# CURRICULUM AND DETAILED SYLLABI

# FOR

# M.E. DEGREE ( Industrial Engineering ) PROGRAMME

## FIRST SEMESTER SUBJECTS

## &

## LIST OF ELECTIVE SUBJECTS

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

**THIAGARAJAR COLLEGE OF ENGINEERING**

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

MADURAI – 625 015, TAMILNADU

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Passed in BOS meeting held on 20.08.2011

## Department of Mechanical Engineering

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

1. Plan the advanced technology of Industrial Engineering concepts into various systems .
2. Analyze and design quality assurance systems.
3. Apply modern management methods to manufacturing systems .
4. Work in a team using common tools and environments to achieve project objectives .

Passed in BOS meeting held on 20.08.2011

## M.E. DEGREE (Industrial Engineering) PROGRAMME

### Scheduling of Courses

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

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI– 625 015 .**

**M.E. DEGREE ( Industrial Engineering) PROGRAMME**

**SUBJECTS OF STUDY**

(For the candidates admitted from 2011-2012 onwards)

**FIRST SEMESTER**

| Subject code | Name of the subject | Category | No. of Hours / Week | | | credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| L11 | Applied Probability and Statistics | BS | 3 | 1 | - | 4 |
| L12 | Optimization Techniques | DC | 4 | 0 | - | 4 |
| L13 | Work Study and Cost Analysis | DC | 3 | 1 | - | 4 |
| L14 | Quality and Reliability Engineering | DC | 3 | 1 | - | 4 |
| L15 | Management Support Systems | DC | 3 | 0 | - | 3 |
| L16 | Industrial Automation and Robotics | DC | 3 | 1 | - | 4 |
| **PRACTICAL** | | | | | | |
| L17 | Industrial Engineering Laboratory | DC | - | - | 1 | 1 |
| **Total** | | | | | | **24** |

BS : Basic Science

DC2 : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

**Note**:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit



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**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 .**

**M.E. DEGREE (IndustrialEngineering) PROGRAMME**

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**FIRST SEMESTER**

| S.No | Sub. code | Name of the subject | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam ** | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | L11 | Applied Probability and Statistics | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | L12 | Optimization Techniques | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | L13 | Work Study and Cost Analysis | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | L14 | Quality and Reliability Engineering | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | L15 | Management Support Systems | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | L16 | Industrial Automation and Robotics | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 7 | L17 | 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. | LEA/WEA | Facilities Planning and Layout Design | 4 |
| 2. | LEB/WEB | Sequencing and Scheduling | 4 |
| 3. | LEC/WEC | Materials Management | 4 |
| 4. | LED/WED | Research Methodology | 4 |
| 5. | LEE/WEE | Total Quality Management | 4 |
| 6. | LEF/WEF | Maintenance Engineering and Management | 4 |
| 7. | LEG/WEG | Machine Vision and its applications in manufacturing | 4 |
| 8. | LEH/WEH | System Simulation | 4 |
| 9. | LEI/WEI | Entrepreneurship Development | 4 |
| 10. | LEJ/WEJ | Product Design and Development | 4 |
| 11. | LEK/WEK | Design for Manufacture and Assembly | 4 |
| 12. | LEL/WEL | Robust Design | 4 |
| 13. | LEM/WEM | Six Sigma | 4 |
| 14. | LEN/W31 | Computer Integrated Manufacturing | 4 |
| 15. | LEO | Modeling and Analysis of Manufacturing Systems | 4 |
| 16. | LEP | Marketing Management | 4 |
| 17. | LEQ | Human Resource Management | 4 |
| 18. | LER | Value Engineering | 4 |
| 19. | LES | Environment Management | 4 |
| 20. | LET | Energy Management | 4 |
| 21. | LEU | Cogeneration and waste heat recovery | 4 |
| 22. | LEV | Industrial Fuel Engineering | 4 |
| 23. | LEW | Renewable Energy Engineering | 4 |
| 24. | LEY | Solar energy technology | 4 |
| 25. | LEZ | Industrial Instrumentation | 4 |



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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L 11 | 3 | 1 | - | 4 |

**L 11 Applied Probability And Statistics 3:1**

**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.

**Competencies**

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

1. Understand the random variables and its distributions.
2. Find the relationship among the various distributions.
3. Find the expectation and moment generating functions of the random variable.
4. Transform the random variables in terms of functions of other random variables.
5. Determine the relationship between the variables using correlation and regression.
6. To test the hypothesis using small and large samples.
7. Study various techniques of multivariate analysis.
8. Know the use of markov process in marketing strategy.

**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 learning objectives:**

**Remember**

1. Describe Continuous random variable with an example.
2. Identify the expectation where X is the outcome when we roll a die

3. Define distribution of order statistics
4. Show that exponential distribution is a valid probability density function
5. Classify the various multivariate analysis techniques
6. Define Markov analysis

**Understand**

1. Interpret the relation between binomial and poisson distribution
2. Estimate the moment generating function of the random variable X given pdf

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

3. Predict the value of 'a' if P(X = x) = c $(\frac{2}{3})^x$ ; x = 1,2,3…..
4. Differentiate between correlation and regression of variables
5. Discuss about multiple correlation
6. Compute $R_{1.23}$ if $r_{12} = 0.77$; $r_{13} = 0.72$; $r_{23} = 0.52$.
7. Distinguish between consumer's risk and producer's risk.
8. Predict the market shares by using markov analysis for future periods
9. Discuss about rotation in factor analysis

**Apply**

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. The distribution function of a R V X is given by F(x) = 1 – (1+ x) $e^{-x}$ ; x ? 0. Find the density function, mean.

3. The number of monthly breakdown of a computer is a R V having a Poisson distribution with me an equal to 1.8. Find the prob. That this computer will function for a month

   i) Without breakdown ii) with only one breakdown iii) with at least one breakdown.

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

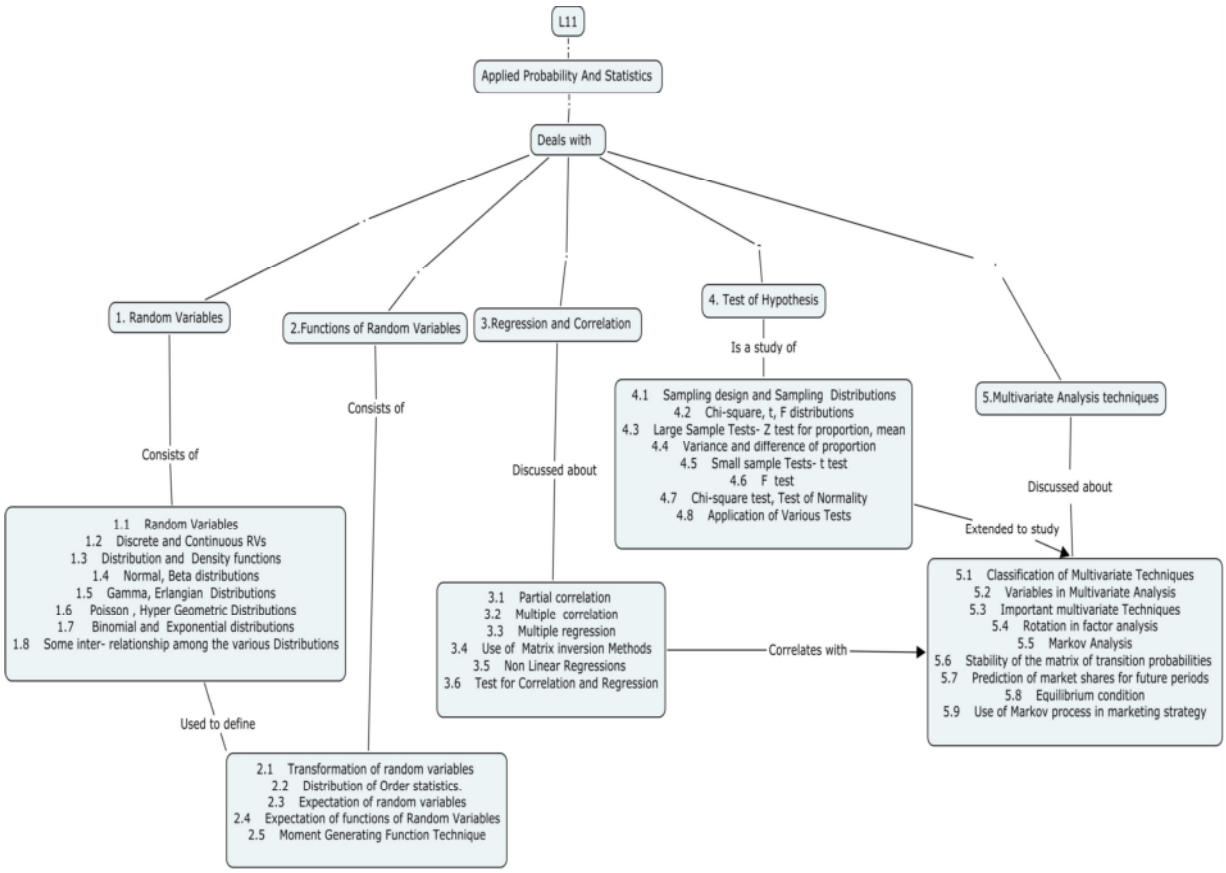
   y = $\sin\frac{px}{2}$

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

6. In a distribution $s_1 = 2, s_2 = 3, s_3 = 3, r_{12} = 0.7, r_{23} = 0.5, r_{31} = 0.5$ Find

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

**Concept M ap**




**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", Eighth Edition, Sultan Chand and Sons, New Delhi, 2001.
2. R.C. Saxena, J.N. Kapoor, "Mathematical Statistics", S.Chand and Co, 1999.
3. J.N.Sharma, J.K.Goel, "Mathematical Statistics", Seventh Edition, Krishna Prakasham Mandir, Meerut, 1998.
4. Athanasios Papoulis, "Probability, Random Variables and Stochastic Processes", McGraw Hill Company, New Delhi, 1984.
5. R.L.Levin, D.S.Rubin," Statistics for Management", Prentice Hall of India, 2001.
6. Miller, Fan, " Probability and Statistics for Engineers", Prentice Hall of India, 2001.
7. Veerarajan.T, " Probablility and Statistics" Tata McGraw -Hill Limited, New Delhi


**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 | Distributi on 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 Distributios | 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 t est, 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 S PSS software. | 1 |
| | Total | 41 |

**Course Designers**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L12/W12 | 4 | - | - | 4 |

**L12/ W12 Optimisation Techniques** **4:0**

**Preamble**

Optimisation is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources. Various techniques of optimization have been dealt on the title "Operations Research". Because of the complexity of most real-world optimization problems, it has been necessary for researchers and practitioners to reduce the complexity of the problem by either simplifying the problem or constraining it by making reasonable assumptions. In this course, the practical aspects of optimization methodology, with a major focus on the techniques and stratagems relevant to manufacturing, design and operations applications. Attention is given primarily to techniques applicable to problems in linear, integer, dynamic and non -linear programming, and network models. Besides, intelligent search heuristics are introduced to understand the concepts so as to apply them in solving large-scale problems.

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

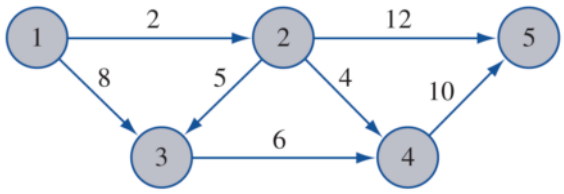
1. What are the characteristics of Linear Programming?
2. Define Bellman's P rinciple of Optimality?
3. What are the advantages of Dynamic Programming over LPP?
4. What do you mean by residuals in Maximal flow network?
5. Name any four applications of minimal spanning problems.
6. What is the importance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

**Understand**

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

**Apply**

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




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

| | Tonnes of raw material per tonne of | | |
|---|---|---|---|
| | Exterior Paint | Interior Paint | Maximum Daily Availability (Tonnes) |
| Raw Material, $M_1$ | 6 | 4 | 24 |
| Raw Material, $M_2$ | 1 | 2 | 6 |
| Profit per tonne (Rs.'000) | 5 | 4 | |

A market survey indicates that the daily demand for interior paint cannot exceed that for exterior paint by more than 1 tonne. Also, the maximum daily demand for interior paint is 2 tonnes. The company wants to determine the optimum (best) product mix of

interior and exterior paints that maximizes the total daily profit.Use simplex method to obtain the optimal solution.

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

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

4. Solve the following Non linear Programming Problem (NLPP), (14)

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

Subject to constraints,

$x_1 + x_2 + 3x_3 = 2$

$5x_1 + 2x_2 + x_3 = 5$

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

Subject to $x_1 + 2x_2 \pounds 15$

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

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

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

**Analyse**

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

| *Activities* | | *Activity Duration in Days* | | |
|---|---|---|---|---|
| *I* | *j* | *Optimistic* | *Most likely* | *Pessimistic* |
| 1 | 2 | 3 | 6 | 15 |

| | | | | |
|---|---|---|---|---|
| 2 | 3 | 6 | 12 | 30 |
| 3 | 5 | 5 | 11 | 17 |
| 7 | 8 | 4 | 19 | 28 |
| 5 | 8 | 1 | 4 | 7 |
| 6 | 7 | 3 | 9 | 27 |
| 4 | 5 | 3 | 6 | 15 |
| 1 | 6 | 2 | 5 | 14 |
| 2 | 4 | 2 | 5 | 8 |

a) Find t he probability of completing the project before 31 weeks?

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

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

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

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

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

   i. Sheet metal working shop by an hour only

   ii. Painting shop by an hour only

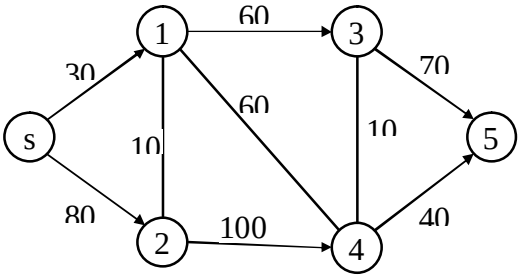
b) What would be the effect on the profit earned if at least one component for jeep had to be produced?

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

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

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

5. Consider a street network as shown below:




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

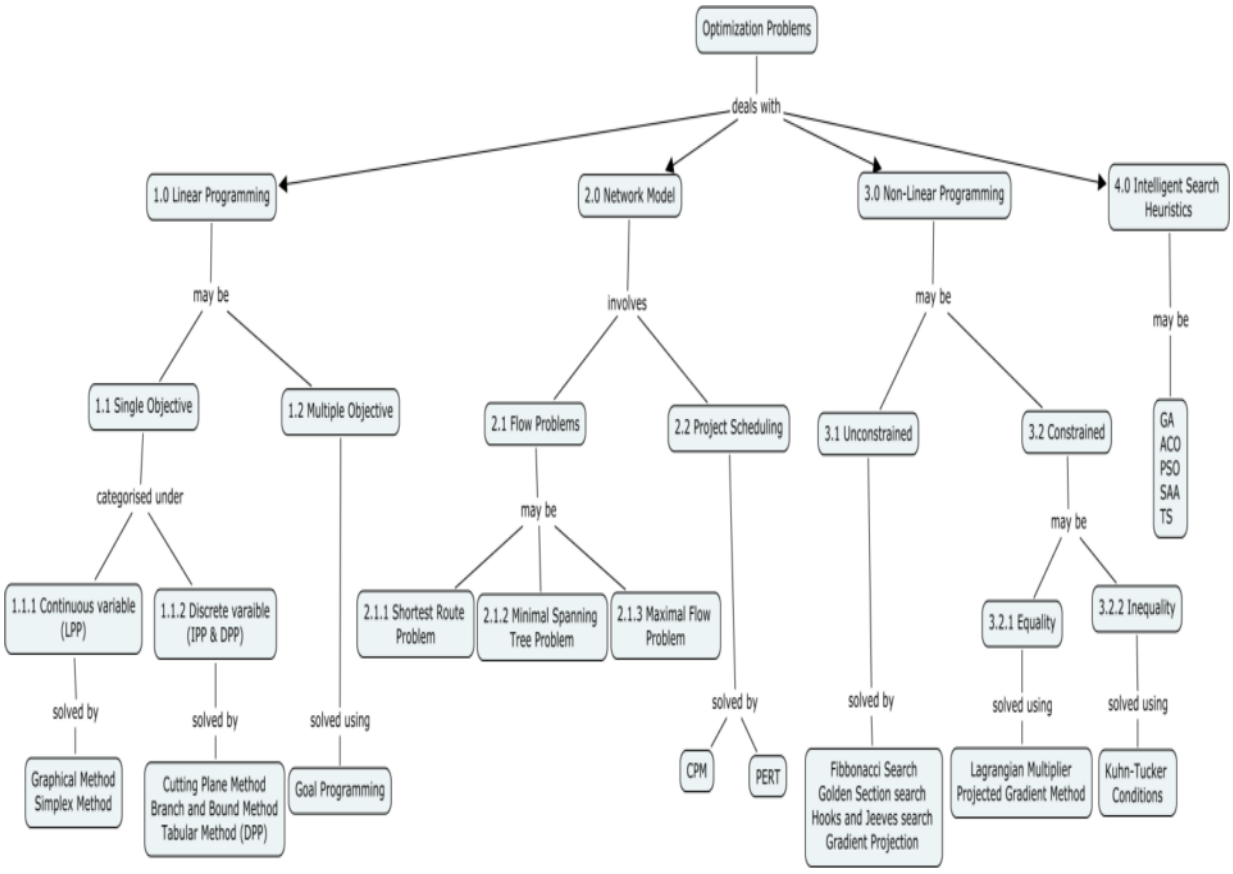
6. Solve the following NLP problem using projected gradient projection method.

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

Subject to $2x_1 + x_2 = 15$

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

**Concept Map**



**Syllabus**

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

**Reference Books**


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

**Course Contents and Lecture schedule**

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

| S.No | Topics | No. of Lectures |
|---|---|---|
| 3.1.3 | Hooks and Jeeves search | 1 |
| 3.1.4 | Gradie nt Projection | 1 |
| 3.2 | Constrained NLP Problems - Basic Concepts | 1 |
| 3.2.1 | NLP problems with Equality Constraints - Basic Concepts - Applications | |
| 3.2.1.1 | Lagrangian Multiplier Method | 1 |
| 3.2.1.2 | Projected Gradient Methods | 1 |
| 3.2.2 | NLP problems with Inequality Constraints - Basic Concepts - Applications | 1 |
| 3.2.2.1 | Khun concept - Khun Tucker conditions | |
| 4.0 | Intelligent search heuristics: Concept | 1 |
| 4.1 | Principle and parameters of Genetic Algorithm (GA) | 1 |
| 4.2 | Principle and parameters of Ant Colony Optimisation (ACO) | 1 |
| 4.3 | Principle and parameters of Particle Swarm Optimisation (PSO) | 1 |
| 4.4 | Principle and parameters of Simulated Annealing Algorithm (SAA) | 1 |
| 4.5 | Principle and parameters of Tabu Search (TS) | 1 |
| | **Total** | **46** |

**Course Designers**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L13/WE N | 3 | 1 | - | 4 |

**L13 / WEN Work Study and Cost Analysis 3:1**

**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.

**Competencies**

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

a. understand the concepts, types and applications of work study, steps in work study.

b. understand how work study can be used to calculate man machine systems and solve related problems.

c. understand the various measurement techniques in time and motion study.

d. understand and apply statistical methods used in productivity measurement.

e. learn to design a ergonomics based structures of real life product.

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

1. Defin e 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?

**Understand**

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. Wha t are the various charting techniques available foe recording a work method for analysis? Explain.
4. What are the objectives and goals of ergonomic studies? Explain fatigue and its consequences in an industrial work.
5. Explain the various aspects of an ergonomic model of man-machine system.
6. Describe the nature and uses of activity sampling.

**Apply**

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

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

compute the standard time assuming rest and personal allowance as 15% and contingency allowance as 2% of the basic time.

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

The observations of the study conducted are given below:

Total number of observations = 160
Manual (hand controlled work) = 14
Machine controlled work = 106
Machine idle time = 40

Average performance rating = 80%

No. of parts produced = 36

Allowance for personal needs And fatigue = 10%

Study conducted for 3 days Available working hours/day = 8 hrs.

Calculate the standard time per piece.

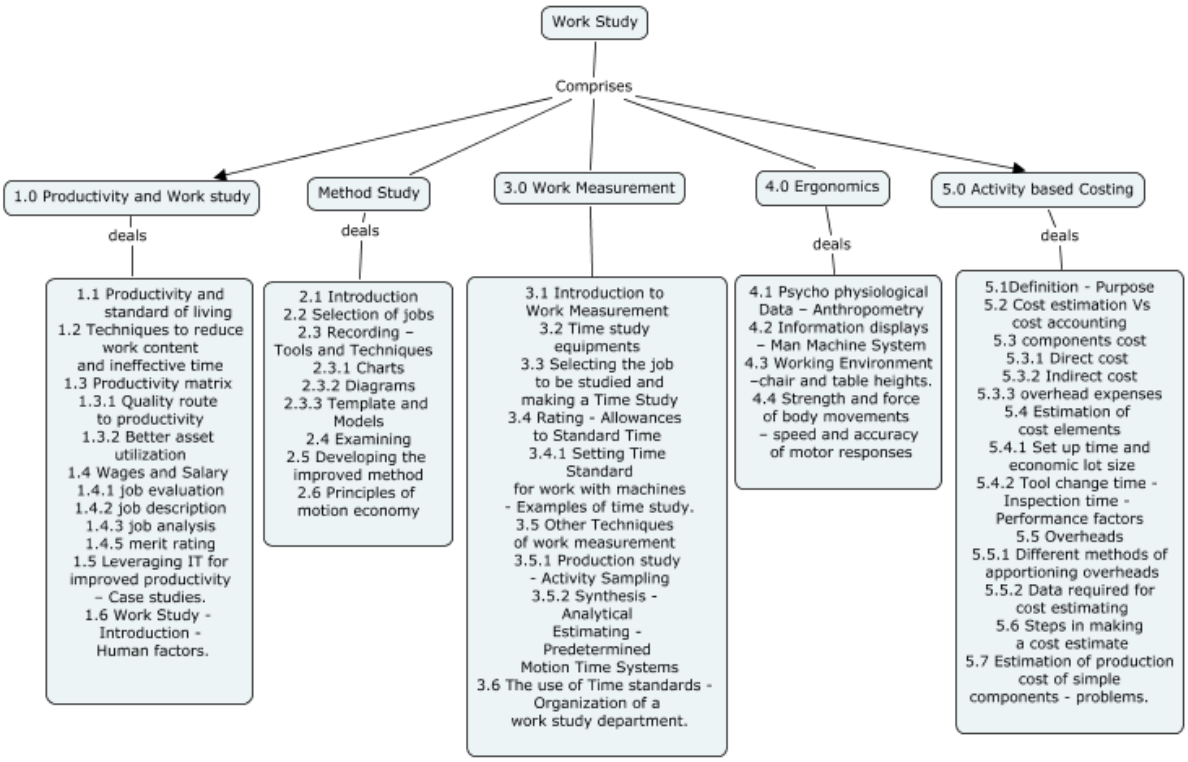
3. In a Machine shop work sampling study was conducted for 160 hrs in order to estimate the standard time. Total numbers of observation recorded were 3500. There were 600 no working activities. Ratio between manual to machine element was 2:1 Average rating factor was 1:2 and total number of jobs produced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

4. 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?

5. 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.

6. 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 eva luation | 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 – Anthro pometry | 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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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L14/WEO | 3 | 1 | - | 4 |

**L14 / WEO Quality and Reliability Engineering 3:1**

**Preamble**

**Quality and Reliability Engineering** is a process by which entities review the quality of all factors involved in production. This approach places an emphasis on three aspects: a) Elements such as controls, job management, defined and well managed processes, performance and integrity criteria, and identification of records. b) Competence, such as knowledge, skills, experience, and qualifications. c) Soft elements, such as personnel integrity, confidence, organizational culture, motivation, team spirit, and quality relationships. The quality of the outputs is at risk if any of these three aspects is deficient in any way. 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.

**Competencies**

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

a. Understand the concepts and applications of Quality Engineering, steps involved in Quality Engineering.
b. understand how Quality Engineering can be used to systems and solve related Problems.
c. understand the various measurement techniques in Quality Engineering.
d. understand and apply statistical methods used in productivity improvement.

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

1. Define – Quality Engineering.
2. State the objectives of X bar and R charts.
3. What do you mean shift in process mean?
4. What do you mean ARL?
5. Define AOQ.
6. What is ISO 14000?

**Understand**

1. Write down the steps in quality control programme.
2. Discuss the need for management of product quality.
3. Write the Step by step procedure to construct a OC curve for double sampling plan
4. State and explain the possible causes of low reliability of modern engineering systems.
5. a) Explain about the availability. b) How does the MTBF differ from MTTF? Explain the relationship between them.
6. Explain the procedure of hazard plotting technique with an example.

**Apply**

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 ?X bar = 627.48 & ?R = 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. How will you implement SIX SIGMA approach to TVS sewing Needles Company?
3. 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.

(b) Determine the sample size when a quality limit not worse than 9% I desirable and a 10% bad product will not be permitted more than three times in thousand.

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

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

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

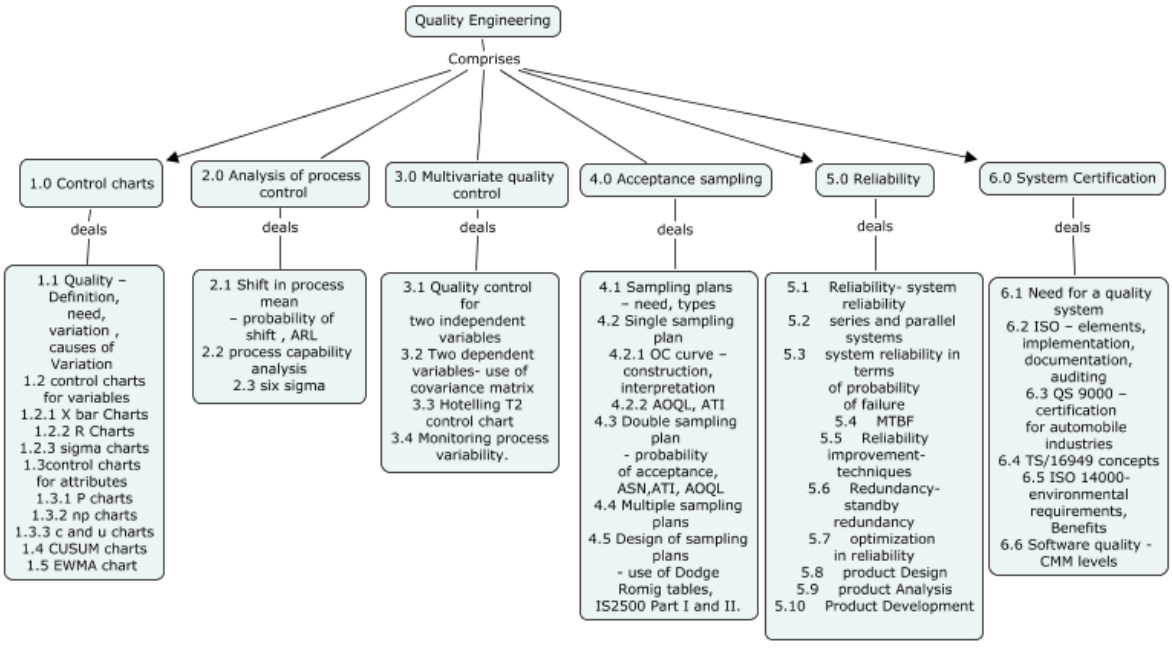
Also compute ATI, ASN for N = 750.

5. i) Calculate a) the expectation b)the second moment about the origin and c)the variance for the following probability distributions.

| X = | 8 | 12 | 16 | 20 | 24 |
|---|---|---|---|---|---|
| p(X) = | 1/8 | 1/6 | 3/8 | 1/4 | 1/12 |

6. 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 are in series and C is in parallel with A&B.

**Concept Map**



**Syllabus**

**Control charts:** Quality – Definition, need variation – causes - control charts for variables X bar, R and s charts - control charts for attributes – p, np, c, u chart, CUSUM charts, Exponential Weighted Moving Average (EWMA) chart. **Analysis of process control:** Shift in process mean – probability of shift, ARL, process capability analysis, six sigma. **Multivariate quality control:** Quality control for two independent variables, two dependent variables- use of covariance matrix – Hotelling $T^2$ control chart – Monitoring process variability. **Acceptance sampling :** Sampling plans – need, types – single sampling plan – OC curve – construction, interpretation, AOQL, ATI- double sampling plan – probability of acceptance, ASN,ATI, AOQL- multiple sampling plans- design of sampling plans – use of Dodge Romig tables,IS2500 Part I and II. **Reliability:** Reliability - system reliability -series and parallel systems-system reliability in terms of probability of failure- MTBF- Reliability improvement-techniques -Redundancy -standby redundancy optimization in reliability -product Design -product Analysis-Product Development product life. **System Certification:** Need for a quality system, ISO – elements, implementation documentation, auditing, QS 9000 – certification for automobile industries- TS/16949 concepts ISO 14000- environmental requirements, Benefits – Software quality - CMM levels.

**Reference Books**


1. Mahajan, "Statistical Quality Control," Dhanpat Rai and Co ( P) Ltd, Third Edition, 2002.
2. Dougles C. Montgomery, "Introduction to Statistical Quality Control", John Wiley and Sons, Inc, Fifth Edition, 2004.
3. Eugene L., Grant Richard S., Leven Worth, "Statistical Quality Control", McGraw Hill, Seventh Edition, 1996.
4. Kannan SM, Jayabalan V, "Total Quality Management", RKR Publications, 2005
5. Seiichi Nakajima, "Introduction to TPM", Productivity press, Second Edition, 1997.
6. Sharma DD, "Total Quality Management", Sultan Chand and Sons, 2002.
7. Connor, P.D.T.O., " Practical Reliability Engineering ", John Wiley (1993).
8. Green A.E., and Bourne A.J. " Reliability, Technology ", Wiley Interscience, 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 |



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| | | |
|---|---|---|
| 1.2.2 | R Charts | 1 |
| 1.2.3 | s 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 |
| 1.5 | Exponential Weighted Moving Average (EWMA) chart. | 1 |
| 2. | **Analysis of process control** | |
| 2.1 | Shift in process mean – probability of shift , ARL | 1 |
| 2.2 | process capability analysis | 2 |
| 2.3 | six sigma | |
| 3 | **Multivariate quality control** | |
| 3.1 | Quality control for two independent variables | 1 |
| 3.2 | Two dependent variables- use of covariance matrix | 1 |
| 3.3 | Hotelling $T^2$ control chart | 1 |
| 3.4 | Monitoring process variability. | 1 |
| 4 | **Acceptance sampling** | |
| 4.1 | Sampling plans – need, types | 1 |
| 4.2 | Single sampling plan | 1 |
| 4.2.1 | OC curve – construction, interpretation | |
| 4.2.2 | AOQL, ATI | 1 |
| 4.3 | Double sampling plan - probability of acceptance, ASN,ATI, AOQL | 2 |
| 4.4 | Multiple sampling plans | 1 |
| 4.5 | Design of sampling plans - use of Dodge Romig tables, IS2500 Part I and II. | 1 |
| 5 | **Reliability** | |
| 5.1 | Reliability - system reliability | 1 |
| 5.2 | series and parallel systems | |
| 5.3 | system reliability in terms of probability of failure | 2 |
| 5.4 | MTBF | 1 |
| 5.5 | Reliability improvement-techniques | 1 |
| 5.6 | Redundancy -standby redundancy | 1 |
| 5.7 | optimization in reliability | 1 |

| | | |
|---|---|---|
| 5.8 | product Design | 1 |
| 5.9 | product Analysis | 1 |
| 5.10 | Product Development | 1 |
| 5.11 | product life | 1 |
| 6 | **System Certification** | |
| 6.1 | Need for a quality system | 1 |
| 6.2 | ISO – elements, implementation, documentation, auditing | 3 |
| 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** | **42** |

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L15 | 3 | 0 | - | 3 |

**L15 MANAGEMENT SUPPORT SYSTEMS 3:0**

**Preamble:**

A 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.

**Competencies**

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

a. understand the concepts, types and applications of MSS, steps in MSS

b. understand how MSS can be used to create a model for complex systems

c. understand the various techniques in Decision Support Systems.

d. understand and apply DSS methods used in Management environment

e. learn to design a DSS Model based structures of real life product.

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

1. 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.

**Understand**

1. What is DSS hardware? How it is used for MSS?
2. What are the tools or technologies of MSS?
3. Draw the Decision Support framework? Explain the each.
4. What are the classifications of models? What is the purpose of such a classification? Give an example of each.
5. Describe the various criteria for measuring the success of an implemented information system.
6. Discuss the importance of Knowledge Management.

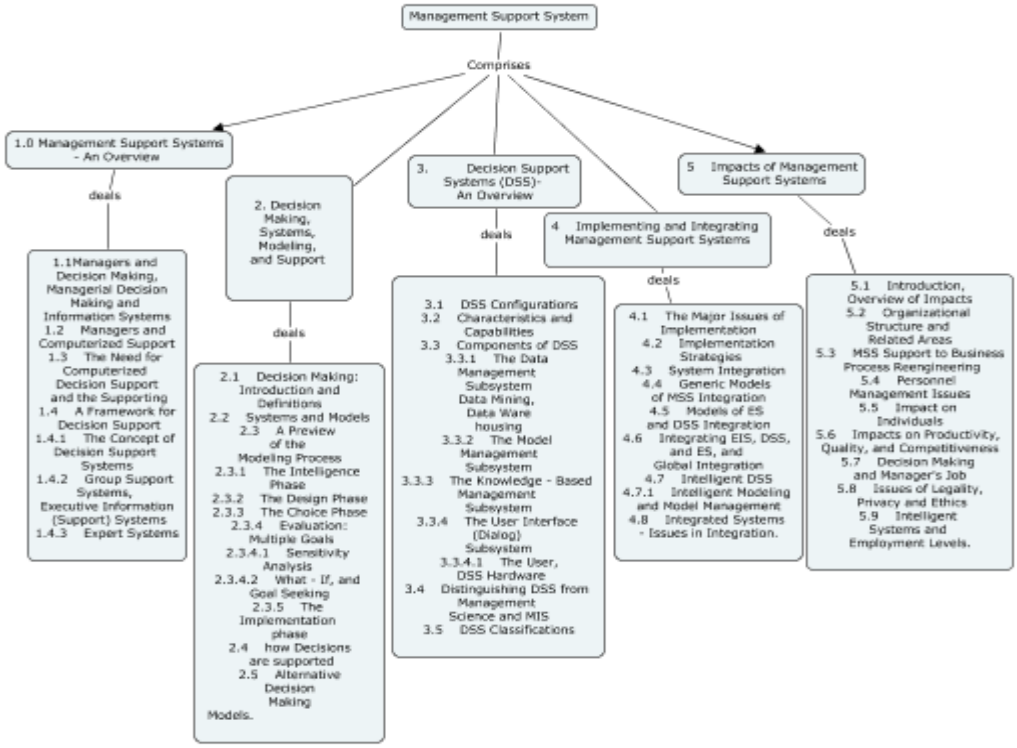
**Apply**

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", Sixth Edition, Prentice Hall, 2001.
2. G.M Marakas, "Decision Support Systems in the 21st century" , Prentice Hall, 1999.
3. C.Holsapple, A.Whinston, "Decision Support Systems: A Knowledge based Approach", Prentice Hall, 2001.
4. Elamsri, Navathe, "Fundamentals of Data base systems", Addison Wesley, 2003.

**Course Contents and Lecture Schedule**

| Sl.No. | Topics | No. Of Periods |
|---|---|---|
| 1. | **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 MS S 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 Produ ctivity, 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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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L16/W14 | 3 | 1 | - | 4 |

**L16/ W14 INDUSTRIAL AUTOMATION AND ROBOTICS 3:1**

**Preamble**

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

**Program Outcomes Addressed**

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

**Competencies**

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**
**Remember**

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

6. What is an end effector?

**Understand**

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

**Apply**

1. A rotary work table is driven by a Geneva mechanism with 5 slots. The driver rotates at 48 rev/min. Determine (a) cycle time, (b) available process time, and (c) indexing time.
2. Illustrate the FMS in-line layouts with examples.
3. Identify the three application areas of AS/RS.
4. Select the suitable sensor for the following applications (a) to indicate distance (b) to indicate the presence (c) Inspection.
5. A 5 kg rectangular block is gripped in the middle and lifted vertically at a velocity of 1 m/s. If it accelerates to a velocity of 27.5m/$s^2$ and the coefficient of friction between the gripping pads and the block is 0.48, calculate the minimum force that would prevent the slippage.
6. Write a homogeneous transform matrix for a rotation of 90° about the z-axis, followed by a rotation of -90° about the x-axis, followed by a translation o f (3, 7, and 9).

**Analyse**

1. A 30- station transfer line has an ideal cycle time of 0.75 min, an average downtime of 6.0 min per line stop occurrence, and a station failure frequency of 0.01 for all stations. A proposal has been submitted to locate a storage buffer between stations 15 and 16 to improve line efficiency. Determine (a) the current line efficiency and production rate that would result from installing the storage buffer.

2. A machine tool builder submits a proposal for a 20-station transfer line to machine a certain component currently produced by conventional methods. The proposal states that the line will operate at a production rate of 50 pieces per hour at 100% efficiency. On similar transfer lines, the probability of station breakdown per cycle is equal for all stations and p= 0.005 breakdowns/cycle. It is also estimated that the average downtime per line stop will b e 0.8min. The starting casting that is machined on the line costs Rs.120 per part. The line operates at a cost of Rs.4000 per hour. The 20 cutting tolls (one tool per station) last for 50 parts each, and the average cost per tool = Rs80 per cutting edge. Based on this

data, compute (a) production rate, (b) line efficiency, and (c) cost per unit piece produced on the line.

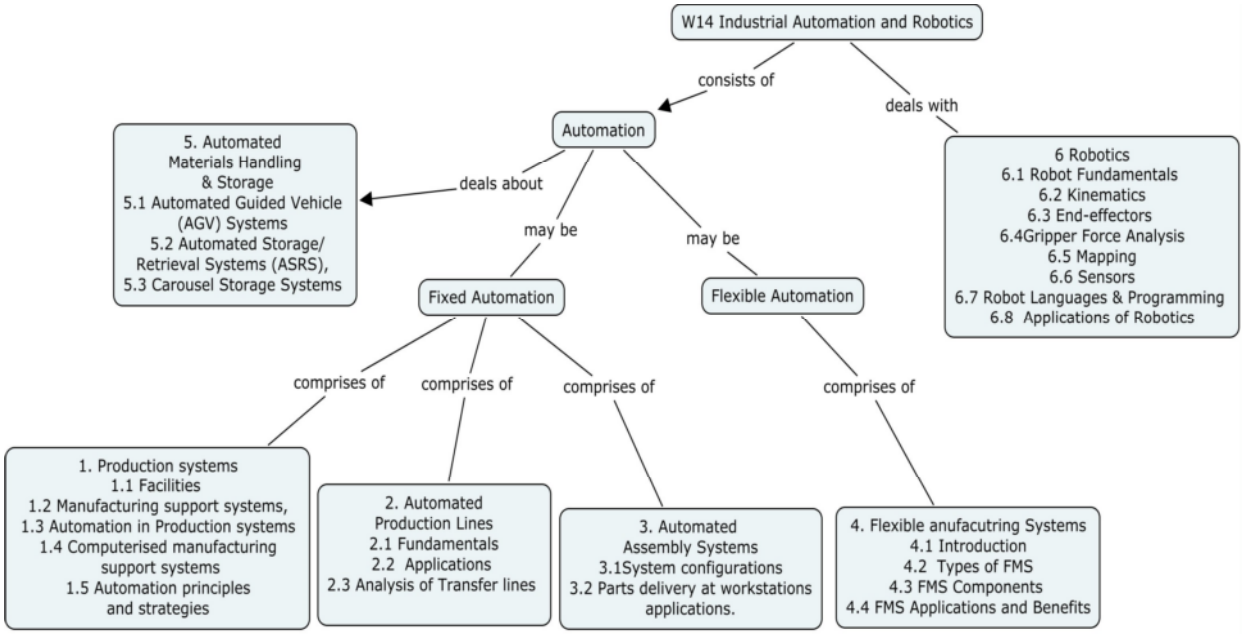
3. A ten -station transfer machine has an ideal cycle time of 30 sec. The frequency of line stops is 0.075 stops per cycle. When a line stop occurs, the average downtime is 4.0 min. Determine (a) average production rate in piece/hour, (b) line efficiency, and (c) proportion downtime.

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

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

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

**Concept Map**




**Syllabus**

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

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

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

**Flexible Manufacturing Systems:** Introduct ion, 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) Limite d, New Delhi, 1994.
4. Deb, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi 2003.
5. Popov and E.I. Yurevih, “Robotics", MIR Publications, Moscow, 1987.
6. Yoram Koren, "Robotics for Engineers", Tata McGraw Hill - International Edition, 1987.

**Course Contents and Lecture schedule**

| S.No | Topics | No. of Lectures |
|---|---|---|
| **1** | **Production systems** | |
| 1.1 | Facilities – Manual work systems | 1 |
| 1.2 | Worker -machine systems and Automated systems, Manufacturing support systems | 1 |

| S.No | Topics | No. of Lectures |
|---|---|---|
| 1.3 | Automation in Production systems – Automated Manufacturing system | 1 |
| 1.4 | Computerised manufacturing support systems, Manual labour in Production systems | 2 |
| 1.5 | Automation principles and strategies. | 2 |
| **2** | **Automated Production Lines** | |
| 2.1 | Fundamentals - System configurations | 1 |
| | Workpan ts 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 wi th internal storage buffers. | 1 |
| **3** | **Automated Assembly Systems** | |
| 3.1 | System configurations | 1 |
| 3.2 | Parts delivery at workstations, and applications. | 2 |
| **4** | **Flexible Manufacturing Systems** | |
| 4.1 | Flexible Manufacturing Systems – Introduction | 1 |
| 4.2 | Types of FMS | 1 |
| 4.3 | FMS Components | 1 |
| 4.4 | FMS Applications and Benefits | 1 |
| **5** | **Automated Material Transport systems** | |
| 5.1 | Types of vehicles, Automated Guided Vehicle (AGV) applications, Vehicle Guidance Technology, Vehicle Management and Vehicle safety. | 2 |
| 5.2 | Automated Storage systems: Automated Storage/Retrieval Systems (ASRS) | 1 |
| 5.3 | Carousel Storage Systems | 1 |
| **6** | **Robotics** | |
| 6.1 | Robot Fundamentals - Definition - Anatomy – Specifications | 1 |
| 6.2 | Robot Kinematics - Forward and Reverse Kinematics (Transformation) of Two and Three Degrees of Freedom Robot Arm | 2 |

| S.No | Topics | No. of Lectures |
|---|---|---|
| 6.3 | Robot End -effectors - Classification - Types of Gripper | 1 |
| | Drive Systems for Grippers, Hooks, Scoops and other Miscellaneous Devices | 2 |
| 6.4 | Gripper Force Analysis | 1 |
| 6.5 | Mapping - General mapping and Compound mapping. | 1 |
| 6.6 | Sensors - Actuators - Types of Sensors | 2 |
| 6.7 | Robot Languages: Robot Languages and Programming | 1 |
| | Classification of Robot languages and Robot Software | 1 |
| 6.8 | Applications of Robotics. | 1 |
| | Total | 39 |

**Course Designers**

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Passed in BOS meeting held on 20.08.2011

| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| L 17 | - | - | 1 | 1 |

**L17 Industrial Engineering Laboratory 0:1**

**Objective:**

- Develop and solve optimization problem using commercial packages
- Generate and test simulation models using commercial packages
- Usage of spreadsheets for quality control charts and simple problems

Students have to complete any twelve exercises before terminal examination

**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

**LABORATORY SOFTWARE REQUIREMENTS**

1. TURBO C++ Software
2. LINGO Software
3. MS excel
4. Arena / Promodel software

**Course designers**

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Passed in BOS meeting held on 20.08.2011

# CURRICULUM AND DETAILED SYLLABI

# FOR

# M.E. DEGREE (Industrial Engineering) PROGRAMME

## SECOND SEMESTER SUBJECTS

## &

## LIST OF ELECTIVE SUBJECTS

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

**THIAGARAJAR COLLEGE OF ENGINEERING**

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

MADURAI – 625 015, TAMILNADU

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**Thiagrajar College of Engineering: Madura625015.**

**Department of Mechanical Engineering**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

**Scheduling of Courses**

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

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 .**

**M.E. DEGREE ( Industrial Engineering) PROGRAMME**

**SUBJECTS OF STUDY**

(For the candidates admitted from 2011-2012 onwards)

**FIRST SEMESTER**

| Subject code | Name of the subject | Category | No. of Hours / Week | | | credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| L11 | Applied Probability and Statistics | BS | 3 | 1 | - | 4 |
| L12 | Optimization Techniques | DC | 4 | 0 | - | 4 |
| L13 | Work Study and Cost Analysis | DC | 3 | 1 | - | 4 |
| L14 | Quality and Reliability Engineering | DC | 3 | 1 | - | 4 |
| L15 | Management Support Systems | DC | 3 | 0 | - | 3 |
| L16 | Industrial Automation and Robotics | DC | 3 | 1 | - | 4 |
| **PRACTICAL** | | | | | | |
| L17 | Industrial Engineering Laboratory | DC | - | - | 1 | 1 |
| **Total** | | | | | | **24** |

BS : Basic Science

DC2 : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

**Note**:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015 .**

**M.E. DEGREE ( Industrial Engineering) PROGRAMME**

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**FIRST SEMESTER**

| S.No | Sub. code | Name of the subject | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam ** | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | L11 | Applied Probability and Statistics | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | L12 | Optimization Techniques | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | L13 | Work Study and Cost Analysis | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | L14 | Quality and Reliability Engineering | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | L15 | Management Support Systems | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | L16 | Industrial Automation and Robotics | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 7 | L17 | 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**

**SUBJECTS OF STUDY**

(For the candidates admitted from 2011-2012 onwards)

**SECOND SEMESTER**

| Subject code | Name of the subject | Category | No. of Hours / Week | | | credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| L21 | Financial Management | DC | 3 | 0 | - | 3 |
| L22 | Operations Management | DC | 4 | 0 | - | 4 |
| LEX | Elective - I | DE | | | | 4 |
| LEX | Elective - II | DE | | | | 4 |
| LEX | Elective - III | DE | | | | 4 |
| LEX | Elective - IV | DE | | | | 4 |
| **PRACTICAL** | | | | | | |
| L27 | Work Systems Engineering Laboratory | DC | - | - | 1 | 1 |
| **Total** | | | | | | **24** |

BS : Basic Science

DC2 : Department Core

DE : Departmental Elective

L : Lecture

T : Tutorial

P : Practical

**Note**:

1 Hour Lecture/Tutorial is equivalent to 1 credit

2/3 Hours Practical is equivalent to 1 credit

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**SECOND SEMESTER**

| S.No | Sub. code | Name of the subject | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam ** | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | L21 | Financial Management | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | L22 | Operations Management | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | LEX | Elective - I | 3 | 50 | 50 | 100 | 25 | 50 |
| 4 | LEX | Elective - II | 3 | 50 | 50 | 100 | 25 | 50 |
| 5 | LEX | Elective - III | 3 | 50 | 50 | 100 | 25 | 50 |
| 6 | LEX | Elective - IV | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 7 | L27 | 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. | LEA/WEA | Facilities Planning and Layout Design | 4 |
| 2. | LEB/WEB | Sequencing and Scheduling | 4 |
| 3. | LEC/WEC | Materials Management | 4 |
| 4. | LED/WED | Research Methodology | 4 |
| 5. | LEE/WEE | Total Quality Management | 4 |
| 6. | LEF/WEF | Maintenance Engineering and Management | 4 |
| 7. | LEG /WEG | Machine Vision and its applications in manufacturing | 4 |
| 8. | LEH/WEH | System Simulation | 4 |
| 9. | LEI/WEI | Entrepreneurship Development | 4 |
| 10. | LEJ/WEJ | Product Design and Development | 4 |
| 11. | LEK/WEK | Design for Manufacture and Assembly | 4 |
| 12. | LEL/WEL | Robust Design | 4 |
| 13. | LEM/WEM | Six Sigma | 4 |
| 14. | LEN/W31 | Computer Integrated Manufacturing | 4 |
| 15. | LEO | Modeling and Analysis of Manufacturing Systems | 4 |
| 16. | LEP | Marketing Management | 4 |
| 17. | LEQ | Human Resource Management | 4 |
| 18. | LER | Value Engineering | 4 |
| 19. | LES | Environment Management | 4 |
| 20. | LET | Energy Management | 4 |
| 21. | LEU | Cogeneration and waste heat recovery | 4 |
| 22. | LEV | Industrial Fuel Engineering | 4 |
| 23. | LEW | Renewable Energy Engineering | 4 |
| 24. | LEY | Solar energy technology | 4 |
| 25. | LEZ | Industrial Instrumentation | 4 |

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

## L21/WEP FINANCIAL MANAGEMENT 3:0

**Preamble**

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

**Competencies**

At the end of the course the students will

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Under stand**

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

**Apply**

1.Journalize the following business transactions :

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

b). He purchases goods worth Rs.5000.

c).He sells goods for Rs.7000

d).He incurs travelling expenses for Rs.200

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

| Debit Balances | Rs. | Credit Balances | Rs. |
|---|---|---|---|
| Buildings | 30000 | Capital | 4000 |
| Machinery | 31400 | Purchase Returns | 2000 |
| Furniture | 2000 | Sales | 280000 |
| Motor Car | 16000 | Sundry creditors | 9600 |
| Purchases | 188000 | Discounts received | 1000 |
| Sales return | 1000 | Provision for bad and doubtful debts | 600 |
| Sundry debtors | 30000 | | |

| | | | |
|---|---|---|---|
| General expenses | 1600 | | |
| Cash at bank | 9400 | | |
| Rates and taxes | 1200 | | |
| Bad debts | 400 | | |
| Insurance premium | 800 | | |
| Discount allowed | 1400 | | |
| Opening stock | 20000 | | |
| Total | 333200 | Total | 333200 |

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

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

Find the following

a) Pay Back Period b) ARR

4. Prepare a balance sheet from the following information

Capital Turnover 2 times

Receivables turnover 3 times

Creditors velocity 2 months

Invent ory turnover 6 times

Fixed Assets turnover 3 times

Gross Profit ratio 20%

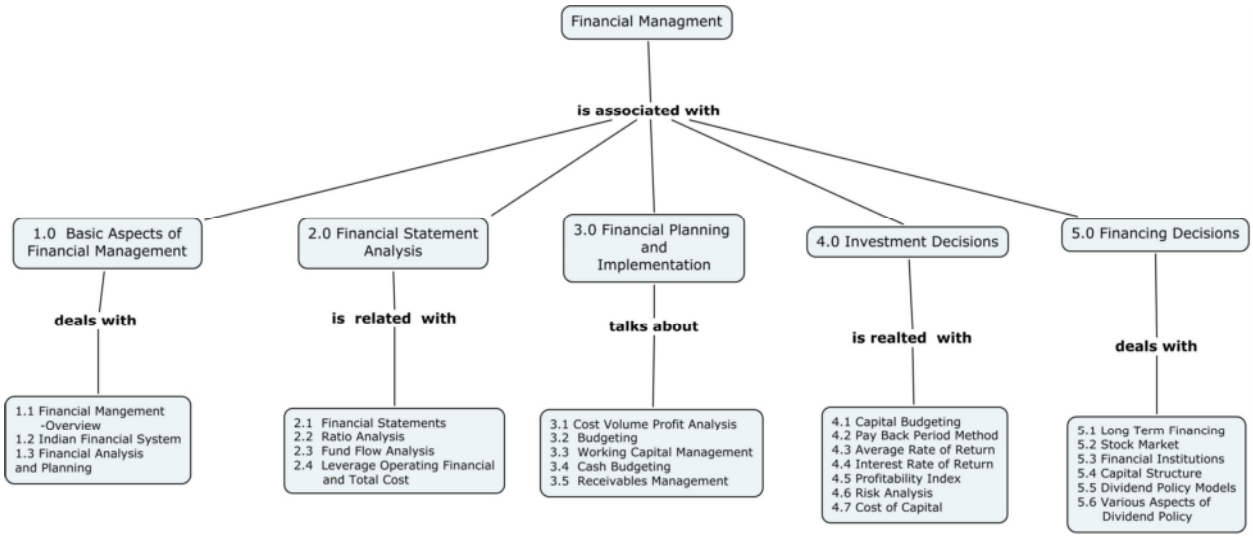
Gross profit during the year Rs.100000

Reserves and surplus Rs. 300000

Closing stock us Rs.4000 more than opening stock

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

**Concept Map**




**Syllabus**

**Financial Management**- An Overview - Indian Financial System- Financial Analysis and Planning - Financial Statements - Balance Sheet - Income Statement **Financial Statement Analysis** - Types of Financial ratios - Predictive power of financial ratios- Funds Flow Analysis - Fund flo w 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 - Factor s 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 B udgeting –Pay Back Period Method, Average Rate of Return, Interest Rate of Return, Profitability Index- Appraisal criteria - Risk Analysis of - Selection of a Project -Cost of Capital. **Financing Decisions** -Long Term Financing - Sources of long term finance - Primary market for long term securities - Public issue - Rights issue - Private placement - Stock market - Function of the stock market- Regulation - Financial Institutions. **Capital Structure** - Theory - Various approaches- Planning the capital structure - Dividend policy and share valuation - Dividend policy models - Practical Aspects - Legal and procedural aspects.

**Reference Books**

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

**Course Contents and Lecture schedule**

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

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

**Course Designers**

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

## L22/ WEQ Operations Management 4:0

**Preamble**

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

**Competencies**

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

1. Explain production and operation strategies for industries (Manufacturing / Service).
2. Explain the concept of JIT and Lean manufacturing
3. Propose a suitable forecasting method
4. Suggest methods for facility location and layout planning.
5. Develop inventory and MRP systems.
6. Apply production management techniques for aggregate planning and scheduling in manufacturing.

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

1. Define Operation Management.
2. What are the inputs for MRP?

3. What is the principle behind JIT?
4. What are forecasting errors?
5. What are the objectives of scheduling?
6. State the most important factors used for selecting a location for a facility.

**Understand**

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

**Apply**

1. Historical demand for a product is:

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

a. Using weighted moving average with weights of 0.60, 0.30, and 0.10, find the July forecast.
b. Using a simple three-month moving average, find the July forecast.
c. Using single exponential smoothing with a = 0.2 and a June forecast = 13, find the July forecast. Make whatever assumptions you wish.

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

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

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

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

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

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

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

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

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

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

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

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

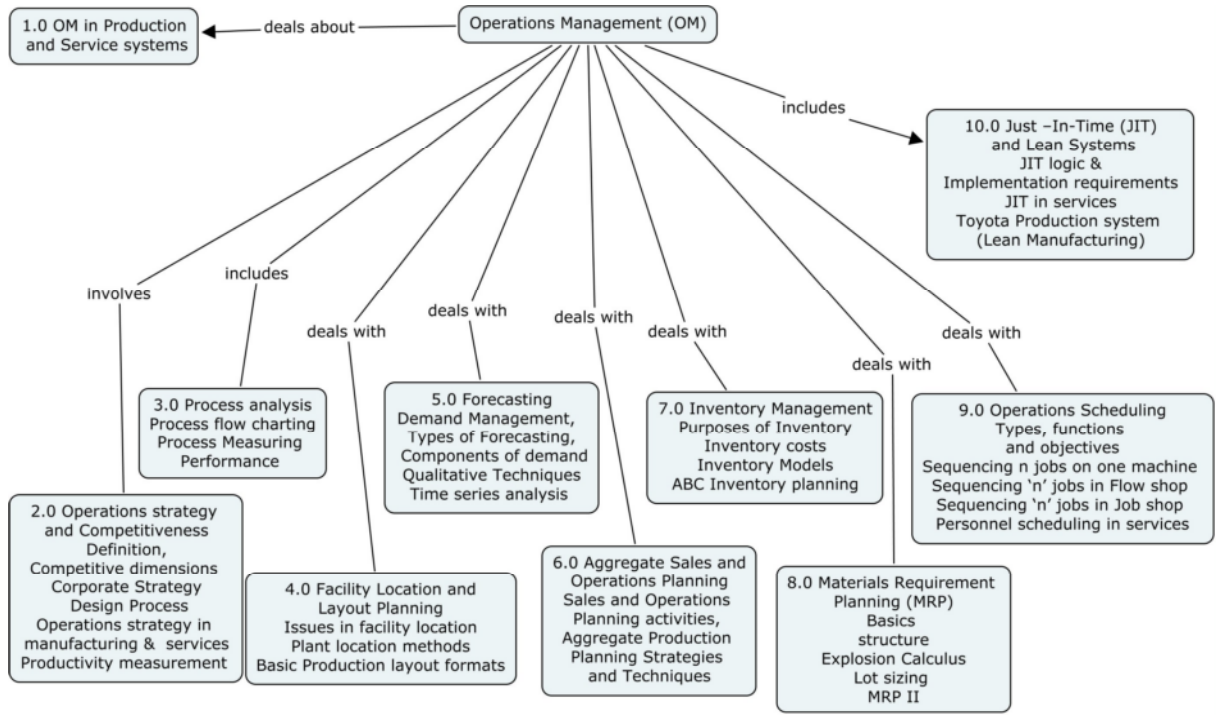
6. A new plant to be established will receive raw material from three suppliers P, Q, and R and supply finished products to three warehouses U, V, and W. The sources of raw material and the destination points may be considered as the existing facilities.

The coordinates of the existing facilities and the amount of material movement between the existing facilities and the new facility are as follows:

| Serial No. | Existing facility | Coordinates | | Material movement to and from new facility $w_i$ |
|---|---|---|---|---|
| | | X | Y | |
| 1 | P | 300 | 300 | 400 |
| 2 | Q | 350 | 500 | 600 |
| 3 | R | 280 | 180 | 700 |
| 4 | U | 100 | 500 | 300 |
| 5 | V | 500 | 600 | 500 |
| 6 | W | 350 | 700 | 450 |

Find the optimal location for the new plant.

**Concept Map**



**Syllabus**

**Introduction to Operations Management (OM):** Definition, OM in organisation chart, OM in Production and Service systems. **Operations strategy and Competitiveness:** Definition, Competitive dimensions and Corporate Strategy Design Process, Operations strategy in manufacturing, Operations strategy in services, Productivity measurement. **Process analysis:** Process flow charting and Process Measuring Performance. **Facility Location and Layout Planning:** Issues in facility location, Plant location methods: Factor rating method and Gravity location method, Basic Production layout formats, Process layout – Craft and Systematic layout Planning, Product layout – Assembly line balancing, and Other layouts- Group Technology layout, Fixed Position layout, Retail service layout and office layout. **Forecasting:** Demand Management, Types of Forecasting, Components of demand, Qualitative Techniques, and Time series analysis in Forecasting. **Aggregate Sales and Operations Planning:** Sales and Operations Planning activities, Aggregate Production Planning Strategies and Techniques. **Inventory Management:** Inventory, Purposes of Inventory, Inventory costs, Inventory Systems: Single period Inventory model & Multi period Inventory systems. Fixed - order quantity Models, Establishing Safety stock levels, Fixed time period models and ABC Inventory planning. **Materials Requirement Planning (MRP):** MRP basics & MRP system structure, Explosion Calculus, Lot sizing in MRP systems: Lot -for-Lot, Economic Order Quantity, Silver Meal Heuristics, and Least Unit Cost. MRP II. **Operations Scheduling:** Scheduling – Types, functions and objectives, Sequencing n jobs on one machine – Schedule using Priority dispatch rules (FCFS, SPT,EDD, LCFS, and Critical Ratio). Sequencing 'n' jobs in Flow shop – Johnson, CDS and Palmer Algorithms. Sequencing 'n' jobs in Job shop – Two jobs on M machines, Gantt chart. Personnel scheduling in services. **Just –In-Time (JIT) and Lean Systems:**JIT logic, Toyota Production system (Lean Manufacturing), JIT Implementation requirements and JIT in services.

**Reference Books**

1. Chase, Jacobs, Aquilano, "Production and Operations Management", Tenth Edition, Irwin McGraw Hill Companies Inc., 2004.
2. Everette. Adam. Jr.Ronald J.Ebert, "Production and Operations Management", Eight Indian Reprinting, PHI 1997.
3. Steven Nahmias, "Production and Operations Analysis", Third Edition, Irwin McGraw Hill Companies Inc., 1997.
4. Paneer Selvam.R, "Production and Operations Management", Prentice-hall of India, 1999.
5. Chary, "Theory and Problems in Production and Operations Management", Second reprint, Tata McGraw Hill, 1996

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

**Course Contents and Lecture schedule**

| SL.NO | TOPICS | No. of Lectures |
|---|---|---|
| **1.0** | **Introduction to Operations Management (OM)** | |
| 1.1 | Definition, OM in organisation chart | 2 |
| 1.2 | OM in Production and Service systems | |
| **2.0** | **Operations strategy and Competitiveness:** | |
| 2.1 | Definition, Competitive dimensions and Corporate Strategy Design Process | 1 |
| 2.2 | Operations strategy in manufacturing | 1 |
| 2.3 | Operations strategy in services | 1 |
| 2.4 | Productivity measurement | 1 |
| **3.0** | **Process analysis** | |
| 3.1 | Process flow charting | 1 |
| 3.2 | Process Measuring Performance | 2 |
| **4.0** | **Facility Location and Layout Planning** | |
| 4.1 | Issues in facility location | 1 |
| 4.2 | Plant location methods: Factor rating method and Gravity location method. | 1 |
| 4.3 | Basic Production layout formats | 1 |
| 4.4 | Process layout – Craft and Systematic layout Planning | 2 |
| 4.5 | Product layout – Assembly line balancing | 1 |
| 4.6 | Other layouts - Group Technology layout, Fixed Position layout, Retail service layout and office layout | 1 |
| **5.0** | **Forecasting** | |
| 5.1 | Demand Management, Types of Forecasting, Components of demand | 1 |
| 5.2 | Qualitative Techniques in Forecasting | 1 |
| 5.3 | Time series analysis in Forecasting | 3 |
| **6.0** | **Aggregate Sales and Operations Planning** | |
| 6.1 | Sales and Operations Planning activities | 1 |
| 6.2 | Aggregate Production Planning Strategies and Techniques | 2 |
| **7.0** | **Inventory Management** | |
| 7.1 | Inventory, Purposes of Inventory, Inventory costs | 1 |
| 7.2 | Inventory Systems: Single period Inventory model & Multi period Inventory systems | 1 |
| 7.3 | Fixed - order quantity Models, Establishing Safety stock levels | 2 |
| 7.4 | Fixed time period models | 1 |
| 7.5 | ABC Inventory planning | 1 |

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

**Course Designers**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| **L27** | 0 | 0 | 1 | 1 |

## L27 Work System Engineering Lab 0:1

**Objective**

- To develop practical awareness of conducting Time Study.
- To enhance practical exposure of conducting Method Study.
- To get exposure in Therapeutic techniques.
- To know how to conduct physical fitness testing.

Students have to complete any eight exercises before terminal examination

**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

Experiments using sound level and lux meters

**Laboratory Equipments Requirements**

1. Time study Trainer
2. Peg board
3. Stop watches
4. Tread mill
5. Ergo cycle

**Course Designers**

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

## LEF/ WEF Maintenance Engineering and Management 4:0

**Preamble**

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

**Competencies**

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Understand**

1. Differentiate between break down maintenance and Preventive maintenance.
2. Explain di fferent types of maintenance systems
3. Explain the various components of maintenance costs.
4. Explain about planning and scheduling of maintenance.
5. Describe the procedure for the implementation of CMMS.
6. Explain about the maintenance performance indices and its usage.

**Apply**

1. An optical sensor has follow the Weibull time to failure distribution with scale parameter of 300 h and shape parameter of 0.6. What is the reliability of the sensor after 500 h of operation?
2. Consider a system with three components A, B and C in parallel. Determine the system reliability for 2000 h of operation, and find the mean time to failure. Assume all the three components have an identical time-to failure distribution that is exponential, with a constant failure rate of 0.0006 per hour. What is the mean time failure of each component?
3. A standby system has a basic unit with four standby components. The time to failure of each component has an exponential distribution with a failure rate of 0.007 per h. For a 400h operation period, find the reliability of the standby system.
4. A machine owner finds from his past records that the costs per year of maintaining a machine whose purchase price is Rs.6000 are as given below:

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

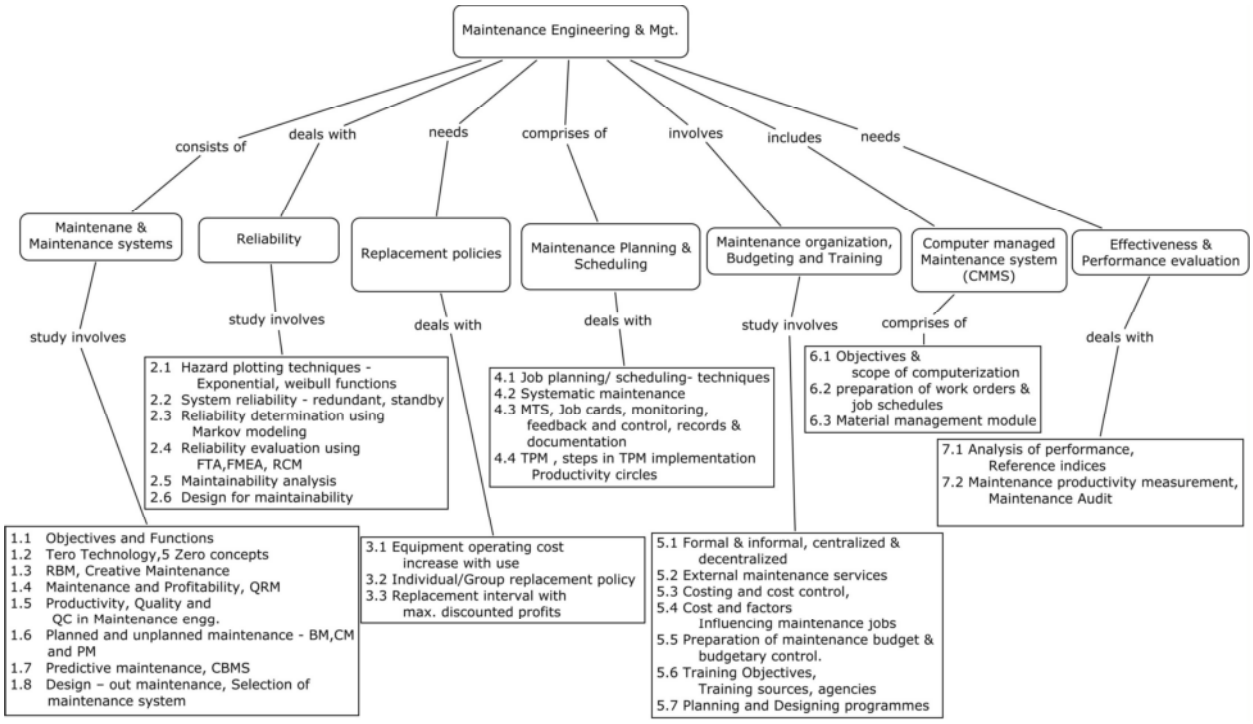
   Determine at what age is replacement due?
5. A manufacturer is offered two machines A and B. A is priced at Rs.5000 and running costs are estimated at Rs.800 for each of the first five years, increasing by Rs.200 per year in the sixth and subsequent years. Machine B, which has the same capacity as A,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

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

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

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

**Concept Map**




**Syllabus**

**Maintenance:** Objectiv es 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 mainte nance, 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 equipm ent 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 Sched uling:** Job planning – job scheduling – scheduling techniques – short term planning, Long term planning – Systematic maintenance – codification and cataloging, Manuals. Maintenance Time Standard (MTS), Job cards, Job execution, monitoring, feedback and control, Maintenance records and documentation. Total Productive Maintenance (TPM) – Basic systems, steps in TPM implementation - Productivity circles.

**Maintenance organization:** Formal and informal – centralized and decentralized – external maintenance services – captive shop facilities – working arrangements. Maintenance Budgeting: Costing and cost control – Behavior of maintenance costs – Types and components of maintenance costs. Cost and factors Influencing maintenance jobs. Budget and Budgeting of maintenance cost. Cost control – preparation of maintenance budget and budgetary control. **Training for maintenance personnel:** Objectives, modes of training/development. Training sources, agencies, institutions - Planning and Designing programmes, Evaluation, Benefits. **Computer Managed Maintenance System (CMMS):** Objectives, Approach towards computerization – scope of computerization – Equipment classification – codification for break downs – preparation of work orders and job schedules – follow up and documentation – material management module**. Maintenance Effectiveness and performance evaluation:** Analysis of maintenance performance. Reference indices, Maintenance productivity measurement - Performance measuring parameters - Maintenance Audit.

**Reference Books**


1. Sushil Kumar Srivastava, "Industrial Maintenance Management", S.Chand and Company Ltd., 2005.
2. Anteny Kelly , "Strategic Maintenance planning", Butterworth-Heinemann, 2006.
3. Gopalakrishnan, P. Banerji, A.K, "Maintenance and Spare Parts Management", Prentice Hall of India, 1991.
4. A.K.S.Jardine and A.H.C. Tsang, "Maintenance, replacement, and reliability: theory and applications", CRC/Taylor & Francis, 2006.
5. L.S.Srinath, "Reliability Engineering", 4th Edition, Affiliated East West Press. New Delhi 2005.
6. C. Balagurus amy, "Reliability Engineering", Tata McGraw Hill Pvt. Ltd. 2003.
7. A.K. Gupta, "Reliability & Tero Technology", Macmillan India Ltd., 2004.


**Course Contents and Lecture schedule**

| S.No | Topics | No. of Lectures |
|---|---|---|
| **1.0** | **Maintenance** | |
| 1.1 | Objectives and Functions, Concepts and Nature of Maintenance | 1 |

| S.No | Topics | No. of Lectures |
|---|---|---|
| 1.2 | Tero Technology, 5 Zero concepts | 1 |
| 1.3 | Reliability Based Maintenance (RBM), Creative Maintenance(CM) | 1 |
| 1.4 | Maintenance and Profitability – Quality, Reliability and Maintainability (QRM) | 1 |
| 1.5 | Productivity, Qua lity 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 | 2 |

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

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| Sub code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LEG/ WEG | 4 | 0 | - | 4 |

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

**Preamble**

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

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

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

**Competencies**

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Understand**

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

**Apply**

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor. Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm.b F-Stop is 8, and there are 16 grey level and 30 images / second. Object dimensions are 7.5 X 7.5 X 1.2 cm. The object occupies 50% of sensor array.
4. A surveillance camera is embedded in one of the walls of a room as shown in figure. The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is .0 5m.The X -Z plane of the camera is parallel to the X-Y Plane of the world coordinate system. The

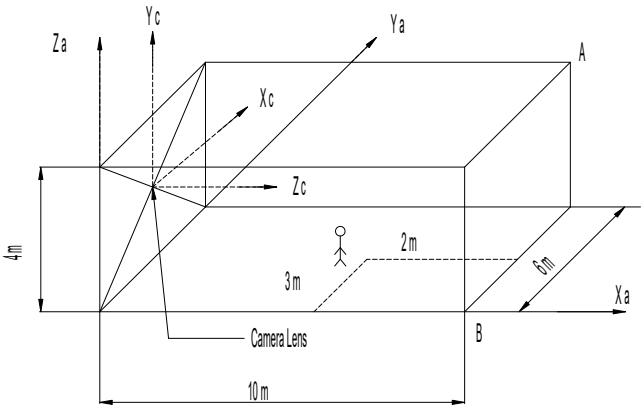
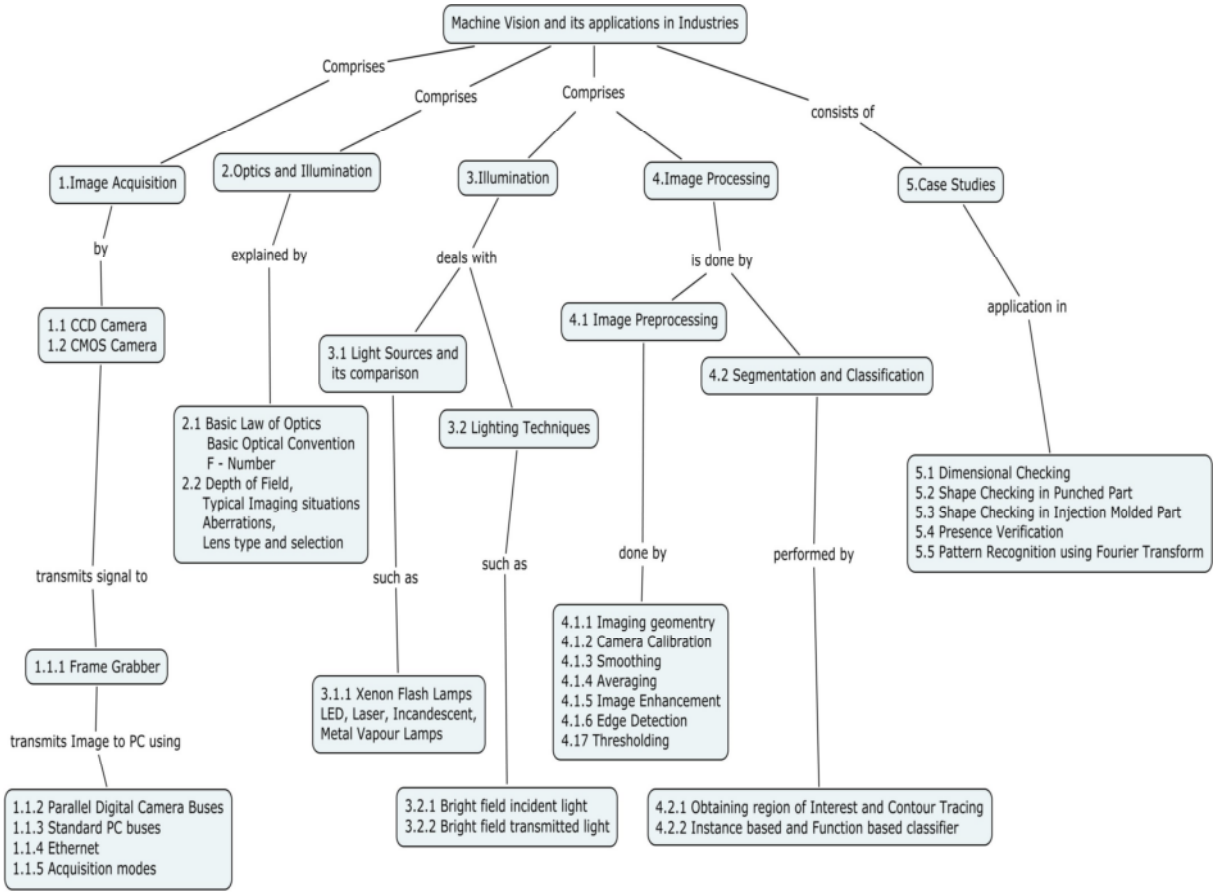


image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner as shown in Figure.

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

**Concept Map**




**Syllabus**

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

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

**Reference B ooks**

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

**Course contents and Lecture Schedule**

| S.No. | Topics | No. of Lectur es |
|---|---|---|
| **1** | **IMAGE ACQUI SITION** | |
| 1 | Photo Det ection, CCD Array Operation | 2 |
| 1.1 | CCD Array Architecture, Charge Conversion, Dark Current. Types of CCD Camera. | 2 |

| S.No. | Topics | No. of Lectures |
|---|---|---|
| 1.2 | CMOS Camera. | 1 |
| 1.1 | Camera Computer Interfaces: Introduction, Analog Camera Buses, Analog Camera Signal, Interlaced Video, Progressive Scan Video, Timing Signals, Analog Image Acquisition, S-Video, Analog connectors | 1 |
| 1.1.1 | Basic Operation of Frame Grabber. | 1 |
| 1.1.1 | Parallel Digital Camera Buses: Digital Video Transmission, Taps, Differential Signaling, Line Scan, Parallel Digital Connectors, camera link, camera link signals, Camera link connectors, | 1 |
| 1.1.3,1.1.4 1.1.5 | Standard PC Buses: USB, IEEE 1394 Gigabit Ethernet. Choosing a Camera Bus. | 2 |
| 1.3 | Acquisition mode: Snap, Grab, Sequence, Ring. | 1 |
| 1.4 | Image Representation, Image Representation in Memory. | 1 |
| **2** | **OPTICS AND ILLUMINATION** | |
| 2.1 | Basic Laws of Geometrical optics. Basic optical conventions. F-Number. | 1 |
| 2.2 | Depth of field, Typical imaging situations. Aberrations, Lens types and selection. | 1 |
| 2.3 | Thin lens imaging equation, image resolution. | 1 |
| 3.0 | **Illumination Technology:**Demands on Machine Vision Lighting. **Light Sources:** Incandescent Lamps, Metal vapour lamps. | 1 |
| 3.1.3,3.1.4 ,3.1.5 | Xenon lamps,Fluorescent lamps,LEDs,Lasers. Light Source comparison. Light Filter-introduction | 1 |
| 3.2 | **Lighting Techniques**: Diffuse Bright Field Incident Light, Directed Bright Field Incident Light. | 1 |
| 3.2.1 | Telecentric Bright Field Incident Light, Structured bright field incident light. Diffuse/directed Dark field Incident Light, Limits of incident lighting, Diffuse Bright field Transmitted lighting, | 2 |
| 3.2.2 | Directed Bright Field Transmitted Light, Tele centric Bright Field Transmitted Light. Diffuse/Directed Transmitted Dark field Light. | 2 |
| 4.1 | **IMAGE PRE PROCESSING** | |
| 4.1.1 | Imaging geometry-Basic Transform ations, Camera Model. | 1 |
| 4.2.3 | Camera Calibration. | 1 |
| 4.1.2, | Preprocessing -Spatial Domain Methods, SmoothingNeighborhood | 2 |

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

**Course Designers**

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

## LEH/ WEH System Simulation 4 :0

**Preamble**

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

**Competencies**

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

a. understand the concepts, types and applications of simulation, steps in simulation study.

b. understand how computer simulation can be used to model complex systems and solve related decision problems.

c. understand the assumptions made in building a discrete event simulation.

d. understand and apply statistical methods used in simulation analysis.

e. learn the techniques of random number generator, testing of random numbers, evaluate generator in a given application, and how to use those generators to phenomena of interest.

f. learn to design a computer simulation, conduct input modeling validation, and output analysis.

g. run a simulation project from start to finish.

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

1. Define Endogenous and Exogenous events.
2. List the tests that are used to validate the properties of random numbers.
3. What are the parameters for the following distributions?
   a) Gamma distribution b) Normal distribution
4. What is the purpose of Output analysis?
5. Give the Test statistic of Chi-square test of Goodness of fit.
6. List a few simulation languages.

**Understand**

1. Draw a flow chart which represents the various steps involved in the simulation process
2. Develop an Acceptance-Rejection technique for generating a Poisson random variable with mean $a = 0.2$
3. Develop a random variate generator for exponential distribution.
4 Mention the factors that are to be considered in selecting a simulation language for a particular application.
5. Considering an Engineering educational system, identify the entities, attributes, and activities of the system.
6. Describe and explain the properties of linear models.
7. What are the steps in the development of a model of input data? Explain.
8. Mention the factors that are to be considered in selecting a simulation language for a particular application.

**Apply**

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

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

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

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

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

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

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

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

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

Determine the estimators for normal distribution.

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

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

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

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

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

Determine the maximum likelihood estimators of the gamma distribution?

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

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

10. A tool crib has exponential inter-arrival and service times and serves a very large group of mechanics. The mean time between arrivals is 4 minutes. It takes 3 minutes on the average for a tool crib attendant to serve a mechanic. The attendant is paid Rs. 40 per hour and the mechanic is paid Rs. 60 per hour. Would it be advisable to have a second tool crib attendant?

## Concept Map


System Simulation
Simulation 1.1
Involves
What is Simulation
When is Simulation appropriate
When is Simulation not appropriate
Advantages and disadvantages
Areas of application
Consist of
Simulation Vs Analytical methds
Examples of Simulation System
- Queuing system
- Inventory system
- Manufacturing plant
- Supply chain management
Steps in Simulation study
Discrete Event Simulation3
Types ofSimulation Models
Static Vs Dynamic
Deterministic Vs Stochastic
Discrete Vs Continuous
Discrete time simulation
Time stepped
Event stepped
On simulating randomness
Use of random numbers
Computer simulation
Random number generator
Random variate generator
Inverse transform
Exponential
Uniform
Weibull
- Triangular
- Empirical
Discrete distributions
Convolution
Accept-Reject
PoissonGamma
Direct transform
Normal distribution
Simulation software
History
Selection Process
Simulation Packages
- GPSS
- ARENA
- PROMODEL
Future trends
Analysis of simulation data
Input Modeling
Data collection
Identifying the distribution with data
Histograms
Selecting the family of distributions
Q-Q Plots
Parameter estimation
Preliminary statistics : Sample mean, sample variance
Suggested estimators
Poisson , Uniform, Normal, Gamma, Exponential, Weibull distribution
Goodness of fit tests
Chi-square test
Chi-square test with equal probabilites
Kolmogrov - Smirnov test
Selecting input model with out data
Verification and Validation Of simulation models
Model building, Verification and Validation,
Verification of Simulation Models
Calibration and Validation of Model
- Face validity
- Validation of model assumptions
- Validating input-output transformations
- Input-output validation: using historical input data
Using a Turing test
Output analysis
Types of simulation with respect to output Analysis
Stochastic nature of output data
Measures of Performance
Output analysis for Terminating simulations
Output analysis for steady state simulations
System models 2
System modeling
Concept of a system
Components
State of a system
Environment
Discrete, continuous
Model of a system
Characterizing a
Simulation model
System studies
Subsystems
Corporate Mode
- Distributed lag Models
- Cob-Web Models
Types
Types of Model
Physical
Static
Dynamic
Linear Model
Non-linear Model
Mathematical
Static
Dynamic
Principles used in Modeling
System Analysis
System design
System postulation
Random numbers in Simulation Pseudo random Numbers Properties
Deviation from true Randomness
Generator
Historical interest
Linear congruential
Combined multiple recursive
Testing
Test for Frequency
Test for Independence
Kolmogrov-Smirnov Chi-square
Runs test
Autocorrelation
Gap test Poker test

**Syllabus Simulation**– Nature of simulation, Systems, Models and Simulation- Advantages and disadvantages, Areas of application – Simulation Vs Analytical methods- Monte Carlo simulation - Statistical models in simulation– discrete and continuous distributions - Examples of simulation systems – Queuing, Inventory, manufacturing plant – Steps in simulation study. **System Models** –Concept of a system, Components, State of a system, System environment, Discrete and continuous systems- Model of a system – Characterizing a simulation model –**Types of model** – Physical, Mathematical –Static, Dynamic –Linear and Nonlinear models – Principles used in Modeling– **System studies** – Sub-systems, Corporate Model – Distributed lag model, Cobweb Model –System analysis, system Design , System Postulation**Discrete Event Simulation** –**Types of Simulation Models** – Discrete time simulation – Time stepped, Event stepped – Use of Random numbers – Computer simulation. **Random number** – Properties – Generator – Linear Congruential method, combined multiple recursive method – Tests for Frequency – Tests for independence. **Random Variate generator** – Inverse transform technique – Exponential, uniform, Weibull, Triangular distributions, Direct transform for normal distribution - Acceptance - Rejection technique convolution method. **Input Modeling** – Data collection, Selecting the family of distributions, Parameter estimation –Sample mean, sample variance, suggested estimators – Poisson, Uniform, Normal, Gamma, and Weibull distributions - Goodness of Fit Tests– Chisquare, Kolmogorov-Smirnov tests - Selecting input Model with out data. **Verification and Validation** – Model building, Verification of Simulation Models - Calibration and Validation of Models – Validation of existing systems, validation of hypothetical systems –Face validity, model assumptions, input-output transformations -Historical data, Turing test. **Output Analysis** – Stochastic nature of output data – Checking for normality – Shapiro –Wilk Test, q -q plot - Types of simulation with respect to output Analysis, Stochastic nature of output data, Measure of Performance, Output Analysis for Termination Simulations, Output Analysis for steady -state simulations. **Simulation Packages** – History, Comparison of simulation packages with programming languages, Selection Process, Simulation Packages (GPSS, ARENA, PROMODEL)*- Simulation of queuing systems, Inventory systems and Manufacturing systems.

**Reference books**


1. Jerry Banks, John S.Carson, Barry L.Nelson, David M. Nicol P.Shahabudeen" Discrete – Event System Simulation "Pearson Edition, 2008
2. Geoffrey Gordon, "System Simulation " Prentice Hall of India, New Delhi, 1996
3. Averill M Law, "Simulation Modeling and Analysis" Tata McGraw-Hill Publishing company Limited, New Delhi, Fourth edition,2008.
4. Narsingh Deo, "System Simulation with digital computer ", Prentice Hall of India, New Delhi, 1997

**Course Contents and Lecture Schedule**

| No | Topic | No. of hours |
|---|---|---|
| 1 | Simulation | |
| 1.1 | Nature of Simulation, Systems, Models, and Simulation, When is simulation appropriate, not appropriate, Advantages and disadvantages, Areas of application, Simulation Vs analytical methods, | 2 |
| 1.2 | Monte-Carlo simulation -Examples of Simulation systems Queuing System, Inventory System, Manufacturing Plant | 2 |
| 1.3 | Steps in Simulation study | 1 |
| 2 | System Models | |
| 2.1.1 | Concept of a System ,Components, State of a System, System Environment, Discrete and Continuous systems | 1 |
| 2.1.2 | Model of a system | 1 |
| 2.1 3 | Characterizing a simulation model | 1 |
| 2.2.1 | Types of Model –Physical, Mathematical- static, dynamic, linear and nonlinear | 2 |
| 2.2.1 | Principles used in modeling | 1 |
| 2.3.1 | System studies – Subsystems, Corporate Model, Distributed Lag Model, Cobweb Model | 2 |
| 2.3.2 | System Analysis, System Design, System Postulation | 1 |
| 3 | Discrete event Simulation | |
| 3.1.1 | Types of Simulation Models – Static Vs Dynamic, Deterministic Vs Stochastic, Discrete Vs Continuous | 1 |
| 3.1.2 | Discrete time Simulation – Time stepped, Eve nt 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, Unif orm, 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 distributio ns | 2 |

| | | |
|---|---|---|
| 3.4.1.2 | Input modeling – Parameter estimation – sample mean, sample variance, suggested estimators – Poisson, Exponential, Uniform, Normal, Gamma, and weibull distributions | 2 |
| 3.4.1.3 | Goodness of Fit Tests – Chisquare and Kolmogorov tests | 2 |
| 3.4.1.4 | Selecting input model without data | 1 |
| 3.4.2.1 | Verification and Validation –Model building, Calibration and validation of Models –Validation of existing systems, Validation of hypothetical systems – Face validity | 2 |
| 3.4.2.2 | Model assumptions, Input-output t ransformations –Historical data, Turing Test | 2 |
| 3.4.3.1 | Output analysis – stochastic nature of output data – Checking for normality –Shapiro Wilk Test, q-q plot - Types of simulation with respect to output Analysis, Stochastic nature of output data, Measure of Performance, Output Analysis for Termination Simulations, Output Analysis for steady -state simulations. | 4 |
| 3.5 | Simulation Packages | |
| 3.5.1 | History | 1 |
| 3.5.2 | Selection of Simulation software -example | 1 |
| 3.5.3 | Simulation in GPSS / ARENA / PROMODEL * – Queuing problem, Inventory Problem , Manufacturing Problem | 5 |
| | Total | 47 |

**Course Designers**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| **LEJ/ WEJ** | 4 | - | - | 4 |

## LEJ/ WEJ -Product Design and Development 4:0

**Preamble**

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

**Competencies**

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

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

**Assessment pattern**

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

**Course level learning objectives**

**Remember**

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

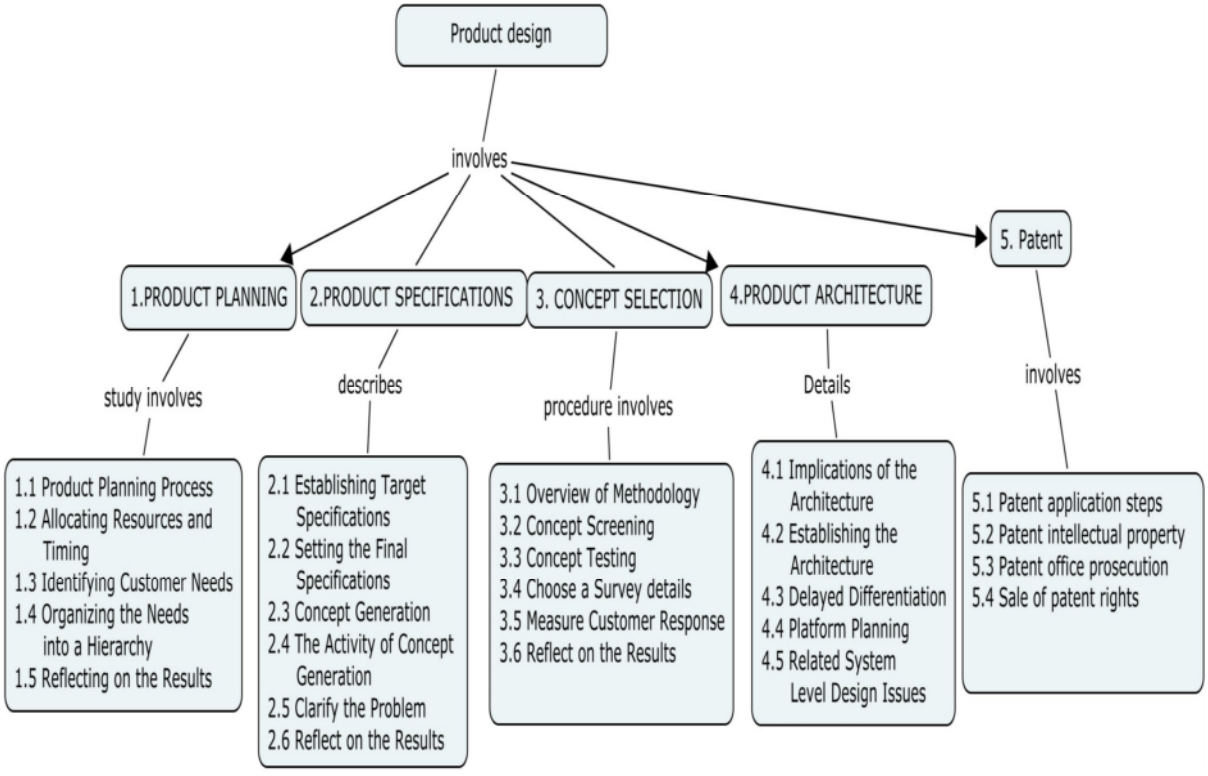
**Understand**

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

**Apply**

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

**Concept Map**



**Syllabus**

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

**Reference Books**

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

**Course content and lecture schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| **1** | **PRODUCT PLANNING** | |
| 1.1 | Product Planning Process - Identify Opportunities | 1 |
| 1.1.1 | Evaluating and Prioritizing Projects | 1 |
| 1.2 | Allocating Resources and Timing | 2 |
| 1.2.1 | Pre-Project Planning -Reflect on the Results and the Process | 2 |
| 1.5 | Identifying Customer Needs- Raw Data from Customers | 2 |
| 1.6 | Interpreting Raw Data in Terms of Customer Needs-Organizing the Needs into a Hierarchy | 2 |
| 1.7 | Organizing the Needs into a Hierarchy -Establishing the Relative Importance of the Needs | 2 |
| 1.7.1 | Case study for motor driven nailer | 2 |
| 1.8 | Reflecting on the Results and the Process | 2 |
| **2** | **PRODUCT SPECIFICATIONS** | |
| | What Are Specifications - When Are Specifications Established | 1 |
| 2.1 | Establishing Target Specifications | 2 |
| 2.1.1 | QFD | 1 |
| 2.2 | Setting the Final Specifications | 1 |
| 2.3 | Concept Generation | 1 |
| 2.4 | The Activity of Concept Generation | 1 |
| 2.5 | Clarify the Problem- Search Externally -Search Internally Explore Systematically | 1 |
| 2.5.1 | Case study for motor driven nailer | 2 |
| 2.6 | Reflect on the Results and the Process Introduction and Classification | 1 |
| **3** | **CONCEPT SELECTION** | |
| 3.1 | Overview of Methodology | 2 |
| 3.2 | Concept Screening | 1 |
| 3.3 | Concept Testing | 1 |
| 3.3.1 | Define the Purpose of the Concept Test | 1 |
| 3.4 | Choose a Survey details | 1 |
| 3.4.1 | Choose a Survey Format | 2 |
| 3.4.2 | Communicate the Concept | 1 |
| 3.5 | Measure Customer Response | 1 |

| | | |
|---|---|---|
| 3.5.1 | Case study for motor driven nailer | 2 |
| 3.6 | Interpret the Results- Reflect on the Results and the Process | 1 |
| **4** | **PRODUCT ARCHITECTURE** | |
| 4.1 | Product Architecture-Implications of the Architecture | 1 |
| 4.2 | Establishing the Architecture- | 1 |
| 4.3 | Delayed Differentiation | 1 |
| 4.4 | Platform Planning | 1 |
| 4.5 | Related System -Level Design Issues | 1 |
| 4.5.1 | Case study for motor driven nailer | 2 |
| **5** | **DESIGN PATENTS** | |
| 5.1 | Patent application steps | 1 |
| 5.2 | Patent intellectual property | 1 |
| 5.3 | Patent office prosecution | 1 |
| 5.4 | Sale of patent rights | 1 |
| | | 50 |

**Course Designers**

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

## LEL/ WEL Robust Design 3:1

**Preamble**

Robust Design is a proven development philosophy focused on achieving target reliability. Approachi ng this aggressive goal requires that Robust Design principles be an early and integral part of the development cycle. The objective is to make the end-product immune to factors that could adversely affect performance. Robust Design requires that the follo wing four factors be considered in the design process: signal, response, noise, and control. Noise factors are disturbances that cause the systems response to shift from specification. These factors are likely beyond the designer's control, such as manufacturing tolerances, aging, usage patterns, environmental conditions, etc. Noise factors must be identified and quantified so that accurate choices can be made about which effects require compensation. Control factors are used by the designer to compensate for noise factors that could significantly influence the system away from nominal performance. Once the critical noise factors are identified and the control factors selected, a Robust Design flow is used to implement and analyze the design to ensure system reliability. The objective of a Robust Design flow is to meet performance requirements with the highest possible system reliability and the most reasonable systems cost.

**Competencies**

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

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

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

1. Cite the unbalanced data in DOE?
2. What is fixed effect model?
3. What do you mean by Hypothesis?
4. State the advantages of Confounding?
5. Plot a sample linear graph
6. Plot the taguchi's quality curve.
7. What is Random effect model?
8. When do we go for 3k factorial design?
9. What is effect of coding in one way ANOVA?
10. List out the nuisance factors in an experiment

**Understand**

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

**Apply**

1. The comp ressive 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 t he hypothesis that mixing us techniques affect the strength of the concrete. Use = 0.5

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

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

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

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

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

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

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

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

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

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

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

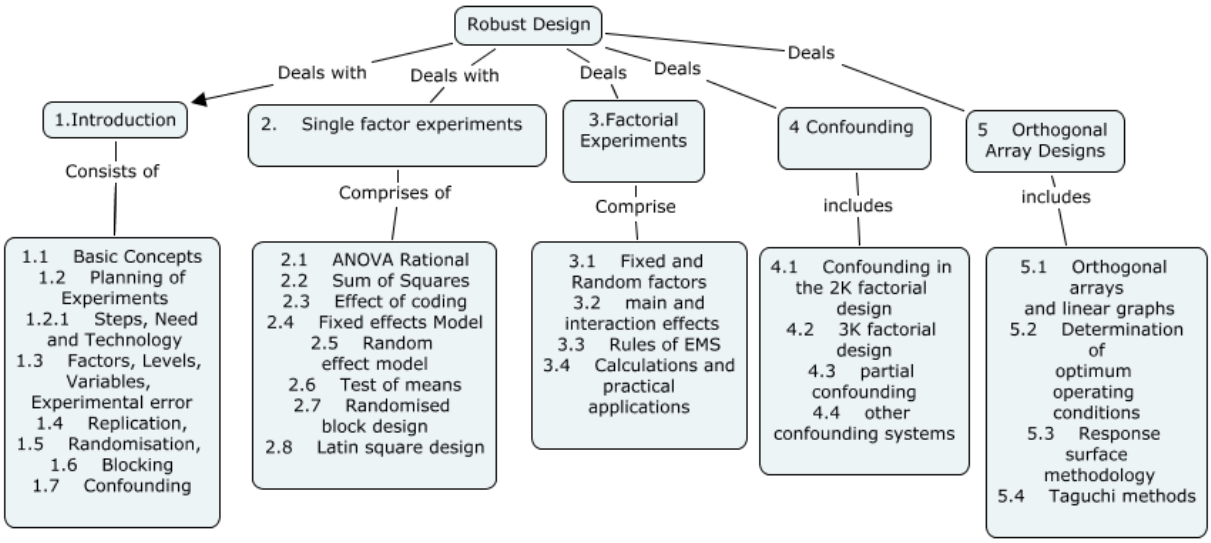
Analyse this experiment assuming that each one of the four replicates represents a block.

6. An experiment to investigate the effect of glass type and phosphor type on the brightness of a television tube. The response measured is the current necessary in microamps to

obtain a specified brightness level. The data are shown here. Analyse the data and draw conclusions. [15]

| Glass Type | Phosphor type | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | 280<br>290 | 300<br>310 | 290<br>285 |
| 2 | 230<br>235 | 260<br>240 | 220<br>225 |

**Concept Map**




**Syllabus**

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

**Reference Books**

1. Charles R. Hicks, "Fundamental Concepts in the Design of Experiments", CBS College Publishing, New York, 1982.
2. Douglas C. M ontgomery, "Design and Analysis of Experiments", Second Edition, John Wiley and Sons, New York, 1984.
3. Philips J. Ross, "Taguchi Techniques for Quality Engineering", McGraw Hill, 1988.

**Course Contents and Lecture Schedule**

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

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

**Course Designers**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LEQ | 4 | - | - | 4 |

## LEQ Human Resource Management 4:0

**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 successfull accomplishment of said goals. When HRM is properly employed,members of the workforce are expressive of the goals and operating practices of the firm.

**Competencies**

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

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

**Assessment Pattern**

| | Bloom's category | Test 1 | Test 2 | Test 3 / End Semester Examination |
|---|---|---|---|---|
| 1 | Remember | 20 | 20 | 10 |
| 2 | Understand | 40 | 40 | 30 |
| 3 | Apply | 40 | 40 | 60 |
| 4 | Analyze | 0 | 0 | 0 |
| 5 | Evaluate | 0 | 0 | 0 |
| 6 | Create | 0 | 0 | 0 |

**Course level learning objectives**

**Remember**

1. What is HRM?
2. Define work analysis?
3. What do we mean by clerical ability?
4. How compensation is determined?
5. What are bonuses?
6. What do we mean by profit sharing?

**Understand**

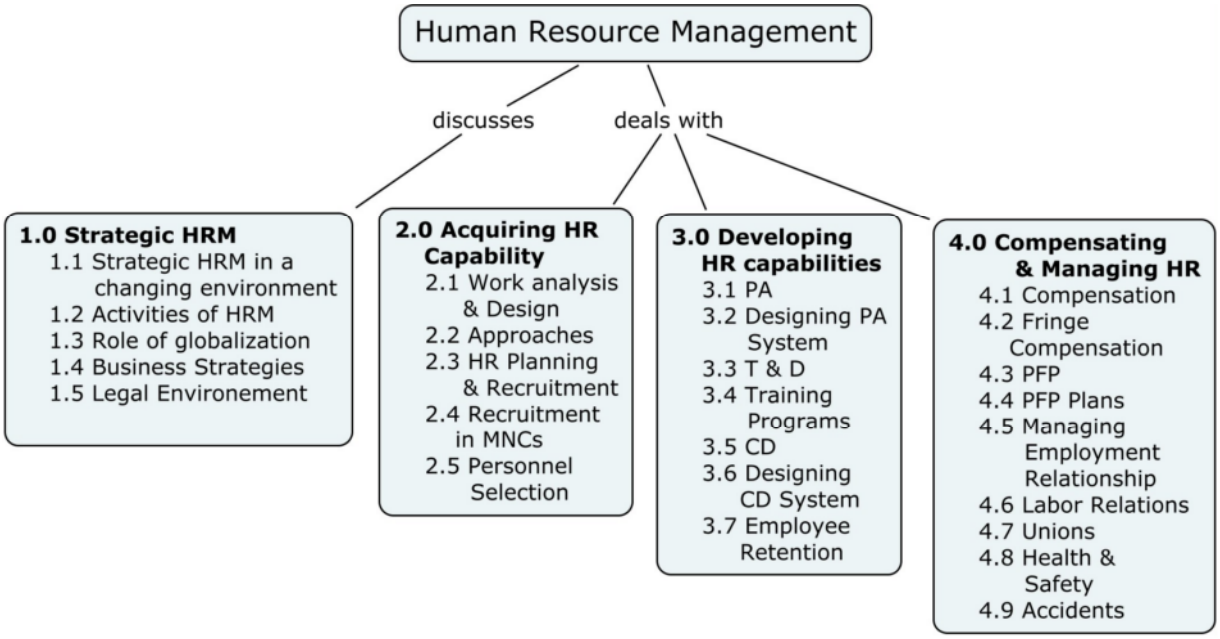
1. Describe the changing status of HRM? What factors have led to these changes?
2. Describe the advantages and disadvantages of using interviews, observations and questionnaires for collecting work analysis.
3. Why is HR Planning an important activity? What are the advantages of effective planning?
4. Why should a training department develop a mission and goals?
5. What is more important for organizational effectiveness – internal equity or external equity? Explain.
6. Why is trust so important for PFP systems?

**Apply**

1. Why is the support line of management critical to the effective functioning of HRM? Provide some suggestions to ensure that this support is maintained.
2. How do HR planning and recruitment complements each other?
3. Describe how an organization might improve the reliability and validity of the interview.
4. Describe a number of ideas for building the motivation of trainees.
5. Some experts argue that a corporation's board of directors should be paid only with stock options. What do you think?

6. How could you as a manager develop a strategy for increasing employees motivation to work more safely?

**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 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 an appraisal system | 2 |
| 3.3 | Training and Development (TD) – Extend of TD – A systems view of training | 2 |

| | | |
|---|---|---|
| 3.4 | Development of Training Programs – Evaluation – Planning for training effectiveness – Special training programs | 2 |
| 3.5 | Career Development (CD) – Implications of work place changes – Importance | 2 |
| 3.6 | Designing CD system – Components of CD system – Career programs for special target groups | 2 |
| 3.7 | Attrition – Employee Retaining Strategies in the current scenario | 2 |
| **4.0** | **Compensatin g 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 a PFP | 2 |
| 4.4 | Individual PFP plans – Group incentive plans – Managerial and executive incentive pay – Managerial implications for PFP | 2 |
| 4.5 | Managing the Employment Relationship – Orga nizational entry – Ongoing relationship – Organizational exit | 2 |
| 4.6 | Labor Relations and Collective Bargaining – Reasons for joining unions – Legal environment 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 De signers**

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# CURRICULUM AND DETAILED SYLLABI

**FOR**

# M.E. DEGREE ( Industrial Engineering) PROGRAM

# THIRD SEMESTER

**FOR THE STUDENTS ADMITTED FROM THE**

**ACADEMIC YEAR 2011-2012 ONWARDS**

**THIAGARAJAR COLLEGE OF ENGINEERING**
(A Government Aided ISO 9001-2000 certified
Autonomous Institution affiliated to Anna University)

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

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

**SUBJECTS OF STUDY**
(For the candidates admitted from 2011-2012 onwards)

**THIRD SEMESTER**

| Subject code | Name of the subject | Category | No. of Hours / Week | | | credits |
|---|---|---|---|---|---|---|
| | | | L | T | P | |
| **THEORY** | | | | | | |
| L31 | Supply Chain Management | DC | 4 | 0 | - | 4 |
| LEX | Elective – V | DE | 4 | 0 | - | 4 |
| LEX | Elective - VI | DE | 4 | 0 | - | 4 |
| **PRACTICAL** | | | | | | |
| L34 | Project Phase I | DC | 0 | 0 | 4 | 4 |
| **Total** | | | | | | **16** |

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

L : Lecture
T : Tutoria l
P : Practical

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**THIRD SEMESTER**

| S.No | Sub. code | Name of the subject | Duration of Terminal Exam. in Hrs. | Marks | | | Minimum Marks for Pass | |
|---|---|---|---|---|---|---|---|---|
| | | | | Continuous Assessment * | Terminal Exam ** | Max. Marks | Terminal Exam | Total |
| **THEORY** | | | | | | | | |
| 1 | L31 | Supply Chain Management | 3 | 50 | 50 | 100 | 25 | 50 |
| 2 | LEX | Elective – V | 3 | 50 | 50 | 100 | 25 | 50 |
| 3 | LEX | Elective - VI | 3 | 50 | 50 | 100 | 25 | 50 |
| **PRACTICAL** | | | | | | | | |
| 4 | L34 | 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. | LEA/WEA | Facilities Plan ning and Layout Design | 4 |
| 2. | LEB/WEB | Sequencing and Scheduling | 4 |
| 3. | LEC/WEC | Materials Management | 4 |
| 4. | L ED/WED | Research Methodology | 4 |
| 5. | LEE/WEE | Total Quality Management | 4 |
| 6. | LEF/WEF | Maintenance Engineering and Management | 4 |
| 7. | LEG /WEG | Machine Vision and its applications in manufacturing | 4 |
| 8. | LEH/WEH | System Simulation | 4 |
| 9. | LEI/WEI | Entrepreneurship Development | 4 |
| 10. | LEJ/WEJ | Product Design and Development | 4 |
| 11. | LEK | Energy Management | 4 |
| 12. | LEL/WEL | Robust Design | 4 |
| 13. | LEM/WEM | Lean and Six Sigma | 4 |
| 14. | LEN/W31 | Computer In tegrated Manufacturing | 4 |
| 15. | LEO | Modeling and Analysis of Manufacturing Systems | 4 |
| 16. | LEP | Logistics and Distribution Management | 4 |
| 17. | LEQ | Human Resource Management | 4 |
| 18. | LER | Value Engineering | 4 |
| 19. | LES | Industrial Instrumentation | 4 |

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

**L31/ WER Supply Chain Management** **4:0**

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

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Understand**

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

**Apply**

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

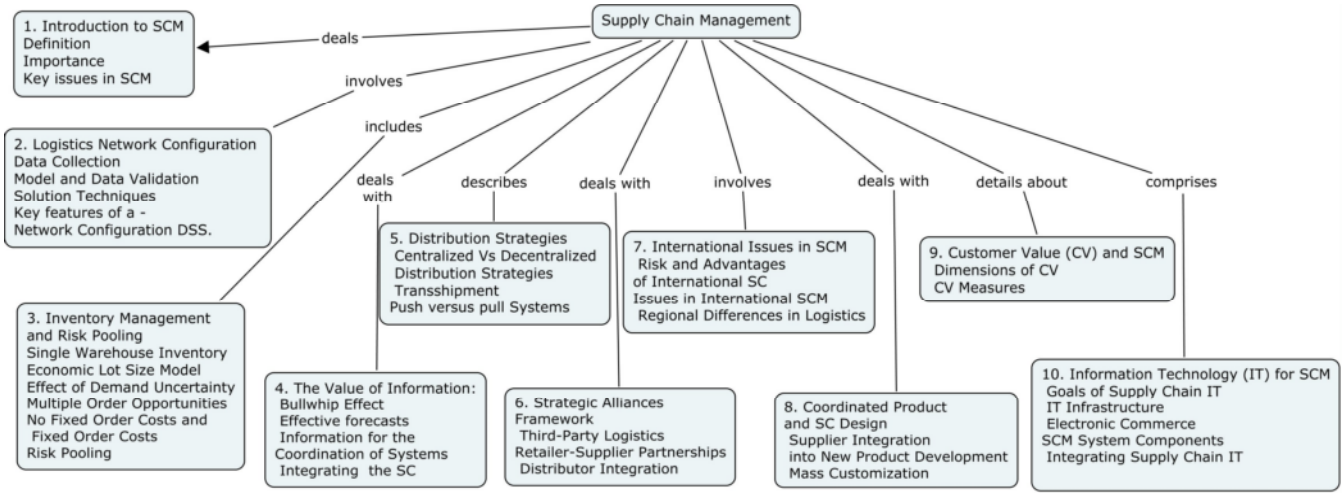
2. A distribution company is involved in the distribution of TV sets. Whenever the distributor places an order for TV sets, there is a fixed cost of Rs2,00,000/- which is independent of the order size.

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

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

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

**Concept Map**




**Syllabus**

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

**Reference Books**

1. Simchi – Levi Davi, Kaminsky Philip and Simchi-Levi Edith, "Designing and Managing the Supply Chain", Tata McGraw Hill Publishing Company Ltd, New Delhi, 2003.
2. Chopra S and Meindl P, "Supply Chain Management: Strategy, Planning, and Operation", Second Edition, Prentice Hall India Pvt. Ltd, New Delhi, 2007.
3. Robert B Handfield and Ernest L Nichols, "Introduction to Supply Chain Management", Prentice Hall, Inc. New Delhi, 1999.
4. Sahay B S, "Supply Chain Management", Macmillan Company, 2000.
5. David Brunt and David Taylor, "Manufacturing Operations and Supply Chain Management : The Lean Approach", Vikas Publishing House, New Delhi, 2001.

**Course Contents and Lecture schedule**

| No. | TOPICS | No. of Lectures |
|---|---|---|
| **1.0** | **Introduction to Supply Chain Management (SCM)** | |
| 1.1 | Definition, Importance | 2 |
| 1.2 | Key issues in SCM | 1 |
| **2.0** | **Logistics Network Configuration** | |
| 2.1 | Data Collection, Model and Data Validation | 2 |
| 2.2 | Solution Techniques and Problems | 2 |
| 2.3 | Key features of a Network Configuration DSS | 1 |
| **3.0** | **Inventory Management and Risk Pooling** | |
| 3.1 | Single Warehouse Inventory - Economic Lot Size Model | 2 |
| 3.2 | Effect of Demand Uncertainty, Multiple Order Opportunities, No Fixed Order Costs and Fixed Order 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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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LEE/WEE | 4 | 0 | - | 4 |

## LEE/ WEE Total Quality Management 4:0

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

**Competencies :**

At the end of the course students should be able to

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Understand**

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

**Apply**

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

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

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

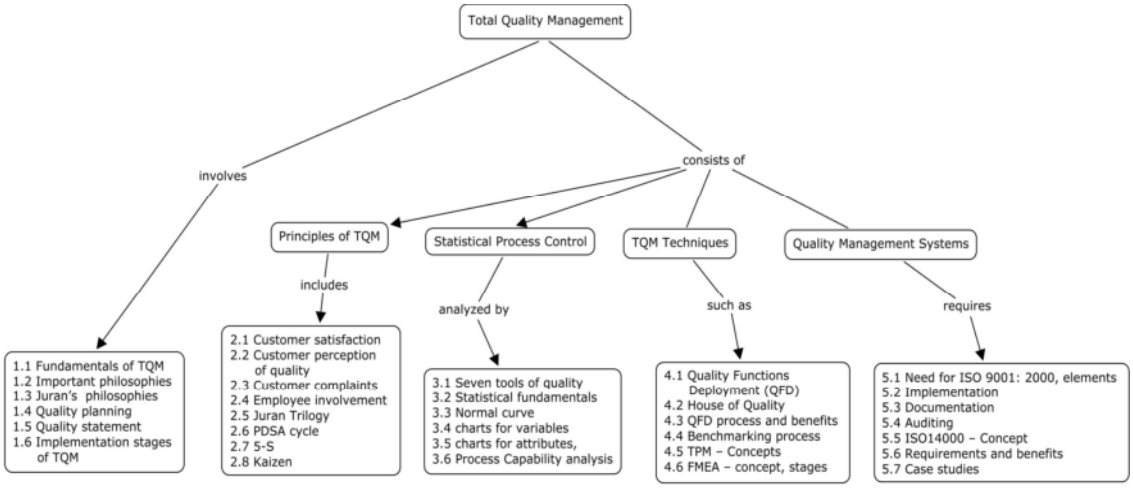
2. The following observations are made in a crankshaft machining process.

| Sample No. | Observations | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | 20.21 | 20.19 | 20.25 | 20. 15 |
| 2 | 20.24 | 20.19 | 20.23 | 20.17 |
| 3 | 20.17 | 20.16 | 20.20 | 20.18 |
| 4 | 20.10 | 20.14 | 20.18 | 20.09 |
| 5 | 20.04 | 20.03 | 20.05 | 19.97 |
| 6 | 20.04 | 19.97 | 19.99 | 20.01 |
| 7 | 20.09 | 20.05 | 20.00 | 20.03 |
| 8 | 19.99 | 19.98 | 20.01 | 19.97 |

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

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

**Concept Map**




**Syllabus**

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

**Reference Books:**

1. Shridhara Bhat, "**TQM – Text & Cases**", Himalaya publishing House, 2002.
2. Berk, Joseph and Berk, S., "**The Essence of TQM**", Prentice Hall of India, 1998.
3. Narayana and Sreenivasan, "**Quality Management – Concepts & Tasks**", New Age International, 1996.
4. Sharma, D.D, "**Total Quality Management**", Sultan Chand & Sons, 2005.
5. Dale H.Besterfiled, Carol Besterfiled-Michna. Glen H. Beseterfiled and Mary Besterfield-Sacre., "**Total Quality Management**", Pearson Education Asia, 2004.

**Course contents and Lecture schedule**

| No | Topics | No. of Lectures |
|---|---|---|
| 1 | **Introduction** | |
| 1.1 | Fundamentals of TQM – Historical developments | 2 |
| 1.2 | Important philosophies - (Deming, Crossby) & their impact of quality | 2 |
| 1.3 | Juran's philosophies and its impact of quality | 2 |
| 1.4 | Quality planning, | 1 |
| 1.5 | Quality statement | 1 |
| 1.6 | TQM implementation Stages | 2 |
| 2 | **Principles of TQM** | |
| 2.1 | Customer satisfaction | 1 |
| 2.2 | Customer perception of quality | 1 |
| 2.3 | Customer complaints | 2 |
| 2.4 | Employee involvement | 1 |
| 2.5 | Juran Trilogy | 2 |
| 2.6 | PDSA cycle | 1 |
| 2.7 | 5S | 1 |
| 2.8 | Kaizen | 1 |
| 3 | **Process Monitoring** | |
| 3.1 | Seven tools of quality | 2 |
| 3.2 | Statistical fundamentals | 1 |
| 3.3 | Normal curve | 1 |
| 3.4 | Charts for variables | 2 |
| 3.5 | Charts for attributes | 2 |
| 3.6 | Process Capability analysis | 2 |
| 4 | **TQM Techniques** | |

| No | Topics | No. of Lectures |
|---|---|---|
| 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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S. Karthikeyan skarthikeyanlme@tce.edu

| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LEK | 4 | 0 | - | 4 |

## LEK Energy Systems 4:0

**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 potentia l 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.

## Competencies:

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

1. Demonstrate the basic concepts of energy planning, management and conservation opportunities in various energy sectors.
2. Understand the basics of energy conservation method and the associated economical benefits.
3. Understand the significance of energy auditing and its benefits.
4. Apply thermal engineering basics in energy conversion systems.
5. Demonstrate an understanding of the importance of energy awareness programmes.
6. Demonstrate the opportunities of energy saving and conservation methods in various types of industries.

## Assessmen t Pattern

| | Bloom's Category | Test 1 | Test 2 | Test3/End -semester examination |
|---|---|---|---|---|
| 1 | Remember | 20 | 20 | 20 |
| 2 | Understand | 40 | 40 | 40 |
| 3 | Apply | 40 | 40 | 40 |
| 4 | Analyze | 0 | 0 | 0 |
| 5 | Evaluate | 0 | 0 | 0 |
| 6 | Create | 0 | 0 | 0 |

## Course level learning objectives

### Remember:

1. What is per capita energy consumption?
2. What is energy strategy?
3. What is combined cycle? State its advantages.
4. Differentiate energy saving and energy conservation.
5. What is cogeneration?
6. What is fluidized bed combustion?

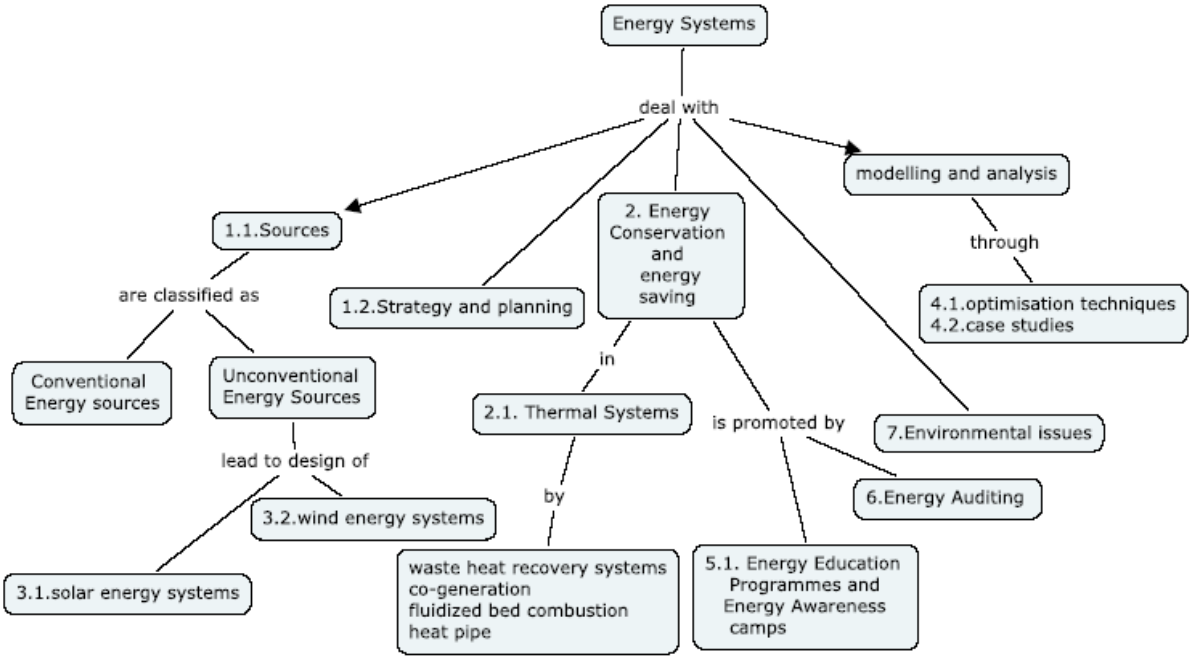
### Understand:

1. Explain the various energy management techniques in detail.
2. Discuss in detail the energy scenario in India.
3. Explain the steps involved in energy auditing of an organization.
4. Explain the energy conservation possibilities in sugar industry.
5. With neat sketches, explain the different methods of co-generat ion in power plants.
6. Describe the various non-conventional energy sources and their potential in meeting the demands in India.

### Apply:

1. Propose the sources of energy for the future, taking into account the current national and global energy scenario.
2. Illustr ate the possible ways of energy conservation and energy saving in domestic energy consumption.
3. Illustrate the opportunities of energy saving and conservation methods in cement industry.
4. Schedule an energy awareness programme or camp on energy conservation for schools and rural people. Demonstrate the possible outcomes and difficulties you may encounter.
5. Suggest energy saving and energy conservation techniques or methods to adopt in transport sector.
6. Demonstrate how instruments can play in the energy conservation in industries.

## Concept Map




## Syllabus:

**Introduction - Energy Sources – scenario -**Conventional and Unconventional energy sources - Indian Scenario & Global Scenario , Energy Units.**Energy strategy** - National energy strategy of India and energy planning / energy management techniques. **Energy Conservation and energy saving -** Energy conservation in Thermal Systems (Waste heat recovery systems, Co-generation, Combined cycle – Types, Fluidized bed combustion, Heat pipe). **Renewable energy systems -** Solar energy (solar thermal flat plate collectors, concentrating collectors, applications - heating, cooling, desalination, power generation, drying, cooking), Wind energy (classification, factors influencing wind - wind shear, turbulence, wind speed monitoring, Betz limit, Aerodynamics of wind turbine rotor- site selection - wind resource assessment- wind energy conversion devices). **Energy Systems Modeling and Analysis -** Optimization Techniques – Objectives, constraints, problem formulation, unconstrained problems, necessary and sufficiency conditions, Constrained optimization, Case studies of optimization in Energy systems, problems dealing with uncertainty, probabilistic techniques, Trade-offs between capital and energy using Pinch analysis. **Energy E ducation**- Energy education programmes**,** Energy conservation awareness camps. **Energy Audit -** Purpose of energy audit, Types, Methodologies, Energy Audit Questionnaire, Challenges with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries. **Environmental Issues -** Air and water pollution,

standardization, methods of control. Environmental Air and water pollution, acid rains, thermal pollution – radioactive legislations/ Government policies.

## Course contents and Lecture schedule

| No. | Topics | No. of Lectures |
|---|---|---|
| **1** | **Introduction** | |
| 1.1 | **Energy Sources - scenario** | |
| 1.1.1 | Conventional and Unconventional energy sources - Indian Scenario & Global Scenario , Energy Units | 2 |
| 1.2 | ***Energy strategy*** | |
| 1.2.1 | National energy strategy of India and energy planning / energy management techniques | 2 |
| **2** | **Energy Conservation and energy saving** | |
| 2.1 | Energy conservation in Thermal Systems (Waste heat recovery systems, Co-generation, Combined cycle – Types, Fluidized bed combustion, Heat pipe) | 8 |
| **3** | **Renewab le energy systems** | |
| 3.1 | Solar energy ( solar thermal flat plate collectors, concentrating collectors, applications - heating, cooling, desalination, power generation, drying, cooking) | 6 |
| 3.2 | Wind energy ( classification, factors influencing wind wind shea r, turbulence, wind speed monitoring, Betz limit, Aerodynamics of wind turbine rotor- site selection - wind resource assessment - wind energy conversion devices) | 6 |
| **4** | **Energy Systems Modeling and Analysis** | |
| 4.1 | Optimization Techniques – Objectives, constraints, problem formulation, unconstrained problems, necessary and sufficiency conditions, Constrained optimization | 4 |
| 4.2 | Case studies of optimization in Energy systems, problems dealing with uncertainty, probabilistic techniques, Trade-offs between capital and energy using Pinch analysis. | 4 |
| **5** | ***Energy Education*** | |
| 5.1 | *Energy education programmes, Energy conservation* | 2 |

| No. | Topics | No. of Lectures |
|---|---|---|
| | *awareness camps* | |
| **6** | **Energy Audit** | |
| 6.1 | Purpose of energy audit, Types, Methodologies, Energy Audit Questionnaire | 2 |
| 6.2 | Challenges with respect to Process Industries, Power Plants, Boilers and Certain Energy Intensive Industries | 1 |
| **7** | **Environmental Issues** | |
| 7.1 | Air and water pollution, standardization, methods of control. Environmental Air and water pollution, acid rains, thermal pollution – radioactive legislations/ Government policies. | 3 |
| | **Total Hours** | **40** |

## Reference Books


1. Murphy W.R., Mckay G., "**Energy Management"**, Butterworth and Co. Publishers Ltd., 2001.
2. Rao S., Parulekar B.B., "**Energy Technology"**, Khanna Publishers, Delhi, 1995.
3. Arora, an d Domkundwar**A Course in Power Plant Engineering"**, Dhanpat Rai & Co., Delhi, 1998.
4. Confederation of Indian Industry, **"Energy Conservation Case Study Booklet",** Chennai, 1998.
5. Sukhatme S P, **Solar Energy**, Tata McGraw Hill, 1984.
6. Freris, L.L., **Wind Energy Conversion Systems**, Prentice Hall, 1990.
7. Meier, P., **Energy Systems Analysis for Developing Countries**, Springer Verlag, 1984.


## Course Designer:

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

## LEN/ W31 Computer Integrated Manufacturing 4:0

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

**Competencies :**

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

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

**Assessment Pattern**

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

**Course level learning objectives under each bloom's category**

**Remember**

1. Identify the different elements of CIM.
2. List out the a dvantages of CNC machine tools.
3. Write down the implementation issues of CIM.

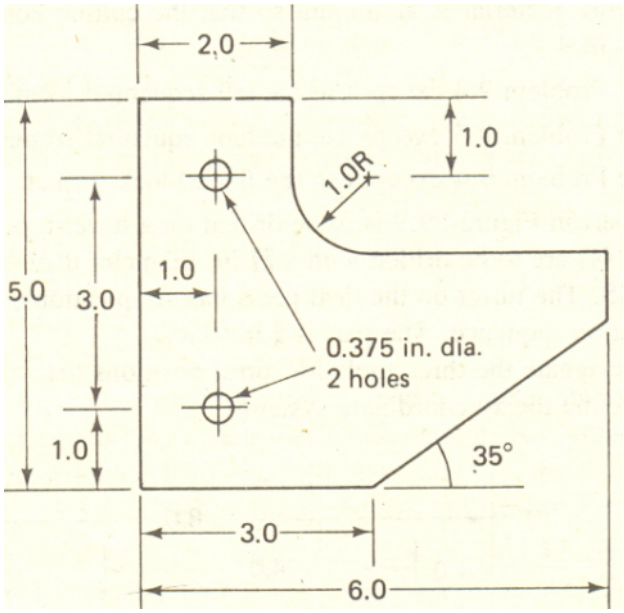
4. Quote the benefits of CAD process.
5. Write down the inputs of MRP.
6. What is capacity planning?

**Understand**

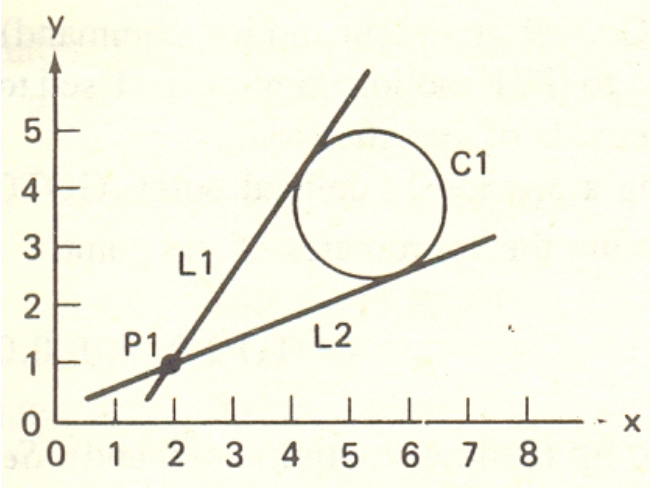
1. Describe the manufacturing automation protocol.
2. Describe the evolution of graphics standard.
3. Discuss about the different topologies of LAN.
4. Explain the concept of Generative type CAPP.
5. Describe the bar code technique briefly.
6. Describe the fundamentals of lean manufacturing.

**Apply**

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

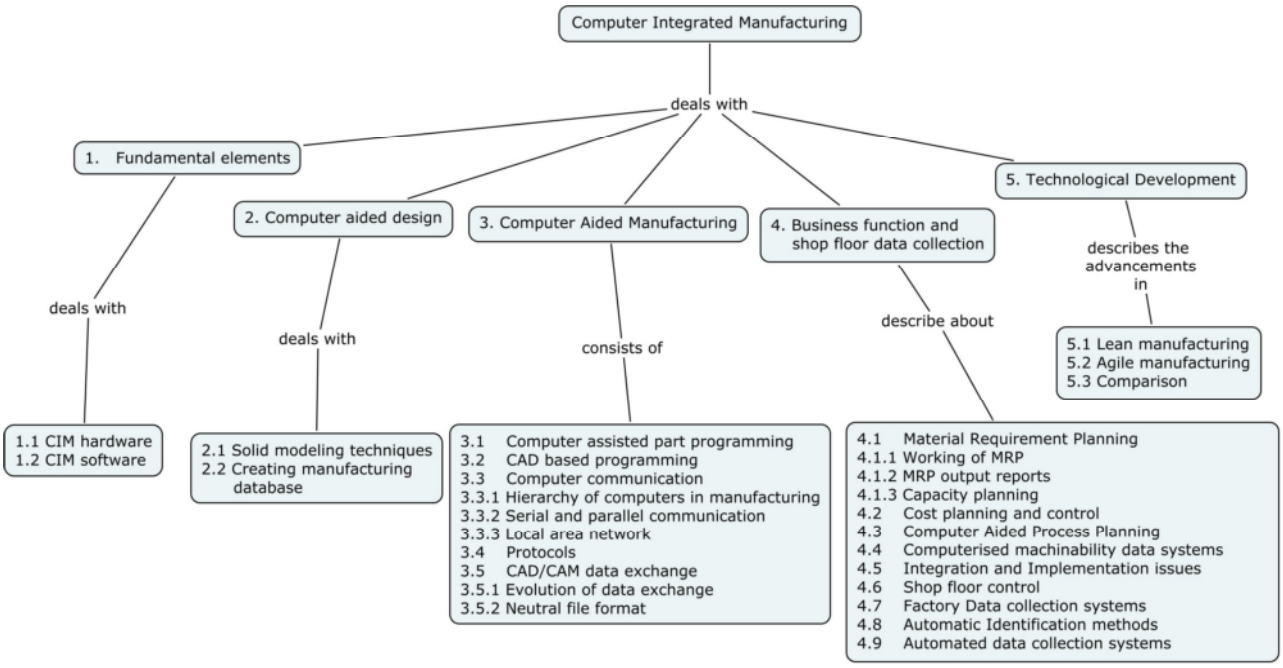



2. Develop IGES neutral format for circle of radius 20 mm with centre (10, 5, 0) and a straight line with two ends (0, 0) and (15, 25).
3. Develop DXF neutral format for a point located at (10, 2, 8) and circle of diameter 40 mm w ith (0, 0, 0) as centre.
4. Design and draw a bar code for representing 8 bit data of (1000 1010) based on AIM USD-2 standard.
5. Write an APT codes for describing lines 1 and 2 shown in the following figure.




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

**Concept map**




**Syllabus**

**Fundamentals Elements:** Nature of CIM, Evolution of CIM, CIM hardware and software. **Computer Aided Design:** Design process, solid modeling techniques, creating manufacturing database. **Computer Aided Manufacturing:** Elements of CNC machine tools, Computer assisted part programming–APT language, CAD based programming, Computer Communication -Hierarchy of computers in manufacturing,Serial and parallel communication, Local area network, Protocols -Manufacturing Automation Protocol and Technical Office Protocol , CAD/CAM data exchange-Method of data exchange, Evolution of data exchange, Neutral file format-DXF, IGES and PDES. **Business function and shop floor data**

**collect ion:** Material Requirement Planning-Inputs to MRP, Working of MRP, MRP output reports, Capacity Planning, Cost planning and control, Computer Aided Process Planning-Retrieval type and Generative type CAPP, Benefits of CAPP, Computerised machinability data systems, Integration and Implementation issues, Shop floor control-functions, information flow, Factory Data collection systems, Automatic Identification methods, automated data collection systems. **Technological Development:** Agile manufacturing, Lean manufacturing, Comparison of Agile and Lean manufacturing.

**Reference Books:**


1. Vajpayee S. Kant, "**Principles of Computer Integrated Manufacturing**", Prentice Hall of India Learning, 2009.
2. Ibrahim Zeid, "**Mastering CAD/ CAM**", Tata McGraw Hill Education (P) Ltd., Special Indian Edition, 2008.
3. Mikell P.Groover, "**Automation, Production Systems and Computer Integrated Manufacturing**", Prentice Hall of India Learning, Third Edition, 2009.
4. Yorem Koren and Joseph Ben-Uri, "**Numerical Control of Machine tools**", Khanna Publishe rs, 1988.
5. David Bedworth, "**Computer Integrated Design and Manufacturing**", Tata Mc Graw Hill publishing company Ltd, 1998.
6. Sureder Kumar and A.K.Jha, "**Technology of Computer Aided Design and manufacturing**" Dhanpat rai and sons, Delhi, 1993.
7. P.Radhakrishnan , S.Subramanyan and V.Raju, "**CAD/ CAM/ CIM**", New Age International (P) Ltd., New Delhi, 2008.


**Course contents and Lecture schedule**

| No. | Topics | No. of Lectures |
|---|---|---|
| 1. | **Fundamentals Elements:** Nature of CIM, Evolution of CIM | 1 |
| 1.1 | CIM hardware | 1 |
| 1.2 | CIM softw are | 1 |
| 2. | **Computer Aided Design:** Design process | 2 |
| 2.1 | Solid modeling techniques | 2 |
| 2.2 | Creating manufacturing database | 2 |
| 3. | **Computer Aided Manufacturing:** Elements of CNC machine tools | 2 |
| 3.1 | Computer assisted part programming–APT language | 2 |
| 3.2 | CAD ba sed programming | 2 |

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

**Course designers**

T. Sornakumar tskmech@tce.edu

C. Paramasivam cpmech@tce.edu

| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LER | 4 | 0 | - | 4 |

## LER Value Engineering 4:0

**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 perform ance. 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.

**Competencies:**

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

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

**Assessment Pattern**

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

**Course level learning objectives**

**Remember**

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?

5. What is Internal Rate of Return (IRR)?
6. What are idea activators?

**Understand**

1. Outline the t echniques 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
4. What is the difference between creative thinking and creative judgment
5. Describe the work function and esteem function
6. What are the essential requirements for promoting creative mental process?

**Apply**

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?
4. A company pro poses 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?
5. 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.

6. 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 |

**Analyse**

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.

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/

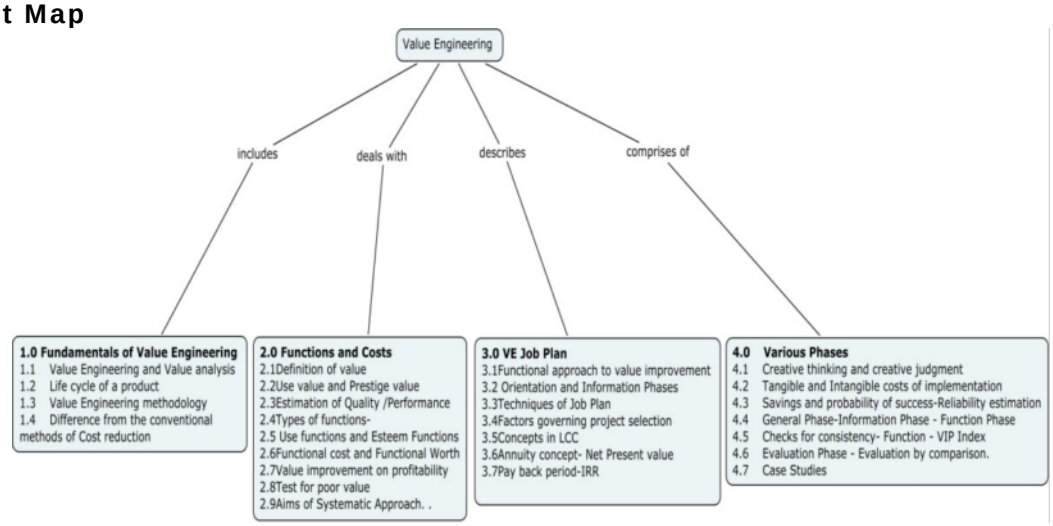
5. Consider the following data for two machines X & Y

| 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 5$^{th}$ 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 whic h alternative the plant manager should select. Also, frame decision rules for MAKE/BUY for various levels of annual demand.

**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.

**Refere nce Books:**


1. Mukhopadhyaya, Anil Kuma, "**Value Engineering**", Response Books, New Delhi ,2003, ISBN: 0 -7619 -9788 -1
2. **Value Engineering – A How to Manual by S S Iyer**, 3rd edition, New Age Publishers, Chennai, 2006, ISBN: 978-81-224-2405 -8
3. Richard J Park, "**Value Engineering – A Plan for Inventions**", St.Lucie Press, London, 1999.
4. A.D.Raven, **Profit Improvement through Value Analysis, value Engineering and Purchase Price Analysis"**, (1971),Cassell and Co. London.
5. Arthur E Mudge, "**Value Engineering**", McGraw Hill Book Company, 1971.


**Course Contents and Lecture Schedule**

| No. | Topic s | 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 fo r 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 | Orie ntation and Information Phases | 2 |
| 3.3 | Techniques of Job Plan | 2 |
| 3.4 | Factors governing project selection – Types of Projects | 2 |

| No. | Topics | No. of Lectures |
|---|---|---|
| 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 | 3 |
| 3.7 | Payback period -Internal rate of return on Investment (IRR)- Examples and Illustrations | 3 |
| **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 cost s - Function Phase | 2 |
| 4.5 | Evaluation of Functional Relationships - Checks for consistency- Function – cost-weight-matrix - VIP Index – High cost and P value areas - | 2 |
| 4.6 | Evaluation Phase – Estimation of costs of ideas- Evaluation by comparison. | 1 |
| 4.7 | Case Studies | 2 |
| | **Total** | **46** |

**Course Designer**

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| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| **LES** | 4 | - | - | 4 |

## LES Industrial Instrumentation 4:0

**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.

**Competencies :**

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

1. Explain the principles of instrumentation.
2. Determine the static and dynamic responses of the instruments.
3. Explain the basic working principle of various transducers for the measurement of motion, strain, force, torque, temperature, pressure, flow and level.
4. Choose appropriate instruments for the measurement of the specified industrial applications

**Assessment Pattern**

| | Bloom's Category | Test 1 | Test 2 | Test3/End - semester examination |
|---|---|---|---|---|
| 1 | Remember | 10 | 10 | 20 |
| 2 | Understand | 30 | 30 | 60 |
| 3 | Apply | 10 | 10 | 20 |
| 4 | Analyze | 0 | 0 | 0 |
| 5 | Evaluate | 0 | 0 | 0 |
| 6 | Create | 0 | 0 | 0 |

**Course Level Learning Objectives**

**Remember**

1. Define time constant.
2. Differentiate b etween accuracy and precision.
3. Distinguish between gauge pressure, absolute pressure.
4. Define Rouths Stability Criterion.
5. Distinguish between Threshold and resolution.
6. Differentiate between kinematic viscosity and dynamic viscosity.

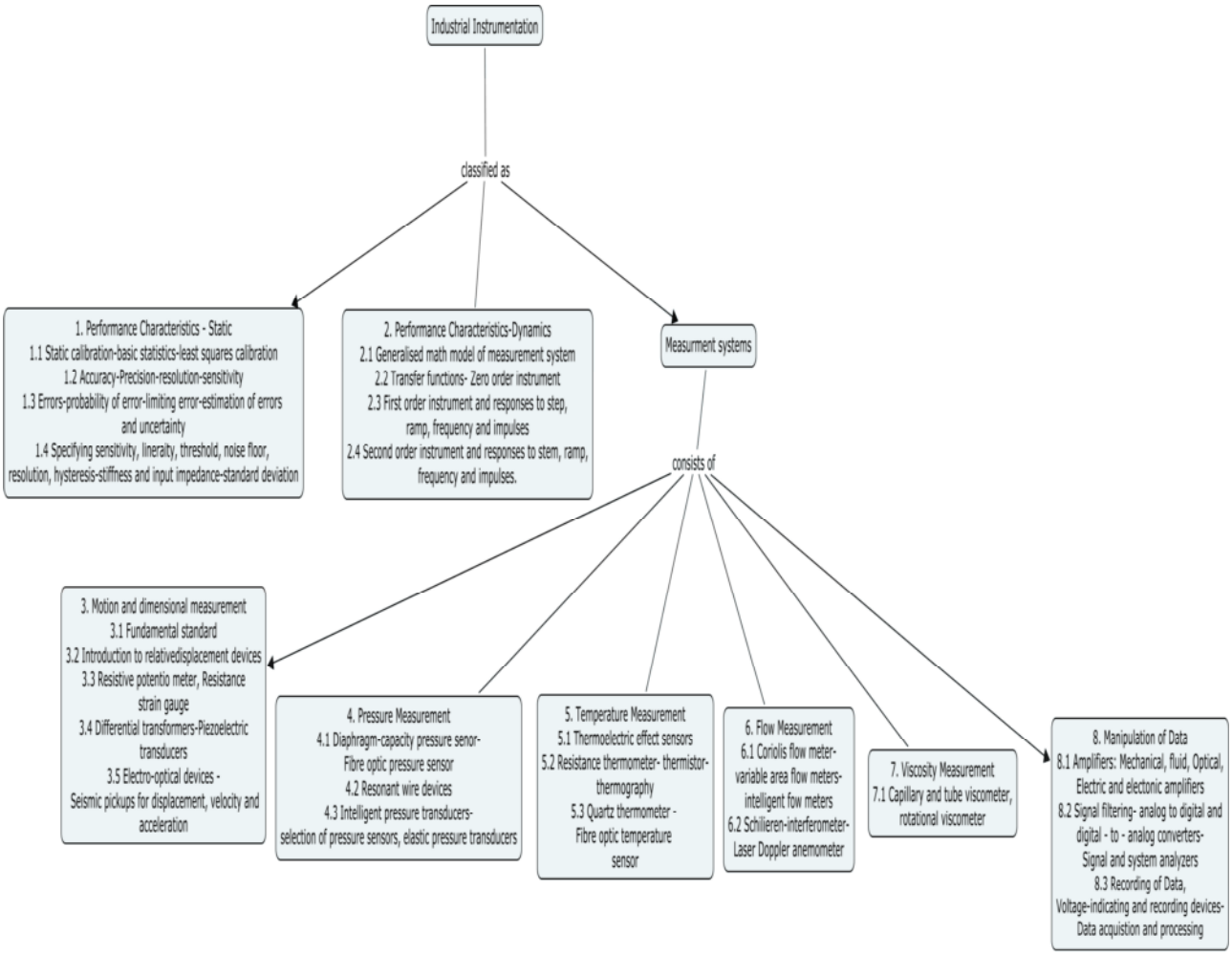
**Understand**

1. Explain bri efly the various errors in a measurement.
2. Explain construction, working, merits and demerits of ultrasonic type flow meters.
3. Explain working of Pressure thermometer and resistance thermometer.
4. Explain with neat sketches any one method for force measurement and acceleration measurement.
5. Describe the step response of a first order thermal system.
6. With neat sketch, discuss the working of Resistive Potentiometers.

**Apply**

1. 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; uncertainty; the deviations from the mean; the average deviation; the standard deviation and variance. One end of long rod of diameter 10 mm is inserted into a furnace.
2. 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.
3. A thermostat for on-off control of room temperature produces a cycle with 30 minute period and $3^0$ C amplitude. If a thermometer with a time lag of 4 minutes is placed beside it, what cycle should it indicate? Assume the thermostat to be a first order instrument.
4. A pilot -stat ic 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$^3$.
5. The output of a transducer with a total resistance of 120 $\Omega$ has been measured with a potentiometer ballast circuit. The supply voltage is 100 volts and maximum sensitivity is attained at the mid plane of the transducer. Make calculations for the sensitivity at 25% and 75% position, and comment on your findings.
6. A thermistor is characterised by the relation: $R_t = R_o\, a\, e^{\frac{b}{T}}$, where $R_o$ is the resistance at the absolute temperature $T^0$ K and a and b are constants. Determine the temperature indicated by such a thermistor if $R_t$ = 1050 $\Omega$, $R_o$ = 4000 $\Omega$, a = 300 x $10^{-6}$ and b = 2850.

**Concept Map**




**Syllabus**

**Perfor mance 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 instru ment 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. Doebelin. E. O, "**Measurement Systems, Application and Design**", 5th edition, McGraw Hill, New York, 2004
2. Holman. J.P., "**Experimental methods for Engineers**", 7th edition, McGraw Hill, 2000.
3. Norman A. Anderson, "**Instrumentation for process measurement and control**", 3rd edition, McGraw Hill, 2004.
4. Allan S. Morris, "**Measurement and instrumentation principles**", Butterworth - Heinermann publication, Oxford, 2001
5. Ramsay. D.C., "**Principles of Engineering Instrumentation**", Butterworth Heinermann publication, Oxford, 1996
6. Singh. S.K., "**Industrial Instrumentation and control**", Tata McGraw Hill, 2010.
7. James W. Dally, William F. Riley, Kenneth G. Mcconnel, "**Instrumentation for Engineering Measurement**", 2nd Edition, Wiley publications, 1993.
8. Kumar, D.S, "**Mechanical Measurements and Control**" 3rd Edition, Metropolitan Book Co. Pvt. Ltd, 2004.

**Course Contents and Lecture Schedule**

| 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 | Specify ing 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 |
| 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 |

| No. | Topic | No. of Lectures |
|---|---|---|
| | | |
| **5** | **Temperature Measurement** | |
| 5.1 | Thermoelectric effect sensors | 1 |
| 5.2 | Resistance thermometer – thermistor – thermography (therma 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 | Amplifi ers: 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 acquis ition and processing. | 2 |
| | **Total** | **45** |

**Course Designer**:

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# CURRICULUM AND DETAILED SYLLABI

# FOR

# M.E. DEGREE Industrial Engineering& M.E Production EngineeringPROGRAMME

## FOURTH SEMESTER SUBJECT

## &

## ELECTIVE SUBJECTS

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

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

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Web: www.tce.edu

**Thiagarajar College of Engineering : Madurai -625015 .**

**Department of Mechanical Engineering**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

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

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

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.**

**M.E. DEGREE (Industrial Engineering) PROGRAMME**

**SUBJECTS OF STUDY**

(For the candidates admitted from 2011-2012 onwards)

**FOURTH SEMESTER**

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

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

L : Lecture
T : Tutorial
P : Practical

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

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**FOURTH SEMESTER**

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

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

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

*** The Duration of Terminal Examination for L34 Project Phase I (Third Semester) and L41 Project Phase II (Fourth Semester) is not specified and will be decided by the Department/ Examiners for the candidates admitted from 20112012 onwards.

**REVISED LIST OF ELECTIVE SUBJECTS- M.E Industrial Engineering**

(For the candidates admitted from 2011-2012 onwards)

| S.No. | Sub. Code | Name of the Subjects | Credit |
|---|---|---|---|
| 1. | LEA/WEA | Plant Layout and Material Handling | 4 |
| 2. | LEB/WEB | Sequencing and Scheduling | 4 |
| 3. | LEC/WEC | Materials Management | 4 |
| 4. | LED/WED | Research Methodology | 4 |
| 5. | LEE/WEE | Total Quality Management | 4 |
| 6. | LEF/WEF | Maintenance Engineering and Management | 4 |
| 7. | LEG/WEG | Machine Vision and its applications in manufacturing | 4 |
| 8. | LEH/WEH | System Simulation | 4 |
| 9. | LEI/WEI | Entrepreneurship Development | 4 |
| 10. | LEJ/WEJ | Product Design and Development | 4 |
| 11. | LEK | Energy Systems | 4 |
| 12. | LEL/WEL | Robust Design | 4 |
| 13. | LEM/WEM | Lean Manufacturing and Six Sigma | 4 |
| 14. | LEN/W31 | Computer Integrated Manufacturing | 4 |
| 15. | LEO | Modeling and Analysis of Manufacturing Systems | 4 |
| 16. | LEP | Logistics and Distribution Management | 4 |
| 17. | LEQ | Human Resource Management | 4 |
| 18. | LER | Value Engineering | 4 |
| 19. | LES | Industrial Instrumentation | 4 |

## M.E. DEGREE (Production Engineering) PROGRAMME

### Scheduling of Courses

(For the candidates admitted from 2011-2012 onwards)

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

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

**THIAGARAJAR COLLEGE OF ENGINEERING: MADURAI – 625 015.**

**M.E. DEGREE (Production Engineering) PROGRAMME**

**SUBJECTS OF STUDY**

(For the candidates admitted from 2011-2012 onwards)

**FOURTH SEMESTER**

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

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

L : Lecture
T : Tutorial
P : Practical

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

**SCHEME OF EXAMINATIONS**

(For the candidates admitted from 2011-2012 onwards)

**FOURTH SEMESTER**

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

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

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

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

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

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

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

**LEA/ WEA Plant Layout and Material Handling 4:0**

(For the candidates admitted from 2011-2012 onwards)

**Preamble**

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

**Competencies**

At the end of the course students will be able to

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

1. List the issues of facility location.
2. Identify the factors to be considered for location selection.
3. Write the equation to compute the Euclidian distance.
4. What is REL chart?
5. List the classification of MH equipment.
6. Define Unit load.

**Understand**

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

**Apply**

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

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

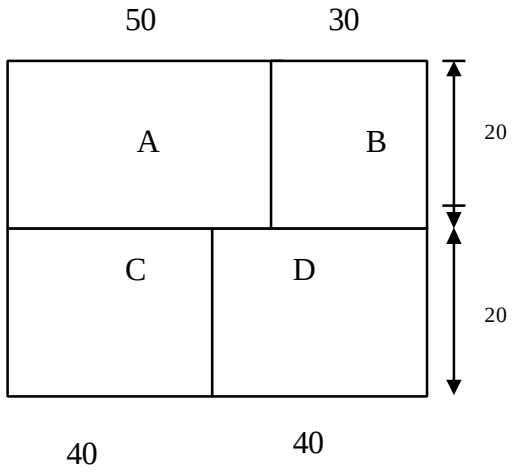
2. Identify the logical part families and machine groups by applying ROC technique. The part-machine incidence matrix is given in the table.

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

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

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

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




Initial Layout

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

Flow Matrix

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

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

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

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

**Analyze**

1. A company produces 60 products per hour on its production line. The operations involved are given below. Balance the line for the given production rate using Ranked positional weight method. Determine the workstations required and balance delay. Analyze the issues when the number of workstations is increased.

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

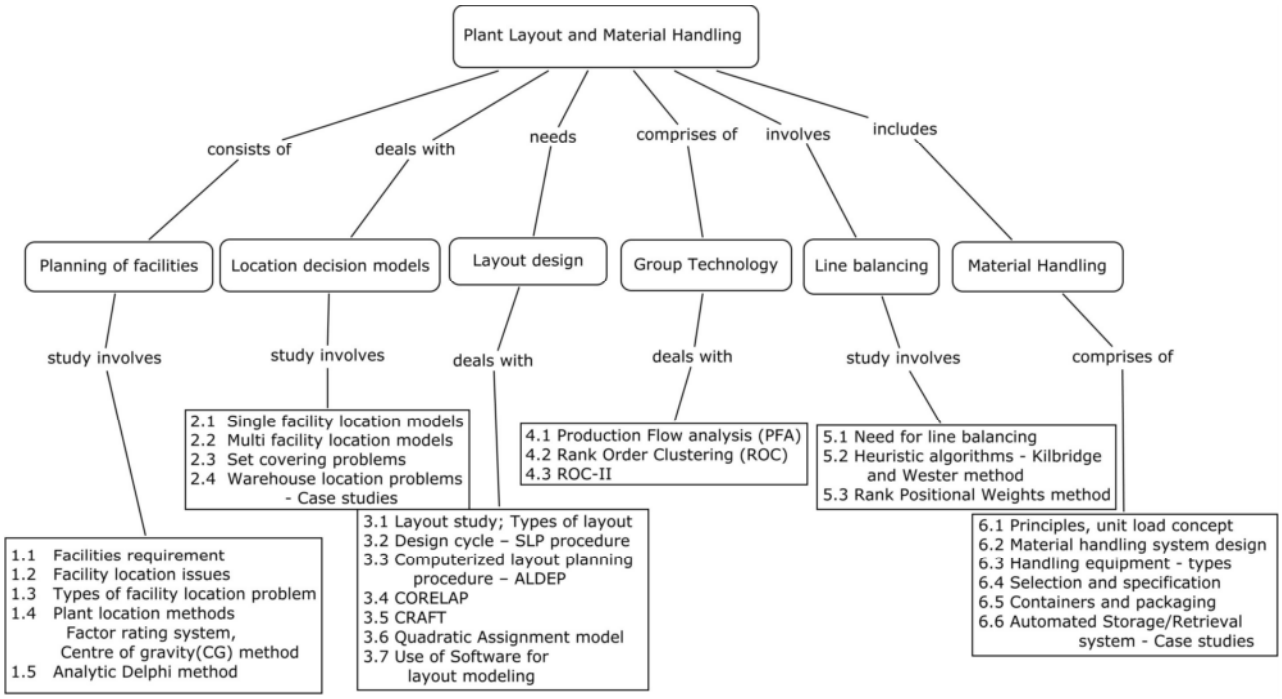
2. Analyze the choice of computerized layout planning procedure for the best layout plan with appropriate example.
3. Discuss about AS/AR system in comparison with the conventional warehousing system with an example.
4. Discuss about the choice of material handling system for a heavy manufacturing industry.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

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

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

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

**Concept Map**




**Syllabus**

**Planning of facilities:** Facilities requirement; Facility location issues; Types of facility location problem; Plant location methods: Factor rating system, Centre of gravity(CG) method, Analytic Delphi method. **Location decision models**: Single facility location models, Multi facility location models - Set covering problems – Warehouse location problems-case studies .**Layout design:** Layout study; Types of layout ; Design cycle – SLP procedure, computerized layout planning procedure – ALDEP, CORELAP, CRAFT; Quadratic Assignment model; Use of Software for layout modeling. **Group Technology:** Production Flow analysis (PFA), Rank Order Clustering (ROC), ROC-II. **Line balancing:** Need, Heuristic algorithms - Kilbridge and Wester method, Rank Positional Weights method. **Material Handling:** Principles, unit load concept, material handling system design; handling equipment - types, selection and specification; containers and packaging; Automated Storage/Retrieval system - case studies .

**Reference Books**

1. Tompkins, J.A. and J.A.White, "Facilities planning", John Wiley, 2003.
2. Richard Francis.L. and John A.White, "Facilities Layout and location - an analytical approach", Prentice Hall of India,2002.
3. James Apple, M.Plant layout and "Material Handling", John Wiley, 1977.
4. Pannerselvam ,R, "Production and Operations Management", Prentice Hall of India,2007

**Course contents and Lecture schedule**

| No | Topic | No. of Lectures |
|---|---|---|
| 1 | **Planning of facilities** | |
| 1.1 | Facilities requirement | 1 |
| 1.2 | Facility location issues | 1 |
| 1.3 | Types of facility location problem | 2 |
| 1.4 | Plant location methods: Factor rating system, Centre of gravity(CG) method | 2 |
| 1.5 | Analytic Delphi method | 1 |
| | | |
| 2 | **Location decision models** | |
| 2.1 | Single facility location models, | 2 |
| 2.2 | Multi facility location models | 2 |
| 2.3 | Set covering problems | 2 |
| 2.4 | Warehouse location problems-case studies | 4 |
| | | |
| 3 | **Layout design** | |
| 3.1 | Layout study; Types of layout; | 1 |
| 3.2 | Design cycle – SLP procedure | 2 |
| 3.3 | Computerized layout planning procedure – ALDEP | 2 |
| 3.4 | CORELAP | 2 |
| 3.5 | CRAFT | 2 |
| 3.6 | Quadratic Assignment model | 2 |
| 3.7 | Use of Software for layout modeling | 2 |
| | | |
| 4 | **Group Technology** | |
| 4.1 | Production Flow analysis (PFA) | 2 |
| 4.2 | Rank Order Clustering (ROC) | 2 |
| 4.3 | ROC-II. | 2 |
| | | |
| 5 | **Line balancing** | |
| 5.1 | Need for line balancing | 1 |
| 5.2 | Heuristic algorithms - Kilbridge and Wester method | 2 |
| 5.3 | Rank Positional Weights method | 2 |
| | | |
| 6 | **Material Handling** | |
| 6.1 | Principles, unit load concept | 1 |
| 6.2 | Material handling system design | 2 |
| 6.3 | Handling equipment - types | 1 |
| 6.4 | Selection and specification | 1 |
| 6.5 | Containers and packaging | 2 |
| 6.6 | Automated Storage/Retrieval system -case studies | 3 |
| | **Total** | **51** |

**Course Designer**

1. ML.Mahadevan mahadevan.malai@yahoo.com

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

**LED/WED Research Methodology** **4:0**

(For the candidates admitted from 2011-2012 onwards)

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

**Competencies**

At the end of the course students will be able to

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

**Understand**

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

**Apply**

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

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

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

4. A certain process produces 10 percent defective articles. A supplier of new raw material claims that the use of his material would reduce the proportion of defectives. A random sample of 400 units using this new material was taken out of which 34 were defective units. Can the supplier's claim be accepted? Test at 1 percent level of significance.

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

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

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

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

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

**Analyze**

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

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

Do the promotions produce different effects on sales?

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

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

3. Determine the size of the sample for estimating the true weight of the cereal containers for the universe with N = 5000 on the basis of the following information:

(1) The variance of weight = 4 ounces on the basis of past records.

(2) Estimate should be within 0.8 ounces of the true average weight with 99% probability.

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

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

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

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

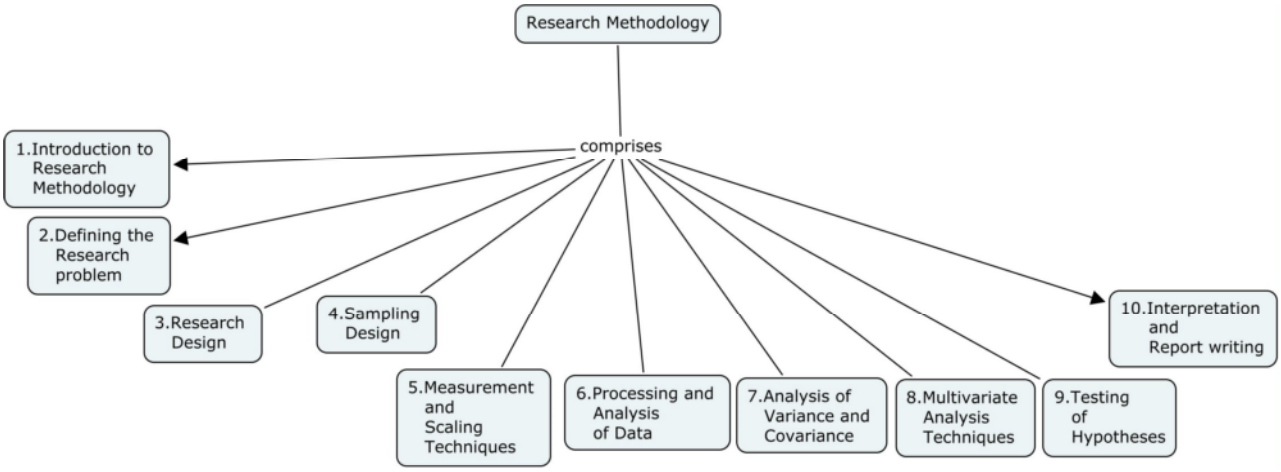
5. Sample of sales in similar shops in two towns are taken for a new product with the following results:

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

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

6. "Report writing is more an art that hinges upon practice and experience". Discuss.

**Concept Map**




**Syllabus**

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

Relationship between spear man's r's and Kendall's W - Characteristics of distribution – Free or non parametric tests. **Interpretation and Report Writing:** Technique of Interpretation - Precaution in Interpretation - Different Steps in Writing Report - Layout of the Research Report - Types of Reports- Oral Presentation- Mechanics of Writing a Research Report- Precautions for Writing Reports.

**Reference Books**


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


**Course contents and Lecture schedule**

| No | Topics | No. of Lectures |
|---|---|---|
| 1 | **Introduction to Research Methodology** | |
| 1.1 | Objectives of Research; Motivation in Research | 1 |
| 1.2 | Types of Research | |
| 1.3 | Research Approaches | 1 |
| 1.4 | Significance of Research | 1 |
| 1.5 | Research Methods versus Methodology | 1 |
| 1.6 | Research Process | 1 |
| 1.7 | Criteria of Good Research | |
| 2 | **Defining the Research Problem** | |
| 2.1 | Selecting the Problem | 2 |
| 2.2 | Necessity of Defining the Problem | 2 |
| 2.3 | Technique Involved in Defining a Problem | 1 |
| **3** | **Research Design** | |
| 3.1 | Need for Research Design | 1 |
| 3.2 | Features of a Good Design | |
| 3.3 | Important Concepts Relating to Research Design | 1 |
| 3.4 | Different Research Designs | 1 |
| 3.5 | Basic Principles of Experimental Designs | 1 |
| **4** | **Sampling Design** | |
| 4.1 | Implications of a Sample Design | 1 |

| No | Topics | No. of Lectures |
|---|---|---|
| 4.2 | Steps in Sampling Design | |
| 4.3 | Criteria for Selecting a Sampling Procedure | 1 |
| 4.4 | Characteristics of Good Sample Design | |
| 4.5 | Different types of Sample Designs | 1 |
| 4.6 | Random Sample from an Indicate Universe | 1 |
| 4.7 | Complex Random Sampling Designs | 2 |
| 4.8 | Standard error | |
| **5** | **Measurement and Scaling Techniques** | |
| 5.1 | Measurement Scales | 1 |
| 5.2 | Sources of Error in Measurement | |
| 5.3 | Tests of Sound Measurement | 1 |
| 5.4 | Technique of Developing Measurement Tools | 1 |
| 5.5 | Scaling | 1 |
| 5.6 | Meaning of Scaling | |
| 5.7 | Scale Classification Bases | |
| 5.8 | Important Scaling Techniques | 1 |
| **6** | **Processing and Analysis of Data** | |
| 6.1 | Processing Operations | 1 |
| 6.2 | Elements/Types of Analysis | |
| 6.3 | Statistics in Research | |
| 6.4 | Measures of Central Tendency | 1 |
| 6.5 | Measures of Dispersion | |
| 6.6 | Measures of Asymmetry (Skewness) | |
| 6.7 | Measures of Relationship | 1 |
| 6.8 | Simple Regression Analysis | 1 |
| 6.9 | Multiple Correlation and Regression Partial Correlation | 1 |
| 6.10 | Association in Case of Attributes | 1 |
| **7** | **Analysis of Variance and Covariance** | |
| 7.1 | Analysis of Variance (ANOVA) | 1 |
| 7.2 | The Basic Principle of ANOVA | |
| 7.3 | ANOVA Technique | 2 |
| 7.4 | Setting up Analysis of Variance Table | |
| 7.5 | Short-cut Method for One-way ANOVA | |
| 7.6 | Coding Method | |

| No | Topics | No. of Lectures |
|---|---|---|
| 7.7 | Two-way ANOVA | 1 |
| 7.8 | ANOVA in Latin -Square Design | |
| 7.9 | Analysis of Co -variance (ANOCOVA) | 2 |
| 7.10 | ANOCOVA Technique | |
| 7.11 | Assumptions in ANOCOVA. | |
| **8** | **Multivariate Analysis Techniques** | |
| 8.1 | Classification of M ultivariate techniques | 1 |
| 8.2 | Variables in multivariate analysis | |
| 8.3 | important multivariate techniques | 1 |
| 8.4 | Rotation in factor analysis | 1 |
| 8.5 | R – type - Q – type factor analyses | 1 |
| 8.6 | Path analyses | 1 |
| **9** | **Testing of Hypotheses** | |
| 9.1 | Non parametric or Distribution free test | 1 |
| 9.2 | Relationship between spear man's r's and Kendall's W - Characteristics of distribution | 2 |
| 9.3 | Free or non parametric tests | 1 |
| **10** | **Interpretation and Report Writing** | |
| 10.1 | Technique of Interpretation | 1 |
| 10.2 | Precaution in Interpretation | |
| 10.3 | Different Steps in Writing Report | 1 |
| 10.4 | Layout of the Research Report | 1 |
| 10.5 | Types of Reports | 1 |
| 10.6 | Oral Presentation | 1 |
| 10.7 | Mechanics of Writing a Research Report | 1 |
| 10.8 | Precautions for Writing Reports | |
| | **Total** | **52** |

**Course De signers**

1. M. PalaniNatharaja pnatharaja@tce.edu
2. A.Sivakumar sivakumar_ie@tce.edu

| Sub Code | Lectures | Tutorial | Practical | Credit |
|---|---|---|---|---|
| LEM/WEM | 4 | 0 | - | 4 |

**LEM/ WEM LEAN MANUFACTURING AND SIX SIGMA 4:0**

(For the candidates admitted from 2011-2012 onwards)

**Preamble**

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

**Competencies**

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

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

**Assessment Pattern**

| | Bloom's Category | Test 1 | Test 2 | Test 3 | End-semester examination |
|---|---|---|---|---|---|
| 1 | Remember | 20 | 20 | 20 | 20 |
| 2 | Understand | 30 | 30 | 20 | 20 |
| 3 | Apply | 50 | 50 | 40 | 40 |
| 4 | Analyze | 0 | 0 | 20 | 20 |
| 5 | Evaluation | 0 | 0 | 0 | 0 |
| 6 | Create | 0 | 0 | 0 | 0 |

**Course Level Learning Objectives**

**Remember**

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

**Understand**

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

**Apply**

1. For a Textile Industry the following are main problems. How would you solve the following issues? which lean tool you would use, Justify it.

   A. High Inventory
   B. Frequent breakdown
   C. Process variability

2. Compare Push vs. Pull system. Demonstrate Pull system is suitable for Lean Manufacturing taking Dell Industry supply chain.

3. In a Copper smelter Maintenance the following are problems

   A. Frequent Breakdowns
   B. All Planned Maintenance activities are rescheduled
   C. No Preventive maintence available

   Execute the Total Productive Maintenance for solving above said problems

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

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

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

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

**Analyze**

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

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

After several brain storming and a thorough study of the shop floor, it was observed that the tube subassembly line consists various forms of non-value-adding activities as follows:

High lead time Accumulation of high inventory Unnecessary material flow High material travel distance Poor Mean-Time-Between-Failure ,underutilized manpower.

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

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

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

A company is mainly focused on manufacturing as per customer's design. HV Axle Ltd. currently has a capacity of about 3, 24,000axles per annum ( inclusive of all varieties), total annual sales volume is US$50 Million-US$100Million and total employees are 1154,

out of which 846 persons work in Axle division where the case study was taken up. In this division 510 employees are permanent as operator's level and 336 in supervisory. This work is on HVAL, Rear Axle (Assembly Line 1) in which target production is 300 Axles per shift but the current production is 210 Axles per shift (8 Hours). This is due to lack of multi-skilled development, lack of training to operators, no proper utilization of resources, and Noninvolvement of staff in Kaizen Program etc. Our main motto was to achieve the target production and find the factors which are responsible for lack of the production in the company. For completing a Rear Axle assemblies there are 35 work-stations corresponding 56 operators.

Problems faced in company are:

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

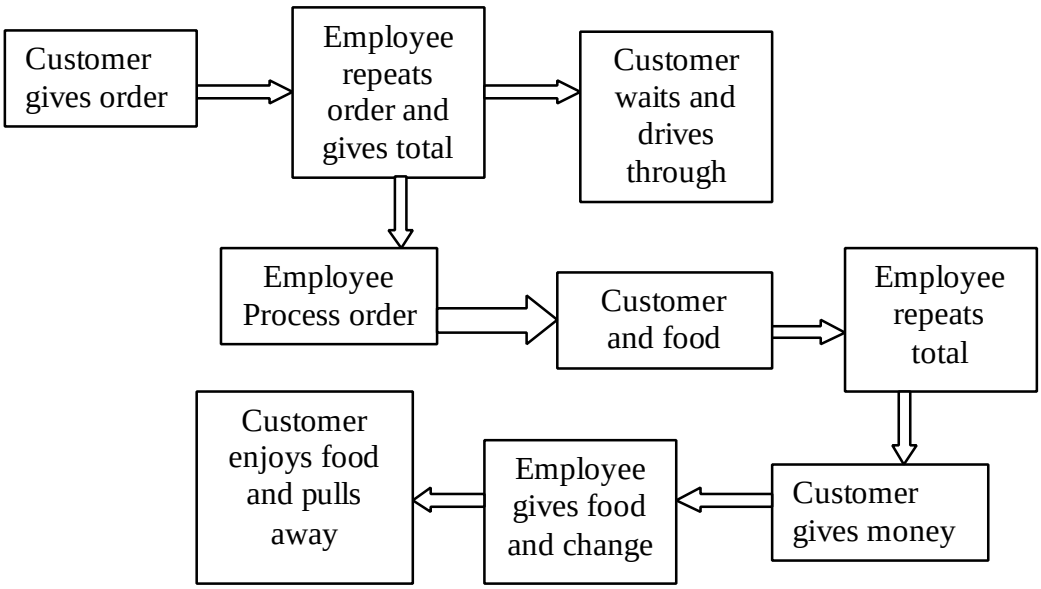
4. A Restaurant conducted consumer surveys and focus groups and identified the most important customer requirements as Healthy food, speedy service, an easy to read menu board, accurate order filling and perceived value. Develop of a set of technical requirements to incorporate into the design of a new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

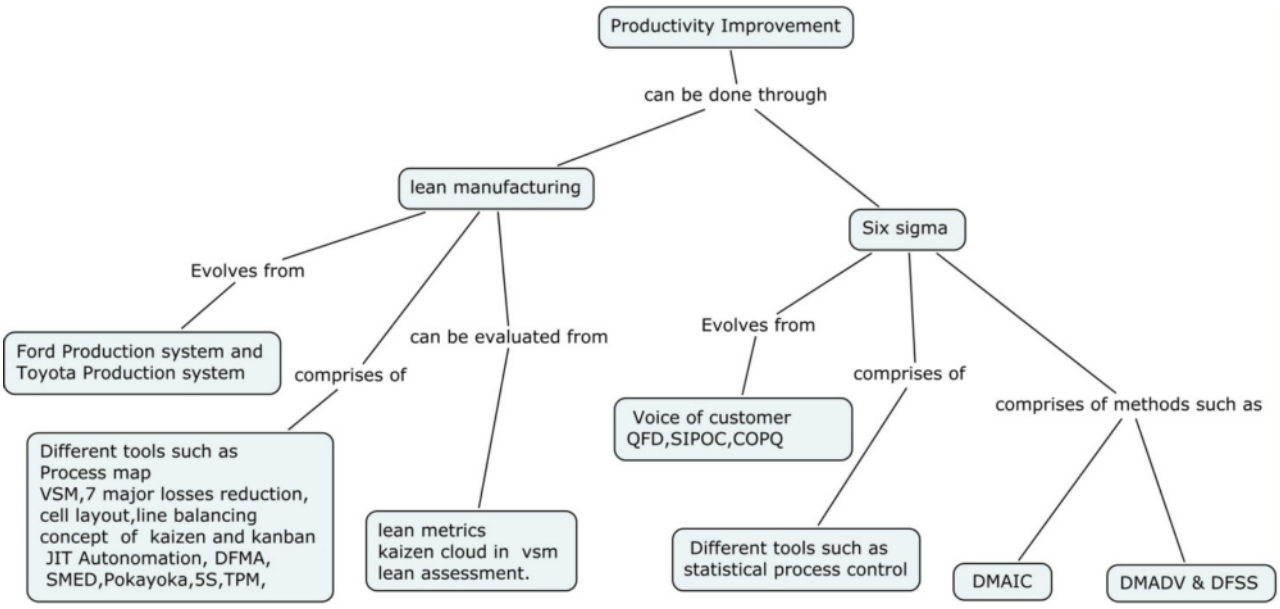
a. Books are not placed in the correct shelf, which include books that are checked out and returned and books taken off from shelves

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** evolutio n 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 - prevent ive, 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 tool s – process maps, pareto charts, cause and effect diagrams, histograms, six sigma measurements – measurement system analysis – process capability calculations. analyze– process analysis – hypothesis testing – statistical tests and tables – tools for analyzing relationships among variables – survival analysis. **Improve and control phase**: process redesign – generating improvement alternatives – design of experiments – pilot experiments – cost/benefit analysis – implementation plan. Control phase control plan – process scorecard – failure mode and effects analysis –final project report and documentation. DMADV,DFSS –six sigma in manufacturing and services case studies& Sustainability of Lean Six Sigma;

**Reference Books**


1. Michael L. George, David Rowlands, Bill Kastle ,What is Lean Six Sigma, Tata McGraw-Hill,2003
2. Thomas Pyzdek, The Six Sigma Handbook , McGraw-Hill, 2000
3. James P. Womack , Daniel T. Jones ,Lean Thinking, Free press business,2003.
4. Kai Yang and Basemel -Haik, "Design for Six Sigma: A Roadmap for Product Development", McGraw Hill, 2003.
5. N.Gopalakrishnan, simplified lean manufacture: Elements, rules, tools and implementation, Prentice Hall of India, NewDelhi 2010


**Course Contents and Lecture schedule**

| S.No | Topics | No. of Lectures |
|---|---|---|
| **1.0** | **Lean Manufacturing and Six sigma-Introduction** | |
| 1.1 | Introduction to lean manufacturing | 2 |
| 1.2 | Symptoms Indicating Requirement of Lean manufacturing | 1 |
| 1.3 | Evolution of lean, Types of Manufacturing | 1 |
| 1.4 | How to meet customer requirement, What Customer want? | 2 |
| 1.5 | Introduction to six sigma | 2 |

| S.No | Topics | No. of Lectures |
|---|---|---|
| 1.6 | Ford and Toyota Production systems | 2 |
| **2.0** | **Lean Tools** | |
| 2.1 | Process mapping -types and steps involved | 1 |
| 2.2 | What is Value,VSM,steps to be followed to prepare VSM | 2 |
| 2.3 | Problems and case studies | 2 |
| 2.4 | 3 M; 7 types of Muda; 7 major losses reduction. | 1 |
| 2.5 | cell layout; line balancing | 2 |
| 2.6 | concept of kaizen; steps involved in kaizen deployment; | 1 |
| 2.7 | kanban concepts ; types of kanbans ; and practical application ; push vs pull | 1 |
| 2.8 | JIT | 1 |
| 2.9 | Autonomation, DFMA, various types of chart | 2 |
| 2.10 | SMED,Pokayoka,5S,TPM,Maintenance of all types | 2 |
| **3.0** | **Lean Metrics** | |
| 3.1 | identify lean metrics | 2 |
| 3.2 | kaizen cloud identification in vsm | 1 |
| 3.3 | lean assessment. improving targets and benchmarks | 1 |
| **4.0** | **Six sigma tools and techniques** | |
| 4.1 | SIPOC, QFD; Voice of the Customer, kano models, | 1 |
| 4.2 | cost of poor quality (COPQ), FMEA | 1 |
| 4.3 | statistical process control | 1 |
| **5.0** | **Six Sigma Methodology** | |
| 5.1 | Define phase | 2 |
| 5.2 | Measure and Analyse phase | 2 |
| 5.3 | Improve and Control phase | 2 |
| 5.4 | DMADV & DFSS | 3 |
| 5.5 | Case studies in manufacturing | 2 |
| 5.6 | Case studies in Service industries | 2 |
| 5.7 | Sustainability of Lean Manufacturing and Six sigma | 1 |
| | **Total** | **46** |

**Course Designers**

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

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

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

**Preamble**

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

**Competencies**

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

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

**Assessment Pattern**

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

**Course Level Learning Objectives**

**Remember**

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

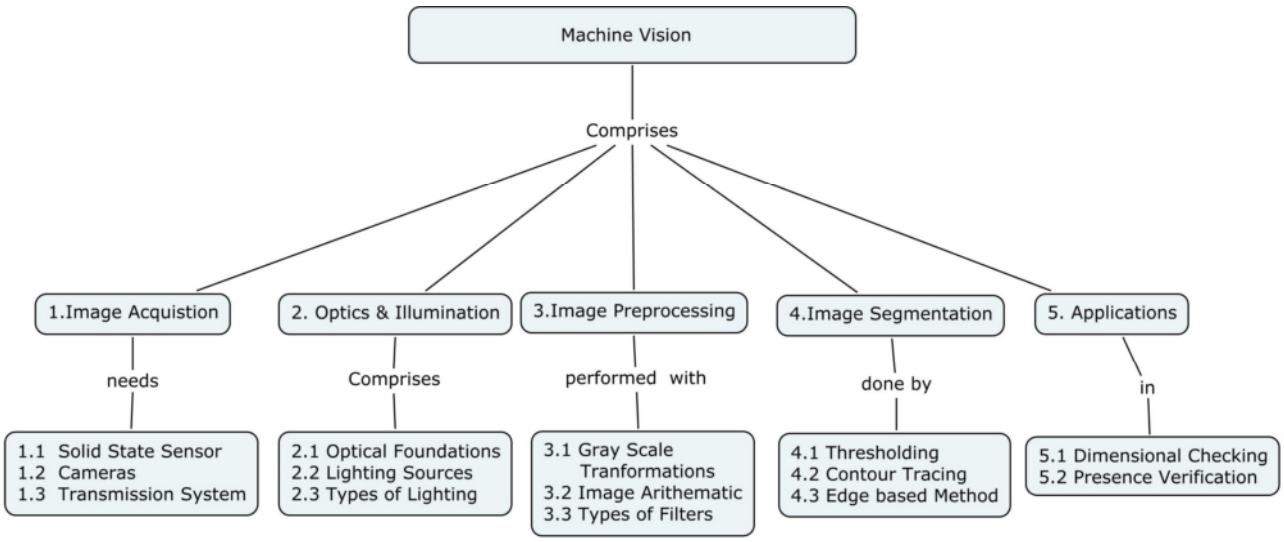
**Understand**

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

**Apply**

1. Determine the focal length of a lens of a vision system requiring a magnification of 0.06 and a working distance of 80 cm.
2. Determine the Magnification of the vision system and the size of the pixel on the sensor, if the size of 200 X 200 solid state sensor array is 40mmX40mm and the size of the object to be measured is 60mmX60mm.
3. Determine the focal length, magnification, Depth of field for an industrial installation inspecting flat plates on a moving conveyor belt with front lighting. You have a solid state camera with 100X 100 array sensor. Sensor dimensions .03X.03 cm. Distance between the lens and work piece is 60 cm.b F-Stop is 8, and there are 16 grey level and 30 images / second. Object dimensions are 7.5 X 7.5 X 1.2 cm. The object occupies 50% of sensor array.
4. A surveillance camera is embedded in one of the walls of a room . The optical axis of the camera is perpendicular to the wall, and the lens centre is in the plane of the wall. The focal length of the lens is .05m.The X-Z plane of the camera is parallel to the X-Y Plane of the world coordinate system. The image plane is behind the wall. Find the image plane coordinates of (a) the room corner A and (b) the head of a person 2m tall standing at a distance of 3m X 2m from the corner.
5. Determine the dimensions of the largest object that can be imaged by a vision system with a magnification of 0.1, a 5 X 5 mm sensor array with 50 X 50 elements. The distance from the object to the lens is 60 cm and F-Stop is 16.
6. Select and illustrate a suitable Machine Vision Technique used for Inspection of Threads in Nuts in a Batch Production Process.

**Concept Map**




**Syllabus**

**Image Acquisition:** Solid State Sensors CCD Sensor Operation, Properties, Image Degradation. Standard Video Cameras: Basic Structure, Sampling of Line Signal and Extension of Video Standards, Image Quality, Progressive Scan Cameras, Asynchronous Camera, Digital Camera, Line Scan Cameras, Line Scan Cameras and its Properties.Transmission to Computer: Basic operation of Frame Grabber and Direct Digital transmission. **Optics and Illumination:** Optical foundations: F number, Thin Lens Imaging Equation, Depth of Field, Typical Imaging Situations, Aberrations, Lens Selection, Special Optical devices. Light Sources, Types of Light Filters, Types of Lighting: Diffuse, Directed, Telecentric, Structured, Bright field, Dark Field, Incident and Transmitted Lighting. **Image Preprocessing:** Gray Scale Transformations: Look up tables, Linear Gray level scaling, Contrast enhancement, Histogram equalization, Local Contrast Enhancement. Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images.Types of Filters: Linear Filters, Median Filter, Morphological and Non Linear Filters, Fourier Transform Applications. **Image Segmentation:** Threshold Determination from Histogram, Gray Level Histogram, Generalizations of Thresholding Contour Tracing: Pixel Correctedness, Generating Object Contours, Contour representation Edge based Methods: Edge probing and Edge Detection Template matching: Basic Operation, Optimizing and Comments on Template Matching.

**Applications:** Dimensional Checking: Simple gauging, Shape Checking, Angle Gauging, High accuracy Gauging, Calibration. Presence Verification: Simple Presence verification, Simple Gauging for asse mbly verification, Glue Check under UV Light, Pin type Verification Alignment Checking.

**Reference Books**


1. C.Demant, B.Streicher Abel, P.Waszkewitz "Industrial Image Processing and Visual Quality control in manufacturing". Springer, 1999.
2. Alexander Hornberg, "Handbook of Machine Vision", Wiley VCH, 2006
3. Gerald C. Holst, "CCD Arrays Cameras and Displays" Second Edition, SPIE Optical Engineering Press, 1998.
4. K.S.Fu,R.C.Gonzalez,C.S.G.Lee "Robotics Control, Sensing, Vision and Intelligence." Tata Mc grawHill, 2008
5. R.C.Gonzalez, Richard E.Woods, "Digital Image Processing." Second Edition, Prentice Hall India, 2005.


**Course contents and Lecture Schedule**

| S.No. | Topics | No. of Lectures |
|---|---|---|
| 1 | **Image Acquisition** | |
| 1.1 | Solid State Sensors: | |
| 1.1.1 | CCD Sensor Oper ation | 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 S can Cameras, Asynchronous Camera, Digita Camera, Line Scan Cameras and its Properties | 2 |
| 1.3 | Transmission to Computer: | |
| 1.3.1 | Basic operation of Frame Grabber | 1 |
| 1.3.2 | Direct Digital transmission | 1 |
| 1.3.3 | USB, IEEE1394, Firewire, Gigabit Ethernet, Choosing Computer Bus | 2 |
| **2** | **Optics and Illumination** | |
| 2.1 | Optical foundations | |
| 2.1.1 | Basic Laws of Optics, F number, Thin Lens Imaging Equation, Depth of Field | 2 |
| 2.1.2 | Typical Imaging Situations, Aberrations | 1 |
| 2.1.3 | Lens Selection, Special Optical devices | 2 |
| 2.2 | Lighting Sources | |
| 2.2.1 | Incandescent Lamps, Metal Vapour Lamps | 1 |
| | Xenon Lamps, Fluorescent, LED, Laser. | 1 |

| S.No. | Topics | No. of Lectures |
|---|---|---|
| 2.2.2 | Types of Light Filters – UV Filter, Day Light Filter, IR Filter Gray Filter, Polarization Filter, Color Filter and Combination. | 2 |
| 2.3 | **Types of Lighting** | |
| 2.3.1 | Diffuse and Directed Bright Field Incident Lighting. | 1 |
| 2.3.2 | Telecentric and Structured Bright Field Incident Lighting Diffuse and Directed Dark Field Incident Lighting | 1 |
| 2.3.3 | Diffuse and Directed transmitted Lighting - Bright Field and Dark Field | 1 |
| **3** | **Image Preprocessing** | |
| 3.1 | Gray Scale Transformations: | |
| 3.1.1 | Look up tables, Linear Gray level scaling | 1 |
| 3.1.2 | Contrast enhancement, Histogram equalization, Local Contrast Enhancement. | 2 |
| 3.1.3 | Image Arithmetic: Image Addition, Subtraction and Averaging, Minimum and Maximum of two images. | 1 |
| 3.1.4 | Types of Filters: Linear Filters, Median Filter | 1 |
| 3.1.5 | Morphological and Non Linear Filters | 1 |
| 3.1.6 | Fourier Transform Applications | 2 |
| 4 | **Image Segmentation** | |
| 4.1 | Thresholding: | |
| 4.1.1 | Threshold Determination from Histogram | 1 |
| 4.1.2 | Gray Level Histogram, Generalizations of Thresholding | 2 |
| 4.2 | Contour Tracing: | |
| 4.2.1 | Pixel Correctedness, Generating Object Contours, Contour representation | 1 |
| 4.2.2 | Edge based Methods: Edge probing and Edge Detection | 1 |
| 4.2.3 | Template matching: Basic Operation, Optimizing and Comments on Template Matching. | 2 |
| 5 | **Applications** | |
| 5.1 | Dimensional Checking: | |
| 5.1.1 | Simple gauging, Shape Checking | 1 |
| 5.1.2 | Angle Gauging, High accuracy Gauging | 1 |
| 5.1.3 | Calibration | 2 |
| 5.2 | Presence Verification: | |
| 5.2.1 | Simple Presence verification, Simple Gauging for assembly verification | 2 |
| 5.2.2 | Glue Check under UV Light | 1 |

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

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