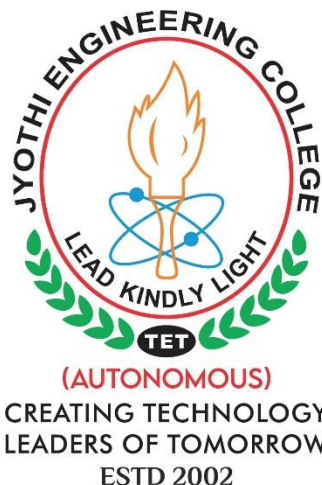


# M. TECH CURRICULUM - 2026



Semester I to IV

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## Transportation Engineering

Branch Code: PTE

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**Jyothi**  
Engineering College  
(AUTONOMOUS)

Reaccredited with NAAC (Grade A) and  
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# **SEMESTER I**

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**Discipline : CIVIL ENGINEERING**

**Stream: TRANSPORTATION ENGINEERING  
(PTE)**

| CODE      | COURSE NAME                | CATEGORY        | L | T |  | P | CREDIT |
|-----------|----------------------------|-----------------|---|---|--|---|--------|
| J1PTET101 | PROBABILITY AND STATISTICS | DISCIPLINE CORE | 3 | 0 |  | 0 | 3      |

**Preamble:** The objective of this course is to expose the students to the fundamental concepts of probability and statistics. The course aims to equip the students to find solutions for many real-world civil engineering problems and to understand basic data analysis tools by applying the principles of statistics.

**Course Outcomes:** After the completion of the course, the student will be able to

|             |                                                                                                        |
|-------------|--------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To create an awareness of the concepts of statistics and probability distributions                     |
| <b>CO 2</b> | To formulate and test hypotheses for civil engineering problems                                        |
| <b>CO 3</b> | To apply statistical data analysis tools such as ANOVA and experimental designs                        |
| <b>CO 4</b> | To build regression models for civil engineering applications and to identify the principal components |
| <b>CO5</b>  | To apply the concepts of data analysis for a time series                                               |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 2    |      | 3    |      |      | 2    |
| <b>CO 2</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |
| <b>CO 3</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |
| <b>CO 4</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |
| <b>CO5</b>  |      |      |      |      |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIA | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects are not permitted. The project may include the implementation of theoretical computation using software packages.

The test papers shall include a minimum 80% of the syllabus.

### **End Semester Examination: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

## **Syllabus**

### **Module 1- Introduction to probability distributions**

Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence. Random Variables—discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.

Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions.

### **Module 2- Statistical Inference**

Populations and samples. Sampling distribution of the mean( $\sigma$  known and unknown), Sampling distribution of the variance( $\sigma$  known and unknown).Interval estimation:- Confidence interval for mean and variance.-Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.-Test of significance of (i) Mean (ii) Mean of two samples (iii)Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence

### Module 3- Analysis of variance

Analysis of variance. Completely randomized designs and randomized block designs.- Latin square designs -Factorial experiments: Two-factor experiments (overview only)

### Module 4- Correlation and regression models

Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient- Multiple linear regression, normal equations -Principal components (brief overview only)

### Module 5-Time Series Models

Components of time series. Identifying linear trend: semi averages method and least squares method. Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient. Forecasting, measuring forecasting accuracy

### Course Plan

| No       | Topic                                                                                                                                                                                                                                                                                          | No. of Lectures |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Introduction to probability distributions</b>                                                                                                                                                                                                                                               |                 |
| 1.1      | Sample Space and Events, Axioms of Probability, Addition rules, Conditional Probability, Multiplication and Total Probability rules, Independence.                                                                                                                                             | 1               |
| 1.2      | Random Variables–discrete and continuous random variables, Probability mass functions and probability density functions. Cumulative distribution functions, Mathematical Expectations, mean and variance.                                                                                      | 2               |
| 1.3      | Standard discrete distributions-Binomial and Poisson distribution. Standard continuous distributions –Exponential and Normal distribution, Mean and variance (derivation is not required). Computing probability using the above distributions, Fitting of binomial and Poisson distributions. | 5               |
|          |                                                                                                                                                                                                                                                                                                |                 |
| <b>2</b> | <b>Statistical Inference</b>                                                                                                                                                                                                                                                                   |                 |
| 2.1      | Populations and samples. Sampling distribution of the mean(sigma known and unknown), Sampling distribution of the variance(sigma known and unknown).Interval estimation:- Confidence interval for mean and variance.                                                                           | 2               |
| 2.2      | Tests of hypotheses:-Null hypothesis and alternative hypothesis, Type I and Type II errors.                                                                                                                                                                                                    | 2               |

|          |                                                                                                                                                                                                                |            |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 2.3      | Test of significance of (i) Mean (ii) Mean of two samples (iii) Proportions (iv) Variance (v) Two variance (vi) Paired t-test (vii) Chi-square test of goodness of fit (viii) Chi-square test for independence | EERIN4G-CE |
| <b>3</b> | <b>Analysis of variance</b>                                                                                                                                                                                    |            |
| 3.1      | Analysis of variance. Completely randomized designs and randomized block designs.                                                                                                                              | 4          |
| 3.2      | Latin square designs                                                                                                                                                                                           | 2          |
| 3.3      | Factorial experiments: Two-factor experiments (overview only)                                                                                                                                                  | 2          |
| <b>4</b> | <b>Correlation and regression models</b>                                                                                                                                                                       |            |
| 4.1      | Linear regression and correlation, method of least squares, normal regression analysis, normal correlation analysis, correlation coefficient                                                                   | 4          |
| 4.2      | Multiple linear regression, normal equations                                                                                                                                                                   | 2          |
| 4.3      | Principal components (brief overview only)                                                                                                                                                                     | 2          |
| <b>5</b> | <b>Time Series Models</b>                                                                                                                                                                                      |            |
| 5.1      | Components of time series. Identifying linear trend: semi averages method and least squares method.                                                                                                            | 2          |
| 5.2      | Smoothing: moving averages, weighted moving averages, exponential smoothing using one smoothing coefficient.                                                                                                   | 3          |
| 5.3      | Forecasting, measuring forecasting accuracy                                                                                                                                                                    | 3          |
|          | <b>Total hours</b>                                                                                                                                                                                             | <b>40</b>  |

### Reference Books

1. Gupta. S. C. and Kapoor. V. K, Fundamentals of Mathematical Statistics, Sultan Chand and Sons, 2020
2. Benjamin, Jack.R and Comell.C, Allin, Probability, Statistics and Decision for Civil Engineers, Mc- McGraw-Hill.
3. Johnson RA , Miller I, Freund J. Miller and Freund's Probability and Statistics for Engineers (9th edition) Pearson. 2018.
4. Response Surface Methodology: Process and Product Optimization Using Designed Experiments, 4th Edition Raymond H. Myers, Douglas C. Montgomery, Christine M. Anderson-Cook ISBN: 978-1-118-91601-8 February 2016.
5. Introduction to Time Series Analysis and Forecasting Second Edition, DOUGLAS C. MONTGOMERY, CHERYL L. JENNINGS, MURAT KULAHCI, John Wiley & Sons, 2015.
6. Papoulis A, Pillai SU Probability, Random Variables and Stochastic Processes McGraw Hill 2022
7. Schiller J, Srinivasan RA, Spiegel M Schaum's Outline of Probability and Statistics, 2012 McGraw Hill
8. Ross S Introduction to Probability and Statistics for Engineers and Scientists Elsevier 6th Edition 2021

## Model Question Paper

### J1PTET101 PROBABILITY AND STATISTICS

Time: 3 Hrs

Max. Marks:60

#### PART A

*(Answer all Questions: Each question carries 5 marks)*

1. Explain the concept of mean, median and mode, and its applicability in various contexts with suitable examples.
2. Explain Type I and Type II errors with example.
3. What are the assumptions involved in Analysis of Variance (ANOVA)?
4. Obtain Karl Pearson's correlation coefficient for Stress and Performance.

|                 |    |    |    |    |    |
|-----------------|----|----|----|----|----|
| Observation no. | 1  | 2  | 3  | 4  | 5  |
| Performance     | 75 | 80 | 85 | 90 | 95 |
| Stress          | 80 | 75 | 80 | 60 | 55 |

5. Explain briefly the components of time series.

#### PART B

*(Answer any five questions: Each carry 7 marks)*

6. The number of products sold by a shop keeper follows Poisson distribution, with a mean of 2 per week. (i) Find the Probability that in the next 4 weeks the shop keeper sells exactly 3 products. (ii) The shop keeper monitors sales in periods of 5 weeks. Find the probability that in the next 15 of these 5-week period, there are exactly 10 periods in which more than 5 products are sold.
7. After conducting series test on Probability and Statistics the following scores were obtained for Batch A and Batch B. Conduct a hypothesis testing for checking the equality of variance in scores of two batches at a significant level corresponding to a  $\beta$  error probability of 0.9.

|   |    |    |    |    |    |    |    |    |    |    |
|---|----|----|----|----|----|----|----|----|----|----|
| A | 35 | 40 | 42 | 30 | 12 | 50 | 45 | 28 | 26 | 30 |
| B | 20 | 24 | 28 | 26 | 18 | 50 | 50 | 48 | 48 | 09 |

8. In order to evaluate safety performance of employees across 3 departments, 5 employees across each department were randomly monitored and their safety behaviour on a hundred scale is given below. Do the departments differ in their safety behaviour?

| Department | 1  | 2  | 3  | 4  | 5  |
|------------|----|----|----|----|----|
| A1         | 68 | 73 | 75 | 65 | 78 |
| A2         | 85 | 85 | 78 | 86 | 79 |
| A3         | 73 | 77 | 72 | 70 | 76 |

9. Develop a Regression Equation between A and B using Method of Least Square. Consider B as the dependent variable. Explain the significance of estimated slope.

| Observation no. | 1  | 2  | 3  | 4  | 5  |
|-----------------|----|----|----|----|----|
| A               | 75 | 80 | 85 | 90 | 95 |
| B               | 80 | 75 | 80 | 60 | 55 |

10. Foodgrain production (in lakh tones) is given below. Find the Trend by using 3-yearly and 4-yearly moving average method, tabulate the trend values and predict the production for the year 2022.

| Years | Production |
|-------|------------|
| 2008  | 40         |
| 2009  | 60         |
| 2010  | 45         |
| 2011  | 85         |
| 2012  | 130        |
| 2013  | 135        |
| 2014  | 150        |
| 2015  | 120        |
| 2016  | 200        |

11. An evaluation of teaching methods shows the following outcomes.

| Method of Teaching    | No of students | Average marks obtained | Population Standard Deviation |
|-----------------------|----------------|------------------------|-------------------------------|
| Chalk and Talk Method | 32             | 70                     | 5                             |
| PPT and Talk Method   | 29             | 65                     | 8                             |

Conduct hypothesis testing for the mean difference of the teaching methods at a significant level corresponding to a Type I error probability of 0.01.

\*\*\*\*\*

| CODE      | COURSE NAME                   | CATEGORY      | L | T | P | CREDIT |
|-----------|-------------------------------|---------------|---|---|---|--------|
| J1PTET102 | URBAN TRANSPORTATION PLANNING | PROGRAM CORE1 | 3 | 0 | 0 | 3      |

**Preamble:** The course aims to introduce to the students the concept of transportation planning and impart in-depth knowledge on the four stage planning process and to highlight the need for sustainable transportation

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                                                                             |
|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To identify the need for transportation planning, the issues and challenges related to transportation and its interaction with urban structure and land use |
| <b>CO 2</b> | To apply the concept of delineation of study area, sampling of data, and data collection techniques for the four-stage planning process                     |
| <b>CO 3</b> | To apply and analyse the techniques for predicting trip generation                                                                                          |
| <b>CO 4</b> | To analyse the methods for estimating trip distribution                                                                                                     |
| <b>CO 5</b> | To examine the methods for predicting mode split and traffic assignment                                                                                     |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      | 3    | 3    | 2    |      |      |
| <b>CO 2</b> |      |      | 3    | 1    | 2    |      |      |
| <b>CO 3</b> |      |      | 3    | 2    | 3    |      |      |
| <b>CO 4</b> |      |      | 3    | 2    | 3    |      |      |
| <b>CO 5</b> |      |      | 3    | 2    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Remember         | 10                       |
| Understand       | 15                       |
| Apply            | 20                       |
| Analyse          | 15                       |
| Evaluate         |                          |
| Create           |                          |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which

student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

## Model Question Paper

### M.Tech Degree Examination

Branch: **Civil Engineering**

Specialisation: **Transportation Engineering**

Subject: **URBAN TRANSPORTATION PLANNING**

Time: 2.5 Hrs

Max. Marks: 60

#### PART A

(Answer All Questions)

1. The goal of an urban community is to “Promote Safe travel”. List two objectives and two standards related to each of the objectives to orient the urban transportation planning process towards the stated goal.
2. Discuss about the need to collect data in the transportation planning process. What are the various types of data that are required to be collected?
3. List down the various factors governing trip generation and trip attraction. Explain the influence of each of them in trip generation and trip attraction.
4. What are diversion curves? How are these used in traffic assignment?
5. Discuss the non-transport solutions for transport problems.

(5x5 = 25 marks)

#### PART B

(Answer any 5 Questions)

6. With the help of a flow chart, discuss the various steps of system approach to transportation planning process. Explain the same with an example.
7. Prepare a sampling plan for conducting an O-D survey in an urban area with 500,000 residents.
8. A study area represented by seven traffic analysis zones has the following characteristics.

| TAZ               | A    | B   | C   | D   | E   | F   | G   |
|-------------------|------|-----|-----|-----|-----|-----|-----|
| Trip Produced     | 1000 | 920 | 650 | 520 | 430 | 275 | 800 |
| Vehicle Ownership | 750  | 625 | 300 | 270 | 190 | 110 | 430 |

Develop a model for trip generation and check the goodness of fit.

9. What is cross-classification analysis? With an example, explain how it is applied to trip generation modelling?
10. What are the principles of traffic assignment? Outline the procedure for the equilibrium trip assignment technique.

11. (a) What are the factors affecting the choice among alternative modes of transport. (b) Discuss application of probit models in modal split analysis.
12. Illustrate and explain the sequence of activities and equation systems of Lowry Model.

(5x7=35 marks)

### Syllabus and Course Plan

| No       | Topic                                                                                                                                                                           | No. of Lectures |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Urban Transportation Planning Process &amp; Concepts (8 hrs)</b>                                                                                                             |                 |
| 1.1      | Role of transportation and changing concerns of society in transportation planning                                                                                              | 2               |
| 1.2      | Systems approach to urban transportation planning concepts; flow chart for transportation planning process                                                                      | 2               |
| 1.3      | Trip-based and Activity-based approaches                                                                                                                                        | 1               |
| 1.4      | Concept of Travel Demand and its Modelling based on Consumer Behaviour of Travel Choices- Independent Variables, Travel Attributes.                                             | 3               |
| <b>2</b> | <b>Study Area and TAZ (7 hrs)</b>                                                                                                                                               |                 |
| 2.1      | Definition of the study area, Cordon line, screen line, zoning                                                                                                                  | 2               |
| 2.2      | Data needs for planning process, Data collection techniques, sample size determination, O-D surveys, Use of secondary data                                                      | 3               |
| 2.3      | Introduction to sequential travel demand modelling- trips, types.                                                                                                               | 2               |
| <b>3</b> | <b>Trip Generation and Trip Distribution Analysis (9 hrs)</b>                                                                                                                   |                 |
| 3.1      | Trip Generation Models- Zonal Models, Category analysis, Household Models                                                                                                       | 2               |
| 3.2      | Trip Attractions of Work Centres & Commercial Trips                                                                                                                             | 1               |
| 3.3      | Trip End and Trip Interchange Models                                                                                                                                            | 1               |
| 3.4      | Trip Distribution Models - Growth Factor Models - Fratar and Furness models.                                                                                                    | 3               |
| 3.5      | Synthetic Models – Gravity Models, Opportunity Models and their Calibration                                                                                                     | 2               |
| <b>4</b> | <b>Mode Split and Route Split Analysis (8 hrs)</b>                                                                                                                              |                 |
| 4.1      | Modal split analysis, Modelling travel behaviour. Aggregate and Dis-aggregate Models                                                                                            | 2               |
| 4.2      | Probabilistic models- Probit and logit models.                                                                                                                                  | 3               |
| 4.3      | Trip assignment models. Minimum path assignment. All or nothing assignment, Equilibrium assignment, Capacity restrained assignment, Multiple path assignment. Diversion curves. | 3               |
| <b>5</b> | <b>Land use-transport models (8 hrs)</b>                                                                                                                                        |                 |
| 5.1      | Land use-transport models. Lowry model. Lowry Garin model. Iterative solutions.                                                                                                 | 3               |
| 5.2      | Non-Transport solutions for transport problems                                                                                                                                  | 2               |
| 5.3      | Introduction to transport planning softwares.                                                                                                                                   | 3               |

## **Reference Books**

1. Hutchinson. B. G, Principles of urban transportation planning, McGraw Hill, New York
2. Dickey. J. W, Metropolitan transportation planning, McGraw Hill, New York.
3. Meyer D Michael and Miller Eric J, Urban transportation planning: a decision-oriented approach, McGraw Hill
4. Bruton M.J, Introduction to transportation planning, Hutchinson, London
5. Partha Chakroborty, Principles of Transportation Engineering, Animesh Das Prentice-Hall, India.
6. Kadiyali L.R, Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi.

| CODE      | COURSE NAME                             | CATEGORY       | L | T | P | CREDIT |
|-----------|-----------------------------------------|----------------|---|---|---|--------|
| J1PTET103 | ANALYSIS AND DESIGN OF PAVEMENT SYSTEMS | PROGRAM CORE 2 | 3 | 0 | 0 | 3      |

**Preamble:** This course is aimed at providing a thorough understanding of the fundamentals of pavement design - factors involved, stress analysis, design approaches in the major types of pavements, and that has better performance and longer service life.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                                         |
|------|---------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the different component parts of pavements and various factors affecting design of pavements |
| CO 2 | Understand the fundamentals of stress distribution within a pavement system                             |
| CO 3 | Analyse the stresses and design flexible pavements with better performance and longer service life      |
| CO 4 | Analyse the stresses and design rigid pavements with better performance and longer service life         |
| CO 5 | Design the reinforcements in cement concrete pavements                                                  |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 |      |      | 3    | 1    | 2    |      |      |
| CO 2 |      |      | 2    | 2    | 3    |      |      |
| CO 3 | 3    |      | 3    | 3    | 3    |      |      |
| CO 4 | 3    |      | 3    | 3    | 3    |      |      |
| CO 5 | 3    |      | 3    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Remember         | 10                       |
| Understand       | 15                       |
| Apply            | 20                       |
| Analyse          | 15                       |
| Evaluate         |                          |
| Create           |                          |

**Mark distribution**

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

**Continuous Internal Evaluation Pattern: 40 marks**

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

## **Model Question Paper**

**M.Tech Degree Examination Branch: Civil**

**Engineering**

**Specialisation: Transportation Engineering**

**Subject: J1PTET103 ANALYSIS AND DESIGN OF PAVEMENT SYSTEMS**

Time: 2.5 Hrs

Max. Marks: 60

### **PART A**

(Answer **All** Questions)

1. Explain Dynamic modulus and flow number of bituminous mixes.
2. What are the assumptions in Burmister's theory? What are the advantages of Burmister's theory over Boussinesq's?
3. Discuss the similarities and the differences between the Asphalt Institute and IRC method of flexible pavement design.
4. Compare the mechanism used in rigid and flexible pavements for handling stresses due to decrease in temperature.
5. Discuss the similarities and differences in the process of designing jointed plain concrete pavements and jointed reinforced concrete pavements as per PCA design method.

(5x5 = 25 marks)

### **PART B**

(Answer **any 5** Questions)

6. Explain Marshal Stability test method of mix design for bituminous mixes. Plot the sample graphs to determine optimum binder content. List out the standard specifications.
7. A pavement structure is comprised of the following layers – 5.75 inch asphalt concrete surface  $E = 400,000$  psi, 23 inches of granular base,  $E = 20,000$  psi and a sub grade having an  $E = 10,000$  psi. All layers are assumed to have  $\mu = 0.5$ . Calibrate the horizontal tensile strain at the bottom of Asphalt concrete layer and the vertical compressive strain at the top of the sub grade layer under the centerline of a 40,000 pound wheel load, 150 psi pressure.
8. A pavement structure is comprised of the following layers – 5.75 inch asphalt concrete surface  $E = 400,000$  psi, 23 inches of granular base,  $E = 20,000$  psi and a sub grade having an  $E = 10,000$  psi. All layers are assumed to have  $\mu = 0.5$ . Calibrate the horizontal tensile strain at the bottom of Asphalt concrete layer and the vertical compressive strain at the top of the sub grade layer under the centerline of a 40,000 pound wheel load.
9. Design a suitable concrete pavement ( 4.5x 3.5cm) as per IRC, situated at Kanpur, for design wheel load of 4100 kg and tyre pressure of 7 kg/cm<sup>2</sup>. The CBR value of the sub grade soil is found to be 4. 5%. The forecasted traffic intensity at the end of design life is 1000 CV/ day. Assume other parameters wherever necessary.

10. Explain the need and requirements of joints in cement concrete pavements. What are the various types of joints? Explain the need of spacing in concrete pavements.
11. Explain in detail the AASHTO design procedure of flexible pavement design.
12. What are the various factors affecting the design of highway pavements. Explain in detail the effect of traffic.

(5x7=35 marks)

**Syllabus and Course Plan**

| No  | Topic                                                                                                                                         | No. of Lectures |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Introduction to Pavements and Pavement Design (8 hrs)</b>                                                                                  |                 |
| 1.1 | Types of pavements, Flexible and rigid pavements, Functions of individual layers, Highway and airport pavements                               | 2               |
| 1.2 | Design of bituminous mixes using Marshall method, and SUPERPAVE method, Dynamic modulus, flow time, flow number, fatigue of bituminous mixes. | 2               |
| 1.3 | Variables Considered in Pavement Design: Traffic factors, Material properties, Climatic effects                                               | 2               |
| 1.4 | Traffic Analysis: ADT, AADT, Truck Factor, Growth Factor, Lane Distribution and Vehicle Damage Factor                                         | 2               |
| 2   | <b>Stresses and strains in flexible pavements (7 hrs)</b>                                                                                     |                 |
| 2.1 | Stress inducing factors in flexible pavements, Vehicle-Pavement interaction, Stresses and deflections in homogeneous soil mass.               | 3               |
| 2.2 | Burmister's layer theory: Solutions for one, two and three layered pavement systems.                                                          | 4               |
| 3   | <b>Methods of flexible pavement design (8 hrs)</b>                                                                                            |                 |
| 3.1 | Principles of Mechanistic- Empirical Pavement Design (MEPD)                                                                                   | 2               |
| 3.2 | Methods of flexible pavement design: IRC Method.                                                                                              | 2               |
| 3.3 | Asphalt Institute Method, AASHTO Method.                                                                                                      | 4               |
| 4   | <b>Stresses in rigid pavements (9hrs)</b>                                                                                                     |                 |
| 4.1 | Westergaard's theory and assumptions.                                                                                                         | 2               |
| 4.2 | Types of stresses: Wheel load stresses, Temperature stresses, Critical combination of stresses.                                               | 3               |
| 4.3 | Rigid pavement design methods: IRC method, AASHTO method and PCA method.                                                                      | 4               |
| 5   | <b>Design of reinforcements in cement concrete pavements (8 hrs)</b>                                                                          |                 |
| 5.1 | Types of joints in cement concrete pavements, functions and requirements Joint spacing                                                        | 3               |
| 5.2 | Design of dowel bars and tie bars (IRC method).                                                                                               | 3               |
| 5.3 | Introduction to softwares for design of pavements                                                                                             | 2               |

## **Reference Books**

1. Yang H. Huang, Pavement Analysis and Design, Prentice Hall, 2004
2. Yoder and Witczak, Principles of Pavement Design, John Wiley and sons, 2007
3. Rajib B. Mallick and Tahar El-Korchi, Pavement Engineering – Principles and Practice, CRC Press (Taylor and Francis Group)
4. Khanna S.K., Justo C.E.G. and Veeraraghavan A, “Highway Engineering”, Nem Chand & Bros., Roorkee, 2014
5. Latest revisions of IRC codes: IRC: 37 and IRC: 58

| CODE      | COURSE NAME                 | CATEGORY   | L | T | P | CREDIT |
|-----------|-----------------------------|------------|---|---|---|--------|
| J1PTET107 | PAVEMENT<br>ENGINEERING LAB | LABORATORY | 0 | 0 | 2 | 1      |

**Preamble:** Nil

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                            |
|-------------|--------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To evaluate characteristics of aggregates used for pavement construction                   |
| <b>CO 2</b> | To grade and evaluate the characteristics bituminous binder used for pavement construction |
| <b>CO 3</b> | To carry out mix design and to evaluate bituminous mixtures                                |
| <b>CO 4</b> | To carry out pavement condition survey and its functional evaluation                       |

**Mapping of course outcomes with program outcomes**

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      |      |      |      |      |      |
| <b>CO 2</b> |      |      |      |      |      |      |      |
| <b>CO 3</b> |      |      |      |      |      |      |      |
| <b>CO 4</b> |      |      |      |      |      |      |      |

Note: 1: Slightly; 2: Moderately; 3: Substantially

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 100 | –   | –            |

**Continuous Internal Evaluation Pattern:**

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

## LIST OF EXPERIMENTS

### Tests on aggregates

1. Familiarization of the basic tests of aggregate- Aggregate impact test, Los Angeles abrasion test, shape test to ensure the suitability of aggregates as per MoRTH
2. Gradation of coarse aggregates, fine aggregates and filler material
3. Specific gravity of coarse aggregates, fine aggregates and filler

### B. Tests on bitumen

1. Specific gravity
2. Absolute and kinematic viscosity
3. Apparent viscosity of bitumen using a rotational viscometer
4. Short term aging of bitumen
5. Ductility and elastic recovery
6. Softening point test of unaged and aged bitumen
7. Tests on emulsion- Residue by evaporation, storage stability, coating ability, Saybolt viscosity

### C. Tests on Bituminous Mixtures

1. Determination of optimum binder content using Marshall mix design
2. Determination of Gmm using CORELOK system
3. Bitumen content and gradation using centrifuge extraction and Ignition oven method
4. Determination of Indirect Strength Ratio of a given bituminous mix
5. Permanent deformation using wheel tracking test
6. Preparation of samples using gyratory compactor

### D. Pavement Evaluation

1. Pavement condition rating
2. Roughness measurement using Roughometer and MERLIN
3. Benkelman beam deflection method
4. Dynamic cone penetrometer
5. Field CBR

**Any three/four sub experiments listed above can be made optional**

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                              | No. of Hrs |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| 1   | <b>Tests on aggregates (2 sessions)</b>                                                                                                                            |            |
| 1.1 | Familiarization of the basic tests of aggregate- Aggregate impact test, Los Angeles abrasion test, shape test to ensure the suitability of aggregates as per MoRTH | 1          |
| 1.2 | Gradation and specific gravity of coarse aggregates, fine aggregates and filler (need to plan such that it can be used as input for mix design)                    | 2          |
| 2   | <b>Tests on bitumen (3 sessions)</b>                                                                                                                               |            |
| 2.1 | Specific gravity                                                                                                                                                   | 0.5        |
| 2.2 | Absolute and kinematic viscosity                                                                                                                                   | 1.5        |
| 2.3 | Apparent viscosity of bitumen using a rotational viscometer                                                                                                        | 1          |
| 2.4 | Short term aging of bitumen                                                                                                                                        | 1          |
| 2.5 | Ductility and elastic recovery                                                                                                                                     | 1          |
| 2.6 | Softening point test- unaged and aged sample                                                                                                                       | 1          |

|     |                                                                                                                      |   |
|-----|----------------------------------------------------------------------------------------------------------------------|---|
| 2.7 | Determination of grade of given unmodified bitumen b @ sieve 75 µm and discussion on grading of modified bitumen     | 1 |
| 2.8 | Tests on emulsion- Residue by evaporation, storage stability, coating ability, Saybolt viscosity                     | 2 |
| 3   | <b>Tests on Bituminous Mixtures (5 sessions)</b>                                                                     |   |
| 3.1 | Determination or discussion of mixing and compaction temperature<br>Sample preparation for Marshall mix design       | 2 |
| 3.2 | Determination of Flow and stability of samples and determination of optimum binder content using Marshall mix design | 1 |
| 3.3 | Determination of Gmm using CORELOK system                                                                            | 1 |
| 3.4 | Bitument content and gradation using centrifuge extraction and Ignition oven method                                  | 2 |
| 3.5 | Determination of Indirect Strength Ratio of a given bituminous mix                                                   | 2 |
| 3.6 | Permanent deformation using wheel tracking test                                                                      | 2 |
| 3.7 | Preparation of samples using gyratory compactor                                                                      | 2 |
| 4   | <b>Pavement Evaluation (3 sessions)</b>                                                                              |   |
| 4.1 | Pavement condition rating                                                                                            | 1 |
| 4.2 | Roughness measurement using Roughometer and MERLIN                                                                   | 2 |
| 4.3 | Benkelman beam deflection method(demonstration and calculation with given values)                                    | 1 |
| 4.4 | Dynamic cone penetrometer                                                                                            | 1 |
| 4.5 | Field CBR                                                                                                            | 2 |

## References:

1. Relevant IS, IRC, ASTM and AASHTO Codes.

(i) MORTH V (2013), IRC codes: IRC: 81(2012), IRC SP 11 (1984), IRC SP 16 (2019)

(ii) IS codes: IS 73: 2018, IS 15462: 2004, IS 2386: 2002, IS 3117: 2019 and IS 8887: 2020.

(iii) ASTM codes: ASTM D2172/D2172M, D6307 – 10, D113 – 07, D2170/D2170M – 18, D2171/D2171M – 18, D70 – 18a, C128 – 15, C127 – 15, C136/C136M – 14, D6930 – 19, D6927 – 15, D6926 – 16

(iv) AASHTO T 283

2. Laboratory Manual in Highway Engineering, Ajay K. Duggal, New Age International Private Limited, 2017, Second Edition.

3. Highway Materials and Pavement Testing, S.K. Khanna, C.E.G. Justo, and A. Veeraragavan, Nem Chand and Bros, Roorkee, India, 2014, Fifth Edition.

4. Highway Material Testing and Quality Control, G.V Rao, I.K International Publishing House Pvt. Ltd., New Delhi, India, 2015.

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**SEMESTER I**

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**PROGRAM ELECTIVE I**

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| CODE      | COURSE NAME                                             | CATEGORY              | L | T | P | CREDIT |
|-----------|---------------------------------------------------------|-----------------------|---|---|---|--------|
| J1PTET114 | OPERATIONS RESEARCH IN<br>TRANSPORTATION<br>ENGINEERING | PROGRAM<br>ELECTIVE 1 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to impart an awareness on the methods of Operations Research and mathematical procedures of linear and nonlinear programming

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                                |
|-------------|----------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To create an awareness on concepts and tools in optimization                                                   |
| <b>CO 2</b> | To build models for simple problems in transportation engineering                                              |
| <b>CO 3</b> | To utilise proper mathematical methods to solve the developed models                                           |
| <b>CO 4</b> | To apply OR techniques constructively to make effective decisions in the area of transportation and management |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 2    |      | 3    |      |      | 2    |
| <b>CO 2</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |
| <b>CO 3</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |
| <b>CO 4</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60$  %.

## Model Question Paper

Course Code & Name:

### J1PTET114 OPERATIONS RESEARCH IN TRANSPORTATION ENGINEERING

Max. Marks: 60

Duration: 2.5 hours

#### PART A

(Answer all Questions: Each question carries 5 marks)

1. Write the dual of the following i. Maximise  $Z = x_1 + 2x_2$   
Subject to:  $2x_1 + 3x_2 \geq 4$ ;  $3x_1 + 4x_2 = 5$ ;  $x_1 \geq 0$  and  $x_2$  unrestricted  
  
ii) Minimise  $Z = 4x_1 + 5x_2 - 3x_3$ ; Subject to:  $x_1 + x_2 + x_3 = 22$ ;  
 $3x_1 + 5x_2 - 2x_3 \leq 65$ ;  $x_1 + 7x_2 + 4x_3 \geq 120$   $x_1, x_2 \geq 0$  and  $x_3$  unrestricted
2. Explain the steps involved in Two-Phase Simplex Method
3. A company has a demand of 12000 units/year for an item and it can produce 2000 such items per month. The cost of one set up is Rs 400 and the holding cost/unit/month is Rs 0.15. Find the optimum lot size and total cost per year, assuming the cost of one unit as Rs 4.
4. Differentiate between constrained and unconstrained problem with the help of an example.
5. Describe the procedure involved in the application of gradient projection method.

#### PART B

(Answer any five questions: Each carries 7 marks)

6. Using Big M Method Maximise  $Z = 3X_1 + 2X_2 + X_3$   
Subject to:  $-3X_1 + 2X_2 + 2X_3 = 8$ ,  $-3X_1 + 4X_2 + X_3 = 7$ ,  $X_1, X_2, X_3 \geq 0$
7. The standard weight of a special brick is 5 kg and it contains two ingredients 'A' and 'B'. 'A' costs Rs 5/kg and 'B' costs Rs 8/kg. Strength considerations dictate that the brick contains not more than 4 kg of 'A' and a minimum of 2 kg of 'B' since the demand for the product is likely to be related to the price of the brick. Formulate the problem and solve it graphically. Also write the Dual.
8. Maximise  $Z = 4x_1 + 3x_2$   
Subject to:  $x_1 + 2x_2 \leq 4$ ;  $2x_1 + x_2 \leq 6$ ;  $x_1, x_2 \geq 0$  and integers
9. Formulate the inventory model with demand rate non uniform and production rate infinite.

10. Determine the optimum solution of the nonlinear programming problem and check whether it maximises or minimises the objective function.

Optimise  $f(x) = x_{12} + x_{22} + 3x_1x_2 - x_1 + 3x_2$ ;

Sub to  $x_{12} + x_{22} = -1$  ;  $x_1, x_2 \geq 0$

11. Apply Wolfe's method to formulate the initial basic feasible solution.

Maximise  $Z = 2x_1 + x_2 - x_{12}$

Subject to:  $2x_1 + 3x_2 \leq 6$  ;  $2x_1 + x_2 \leq 4$  ,  $x_1, x_2 \geq 0$

12. Determine whether the following functions are convex, concave or neither.

i.  $f(x) = 4x_{12} + 3x_{22} + x_{32} - 6x_1x_2 + x_1x_3 - 0.5x_1 - 2x_2 + 15$  ;

ii)  $f(x) = x_1 + 2x_3 + x_2x_3 - x_{12} - x_{22} - x_{32}$

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                       | No. of Lectures |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | Introduction to Operations Research                                                                                                                                                         |                 |
| 1.1 | Basics definition, scope, objectives, phases, models and limitations of Operations Research                                                                                                 | 2               |
| 1.2 | Linear Programming Problem – Formulation of LPP, Simplex Method, Artificial variables, Big-M method, two-phase method, degeneracy and unbound solutions.                                    | 4               |
| 1.3 | Duality Theory, The Primal Vs- Dual-Solutions                                                                                                                                               | 2               |
|     |                                                                                                                                                                                             |                 |
| 2   | Sensitivity Analysis and Integer programming                                                                                                                                                |                 |
| 2.1 | Sensitivity Analysis: Changes in Objective-Function<br>Changes in RHS.- revised simplex method –parametric programming                                                                      | 2               |
| 2.2 | Integer programming: Relevance of integer variables and relevance of integer programming                                                                                                    | 2               |
| 2.3 | Formulation of problems with binary variables-cutting plane method                                                                                                                          | 2               |
| 2.4 | Mixed integer programming-branch and bound methods                                                                                                                                          | 2               |
|     |                                                                                                                                                                                             |                 |
| 3   | Inventory models                                                                                                                                                                            |                 |
| 3.1 | Inventory costs                                                                                                                                                                             | 2               |
| 3.2 | Models with deterministic demand – demand rate uniform and production rate infinite - demand rate non-uniform and production rate infinite - demand rate uniform and production rate finite | 6               |
|     |                                                                                                                                                                                             |                 |
| 4   | Nonlinear programming                                                                                                                                                                       |                 |
| 4.1 | Multi-variable optimisation with equality constraints- Langarange multiplier method                                                                                                         | 2               |

|     |                                                                  |    |
|-----|------------------------------------------------------------------|----|
| 4.2 | Optimisation in the presence of inequality constraints           | 2  |
| 4.3 | Convexity and role in optimization                               | 2  |
| 4.4 | Kuhn Tucker conditions                                           | 2  |
|     |                                                                  |    |
| 5   | Quadratic programming                                            |    |
| 5.1 | Wolf's method- Beale's method-Frank & Wolfe Method               | 2  |
| 5.2 | Reduced Gradient method                                          | 2  |
| 5.3 | Gradient projection method                                       | 2  |
| 5.4 | Convex simplex method                                            | 1  |
| 5.5 | Case studies on applications of OR in transportation engineering | 1  |
|     | Total hours                                                      | 40 |

### Reference Books

1. Bazaraa M S, Jarvis & herali H D ,Linear Programming and Network flows, John Wiley & Sons, Singapore 1990.
2. Bazaraa M S, Sherali H D & Shetty, C. M., Non Linear Programming, Theory & Algorithms 2nd edition, John Wiley & Sons, Singapore 1995.
3. Goel B S and Mittal S K ' Operations Research' 1999
4. Taha, Hamdy, Operations Research, 7th edition, (USA: Macmillan Publishing Company), 2003

| CODE      | COURSE NAME                | CATEGORY           | SEM | IN | TE | CREDIT |
|-----------|----------------------------|--------------------|-----|----|----|--------|
| J1PTET124 | SUSTAINABLE TRANSPORTATION | PROGRAM ELECTIVE 1 | 3   | 0  | 0  | 3      |

**Preamble:** Objective of the course is to introduce the principles and practice of sustainability on transportation systems and development of an eco-friendly transport system.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                              |
|------|------------------------------------------------------------------------------|
| CO 1 | Understanding the importance and principles of sustainability                |
| CO 2 | Analyse Transportation network for eco-friendliness and quantify the levels. |
| CO 3 | Apply the basic principles of demand management and alternate modes          |
| CO 4 | Apply concepts of sustainability in developing green fuels and vehicles.     |
| CO 5 | Design for sustainability in public transport                                |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 | 2    |      | 2    | 3    |      |      |      |
| CO 2 |      | 3    |      | 2    |      |      |      |
| CO 3 | 3    |      |      | 2    |      |      |      |
| CO 4 |      | 2    |      | 3    |      |      |      |
| CO 5 | 2    |      | 3    |      |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination (%) |
|------------------|------------------------------|
| Apply            | 20                           |
| Analyse          | 30                           |
| Evaluate         | 25                           |
| Create           | 25                           |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60\%$ .

## **Model Question paper**

*Course Code & Name:*

**J1PTET124 Sustainable Transportation**

Max. Marks: 60

Duration: 2.5 hours

### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. What are problems of present transportation systems?
2. Discuss the basic concepts of sustainable network planning?
3. Explain the necessity of Multi Modal Transport.
4. Write a brief note on alternate fuels.
5. Explain the ways to improve sustainability in public transport.

### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. Discuss how the land use and travel behaviour affect sustainability.
7. Explain the difference between Elastic and Fixed Networks
8. Discuss the various strategies for travel demand management.
9. Explain the concept and design principles of Green pathways.
10. Discuss the Non Motorised Transport Policy of India.
11. Suggest various strategies to improve public transport
12. What is Green logistics and why does it matter?

**Syllabus and Course Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

| No  | Topic                                                                                            | No. of Lectures |
|-----|--------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Introduction to sustainable transportation</b>                                                |                 |
| 1.1 | Introduction to sustainable transportation, definition, necessity                                | 1               |
| 1.2 | Problems of present transportation system                                                        | 1               |
| 1.3 | Fundamental Principles, Quantifying sustainability                                               | 2               |
| 1.4 | Sustainable transportation planning: Paradigm shift in planning                                  | 2               |
| 1.5 | Land use and Travel behaviour                                                                    | 2               |
| 2   | <b>Sustainable Transportation Networks</b>                                                       |                 |
| 2.1 | Sustainable Network planning and design                                                          | 3               |
| 2.2 | Elastic and fixed demands on networks                                                            | 2               |
| 2.3 | Measurement of network performance, factors and parameters                                       | 2               |
| 2.4 | Viability of networks                                                                            | 1               |
| 3   | <b>Demand Management and Alternate Modes</b>                                                     |                 |
| 3.1 | Demand Management – need, strategies for demand management                                       | 3               |
| 3.2 | Alternate modes – various modes, benefits                                                        | 2               |
| 3.3 | Multi modal transport – necessity, advantages, multimodal transport linkages, pricing strategies | 3               |
| 4   | <b>Emerging Concepts in Sustainable Transportation</b>                                           |                 |
| 4.1 | Eco friendly transport – Environmental issues, alternate fuels, green fuels                      | 3               |
| 4.2 | Green pathways, introduction, design concepts                                                    | 2               |
| 4.3 | Energy and emission standards                                                                    | 2               |
| 4.4 | Non Motorised Modes                                                                              | 1               |
| 5   | <b>Sustainable Public Transport</b>                                                              |                 |
| 5.1 | Sustainability in personal and public transport                                                  | 1               |
| 5.2 | Methods to promote public transport                                                              | 1               |
| 5.3 | Transit Oriented Developments – introduction only                                                | 2               |
| 5.4 | Freight and Green logistics                                                                      | 4               |

## Reference

1. Sustainable and Efficient Transport: Incentives for Promoting a Green Transport Market Edited by Ellen Eftestøl-Wilhelmsson, et al, Edward Elgar
2. Thomas Abdallah: Sustainable Mass Transit: Challenges and Opportunities in Urban Public Transportation.
3. McClintock, H. Planning for Cycling – principles, practice and solutions for urban planners. Cambridge: CRC Press.
4. Frumkin, H.; Frank, L. and Jackson, R. Urban Sprawl and Public Health, designing, planning, and building for healthy communities. Washington DC: Island Press

5. Green Transportation Logistics: The Quest for Win-Win Solutions Editors: Psaraftis, Harilaos N. (Ed.), Springer

| CODE      | COURSE NAME                                                  | CATEGORY           | SEM | IN | PR | CRED |
|-----------|--------------------------------------------------------------|--------------------|-----|----|----|------|
| J1PTET134 | GEOSYNTHETICS AND GROUND IMPROVEMENT TECHNIQUES FOR PAVEMENT | PROGRAM ELECTIVE 1 | 3   | 0  | 0  | 3    |

**Preamble:** This course describes the fundamental aspects of geosynthetics and their applications in infrastructure development including foundations, embankments, earth retaining structures, pavements and slope stabilization. This course also describes the basic concepts of different ground improvement techniques for varied subsoil types and profiles. Upon completion of this course, the student will be able to select and design appropriate technique for a given soil condition, type of structure and type of loading.

**Course outcomes:** After the completion of the course the student will be able to

|      |                                                                        |
|------|------------------------------------------------------------------------|
| CO 1 | Analyse the various type of geotextiles and its functions              |
| CO 2 | Evaluate the various properties of geotextiles and its testing methods |
| CO 3 | Apply the design principles of reinforced soil structures in field     |
| CO 4 | Analyse specific applications of geotextile in pavement Construction   |
| CO 5 | Analyse various other ground improvement techniques available          |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 | 2    | 1    | 1    | 3    | 3    | 1    |      |
| CO 2 | 2    | 1    | 1    | 3    | 3    | 1    |      |
| CO 3 | 3    | 2    | 2    | 3    | 3    | 1    |      |
| CO 4 | 3    | 1    | 2    | 3    | 3    | 1    |      |
| CO 5 | 3    | 1    | 2    | 3    | 3    | 1    |      |
|      |      |      |      |      |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60$  %.

## **Model Question Paper**

*Course Code & Name:*

**J1PTET134 Geosynthetics and Ground Improvement Techniques for Pavements**

Max. Marks: 60

Duration: 2.5 hours

### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Write a brief note on geosynthetics and various potential area of applications.
2. List the various functions of geotextiles and explain the separation function in the context of pavement application.
3. Discuss the internal and external stability of retaining wall design.
4. Enlist the various Mechanical properties of geotextiles?
5. Explain the test procedure to find tensile strength of geosynthetics.

### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. Write a brief note on coir geotextiles and its special areas of application.
7. Explain the concept of Giroud and Noiray approach and its practical significance.
8. Explain the test procedure to find tensile strength of geosynthetics.
9. Explain the basic concept of dynamic compaction.
10. Discuss the features and design principles of stone column.
11. Write a brief note on vibro floatation technique.
12. Illustrate the mechanism and method on fly ash stabilization.

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                                                                                                                                                                                                                                  | No. of Lectures |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Geo synthetics -overview</b>                                                                                                                                                                                                                                                                                                                                                                                        |                 |
| 1.1 | Introduction, types manufacturing methods ( brief description)                                                                                                                                                                                                                                                                                                                                                         | 3               |
| 1.2 | Functions of Geo synthetics- Reinforcement,separation, filtration, Drainage, Fluid transmission, protection                                                                                                                                                                                                                                                                                                            | 4               |
| 2   | <b>Natural Geotextiles</b>                                                                                                                                                                                                                                                                                                                                                                                             |                 |
| 2.1 | Types –jute- coir- Factors governing the usage of natural geotextiles, Importance                                                                                                                                                                                                                                                                                                                                      | 2               |
| 2.2 | Functions-of natural geotextiles                                                                                                                                                                                                                                                                                                                                                                                       | 2               |
| 2.3 | Civil Engineering Applications of natural geotextiles                                                                                                                                                                                                                                                                                                                                                                  | 2               |
| 3   | <b>Testing and Evaluation</b>                                                                                                                                                                                                                                                                                                                                                                                          |                 |
| 3.1 | Importance of testing, test conditions, sampling, Various testing Standards                                                                                                                                                                                                                                                                                                                                            | 2               |
| 3.2 | Basic Properties- physical(Mass per unit area, thickness, compressibility, apparent opening size, width and length),Hydraulic properties-Permeability-in plane& cross plane, Filtration and Drainage: geotextile filter requirements, drain and filter properties design criteria                                                                                                                                      | 4               |
| 3.3 | Mechanical properties (Tensile strength, narrow strip tensile test, grab test, strip wide width tensile test, seam testing, interface friction, creep resistance)- constructability/survivability (puncture test, CBR push through test, trapezoidal tear test, diaphragm bursting strength test, cone drop test), durability (abrasion resistance, ultraviolet resistance, temperature stability, chemical stability) | 4               |
| 4   | <b>Design principles</b>                                                                                                                                                                                                                                                                                                                                                                                               |                 |
| 4.1 | Principle of reinforced earth- soil retaining structures-type-components- load calculation- Design of reinforced Retaining wall, Internal and external stability                                                                                                                                                                                                                                                       | 3               |
| 4.2 | Embankments in soft soil: stability analysis influence of reinforcement extensibility, relationships for design, settlement Analysis                                                                                                                                                                                                                                                                                   | 3               |
| 4.3 | Design of unpaved road by Giroud-Noiray method                                                                                                                                                                                                                                                                                                                                                                         | 2               |
| 5   | <b>Specific Applications &amp; ground improvement techniques</b>                                                                                                                                                                                                                                                                                                                                                       |                 |
| 5.1 | Geotextiles for separation and reinforcement - application in flexible pavements, Rehabilitation, Reflective Crack Treatment for Pavements -Ground improvement using stone columns- Prefabricated vertical drains-                                                                                                                                                                                                     | 3               |
| 5.2 | Improvement of bearing capacity using Geocell- Use of geotextiles for construction of heavy container yards and railway lines.                                                                                                                                                                                                                                                                                         | 3               |
| 5.3 | Ground improvement techniques-principle of compaction-shallow stabilization with additives-lime-fly ash-cement-dynamic compaction- vibro-floatation- electro osmosis; Grouting..                                                                                                                                                                                                                                       | 3               |

## Reference Books

1. Koerner, R.M. Designing with Geo synthetics, Prentice Hall, New Jersey, USA, 4th edition, 1999.
2. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana. Geo synthetics - New Horizons, Asian Books Private Ltd., New Delhi, 2004.
3. G. Venkatappa Rao, Geo synthetics-An Introduction, Sai Master Geo environmental Services Pvt Ltd., Hyderabad, 2011.
4. G. Venkatappa Rao & Goutam K. Pothal, Geo synthetics Testing-A Laboratory Manual, Sai Master Geo environmental Services Pvt Ltd., Hyderabad, 2008.
5. Hausmann M R, Engineering Principles of Ground Modification, McGraw Hill (2013).
6. Jie H, Principles and Practice of Ground Improvement, John Wiley & Sons (2015)
7. J.N. Mandal, —Geo synthetics World, Willey Eastern Ltd., New Delhi.
8. G.L Siva Kumar Babu, —An Introduction to Soil Reinforcement and Geo synthetics, university press(India) private limited hyderabad,2006
9. (2015). 3. Shukla S K, Geosynthetics and their Applications, Thomas Telford (2002

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**SEMESTER I**

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**PROGRAM ELECTIVE II**

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| CODE      | COURSE NAME              | CATEGORY           | EN | IN | PR | CREDIT |
|-----------|--------------------------|--------------------|----|----|----|--------|
| J1PTET115 | TRANSPORTATION ECONOMICS | PROGRAM ELECTIVE 2 | 3  | 0  | 0  | 3      |

**Preamble:** Objective of the course is to impart an awareness on the fundamentals of transportation economics and techniques of economic analysis.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                        |
|-------------|------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the fundamentals of economic analysis                       |
| <b>CO 2</b> | Understand the benefits and cost components of transportation projects |
| <b>CO 3</b> | Develop generalized cost for transportation projects                   |
| <b>CO 4</b> | Conduct economic analysis of transportation infrastructure projects    |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 2</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 3</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 4</b> | 2    |      |      | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

#### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60$  %.

## Model Question Paper

*Course Code & Name:*

**J1PTET115 TRANSPORTATION ECONOMICS**

Max. Marks: 60

Duration: 2.5 hours

### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Explain various parameters used in Economic Analysis.
2. What is opportunity cost? Explain with example.
3. Write a note on social accounting.
4. Compare IRR and NPV methods of economic analysis.
5. Compare user optimal assignment and system optimal assignment.

### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. The cost of construction of a road is Rs 250 crore at current price and is met with by raising a loan. What is the annual payment of equal amount for 20 years to repay the loan? Assume 4.5% rate of interest.
7. Calculate the internal rate of return of an investment of 21 lakh which yields the following cash inflows of 5 lakh, 7 lakh, 8 lakh, 3 lakh in first 4 years respectively. Is it viable to invest here if the market interest rate is 11.5%?
8. Explain incremental analysis with suitable examples.
9. Explain Private Public Partnership with Toll collection as example.
10. Compare economic cost and financial cost.
11. Explain the concept of Build-Operate-Transfer Schemes in transportation projects.

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                             | No. of Lectures |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | Introduction to transportation economics                                                                                                                                                                          |                 |
| 1.1 | Need for economic evaluation, costs and benefits of transport project, time horizon.                                                                                                                              | 2               |
| 1.2 | Basic principles, interest rate, time value of money. Supply and demand Models, Consumer's surplus and social surplus criteria.                                                                                   | 4               |
| 1.3 | Framework of social accounting: accounting rate of interest, social opportunity cost, rate of interest, social time preference rate of interest.                                                                  | 2               |
|     |                                                                                                                                                                                                                   |                 |
| 2   | Transportation cost                                                                                                                                                                                               |                 |
| 2.1 | Accounting prices of goods and services, measuring input costs, applications of social accounting frame work.                                                                                                     | 2               |
| 2.2 | Transport Costs: Fixed and Variable costs, cost of improvement.                                                                                                                                                   | 2               |
| 2.3 | Maintenance cost and other related costs, cost estimating methods.                                                                                                                                                | 2               |
| 2.4 | Accounting for inflation, theory of transport supply and road planning.                                                                                                                                           | 2               |
|     |                                                                                                                                                                                                                   |                 |
| 3   | Transportation benefits                                                                                                                                                                                           |                 |
| 3.1 | Benefits due to Transport Improvements: Direct Benefits: Reduced vehicle operation costs.                                                                                                                         | 2               |
| 3.2 | Value of travel time savings, value of increased comfort and convenience, cost of accident reduction, reduction in maintenance cost.                                                                              | 6               |
|     |                                                                                                                                                                                                                   |                 |
| 4   | Techniques of economic analysis                                                                                                                                                                                   |                 |
| 4.1 | The generation and screening of project ideas. Different methods of economic analysis.                                                                                                                            | 2               |
| 4.2 | Annual cost and benefit ratio methods, discounted cash flow method, determination of IRR and NPV.                                                                                                                 | 2               |
| 4.3 | Examples of economic analysis of (i) different types of road surfaces (ii) different options for intersection improvement (iii) proposals for bypass to a city (iv) different strategies of pavement maintenance. | 2               |
|     |                                                                                                                                                                                                                   |                 |
| 5   | Economic analysis of projects                                                                                                                                                                                     |                 |
| 5.1 | Application of economic theory in traffic assignment problem - user optimal assignment and system optimal assignment.                                                                                             | 2               |
| 5.2 | Economic analysis of projects-Financing of road projects                                                                                                                                                          | 2               |
| 5.3 | Methods of Private Public Partnership (PPP)                                                                                                                                                                       | 2               |

|     |                                                                                                 |                 |
|-----|-------------------------------------------------------------------------------------------------|-----------------|
| 5.4 | Toll collection Economic viability of Build-Operate-Transfer Schemes, Risk Analysis. CIVIL ENGI | 1<br>EERING-CE5 |
| 5.5 | Case Studies.                                                                                   | 1               |
|     | <b>Total hours</b>                                                                              | <b>38</b>       |

### Reference Books

1. Hensher, David, and Ann Brewer. "Transport: an economics and management perspective." OUP Catalogue (2000).
2. Quinet, Emile, and Roger William Vickerman. Principles of transport economics. Northampton, MA, 2004.
3. Wright, Paul H., and Norman J. Ashford. "Transportation engineering." (1989).
4. Wright, Paul H., and Radnor Joseph Paquette. Highway engineering. 1987.

| CODE      | COURSE NAME                                                   | CATEGORY           | L | T | P | CREDIT |
|-----------|---------------------------------------------------------------|--------------------|---|---|---|--------|
| J1PTET125 | PAVEMENT MATERIAL CHARACTERISATION AND CONSTRUCTION PRACTICES | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of this course is to make the students aware of the characterization of different materials, to understand the constituents and behaviour of bitumen and to study the different bituminous mix design procedures used in pavement construction. To understand the construction practices for bituminous and concrete pavements.

**Course outcome:** After the completion of the course the student will be able to

|      |                                                                                                                              |
|------|------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Characterize the pavement materials including soil and aggregate                                                             |
| CO 2 | Understand the constituents and behaviour of bitumen, also characterise and grade binder                                     |
| CO 3 | Understand the mix design procedure; evaluate different mix design approaches and understand mixture performance tests       |
| CO 4 | Understand the operations, construction practises and quality control aspects of subgrade, unbound and bound granular layers |
| CO 5 | Understand asphalt paving operations and construction of various types of bituminous layers and concrete pavements           |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 | 3    | 1    | 3    | 3    | 2    | 2    | 1    |
| CO 2 | 3    | 1    | 3    | 3    | 2    | 2    | 1    |
| CO 3 | 3    | 1    | 3    | 3    | 2    | 2    | 1    |
| CO 4 | 3    | 1    | 3    | 3    | 2    | 2    | 1    |

Note: 1: Slightly; 2: Moderately; 3: Substantially

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

### End semester examination pattern

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60\%$ .

## **Model Question Paper**

**Course Code & Name:**

### **J1PTET125 PAVEMENT MATERIAL CHARACTERISATION AND CONSTRUCTION PRACTICES**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Briefly discuss the test procedure to find resilient modulus of soils and aggregate materials.
2. Describe the importance of bitumen grading system. Why the grading system adopted in India and US are different.
3. Explain the balanced mix design procedure
4. Describe the use of crack relief layer and SAMI layer in pavements.
5. Explain the definition and selection criteria for White toppings, Thin and ultra thin.

#### **PART B**

**(Answer any five questions: Each carries 7 marks)**

6. Discuss the methods used for grading aggregates to use in different layers.
7. List the step-by-step procedure for aging asphalt binders to simulate long term aging in the laboratory. What are the assumptions?
8. How do you conduct a creep test in laboratory for asphalt mixtures and how will you relate it to the rutting occurring in the field?
9. Explain briefly the procedure of Marshal Mix design including the volumetric calculations
10. How do we select a rehabilitation process for an existing damaged pavement? Explain the significance of FDR in Indian scenario.
11. Explain the methodology of design and construction of subgrade for receiving the pavement layers including the quality control.
12. One of the existing four-lane highways in Kerala, which is a bituminous pavement, is proposed to be converted as a six lane concrete pavement. Compare the relative merits of the options listed below and explain the construction and quality control steps of your recommended choice.

- (i) Conventional Concrete Pavement
- (ii) Continuous Reinforced Concrete Pavement
- (iii) White topping
- (iv) Pre-cast Concrete Pavement

## **Syllabus**

### **MODULE 1**

**Introduction to Pavement Materials:** with emphasis on bitumen, bituminous concrete, cement concrete and granular materials and need for characterisation.

#### **Subgrade Soil**

Characterization of subgrade soil for pavement design: compaction characteristics; stiffness and strength of soil, resilient modulus ( $M_r$ );

**Aggregates:** aggregate gradations for pavement layers; aggregate packing characteristics: Fuller Thomson; aggregate blending;

Factors affecting the performance of unbound aggregate layers; non-linear behavior of granular materials; permanent deformation behavior of unbound aggregate layers; recycled aggregates and marginal aggregates in pavement construction.

### **MODULE II**

#### **Bituminous Binder:**

Types of bituminous binder: unmodified and modified binder, bituminous emulsion, and cutback

Constitution and structure of bitumen; physical characterization; requirements and specifications of paving grade binder; binder grading: penetration, viscosity, and performance grading;

Rheology of bitumen: concept of linear viscoelasticity; rheological characterization of binders, performance tests to assess rutting, cracking, healing and aging susceptibility.

### **MODULE III**

**Bituminous mix design and performance tests:** Objectives of bituminous mix design; volumetrics of compacted bituminous mixes; Marshall mix design; Superpave mix design; Balanced mix design concept;

Mechanical characterization of bituminous mixtures for Design and Distress - dynamic modulus, resilient modulus and flexural modulus. Fatigue, creep and moisture-induced damage.

#### **Pavement rehabilitation**

Rehabilitation options: Recycled pavement mixtures- hot recycling and cold recycling, full depth reclamation

### **MODULE IV**

**Construction of Subgrade:** Earthwork grading; compaction requirement for subgrade; subgrade stabilization: compaction equipment, curing and opening to construction operation; subgrade construction.

## **Construction of Unbound and Bound Granular Layers:**

Gradation and material quality requirement for granular subbase and base layers, blending and proportioning, mix design, placing, laying and compaction requirements; field quality control; crack relief and SAMI layer; construction of subsurface drainage for highways;

## **MODULE V**

**Asphalt Paving Operation:** Preparing for paving; new construction/overlay, prime coat, tack coats: recommended applications, distribution, verifying the application rates; asphalt pavers and compaction;

Screed operations and control; joints; roller types; sequence of rolling: tender mixes and compaction troubleshooting; quality assurance: sampling methods for asphalt mixtures

Construction procedures for various pavement component layers and types.

Non-destructive tests: nuclear gauge, geogauge, ground penetrating radar (Introduction only)

### **Construction of concrete pavements:**

Concrete production; preparation of subgrade and base; reinforcement presetting for JPCP and CRCP; PCC slab constructions: slip form paving, fixed form paving; curing process; Roller compacted concrete, white topping, Thin and ultra-thin white topping, Interlocking concrete block pavements

## **Course Plan**

| <b>Sl. No</b>              | <b>Topic</b>                                                                                                                                                         | <b>No. of hrs</b> |
|----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|
| <b>MODULE 1 (8 hrs)</b>    |                                                                                                                                                                      |                   |
| 1                          | Introduction to Pavement Materials with emphasis on bitumen, bituminous concrete, cement concrete and granular materials and need for characterization               | 2                 |
| 2                          | Characterization of subgrade soil for pavement design: compaction characteristics;                                                                                   | 1                 |
| 3                          | Stiffness and strength of soil, resilient modulus (Mr);                                                                                                              | 1                 |
| 4                          | Aggregate gradations for pavement layers; Aggregate packing characteristics: Fuller Thomson; aggregate blending;                                                     | 2                 |
| 5                          | Factors affecting the performance of unbound aggregate layers; non-linear behavior of granular materials; permanent deformation behavior of unbound aggregate layers | 1                 |
| 6                          | Recycled aggregates and marginal aggregates in pavement construction.                                                                                                | 1                 |
| <b>MODULE 2 (8hrs)</b>     |                                                                                                                                                                      |                   |
| 7                          | Types of bituminous binder: unmodified and modified binder, bituminous emulsion, and cutback                                                                         | 2                 |
| 8                          | Constitution and structure of bitumen; physical characterization;                                                                                                    | 1                 |
| 9                          | Requirements and specifications of paving grade binder                                                                                                               | 1                 |
| 10                         | binder grading: penetration, viscosity, and performance grading;                                                                                                     | 1                 |
| 11                         | Rheology of bitumen: concept of linear viscoelasticity                                                                                                               | 1                 |
| 12                         | Aging phenomena; performance tests to assess rutting, cracking, healing                                                                                              | 2                 |
| <b>MODULE III (11 hrs)</b> |                                                                                                                                                                      |                   |

|                          |                                                                                                                                                                                 |                            |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|
| 13                       | Objectives of bituminous mix design; volumetrics of bituminous mixes;                                                                                                           | CIVIL ENGINEERING<br>-1CE5 |
| 14                       | Marshall mix design;                                                                                                                                                            | 2                          |
| 15                       | Superpave mix design; Balanced mix design concept;                                                                                                                              | 2                          |
| 16                       | Mechanical characterization of bituminous mixtures for Design and Distress - dynamic modulus, resilient modulus and flexural modulus.                                           | 2                          |
| 17                       | Fatigue, creep and moisture-induced damage. Relation between binder and mixture mechanical response.                                                                            | 2                          |
| 18                       | Rehabilitation options: Recycled pavement mixtures- hot recycling and cold recycling, full depth reclamation                                                                    | 2                          |
| <b>MODULE IV (7 hrs)</b> |                                                                                                                                                                                 |                            |
| 19                       | Construction of Subgrade: Earthwork grading; compaction requirement for subgrade; subgrade stabilization:                                                                       | 2                          |
| 20                       | Preparation, compaction equipment, curing and opening to construction operation; subgrade construction.                                                                         | 1                          |
| 21                       | Gradation and material quality requirement for granular subbase and base layers, blending and proportioning, mix design,                                                        | 2                          |
| 22                       | Placing, laying and compaction requirements; field quality control;                                                                                                             | 1                          |
| 23                       | Crack relief and SAMI layer; construction of subsurface drainage for highways,                                                                                                  | 1                          |
| <b>MODULE V (8 hrs)</b>  |                                                                                                                                                                                 |                            |
| 24                       | Preparing for paving: new construction/overlay, prime coat, tack coats: recommended applications, distribution, verifying the application rates; asphalt pavers and compaction; | 1                          |
| 25                       | Screed operations and control; joints; roller types; sequence of rolling: tender mixes and compaction troubleshooting; quality assurance: sampling methods for asphalt mixtures | 1                          |
| 26                       | Construction procedures for various pavement component layers and types; quality control tests                                                                                  | 2                          |
| 27                       | Non-destructive tests: nuclear gauge, geogauge, ground penetrating radar                                                                                                        | 1                          |
| 28                       | Concrete production; preparation of subgrade and base; reinforcement presetting for JPCP and CRCP;                                                                              | 1                          |
| 29                       | PCC slab constructions: slip form paving, fixed form paving; curing process;                                                                                                    | 1                          |
| 30                       | Roller compacted concrete, white topping and ultra-thin white topping, Interlocking concrete block pavements                                                                    | 1                          |

## References

1. James G Speight, Asphalt Science and Technology, Elsevier
2. Asphalt Institute. Asphalt Mix Design Methods Manual Series No. 2 (MS-2), Seventh Edition, Asphalt Institute, Kentucky, USA, 2014.
3. Atkins, H.N. Highway Materials, Soils, and Concretes, Reston Publishing Company, Virginia, USA, 1980.
4. Huang, Y.H. Pavement Analysis and Design, Pearson Prentice Hall, New Jersey, USA, 2004.

5. IRC:44-2017 Guidelines for Cement Concrete Mix Design for Pavements, The Indian Roads Congress, New Delhi, India, 2017.
6. Kandhal, P.S. Bituminous Road Construction in India, PHI Learning Pvt. Ltd., New Delhi, India, 2016.
7. Kim, Y.R. Modeling of Asphalt Concrete, ASCE Press, New York, USA, 2009. Mallick, R.B. and T. El-Korchi Pavement Engineering – Principles and Practice, CRC Press, Taylor and Francis Group, Florida, USA, 2018.
8. Ministry of Road Transport and Highways. Specifications for Road and Bridge Works, Fifth Edition, Indian Roads Congress, New Delhi, India, 2013.
9. Papagiannakis, A.T. and E.A. Masad Pavement Design and Materials, John Wiley and Sons, New Jersey, USA, 2008.
10. P. H. Wright and Karen Dixon, Highway Engineering, John Wiley & Sons, 1996
11. Hunter, R.N., Self, A. and J. Read The Shell Bitumen Handbook, Sixth Edition, ICE Publishing, London, UK, 2015.
12. Sherwood, P.T. Alternative materials in road construction, Thomas Telford, New York, USA, 1997.
13. Relevant IRC, IS, and ASTM codes,

| CODE      | COURSE NAME                                        | CATEGORY              | L | T | P | CREDIT |
|-----------|----------------------------------------------------|-----------------------|---|---|---|--------|
| J1PTET135 | GEOINFORMATICS IN<br>TRANSPORTATION<br>ENGINEERING | PROGRAM<br>ELECTIVE 2 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to impart an awareness on the applications of Geoinformatics in the context of intelligent transportation system, land use and transportation planning

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                      |
|-------------|------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To conduct surveys for land use and transportation planning by applying suitable sampling techniques |
| <b>CO 2</b> | To estimate travel demand in various traffic analysis zones                                          |
| <b>CO 3</b> | To develop database for transportation analysis in GIS environment                                   |
| <b>CO 4</b> | To create and analyse transportation networks and maps in GIS platform                               |
| <b>CO 5</b> | To illustrate the applications of GIS in transportation and ITS                                      |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 3    | 3    | 3    | 3    |      |      |
| <b>CO 2</b> | 3    |      | 3    | 3    | 3    |      |      |
| <b>CO 3</b> | 3    |      | 3    | 3    | 3    |      |      |
| <b>CO 4</b> | 3    |      | 3    | 3    | 3    |      |      |
| <b>CO 5</b> | 3    |      | 3    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60$  %.

## **Model Question Paper**

*Course Code & Name:*

**J1PTET135 GEOINFORMATICS IN TRANSPORTATION ENGINEERING**

Max. Marks: 60

Duration: 2.5 hours

### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Define Capacity and Level of Service. Explain the factors affecting level of service.
2. Substantiate the statement “Transportation and land use are interconnected”
3. What is the importance of road networks and maps in GIS?
4. Illustrate ITS architecture.
5. How traffic management can be done with GIS-ITS integration?

### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. What is sampling? Why is it needed? Explain any two random sampling techniques which can be adopted in transportation surveys.
7. What is the importance of trip generation in four stage planning process? Explain any two methods of trip generation in detail.
8. Differentiate primary and secondary data. What are the different types of surveys in planning? Explain any two in detail.
9. Illustrate any one land use model in detail.
10. How is road network mapping procedure done? Explain in detail with a flowchart.
11. How travel time analysis can be done by integrating GPS and GIS? Explain with a case study.
12. What is ITS? Explain the components of ITS in detail.

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                                                                         | No. of Lectures |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | Traffic Engineering Studies and data collection                                                                                                                                                                                                               |                 |
| 1.1 | Sampling in traffic studies-random and non-probability sampling techniques, sample size determination                                                                                                                                                         | 2               |
| 1.2 | Data collection techniques- Spot speed, Speed and delay, Volume, Origin Destination and Parking surveys                                                                                                                                                       | 3               |
| 1.3 | Concept of PCU, Capacity and level of service                                                                                                                                                                                                                 | 2               |
| 1.4 | Types of manoeuvres and conflict points                                                                                                                                                                                                                       | 1               |
|     |                                                                                                                                                                                                                                                               |                 |
| 2   | Transportation Planning process                                                                                                                                                                                                                               |                 |
| 2.1 | Travel Demand Estimation, Traffic Analysis Zone (TAZ), screen lines and desire lines                                                                                                                                                                          | 1               |
| 2.2 | Four Stage Planning Process (Description only)                                                                                                                                                                                                                | 4               |
| 2.3 | Land use and Transport Planning- Introduction of TLUM models- Lowry models                                                                                                                                                                                    | 3               |
|     |                                                                                                                                                                                                                                                               |                 |
| 3   | Role of GIS in Land use and Transportation Planning                                                                                                                                                                                                           |                 |
| 3.1 | Introduction to GIS, Spatial and Non spatial data for land use and transportation, spatial database management system                                                                                                                                         | 1               |
| 3.2 | Transport Network, Network representation - incidence matrices                                                                                                                                                                                                | 1               |
| 3.3 | Map and Network creation in GIS - steps involved - geo referencing, digitisation of the road network, topology creation, database development, overlay of maps (Introduction with any available GIS software), Route building in GIS                          | 4               |
| 3.4 | Shortest Path determination- shortest path algorithm, network analysis tool in GIS                                                                                                                                                                            | 1               |
| 3.5 | Introduction of GIS-T- Software (CUBE, TRANSCAD, EMME)                                                                                                                                                                                                        | 1               |
|     |                                                                                                                                                                                                                                                               |                 |
| 4   | Intelligent Transportation system and GIS                                                                                                                                                                                                                     |                 |
| 4.1 | Introduction to Intelligent Transport System- ITS architecture, Components of ITS- Advanced traffic management system, Advanced traveller information system, Advanced vehicle control system, Advanced public transport system, Commercial vehicle operation | 2               |
| 4.2 | Applications of ITS- electronic toll collection, Incident management system (IMS)-components, benefits and stages of IMS                                                                                                                                      | 2               |
| 4.3 | Application of GIS in accident management – Accident database, GIS based accident analysis, black spot identification                                                                                                                                         | 1               |
| 4.4 | Integration of ITS and GIS - In-vehicle navigation, emergency response management                                                                                                                                                                             | 1               |

|     |                                                                                                                                                    |    |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 4.5 | Automatic number plate recognition, vehicle information and communication system                                                                   | 1  |
| 4.6 | Case studies on applications of ITS                                                                                                                | 1  |
|     |                                                                                                                                                    |    |
| 5   | Integration of GPS and GIS in transportation                                                                                                       |    |
| 5.1 | Types of positioning Systems, Applications of GPS-GIS integration- Route guidance, emergency response, Fleet Management, Automated Highway Systems | 2  |
| 5.2 | Travel time analysis using GPS-GIS integration                                                                                                     | 2  |
| 5.3 | Case studies on Integration of GPS and GIS in transportation                                                                                       | 2  |
| 5.4 | Application of GIS in land use and transportation planning-case Studies                                                                            | 2  |
|     | Total hours                                                                                                                                        | 40 |

### Reference Books

1. Hensher D. A., Button K. J., Haynes K. E., and Stopher P. R. (Eds.), Handbook of Transport Geography and Spatial Systems”, Elsevier,2004.
2. Thill Jean-Claude, Geographical Information Systems in Transportation Research, Pergamon, 2000.
3. Longley P. A., Barnsley M. J., Donnay Jean-Paul, Remote Sensing and Urban Analysis, Taylor & Francis, 2001.
4. Caliper Corporation, Travel Demand Modelling with TransCAD, 2009.
5. Hutchinson, B. G., Principles of Urban Transportation Planning, Mc Graw Hill, 1979
6. Kadiyali, L.R.Traffic Engineering and Transportation Planning, Khanna Publishers

| CODE      | COURSE NAME             | CATEGORY           | L | T | P | CREDIT |
|-----------|-------------------------|--------------------|---|---|---|--------|
| J1PTET145 | PUBLIC TRANSPORT SYSTEM | PROGRAM ELECTIVE 2 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to enable the students to understand the objectives, principles and geometric characteristics of transit networks, concepts and principles to plan, design and evaluate the transit networks and infrastructure facilities.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                      |
|------|----------------------------------------------------------------------|
| CO 1 | Discuss the relevance of Public Transit Units.                       |
| CO 2 | Undertake planning activities connected with Transit operations.     |
| CO 3 | Plan and prepare transit routes and schedules and the transit fares. |
| CO 4 | Design transit infrastructure facilities.                            |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 | 2    |      |      |      |      |      |      |
| CO 2 | 2    |      | 3    | 3    |      |      |      |
| CO 3 | 2    |      | 3    | 3    |      |      |      |
| CO 4 | 2    |      | 3    | 3    |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60$  %.

## **Model Question Paper**

*Course Code & Name:*

### **J1PTET145 PUBLIC TRANSPORT SYSTEM**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Explain the characteristics of basic ROW categories.
2. Describe transit planning process with the help of a flowchart.
3. Illustrate and describe various route configurations.
4. List out the major components of schedule development that are influenced by service standards and policies.
5. Describe the influence of fare increase on operating cost.

#### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. Describe the Semi-Rapid transit system with an example.
7. Explain the need for comprehensive planning.
8. Define interlining and explain its significance.
9. Explain the various factors affecting the layout of bus terminals.
10. Discuss the advantages & disadvantages of far side bus stop placement.
11. Describe the influence of fare increase on operating cost.
12. Explain the benefits of integrated public transport systems

## Syllabus and Course Plan

| No  | Topic                                                                         | No. of Lectures |
|-----|-------------------------------------------------------------------------------|-----------------|
| 1   | Introduction to public transport systems.                                     |                 |
| 1.1 | Historical Growth, Modes of public transport and comparison.                  | 2               |
| 1.2 | Public transport travel characteristics.                                      | 2               |
| 1.3 | The technology of bus, rail, rapid transit systems, basic operating elements. | 4               |
|     |                                                                               |                 |
| 2   | Transit Network Planning                                                      |                 |
| 2.1 | Objectives and principles.                                                    | 2               |
| 2.2 | Transit lines: types, geometry and characteristics.                           | 2               |
| 2.3 | Transit routes and their characteristics- Timed transfer networks.            | 2               |
| 2.4 | Prediction of transit usage, network evaluation, accessibility consideration. | 2               |
|     |                                                                               |                 |
| 3   | Transit Scheduling                                                            |                 |
| 3.1 | Components, determination of service requirements, scheduling procedure       | 2               |
| 3.2 | marginal ridership, crew scheduling                                           | 6               |
|     |                                                                               |                 |
| 4   | Transit Infrastructure Facilities                                             |                 |
| 4.1 | Design of bus stops, design of terminals– principles of good layout.          | 2               |
| 4.2 | Types of layouts, depot location.                                             | 2               |
| 4.3 | Twin depot concept, crew facilities and amenities.                            | 2               |
|     |                                                                               |                 |
| 5   | Transit Agency and Economics                                                  |                 |
| 5.1 | Organizational structure of transit agency.                                   | 2               |
| 5.2 | Management and personnel Transit system statistics.                           | 2               |
| 5.3 | Performance and economic measures.                                            | 2               |
| 5.4 | Operations.                                                                   | 1               |
| 5.5 | Fare structure.                                                               | 1               |
|     | Total hours                                                                   | 38              |

## Reference Books

1. Vukan R. Vuchic, “Urban Transit: Operations, Planning and Economics”, Wiley Sons Publishers.
2. Kadiyali L.R., “Traffic Engineering and Transport Planning”, Khanna Publishers
3. TCRP Report 30, TCRP Report 95, TCRP Report100
4. Papacostas, C. S and P.D. Prevedouros., “Transportation Engineering and Planning”, Pearson.

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# **SEMESTER II**

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| CODE      | COURSE NAME                                                                | CATEGORY          | L | T | P | CREDIT |
|-----------|----------------------------------------------------------------------------|-------------------|---|---|---|--------|
| J1PTET201 | DATA ANALYTICS AND COMPUTATIONAL SIMULATION FOR TRANSPORTATION ENGINEERING | DISCIPLINE CORE 2 | 3 | 0 | 0 | 3      |

**Preamble:** The objective of this course is to introduce students to transportation data analytics, computational modelling, simulation techniques and intelligent transportation systems for solving complex transportation engineering problems. The course aims to develop analytical and computational skills using modern data-driven and simulation-based approaches for sustainable and efficient transportation systems.**Course Outcomes:** After the completion of the course, the student will be able to

|             |                                                                                                       |
|-------------|-------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand transportation data sources, data analytics concepts and preprocessing techniques          |
| <b>CO 2</b> | Apply statistical and machine learning techniques for transportation data analysis and prediction     |
| <b>CO 3</b> | Apply statistical and machine learning techniques for transportation data analysis and prediction     |
| <b>CO 4</b> | Develop and analyse computational simulation models for transportation systems                        |
| <b>CO 5</b> | Apply artificial intelligence and deep learning techniques in transportation engineering applications |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    |      |      | 3    |      |      |      |
| <b>CO 2</b> | 3    |      |      | 3    |      |      |      |
| <b>CO 3</b> | 3    |      |      | 3    |      |      |      |
| <b>CO 4</b> | 1    |      | 2    | 2    | 2    | 2    |      |
| <b>CO 5</b> | 3    |      |      | 2    | 2    | 2    |      |

(1-Weak, 2-Medium, 3- strong)

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Preparing a review article based on peer reviewed original publications  
(Minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**Note:** Enough opportunity to explore the practical examples from specialization should be given to the students. One assignment/course project should be based on the coding or use of packages

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

## Model Question Paper

QP CODE:

Reg No.: \_\_\_\_\_

Name: \_\_\_\_\_

**M.TECH. DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: J1PTET201**

### **DATA ANALYTICS AND COMPUTATIONAL SIMULATION FOR TRANSPORTATION ENGINEERING**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

(Answer **ALL** questions; each question carries 5 marks)

1. Explain the various types of transportation data and their applications in intelligent transportation systems.
2. Explain the components of time series analysis and the importance of ARIMA models in transportation forecasting.
3. Discuss the applications of multivariate data analysis techniques in transportation engineering.
4. Explain the different types of transportation simulation models with suitable examples.
5. Explain the applications of artificial intelligence and digital twin concepts in transportation systems.

#### **PART B**

(Answer **any FIVE** questions; each question carries 7 marks)

6. Explain transportation data collection techniques using sensors, detectors, cameras, drones and mobile data. Discuss the importance of preprocessing methods in transportation analytics.
7. Discuss demographic forecasting models used in transportation planning. Explain the linear, exponential and logistic models with suitable applications.
8. Explain the methodology of traffic forecasting on highways using time series analysis. Discuss smoothing and decomposition methods used in forecasting.
9. Explain the following multivariate data analysis techniques used in transportation engineering:
  - (a) Cluster Analysis
  - (b) Factor Analysis
  - (c) Logistic Regression
10. Discuss the principles of microscopic, macroscopic and mesoscopic simulation models. Compare their advantages and limitations in transportation studies.
11. Explain the procedure for signalized intersection simulation using

transportation simulation software. Discuss calibration and validation of simulation models.

12. Explain the applications of reinforcement learning in adaptive traffic signal control. Discuss the role of big data analytics, IoT and smart city transportation systems in future mobility.

\*\*\*\*\*

## **Syllabus**

### **Module 1**

**(7 hours)**

Transportation Data Analytics Fundamentals - Introduction to intelligent transportation systems and transportation data analytics- Types of transportation data – traffic volume, speed, travel time, GPS, trajectory, accident and public transport data- transportation data collection techniques – sensors, detectors, cameras, drones and mobile data- Data preprocessing – cleaning, normalization, missing data handling and visualization-Introduction to Python/MATLAB tools for transportation analytics

### **Module 2**

**(7 hours)**

Demographic and Employment Forecasting Models: Demographic Models - Linear, Exponential and Logistic Models - Forecasting using Time Series Analysis: Basic Components of Time Series – Stationery and Non-Stationery Processes- Smoothing and Decomposition Methods – Correlation and Line Spectral Diagrams – Auto Correlations and Moving Averages- Moving average models – ARMA and ARIMA models – Model Identification – Parameter estimation. Traffic forecasting on highways: Basic Concepts and Methodology

### **.Module 3**

**(7 hours)**

Multivariate Data Analysis Techniques: Types of Data, Basic Vectors and Matrices, Cluster Analysis, Exploratory and Confirmatory Factor Analysis, Multiple Discriminant Analysis, Logistic Regression, Overview of Structural Equation Modelling, MANOVA and Cross Classification Procedure in Multivariate Data Analysis - Introduction to machine learning – supervised and unsupervised learning- Neural networks and deep learning fundamentals

### **Module 4**

**(7 hours)**

Fundamentals of transportation simulation and modelling- Microscopic, macroscopic and mesoscopic simulation models-. Traffic flow modelling and network representation - Simulation software – SUMO, VISSIM and AIMSUN (overview)- Signalized intersection simulation, calibration and validation of models

### **Module5**

**(7 hours)**

Artificial Intelligence and Deep Learning Applications- Introduction to artificial intelligence in transportation- Traffic congestion analysis and adaptive signal control using reinforcement learning- Spatial data analysis and accident hotspot mapping- Digital twin concepts in transportation infrastructure- Big data analytics, IoT and smart city transportation systems- Sustainable transportation systems and future trends in transportation analytics

### **Text Books**

1. Gupta, S.K. Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1995.
2. Cook, R.D. Concepts and Applications of Finite Element Analysis , Wiley.

## Reference Books

1. Gilbert Strang, Linear Algebra and its Applications (4th Ed.), Wellesley Cambridge Press 2009
  2. Gourdin, A. and M Boumhrat. Applied Numerical Methods. Prentice Hall India, New Delhi 2000
  3. Chopra S.C. and Canale R.P. Numerical Methods for Engineers, McGraw Hill 2006
  4. Krishnamoorthy C S, *Finite Element Analysis- Theory and Programming*, Tata McGraw Hill, New Delhi., 1994
  5. Rao, SS. Finite Element Analysis, Elsevier Butterworth-Heinemann
  6. Gerald and Wheatly, *Applied Numerical Analysis*, Pearson Education.
  7. Rajasekharan S., *Numerical Methods in Science and Engineering*, S Chand & Company, 2003.
  8. Bathe K J, *Finite Element Procedures in Engineering Analysis*, Prentice Hall, New Delhi. 1982
  9. Chandrupatla T R and Belegundu A D, *Introduction to Finite Elements in Engineering*, Pearson Education, New Delhi 1998
  10. Rajasekharan S, *Finite Element Analysis in Engineering Design*, Wheeler, New Delhi
  11. Hutton D V, *Fundamentals of Finite Element Analysis*, Tata McGraw Hill Education Private Ltd, New Delhi
- .

| CODE      | COURSE NAME         | CATEGORY       | L | T | P | CREDIT |
|-----------|---------------------|----------------|---|---|---|--------|
| J1PTET202 | TRAFFIC ENGINEERING | PROGRAM CORE 3 | 3 | 0 | 0 | 3      |

**Preamble:** This course is aimed at providing a thorough understanding of the fundamentals of traffic flow, factors involved, concepts, design, operations and control, and to enable a student to model and analyse traffic scenarios.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

|             |                                                                                                                                 |
|-------------|---------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To <b>Understand</b> the fundamentals of traffic engineering and to <b>Distinguish</b> the levels of analysing traffic flow.    |
| <b>CO 2</b> | To conduct the various surveys in traffic Engineering and to <b>Analyse</b> the various parameters based on surveys             |
| <b>CO 3</b> | To <b>Apply</b> the fundamentals of traffic operations at uninterrupted facilities, and to <b>Design</b> traffic signal control |
| <b>CO 4</b> | To <b>Analyse</b> the various microscopic models and to <b>Understand</b> advanced theories of traffic flow.                    |
| <b>CO 5</b> | To <b>Demonstrate</b> traffic flow <b>Applying</b> the concept of traffic simulation models                                     |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 1    |      |      | 1    | 3    |      |      |
| <b>CO 2</b> | 1    | 2    |      | 1    | 3    |      |      |
| <b>CO 3</b> | 1    | 2    | 3    | 1    | 3    |      |      |
| <b>CO 4</b> | 1    |      | 3    | 1    | 3    |      |      |
| <b>CO 5</b> | 1    |      | 3    | 1    | 3    |      |      |
| <b>CO 6</b> |      |      |      |      |      |      |      |

#### Assessment Pattern

Evaluation shall only be based on application, analysis or design based questions (for both internal and end semester examinations)

| <b>Bloom's Category</b> | <b>End Semester Examination</b> |
|-------------------------|---------------------------------|
| Apply                   | 25                              |
| Analyse                 | 25                              |
| Evaluate                | 5                               |
| Create                  | 5                               |

### **Mark distribution**

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

### **Continuous Internal Evaluation Pattern: 40**

**marks** Micro project/course based project: 20

marks Course based task/seminar/Quiz: 10 marks

Test paper 1 No. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

### **End Semester Examination Pattern:**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**SECOND SEMESTER M.TECH DEGREE  
EXAMINATION, -----**

**Branch: Civil Engineering**

**J1PTET202 TRAFFIC ENGINEERING**

Max. Marks: 60

Duration: 2.5 hours

**PART A Answer all questions**

- |    |                                                                              |   |
|----|------------------------------------------------------------------------------|---|
| 1. | . Explain the factors on which PIEV theory depends?                          | 5 |
| 2  | . Distinguish between Gap and headway and how the critical gap is determined | 5 |
| 3  | Explain the factors affecting Capacity and Level of Service?                 | 5 |
| 4  | Explain the concept of shock wave phenomenon in a traffic stream?            | 5 |
| 5  | Explain the need of simulation in traffic Engineering                        | 5 |

**PART B Answer any five questions**

- |    |                                                                                                                           |   |
|----|---------------------------------------------------------------------------------------------------------------------------|---|
| 6  | Outline the four components of traffic engineering and explain their characteristics as well as their inter relationship? | 7 |
| 7  | a Explain the characteristics of merging and diverging areas with the help of a sketch?                                   | 4 |
|    | b Illustrate an uninterrupted flow with an example?                                                                       | 3 |
| 8  | a Explain the LOS criteria for multi lane highways as per HCM                                                             | 4 |
|    | b What are the base conditions for the highest operating level of multi lane highways                                     | 3 |
| 9. | a Explain the concept of phase diagram in the design of traffic signals                                                   | 3 |
|    | b. Explain the concept of band width and offset for a one way and two way street in a coordinated traffic signal          | 4 |
| 10 | a. Explain the concept of various traffic stream models with the help of sketches                                         | 4 |
|    | b. Write short note on heat flow analogy models                                                                           | 3 |
| 11 | a. What are microscopic and macroscopic traffic flow modelling                                                            | 3 |

- b. The maximum capacity of a 2 lane carriageway of a four lane dual carriageway is 3000 veh/hr. Due to pipe laying operations the width of the 2 lane is reduced to, restricting the maximum capacity to 1000 veh/hr. When the flow upstream beyond the influence of the bottleneck is reasonably steady and free flowing at 2500veh/hr, find: i) the mean speed of traffic in the bottleneck ii) the rate at which the queue of congested conditions outside bottleneck grows. The mean space headway when the vehicles are stationary is 8m. The relation between speed and concentration is linear. 4
- 12 a. Explain how the simulation of a heterogeneous traffic condition is performed. 3
- b. The spot speeds at a particular location are normally distributed with a mean of 51.7 kmph and a standard deviation of 8.3kph. What is the probability that a) the speeds exceed 65kph? b) the speeds lie between 40kph and 70kph c) what is the 85<sup>th</sup> percentile speed 4

### Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                 | No. of Lectures |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Module 1</b>                                                                                                                                                                                       | <b>6</b>        |
| 1.1 | Objectives and scope of traffic engineering- Components and characteristics of Traffic stream- Microscopic and Macroscopic characteristics                                                            | 2               |
| 1.2 | Components of road traffic : the vehicle , static and dynamic characteristics of vehicle                                                                                                              | 2               |
| 1.3 | Human, road and environment factors: Characteristics of road user, road characteristics, environment.                                                                                                 | 2               |
| 2   | <b>Module 2</b>                                                                                                                                                                                       | <b>6</b>        |
| 2.1 | Traffic Surveys-Types, Data collection and Analysis- Measurement of traffic parameters like volume, speed, density, parking studies, travel time and delay                                            | 2               |
| 2.2 | Headways and Gaps, Critical Gap-Gap acceptance studies, pedestrian studies, accident studies                                                                                                          | 2               |
| 2.3 | Congestion studies: Performance measures, intensity, duration, extent of congestion, traveller perception, remedial measures                                                                          | 2               |
| 3   | <b>Module 3</b>                                                                                                                                                                                       | <b>8</b>        |
| 3.1 | Uninterrupted flow: Capacity and Level of service HCM methods; Multilane highways: Characteristics, capacity and level of service. Freeway sections- Merging and diverging areas; speed at ramps      | 3               |
| 3.2 | Signalised intersection- Principles, fundamentals of signal timing and design. Coordinated traffic signal: Concepts of offset, common cycle length, bandwidth, offset for one-way and two way streets | 3               |

|     |                                                                                                                                                                                                                                                                                   |                 |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 3.3 | Vehicle actuated signals and Area traffic control. Basic principles                                                                                                                                                                                                               | EERING-CE5<br>2 |
| 4   | <b>Module 4</b>                                                                                                                                                                                                                                                                   | <b>10</b>       |
| 4.1 | Traffic stream parameters –Fundamental diagrams of traffic flow.<br>Traffic Flow Modelling: Traffic stream models: Traffic flow characteristics, Greenshield's model, Greenberg's logarithmic model, Underwood's exponential model, pipe's generalized model, multiregime models; | 3               |
| 4.2 | Car following, acceleration noise. Traffic flow modelling analogies: Fluid flow analogy, heat flow analogy, granular Flow.                                                                                                                                                        | 4               |
| 4.3 | Lighthill-Whithams theory, Boltzman like behaviour of traffic. Flow at different densities- Shock wave phenomenon                                                                                                                                                                 | 3               |
| 5   | <b>Module 5</b>                                                                                                                                                                                                                                                                   | <b>10</b>       |
| 5.1 | Application of probability and statistics in traffic Engineering-fitting of distributions, sampling in traffic studies, statistical analysis of traffic stream parameters                                                                                                         | 6               |
| 5.2 | Introduction to simulation, Simulation in Traffic Engineering : variables, parameters, testing, calibration, validation and application- Simulation software - Case studies in traffic simulation.                                                                                | 4               |

### Reference Books

1. Roess, R. P , Prassas,E.H., and McShane, W.R., Traffic Engineering, Pearson Prentice Hall, Fourth Edition, Upper Saddle River, NJ, 2011.
2. Pignataro, Louis J., Traffic Engineering, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1983.
3. Kadiyali, L.R. Traffic Engineering and Transport Planning, Khanna Publishers, New Delhi.
4. Highway Capacity Manual, Transportation Research Board, Washington, D.C., 2010.
5. May, Adolf D., Traffic Flow Fundamentals, Prentice Hall, Englewood Cliffs, N.J., 1990.
6. Gazis, Denos C., Traffic Theory, Kluwer Academic Publishers, Norwell, MA, 2002.
7. Papacostas,C. S, Prevedouros, P. D., Transportation Engineering and Planning, PHI Publication, 3rd edition , 2002.
8. Khisty C.J. Transportation Engineering- An introduction, Prentice Hall, New Jersey, 1990.
9. Ceder A, Transportation and traffic theory. Pergamon Elsevier Science Ltd., Oxford. 1999.

10. Traffic Flow Theory: A State-of-the-Art Report, TRB,  
<http://www.tfhrc.gov/its/tft/tft.htm>.
11. Traffic Theory, Gazis, Denos C. Springer, 2002.
12. IRC Publications, codes.

| <b>COURSE CODE</b> | <b>COURSE NAME</b>  | <b>CATEGORY</b> | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|--------------------|---------------------|-----------------|----------|----------|----------|---------------|
| <b>J1PTEP206</b>   | <b>MINI PROJECT</b> | <b>PROJECT</b>  | <b>0</b> | <b>0</b> | <b>4</b> | <b>2</b>      |

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem solving skills.

The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Evaluation Committee - Programme Coordinator, One Senior Professor and Guide.

| <b>Sl. No</b> | <b>Type of evaluations</b>      | <b>Mark</b> | <b>Evaluation criteria</b>                                                                                                                                               |
|---------------|---------------------------------|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1             | Interim evaluation 1            | 20          |                                                                                                                                                                          |
| 2             | Interim evaluation 2            | 20          |                                                                                                                                                                          |
| 3             | Final evaluation by a Committee | 35          | Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement |
| 4             | Report                          | 15          | the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level( not more than 25% )               |
| 5             | Supervisor/Guide                | 10          |                                                                                                                                                                          |
| Total Marks   |                                 | 100         |                                                                                                                                                                          |

| CODE      | COURSE NAME                             | CATEGORY   | L | T | P | CREDIT |
|-----------|-----------------------------------------|------------|---|---|---|--------|
| J1PTEL207 | TRAFFIC ENGINEERING<br>AND SOFTWARE LAB | LABORATORY | 0 | 0 | 2 | 1      |

**Preamble:** The objective of this course is to enable students to conduct traffic surveys and to record, analyse and interpret traffic data. The course is also designed to make students familiar with different transportation planning and traffic engineering software.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                               |
|------|-------------------------------------------------------------------------------|
| CO 1 | To conduct traffic surveys for transportation projects.                       |
| CO 2 | To measure various pollution parameters of vehicles.                          |
| CO 3 | To conduct road and house hold interviews for transportation projects         |
| CO 4 | To analyze and interpret traffic data                                         |
| CO 5 | To apply software packages in transportation planning and traffic engineering |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 |      | 3    | 3    |      |      |      |      |
| CO 2 |      | 3    | 3    |      |      |      |      |
| CO 3 |      | 3    | 3    |      |      |      |      |
| CO 4 | 3    | 3    | 3    |      |      |      |      |
| CO 5 |      | 3    | 2    |      |      |      |      |

#### Mark distribution

| Total Marks | CIE |
|-------------|-----|
| 100         | 100 |

#### Continuous Internal Evaluation Pattern:

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

## Syllabus and Course Plan

**Note: Any twelve experiments are mandatory**

| No | Topic                                                                    | No. of lab hours |
|----|--------------------------------------------------------------------------|------------------|
| 1  | Traffic control devices inventory                                        | 2                |
| 2  | Travel time and delay study                                              | 2                |
| 3  | Spot speed study                                                         | 2                |
| 4  | Turning movement and peak hour factor                                    | 2                |
| 5  | Sight distance and gap study at intersections                            | 2                |
| 6  | Saturation flow rates                                                    | 2                |
| 7  | Level of service analysis                                                | 2                |
| 8  | Parking study                                                            | 2                |
| 9  | Pedestrian facilities                                                    | 2                |
| 10 | Traffic impact studies                                                   | 2                |
| 11 | Transportation system performance monitoring                             | 2                |
| 12 | Transportation and air quality management                                | 2                |
| 13 | Application of queuing analysis                                          | 2                |
| 14 | Intelligent transportation system                                        | 2                |
| 15 | Computer software Applications in Transportation and Traffic Engineering | 2                |

## Reference Books

1. L.R.Kadiyali and N.B Lal., “Principles and Practices of Highway Engineering”, KhannacPublishers.
2. Khanna, S.K., Justo, C.E.G. and Veeraragavan, A., “Highway Materials and Pavement Testing”, Nem Chand & Bros., Roorkee
3. A. D. May, Traffic Flow Fundamentals, Prentice–Hall, 1990.
4. Indian Highway Capacity Manual (Indo-HCM), CSIR, New Delhi, 2017

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**SEMESTER II**

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**PROGRAM ELECTIVE III**

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| CODE      | COURSE NAME                          | CATEGORY             | L | T | P | CREDIT |
|-----------|--------------------------------------|----------------------|---|---|---|--------|
| J1PTET213 | ANALYSIS AND DESIGN OF INTERSECTIONS | PROGRAMME ELECTIVE 3 | 3 | 0 | 0 | 3      |

**Preamble:** This course aims to high light the basic principles of intersection design, operation and control and to cover the capacity and performance analysis of various types of intersections.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                           |
|-------------|---------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the concepts of design of intersection                         |
| <b>CO 2</b> | Analyze and design of uncontrolled intersections                          |
| <b>CO 3</b> | Understand intersection control for the design of signalised intersection |
| <b>CO 4</b> | Design and evaluate a traffic signal for signalised intersections         |
| <b>CO 5</b> | Analyze the performance of signalised intersection                        |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      | 3    | 3    | 3    |      |      |
| <b>CO 2</b> |      |      | 3    | 3    | 3    |      |      |
| <b>CO 3</b> |      |      | 3    | 3    | 3    |      |      |
| <b>CO 4</b> | 2    |      | 3    | 3    | 3    |      |      |
| <b>CO 5</b> | 3    |      | 3    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Remember         | 10                       |
| Understand       | 15                       |
| Apply            | 20                       |
| Analyse          | 15                       |
| Evaluate         |                          |
| Create           |                          |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the college. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

## Model Question Paper

**M.Tech Degree Examination Branch: Civil**

**Engineering**

**Specialisation: Transportation Engineering**

**Subject: J1PTET213 ANALYSIS AND DESIGN OF INTERSECTIONS**

Time: 2.5 Hrs

Max. Marks: 60

### **PART A**

(Answer **All** Questions)

1. Discuss on the suitability of different type of intersection for a site.
2. How is LOS of an at grade intersection evaluated?
3. Elaborate on warrants for signal design.
4. Illustrate the difference between stopped and control delay.
5. What are the different methods of pedestrian safety at intersections?

(5x5 = 25 marks)

### **PART B**

(Answer **any 5** Questions)

6. Briefly describe the design of a speed change lane.
7. Describe in detail the design of a mini roundabout.
8. Derive an expression for cycle length.
9. Explain the analysis of delay at an oversaturated conditions.
10. Explain the procedure of analysis of a signalised intersection using HCM method.
11. Elaborate on the procedure for capacity determination of a TWSC intersection.
12. Describe the HCM method for signal design at an intersection.

(5x7=35 marks)

## **Syllabus and Course Plan**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                 | <b>No. of Lectures</b> |
|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1</b>  | <b>Basics of intersection design (9 hrs)</b>                                                                                                                                                 |                        |
| 1.1       | Intersection-need and classification- General considerations for the location of various intersection types, principles of intersection design, factors affecting operation of intersection. | 3                      |
| 1.2       | Types of intersections and their suitability, types of maneuvers, relative speed, conflict points and areas.                                                                                 | 3                      |

|     |                                                                                                         |   |
|-----|---------------------------------------------------------------------------------------------------------|---|
| 1.3 | Design surveys for intersection, design of speed change lanes and median lanes.                         | 3 |
| 2   | <b>Analysis of un-signalised intersections, roundabouts (8 hrs)</b>                                     |   |
| 2.1 | Capacity and LOS Concepts of various types of at grade intersection.                                    | 2 |
| 2.2 | Capacity and performance evaluation of un-signalised intersections–TWSC and AWSC.                       | 3 |
| 2.3 | Rotary Intersections-design and capacity analysis, Mini roundabout- design and analysis.                | 3 |
| 3   | <b>Design of intersection controls and performance analysis of signalised intersection (6 hrs)</b>      |   |
| 3.1 | Warrants for signals, Traffic signal design: Elements of traffic signal: Definitions.                   | 3 |
| 3.2 | Analysis of saturation headway, saturation flow, lost time, critical flows, derivation of cycle length. | 3 |
| 4   | <b>Design principles of a traffic signal (9 hrs)</b>                                                    |   |
| 4.1 | Phase design, cycle time determination, green splitting, pedestrian phases, and performance measures.   | 3 |
| 4.2 | Evaluation of a traffic signal: Definitions and measurement of stopped and control delay.               | 3 |
| 4.3 | Webster's delay model, over saturated conditions.                                                       | 3 |
| 5   | <b>Capacity and LOS analysis of signalized intersection (8 hrs)</b>                                     |   |
| 5.1 | HCM method of analysis of a signalised intersection and determination of the level of service.          | 4 |
| 5.2 | General traffic control by islands, pedestrian control, signs, markings, intersection lighting etc.     | 4 |

### Reference Books

1. Roess, Prassas and McShane, "Traffic Engineering", Pearson Prentice Hall, Fourth Edition, Upper Saddle River, New Jersey 2011
2. Garbeland Hoel, Traffic and Highway Engineering, Third Edition, Books/Cole Publishers
3. L. R. Kadiyali, Traffic Engineering and Transport Planning, Khanna publishers, New Delhi
4. Transportation Research Board, Highway Capacity Manual 2000, 2010
5. Relevant IRC Codes

| CODE      | COURSE NAME                              | CATEGORY                | L | T | P | CREDIT |
|-----------|------------------------------------------|-------------------------|---|---|---|--------|
| J1PTET223 | INTELLIGENT<br>TRANSPORTATION<br>SYSTEMS | PROGRAMME<br>ELECTIVE 3 | 3 | 0 | 0 | 3      |

**Preamble:** This course is aimed at providing an understanding of the need for Intelligent applications in transportation systems, to identify different intelligent user systems and to differentiate conventional methods with ITS applications in case studies.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                                                                                                             |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Understand the need of the ITS and ITS System requirements                                                                                                                  |
| CO 2 | Identify and differentiate ITS user services and their components                                                                                                           |
| CO 3 | Suggest the appropriate tools and components in various functional areas of transportation for field conditions.                                                            |
| CO 4 | Identify the importance of automated highway systems and New technology applications in autonomous vehicles                                                                 |
| CO 5 | To plan and implement the applications of ITS in transportation planning and equip the students with practical case studies leading to ITS rather than conventional methods |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 | 3    |      | 2    |      |      |      |      |
| CO 2 | 3    |      | 2    |      |      |      |      |
| CO 3 | 3    | 3    | 2    | 3    | 3    |      |      |
| CO 4 | 3    | 3    | 2    | 3    | 3    | 3    | 3    |
| CO 5 | 3    | 3    | 2    | 3    | 3    | 3    | 3    |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60\%$ .

## **Model Question Paper**

**Course Code & Name: J1PTET223 INTELLIGENT TRANSPORTATION SYSTEMS**

Max. Marks: 60

Duration: 2.5 hours

### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Differentiate metropolitan ITS with Rural ITS
2. Describe the time line of Incident Management system
3. Explain the role of technology applications in commercial vehicle operations
4. Explain how implementation of AHS is having an impact on environment.
5. What are the challenges in implementing ITS in India

### **PART B**

**(Answer any five questions: Each carries 7 marks)**

6. Explain the history of ITS. List and elaborate the ITS developments in India and world wide.
7. What is ITS System design. Explain the components in ITS systems and describe the system requirements for ITS with examples
8. How is GPS – GIS integrations done. Explain the role of GSM technology applications in Transportation systems.
9. If we are planning to implement AHS in India, Discuss the implementation process specific to Indian condition.
10. Apply the ITS approach to a specific transportation problem as a case study and explain how it is different from a conventional approach
11. What are Advanced Traveler Information systems (ATIS). Describe in detail the different types of Information dissemination systems available to support ATIS
12. Explain the following :1. Advanced Traffic Management Systems, 2. Bus Rapid Transit, 3. Electronic Toll collection and Electronic payments, 4. ITS in parking management

## **Syllabus and Course Plan**

### **MODULE 1**

#### **ITS History, System architecture and design , ITS functional areas**

Introduction to Intelligent Transportation Systems (ITS), ITS : Need, Standards and Policy.

History of ITS, ITS developments worldwide and Indian scenario. Metropolitan and Rural ITS.

National and regional ITS Architecture, ITS System design: components and requirements including standards with examples. Challenges and opportunities in ITS

ITS functional areas: Advanced Traveller Information systems (ATIS), Advanced Traffic Management Systems (ATMS), Advanced Public Transportation Systems (APTS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), Emergency Management Systems (EMS)

### **MODULE 2**

#### **ITS user services and applications**

**ATIS:** Pre trip information, en-route driver information, ATIS data collection techniques and dissemination mediums, Route guidance systems.

**Travel Demand Management:** Congestion Mitigation, Supply and Demand Strategy: Congestion pricing, Parking management and control, Traffic Management Centres. Access Control systems, Ramp metering.

**Public transportation operations:** Public Transportation Management, en-route Transit Information, Personalized Public Transit. BRT, Electronic payments. Expected Time of Arrivals and applications in Public transit information.

Emergency Management Systems (EMS), Signal pre-emption, Incident management.

### **MODULE 3**

#### **ITS –vehicle operations , ITS tools and components**

**Advance vehicle control and safety systems:** Longitudinal and Lateral Collision Avoidance, Intersection Collision Avoidance, Dynamic Speed Adaptation Systems,

**Commercial vehicle operations:** Commercial Vehicle Electronic Clearance, Automated Roadside Safety Inspection, On-board Safety Monitoring, Commercial Vehicle Administrative Processes, Hazardous Materials Incident Response, Freight Mobility, Fleet management. Weigh in motion.

**Tools and components of ITS :** Electronic Toll collection and Electronic payments, Automatic Vehicle Location, Automatic Vehicle Identification, Automatic Vehicle Monitoring, Geographic Information Systems, Global Positioning Systems, GPS – GIS integrations, GSM technology applications.

## **MODULE 4**

### **Automated Highway Systems and Environment**

**Automated Highway Systems (AHS):** Smart cars, Smart roads, Infrastructure to Infrastructure Communications, Vehicle to infrastructure communications, Vehicle to vehicle communications: case studies.

Evolution of AHS, , Technologies used in AHS, Vehicle in platoons, Integration of AHS, System Configuration, Communication, control and sensor requirements in AHS, AHS Implementation and its impact on Environment.

Driverless Cars: Classifications and Technology, Application and Challenges .

Artificial Intelligence (AI) for smart Transportation systems: Self parking and Advanced cruise control

## **MODULE 5**

### **ITS Planning**

**Transportation Planning And ITS:-**Relationships Between Problems, Conventional Approach And ITS Approach with case studies, Integration of ITS Into Transportation Planning. Issues And Challenges

Environmental, Economic And Safety Impacts Of Intelligent Transportation Systems.

**International ITS Programs:** Applications In Bus Transport, Metro And Highways: Case Studies

Possibilities And Challenges Of ITS In India: Case Studies.

### **Course Plan**

| <b>No</b> | <b>Topic</b>                                                                                                                                                                                  | <b>No. of Lectures</b> |
|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|
|           | MODULE 1 (8hrs)                                                                                                                                                                               |                        |
| 1         | <b>ITS History, System architecture and design , ITS functional areas</b>                                                                                                                     |                        |
| 1.1       | Introduction to Intelligent Transportation Systems (ITS), ITS : Need, Standards and Policy.<br>History of ITS, ITS developments worldwide and Indian scenario.<br>Metropolitan and Rural ITS. | 3                      |
| 1.2       | National and regional ITS Architecture, ITS System design: components and requirements including standards with examples. Challenges and opportunities in ITS                                 | 2                      |

|     |                                                                                                                                                                                                                                                                                                       |   |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 1.3 | ITS functional areas: Advanced Traveller Information systems (ATIS), Advanced Traffic Management Systems (ATMS), Advanced Public Transportation Systems (APTS), Advanced Vehicle Control Systems (AVCS), Commercial Vehicle Operations (CVO), Emergency Management Systems (EMS)                      | 3 |
|     | MODULE 2 (9hrs)                                                                                                                                                                                                                                                                                       |   |
| 2   | <b>ITS user services and applications</b>                                                                                                                                                                                                                                                             |   |
| 2.1 | <b>ATIS:</b> Pre trip information, en-route driver information, ATIS data collection techniques and dissemination mediums, Route guidance systems.                                                                                                                                                    | 3 |
| 2.2 | <b>Travel Demand Management:</b> Congestion Mitigation, Supply and Demand Strategy: Congestion pricing, Parking management and control, Traffic Management Centres. Access Control systems, Ramp metering.                                                                                            | 2 |
| 2.3 | <b>Public transportation operations:</b> Public Transportation Management, en-route Transit Information, Personalized Public Transit. BRT, Electronic payments. Expected Time of Arrivals and applications in Public transit information                                                              | 2 |
| 2.4 | Emergency Management Systems (EMS), Signal pre-emption, Incident management.                                                                                                                                                                                                                          | 2 |
|     | MODULE 3 (8hrs)                                                                                                                                                                                                                                                                                       |   |
| 3   | <b>ITS –vehicle operations , ITS tools and components</b>                                                                                                                                                                                                                                             |   |
| 3.1 | <b>Advance vehicle control and safety systems:</b> Longitudinal and Lateral Collision Avoidance, Intersection Collision Avoidance, Dynamic Speed Adaptation Systems,                                                                                                                                  | 2 |
| 3.2 | <b>Commercial vehicle operations:</b> Commercial Vehicle Electronic Clearance, Automated Roadside Safety Inspection, On-board Safety Monitoring, Commercial Vehicle Administrative Processes, Hazardous Materials Incident Response, Freight Mobility, Fleet management. Weigh in motion.             | 2 |
| 3.3 | <b>Tools and components of ITS :</b> Electronic Toll collection and Electronic payments, Automatic Vehicle Location, Automatic Vehicle Identification, Automatic Vehicle Monitoring, Geographic Information Systems, Global Positioning Systems, GPS – GIS integrations, GSM technology applications. | 4 |
|     | MODULE 4 (7hrs)                                                                                                                                                                                                                                                                                       |   |
| 4   | <b>Automated Highway Systems and Environment</b>                                                                                                                                                                                                                                                      |   |
| 4.1 | <b>Automated Highway Systems (AHS):</b> Smart cars, Smart roads, Infrastructure to Infrastructure Communications, Vehicle to infrastructure communications, Vehicle to vehicle communications: case studies.                                                                                          | 3 |

|     |                                                                                                                                                                                                                                                                                                        |   |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.2 | Evolution of AHS, , Technologies used in AHS, Vehicle in platoons, Integration of AHS, System Configuration, Communication, control and sensor requirements in AHS, AHS Implementation and its impact on Environment.<br>Driverless Cars: Classifications and Technology, Application and Challenges . | 3 |
| 4.3 | Artificial Intelligence (AI) for smart Transportation systems: Self parking and Advanced cruise control                                                                                                                                                                                                | 1 |
|     | MODULE 5 (8hrs)                                                                                                                                                                                                                                                                                        |   |
| 5   | <b>ITS Planning</b>                                                                                                                                                                                                                                                                                    |   |
| 5.1 | <b>Transportation Planning And ITS:-</b> Relationships Between Problems, Conventional Approach And ITS Approach with case studies, Integration of ITS Into Transportation Planning. Issues And Challenges                                                                                              | 2 |
| 5.2 | Environmental, Economic And Safety Impacts Of Intelligent Transportation Systems.                                                                                                                                                                                                                      | 2 |
| 5.3 | <b>International ITS Programs:</b> Applications In Bus Transport, Metro And Highways: Case Studies                                                                                                                                                                                                     | 2 |
| 5.4 | Possibilities And Challenges Of ITS In India: Case Studies.                                                                                                                                                                                                                                            | 2 |

### Reference Books

1. Fundamentals of Intelligent Transportation Systems Planning, M.A. Chowdhury and A. Sadek, Artech House, 2010, First Edition.
2. Intelligent Transport Systems, Sarkar, Pradip Kumar, and Amit Kumar Jain, PHI Learning, 2018, First Edition.
3. Intelligent Transport Systems Standards, Bob Williams, Artech House Publishers, 2008.
4. Ghosh, S., Leer, T.S. Intelligent Transportation Systems: New Principles and Architectures, CRC Press, 2000.
5. Perspectives on Intelligent Transportation Systems (ITS), J.M. Sussman, Springer, 2005, First Edition.
6. R.P Roess, E.S. Prassas, W.R. McShane. Traffic Engineering, Pearson Educational International, Third Edition, 2004.
7. Chris Drane and Chris Rizos, "Positioning Systems in Intelligent Transportation Systems", Artech House Publishers, London.
8. National ITS Architecture Documentation, US Department of Transportation, 2007
9. ITS Hand Book 2000: Recommendations for World Road Association (PIARC) by Kan Paul Chen, John Miles.

10. Asier Perallos, Unai Hernandez-Jayo, Enrique Onieva and Ignacio Julio García Zuazola, *Intelligent Transport Systems: Technologies and Applications*, Wiley, 2015.
11. Petros A. Ioannou, *Automated Highway Systems*, Springer Science & Business Media, 2013
12. *Systems Engineering for Intelligent Transportation Systems-an introduction to transportation professionals*, FHWA, Department of Transportation, January 2007
13. *Economic Impacts of Intelligent Transportation Systems: Innovations and Case Studies*, Bekiaris and Y.J. Nakanishi, Elsevier/JAI, 2004.
14. IET Intelligent Transport Systems and 15th International IEEE Conference on Intelligent Transportation Systems (ITSC), September 2012.
15. *Intelligent Transport Systems: Cases and Policies*, RogerStough, Edward Elgar, 2001.
16. *Intelligent Vehicle Technologies – Theory and Applications*, L. Vlacic, M. Parent, F. Harashima, Butterworth-Heinemann, 2010.
17. *The Implication of Intelligent Transport Systems for Road Safety*, Austroads Incorporated, 1999.

| CODE      | COURSE NAME                            | CATEGORY                | L | T | P | CREDIT |
|-----------|----------------------------------------|-------------------------|---|---|---|--------|
| J1PTET233 | REGIONAL<br>TRANSPORTATION<br>PLANNING | PROGRAMME<br>ELECTIVE 3 | 3 | 0 | 0 | 3      |

**Preamble:** This course enables a student to recollect transportation planning basics in the context of regions, understand the necessity for regional accessibility and connectivity, design for travel demand studies, learn network theories and to apply them in solving regional transport planning issues.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                        |
|-------------|----------------------------------------------------------------------------------------|
| <b>CO 1</b> | <b>Understand</b> basic concepts on theories of Regional Development demand for travel |
| <b>CO 2</b> | <b>Design</b> a regional planning project for disaster management                      |
| <b>CO 3</b> | <b>Understand</b> Demographic and Employment Forecasting Models                        |
| <b>CO 4</b> | <b>Evaluate</b> network structure and its components for its suitability in a region   |
| <b>CO 5</b> | <b>Analyse</b> transport network based on graph theory, measures and indices           |
| <b>CO 6</b> | <b>Apply</b> principles of regional planning and graph theory to practical situations  |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 2    |      |      |      |      |      |
| <b>CO 2</b> | 3    | 3    |      |      |      |      |      |
| <b>CO 3</b> | 3    | 2    |      |      |      |      |      |
| <b>CO 4</b> | 3    | 2    |      |      |      |      |      |
| <b>CO 5</b> | 3    | 3    |      |      |      |      |      |
| <b>CO 6</b> | 3    |      |      |      |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 20                       |
| Analyse          | 20                       |
| Evaluate         | 10                       |
| Create           | 10                       |

#### Mark distribution

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

### **Continuous Internal Evaluation Pattern:**

Assignment: 10

Course Project: 10

Tests: 20

### **End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60\%$ .

## **Model Question Paper**

### **Model Question paper**

#### **J1PTET233 REGIONAL TRANSPORTATION PLANNING**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Explain the differences between Perroux and Christaller theories on regional development
2. How are ARIMA models utilised in forecasting employment?
3. Explain any two methods used for Passenger demand forecasting
4. What do the Alpha, Beta and Gamma indices signify in a transportation network?
5. Explain the terms Geographic Accessibility and Potential accessibility.

#### **PART B**

**(Answer any five questions: Each carries 7 marks)**

6. What are the requirements of a planning region? What are the steps involved in regionalisation?
7. Discuss the features of any four demographic models, along with their applicability in regional transport planning.
8. Discuss the needs for inventory of transport infrastructure, and propose a method for acquiring the inventory data in for a region in India.
9. Bring out the features and limitations of the shift and share model for travel demand forecasting.
10. Discuss the necessity for and the techniques involved in forecasting interzonal movements on a road network.
11. Describe how graph theory is applied to transportation networks.
12. Illustrate the various network structures used in transportation

## Syllabus and Course Plan

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| <p style="text-align: center;"><b>Syllabus</b></p> <p>Concept of region space, classification of region, theories of regional development- delineation of region- Regional Transportation Planning for Specific Purposes- demographic models used in transportation planning- financial analysis- Economic Base Mechanism, Population and Employment multiplier models-Input and output models-Dynamic models inventory - Consumption and stock Piling Models-freight demand models-forecast of inter-zonal movements on the road network Transportation Networks Structure and Applications of Graph Theory Concepts.</p> |  |
| <p><b>Expected Outcome</b></p> <p>After successful completion of the course, students should make use of these theories and models for forecasting the goods demand and thus, national transportation planning</p>                                                                                                                                                                                                                                                                                                                                                                                                         |  |

## Course Plan

| No       | Topic                                                                                                                                                   | No. of Lectures |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Theories of Regional Development and Delineation of Transportation</b>                                                                               |                 |
| 1.1      | Planning Regions: Concept of region and space. Types of regions- Classification of Regions-regional balance                                             | 2               |
| 1.2      | Christaller and Perroux Theories of Regional Development- Delineation of Regions for Transportation Planning of a Nation                                | 2               |
| 1.3      | Regional Transportation Planning for Specific Purposes- Disasters-Regional Transport Emergency Management Plans                                         | 2               |
| <b>2</b> | <b>Demographic and Employment Forecasting Models</b>                                                                                                    |                 |
| 2.1      | Demographic models-Linear, Exponential and Logistic models, Cohort Survival models-Birth, Aging and Migration models (basics only)                      | 2               |
| 2.2      | Employment Forecasting models-Economic Base Mechanism, Population and Employment multiplier models- financial analysis (concepts and basic models only) | 3               |
| 2.3      | Input and output models -Dynamic models of population and employment-Multi regional Extensions                                                          | 2               |
| <b>3</b> | <b>Studies on Travel Demand</b>                                                                                                                         |                 |
| 3.1      | Inventory of transport infrastructure-fleet traffic parameters-revenues-energy use -collection of data                                                  | 3               |
| 3.2      | Studies and plans relevant to nonurban transportation services- Estimating and Forecasting of Passenger and Goods Demand (elementary ideas only)        | 4               |
| <b>4</b> | <b>Travel demand models</b>                                                                                                                             |                 |
| 4.1      | Mode Specific and Mode Abstract models, Programming model, Shift and Share model                                                                        | 2               |

|          |                                                                                                                                                                                                      |   |
|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.2      | Excess Production, Consumption and stockpiling Models, Models based on Behavioral Characteristic of Shippers (basic concepts only)                                                                   | 1 |
| 4.3      | Model fitting-model calibration- measures of Precision- forecast of inter-zonal movements on the road network- (methods and application only)                                                        | 3 |
| <b>5</b> | <b>Transportation Networks and Applications of Graph Theory</b>                                                                                                                                      |   |
| 5.1      | Graph Theory: Directed Graph, Partial Graph, Sub-Graph, Complete Graph, Bi-Partite Graph, Chain, Cycle, Paths and Meshes, Cut sets, Trees and Arborescence (basic introduction and comparisons only) | 4 |
| 5.2      | Spatial Measures of Output and spatial Attributes of Transportation System: Accessibility, Comprehensiveness, Circuitry and Connectivity of Transportation Network.                                  | 3 |
| <b>6</b> | <b>Network Structure, Measures and indices</b>                                                                                                                                                       |   |
| 6.1      | Network structure - Measures and Theoretical indices at network level: Such as Alpha, Beta and Gamma- Accessibility Indices                                                                          | 2 |
| 6.2      | <i>Course Project:</i> RTP Practical application- Applying concepts in Regional Transportation Planning- Achieving regional balance through transport network planning                               | 4 |

### Reference Books

1. Hutchinson B. G Principles of Transportation System Planning, McGraw Hill
2. Oppenheim N, Applied models in Urban and Regional Analysis, Prentice Hall
3. Dickey. J. W; et.al; Metropolitan Transportation planning; Tata McGraw-Hill Wilson AG
4. Urban and regional models in Geography and Planning; John Wiley and Sons
5. Mishra R. P.et.al; Regional Development Planning in India, Vikas Publishing House, New Delhi
6. Heggeil G; Transportation Engineering Economics; Mc-Graw Hill Book Company, New York
7. IRC Journals: 42-4, 44-1, 44-3 for Rural Road Network Planning
8. Michael D. Meyer. Transportation Planning Handbook, Institute of Transportation Engineers.
9. NCHRP Report 777. A Guide to Regional Transportation Planning for Disasters, Emergencies, and Significant Events. Washington, DC: The National Academies Press.

| CODE      | COURSE NAME                 | CATEGORY             | L | T | P | CREDIT |
|-----------|-----------------------------|----------------------|---|---|---|--------|
| J1PTET243 | PAVEMENT MANAGEMENT SYSTEMS | PROGRAMME ELECTIVE 3 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to enable the students to predict the performance of pavement using various modelling techniques and to understand various concepts of expert system.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                                        |
|-------------|------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Recall the components of pavement management systems                                                                   |
| <b>CO 2</b> | Compare the various pavement performance prediction models                                                             |
| <b>CO 3</b> | Compute the performance of the pavement and adopt appropriate techniques and expert systems for the management purpose |
| <b>CO 4</b> | Summarize the importance of expert system for pavement management system                                               |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 2</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 3</b> | 2    |      |      | 3    | 3    |      |      |
| <b>CO 4</b> | 2    |      |      | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

#### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60\%$ .

## **Model Question Paper**

*Course Code & Name:*

### **J1PTET243 PAVEMENT MANAGEMENT SYSTEM**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Discuss the need and objectives of PMS.
2. Explain in detail about preventive and corrective maintenance.
3. Explain the concept of optimal design strategy.
4. Write a note on pavement preservation programmes
5. Discuss the applications of expert systems for managing pavements.

#### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. With the help of flow chart, explain the components and sub systems in PMS
7. List out the types of deterministic models and explain in detail about mechanistic empirical method
8. Write a note on HDM-4 discussing the primary features, applications and limitations
9. Explain about the physical design inputs
10. Explain in detail the components of pavement preservation programmes.
11. Give a case study illustrating the implementation of pavement management system

## Syllabus and Course Plan

| No  | Topic                                                                                           | No. of Lectures |
|-----|-------------------------------------------------------------------------------------------------|-----------------|
| 1   | Introduction to pavement management system                                                      |                 |
| 1.1 | Components of pavement management systems, pavement maintenance measures.                       | 2               |
| 1.2 | Planning investment, research management. Recent developments, sample size selection.           | 4               |
| 1.3 | Economic optimisation of pavement maintenance and rehabilitation.                               | 2               |
|     |                                                                                                 |                 |
| 2   | Pavement Performance Prediction                                                                 |                 |
| 2.1 | Concepts, modelling techniques, structural condition deterioration models                       | 2               |
| 2.2 | Functional deterioration models, mechanistic and empirical models.                              | 2               |
| 2.3 | HDM and other models, Modelling in rehabilitation budget planning.                              | 2               |
| 2.4 | case studies                                                                                    | 2               |
|     |                                                                                                 |                 |
| 3   | Design Alternatives and Selection                                                               |                 |
| 3.1 | Design objectives and constraints, basic structural response models                             | 2               |
| 3.2 | Physical design inputs, alternate pavement design strategies and economic evaluation            | 6               |
|     |                                                                                                 |                 |
| 4   | Reliability concepts in pavement engineering                                                    |                 |
| 4.1 | Life cycle costing, analysis of alternate pavement strategies based on distress and performance | 2               |
| 4.2 | Case studies, Road Asset Management                                                             | 2               |
| 4.3 | Pavement Preservation Programmes, Techniques and Tools.                                         | 2               |
|     |                                                                                                 |                 |
| 5   | Role of computers in pavement management                                                        |                 |
| 5.1 | Applications of expert systems for managing pavements                                           | 2               |
| 5.2 | Expert system for pavement evaluation and rehabilitation                                        | 2               |
| 5.3 | Knowledge-based expert systems                                                                  | 2               |
| 5.4 | Case studies Implementation of pavement management systems                                      | 1               |
|     | Total hours                                                                                     | 37              |

## Reference Books

1. Ralph Haas and Ronald Hudson, "Pavement Management System", McGraw Hill Book Co. 1978
2. Ralph Haas, Ronald Hudson and Zanieswki, "Modern Pavement Management", Kreiger Publications OECD, Pavement Management Systems, O E C D1987.
3. Shahin M Y, "Pavement Management for Airport, Roads and Parking Lots", Chapman and Hall 1994
4. Susan Brown, Pavement Management Systems, Transportation Research Board,1993.

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**SEMESTER II**

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**PROGRAM ELECTIVE IV**

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| CODE      | COURSE NAME                                | CATEGORY                | L | T | P | CREDIT |
|-----------|--------------------------------------------|-------------------------|---|---|---|--------|
| J1PTET214 | ANALYTICAL TECHNIQUES<br>IN TRANSPORTATION | PROGRAMME<br>ELECTIVE 4 | 3 | 0 | 0 | 3      |

**Preamble:** Nil

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

|             |                                                                                                                                             |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Apply the rule of probability and discrete distributions in solving problems and to test the goodness of fit by using statistical decision. |
| <b>CO 2</b> | To understand multivariate data analysis technique.                                                                                         |
| <b>CO 3</b> | Understand the concept of network flow theory and econometric models                                                                        |
| <b>CO 4</b> | Able to apply these techniques in transportation problems                                                                                   |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 3    |      | 3    |      | 2    | 2    |
| <b>CO 2</b> | 2    | 2    | 2    | 2    | 3    |      | 2    |
| <b>CO 3</b> | 3    | 2    | 3    | 3    | 3    | 1    | 2    |
| <b>CO 4</b> | 3    | 2    | 2    | 3    | 3    |      | 2    |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

#### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

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## Model Question Paper

*Course Code & Name:*

### **J1PTET214 Analytical Techniques in Transportation**

Max. Marks: 60

Duration:

2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. What are the statistical methods for analysis of accident data??
2. Explain importance of median test?
3. What are the assumptions of the Linear Regression Model.
4. Write a brief note on Standardized Regression Models.
5. Explain in detail about Simultaneous-Equation Models.

#### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. 200 drivers are asked to indicate their preference for receiving pretrip travel time information via the Internet or via their mobile phones. Results show that 72 drivers preferred receiving the information via the Internet, 103 via their mobile phones, and 25 indicated no difference between the two methods. Do the responses to the questionnaire indicate a significant difference between the two methods in terms of how pretrip travel time information.
7. Explain the different steps in Time series analyses
8. Explain Stochastic Volatility Models.
9. Explain Factor Analysis in transportation engineering.
10. Why Nested Logit Model is considered as a Generalized Extreme Value Models. Justify

### **Syllabus and Course Plan**

| No  | Topic                                                                                                                  | No. of Lectures |
|-----|------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Parameter Estimation and hypothesis Testing:</b>                                                                    |                 |
| 1.1 | Random samples, sampling distributions of mean and variance.                                                           | 2               |
| 1.2 | Point estimators, the method of maximum likelihood, and the method of moments.                                         | 2               |
| 1.3 | Confidence interval, Statistical hypothesis tests, Operations characteristic curve.                                    | 3               |
| 1.4 | Tests of hypothesis on the mean of a Normal Distribution, Tests of hypothesis on the means of two Normal distributions | 2               |

|          |                                                                                                                                                                                                                |        |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|
| 1.5      | The paired t-test, Tests of hypothesis on one variable, Test of hypothesis for the equality of two variances                                                                                                   | G-C1E5 |
| 1.6      | The testing of goodness of fit.                                                                                                                                                                                | 2      |
| <b>2</b> | <b>Regression and Correlation Analysis: Introduction,</b>                                                                                                                                                      |        |
| 2.1      | Bi-Variate Normal distribution and the associated marginal and conditional distributions, estimation and analysis of simple regression models, correlation coefficients, analysis of correlation coefficients, | 1      |
| 2.2      | Hypothesis tests associated with regression and correlation coefficients, curvilinear regression models,                                                                                                       | 3      |
| 2.3      | Multiple regression models, multiple and partial correlation coefficients.                                                                                                                                     | 2      |
| <b>3</b> | <b>Multivariate data analysis techniques- Types of data, basic vectors and matrices, Cross</b>                                                                                                                 |        |
| 3.1      | Sample Estimation of Centroid, Standard deviation, Dispersion, Variance and Covariance, Correlation matrices,                                                                                                  | 2      |
| 3.2      | Principle component, Factor Analysis, Cluster Analysis,                                                                                                                                                        | 3      |
| 3.3      | Classification procedure in Multivariate data analysis, Application to problems in traffic and transportation planning                                                                                         | 2      |
| <b>4</b> | <b>Network Flow Theory- Basic Concepts and definitions – directed and undirected graphs-nodes-links-trees-path-cycles-connectivity cut</b>                                                                     |        |
| 4.1      | network representation - Node-arc incidence Matrix, Node adjacency Matrix- adjacency Lists- forward and reverse star representations-                                                                          | 2      |
| 4.2      | Network transformations- berth and search algorithms- formulation of shortest path problem                                                                                                                     | 3      |
| 4.3      | Maximum flow problem- minimum cost flow problem- algorithm- applications in transportation network problem.                                                                                                    | 2      |
| <b>5</b> | <b>Econometric Models- Latent Variable Models Multinomial Logit Models</b>                                                                                                                                     |        |
| 5.1      | Structural Equation modelling – Duration models – Hazard based duration models                                                                                                                                 | 2      |
| 5.2      | Non parametric, semi parametric and fully parametric models – Discrete outcome models                                                                                                                          | 3      |
| 5.3      | Nested Logic Models – Overview of discrete continuous models.                                                                                                                                                  | 3      |

### Reference Books

1. Ravindra K. Ahuja, Thomas L. Magnanti, James B. Orlin. Network Flows Theory, Algorithms and Applications, Prentice Hall, New Jersey.
2. Juan de Dios Ortuzar and Luls G. Willumsen. Modelling transport, John Wiley and Sons
3. Kalyanmoy Deb. Multi-Objective using Evolutionary Algorithms, John Wiley and Sons Ltd.
4. Simon P., Mathew G. Karalftis, Fred L. Mannering. Statistical and Econometric Methods for Transportation Data Analysis, CRC Press LLC, Florida
5. Cooley, W. W. And Lohnes, R. R. Multivariate Data Analysis.-

| CODE      | COURSE NAME                         | CATEGORY                | L | T | P | CREDIT |
|-----------|-------------------------------------|-------------------------|---|---|---|--------|
| J1PTET224 | ADVANCED TRAVEL<br>DEMAND MODELLING | PROGRAMME<br>ELECTIVE 4 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to impart an awareness on the theories of individual choice behavior, process of conducting choice surveys, development of discrete choice models, model aggregation and transferability of developed models and simplified transport demand models.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                      |
|-------------|--------------------------------------------------------------------------------------|
| <b>CO 1</b> | To design a questionnaire and conduct choice preference surveys                      |
| <b>CO 2</b> | To develop discrete choice models using the collected choice data                    |
| <b>CO 3</b> | To interpret and assess the quality of discrete choice models                        |
| <b>CO 4</b> | To apply the developed model in aggregate level and transfer to other suitable areas |
| <b>CO 5</b> | To apply simplified transport demand models in appropriate conditions                |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 3    | 2    | 3    | 3    |      |      |
| <b>CO 2</b> | 3    |      | 2    | 3    |      |      |      |
| <b>CO 3</b> | 3    |      | 2    | 3    |      |      |      |
| <b>CO 4</b> | 3    |      | 2    | 3    | 3    |      |      |
| <b>CO 5</b> | 3    |      | 2    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60\%$ .

## Model Question Paper

Course Code & Name:

### J1PTET224 ADVANCED TRAVEL DEMAND MODELLING

Max. Marks: 60

Duration:

2.5 hours

#### PART A

(Answer all Questions: Each question carries 5 marks)

1. What are the assumptions and limitations of MNL models?
2. Evaluate the goodness- of- fit measures adopted for discrete choice modeling?
3. What is RP survey? Indicate the limitations of RP data.
4. Illustrate fractional factorial design with an example.
5. Summarize incremental elasticity analysis?

#### PART B

(Answer any *five* questions: Each carries 7 marks)

6. What are the key aspects and assumptions of UMOT model?
7. How is model transferability evaluated?
8. Illustrate basic rating scales used in SP survey with examples?
9. How is logsum parameter important in nested logit modeling?
10. What does it mean to validate a model? Explain about the different approaches of model validation.
11. Assess the role of soft variables in travel demand modelling?
12. Consider a binary logit model for car and bus, where the following representative utility functions have been estimated:  
 $U(\text{car}) = 3.5 - 0.25 \cdot t_{\text{car}} - 0.42 \cdot e_{\text{car}} - 0.1 \cdot c_{\text{car}}$   
 $U(\text{bus}) = -0.25 \cdot t_{\text{bus}} - 0.42 \cdot e_{\text{bus}} - 0.1 \cdot c_{\text{bus}}$   
Where,  $t$  is the in-vehicle travel time (min),  $e$  is the access time (min) and  $c$  is the travel cost (Rs.). Assume that the following average data is known:

| 13.Mode | 14.Variable |      |        |
|---------|-------------|------|--------|
|         | 15.t        | 16.e | 17.c   |
| 18.Car  | 19.20       | 20.6 | 21.135 |
| 22.Bus  | 23.35       | 24.9 | 25.50  |

Calculate the percent variation in the probability of choosing car, if the bus fare goes up by 15%. Find out what would happen if the car cost increases by 100%.

## Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                                                    | No. of Lectures |
|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Design of surveys</b>                                                                                                                                                                                                                 |                 |
| 1.1 | Stages in data collection                                                                                                                                                                                                                | 2               |
| 1.2 | Types of surveys: Revealed preference (RP) and Stated preference (SP) surveys, comparison of RP and SP data                                                                                                                              | 2               |
| 1.3 | Identification of preferences-ranking, rating and choice                                                                                                                                                                                 | 2               |
| 1.4 | Basic rating scales                                                                                                                                                                                                                      | 2               |
|     |                                                                                                                                                                                                                                          |                 |
| 2   | <b>Discrete choice modelling</b>                                                                                                                                                                                                         |                 |
| 2.1 | Elements of choice theory, decision heterogeneity                                                                                                                                                                                        | 1               |
| 2.2 | Discrete choice theory, Concept of utility                                                                                                                                                                                               | 1               |
| 2.3 | Discrete choice models: Multinomial logit model and Nested logit model (functional form, Interpretation and problems), limitation of MNL models- IIA property, red bus-blue bus problem<br>Multinomial probit models (introduction only) | 5               |
| 2.4 | Introduction of N-logit software                                                                                                                                                                                                         | 1               |
|     |                                                                                                                                                                                                                                          |                 |
| 3   | <b>Specification and estimation of discrete choice models</b>                                                                                                                                                                            |                 |
| 3.1 | Choice set formation, functional form                                                                                                                                                                                                    | 1               |
| 3.2 | Model estimation- likelihood function                                                                                                                                                                                                    | 1               |
| 3.3 | Measures of goodness of fit- significance of the variables, R-square and Rho-square statistics, Chi-square, Akaike Information criteria, likelihood ratio test                                                                           | 4               |
| 3.4 | Validation of the models- approaches                                                                                                                                                                                                     | 2               |
|     |                                                                                                                                                                                                                                          |                 |
| 4   | <b>Modelling with SP data</b>                                                                                                                                                                                                            |                 |
| 4.1 | Experimental design – Full factorial and fractional factorial design                                                                                                                                                                     | 2               |
| 4.2 | Discrete choice modelling with rating, ranking and choice data- Naïve or graphical method-subjective value of time, least square fitting including linear regression, Non metric scaling, logit or probit analysis                       | 3               |
| 4.3 | Role of Soft variables in Travel Demand Forecasting                                                                                                                                                                                      | 1               |
| 4.4 | Model aggregation and transferability- aggregation methods, measures to evaluate model transferability-test of model parameter for equality, disaggregate transferability measures                                                       | 2               |
|     |                                                                                                                                                                                                                                          |                 |
| 5   | <b>Simplified Transport Demand Models</b>                                                                                                                                                                                                |                 |
| 5.1 | Sketch planning Methods                                                                                                                                                                                                                  | 1               |
| 5.2 | Incremental Demand Models                                                                                                                                                                                                                | 1               |
| 5.3 | Model estimation from traffic Counts                                                                                                                                                                                                     | 1               |

|     |                                                    |    |
|-----|----------------------------------------------------|----|
| 5.4 | Freight demand modelling                           | 1  |
| 5.5 | Activity based modelling                           | 1  |
| 5.6 | Case studies on simplified transport demand models | 3  |
|     | Total hours                                        | 40 |

### Reference Books

1. Orturzar, J.de D. and L. G. Willumsen (2011 )Modelling Transport,Wiley Publishers
2. Oppenheim N (1995) Urban Travel Demand Modelling: From Individual Choices to general equilibrium. John Wiley & sons, Inc
3. Time use Analysis, Special Issue, Transportation, 26, Kluwer Academic Publishers
4. Michael Florian (2000) Economics & Mathematical Systems: Traffic Equilibrium Methods.
5. Ben Akiva (1985) Discrete Choice Analysis: Theory and Application to Travel Demand, MITPress
6. Orturzar, J.deD(2000) Stated Preference Modelling Techniques, PTRC Education and Research Services
7. Jordan J.Louviere, David A. Hensher, Joffre D. Swait (2000) Stated Choice Methods: Analysis and Applications

| CODE      | COURSE NAME                                         | CATEGORY                | L | T | P | CREDIT |
|-----------|-----------------------------------------------------|-------------------------|---|---|---|--------|
| J1PTET234 | TRANSPORTATION SYSTEM<br>MANAGEMENT AND<br>ANALYSIS | PROGRAMME<br>ELECTIVE 4 | 3 | 0 | 0 | 3      |

**Preamble:** This course is aimed at providing a Knowledge to analyse traffic problems and plan transportation system management actions to evaluate transport systems using microeconomic concepts.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                                          |
|-------------|--------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand TSM, the need for TSM and the objectives of TSM and Apply a strategy based on a TSM goal or objective.        |
| <b>CO 2</b> | Recommend methods to manage a transit system to improve its management efficiency.                                       |
| <b>CO 3</b> | Recommend a detailed transportation demand management strategy for a transportation system based on a goal or objective. |
| <b>CO 4</b> | Implement suitable improvement strategies traffic operations                                                             |
| <b>CO 5</b> | Perform evaluation of transportation network systems.                                                                    |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      | 3    | 3    | 3    |      |      |
| <b>CO 2</b> |      |      | 3    | 3    | 3    |      |      |
| <b>CO 3</b> | 3    |      | 3    | 3    | 3    |      |      |
| <b>CO 4</b> | 2    |      | 3    | 3    | 3    |      |      |
| <b>CO 5</b> |      |      | 3    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Remember         | 10                       |
| Understand       | 15                       |
| Apply            | 20                       |
| Analyse          | 15                       |
| Evaluate         |                          |
| Create           |                          |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Micro project/Course based project : 20 marks

Course based task/Seminar/Quiz : 10 marks

Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The end semester examination will be conducted by the University. There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

**Model Question Paper**

**M.Tech Degree Examination Branch: Civil  
Engineering**

Specialisation: **Transportation Engineering**

Subject: **J1PTET234 TRANSPORTATION SYSTEM MANAGEMENT & ANALYSIS**

Time: 2.5 Hrs

Max. Marks: 60

**PART A**

**(Answer All Questions)**

1. List out the classifications of strategic categories
2. Enumerate the approaches to Area wide data collection methodology.
3. What is meant by short-term reserved parking?
4. Comment on Dial a ride for elderly & handicapped?
5. How is congestion pricing carried out to improve traffic flow?

(5x5 = 25 marks)

**PART B**

**(Answer any 5 Questions)**

6. Draw a flow chart of generalized TSM process and describe in detail
7. Discuss about the relevance of TSM actions in Indian context?
8. Elaborate the terms park and ride, carpooling and shared ride
9. Describe in details about Staggered workhours and flexible work hour
10. Describe in detail about traffic calming with their benefits.
11. How can be Parking Management regulated by increased time duration limits. Explain?
12. What are reversible lanes? How does it help to improve traffic flow?
13. Describe micro economic concepts for transportation systems.

(5x7=35 marks)

**Syllabus and Course Plan**

| No  | Topic                                                                                                                                                                                 | No. of Lectures |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Methodology (9 hrs)</b>                                                                                                                                                            |                 |
| 1.1 | Methodological framework, objectives and problems, conflicts resolution, strategic categories and action elements.                                                                    | 3               |
| 1.2 | Travel behaviour impact and response time, TSM actions combinations and interactions, Study of following TSM actions with respect to problems addressed, conditions for applications, | 4               |
| 1.3 | Potential implementation problems, evaluation & impact analysis monitoring and surveillance                                                                                           | 2               |
| 2   | <b>Data Collection and Public transportation &amp; HOV treatment (8 hrs)</b>                                                                                                          |                 |
| 2.1 | Toll discounts for carpools during peak periods, park and ride, carpooling, exclusive lanes.                                                                                          | 3               |
| 2.2 | Priority at ramp terminals, bus transfer stations, limited and skip-stop bus services, shared ride                                                                                    | 3               |
| 2.3 | Area wide data collection methodology, corridor data collection methodology.                                                                                                          | 2               |
| 3   | <b>Demand and Parking Management (8 hrs)</b>                                                                                                                                          |                 |
| 3.1 | Staggered work hours, flexible work hours, high peak period tolls, shuttle services, circulation services, extended routes.                                                           | 4               |
| 3.2 | Short term reserved parking, increased parking rates, time duration limits, expanded off-street parking                                                                               | 4               |
| 4   | <b>Traffic Operations Improvement (8 hrs)</b>                                                                                                                                         |                 |
| 4.1 | Freeway ramp control & closure, travel on shoulders, one-way streets, reversible lanes                                                                                                | 3               |
| 4.2 | On-street parking ban, Traffic calming, Right turn phase, right turn lanes, reroute turning traffic.                                                                                  | 3               |
| 4.3 | Non-Motorized Transport- pedestrian-only streets, Dial a ride for elderly & handicapped.                                                                                              | 2               |
| 5   | <b>Evaluation (7 hrs)</b>                                                                                                                                                             |                 |
| 5.1 | Evaluation of urban transport investments – Traffic system evaluation – Microeconomic concepts central to transportation systems                                                      | 4               |
| 5.2 | Pricing theory – Congestion pricing.                                                                                                                                                  | 3               |

**Reference Books**

1. D. Arlington, Transportation System Management in 1980: State of the Art and Future Directions, Transportation Research Board, 1980.
2. Manheim M, "Fundamentals of Transportation system approach", MIT press, Cambridge, MA, 1985.

3. Institute of Transportation Engineers, Transportation and Traffic Engg. Hand Book, Prentice Hall, 1982.

4. John G Schoon, "Transportation system and service policy", Chapman and Hall, New York, 1996.

| CODE      | COURSE NAME                            | CATEGORY             | L | T | P | CREDIT |
|-----------|----------------------------------------|----------------------|---|---|---|--------|
| J1PTET244 | ROAD SAFETY AND ACCIDENT INVESTIGATION | PROGRAMME ELECTIVE 4 | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to impart an awareness on role of road safety in planning and design of urban infrastructures and to understand various road safety management measures.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                      |
|-------------|------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | To understand fundamental of traffic engineering, surveys and statistical methods in safety analysis |
| <b>CO 2</b> | To understand various road safety management measures                                                |
| <b>CO 3</b> | To design & planning various road geometrics from incorporating safety considerations                |
| <b>CO 4</b> | To understand road safety awareness program and its limitations                                      |
| <b>CO 5</b> | To investigate & determine the collective factors & remedies of accident involved                    |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 3    | 3    | 2    | 3    | 3    |      |      |
| <b>CO 2</b> | 3    |      | 2    | 3    |      |      |      |
| <b>CO 3</b> | 3    |      | 2    | 3    |      |      |      |
| <b>CO 4</b> | 3    |      | 2    | 3    | 3    |      |      |
| <b>CO 5</b> | 3    |      | 2    | 3    | 3    |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 25                       |
| Analyse          | 25                       |
| Evaluate         | 5                        |
| Create           | 5                        |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

#### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 10 marks  
 Test paper, 1 no. : 10 marks  
 Test paper shall include minimum 80% of the syllabus.

### **End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60\%$ .

## **Model Question Paper**

*Course Code & Name:*

### **J1PTET244 ROAD SAFETY AND ACCIDENT INVESTIGATION**

Max. Marks: 60

Duration:

2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. What are the different traffic Control Devices ?
2. Explain importance of road safety audit in safety management ?
3. State the Important points in cross section and geometric design to be considered from safety point of view.
4. Write a brief note on Benefit Cost Analysis Module of RSAP.
5. Differentiate between Collision Diagram and Condition Diagram?

#### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. What are the assumptions of Poisson model and its applications?
7. Differentiate between Site-Level Safety Management and System-Level Safety Management?
8. Explain various Traffic Control, Vehicle Design and Protective Devices for road safety with examples?
9. Advantages and Limitations of Stochastic Solution Method?
10. Define Crash. Determine Possible Causes of Crashes and Crash Reduction Capabilities and Countermeasures.
11. Explain the role of ITS in road safety management?
12. Explain different methods to Identify and Prioritize Hazardous Locations and Elements in Roadways?

## Syllabus and Course Plan

| No       | Topic                                                                                                                                                    | No. of Lectures |
|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Fundamentals of Traffic Engineering</b>                                                                                                               |                 |
| 1.1      | Traffic Characteristics, Traffic stream characteristics                                                                                                  | 1               |
| 1.2      | Traffic Studies, Traffic Control devices                                                                                                                 | 2               |
| 1.3      | Importance of Safety, Road Safety Improvement Strategies                                                                                                 | 1               |
| 1.4      | Statistical Methods in Traffic Safety Analysis – Regression Methods, Poisson Distribution, Chi- Squared Distribution, Statistical Comparisons            | 4               |
|          |                                                                                                                                                          |                 |
| <b>2</b> | <b>Road Safety Management Measures</b>                                                                                                                   |                 |
| 2.1      | Measuring Safety - Types of Safety Data -Road Safety Management Process- Site-Level Safety Management, System-Level Safety Management                    | 1               |
| 2.2      | Role of Urban infrastructure design in safety:, Road Safety in Urban Transport, Sustainable Modes and their Safety                                       | 1               |
| 2.3      | Traffic Management Systems for Safety, Road Safety Audits and Tools for Safety Management Systems                                                        | 5               |
| 2.4      | Road Safety Audit Process, Approach to Safety, Road Safety Improvement Strategies, ITS and Safety                                                        | 1               |
|          |                                                                                                                                                          |                 |
| <b>3</b> | <b>Road Safety in Planning And Geometric Design</b>                                                                                                      |                 |
| 3.1      | Introduction                                                                                                                                             | 1               |
| 3.2      | Vehicle And Human Characteristics, Road Design and Road Equipments                                                                                       | 2               |
| 3.3      | Redesigning Junctions, Cross Section Improvements, Reconstruction and Rehabilitation of Roads                                                            | 3               |
| 3.4      | Road Maintenance, Traffic Control, Vehicle Design and Protective Devices                                                                                 | 2               |
|          |                                                                                                                                                          |                 |
| <b>4</b> | <b>Road Safety Awareness Program</b>                                                                                                                     |                 |
| 4.1      | Road Safety Awareness Program-Cost Effectiveness Procedure                                                                                               | 2               |
| 4.2      | Encroachment Module-Crash Prediction Module-Severity Prediction Module-Benefit/Cost Analysis Module                                                      | 3               |
| 4.3      | Stochastic Solution Method, Advantages and Limitations of Stochastic Solution Method                                                                     | 2               |
| 4.4      | Limitations of RSAP                                                                                                                                      | 1               |
|          |                                                                                                                                                          |                 |
| <b>5</b> | <b>Accident Investigations and Risk Management</b>                                                                                                       |                 |
| 5.1      | Collection and Analysis of Accident Data, Condition and Collision Diagram, Causes and Remedies                                                           | 2               |
| 5.2      | Methods to Identify and Prioritize Hazardous Locations and Elements                                                                                      | 2               |
| 5.3      | Traffic Management Measures and Their Influence on Accident Prevention, Assessment of Road Safety,                                                       | 2               |
| 5.4      | Determine Possible Causes of Crashes, Crash Reduction Capabilities and Countermeasures, Effectiveness of Safety Design Features, Accident Reconstruction | 2               |

|  |             |                       |
|--|-------------|-----------------------|
|  | Total hours | CIVIL ENGINEERING-CE5 |
|--|-------------|-----------------------|

### Reference Books

1. Traffic Engineering and Transportation Planning – L.R. Kadiyali, Khanna Publishers
2. Fundamentals of Transportation Engineering – C.S. Papacostas, Prentice Hall India.
3. Transportation Engineering – An Introduction, C.Jotinkhisty, B. Kent Lall
4. Fundamentals of Traffic Engineering, Richardo G Sigua
5. Handbook of Road Safety measures, second Edition, Rune Elvik, Alena Hoyer, Truls Vaa, Michael Sorenson
6. Road Safety by NCHRP

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**SEMESTER II**

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**INTERDISCIPLINARY ELECTIVE**

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| CODE      | COURSE NAME                      | CATEGORY                   | L | T | P | CREDIT |
|-----------|----------------------------------|----------------------------|---|---|---|--------|
| J1PTE0215 | MECHANICS OF COMPOSITE MATERIALS | INTERDISCIPLINARY ELECTIVE | 3 | 0 | 0 | 3      |

**Preamble:** Fibre reinforced plastic composite materials are finding wide range of applications in the field of aerospace structures, automobile engineering, offshore structures, maritime structures, ships and civil engineering structures presently due to its outstanding material capabilities such as High strength, low weight, high corrosion resistance, high fatigue strength and faster assembly. The everyday applications of composites in the commercial markets and hence the job opportunities in this field are drastically increasing nowadays. This course will equip the students with the specialist knowledge and skills required by the leading employers in aerospace, marine, automobile, construction and renewable energy industries to design and develop next generation environmental-friendly and structural-efficient advanced lightweight composite materials and components.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the Advanced Composite Structures course the student will be able to

|             |                                                                                                                                       |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Identify the properties of fibre and matrix materials used in commercial composites, as well as some common manufacturing techniques. |
| <b>CO 2</b> | Explain linear elasticity with emphasis on the difference between layered composite materials and isotropic materials.                |
| <b>CO 3</b> | Apply constitutive equations of composite materials and understand the mechanical behaviour at micro and macro levels.                |
| <b>CO 4</b> | Predict the failure mode and strength of laminated composite structures.                                                              |
| <b>CO 5</b> | Apply the ideas developed in the analysis of composites towards using composites in various fields of engineering.                    |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      | 3    | 3    | 2    |      |      |
| <b>CO 2</b> |      |      | 3    | 3    | 2    |      |      |
| <b>CO 3</b> |      |      | 3    | 3    | 2    |      |      |
| <b>CO 4</b> |      |      | 3    | 3    | 2    |      |      |
| <b>CO 5</b> |      |      | 3    | 3    | 2    |      |      |

### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Remember         | 15                       |
| Understand       | 15                       |
| Apply            | 25                       |
| Analyse          | 5                        |
| Evaluate         | -                        |
| Create           | -                        |

### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

### Continuous Internal Evaluation Pattern:

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred): 15 marks

Course based task/Seminar/Data collection and interpretation: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 70% of the syllabus.

### End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

**Note:** The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the

average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40 + 20 = 60$  %.

### Model Question paper

#### PART A

Answer **all** questions.

All Questions carry **equal** marks

1. How is the mechanical advantage of a composite measured?
2. Write the number of independent elastic constants for three dimensional anisotropic, orthotropic, transversely isotropic and isotropic materials.
3. What is Classical Lamination Theory? Explain its significance in composite analysis.
4. The weight fraction of glass in a glass epoxy composite is 0.8. If the specific gravity of glass and epoxy are 2.5 and 1.2 respectively, find (i) fibre and matrix volume fractions (ii) density of composite?
5. Explain briefly the progressive failure analysis in a composite laminate.

#### PART B

Answer any **FIVE** questions only

6. Briefly explain the Hooke's law for Anisotropic materials. Derive the stress-strain relation for a material with three planes of reflection and one  $90^\circ$  rotation symmetry
7. (a) Explain any two methods of manufacturing of composite in detail.  
(b) Derive the relations connecting the engineering constants and the elements of stiffness and compliance matrices for a specially orthotropic lamina.
8. (a) Calculate the longitudinal modulus and tensile strength of a unidirectional composite containing 60% by volume of carbon fibres ( $E_{1f} = 294$  GPa and  $\sigma_{1fu} = 5.6$  GPa) in a toughened epoxy matrix ( $E_m = 3.6$  GPa and  $\sigma_{mu} = 105$  GPa). Compare these values with the experimentally determined values of  $E_1 = 162$  GPa and  $\sigma_{1u} = 2.94$  GPa. What fraction of load is carried by fibres in the composite?  
(b) Explain how to calculate the effective moduli of a composite lamina in terms of its constituent properties.
9. (a) Explain the free edge effects and interlaminar stresses in composite laminates  
(b) Explain how to determine the laminae stresses and strains from the analysis of a laminate?
10. Calculate the A, B, D matrices for a  $[0/90^\circ]$  laminate each layer of which is of 0.125 mm thickness. The lamina properties are given by  $E_1 = 140$  GPa,  $E_2 = 10$  GPa,  $G_{12} = 5$  GPa,  $\nu_{12} = 0.3$
11. (a) Explain the effect of interlaminar stresses in composite laminate in detail  
(b) Explain the importance of the sign of shear stress on strength of composites.

12. Find the maximum value of  $S > 0$  if a stress of  $\sigma_x = 2S$ ,  $\sigma_y = -3S$ , and  $\tau_{xy} = 4S$  is applied to a  $60^\circ$  Graphite/epoxy Lamina. Use Tsai-Hill Failure theory.

Given  $(\sigma_1^t)_{ult} = 1500 \text{ MPa}$ ,  $(\sigma_1^c)_{ult} = 1500 \text{ MPa}$ ,  $(\sigma_2^t)_{ult} = 40 \text{ MPa}$ ,  $(\sigma_2^c)_{ult} = 246 \text{ MPa}$ ,  
 $(\tau_{21})_{ult} = 68 \text{ MPa}$

### Syllabus and Course Plan

| No  | Topic                                                                                                                                                                                                                                                                       | No. of Lectures |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Introduction to Composite Materials (6)</b>                                                                                                                                                                                                                              |                 |
| 1.1 | Definition of composites, Objectives, constituents and Classification of composites.                                                                                                                                                                                        | 2               |
| 1.2 | Basic terminology used in fibre reinforced composite materials- Lamina, Laminates, General Characteristics of reinforcement and classifications, Characteristics of matrix- Polymer matrix, Thermoplastics and thermosetting resins, Glass transition temperature, Prepregs | 2               |
| 1.3 | Structural applications of Composite Materials                                                                                                                                                                                                                              | 1               |
| 1.4 | Processing of Composites                                                                                                                                                                                                                                                    | 1               |
| 2   | <b>Macro mechanical behaviour of a composite lamina (9)</b>                                                                                                                                                                                                                 |                 |
| 2.1 | Review of Basic Equations of Mechanics and Materials, Hooke's law for different types of materials- Anisotropic, orthotropic, isotropic, monoclinic and Transversely isotropic materials.                                                                                   | 2               |
| 2.2 | Stress-Strain relations for a Two dimensional unidirectional and orthotropic lamina, lamina of arbitrary orientation, Transformations of stress and strain                                                                                                                  | 3               |
| 2.3 | Relationship of Compliance and stiffness matrix to elastic constants of a lamina                                                                                                                                                                                            | 1               |
| 2.4 | Strength and Failure theories of Continuous Fibre-reinforced orthotropic Lamina- Failure envelopes, Maximum stress/strain criteria, Tsai-Hill and Tsai-Wu criterion.                                                                                                        | 2               |
| 2.5 | Hygrothermal stresses and strains in a lamina –unidirectional and angle lamina                                                                                                                                                                                              | 1               |
| 3   | <b>Micromechanical Behaviour of a Lamina (6)</b>                                                                                                                                                                                                                            |                 |
| 3.1 | Volume and Mass fractions, density and void content                                                                                                                                                                                                                         | 1               |
| 3.2 | Effective Moduli of a continuous fibre-reinforced lamina – Models based on mechanics of materials, theory of elasticity and experimental methods, Mechanics of materials approach to strength, Numerical Examples                                                           | 2               |
| 3.3 | Ultimate Strengths of unidirectional Lamina- longitudinal and transverse tensile and compressive strengths                                                                                                                                                                  | 2               |
| 3.4 | Coefficients of moisture and thermal expansion                                                                                                                                                                                                                              | 1               |
| 4   | <b>Macro mechanical behaviour of Laminates (10)</b>                                                                                                                                                                                                                         |                 |

|     |                                                                                                                                                               |   |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 4.1 | Classical Lamination Theory-Laminae Stress-strain behaviour, In-plane forces, stress-strain variation in a laminate, resultant laminate stresses and strains, | 3 |
| 4.2 | Special cases of laminate stiffnesses-symmetric and antisymmetric laminates, cross ply and angle ply laminates, quasi-isotropic laminates                     | 3 |
| 4.3 | Inplane and flexural modulus of a laminate                                                                                                                    | 1 |
| 4.4 | Effects of stacking sequence-Laminate code                                                                                                                    | 1 |
| 4.5 | Free-Edge Interlaminar Effects, Hygro-thermal effects and warpage in a laminate                                                                               | 2 |
| 5   | <b>Strength and Design of Laminates (9)</b>                                                                                                                   |   |
| 5.1 | Determination of laminae stresses and strains, numerical examples                                                                                             | 2 |
| 5.2 | Laminate strength analysis procedure, Failure envelopes                                                                                                       | 3 |
| 5.3 | Analysis of laminates after initial failures, Progressive failure Analysis. Numerical Examples                                                                | 2 |
| 5.4 | Composite mechanical design issues-Long-term environmental effects, impact resistance, fracture resistance, fatigue resistance                                | 2 |

### **Text Books**

1. Jones M. Roberts, Mechanics of Composite Materials, Taylor and Francis, 1998
2. Reddy, J.N , Mechanics of Laminated Composite Plates: Theory and Analysis, CRC Press, 2003

### **Reference Books**

1. Calcote, L. R., Analysis of Laminated Composite structures, Van Nostrand, 1969
2. Vinson, J. R. and Chou P, C., Composite materials and their use in Structures, Applied Science Publishers, Ltd. London, 1975
3. Agarwal, B.D. and Broutman, L. J., Analysis and performance of Fibre composites. 3<sup>rd</sup>Edn.

| CODE      | COURSE NAME                       | CATEGORY                   | L | T | P | CREDIT |
|-----------|-----------------------------------|----------------------------|---|---|---|--------|
| J1PTE0225 | PROJECT EVALUATION AND MANAGEMENT | INTERDISCIPLINARY ELECTIVE | 3 | 0 | 0 | 3      |

**Preamble:** Objective of the course is to enable the students to understand the management aspects of project idea formulations, feasibility studies and report preparation, costing of project, project appraisal and project funding.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

|             |                                                                   |
|-------------|-------------------------------------------------------------------|
| <b>CO 1</b> | To develop project ideas                                          |
| <b>CO 2</b> | To do the feasibility analysis of projects                        |
| <b>CO 3</b> | To plan and arrive at Project Costs                               |
| <b>CO 4</b> | To carry out project appraisals                                   |
| <b>CO 5</b> | To identify the various funding sources and select the apt source |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    |      | 3    | 2    |      | 2    |      |
| <b>CO 2</b> | 2    |      | 2    |      |      |      |      |
| <b>CO 3</b> | 3    | 2    |      | 3    |      |      |      |
| <b>CO 4</b> | 2    |      | 2    | 2    | 2    |      |      |
| <b>CO 5</b> | 2    |      | 2    | 1    |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Understand       | 20                       |
| Apply            | 10                       |
| Analyse          | 10                       |
| Evaluate         | 20                       |
| Create           |                          |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern:**

Preparing a review article based on peer reviewed

Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The end semester examination will be conducted by the respective College. There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is  $40+20 = 60\%$ .

## **Model Question Paper**

### **Model Question paper**

*Course Code & Name:*

#### **Project Evaluation and Management**

Max. Marks: 60

Duration: 2.5 hours

#### **PART A**

**(Answer all Questions: Each question carries 5 marks)**

1. Discuss the need for project idea generation ?
2. Why feasibility studies are essential?
3. What do you understand by Present value of a single amount?
4. Explain the international practice of Project Appraisal.
5. Discuss the means of Project Financing.

#### **PART B**

**(Answer any *five* questions: Each carries 7 marks)**

6. Describe the various steps involved in Project Identification.
7. How will you assess the technical feasibility of a project?
8. Explain cash flow and what are the benefits of cash flow statement..
9. Discuss the various methods of Risk Analysis
10. Bluebell Enterprises had invested Rs.2,00,00,000 for the purpose of replacing some of its machinery components. This renovation is expected to result in incremental benefits of Rs.5000000 in 1<sup>st</sup> year, Rs.3000000 in 2<sup>nd</sup> year and Rs. 4000000 in 3<sup>rd</sup> year. Calculate the benefit-cost ratio of the replacement project if the applicable discounting rate is 5%..
11. Discuss the role of various institutions for project financing
12. Discuss the Private Sector Participation on Infrastructure Projects in India

**Syllabus and Corse Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

| No  | Topic                                                                                                                                                                                               | No. of Lectures |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | Project formulation                                                                                                                                                                                 |                 |
| 1.1 | Concepts of Project, Capital Investments                                                                                                                                                            | 2               |
| 1.2 | Purpose and need for Project Identification                                                                                                                                                         | 2               |
| 1.3 | Methodology for Project Identification                                                                                                                                                              | 2               |
| 1.4 | Steps in Project Identification                                                                                                                                                                     | 2               |
| 2   | Project Feasibility                                                                                                                                                                                 |                 |
| 2.1 | Introduction to feasibility Studies, need for feasibility studies                                                                                                                                   | 2               |
| 2.2 | Components of Feasibility Analysis - Market, Technical, Financial, Economic                                                                                                                         | 4               |
| 2.3 | Feasibility Reports and approvals                                                                                                                                                                   | 2               |
| 3   | Project Costing                                                                                                                                                                                     |                 |
| 3.1 | Time Value of Money - Future value of single amount, Present value of single amount, Future value of an annuity, Present value of an annuity, Simple interest-Compound interest                     | 3               |
| 3.2 | Project Cash Flows                                                                                                                                                                                  | 3               |
| 3.3 | Cost of capital                                                                                                                                                                                     | 2               |
| 4   | Project Appraisal                                                                                                                                                                                   |                 |
| 4.1 | Investment Criteria- Discounting criteria-Net present value (NPV), Benefit cost ratio(BCR), internal rate of return(IRR)- Non-Discounting criteria - Pay Back Period, Accounting rate of return(ARR | 4               |
| 4.2 | Indian and International Practice of Appraisal                                                                                                                                                      | 2               |
| 4.3 | Methods of Analysis of Risk                                                                                                                                                                         | 2               |
| 5   | Project Financing                                                                                                                                                                                   |                 |
| 5.1 | Project Financing – Means of Finance                                                                                                                                                                | 2               |
| 5.2 | Financial Institutions, schemes                                                                                                                                                                     | 3               |
| 5.3 | Private sector participation in Infrastructure Development Projects - BOT, BOLT, BOOT                                                                                                               | 2               |
| 5.4 | Technology Transfer and Foreign Collaboration                                                                                                                                                       | 1               |

### Reference Books

- 1 Project Planning Analysis selection financing Implementation and Review- Tata Mc Graw Hill Publication, 7th edition 2010, Prasana Chandra
- 2 United Nations Industrial Development Organization (UNIDO) Manual for the preparation of Industrial Feasibility Studies, (IDSi Reproduction), Bombay, 2007.

- 3 A Systems Approach to Planning, Scheduling, and Controlling  
Project Management Harold Kerzner (2013), Wiley India, New  
Delhi
- 4 Project planning scheduling & control, James P.Lawis, Meo  
Publishing Company 2001
- 5 Project planning analysis selection implementation &  
review Prasanna Chandra, ISBN0-07-462049-5 2002.



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# SEMESTER III

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## **MOOC COURSES**

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

## TEMPLATE FOR SYLLABUS

| CODE      |                  | CATEGORY     | L | T | P | CREDIT |
|-----------|------------------|--------------|---|---|---|--------|
| J1PAGT312 | ACADEMIC WRITING | AUDIT COURSE | 3 | 0 | 0 | NIL    |

**Preamble:** Learning academic writing sharpens minds, teaches students how to communicate, and develops their thinking capacities and ability to understand others. Writing is thinking, and every student deserves to be a strong thinker. It can also make them think more carefully about what they write. Showing work to others can help to foster a better culture of learning and sharing among students. It also gives students a sense of how they are contributing to the body of work that makes up an academic subject.

**Course Outcomes:** The COs shown are only indicative. For each course, there can be 4 to 6 COs.

After the completion of the course the student will be able to

|             |                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the principles of scientific/ academic writing                                               |
| <b>CO 2</b> | Analyse the technique of scientific writing from the reader's perspective                               |
| <b>CO 3</b> | Apply the concepts of setting expectations and laying the progression tracks                            |
| <b>CO 4</b> | Evaluate the merits of a title, abstract , introduction, conclusion and structuring of a research paper |
| <b>CO 5</b> | Justify the need using a project proposal or a technical report                                         |
| <b>CO 6</b> | Prepare a review paper, an extended abstract and a project proposal                                     |

### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|------|------|------|------|------|------|------|------|
| CO 1 |      | 3    | 1    |      |      |      |      |
| CO 2 |      | 3    | 1    |      |      |      |      |
| CO 3 |      | 3    | 1    |      |      | 2    |      |
| CO 4 |      | 3    | 1    |      |      |      |      |
| CO 5 |      | 3    | 2    | 2    |      | 2    |      |
| CO 6 | 1    | 3    | 3    | 2    |      | 2    |      |

### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 40%                      |
| Analyse          | 30%                      |
| Evaluate         | 30%                      |

**Mark distribution**

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

|                                                                      |                                                                                                                                                        |             |                     |                     |    |
|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|---------------------|---------------------|----|
|                                                                      |                                                                                                                                                        | <b>SET1</b> |                     | <b>Total Pages:</b> |    |
| Reg No.: _____                                                       |                                                                                                                                                        |             | Name: _____         |                     |    |
| THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024                 |                                                                                                                                                        |             |                     |                     |    |
| <b>Course Code: J1PAGT312</b>                                        |                                                                                                                                                        |             |                     |                     |    |
| <b>Course Name: Academic Writing</b>                                 |                                                                                                                                                        |             |                     |                     |    |
| Max. Marks: 60                                                       |                                                                                                                                                        |             | Duration: 2.5 Hours |                     |    |
| <b><i>Answer any five full questions, each carries 12 marks.</i></b> |                                                                                                                                                        |             |                     |                     |    |
| 1 a)                                                                 | Make clear-cut distinctions between 6 factors that take their toll on readers' memory.                                                                 |             |                     |                     | 6  |
| 1 b)                                                                 | How can you sustain the attention of the reader to ensure continuous reading?                                                                          |             |                     |                     | 6  |
| 2 a)                                                                 | What are the different methods by which you can create expectations in the reader?                                                                     |             |                     |                     | 6  |
| 2 b)                                                                 | Give an account of the topic and non-topic based progression schemes.                                                                                  |             |                     |                     | 6  |
| 3 a)                                                                 | Bring out the differences between an abstract and the introduction of a research paper.                                                                |             |                     |                     | 8  |
| 3 b)                                                                 | How are the title of the research paper and its structure related?                                                                                     |             |                     |                     | 4  |
| 4                                                                    | What are 7 principles for including visuals in your research paper. What are the recommended constituents of a conclusion segment of a research paper? |             |                     |                     | 12 |

|       |                                                                                                        |    |
|-------|--------------------------------------------------------------------------------------------------------|----|
| 5     | Give a detailed description of the process and contents of a project proposal for funding.             | 12 |
| 6 a)  | What are the contexts recommended for choosing between active and passive voices in technical writing? | 8  |
| 6 b)  | What are the different visual forms that are relevant in a research paper and how do you choose them?  | 4  |
| 7     | Give the design of a research paper with the purposes each part serves.                                | 12 |
| ***** |                                                                                                        |    |

**Syllabus and Course Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

**Syllabus:**

| <b>CODE<br/>25PAG<br/>T311</b> | <b>ACADEMIC WRITING</b>                                                                                                                                                                                                                 | <b>Audit</b> |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| Module No.                     | Topics in a module                                                                                                                                                                                                                      | Hours        |
| 1                              | Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghetos, abusive detailing, cryptic captions, long sentences : all that take their toll on readers' memory. | 6            |
| 2                              | Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption                                                                                                              | 6            |
| 3                              | How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings                                                                                                                                      | 6            |
| 4                              | Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing                                                                                                                             | 6            |
| 5                              | Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.                                                                                                                                  | 6            |

**Course Plan:**

| No  | Topic                                                                                                                                                                                                                            | No. of Lectures |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghetos, abusive detailing, cryptic captions, long sentences all take their toll on readers' memory. |                 |
| 1.1 | The Reading tool-kit to reduce memory required; reduce reading time                                                                                                                                                              | 1               |
| 1.2 | Acronyms, Pronouns, Synonyms; Background, broken couple, words overflow                                                                                                                                                          | 1               |
| 1.3 | Sustain attention: Keep the story moving forward; Twists, shouts, Pause to clarify, recreate suspense                                                                                                                            | 2               |

|     |                                                                                                                                                                                                                                                               |   |
|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| 1.4 | Keep the reader motivated: Fuel and meet Expectations; Bridge knowledge gap: ground level; Title words; Just In Time to local background                                                                                                                      | 2 |
| 2   | Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption                                                                                                                                    |   |
| 2.1 | Setting expectations of the reader from Grammar, from theme                                                                                                                                                                                                   | 1 |
| 2.2 | Progression tracks for fluid reading: Topic & stress; topic and non topic based progression tracks; pause in progression                                                                                                                                      | 2 |
| 2.3 | Detection of sentence fluidity problems: No expectations/ Betrayed expectations                                                                                                                                                                               | 2 |
| 2.4 | Controlling reading energy consumption: the energy bill; Energy fuelling stations: Pause                                                                                                                                                                      | 1 |
| 3   | How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings                                                                                                                                                            |   |
| 3.1 | Title: Face of the paper: Techniques, Qualities & Purpose of title; Metrics                                                                                                                                                                                   | 1 |
| 3.2 | Abstract: Heart of the paper: 4 parts; coherence; tense of verbs, precision; purpose & qualities of the abstract; Metrics                                                                                                                                     | 2 |
| 3.3 | Structure: Headings & sub-headings: Skeleton of the paper: principles for a good structure; Syntactic rules; Quality & Purpose of structures; Metrics                                                                                                         | 1 |
| 3.4 | Introduction: Hands of the paper: Start, finish; scope, definitions; answers key reader questions; As a personal active story; Traps, qualities; Metrics                                                                                                      | 2 |
| 4   | Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing                                                                                                                                                   |   |
| 4.1 | Visuals as the voice of your paper: principles; purpose & qualities of visuals; metrics                                                                                                                                                                       | 2 |
| 4.2 | Conclusion: contents; purpose, quality; metrics; Abstracts Vs. Conclusion; examples, counter-examples                                                                                                                                                         | 1 |
| 4.3 | References, Bibliography: Styles, punctuation marks, quotes, citations                                                                                                                                                                                        | 1 |
| 4.4 | Grammar in Technical writing: Articles, Syntax, Main and subordinate clauses; Active & passive voices; some commonly made mistakes in technical writing.                                                                                                      | 2 |
| 5   | Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.                                                                                                                                                        |   |
| 5.1 | Extended abstract: abstract and keywords, introduction and objective, method, findings and argument, conclusion and suggestions and references.                                                                                                               | 1 |
| 5.2 | Project Proposal:Types, executive summary, background including status, objectives, solution, milestones, deliverables, timelines, resources, budgeting, conclusion                                                                                           | 2 |
| 5.3 | Research paper: writing an overview article: provide a comprehensive foundation on a topic; explain the current state of knowledge; identify gaps in existing studies for potential future research; highlight the main methodologies and research techniques | 2 |

|     |                                                                                                                                                              |    |
|-----|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 5.4 | Writing Technical Reports: Title page; Summary; Table of contents; Introduction; Body; Figures, tables, equations and formulae; Conclusion; Recommendations. | 1  |
|     |                                                                                                                                                              | 30 |

## Reference Books

1. SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide: Jean-Luc Lebrun, World Scientific Publishing Co. Pte. Ltd., 2011
2. How to Write and Publish a Scientific Paper: Barbara Gastel and Robert A. Day, Greenwood publishers, 2016
3. Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors.  
[www.sti.nasa.gov/publish/sp7084.pdf](http://www.sti.nasa.gov/publish/sp7084.pdf) [www.sti.nasa.gov/sp7084/contents.html](http://www.sti.nasa.gov/sp7084/contents.html)
4. Everything You Wanted to Know About Making Tables and Figures. <http://abacus.bates.edu/%7Eganderso/biology/resources/writing/HTWtableVigs.html>

|                  |                                       |                     |          |          |          |               |
|------------------|---------------------------------------|---------------------|----------|----------|----------|---------------|
| <b>J1PAGT322</b> | <b>ADVANCED ENGINEERING MATERIALS</b> | <b>CATEGORY</b>     | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                  |                                       | <b>AUDIT COURSE</b> | <b>3</b> | <b>0</b> | <b>0</b> | <b>-</b>      |

**Preamble:** This course is designed in a way to provide a general view on typically used advanced classes of engineering materials including metals, polymers, ceramics, and composites.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                           |
|-------------|-------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Analyse the requirement and find appropriate solution for use of materials.               |
| <b>CO 2</b> | Differentiate the properties of polymers, ceramics and composite materials.               |
| <b>CO 3</b> | Recognize basic concepts and properties of functional materials.                          |
| <b>CO 4</b> | Comprehend smart and shape memory materials for various applications.                     |
| <b>CO 5</b> | Appraise materials used for high temperature, energy production and storage applications. |

#### Mapping of course outcomes with program outcomes

|             | <b>PO 1</b>              | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b>              | <b>PO 6</b>              | <b>PO 7</b> |
|-------------|--------------------------|-------------|-------------|-------------|--------------------------|--------------------------|-------------|
| <b>CO 1</b> | <input type="checkbox"/> |             |             |             | <input type="checkbox"/> | <input type="checkbox"/> |             |
| <b>CO 2</b> | <input type="checkbox"/> |             |             |             | <input type="checkbox"/> | <input type="checkbox"/> |             |
| <b>CO 3</b> | <input type="checkbox"/> |             |             |             | <input type="checkbox"/> | <input type="checkbox"/> |             |
| <b>CO 4</b> | <input type="checkbox"/> |             |             |             | <input type="checkbox"/> | <input type="checkbox"/> |             |
| <b>CO 5</b> | <input type="checkbox"/> |             |             |             | <input type="checkbox"/> | <input type="checkbox"/> |             |

#### Assessment Pattern

| <b>Bloom's Category</b> | <b>End Semester Examination</b> |
|-------------------------|---------------------------------|
| Understand              | 60%                             |
| Apply                   | 20%                             |
| Analyse                 | 20%                             |

#### Mark distribution

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper****AUDIT COURSE****J1PAGT322 - ADVANCED ENGINEERING MATERIALS**

**(Answer any five questions. Each question carries 12 Marks)**

- |    |                                                                                                                                        |   |
|----|----------------------------------------------------------------------------------------------------------------------------------------|---|
| 1. | a) State the relationship between material selection and processing.                                                                   | 5 |
|    | b) Write about the criteria for selection of materials with respect to the cost and service requirements for engineering applications. | 7 |
| 2. | a) Differentiate thermosetting and thermoplastics with suitable examples.                                                              | 5 |
|    | b) Briefly discuss about the properties and applications of polymer nano composite materials.                                          | 7 |
| 3. | a) Write about the potential application areas of functionally graded materials.                                                       | 5 |
|    | b) With a neat sketch describe any one processing technique of functionally graded materials.                                          | 7 |
| 4. | a) “Smart materials are functional”? Justify the statement.                                                                            | 5 |
|    | b) Explain the terms electrostriction and magnetostriction with its application.                                                       | 7 |

5. a) What are the factors influencing functional life of components at elevated temperature? 5
- b) What are super alloys and what are their advantages? 7
- 6 a) What is a shape memory alloy? What metals exhibit shape memory characteristics? 4
- b) Explain about the detection capabilities and uses of pyroelectric sensors. 8
- 7 a) Differentiate between conventional batteries and fuel cells. 4
- b) Explain the construction and working of a Li-ion battery. 8

### Syllabus

| Module | Content                                                                                                                                                                                                                                                                  | Hours | Semester Exam Marks (%) |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------|
| I      | Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing. | 5     | 20                      |
| II     | Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nano Composites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications.                               | 7     | 20                      |
| III    | Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs.                                                                                                                                | 6     | 20                      |
| IV     | Smart Materials: Introduction, smart material types - pyroelectric sensors, piezoelectric materials, electrostrictors and magnetostrictors, shape memory alloys – associated energy stimulus and response forms, applications.                                           | 5     | 20                      |
| V      | High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications.<br>Energy Materials: materials for batteries.                                                                                                         | 7     | 20                      |

## Course Plan

| No       | Topic                                                                                                               | No. of Lectures |
|----------|---------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Selection of materials for engineering applications</b>                                                          |                 |
| 1.1      | Benefits of advanced materials, classification of materials, importance of materials selection                      | 2               |
| 1.2      | Selection of materials for different properties, strength, toughness, fatigue and creep                             | 1               |
| 1.3      | Selection for surface durability, corrosion and wear resistance                                                     | 1               |
| 1.4      | Relationship between materials selection and processing                                                             | 1               |
| <b>2</b> | <b>Classification of non-metallic materials &amp; nano composites</b>                                               |                 |
| 2.1      | Rubber: properties, processing and applications.                                                                    | 1               |
| 2.2      | Plastics: thermosetting and thermoplastics, applications and properties.                                            | 2               |
| 2.3      | Ceramics: properties and applications.                                                                              | 1               |
| 2.4      | Introduction to nano composites, classification                                                                     | 1               |
| 2.5      | Processing and characterisation techniques applicable to polymer nanocomposites.                                    | 2               |
| <b>3</b> | <b>Functionally graded materials</b>                                                                                |                 |
| 3.1      | General concept, Potential Applications of FGMs                                                                     | 2               |
| 3.2      | Classification of FGMs                                                                                              | 1               |
| 3.3      | FGMs processing techniques: powder metallurgy route, melt-processing route                                          | 2               |
| 3.4      | Limitations of FGMs                                                                                                 | 1               |
| <b>4</b> | <b>Smart materials</b>                                                                                              |                 |
| 4.1      | Introduction to smart materials, types                                                                              | 1               |
| 4.2      | Pyroelectric sensors-material class, stimulus, detection capabilities and uses                                      | 1               |
| 4.3      | Piezoelectric materials- material class, stimulus, sensing and actuating applications                               | 1               |
| 4.4      | Electrostrictors and magnetostrictors - material class, stimulus, micro positioning capabilities and applications   | 1               |
| 4.5      | Shape memory alloys (SMAs) - material class, stimulus, temperature sensing and high strain responses, applications. | 1               |
| <b>5</b> | <b>High Temperature Materials and Energy Materials</b>                                                              |                 |
| 5.1      | Characteristics of high-temperature materials, superalloys as high-temperature materials                            | 1               |
|          | superalloys - properties and applications                                                                           | 2               |
| 5.2      | Introduction to lithium-ion battery (LIBs), operating mechanisms and applications                                   | 2               |
| 5.3      | Introduction to Zn-based battery system, types and existing challenges                                              | 2               |

## Reference Books

1. DeGarmo et al, "Materials and Processes in Manufacturing", 10th Edition, Wiley, 2008.
2. R.E. Smallman and A.H.W. Ngan, Physical Metallurgy and Advanced Materials, Seventh Edition, Butterworth-Heinemann, 2007
3. Vijayamohanan K. Pillai and Meera Parthasarathy, "Functional Materials: A chemist's perspective", Universities Press Hyderabad (2012).
4. M.V. Gandhi, B.S. Thompson: Smart Materials and Structures, Chapman & Hall, 1992.
5. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
6. Inderjit Chopra, Jayant Sirohi, "Smart Structures Theory", Cambridge University Press, 2013

|           |                            |              |   |   |   |        |
|-----------|----------------------------|--------------|---|---|---|--------|
| J1PAGT332 | DATA SCIENCE FOR ENGINEERS | CATEGORY     | L | T | P | CREDIT |
|           |                            | AUDIT COURSE | 3 | 0 | 0 | 0      |

**Preamble:** This course covers essentials of statistics and Linear Algebra and how to prepare the data before processing in real time applications. The students will be able to handle missing data and detection of any outliers available in the dataset. This course explores data science, Python libraries and it also covers the introduction to machine learning for engineers.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                           |
|------|-------------------------------------------------------------------------------------------|
| CO 1 | Study Data Science Concepts and statistics                                                |
| CO 2 | Demonstrate Understanding of Mathematical Foundations needed for Data Science             |
| CO 3 | Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset |
| CO 4 | Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression |
| CO 5 | Build real time data science applications and test use cases                              |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO7 |
|------|------|------|------|------|------|------|-----|
| CO 1 | 2    |      | 2    |      |      | 2    |     |
| CO 2 | 2    |      | 2    | 1    |      | 2    |     |
| CO 3 | 2    |      | 2    | 2    | 2    | 2    |     |
| CO 4 | 2    |      | 2    | 2    | 3    | 2    |     |
| CO 5 | 2    |      | 2    | 3    | 3    | 3    | 2   |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Understand       | 50%                      |
| Apply            | 30%                      |
| Analyse          | 20%                      |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 mark.

**Syllabus**

| <b>Module</b> | <b>Content</b>                                                                                                                                                                                                                                                                                                                                                                                                                                      | <b>Hours</b> | <b>Semester Exam Marks (%)</b> |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------------------|
| <b>I</b>      | <b>Statistics for Data science</b><br>Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation, Gaussian/Normal Distribution, covariance, correlation. | <b>6</b>     | <b>20</b>                      |
| <b>II</b>     | <b>Linear Algebra</b><br>Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices, Inverse of Matrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition                                                                                                                                                                                         | <b>6</b>     | <b>20</b>                      |
| <b>III</b>    | <b>Hypothesis Testing</b><br>Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error, Type2 Error, Types of Hypothesis Test Z Test, Chi-Square                                                                                                                                                                       | <b>6</b>     | <b>20</b>                      |

|           |                                                                                                                                                                                                                                                                   |          |           |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|-----------|
| <b>IV</b> | <b>Exploratory Data Analysis</b><br>Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration,Data-Reduction,Data Transformation                    | <b>6</b> | <b>20</b> |
| <b>V</b>  | <b>Machine Learning and Python for Data Science</b><br>Python Data structures-List, Tuple, Set, Dictionary, Pandas, Numpy, Scipy, Matplotlib, Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning,Regression, Classification, Naïve-Bayes | <b>6</b> | <b>20</b> |

### Course Plan

| <b>No</b> | <b>Topic</b>                                                                                                      | <b>No. of Lectures</b> |
|-----------|-------------------------------------------------------------------------------------------------------------------|------------------------|
| <b>1</b>  | <b>Statistics for Data science</b>                                                                                |                        |
| 1.1       | Probability: Basic concepts of probability, conditional probability, total probability                            | 1                      |
| 1.2       | independent events, Bayes' theorem, random variable, Population                                                   | 1                      |
| 1.3       | Sample, Population Mean, Sample Mean, Population Distribution                                                     | 1                      |
| 1.4       | Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Propositional logic and predicate logic | 1                      |
| 1.5       | Measure of Dispersion, Variance, Standard Deviation                                                               | 1                      |
| 1.6       | Gaussian/Normal Distribution, covariance, correlation.                                                            | 1                      |
| <b>2</b>  | <b>Linear Algebra</b>                                                                                             |                        |
| 2.1       | Vectors and their properties,                                                                                     | 1                      |
| 2.2       | Sum and difference of Vectors, distance between Vectors                                                           | 1                      |
| 2.3       | Matrices,Inverse of Matrix,                                                                                       | 2                      |
| 2.4       | Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition    | 2                      |
| <b>3</b>  | <b>Hypothesis Testing</b>                                                                                         |                        |
| 3.1       | Understanding Hypothesis Testing, Null and Alternate Hypothesis                                                   | 1                      |
| 3.2       | Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method,                         | 2                      |
| 3.3       | Types of Errors-Type1 Error,Type2 Error,                                                                          | 1                      |
| 3.4       | Types of Hypothesis Test Z Test, Chi-Square,                                                                      | 2                      |
| <b>4</b>  | <b>Exploratory Data Analysis</b>                                                                                  |                        |
| 4.1       | Data Collection –Public and Private Data                                                                          | 1                      |
| 4.2       | Data Cleaning-Fixing Rows and Columns                                                                             | 1                      |
| 4.3       | Missing Values                                                                                                    | 1                      |
| 4.4       | Standardizing values                                                                                              | 1                      |
| 4.5       | Invalid values, filtering data                                                                                    | 1                      |
| 4.6       | Data Integration, Data Reduction, Data Transformation                                                             | 1                      |

|     |                                                                                |   |
|-----|--------------------------------------------------------------------------------|---|
| 5   | <b>Machine Learning and Python for Data Science</b>                            |   |
| 5.1 | Python Data structures-List, Tuple, Set,                                       | 1 |
| 5.2 | Dictionary, Pandas, Numpy, Matplotlib                                          | 2 |
| 5.3 | Machine Learning-Supervised Machine Learning,<br>Unsupervised Machine Learning | 1 |
| 5.4 | Regression, Classification                                                     | 1 |
| 5.5 | Naïve-Bayes                                                                    | 1 |

## Reference Books

1. Python Data Science Handbook. Essential Tools for Working with Data, Author(s): Jake VanderPlas, Publisher: O'Reilly Media, Year: 2016
2. Practical Statistics for Data Scientists: 50 Essential Concepts, Author(s): Peter Bruce, Andrew Bruce, Publisher: O'Reilly Media, Year: 2017
3. Practical Linear Algebra for Data Science, by Mike X Cohen, Released September 2022, Publisher(s): O'Reilly Media, Inc.
4. Data Science from Scratch 'by Joel Grus, Released, April 2015, Publisher(s): O'Reilly Media, Inc.
5. Hands-On Exploratory Data Analysis with Python, by Suresh Kumar Mukhiya, Usman Ahmed, Released March 2020, Publisher(s): Packt Publishing

SET1

Total Pages:

Reg  
No.: \_

Name: \_\_\_\_\_

—

THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024

Course Code: J1PAGT332

Course Name: DATA SCIENCE FOR ENGINEERS

Max. Marks: 60

Duration: 2.5 Hours

*Answer any five full questions, each carries 12 marks.*

1. a) It is observed that 50% of mails are spam. There is software that filters spam mail before reaching the inbox. Its accuracy for detecting a spam mail is 99% and chances of tagging a non-spam mail as spam mail is 5%. If a certain mail is tagged as spam, find the probability that it is not a spam mail. 5  
b) Depict the relevance of measures of central tendency in data wrangling with a suitable example. 7
2. a) Calculate the inverse of the Matrix 4  
$$\begin{bmatrix} 2 & 4 & -6 \\ 7 & 3 & 5 \\ 1 & -2 & 4 \end{bmatrix}$$
  
b) Find all Eigenvalues and Corresponding Eigenvectors for the matrix if 8  
$$\begin{bmatrix} 2 & -3 & 0 \\ 2 & -5 & 0 \\ 0 & 0 & 3 \end{bmatrix}$$
3. a) A statistician wants to test the hypothesis  $H_0: \mu = 120$  using the alternative hypothesis  $H_a: \mu > 120$  and assuming that  $\alpha = 0.05$ . For that, he took the sample values as  $n = 40$ ,  $\sigma = 32.17$  and  $\bar{x} = 105.37$ . Determine the conclusion for this hypothesis? 5  
b) Hypothesis testing is an integral part of statistical inference, list out the various types of hypothesis testing and also mention their significances in data science. 7
4. a) Brief in detail directional and non-directional hypothesis 6  
b) Differentiate null and alternate hypothesis and also elaborate on type 1 and type 2 errors 6
5. a) Explain the concepts of Tuple, List and Dictionary in python with example 6  
b) Elucidate reinforcement learning and application in real world. 6

6. a) What is Feature Engineering , demonstrate with an example 6
- b) Describe in detail different steps involved in data preprocessing. 6
7. a) Illustrate supervised learning model with linear regression model 5
- b) Predict the probability for the given feature vector if an accident will happen or not? 7

Weather condition: rain, Road condition: good, Traffic condition: normal,  
Engine problem: no, the task is to predict using Naïve Bayes classification.

| SNo. | Weather condition | Road condition | Traffic condition | Engine problem | Accident |
|------|-------------------|----------------|-------------------|----------------|----------|
| 1    | Rain              | bad            | high              | no             | yes      |
| 2    | snow              | average        | normal            | yes            | yes      |
| 3    | clear             | bad            | light             | no             | no       |
| 4    | clear             | good           | light             | yes            | yes      |
| 5    | snow              | good           | normal            | no             | no       |
| 6    | rain              | average        | light             | no             | no       |
| 7    | rain              | good           | normal            | no             | no       |
| 8    | snow              | bad            | high              | no             | yes      |
| 9    | clear             | good           | high              | yes            | no       |
| 10   | clear             | bad            | high              | yes            | yes      |

| J1PAGT342 | DESIGN THINKING | CATEGORY     | L | T | P | CREDIT |
|-----------|-----------------|--------------|---|---|---|--------|
|           |                 | AUDIT COURSE | 3 | 0 | 0 | -      |

### Preamble:

This course offers an introductory exploration of fundamental engineering concepts and techniques, the design process, analytical thinking and creativity, as well as the fundamentals and development of engineering drawings, along with their application in engineering problems.

### Course Outcomes:

After the completion of the course the student will be able to

|             |                                                            |
|-------------|------------------------------------------------------------|
| <b>CO 1</b> | Identify and frame design challenges effectively.          |
| <b>CO 2</b> | Generate creative ideas through brainstorming and ideation |
| <b>CO 3</b> | Iterate on designs based on user insights                  |
| <b>CO 4</b> | Apply Design Thinking to real-world problems and projects. |

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      |      | 2    |      | 2    | 2    |
| <b>CO 2</b> | 2    |      | 2    | 2    |      |      | 2    |
| <b>CO 3</b> |      | 2    |      | 2    |      | 2    | 2    |
| <b>CO 4</b> | 2    |      | 2    | 3    | 2    |      | 2    |

### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 40                       |
| Analyse          | 30                       |
| Evaluate         | 30                       |
| Create           |                          |

### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

### Continuous Internal Evaluation Pattern:

### AUDIT COURSES

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

|                                                                      |                                                                                              |             |                     |
|----------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------|---------------------|
|                                                                      |                                                                                              | <b>SET1</b> | <b>Total Pages:</b> |
| Reg No.: _____                                                       |                                                                                              |             | Name: _____         |
| <b>THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024</b>          |                                                                                              |             |                     |
| <b>Course Code: J1PAGT342</b>                                        |                                                                                              |             |                     |
| <b>Course Name: DESIGN THINKING</b>                                  |                                                                                              |             |                     |
| Max. Marks: 60                                                       |                                                                                              |             | Duration: 2.5 Hours |
| <i><b>Answer any five full questions, each carries 12 marks.</b></i> |                                                                                              |             |                     |
| 1 a)                                                                 | How can a multidisciplinary team collaborate effectively to implement design principles?     |             | 7                   |
| 1 b)                                                                 | What are the key differences between human-centred design and other design methodologies?    |             | 5                   |
| 2 a)                                                                 | How do you measure the success of a design project in terms of user satisfaction and impact? |             | 7                   |
| 2 b)                                                                 | How does the iterative nature of the design process contribute to better outcomes            |             | 5                   |

|       |                                                                                                                                                                                        |    |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 3 a)  | What are the fundamental principles of effective brainstorming, and how do they differ from traditional problem-solving approaches?                                                    | 7  |
| 3 b)  | What are some key principles of ergonomic design, and how do they contribute to the usability and comfort of products?                                                                 | 5  |
| 4 a)  | Enumerate some examples of successful and unsuccessful market testing scenarios, and what lessons can be learned from these experiences to improve future product or service launches? | 7  |
| 4b)   | What is the primary purpose of creating prototypes in the design and development process?                                                                                              | 5  |
| 5     | What strategies and methodologies can designers use to embrace agility and respond quickly to changing user needs and market dynamics?                                                 | 12 |
| 6     | Illustrate any four examples of successful bio-mimicry applications in various industries.                                                                                             | 12 |
| 7     | What ethical considerations should designers keep in mind when designing for diverse user groups?                                                                                      | 12 |
| ***** |                                                                                                                                                                                        |    |

## **Syllabus:**

### **Module 1**

Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centred design process. Design space, Design Thinking in a Team Environment, Team formation.

### **Module 2**

Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.

### **Module 3**

Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.

### **Module 4**

Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest

### **Module 5**

Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges

**Corse Plan SyllabusandCorsePlan** (For 3credit courses, the content can be for 40 hrs and for 2credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30hours).

| No       | Topic                                                                                                                                    | No. of lectures |
|----------|------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Design process:</b>                                                                                                                   |                 |
| 1.1      | Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking. | 3               |
| 1.2      | Role of design thinking in the human-centred design process. Design space,                                                               | 2               |
| 1.3      | Design Thinking in a Team Environment, Team formation.                                                                                   | 2               |

|          |                                                                                                                                  |   |
|----------|----------------------------------------------------------------------------------------------------------------------------------|---|
| <b>2</b> | <b>Design Thinking Stages:</b>                                                                                                   |   |
| 2.1      | Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test.                                                           | 2 |
| 2.2      | The importance of empathy, Building a user-centred mindset.                                                                      | 2 |
| 2.3      | Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications. | 3 |
| <b>3</b> | <b>Ideation</b>                                                                                                                  |   |
| 3.1      | Generating Ideas, Brainstorming techniques.                                                                                      | 2 |
| 3.2      | Application of Aesthetics and Ergonomics in Design. Bio-mimicry.                                                                 | 3 |
| 3.3      | Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.                                                         | 2 |
| <b>4</b> | <b>Prototyping and testing</b>                                                                                                   |   |
| 4.1      | Use of prototyping, Types of prototypes, Rapid prototyping techniques.                                                           | 3 |
| 4.2      | User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest                           | 2 |
| <b>5</b> | <b>IPR in design</b>                                                                                                             |   |
| 5.1      | Entrepreneurship/business ideas, Patents and Intellectual Property.                                                              | 2 |
| 5.2      | Agility in design, Ethical considerations in design. Overcoming common implementation challenges                                 | 2 |

## Reference Books

1. Christoph Meinel, Larry Leifer and Hasso Plattner- "Design Thinking: Understand – Improve – Apply", Springer Berlin, Heidelberg, 2011.
2. Thomas Lockwood and Edgar Papke – "Design Thinking: Integrating Innovation, Customer Experience, and Brand Value", Allworth Press, 2009.
3. Pavan Soni – "Design Your Thinking", Penguin Random House India Private Limited, 2020.
4. Andrew Pressman- "Design Thinking : A Guide to Creative Problem Solving for Everyone", Taylor & Francis, 2018.
5. N Siva Prasad, "Design Thinking Techniques an Approaches" Ane Books Pvt. Ltd.,2023

## SYLLABUS

| CODE      | COURSE NAME                       | CATEGORY     | L | T | P | CREDIT |
|-----------|-----------------------------------|--------------|---|---|---|--------|
| J1PAGT352 | FUNCTIONAL PROGRAMMING IN HASKELL | AUDIT COURSE | 3 | 0 | 0 | -      |

**Preamble:** This course introduces a functional programming approach in problem solving. Salient features of functional programming like recursion, pattern matching, higher order functions etc. and the implementation in Haskell are discussed.

### Course Outcomes:

After the completion of the course the student will be able to

|             |                                                                                                                                                  |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Understand the functional programming paradigm which is based on the mathematics of lambda calculus.                                             |
| <b>CO 2</b> | Develop Haskell programs using functions, guards and recursive functions                                                                         |
| <b>CO 3</b> | Apply the concept of tuples, lists and strings in Haskell programming                                                                            |
| <b>CO 4</b> | Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming |
| <b>CO 5</b> | Develop Haskell programs with files for reading input and storing output                                                                         |

### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 | PO 7 |
|-------------|------|------|------|------|------|------|------|
| <b>CO 1</b> |      |      |      |      | 3    |      |      |
| <b>CO 2</b> | 2    |      |      | 2    | 3    |      |      |
| <b>CO 3</b> | 2    |      |      | 2    | 3    |      |      |
| <b>CO 4</b> | 2    |      |      | 2    | 3    |      |      |
| <b>CO 5</b> | 2    |      |      | 2    | 3    |      |      |

### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Apply            | 40%                      |
| Analyse          | 40%                      |
| Evaluate         | 20%                      |
| Create           |                          |

### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

**Continuous Internal Evaluation: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

|                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |
|----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|---------------------|
|                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     | <b>Total Pages:</b> |
| Reg No.:                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Name:               |                     |
| <b>THIRD SEMESTER M.TECH DEGREE EXAMINATION, DECEMBER 2023</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |
| <b>Course Code: J1PAGT352</b>                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |
| <b>Course Name: Functional Programming in Haskell</b>          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |
| Max. Marks: 60                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Duration: 2.5 Hours |                     |
| <b>Answer any five full questions, each carries 12 marks.</b>  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                     |                     |
| 1 a.                                                           | Explain the basic differences between imperative style programming and functional style programming.                                                                                                                                                                                                                                                                                                                                                                                                                     |                     | 3                   |
| 1 b.                                                           | Analyse each of the following lambda expressions to clarify its structure. If the expression is a function, identify the bound variable and the body expression, and then analyse the body expression. If the expression is an application, identify the function and argument expressions, and then analyse the function and argument expressions:<br>i) $\lambda a.(a \lambda b.(b a))$<br>ii) $\lambda x.\lambda y.\lambda z.((z x) (z y))$<br>iii) $(\lambda f.\lambda g.(\lambda h.(g h) f) \lambda p.\lambda q.p)$ |                     | 9                   |
| 2 a.                                                           | Design a recursive function to find $2^n$ where n is a natural number.                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                     | 4                   |

|       |                                                                                                                                                                                                                        |    |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| 2 b.  | Explain various forms of function definitions in Haskell with the help of examples.                                                                                                                                    | 8  |
| 3 a.  | Explain any three list operations along with function definitions and examples.                                                                                                                                        | 6  |
| 3 b.  | Write a program to duplicate only even numbers among the elements of a list using a Haskell function by (i) Recursion (ii) List Comprehension and explain.<br>Example : $\lambda > \text{dupli } [1, 2, 3]$ ANS: [2,2] | 6  |
| 4     | Write Recursive definitions along with an explanation for the below arithmetic operations. Illustrate the recursive flow with the help of a diagram.<br>i. add x y<br>ii. mult x y<br>iii. div x y                     | 12 |
| 5     | Write the Haskell code to split a list into two lists such that the elements with odd index are in one list while the elements with even index are in the other list.                                                  | 12 |
| 6 a   | Give the type definition of a binary tree along with explanation of two functions on binary trees.                                                                                                                     | 6  |
| 6 b   | Define a queue data type in Haskell along with any two operations on it with examples.                                                                                                                                 | 6  |
| 7 a.  | Explain the basic steps of reading from files and writing to files in Haskell.                                                                                                                                         | 4  |
| 7 b.  | Write a Haskell program to read from the file "input.txt", display the contents on the screen and write the contents to another file "output.txt".                                                                     | 8  |
| ***** |                                                                                                                                                                                                                        |    |

**Syllabus and Corse Plan** (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

### Module 1 (5 Hrs)

**Introduction to Functional Programming:** Programming language paradigms, imperative style programming, comparison of programming paradigms.

Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as functions, Functional programming Languages. Haskell basics, GHCi interpreter.

## Module 2 (6 Hrs)

**Programming in Haskell:** Expressions and evaluation, Lazy evaluation, let expressions, scopes.

Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions.

types, definitions, currying and uncurrying, type abstraction.

Function definitions, pattern matching, guards, anonymous functions, higher order functions.

Recursion, Programming exercises.

## Module 3 (7 Hrs)

**Data types: tuples and lists:** Tuples , Lists: building lists, decomposing lists, functions on lists, built-in functions on lists, primitive and general recursion over lists, infinite lists.

Strings: functions on strings.

Polymorphism and overloading, conditional polymorphism

## Module 4 (6 Hrs)

Type classes, Algebraic data types, Modules, Recursive data types.

User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors.

## Module 5 (6 Hrs)

Functor, Applicative functor, Monad

**Programming with actions:** Functions vs actions, Basics of input / output, the do notation, interacting with the command line and lazy I/O, File I/O.

| No  | Topic                                                                                             | No. of Lectures |
|-----|---------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Introduction to Functional Programming</b>                                                     |                 |
| 1.1 | Programming language paradigms, imperative style programming, comparison of programming paradigms | 1               |
| 1.2 | Functional programming, Functions - Mathematical concepts and terminology                         | 1               |
| 1.3 | Lambda calculus                                                                                   | 1               |
| 1.4 | Function definitions, programs as functions, Functional programming Languages                     | 1               |
| 1.5 | Haskell basics, GHCi interpreter                                                                  | 1               |
| 2   | <b>Haskell basics</b>                                                                             |                 |
| 2.1 | Expressions and evaluation, Lazy evaluation                                                       | 1               |
| 2.2 | let expressions, scopes, Basic data types in Haskell                                              | 1               |
| 2.3 | operators, infix operators, associativity and precedence, Arithmetic                              | 1               |

|     |                                                                                           |   |
|-----|-------------------------------------------------------------------------------------------|---|
|     | Functions                                                                                 |   |
| 2.4 | types, definitions, currying and uncurrying, type abstraction.                            | 1 |
| 2.5 | Function definitions, pattern matching, Guards                                            | 1 |
| 2.6 | anonymous functions, higher order functions, Recursion                                    | 1 |
| 3   | <b>Data types: tuples and lists</b>                                                       |   |
| 3.1 | Tuples , Lists: building lists, decomposing lists                                         | 1 |
| 3.2 | functions on lists, built-in functions on lists                                           | 1 |
| 3.3 | primitive and general recursion over lists                                                | 1 |
| 3.4 | infinite lists                                                                            | 1 |
| 3.5 | Strings: functions on strings                                                             | 1 |
| 3.6 | Polymorphism and overloading                                                              | 1 |
| 3.7 | conditional polymorphism                                                                  | 1 |
| 4   | <b>User defined data types</b>                                                            |   |
| 4.1 | Type classes, Algebraic data types, Modules                                               | 1 |
| 4.2 | Recursive data types                                                                      | 1 |
| 4.3 | User defined data types, Records                                                          | 1 |
| 4.4 | Stacks, Queues                                                                            | 1 |
| 4.5 | Binary trees                                                                              | 1 |
| 4.6 | Constructors, Destructors                                                                 | 1 |
| 5   | <b>Programming with actions</b>                                                           |   |
| 5.1 | Functor, Applicative functor,                                                             | 1 |
| 5.2 | Monad                                                                                     | 1 |
| 5.3 | Programming with actions: Functions vs actions, Basics of input / output, the do notation | 1 |
| 5.4 | interacting with the command line and lazy I/O                                            | 1 |
| 5.5 | File I/O                                                                                  | 2 |

## Reference Books

[1] Richard Bird, "Introduction to functional programming using Haskell", second edition, Prentice hall series in computer science

[2] Bryan O'Sullivan, Don Stewart, and John Goerzen, "Real World Haskell"

- [3] Richard Bird, “Thinking Functionally with Haskell”, Cambridge University Press, 2014
- [4] Simon Thompson, “Haskell: The Craft of Functional Programming”, Addison-Wesley, 3<sup>rd</sup> Edition, 2011
- [5] H. Conrad Cunningham, “Notes on Functional Programming with Haskell”, 2014
- [6] Graham Hutton, “Programming in Haskell”, Cambridge University Press, 2<sup>nd</sup> Edition, 2016
- [7] Alejandro Serrano Mena, “Practical Haskell: A Real-World Guide to Functional Programming”, 3rd Edition, Apress, 2022
- [8] Miran Lipovaca, “Learn You a Haskell for Great Good!: A Beginner's Guide”, No Starch Press, 2011

|           |                              |              |   |   |   |        |
|-----------|------------------------------|--------------|---|---|---|--------|
| J1PAGT372 | REUSE AND RECYCLE TECHNOLOGY | CATEGORY     | L | T | P | CREDIT |
|           |                              | AUDIT COURSE | 3 | 0 | 0 | -      |

**Preamble:** "Reuse and Recycle Technology" typically focuses on sustainable practices and technologies aimed at reducing waste, conserving resources, and promoting environmental responsibility.

**Course Outcomes:** After the completion of the course the student will be able to

|      |                                                                                                                                                               |
|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CO 1 | Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices                                              |
| CO 2 | Describe and Analyze waste generation and management.                                                                                                         |
| CO 3 | Apply the knowledge of various reuse strategies and their application in different industries and Analyze various recycling technologies                      |
| CO 4 | Appraise the methods of E-waste management and Eco friendly packaging                                                                                         |
| CO 5 | Comprehend Environmental Regulations and Policies, Understand the importance of environmental regulations and policies in addressing environmental challenges |

#### Mapping of course outcomes with program outcomes

|      | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|------|------|------|------|------|------|------|
| CO 1 |      |      | 3    |      |      |      |
| CO 2 |      |      |      | 3    |      |      |
| CO 3 |      |      |      | 3    |      |      |
| CO 4 |      |      |      |      | 3    |      |
| CO 5 |      |      | 3    |      |      |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Understand       | 60%                      |
| Apply            | 20%                      |
| Analyse          | 20%                      |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |



**Continuous Internal Evaluation Pattern: 40 marks**

Course based task : 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

## AUDIT COURSE

**J1PAGT372- REUSE AND RECYCLE TECHNOLOGY**

*Answer any five full questions, each carries 12 marks.*

|    |                                                                                                          |    |
|----|----------------------------------------------------------------------------------------------------------|----|
| 1. | (a) What are the 3 pillars of sustainability?                                                            | 5  |
|    | (b) What is sustainable waste management? What makes sustainable waste management so important?          | 7  |
| 2. | (a) How do the three categories of municipal solid waste differ?                                         | 5  |
|    | (b) Discuss the municipal waste collection and management?                                               | 7  |
| 3. | (a) Explain the major differences between Reuse and Recycle?                                             | 5  |
|    | (b) Give an overview of recycling technologies used for any two materials. Discuss the Process involved. | 7  |
| 4. | (a) What are the common source of E-waste                                                                | 5  |
|    | (b) What are the challenges and opportunities in E-waste management                                      | 7  |
| 5. | (a) What is the case law for waste recycling in India                                                    | 5  |
|    | (b) Discuss sustainable packaging and its environmental impacts                                          | 7  |
| 6. | Explain the various environmental regulations in India for addressing Environmental challenges           | 12 |
| 7. | a) Give examples of water reuse technologies in circular economy                                         | 5  |
|    | b) How can we reduce e-waste with sustainable solutions                                                  | 7  |

## Syllabus

| Module | Content                                                                                                                                                                                                                                                                                                                    | Hours | Semester Exam Marks (%) |
|--------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------|
| I      | <b>Introduction to Sustainability</b> , Understanding sustainability and its importance, The three pillars of sustainability: Environmental, Social, and Economic. Biodiversity conservation, Climate change and mitigation Sustainable resource management.                                                               | 6     | 20                      |
| II     | <b>Waste Management</b> , Definition and classification of waste, Waste Generation and Composition, Waste Collection and Transportation, Waste Segregation and Sorting. Waste Disposal Methods Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle.                                      | 6     | 20                      |
| III    | <b>Recycling and Reuse</b> : Importance of reuse, Application of reuse in various industries, Challenges and opportunities in reuse, Overview of recycling technologies, Circular economy, Sorting and processing of recyclable materials, Advanced recycling methods. Emerging technologies in recycling.                 | 6     | 20                      |
| IV     | <b>E-waste Recycling</b> , Challenges and environmental impact of electronic waste, E-waste recycling methods and regulations, Sustainable electronics design, <b>Sustainable Packaging</b> , Packaging materials and their environmental impact, Eco-friendly packaging alternatives, Packaging design for sustainability | 6     | 20                      |
| V      | <b>Environmental Regulations and Policies</b> , Understand the importance of environmental regulations and policies in addressing environmental challenges, National and international waste and recycling regulations, Compliance and enforcement, Industry standards and certifications                                  | 6     | 20                      |

## Course Plan

| No       | Topic                                                                                       | No. of Lectures |
|----------|---------------------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Introduction to Sustainability (6)</b>                                                   |                 |
| 1.1      | Understanding sustainability and its importance                                             | 1               |
| 1.2      | The three pillars of sustainability: Environmental, Social, and Economic.                   | 3               |
| 1.3      | Biodiversity conservation, Climate change and mitigation                                    | 1               |
| 1.4      | Sustainable resource management                                                             | 1               |
| <b>2</b> | <b>Waste Management (6)</b>                                                                 |                 |
| 2.1      | Definition and classification of waste                                                      | 1               |
| 2.2      | Waste Generation and Composition                                                            | 1               |
| 2.3      | Waste Collection and Transportation.                                                        | 1               |
| 2.4      | Waste Segregation and Sorting.                                                              | 1               |
| 2.5      | Waste Disposal Methods                                                                      | 1               |
| 2.6      | Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle.      | 1               |
| <b>3</b> | <b>Recycling and Reuse (6)</b>                                                              |                 |
| 3.1      | Importance of reuse, Examples of reuse in various industries.                               | 1               |
| 3.2      | Challenges and opportunities in reuse                                                       | 1               |
| 3.3      | Overview of recycling technologies, Sorting and processing of recyclable materials          | 2               |
| 3.4      | Advanced recycling methods                                                                  | 1               |
| 3.5      | Emerging technologies in recycling.                                                         | 1               |
| <b>4</b> | <b>E-waste Recycling (6)</b>                                                                |                 |
| 4.1      | Challenges and environmental impact of electronic waste                                     | 1               |
| 4.2      | E-waste recycling methods and regulations                                                   | 1               |
| 4.3      | Sustainable electronics design                                                              | 1               |
| 4.4      | Packaging materials and their environmental impact                                          | 1               |
| 4.5      | Eco-friendly packaging alternatives                                                         | 1               |
| 4.6      | Packaging design for sustainability                                                         | 1               |
| <b>5</b> | <b>Environmental Regulations and Policies (6)</b>                                           |                 |
| 5.1      | Importance of environmental regulations and policies in addressing environmental challenges | 2               |
| 5.2      | National and international waste and recycling regulations                                  | 2               |
| 5.3      | Industry standards and certifications, Compliance and Enforcement                           | 2               |

## Reference Books

1. Sustainable Engineering: Concepts, Design and Case Studies, David T. Allen, Pearson Publication.
2. A Comprehensive Book on Solid Waste Management with Application, Dr. H.S. Bhatia , Misha Books, 2019
3. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
4. "Recycling of Plastic Materials" edited by Vijay Kumar Thakur
5. E-waste: Implications, Regulations and Management in India and Current Global Best Practices, Rakesh Johri, TERI
6. "Sustainable Packaging”, Subramanian Senthilkannan Muthu , Springer Nature.
7. Indian Environmental Law: Key Concepts and Principles " Orient Black swan Private Limited, New Delhi.

|                  |                       |                     |          |          |          |               |
|------------------|-----------------------|---------------------|----------|----------|----------|---------------|
| <b>J1PAGT392</b> | <b>EXPERT SYSTEMS</b> | <b>CATEGORY</b>     | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                  |                       | <b>AUDIT COURSE</b> | <b>3</b> | <b>0</b> | <b>0</b> | <b>-</b>      |

**Preamble:** The course aims to provide an understanding of the basic concepts of Artificial Intelligence (AI) and Expert Systems. The course also covers the knowledge representation in expert systems, classes of expert systems, applications of expert systems.

**Course Outcomes:** After the completion of the course the student will be able to:

|             |                                                                                                                              |
|-------------|------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the concepts of Artificial Intelligence and different ways of knowledge representations.                             |
| <b>CO 2</b> | Explain the components of expert systems, development stages of expert systems and tools available for expert system design. |
| <b>CO 3</b> | Apply the concept of knowledge representation in expert systems                                                              |
| <b>CO 4</b> | Differentiate the classes of expert systems and examine properties of existing systems                                       |

#### Mapping of course outcomes with program outcomes

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO7</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|
| <b>CO 1</b> | 1           |             | 2           | 1           | 2           | 2           |            |
| <b>CO 2</b> | 1           |             | 1           | 3           | 2           | 2           |            |
| <b>CO 3</b> | 1           |             | 1           | 2           | 2           | 2           |            |
| <b>CO 4</b> | 2           |             | 2           | 2           | 3           | 2           |            |

#### Assessment Pattern

| <b>Bloom's Category</b> | <b>End Semester Examination</b> |
|-------------------------|---------------------------------|
| Understand              | 60%                             |
| Apply                   | 20%                             |
| Analyse                 | 20%                             |

#### Mark distribution

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

#### Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz : 15 marks

Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 mark.

|                                                               |                                                                                                               |                     |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|
|                                                               |                                                                                                               |                     |
| THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024          |                                                                                                               |                     |
| Course Code: J1PAGT392                                        |                                                                                                               |                     |
| Course Name: EXPERT SYSTEMS                                   |                                                                                                               |                     |
| Max. Marks: 60                                                |                                                                                                               | Duration: 2.5 Hours |
| <i>Answer any five full questions, each carries 12 marks.</i> |                                                                                                               |                     |
| 1.                                                            | a) What are the types of AI? Explain with examples .                                                          | 6                   |
|                                                               | b) What do you mean by knowledge in AI and explain the different ways of knowledge representation used in AI? | 6                   |
| 2.                                                            | a) Write note on semantic network.                                                                            | 6                   |
|                                                               | b) What are Predicates? Explain its syntax and semantics.                                                     | 6                   |
| 3.                                                            | a) Write notes on different tools available for expert system design.                                         | 6                   |
|                                                               | b). What are the different stages in the development of an expert system?                                     | 6                   |
| 4.                                                            | a) Illustrate Conceptual Dependencies with an example.                                                        | 6                   |
|                                                               | b) Illustrate with an example the Structured Knowledge representation of an Expert System.                    | 6                   |
| 5.                                                            | a) What do you mean by Frame based Expert System? Explain                                                     | 6                   |
|                                                               | b) Explain the architecture of MYCIN                                                                          | 6                   |
| 6.                                                            | a) Explain Fuzzy based expert systems                                                                         | 6                   |
|                                                               | b) Explain the neural network based expert systems                                                            | 6                   |
| 7.                                                            | a) Explain any two applications of expert systems?                                                            | 6                   |
|                                                               | b) What are the limitations of expert system ? Explain                                                        | 6                   |

## Syllabus

| <b>Module</b> | <b>Content</b>                                                                                                                                                                                                                                                                                                                                                        | <b>Hours</b> | <b>Semester Exam Marks (%)</b> |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|--------------------------------|
| <b>I</b>      | <p>Overview of Artificial Intelligence (AI): Definition &amp; Importance of AI.</p> <p>Knowledge general concepts: Definition and Importance of knowledge, Knowledge-Based Systems, Knowledge organization, Knowledge Manipulation and acquisition.</p> <p>Knowledge Representation: Introduction, Syntax and Semantics- Propositional logic and predicate logic.</p> | <b>6</b>     | <b>20</b>                      |
| <b>II</b>     | <p>Basic concepts of expert systems-Introduction to expert systems, Components of expert systems. Features of Expert System, Stages in the development of expert system, Types of tools available for expert system design</p>                                                                                                                                        | <b>6</b>     | <b>20</b>                      |
| <b>III</b>    | <p>Knowledge representation in expert systems: Structured Knowledge representation: Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation.</p>                                                                                                                                        | <b>6</b>     | <b>20</b>                      |
| <b>IV</b>     | <p>Classes of expert systems: Rule-based expert systems, Example- MYCIN, Frame-based expert system, terminologies, IF-THEN structure. Fuzzy and Neural network based expert systems(basic concepts)</p>                                                                                                                                                               | <b>7</b>     | <b>20</b>                      |
| <b>V</b>      | <p>Currents trends in expert systems, Advantages and limitations of expert systems, Applications of expert systems.</p>                                                                                                                                                                                                                                               | <b>5</b>     | <b>20</b>                      |

## Course Plan

| No       | Topics                                                                     | No. of Lectures |
|----------|----------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Overview of Artificial Intelligence&amp; Knowledge general concepts</b> |                 |
| 1.1      | Definition & Importance of AI                                              | 1               |
| 1.2      | Definition and Importance of Knowledge,                                    | 1               |
| 1.3      | Knowledge-Based Systems, Knowledge Organization                            | 1               |
| 1.4      | Knowledge Manipulation and acquisition                                     | 1               |
| 1.5      | Knowledge Representation: Introduction, Syntax and Semantics               | 1               |
| 1.6      | Propositional logic and predicate logic                                    | 1               |
| <b>2</b> | <b>Basic concepts of expert systems</b>                                    |                 |
| 2.1      | Introduction to Expert System, Components of expert systems                | 2               |
| 2.2      | Features of Expert System, Stages in the development of expert system      | 2               |
| 2.3      | Types of tools available for expert system design                          | 2               |
| <b>3</b> | <b>Knowledge representation in expert systems</b>                          |                 |
| 3.1      | Structured Knowledge representation                                        | 1               |
| 3.2      | Graphs, Frames and Related Structures                                      | 2               |
| 3.3      | Associative Networks, Conceptual Dependencies                              | 2               |
| 3.4      | Examples of structured knowledge representation                            | 1               |
| <b>4</b> | <b>Classes of expert systems</b>                                           |                 |
| 4.1      | A rule-based expert system -Introduction                                   | 1               |
| 4.2      | MYCIN                                                                      | 1               |
| 4.3      | IF-THEN structure                                                          | 1               |
| 4.4      | Frame-based expert system                                                  | 2               |
| 4.5      | Fuzzy based expert systems                                                 | 1               |
| 4.6      | Neural network based expert systems                                        | 1               |
| <b>5</b> | <b>Currents trends and applications of expert systems</b>                  |                 |
| 5.1      | Currents trends of expert systems                                          | 2               |
| 5.2      | Advantages and limitations of expert systems                               | 1               |
| 5.3      | Applications of expert systems                                             | 2               |

## Reference Books

1. E. Rich & K. Knight - Artificial Intelligence, 2/e, TMH, New Delhi, 2005.
2. P.H. Winston - Artificial Intelligence, 3/e, Pearson Edition, New Delhi, 2006.
3. D.W. Rolston - Principles of AI & Expert System Development, TMH, New Delhi
4. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE) ", McGraw Hill – 2010
5. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', Prentice Hall of India Pvt. Ltd, 2007
6. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education series in AI', 3rd Edition, 2009.
7. I. Gupta, G. Nagpal · Artificial Intelligence and Expert Systems, Mercury Learning and Information -2020

|           |                  |              |   |   |   |        |
|-----------|------------------|--------------|---|---|---|--------|
| J1PAGT382 | SYSTEM MODELLING | CATEGORY     | L | T | P | CREDIT |
|           |                  | AUDIT COURSE | 3 | 0 | 0 | -      |

**Preamble:** Study of this course provides the learners a clear understanding of fundamental concepts in simulation and modelling. This course covers the different statistical models, importance of data collection and various types of simulations. The course helps the learners to find varied applications in engineering, medicine and bio-technology.

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                          |
|-------------|--------------------------------------------------------------------------|
| <b>CO 1</b> | Analyse the requirement and find appropriate tool for simulation.        |
| <b>CO 2</b> | Differentiate the different statistical models.                          |
| <b>CO 3</b> | Discuss the different techniques for generating random numbers.          |
| <b>CO 4</b> | Analyse the different methods for selecting the different input models.. |
| <b>CO 5</b> | Discuss the different measures of performance and their estimation       |

#### Mapping of course outcomes with program outcomes

|             | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 | PO 6 |
|-------------|------|------|------|------|------|------|
| <b>CO 1</b> | 2    |      | 1    | 1    | 2    |      |
| <b>CO 2</b> | 2    |      | 1    | 1    | 1    |      |
| <b>CO 3</b> | 1    |      |      |      |      |      |
| <b>CO 4</b> | 1    |      | 1    | 1    |      |      |
| <b>CO 5</b> | 2    |      | 1    | 1    | 1    |      |

#### Assessment Pattern

| Bloom's Category | End Semester Examination |
|------------------|--------------------------|
| Understand       | 60%                      |
| Apply            | 20%                      |
| Analyse          | 20%                      |

#### Mark distribution

| Total Marks | CIE | ESE | ESE Duration |
|-------------|-----|-----|--------------|
| 100         | 40  | 60  | 2.5 hours    |

#### Continuous Internal Evaluation Pattern:

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern:**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

**Model Question paper**

AUDIT COURSE

**J1PAGT382– SYSTEM MODELLING**

*Answer any five questions Each carries 12 marks*

**PART A**

1. a. Discuss the advantages and disadvantages of simulation. (5marks)  
b. What are the areas of applications of simulation (7 marks)
2. a. A bus arrives every 20 minutes at a specified stop beginning at 6:40 A.M. and continuing until 8:40 A.M. A certain passenger does not know the schedule, but arrives randomly (uniformly distributed) between 7:00A.M. and 7:30 A.M. every morning. What is the probability that the passenger waits more than 5 minutes for a bus? (5 marks)  
b. A production process manufactures computer chips on the average at 2% nonconforming. Every day, a random sample of size 50 is taken from the process. If the sample contains more than two nonconforming chips, the process will be stopped. Compute the probability that the process is stopped by the sampling scheme. (7 marks)
3. a. Discuss the different types of tests for random numbers. (5 marks)  
b. Generate random numbers using multiplicative congruential method with  $X_0 = 5$ ,  $a = 11$ , and  $m = 64$ . (7 marks)
4. a. What are the different methods of data collection. (4marks)  
b. Records pertaining to the monthly number of job-related injuries at an underground coalmine were being studied by a federal agency. The values for the past 100 months were as follows:

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

- (a) Apply the chi-square test to these data to test the hypothesis that the underlying distribution is Poisson. Use the level of significance  $\alpha = 0.05$ .
- (b) Apply the chi-square test to these data to test the hypothesis that the distribution is Poisson with mean 1.0. Again let  $\alpha = 0.05$ .
- c) What are the differences between parts (a) and (b), and when might each case arise? (8 marks)

5. a. What is the difference between validation and verification.(5 marks)  
b. Discuss the different measures of performance and their estimation(7 marks)
6. a. Discuss the different methods of parameter estimation(5 marks)  
b. With an example, describe the Poisson process.(7 marks)
7. a. Distinguish between discrete and continuous systems(5 marks)  
b. What are the different components of a simulation system(7 marks)

### Syllabus

| Module | Content                                                                                                                                                                                                                                                                                                | Hours | Semester Exam Marks (%) |
|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------------------------|
| I      | When simulation is the appropriate tool. Advantages and disadvantages of Simulation; Areas of application, Systems and system environment; Components of a system; Discrete and continuous systems, Model of a system; Types of Models, Discrete-Event System Simulation, Steps of a simulation study. | 6     | 20                      |
| II     | Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only)                                                                                                                           | 6     | 20                      |
| III    | Properties of random numbers; Generation of pseudo-random numbers, Techniques for generating random numbers, Tests for Random Numbers                                                                                                                                                                  | 6     | 20                      |
| IV     | Data Collection; Identifying the distribution with data, Parameter estimation, Goodness of Fit Tests, Fitting a non-stationary Poisson process, Selecting input models without data, Multivariate and Time-Series input models.                                                                        | 6     | 20                      |
| V      | Measures of performance and their estimation, Output analysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibration and validation                                                                                                                      | 6     | 20                      |

### Course Plan

| No       | Topic                                                                          | No. of Lectures |
|----------|--------------------------------------------------------------------------------|-----------------|
| <b>1</b> | <b>Introduction</b>                                                            |                 |
| 1.1      | When simulation is the appropriate tool                                        | 1               |
| 1.2      | Advantages and disadvantages of Simulation;                                    | 1               |
| 1.3      | Areas of application, Systems and system environment;                          | 1               |
| 1.4      | Components of a system; Discrete and continuous systems,                       | 1               |
| 1.5      | Model of a system; Types of Models,                                            | 1               |
| 1.6      | Discrete-Event System Simulation ,Steps of a simulation study                  | 1               |
| <b>2</b> | <b>Statistical Models in Simulation</b>                                        |                 |
| 2.1      | Review of terminology and concepts, Empirical distributions. (basic idea only) | 1               |
| 2.2      | Useful statistical models,                                                     | 1               |
| 2.3      | Discrete distributions.                                                        | 1               |
| 2.4      | Continuous distributions,.                                                     | 1               |
| 2.5      | Poisson process                                                                | 1               |
| 2.6      | Empirical distributions                                                        | 1               |
| <b>3</b> | <b>Random Number Generation</b>                                                |                 |
| 3.1      | Properties of random numbers;                                                  | 1               |
| 3.2      | Generation of pseudo-random numbers,                                           |                 |
| 3.3      | Techniques for generating random numbers                                       | 1               |
| 3.4      | Techniques for generating random numbers(cont)                                 | 1               |
| 3.5      | Tests for Random Numbers                                                       | 1               |
| 3.6      | Tests for Random Numbers(cont)                                                 | 1               |
| <b>4</b> | <b>Input Modelling</b>                                                         |                 |
| 4.1      | Data Collection;                                                               | 1               |
| 4.2      | Identifying the distribution with data.                                        | 1               |
| 4.3      | Parameter estimation, Goodness of Fit Tests                                    | 1               |
| 4.4      | Fitting a non-stationary Poisson process                                       | 1               |
| 4.5      | Selecting input models without data,                                           | 1               |
| 4.6      | Multivariate and Time-Series input models                                      | 1               |
| <b>5</b> | <b>Measures of Performance and their Estimation</b>                            |                 |
| 5.1      | Measures of performance and their estimation                                   | 1               |
| 5.2      | Measures of performance and their estimation(cont)                             | 1               |
| 5.3      | Output analysis for terminating simulations                                    | 1               |
| 5.4      | Output analysis for steady-state simulations                                   | 1               |
| 5.5      | Verification, calibration and validation                                       | 1               |
| 5.6      | Verification, calibration and validation(cont)                                 | 1               |

**Textbooks:**

1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.

**Reference Books:**

1. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006.

2. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007

3. System Modelling and Response by Ernest O. Doebelin

4. Averill M Law, “Simulation Modeling and Analysis”,McGraw-Hill Inc,2007 Geoffrey Gorden, “System Simulation”,Prentice Hall of India,1992.

|                  |                                 |                      |          |          |          |               |
|------------------|---------------------------------|----------------------|----------|----------|----------|---------------|
| <b>J1PAGT362</b> | <b>Principles of Automation</b> | <b>CATEGORY</b>      | <b>L</b> | <b>T</b> | <b>P</b> | <b>CREDIT</b> |
|                  |                                 | <b>CREDIT COURSE</b> | <b>3</b> | <b>0</b> | <b>0</b> | <b>0</b>      |

### Preamble:

This course deals in detail with the various aspects of automation such as sensors, actuators, controllers, mechanical and electrical elements and their integration for automating new and existing manufacturing and process industries and applications. This course will be beneficial to students in designing automation schemes for industries and to design automated systems

**Course Outcomes:** After the completion of the course the student will be able to

|             |                                                                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CO 1</b> | Explain the fundamentals of sensor systems and to choose a suitable sensor system for the given application based on the evaluation of the constraints. |
| <b>CO 2</b> | Explain the fundamentals of signal conditions and to design a suitable signal conditioning scheme for given application.                                |
| <b>CO 3</b> | Describe the characteristics of various actuator systems and to decide the right type of actuator for the given application.                            |
| <b>CO 4</b> | Describe the importance of an industrial robot and fundamentals of numerical control in automation.                                                     |
| <b>CO 5</b> | Explain the fundamentals of controllers used in industrial automation and to construct simple automation schemes by ladder logic programs.              |

### Mapping of course outcomes with program outcomes

|             | <b>PO 1</b> | <b>PO 2</b> | <b>PO 3</b> | <b>PO 4</b> | <b>PO 5</b> | <b>PO 6</b> | <b>PO 7</b> |
|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>CO 1</b> | 2           |             | 2           | 2           | 2           |             |             |
| <b>CO 2</b> | 2           |             | 2           | 2           | 2           |             |             |
| <b>CO 3</b> | 2           |             | 2           | 2           | 2           |             |             |
| <b>CO 4</b> | 2           |             | 2           | 2           | 2           |             |             |
| <b>CO 5</b> | 2           |             | 2           |             |             |             |             |

### Assessment Pattern

| <b>Bloom's Category</b> | <b>End Semester Examination</b> |
|-------------------------|---------------------------------|
| Understand              | 70 %                            |
| Apply                   | 30 %                            |

### Mark distribution

| <b>Total Marks</b> | <b>CIE</b> | <b>ESE</b> | <b>ESE Duration</b> |
|--------------------|------------|------------|---------------------|
| 100                | 40         | 60         | 2.5 hours           |

**Continuous Internal Evaluation Pattern: 40 marks**

Course based task (Project/Assignments/Simulations/Case studies): 15 marks

Seminar/Quiz: 15 marks

Test paper, 1 no.: 10 marks

Test paper shall include minimum 80% of the syllabus.

**End Semester Examination Pattern: 60 marks**

The examination will be conducted by the respective College. The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any five. Each question can carry 12 marks.

Model Question Paper  
**J1PAGT362 Principles of Automation**

Time 2.5 Hrs

Marks 60

***Answer any five questions Each carries 12 marks***

1. (a) Differentiate the static and dynamic characteristics of a temperature sensor and explain how it affects the selection of a suitable temperature sensor. (6 marks)  
(b) Explain the working of a strain-gauge. (6 marks)
2. (a) Explain why anti-aliasing filters are used in analog to digital converters. (3 marks)  
(b) Design a first order low pass filter with a cutoff frequency of 2 kHz. (9 marks)
3. (a) What are the factors to consider while deciding choosing between hydraulic, pneumatic or electrical actuation systems for an automation scheme? (4 marks)  
(b) Explain the working of a three-way pressure reducing valve. (4 marks)  
(c) Explain the working of solenoids. In what applications would you use a Solenoid valve. (4 marks)
4. (a) Explain the principle of the Touch sensor and also mention how they are used in robots. (5 marks)  
(b) Explain the basic terminologies in robotic system and also explain the components of robotic system. (7 marks)
5. (a) With neat schematic explain the architecture of the PLC. (6 marks)  
(b) Explain the use of an up-down counter in PLC with a suitable example. (6 marks)
6. (a) Write short note on SCADA. What is difference PLC and SCADA? (3 marks)  
(b) Construct a ladder logic for controlling a process tank as per the logic given below;  
i. The tank should be filled by a valve V1 when low level float switch L1 is ON and an external input S1 is received.

- ii. V1 should be closed when the liquid level reaches a high-level float switch L2.
  - iii. An agitator motor should be turned on after a delay of 5sec after L2 is triggered.
  - iv. After agitating for 30mins, contents of the tank should be emptied by opening another valve V2.
  - v. The temperature should be maintained at 70°C using a thermostat T1 and Heater H
- (9 marks)

7. (a) Explain the levels of Automation. (6 marks)
- (b) Explain the working of Flow sensor (6 marks)

### Syllabus and Course Plan

| No  | Topics                                                                                                                                                                                                                                                                                                                                    | No. of Lectures |
|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| 1   | <b>Introduction to Industrial Automation</b>                                                                                                                                                                                                                                                                                              |                 |
| 1.1 | Basic Elements of an Automated System, Levels of Automation                                                                                                                                                                                                                                                                               | 2               |
| 1.2 | Hardware components for Automation: Sensors, classification, Static and dynamic behaviour of sensors.                                                                                                                                                                                                                                     | 2               |
| 1.3 | Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors                                                                                                                                                                                     | 4               |
| 2   | <b>Signal conditioning</b>                                                                                                                                                                                                                                                                                                                |                 |
| 2.1 | Need for signal conditioning, Types of signal conditioning.                                                                                                                                                                                                                                                                               | 2               |
| 2.2 | Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter.                                                                                                                                                                      | 2               |
| 2.3 | Signal conditioning for data acquisition systems, anti-aliasing filters, Analog-Digital Conversions, Analog-to-Digital Converters (ADC)- Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits | 4               |
| 3   | <b>Actuators</b>                                                                                                                                                                                                                                                                                                                          |                 |
| 3.1 | Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators. (Basic working principle)                                                                                                                                                                                                                                  | 2               |
| 3.2 | Mechanical systems for motion conversion, transmission systems                                                                                                                                                                                                                                                                            | 3               |
| 3.3 | Solenoids, Electric and stepper motors control.                                                                                                                                                                                                                                                                                           | 3               |
| 4   | <b>Robotics and Automated Manufacturing Systems</b>                                                                                                                                                                                                                                                                                       |                 |
| 4.1 | Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts)                                                                                                                                                                                            | 3               |
| 4.2 | Robot Control Systems, Applications of Industrial Robots- Material handling                                                                                                                                                                                                                                                               | 4               |
| 4.3 | Fundamentals of Numerical control (NC) Technology                                                                                                                                                                                                                                                                                         | 1               |
| 5   | <b>Discrete Control and Programmable Logic Controllers</b>                                                                                                                                                                                                                                                                                |                 |

|     |                                                                                                                                              |   |
|-----|----------------------------------------------------------------------------------------------------------------------------------------------|---|
| 5.1 | Discrete Process Control: Logic and Sequence control                                                                                         | 2 |
| 5.2 | Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only) | 4 |
| 5.3 | Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA)                                | 2 |

### Reference Books

1. Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems", TataMcGraw Hill Edition 2005.
3. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
4. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - PrenticeHall- 2013 - 5th Edition.
5. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
6. Krishna Kant, Computer Based Industrial Control-, EEE-PHI, 2nd edition, 2010.
7. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
8. Salivahanan, S., and VS Kanchana Bhaaskaran. Linear integrated circuits. McGraw-Hill Education, 2<sup>nd</sup> edition, 2014.
9. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005
10. Chapman and Hall, "Standard Handbook of Industrial Automation", Onsidine DM C & Onsidine GDC", NJ, 1986



## **INTERNSHIP**

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialisation after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

### **Objectives**

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

### **Benefits of Internship**

#### **Benefits to Students**

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom

teaching.

- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an industrial setup.
- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

### **Benefits to the Institute**

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

### **Benefits to the Industry**

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus.

- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

### **Types of Internships**

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes
- Internship with Incubation centres /Start-ups

## Guidelines

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
  - Report of work done
  - Internship certificate copy
  - Feedback from employer / internship mentor
  - Stipend proof (in case of paid internship).

**Total Marks 100:** The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

## Continuous Internal Evaluation: 50 marks

Student's diary - 25 Marks

Evaluation done by the industry - 25 Marks

**Student's Diary/ Daily Log:** The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day to day account of the observations,

impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

### **The format of student's diary**

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

| Day | Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc. |
|-----|------------------------------------------------------------------------------------------------------------------------------------|
| 1   |                                                                                                                                    |
| 2   |                                                                                                                                    |
| 3   |                                                                                                                                    |

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager*

*Office Seal*

## Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

| Month<br>& Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | ... |
|-----------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|-----|
|                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
| Month<br>& Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
|                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
| Month<br>& Year |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |
|                 |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |     |

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager*

*Office Seal*

### Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

## Evaluation done by the Industry (Marks 25)

### Format for Supervisor Evaluation of Intern

Student Name : \_\_\_\_\_ Date: \_\_\_\_\_

Supervisor Name : \_\_\_\_\_ Designation: \_\_\_\_\_

Company/Organization : \_\_\_\_\_

Internship Address: \_\_\_\_\_

Dates of Internship: From \_\_\_\_\_ To \_\_\_\_\_

***Please evaluate intern by indicating the frequency with which you observed the following parameters:***

| Parameters                               | Marks | Needs improvement<br>(0 – 0.25 mark) | Satisfactory<br>(0.25 – 0.50 mark) | Good<br>(0.75 mark) | Excellent<br>(1 mark) |
|------------------------------------------|-------|--------------------------------------|------------------------------------|---------------------|-----------------------|
| Behavior                                 |       |                                      |                                    |                     |                       |
| Performs in a dependable Manner          |       |                                      |                                    |                     |                       |
| Cooperates with coworkers and supervisor |       |                                      |                                    |                     |                       |
| Shows interest in work                   |       |                                      |                                    |                     |                       |
| Learns quickly                           |       |                                      |                                    |                     |                       |
| Shows initiative                         |       |                                      |                                    |                     |                       |
| Produces high quality work               |       |                                      |                                    |                     |                       |
| Accepts responsibility                   |       |                                      |                                    |                     |                       |
| Accepts criticism                        |       |                                      |                                    |                     |                       |
| Demonstrates organizational skills       |       |                                      |                                    |                     |                       |
| Uses technical knowledge and expertise   |       |                                      |                                    |                     |                       |
| Shows good judgment                      |       |                                      |                                    |                     |                       |
| Demonstrates creativity/originality      |       |                                      |                                    |                     |                       |
| Analyzes problems effectively            |       |                                      |                                    |                     |                       |
| Is self-reliant                          |       |                                      |                                    |                     |                       |
| Communicates well                        |       |                                      |                                    |                     |                       |
| Writes effectively                       |       |                                      |                                    |                     |                       |
| Has a professional attitude              |       |                                      |                                    |                     |                       |
| Gives a professional appearance          |       |                                      |                                    |                     |                       |
| Is punctual                              |       |                                      |                                    |                     |                       |
| Uses time effectively                    |       |                                      |                                    |                     |                       |

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

*Signature of Industry Supervisor*

*Signature of Section Head/HR Manager*

*Office Seal*

## **End Semester Evaluation (External Evaluation): 50 Marks**

|                   |   |          |
|-------------------|---|----------|
| Internship Report | - | 25 Marks |
| Viva Voce         | - | 25 Marks |

**Internship Report:** After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

## **RESEARCH PROJECT/DISSERTATION**

**Research Project:** Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

**Dissertation:** All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

### **Mark Distribution:**

**Phase 1: Total marks: 100, only CIA**

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# SEMESTER - IV

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| CODE      | COURSE NAME           | CATEGORY     | L | T | P  | CREDIT |
|-----------|-----------------------|--------------|---|---|----|--------|
| J1PTED401 | DISSERTATION PHASE II | Project Work | 0 | 0 | 24 | 16     |

All categories of students in track 1 are to carry out the DISSERTATION PHASE II in the institute they are studying or in any Industrial/ R&D organization/any other reputed institute which have facilities for dissertation work in the area proposed. DISSERTATION PHASE II shall not compulsorily continuation of DISSERTATION PHASE I. The student has to publish a research article in a conference or a reputed journal before appearing for the end-semester examination. The eligibility criteria for registering to the end semester examination are attendance in the course and no pending disciplinary action. The minimum attendance for appearing for the end semester examination is 75%. Students who do not meet these eligibility criteria are ineligible (identified by FE grade) to appear for the ESE. Students, who have completed a course but could not appear for the end semester examination, shall be awarded 'AB' Grade, provided they meet other eligibility criteria. The pass minimum for the course is 45% for ESE and 50% for (CIA and ESE) put together.

#### **Continuous Internal Assessment (CIA) Total Marks: 100**

The evaluation committee comprises

- 1- Project Coordinator(s)
- 2- A Senior faculty member
- 3- Supervisor of the student

#### **Pattern (CIA)**

|                                                |          |
|------------------------------------------------|----------|
| Zeroth evaluation by the Evaluation Committee  | -        |
| Interim evaluation by the Evaluation Committee | 30 marks |
| Final evaluation by the Evaluation Committee   | 50 marks |
| Project progress evaluation by supervisor      | 20 marks |

#### **Evaluation by the supervisor**

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action.

**Student's Diary/ Log book:** The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

#### **End Semester Evaluation (ESE) Total Marks: 100**

The evaluation committee comprises

- 1- Project Coordinator(s)
- 2- An external expert (from Industry or research/academic institute)
- 3- Supervisor of the student

## **Pattern (ESE)**

### **1. Innovation and Originality (10 marks):**

Assessment of the uniqueness and innovation demonstrated in the project work.

Original contributions, if any, to the field or problem area.

### **2. Implementation and Execution (20 marks):**

Evaluation of the actual implementation or execution of the project, including:

Quality of work done

Demonstrated skills and techniques applied

Adherence to project timelines and milestones

### **3. Project Documentation (25 marks):**

Comprehensive project report evaluation including:

Introduction and problem statement

Literature review

Methodology and approach

Results and analysis

Conclusion and recommendations

References and citations

Details of the publications

Plagiarism certificate

The Plagiarism level in the project report shall be less than 25%.

### **4. Presentation and Defence (40 marks):**

Oral presentation of the project to a panel of examiners, including:

Clarity and effectiveness of the presentation

Ability to explain the project objectives, methodologies, and findings

Handling questions and providing satisfactory answers during the defence

### **5. Publication of the work either in a conference or in a journal (5 marks)**

#### **SYLLABUS:**

| DETAILS                                                                                                                                                                                                                                                                                                                                                                                                                                          | HOURS |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| <ol style="list-style-type: none"><li>1. Literature study/survey of published literature on the assigned topic</li><li>2. Topic Selection and Proposal</li><li>3. Formulation of objectives</li><li>4. Research and Planning</li><li>5. Formulation of work plan and task allocation.</li><li>6. Execution</li><li>7. Documentation and Reporting</li><li>8. Project Showcase reflecting on the project experience and lessons learned</li></ol> | 200   |

**Dissertation outside the Institute:** For doing dissertation outside the Institution, the following conditions are to be met:

- i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
- ii. The student has to get prior approval from the DLAC and CLAC.
- iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
- iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
- v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.
- vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.