulation of Data**	
8.1	Amplifiers: Mechanical, Fluid, Optical, Electric and Electronic amplifiers	2
8.2	Signal filtering -Analog-to-Digital and Digital-to-Analog converters - Signal and system analyzers	2
8.3	Recording of Data, Voltage-indicating and recording devices - Data acquisition and processing.	2
	Total	**45**

Course Designers:

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14IEPP0 RESEARCH METHODOLOGY

Category	L	T	P	Credit
PE**	4	0	0	4

Preamble

Research Methodology will enable the Researchers to develop the most appropriate methodology for their Research Studies. The mission of the course is to impart research skills to the beginners and help improve the quality of Research by the existing researchers. This course aims at giving adequate exposure in research process, data analysis techniques, report writing. Methodologies are often conflated with methods and techniques of data analyses, with limited understanding of the logic underlying the various techniques and methods. Further, engineering sciences also increasingly draw from developments in natural sciences and technology studies to enhance its explanatory domain. This has also strengthened the scope for trans-disciplinary research drawing upon perspectives from varied disciplines. Choice of methods is guided by the nature of the research questions posed. There is a scope for the researcher to learn from each other, and importantly understand the validity of the approaches that each study adopts.

Prerequisite

- NIL

Course Outcomes

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

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

Mapping with Programme Outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1.	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO2.	**S**	**S**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO3.	**S**	**M**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO4.	**S**	**S**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO5.	**S**	**S**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**
CO6.	**S**	**S**	**M**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**	**L**

S- Strong; M-Medium; L-Low

Assessment Pattern

Bloom's Category	Continuous Assessment Tests			Terminal Examination
	1	2	3	
Remember	20	20	20	20
Understand	80	40	60	40
Apply	0	40	20	40
Analyse	0	0	0	0
Evaluate	0	0	0	0
Create	0	0	0	0

Course Outcome 1 (CO1):

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

Course Outcome 2 (CO2):

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

Course Outcome 3 (CO3):

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

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

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

Course Outcome 4 (CO4):

1. A certain process produces 10 percent defective articles. A supplier of new raw material claims that the use of his material would reduce the proportion of defectives. A random

sample of 400 units using this new material was taken out of which 34 were defective units. Can the supplier's claim be accepted? Test at 1 percent level of significance.

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

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

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

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

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

Course Outcome 5 (CO5):

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

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

Do the promotions produce different effects on sales?

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

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

3. Determine the size of the sample for estimating the true weight of the cereal containers for the universe with N = 5000 on the basis of the following information:
   (1) The variance of weight = 4 ounces on the basis of past records.
   (2) Estimate should be within 0.8 ounces of the true average weight with 99% probability.

Will there be a change in the size of the sample if we assume infinite population in the given case? If so, explain by how much.

Course Outcome 6 (CO6):

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

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

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

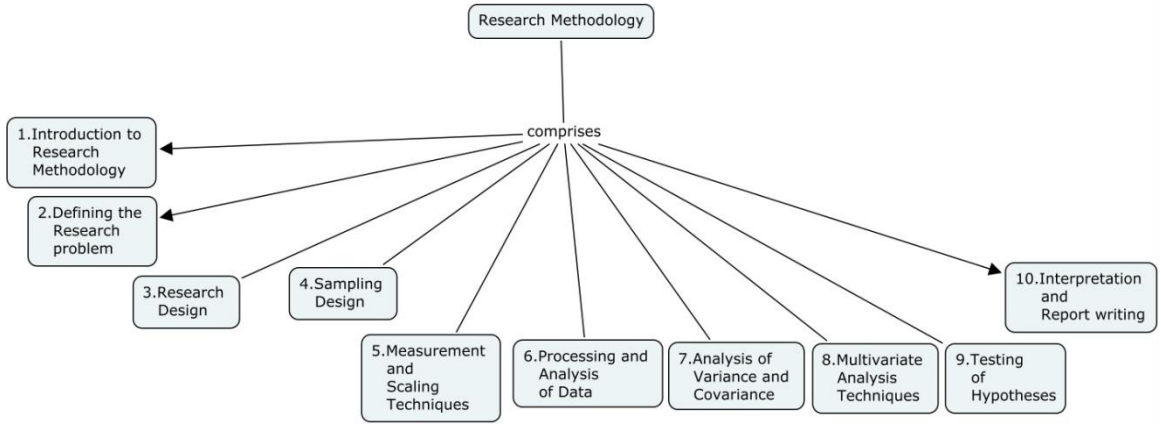
2. Sample of sales in similar shops in two towns are taken for a new product with the following results:

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

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

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

Concept Map



Syllabus

Introduction to Research Methodology: Objectives of Research; Motivation in Research - Types of Research - Research Approaches - Significance of Research - Research Methods versus Methodology - Research Process - Criteria of Good Research. **Defining the Research Problem:** Selecting the Problem - Necessity of Defining the Problem - Technique Involved in Defining a Problem. **Research Design:** Need for Research Design - Features of a Good Design - Important Concepts Relating to Research Design - Different Research Designs - Basic Principles of Experimental Designs. **Sampling Design:** Implications of a Sample Design - Steps in Sampling Design - Criteria for Selecting a Sampling Procedure - Characteristics of Good Sample Design- Different types of Sample Designs - Random Sample from an Indicate Universe- Complex Random Sampling Designs - Standard error. **Measurement and Scaling Techniques:**

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

Reference Books

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

Course Contents and Lecture Schedule

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

S.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	
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

S.No	Topics	No. of Lectures
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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