

# **SEMESTER 6**

## **INDUSTRIAL ENGINEERING**

## SEMESTER S6

### SYSTEM MODELLING AND SIMULATION

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>PCIET601</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:1:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 4               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To enable students to construct a theoretical base to model discrete and continuous systems.
2. To equip students to model and simulate discrete and continuous systems.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>   | <b>Contact Hours</b> |
|-------------------|---|----------------------|
| <b>1</b>          | <b>Introduction to system modelling:</b> Concepts of a system, system environment, continuous and discrete systems, system models, comparison of analytical methods and simulation, areas of application of simulation, steps in discrete event simulation study.<br><b>Random Numbers:</b> Properties of random numbers, generation of pseudo-random numbers, random number generators. Tests for random numbers-frequency, gap, run, and Poker tests, test for autocorrelation, Monte Carlo method.   | <b>11</b>            |
| <b>2</b>          | <b>Generation of random variates:</b> Inverse transformation method for exponential, uniform, Weibull, triangular, and discrete distributions, Direct transformation method for normal and lognormal distributions, Acceptance-rejection technique for Poisson and Gamma distributions.<br><b>Input modelling:</b> Data collection, identifying the distribution with the collected data, goodness of fit tests, selecting input models without data. Verification and validation of simulation models, Output data analysis, Variance reduction techniques.<br><b>Time Advance Mechanisms for discrete event simulation:</b> Next-Event time advance and fixed increment time advance methods. | <b>11</b>            |

|          |  |           |
|----------|--|-----------|
| <b>3</b> | <b>System dynamic modelling:</b> Evolution of system dynamics as a system enquiry methodology, elements of system dynamics modelling- physical flows, information flows, level & rate variables, delays, information smoothing, table functions and table function multipliers, causal loop diagramming, flow diagrams. Steps for Modelling in system dynamics.  | <b>11</b> |
| <b>4</b> | <p><b>Behaviour of linear lower order systems:</b> Analytical approach - first order positive and negative feedback systems, pure second order positive and negative feedback systems.</p> <p><b>Modes of dynamic behaviour:</b> Exponential growth, goal seeking, oscillation, interactions of fundamental modes. Principles of simulation modelling, developing model equations, algorithms for Euler integration, hand simulation of system dynamics models. S-Shaped growth- epidemics, innovation, diffusion and growth of new products. Overview of Software packages for System modelling and simulation.</p> | <b>11</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| <b>Part A</b>   | <b>Part B</b>   | <b>Total</b> |
|---|---|--------------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 = 24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 subdivisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b>    |

### Course Outcomes (COs)

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

| Course Outcomes |   | Bloom's Knowledge Level (KL) |
|-----------------|---|------------------------------|
| <b>CO1</b>      | Explain the basic concepts of the system and its simulation, Demonstrate the generation of random numbers and its testing.                    | <b>K2</b>                    |
| <b>CO2</b>      | Perform input modeling for discrete simulation, verify and validate simulation models and perform output data analysis                        | <b>K3</b>                    |
| <b>CO3</b>      | Illustrate various elements of system dynamics modelling, Construct causal loop diagrams and Flow diagrams.                                   | <b>K3</b>                    |
| <b>CO4</b>      | Develop the fundamental modes of dynamic behaviour and their interactions; Model and Analyze systems using the principles of system dynamics. | <b>K4</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 2   | 2   | 2   | 3   | 1   | -   | -   | 1   | 1    | 1    | 2    |
| <b>CO2</b> | 3   | 3   | 3   | 2   | 3   | 2   | -   | -   | 1   | 1    | 1    | 2    |
| <b>CO3</b> | 3   | 3   | 2   | 2   | 3   | 3   | -   | -   | 1   | 1    | 1    | 2    |
| <b>CO4</b> | 3   | 3   | 3   | 3   | 3   | 3   | -   | -   | 1   | 1    | 1    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |   |   |                       |                               |
|------------|---|---|-----------------------|-------------------------------|
| Sl. No     | Title of the Book                       | Name of the Author/s                        | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Discrete Event System Simulation        | Jerry Banks                                 | Pearson Education     | 5 <sup>th</sup> Edition, 2013 |
| <b>2</b>   | Introduction to System Dynamic Modeling | M C Bora, Pratap K J Mohapatra and P Mandal | Universities Press    | 1 <sup>st</sup> Edition, 1994 |

| Reference Books |   |                      |  |                                |
|-----------------|---|----------------------|--|--------------------------------|
| Sl. No          | Title of the Book   | Name of the Author/s | Name of the Publisher                                      | Edition and Year               |
| 1               | Simulation Modeling and Analysis                                      | A M Law              | McGraw Hill  | 6 <sup>th</sup> Edition, 2024  |
| 2               | System Simulation   | Geoffrey Gordon      | Prentice Hall India  | 2 <sup>nd</sup> Edition, 1979  |
| 3               | Discrete Event Simulation: Modeling, Programming and Analysis         | George Fishman       | Springer series in Operations Research and Financial Engg. | 1 <sup>st</sup> Edition, 2001  |
| 4               | System Simulation with Digital Computer                               | Deo Narsingh         | Prentice Hall India  | 24 <sup>th</sup> Edition, 2011 |
| 5               | Simulation  | Sheldon M. Ross      | Elsevier   | 6 <sup>th</sup> Edition, 2023  |
| 6               | Business Dynamics – Systems Thinking and Modeling for a Complex World | John D. Sterman      | McGraw Hill  | 1 <sup>st</sup> Edition, 2000  |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://nptel.ac.in/courses/112107220">https://nptel.ac.in/courses/112107220</a>               |
|                                | <a href="https://onlinecourses.nptel.ac.in/noc22_me18">https://onlinecourses.nptel.ac.in/noc22_me18</a> |

**SEMESTER S6**

**FINANCIAL ENGINEERING**

|                                      |                 |                    |                |
|--------------------------------------|-----------------|--------------------|----------------|
| <b>Course Code</b>                   | <b>PEIET602</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week (L:T:P:R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                       | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>        | None            | <b>Course Type</b> | Theory         |

**Course Objectives:**

1. To enable to understand financial engineering, investment and apply mathematics in financial engineering
2. To enable tools related to capital budgeting, cost of capital, working capital and capital structure.

**SYLLABUS**

| <b>Module No.</b> | <b>Syllabus Description</b>   | <b>Contact Hours</b> |
|-------------------|---|----------------------|
| <b>1</b>          | <b>Introduction to finance and financial engineering:</b> Definitions, financial literacy - needs, financial decisions - goals, financial systems - functions, financial markets - types, financial investment - investment techniques, financial intermediaries, asset types - real estate, securities, commodities, derivatives, and futures.   | <b>9</b>             |
| <b>2</b>          | <b>Financial mathematics:</b> Principal and interest - simple interest and compound interest - continuous compounding. Interest rate - risk free interest rates, term structure of interest rates and short rate models. Time value of money - investment and maturity period, doubling period, present value of annuity and future value of annuity - calculations. Equated monthly instalment (EMI) - EMI calculation. Stocks - valuation of stocks and intrinsic value of stock. | <b>9</b>             |
| <b>3</b>          | <b>Capital budgeting and capital cost:</b> Capital budgeting process - investment criteria, conventional and discounted cash flow methods - net present value (NPV) and internal rate of return (IRR) - Computation of NPV, IRR, benefit cost ratio, equivalent maintenance cost and payback period.  | <b>9</b>             |

|          |  |          |
|----------|--|----------|
|          | <b>Cost of capital:</b> Weighted average cost and weighted marginal cost - factors affecting. Company's cost of capital and project cost of capital - cost of debt - cost of preference - cost of equity - capital asset pricing model (CAPM).   |          |
| <b>4</b> | <b>Working capital and capital structure theories:</b> Working capital - factors affecting capital requirements. Cash management - models of cash management, operating cycle and cash cycle calculations. Capital structure - net income approach, net operating income approach, traditional position, and Modigliani-Miller (MM) hypothesis. Trade off and signalling theory. | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/<br>Microproject | Internal<br>Examination-1<br>(Written) | Internal<br>Examination- 2<br>(Written) | Total     |
|------------|-----------------------------|--|---|-----------|
| <b>5</b>   | <b>15</b>                   | <b>10</b>                              | <b>10</b>                               | <b>40</b> |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A  | Part B  | Total     |
|---|---|-----------|
| <ul style="list-style-type: none"> <li>2 Questions from each module.</li> <li>Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 = 24 marks)</b></p> | <ul style="list-style-type: none"> <li>Each question carries 9 marks.</li> <li>Two questions will be given from each module, out of which 1 question should be answered.</li> <li>Each question can have a maximum of 3 subdivisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b> |

### Course Outcomes (COs)

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

| Course Outcomes |   | Bloom's Knowledge Level (KL) |
|-----------------|---|------------------------------|
| <b>CO1</b>      | Understand finance, financial engineering, and related areas.                           | <b>K2</b>                    |
| <b>CO2</b>      | Apply financial mathematics including time value of money.                              | <b>K3</b>                    |
| <b>CO3</b>      | Apply tools and techniques for capital budgeting and cost of capital.                   | <b>K3</b>                    |
| <b>CO4</b>      | Understand capital structure theories and apply techniques of working capital and cash. | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping (Mapping of Course Outcomes to Program Outcomes)

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1 | 2   | -   | -   | -   | -   | 1   | -   | -   | 1   | -    | -    | 2    |
| CO2 | 2   | 1   | 3   | -   | -   | 1   | -   | -   | -   | -    | -    | 2    |
| CO3 | 2   | 1   | 3   | -   | -   | 1   | -   | -   | -   | -    | 3    | 2    |
| CO4 | 2   | 1   | 3   | -   | -   | 1   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation<sup>2</sup>

| Text Books |   |                                    |                       |                                |
|------------|---|------------------------------------|-----------------------|--------------------------------|
| Sl. No     | Title of the Book                                 | Name of the Author/s               | Name of the Publisher | Edition and Year               |
| 1          | Financial Management                              | Prasanna Chandra                   | McGraw Hill           | 10 <sup>th</sup> Edition, 2019 |
| 2          | Financial Accounting                              | R Narayanaswamy                    | PHI Learning          | 4 <sup>th</sup> Edition, 2017  |
| 3          | Understanding the Mathematics of Personal Finance | Lawrence N. Dworsky                | Wiley Publication     | 1 <sup>st</sup> Edition, 2009  |
| 4          | Fundamentals of Financial Management              | Eugene F. Brigham, Joel F. Houston | Cengage Publication   | 15 <sup>th</sup> Edition, 2019 |

| Reference Books |                           |                      |                        |                                |
|-----------------|---------------------------|----------------------|------------------------|--------------------------------|
| Sl. No          | Title of the Book         | Name of the Author/s | Name of the Publisher  | Edition and Year               |
| 1               | Applied corporate finance | Aswath Damodaran     | Wiley publication      | 4 <sup>th</sup> Edition, 2015  |
| 2               | Financial Management      | I M Pandey           | Vikas publishing house | 11 <sup>th</sup> Edition, 2016 |



| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/110/107/110107144/">https://archive.nptel.ac.in/courses/110/107/110107144/</a> |

## SEMESTER S6

### TOTAL QUALITY MANAGEMENT AND SIX SIGMA

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>PEIET631</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To enable the students to understand the principles and philosophy of Total Quality Management and Six Sigma.
2. To equip students to apply TQM and Six Sigma principles to real world scenarios.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>   | <b>Contact Hours</b> |
|-------------------|---|----------------------|
| <b>1</b>          | <b>Introduction to quality and TQM:</b> Quality - definition, quality quantified, dimensions of quality. TQM – definition, new and old cultures. Gurus of TQM – Deming, Juran, Shewhart, Crosby, Fiegenbaum, Ishikawa, Taguchi – their main contributions, obstacles to TQM, benefits of TQM. quality circles, cost of quality, Taguchi quality loss function.                            | <b>9</b>             |
| <b>2</b>          | <b>Axioms of TQM, Customer satisfaction and Employee involvement:</b> TQM axioms - commitment, scientific knowledge and involvement, Deming's fourteen points on quality management, quality council, quality statements, customer satisfaction, customer perception of quality, customer retention, employee involvement, motivation, empowerment, team and teamwork, suggestion system. | <b>9</b>             |
| <b>3</b>          | <b>Quality Management Systems (QMS):</b> Introduction, benefits of ISO registration, ISO 9000 series of standards, sector-specific standards - AS 9100, ISO/TS 16949 and TL 9000, ISO 9001 requirements - implementation, documentation, internal audits, registration. Environmental Management System.<br><b>Continuous process improvement and QMS:</b> Continuous process             | <b>9</b>             |

|          |  |          |
|----------|--|----------|
|          | improvement - Juran's quality trilogy, PDCA cycle, Kaizen, seven basic tools of quality, seven new management tools, Benchmarking.   |          |
| <b>4</b> | <b>Quality improvement through Six Sigma:</b> Six sigma –meaning, history of six sigma, working of six sigma. Process capability – meaning, significance and measurement. Six sigma roles and responsibilities, DMAIC process-various phases. Case examples of DMAIC, six sigma in manufacturing and service industries. | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| <b>Part A</b>   | <b>Part B</b>  | <b>Total</b> |
|---|--|--------------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 = 24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 sub divisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b>    |

### Course Outcomes (COs)

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

| Course Outcome |  | Bloom's Knowledge Level (KL) |
|----------------|--|------------------------------|
| <b>CO1</b>     | Explain the basic concepts of quality highlighting the contributions given by quality gurus. | <b>K2</b>                    |
| <b>CO2</b>     | Demonstrate knowledge on TQM axioms and focus on customer-centric approach with teamwork.    | <b>K2</b>                    |
| <b>CO3</b>     | Apply various tools and techniques for continuous process improvement.                       | <b>K3</b>                    |
| <b>CO4</b>     | Make use of six sigma and its methodology in industries.                                     | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO2</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO3</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO4</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |  |                            |                       |                               |
|------------|--|----------------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book                          | Name of the Author/s       | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Total Quality Management                   | Besterfield Dale H. et al. | Pearson Education     | 5 <sup>th</sup> Edition, 2018 |
| <b>2</b>   | Transactional Six Sigma and Lean Servicing | Betsi Harris Ehrlich       | St. Lucie Press       | 1 <sup>st</sup> Edition, 2002 |

| Reference Books |                                       |                               |                       |                               |
|-----------------|---------------------------------------|-------------------------------|-----------------------|-------------------------------|
| Sl. No          | Title of the Book                     | Name of the Author/s          | Name of the Publisher | Edition and Year              |
| 1               | Total Quality Management              | Subburaj Ramasamy             | McGraw Hill Education | 4 <sup>th</sup> Edition, 2017 |
| 2               | Total Quality Management              | Arora K. C.                   | S K Kataria and Sons  | 4 <sup>th</sup> Edition, 2016 |
| 3               | The Management and Control of Quality | James R. E., William M. L.    | Cengage Learning      | 8 <sup>th</sup> Edition, 2012 |
| 4               | Managing Quality – Concepts and Tasks | Narayana V., Sreenivasan, N.S | New Age International | 1 <sup>th</sup> Edition, 2005 |
| 5               | The Six Sigma Handbook                | Pyzdek T., Keller, P          | McGraw-Hill           | 5 <sup>th</sup> Edition 2018  |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://nptel.ac.in/courses/110104080">https://nptel.ac.in/courses/110104080</a> |
|                                | <a href="https://nptel.ac.in/courses/110105123">https://nptel.ac.in/courses/110105123</a> |

**SEMESTER S6**

**RELIABILITY ENGINEERING**

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>PEIET632</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

**Course Objectives:**

1. To enable students to understand important concepts of reliability engineering
2. To equip students to apply various tools, techniques and procedures of reliability engineering for practical scenarios.

**SYLLABUS**

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <p><b>Reliability concepts:</b> Definition of reliability, reliability vs. quality, reliability function, MTTF, hazard rate function, bathtub curve, derivation of the reliability function, failure and failure modes, causes of failures and unreliability.</p> <p><b>Reliability models:</b> Constant failure rate model, time dependent failure models. Weibull distribution, normal distribution, lognormal distribution. Serial configuration, parallel configuration, combined series parallel systems, K-out-of-m systems.</p> | <b>10</b>            |
| <b>2</b>          | <p><b>Redundancy techniques in system design:</b> Component vs unit redundancy, weakest-link technique, mixed redundancy, standby redundancy, redundancy optimization, double failures and redundancy, Markov analysis, load sharing systems, standby systems, degraded systems, three state devices, covariate models.</p>  | <b>8</b>             |
| <b>3</b>          | <p><b>Reliability in design:</b> Reliability in design process, system effectiveness, economic analysis and life cycle cost. Reliability allocation- optimal allocations, ARINC and AGREE methods. System safety and fault tree analysis- Tieset and Cut-set methods. Use of boolean algebra in reliability analysis.</p>  | <b>8</b>             |

|          |   |           |
|----------|---|-----------|
| <b>4</b> | <p><b>Maintainability and availability:</b> Definitions and basic concepts, relationship between reliability, availability and maintainability, inherent availability, achieved availability, operational availability.</p> <p><b>Economics of reliability:</b> Economic issues, manufacturers cost, customers cost, reliability achievement cost models, reliability utility cost models, depreciation cost models, availability cost model for parallel systems. Reliability management and reliability management by objectives.</p> | <b>10</b> |
|----------|---|-----------|

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/<br>Microproject | Internal<br>Examination-1<br>(Written) | Internal<br>Examination- 2<br>(Written) | Total     |
|------------|-----------------------------|--|---|-----------|
| <b>5</b>   | <b>15</b>                   | <b>10</b>                              | <b>10</b>                               | <b>40</b> |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A   | Part B   | Total     |
|--|--|-----------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 =24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 sub divisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b> |

### Course Outcomes (COs)

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

| Course Outcome |  | Bloom's Knowledge Level (KL) |
|----------------|--|------------------------------|
| <b>CO1</b>     | Explain the basic concepts of reliability, various models of reliability and failure concepts.                   | <b>K2</b>                    |
| <b>CO2</b>     | Apply mathematical models of reliability and failure modes.  | <b>K3</b>                    |
| <b>CO3</b>     | Make use of the design process of reliability.   | <b>K3</b>                    |
| <b>CO4</b>     | Demonstrate the relation between reliability, availability, maintainability and economic aspects of reliability. | <b>K2</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 3   | -   | 1   | 1   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO2</b> | 3   | 3   | -   | 3   | 3   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO3</b> | 3   | 2   | 3   | 1   | 1   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO4</b> | 3   | 2   | 2   | 1   | 1   | -   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |   |  |                       |                               |
|------------|---|--|-----------------------|-------------------------------|
| Sl. No     | Title of the Book                           | Name of the Author/s                   | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Reliability Engineering                     | Balagurusamy E.                        | Tata McGraw Hill      | 1 <sup>st</sup> Edition, 2017 |
| <b>2</b>   | Reliability Engineering                     | Srinath L. S.                          | East West Press       | 4 <sup>th</sup> Edition, 2005 |
| <b>3</b>   | Reliability and Maintainability Engineering | Charles E. Ebeling                     | Tata McGraw Hill      | 1 <sup>st</sup> Edition, 2017 |
| <b>4</b>   | Practical Reliability Engineering           | Patrick D. T., O'Connor, Andre Kleyner | John Wiley & Sons Ltd | 5 <sup>th</sup> Edition, 2012 |



| Reference Books |   |                            |                       |                               |
|-----------------|---|----------------------------|-----------------------|-------------------------------|
| Sl. No          | Title of the Book                       | Name of the Author/s       | Name of the Publisher | Edition and Year              |
| 1               | Introduction to Reliability Engineering | E. E. Lewis                | Wiley                 | 2 <sup>nd</sup> Edition, 1994 |
| 2               | Quality Planning and Analysis           | J.M. Juran, Frank M. Gryna | Tata McGraw Hill      | 5 <sup>th</sup> Edition, 2007 |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/127/105/127105234/">https://archive.nptel.ac.in/courses/127/105/127105234/</a> |

## SEMESTER S6

### INDUSTRIAL SCHEDULING

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>PEIET633</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To enable students to solve scheduling problems.
2. To equip students to apply mathematical and heuristic methods in industries.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Introduction to scheduling:</b> Definition of scheduling, role of scheduling, terminologies involved in scheduling, classification of scheduling models - Graham et al. $\alpha/\beta/\gamma$ notations to classify scheduling problems, performance measures, relationship between performance measures, theorems related to performance measures (proof and problems). Classes of schedules - non-delay schedules, active schedules and semi-active schedules. Single machine models without due dates (proof of theorems and problems) - permutation schedules theorems, shortest processing time (SPT) rule, weighted shortest processing time (WSPT) rule. | <b>9</b>             |
| <b>2</b>          | <b>Single machine models with due dates:</b> Problems with due dates, minimizing total lateness, minimizing maximum lateness and maximum tardiness, minimizing the number of tardy jobs - Moore and Hodgson algorithm, minimizing mean tardiness - Wilkerson-Irwin algorithm, minimizing regular performance measures with precedence constraints - Lawler's algorithm, application of Smith's algorithm. General purpose methodologies for single machine problem - neighborhood search techniques, dynamic programming approach, branch & bound approach.  | <b>9</b>             |
| <b>3</b>          | <b>Parallel machine problems and flow shop problems:</b> Parallel identical processors and independent jobs with preemptions and without preemptions,  | <b>9</b>             |

|          |   |          |
|----------|---|----------|
|          | parallel identical processors and dependent jobs, permutation schedule- Johnson's algorithm, two jobs and m machine problems - Aker's graphical method. Special cases of three-machine problem - extension of Johnson's algorithm, branch & bound algorithms for makespan problems, heuristic approaches - Palmer's algorithm, CDS algorithm and insertion heuristics.  |          |
| <b>4</b> | <b>Job shop scheduling and stochastic single machine models:</b> Types of schedules, schedule generation, heuristic procedure - shifting bottleneck procedure, integer programming formulation, simulation studies of the dynamic job shop (overview only). Stochastic models - preliminaries, stochastic based on expectation, stochastic dominance based on variance, impact of randomness on fixed schedules, classes of policies - non-preemptive static list policy, preemptive static list policy, non-preemptive dynamic policy and preemptive dynamic policy, stochastic single machine models - arbitrary distributions without preemptions, arbitrary distributions with preemptions - the Gittins Index, likelihood ratio ordered distributions and exponential distributions. | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| <b>Part A</b>   | <b>Part B</b>   | <b>Total</b> |
|---|---|--------------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 = 24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 subdivisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b>    |

### Course Outcomes (COs)

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

| Course Outcomes |   | Bloom's Knowledge Level (KL) |
|-----------------|---|------------------------------|
| <b>CO1</b>      | Apply a variety of problem solving approaches for single machine problems in scheduling.                                | <b>K3</b>                    |
| <b>CO2</b>      | Develop computational and algorithmic skills to apply in solving single machine problems.                               | <b>K3</b>                    |
| <b>CO3</b>      | Apply mathematical as well as applied methods in parallel and flow shop scheduling problems.                            | <b>K3</b>                    |
| <b>CO4</b>      | Identify job shop and stochastic scheduling problems and to apply various heuristics for the given job shop scheduling. | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 1   | 2   | 1   | 1   | 2   | -   | -   | -   | -    | -    | 2    |
| <b>CO2</b> | 3   | 1   | 2   | 1   | 1   | 2   | -   | -   | -   | -    | -    | 2    |
| <b>CO3</b> | 3   | 2   | 2   | 2   | 3   | 3   | -   | -   | -   | -    | -    | 2    |
| <b>CO4</b> | 3   | 2   | 2   | 3   | 3   | 3   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |  |                      |                       |                               |
|------------|--|----------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book  | Name of the Author/s | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Sequencing and Scheduling – An Introduction to the mathematics of the job-shop | Simon French         | Ellis Horwood Series  | 1 <sup>st</sup> Edition, 1981 |
| <b>2</b>   | An Introduction to the Mathematics of Planning and Scheduling                  | Geza Paul Bottlik    | Routledge             | 1 <sup>st</sup> Edition, 2017 |
| <b>3</b>   | Scheduling: Theory, Algorithms, and Systems                                    | Michael L. Pinedo    | Springer              | 5 <sup>th</sup> Edition, 2016 |

| Reference Books |  |                                |                         |                                 |
|-----------------|--|--------------------------------|-------------------------|---------------------------------|
| Sl. No          | Title of the Book  | Name of the Author/s           | Name of the Publisher   | Edition and Year                |
| 1               | Principles of Sequencing and Scheduling                              | Kenneth R. Baker, Dan Trietsch | John Wiley & Sons, Inc. | 2 <sup>nd</sup> Edition<br>2019 |
| 2               | Handbook of Scheduling: Algorithms, Models, and Performance Analysis | Joseph Y-T. Leung              | Chapman & Hall/CRC      | 1 <sup>st</sup> Edition<br>2004 |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/110/106/110106045/">https://archive.nptel.ac.in/courses/110/106/110106045/</a> |

## SEMESTER S6

### HEURISTICS FOR DECISION MAKING

|   |                 |                    |                |
|---|-----------------|--------------------|----------------|
| <b>Course Code</b>                          | <b>PEIET634</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T: P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                              | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>               | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To provide basic understanding of decision theory and various heuristic solution methods.
2. To enable students to apply these heuristic algorithms for various decision situations.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Decision theory:</b> Types of decision making environment, decision making under uncertainty and under risk, decision tree analysis.<br><b>Basic concepts &amp; evolutionary algorithms:</b> Genetic Algorithm (GA) - types of encoding, selection, crossover and mutation, binary, continuous hybrid and parallel GA, applications of GA in solving constrained and combinatorial optimization problems.   | <b>9</b>             |
| <b>2</b>          | <b>Ant colony algorithms:</b> Overview, basic algorithm, variants, Formalization and properties of ant colony optimization, applications in scheduling and vehicle routing problems.<br><b>Particle swarm optimization (PSO):</b> Basic concepts, swarm intelligence principles, computational characteristics, PSO in real number space, velocity updating, topology of the particle swarm, parameter selection; discrete PSO, PSO variants and PSO applications. | <b>9</b>             |
| <b>3</b>          | <b>Search based algorithms:</b> Scatter search - components, algorithm, applications, greedy randomized adaptive search procedure, Tabu Search (TS) - principles, neighbourhood, candidate list, short term and long term memory, threshold accepting, application of TS in decision making.<br><b>Simulated Annealing:</b> Main components of simulated annealing, homogenous vs. in-homogenous simulated annealing, annealing schedules,                         | <b>9</b>             |

|          |   |          |
|----------|---|----------|
|          | applications in sequencing and scheduling, travelling salesman problems. variants of simulated annealing.   |          |
| <b>4</b> | <b>Artificial Neural Networks:</b> Biological and artificial neural networks, basic concepts, generic algorithm, application areas, application of ANN to solve transportation problems, Knapsack Problems.<br><b>Constraint Programming:</b> Problem Formulation in constraint programming, basic search and constraint propagation, constraint programming vs mathematical programming, applications. | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/<br>Microproject | Internal<br>Examination-1<br>(Written) | Internal<br>Examination- 2<br>(Written) | Total     |
|------------|-----------------------------|--|---|-----------|
| <b>5</b>   | <b>15</b>                   | <b>10</b>                              | <b>10</b>                               | <b>40</b> |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A  | Part B  | Total     |
|---|---|-----------|
| <ul style="list-style-type: none"> <li>2 Questions from each module.</li> <li>Total of 8 Questions, each carrying 3 marks<br/>(8x3 = 24 marks)</li> </ul> | <ul style="list-style-type: none"> <li>Each question carries 9 marks.</li> <li>Two questions will be given from each module, out of which 1 question should be answered.</li> <li>Each question can have a maximum of 3 subdivisions.<br/>(4x9 = 36 marks)</li> </ul> | <b>60</b> |

**Course Outcomes (COs)**

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

| Course Outcomes |   | Bloom's<br>Knowledge<br>Level (KL) |
|-----------------|---|------------------------------------|
| <b>CO1</b>      | Apply decision theory concepts and evolutionary algorithms for decision making.   | <b>K3</b>                          |
| <b>CO2</b>      | Solve combinatorial optimization problems using nature inspired algorithms.   | <b>K3</b>                          |
| <b>CO3</b>      | Make use of effective searches to arrive at smart solutions to complex decision problems in engineering and management. | <b>K3</b>                          |
| <b>CO4</b>      | Apply artificial neural network and constraint programming to solve complex problems.                                   | <b>K3</b>                          |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

**CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)**

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 3   | 3   | -   | 3   | -   | -   | -   | -   | -    | -    | 3    |
| <b>CO2</b> | 3   | 3   | 3   | -   | 3   | -   | -   | -   | -   | -    | -    | 3    |
| <b>CO3</b> | 3   | 3   | 3   | -   | 3   | -   | -   | -   | -   | -    | -    | 3    |
| <b>CO4</b> | 3   | 3   | 3   | -   | 3   | -   | -   | -   | -   | -    | -    | 3    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| <b>Text Books</b> |  |   |  |                               |
|-------------------|--|---|--|-------------------------------|
| Sl. No            | Title of the Book                                      | Name of the Author/s  | Name of the Publisher                      | Edition and Year              |
| <b>1</b>          | Modern Heuristic Techniques for Combinatorial Problems | Colin R. Reeves   | Orient Black Swan                          | 1 <sup>st</sup> Edition, 1993 |
| <b>2</b>          | Metaheuristics for Hard Optimization                   | Johann Dréo, Alain Pétrowski, Patrick Siarry, Eric Taillard | Springer-Verlag Berlin and Heidelberg Gmbh | 1 <sup>st</sup> Edition, 2010 |
| <b>3</b>          | First Course in Artificial Intelligence                | Deepak Khemani  | McGraw Hill Education                      | 5 <sup>th</sup> Edition, 2017 |

| <b>Reference Books</b> |  |   |  |                                |
|------------------------|--|---|--|--------------------------------|
| Sl. No                 | Title of the Book  | Name of the Author/s  | Name of the Publisher                      | Edition and Year               |
| <b>1</b>               | Metaheuristic Search Concepts-A Tutorial with Applications to Production and Logistics | Günther Zäpfel, Roland Braune, Michael Bögl                         | Springer-Verlag Berlin and Heidelberg Gmbh | 20 <sup>th</sup> Edition, 2014 |
| <b>2</b>               | Meta-Heuristics: Theory and Applications   | Ibrahim H. Osman, James P. Kelly                                    | Springer                                   | 1 <sup>st</sup> Edition, 1996  |
| <b>3</b>               | Meta-Heuristics: Advances and Trends in Local Search Paradigms for optimization        | Stefan Voß, Silvano Martello, Ibrahim H. Osman, Cathérine Roucairol | Springer                                   | 1 <sup>st</sup> Edition, 1998  |
| <b>4</b>               | Genetic Algorithms + Data Structures = Evolution Programs                              | Z. Michalewicz  | Springer-Verlag Berlin and Heidelberg Gmbh | 2 <sup>nd</sup> Edition, 1994  |

| <b>Video Links (NPTEL, SWAYAM...)</b> |   |
|---------------------------------------|---|
| <b>Link ID</b>                        | <a href="https://archive.nptel.ac.in/courses/106/106/106106226/">https://archive.nptel.ac.in/courses/106/106/106106226/</a> |
|                                       | <a href="https://archive.nptel.ac.in/courses/110/106/110106134/">https://archive.nptel.ac.in/courses/110/106/110106134/</a> |



## SEMESTER S6

### ENTERPRISE RESOURCE PLANNING

|                                      |                 |                    |                |
|--------------------------------------|-----------------|--------------------|----------------|
| <b>Course Code</b>                   | <b>PEIET635</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week (L:T:P:R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                       | 5/3             | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>        | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To impart knowledge in architecture, different packages and modern trends in ERP .
2. To enable students to identify the important issues pertaining to implementation of ERP software in industries.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>   | <b>Contact Hours</b> |
|-------------------|---|----------------------|
| <b>1</b>          | <b>Introduction to Enterprise Resource Planning (ERP):</b> Overview, need, history, risks and benefits, enterprise applications, ERP and related technologies, ERP in manufacturing perspective.<br><b>Business process reengineering:</b> Business process modelling, business modeling, procedure for implementation, applications, case studies.   | <b>9</b>             |
| <b>2</b>          | <b>ERP software packages:</b> Selection of ERP package, various approaches to ERP selection, procurement process for ERP package, features of various modules of ERP.<br><b>ERP implementation:</b> Life cycle, methodologies, issues, hidden costs, vendors, consultants and users, ERP project management, ERP security, ERP training, change management, application support.                                    | <b>9</b>             |
| <b>3</b>          | <b>ERP Functional Modules:</b> Human capital management, financial management, procurement and inventory management, supplier relationship management, production planning and execution, supply chain planning, sales and service, warehouse and transport management, customer relationship management, quality management, maintenance management and enterprise asset management, product lifecycle management. | <b>9</b>             |

|   |   |   |
|---|---|---|
| 4 | <p><b>ERP Market:</b> SAP AG, Baan Company, PeopleSoft, Oracle Corporation, Microsoft Dynamics, JD Edwards world solution company, QUAD system software associates, Epicor ERP and Lawson ERP, open source ERP packages.</p> <p><b>ERP and eBusiness:</b> ERP II, future directions and trends in ERP, ERP resources on the web.</p> <p>Case studies in ERP: HRM, finance, production, materials, sales and distribution.</p> | 9 |
|---|---|---|

**Course Assessment Method  
(CIE: 40 marks, ESE: 60 marks)**

**Continuous Internal Evaluation Marks (CIE):**

| <i>Attendance</i> | <i>Internal Examination</i> | <i>Analyse</i> | <i>Evaluate</i> | <i>Total</i> |
|-------------------|-----------------------------|----------------|-----------------|--------------|
| 5                 | 15                          | 10             | 10              | 40           |

**Criteria for Assessment (Analyse and Evaluate): 20 marks**

| <b>Phases</b>   | <b>Assessment Criteria</b>  | <b>Marks</b> |
|-----------------|---|--------------|
| <b>Analyse</b>  | <p><b><i>Problem Definition</i></b></p> <p><i>a. Clearly defines the real-world quality issue.</i></p> <p><i>b. Examine and identify relevant contextual factors.</i></p>   | 5            |
|                 | <p><b><i>Problem Analysis</i></b></p> <p><i>a. Present a structured realistic solution methodology.</i></p> <p><i>b. Compare and justify the proposed solutions with evidence and logical reasoning</i></p>   | 5            |
| <b>Evaluate</b> | <p><b><i>Validation of Results</i></b></p> <p><i>a. Thoroughly evaluate the proposed solutions.</i></p> <p><i>b. Compares trade-offs, advantages, and disadvantages.</i></p> <p><i>c. Considers feasibility, scalability, and practical implications.</i></p> | 5            |
|                 | <p><b><i>Conclusion and Report Writing</i></b></p> <p><i>a. Summarizes procedure, findings and insights, limitation, and scope for future work.</i></p> <p><i>b. Preparation of Report with all components of project report.</i></p>                         | 5            |

### End Semester Examination Marks (ESE)

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A   | Part B   | Total     |
|--|--|-----------|
| <ul style="list-style-type: none"><li>2 Questions from each module.</li><li>Total of 8 Questions, each carrying 3 marks<br/>(8x3 = 24 marks)</li></ul> | <ul style="list-style-type: none"><li>Each question carries 9 marks.</li><li>Two questions will be given from each module, out of which 1 question should be answered.</li><li>Each question can have a maximum of 3 sub divisions.<br/>(4x9 = 36 marks)</li></ul> | <b>60</b> |

### Course Outcomes (COs)

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

| Course Outcomes |  | Bloom's Knowledge Level (KL) |
|-----------------|--|------------------------------|
| <b>CO1</b>      | Explain basics of ERP system and apply business process reengineering in organisations.  | <b>K3</b>                    |
| <b>CO2</b>      | Demonstrate software packages and its implementation in industries.                      | <b>K2</b>                    |
| <b>CO3</b>      | Apply functional modules of ERP in organisations.  | <b>K3</b>                    |
| <b>CO4</b>      | Identify ERP solution providers and to apply ERP in various sections in an organisation. | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 2   | 2   | -   | 2   | 2   | -   | -   | -   | 3   | 3    | -    | 3    |
| <b>CO2</b> | 2   | 2   | -   | 2   | 2   | -   | -   | -   | 3   | 3    | -    | 3    |
| <b>CO3</b> | 3   | 3   | -   | 3   | 3   | -   | -   | 2   | 3   | 3    | -    | 3    |
| <b>CO4</b> | 3   | 3   | -   | 3   | 3   | -   | -   | -   | 3   | 3    | -    | 3    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| <b>Text Books</b> |  |                             |                                       |                               |
|-------------------|--|-----------------------------|---------------------------------------|-------------------------------|
| <b>Sl. No</b>     | <b>Title of the Book</b>                               | <b>Name of the Author/s</b> | <b>Name of the Publisher</b>          | <b>Edition and Year</b>       |
| <b>1</b>          | ERP Demystified  | Alexis Leon                 | McGraw-Hill Education India Pvt. Ltd. | 3 <sup>rd</sup> Edition, 2015 |
| <b>2</b>          | Enterprise Resource Planning                           | Rajesh Ray                  | McGraw-Hill Education India Pvt. Ltd. | 1 <sup>st</sup> Edition, 2011 |
| <b>3</b>          | Enterprise Resource Planning                           | Mary Sumner                 | Pearson                               | 1 <sup>st</sup> Edition, 2004 |
| <b>4</b>          | Enterprise Resource Planning: A Managerial Perspective | Veena Bansal                | Pearson                               | 1 <sup>st</sup> Edition, 2013 |

| <b>Reference Books</b> |   |   |                              |                               |
|------------------------|---|---|------------------------------|-------------------------------|
| <b>Sl. No</b>          | <b>Title of the Book</b>  | <b>Name of the Author/s</b>                                       | <b>Name of the Publisher</b> | <b>Edition and Year</b>       |
| <b>1</b>               | Enterprise Resource Planning: Fundamentals of Design and Implementation | K. Ganesh, Sanjay Mohapatra, S. P. Anbu Udayasankar, P. Sivakumar | Springer                     | 1 <sup>st</sup> Edition, 2014 |
| <b>2</b>               | Enterprise Resource Planning  | Daniel E. O’Leary   | Cambridge University Press   | 1 <sup>st</sup> Edition, 2000 |
| <b>3</b>               | Concepts in Enterprise Resource Planning                                | Ellan F. Monk, Bret J. Wagner                                     | Thomson Course Technology    | 2 <sup>nd</sup> Edition, 2006 |

| <b>Video Links (NPTEL, SWAYAM...)</b> |   |
|---------------------------------------|---|
| <b>Link ID</b>                        | <a href="https://archive.nptel.ac.in/courses/112/107/112107238/">https://archive.nptel.ac.in/courses/112/107/112107238/</a> |

**SEMESTER S6**  
**APPLIED ERGONOMICS**

|                                       |                 |                    |                |
|---------------------------------------|-----------------|--------------------|----------------|
| <b>Course Code</b>                    | <b>PBIET604</b> | <b>CIE Marks</b>   | 60             |
| <b>Teaching Hours/Week (L:T:P: R)</b> | 3:0:0:1         | <b>ESE Marks</b>   | 40             |
| <b>Credits</b>                        | 4               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>         | None            | <b>Course Type</b> | Theory         |

**Course Objectives:**

1. To provide a detailed understanding of ergonomics and its application in the real working environments.
2. To provide an adequate insight about the functioning and capability of humans in work settings.

**SYLLABUS**

| <b>Module No.</b> | <b>Syllabus Description</b>   | <b>Contact Hours</b> |
|-------------------|---|----------------------|
| <b>1</b>          | <b>Introduction to ergonomics:</b> Definition, multidisciplinary engineering approach in ergonomics, various disciplines of ergonomics- industrial ergonomics, visual ergonomics and organizational ergonomics.<br><br><b>Human Technological System (HTS):</b> Concept and classifications, design of HTS, conceptual design, advanced development, detailed design and development, system reliability and modelling.     | <b>11</b>            |
| <b>2</b>          | <b>Design of displays and controls:</b> Definition and measurement of information, information processing in human, information processing model, design of visual, auditory, tactual and olfactory displays, input and output in displays, usage of text, graphics, symbols and codes in design of visual displays, motor skills in human, human control of systems, design of controls, design of hand tools and devices. | <b>11</b>            |
| <b>3</b>          | <b>Biomechanics and occupational stress:</b> Biomechanics, mechanics of upper extremity of hand, lower extremity, and foot, bending, lifting and carrying,  | <b>11</b>            |

|          |   |           |
|----------|---|-----------|
|          | human physiology, oxygen consumption, energy expenditure, cardiovascular and respiratory effects, work capacity and fatigue, occupational stress and musculoskeletal disorders.   |           |
| <b>4</b> | <b>Design of workplace and work environment:</b> Anthropometry and workplace, workspace and work surface design, principles of seat design, environmental factors influencing human performance, effects of illumination, noise and vibration in design of workplaces, design of virtual environments and applications, safety and security aspects in workplaces, assessment of risks in workplaces. | <b>11</b> |

**Suggestion on Project Topics:** Each student team can choose some simple close to real life projects from the areas discussed in the syllabus, such as

- Workplace design with digital human modelling software
- Design of thermal environment with software support
- Physiological measurement with heart rate monitor
- Anthropometric data collection of different demographic segments

**Course Assessment Method**  
(CIE: 60 marks, ESE: 40 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Project | Internal Ex-1 | Internal Ex-2 | Total |
|------------|---------|---------------|---------------|-------|
| 5          | 30      | 12.5          | 12.5          | 60    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A   | Part B   | Total     |
|--|--|-----------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 2 marks<br/>(8x2 =16 marks)</li> </ul> | <ul style="list-style-type: none"> <li>• 2 questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 2 sub divisions.</li> <li>• Each question carries 6 marks.<br/>(4x6 = 24 marks)</li> </ul> | <b>40</b> |

### Course Outcomes (COs)

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

| Course Outcomes |  | Bloom's Knowledge Level (KL) |
|-----------------|--|------------------------------|
| <b>CO1</b>      | Apply ergonomic concepts in design and modelling of human technological systems.   | <b>K3</b>                    |
| <b>CO2</b>      | Make use of display and control concepts in design of systems.                     | <b>K3</b>                    |
| <b>CO3</b>      | Apply biomechanics and human physiology in reduction of workplace risks.           | <b>K3</b>                    |
| <b>CO4</b>      | Develop workplaces that fits to the worker and to identify safe work environments. | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping (Mapping of Course Outcomes with Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 3   | 2   | -   | 3   | -   | -   | -   | 2   | -    | -    | 3    |
| <b>CO2</b> | 3   | 3   | 2   | -   | 3   | -   | -   | -   | 2   | -    | -    | 3    |
| <b>CO3</b> | 3   | 3   | 2   | -   | 3   | -   | -   | -   | 2   | -    | -    | 3    |
| <b>CO4</b> | 3   | 3   | 2   | -   | 3   | -   | -   | -   | 2   | -    | -    | 3    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

| Text Books |  |                      |                       |                               |
|------------|--|----------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book                            | Name of the Author/s | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Introduction to Human Factors and Ergonomics | Bridger, R. S.       | CRC                   | 4 <sup>th</sup> Edition, 2017 |
| <b>2</b>   | Human Factors in Engineering and Design      | Sanders, M. S.       | McGraw Hill           | 7 <sup>th</sup> Edition, 1992 |
| <b>3</b>   | Human Factors Engineering.                   | Phillips, C. A.      | John Wiley & Sons.    | 1 <sup>th</sup> Edition, 2000 |

| Reference Books |  |  |                       |                               |
|-----------------|--|--|-----------------------|-------------------------------|
| Sl. No          | Title of the Book  | Name of the Author/s                                     | Name of the Publisher | Edition and Year              |
| 1               | A Guide to Human Factors and Ergonomics                                    | Helander M.  | CRC Press             | 2 <sup>nd</sup> Edition, 2002 |
| 2               | Designing for People: An Introduction to Human Factors Engineering         | John D. Lee, Christopher D. Wickens, Liu Y., Boyle L. N. | CreateSpace           | 3 <sup>rd</sup> Edition, 2017 |
| 3               | Fitting the Human - Introduction to Ergonomics / Human Factors Engineering | Kroemer K. H. E.   | CRC Press             | 7 <sup>th</sup> Edition, 2017 |
| 4               | Handbook of Standards and Guidelines in Human Factors and Ergonomics       | Karwowski W., Szopa A., Soares M. M.                     | CRC Press             | 2 <sup>nd</sup> Edition, 2021 |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/110/105/110105162/">https://archive.nptel.ac.in/courses/110/105/110105162/</a> |

### PBL Course Elements

| L: Lecture<br>(3 Hrs.)                                    | R: Project (1 Hr.), 2 Faculty Members    |   |  |
|---|--|---|--|
|   | Tutorial                                 | Practical                                   | Presentation   |
| Lecture delivery  | Project identification                   | Simulation/<br>Laboratory<br>Work/Workshops | Presentation<br>(Progress and Final<br>Presentations)  |
| Group discussion  | Project Analysis                         | Data Collection                             | Evaluation   |
| Question answer<br>Sessions/<br>Brainstorming<br>Sessions | Analytical thinking and<br>self-learning | Testing                                     | Project Milestone Reviews,<br>Feedback, Project reformation<br>(If required)                               |
| Guest Speakers<br>(Industry Experts)                      | Case Study / Field<br>Survey Report      | Prototyping                                 | Poster Presentation/<br>Video Presentation: Students<br>present their results in a 2 to 5<br>minutes video |

### Assessment and Evaluation for Project Activity

| Sl. No       | Evaluation for  | Allotted Marks |
|--------------|---|----------------|
| 1            | Project Planning and Proposal                                       | 5              |
| 2            | Contribution in Progress Presentations and Question Answer Sessions | 4              |
| 3            | Involvement in the project work and Team Work                       | 3              |
| 4            | Execution and Implementation  | 10             |
| 5            | Final Presentations   | 5              |
| 6            | Project Quality, Innovation and Creativity                          | 3              |
| <b>Total</b> |   | <b>30</b>      |



**1. Project Planning and Proposal (5 Marks)**

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

**2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

**3. Involvement in the Project Work and Team Work (3 Marks)**

- Active participation and individual contribution
- Teamwork and collaboration

**4. Execution and Implementation (10 Marks)**

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

**5. Final Presentation (5 Marks)**

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

**6. Project Quality, Innovation, and Creativity (3 Marks)**

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches

**SEMESTER S6**

**STATISTICAL QUALITY CONTROL**

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>OEIET611</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

**Course Objectives:**

1. To enable the students to understand the principles of statistical quality control and its importance in industry.
2. To apply statistical quality control techniques to achieve continuous quality improvement in products and services.

**SYLLABUS**

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Concepts related to statistical quality control (SQC):</b> Introduction, definitions of quality, basic concept of quality, quality control, definition of SQC, benefits and limitations of SQC, quality objectives, quality policy, quality function, quality assurance, quality costs. Total quality management - philosophies, models, implementation.  | <b>9</b>             |
| <b>2</b>          | <b>Statistical process control:</b> Process variability, process control, control chart for variables - $\bar{x}$ and R charts, $\bar{x}$ and s charts, control chart for attributes - p chart, np chart, c chart, u chart and D chart. State of control and process out of control identification in control charts. Process capability - process capability indices and process capability analysis. | <b>9</b>             |

|          |   |          |
|----------|---|----------|
| <b>3</b> | <b>Acceptance Sampling Plans:</b> The concept of acceptance sampling, economics of inspections, types of acceptance sampling plans, probability of acceptance in single, double and multiple sampling techniques. Operating characteristic curve, AQL, LTPD, producer's risk, consumer's risk, AOQL and ATI. Standard sampling plans - MIL-STD 105E sampling method and its equivalents, Dodge - Romig sampling plans.                | <b>9</b> |
| <b>4</b> | <b>Six Sigma:</b> Meaning, history of six sigma, working of six sigma. six sigma roles and responsibilities, DMAIC process- various phases, six sigma in manufacturing and service industries.<br><b>Quality Management Systems:</b> Benefits of ISO registration, ISO 9000 series of standards, ISO 9001 requirements- implementation, documentation, internal audits, registration, sector-specific standards, ISO 14000 standards. | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| <b>Part A</b>  | <b>Part B</b>  | <b>Total</b> |
|--|--|--------------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p style="text-align: center;"><b>(8x3 =24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 sub divisions.</li> </ul> <p style="text-align: center;"><b>(4x9 = 36 marks)</b></p> | <b>60</b>    |

### Course Outcomes (COs)

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

| Course Outcome |  | Bloom's Knowledge Level (KL) |
|----------------|--|------------------------------|
| <b>CO1</b>     | Explain the concepts related to statistical quality control for quality improvement. | <b>K2</b>                    |
| <b>CO2</b>     | Apply statistical tools to monitor and improve process performance.                  | <b>K3</b>                    |
| <b>CO3</b>     | Apply the concepts and methodology of accepting sampling in industries.              | <b>K3</b>                    |
| <b>CO4</b>     | Demonstrate expertise in six sigma methodology and quality improvement tools.        | <b>K2</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO2</b> | 3   | 2   | 2   | 2   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO3</b> | 3   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO4</b> | 3   | 2   | 2   | 2   | -   | -   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |   |                      |                       |                               |
|------------|---|----------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book                               | Name of the Author/s | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Statistical Quality Control                     | Grant E. L           | McGraw Hill           | 7 <sup>th</sup> Edition, 2000 |
| <b>2</b>   | Fundamentals of Quality Control and Improvement | Amitava Mitra        | Pearson Education     | 7 <sup>th</sup> Edition, 2002 |

| Reference Books |   |                      |                       |                                |
|-----------------|---|----------------------|-----------------------|--------------------------------|
| Sl. No          | Title of the Book                           | Name of the Author/s | Name of the Publisher | Edition and Year               |
| 1               | Statistical Quality Control                 | Gupta R. C.          | Khanna Publishers     | 10 <sup>th</sup> Edition, 2003 |
| 2               | Introduction to Statistical Quality Control | Montgomery           | John Wiley & Sons     | 8 <sup>th</sup> Edition, 2019  |
| 3               | Statistical Quality Control                 | Mahajan M.           | Dhanpat Rai & Sons    | 3 <sup>rd</sup> Edition, 2001  |
| 4               | Transactional Six Sigma and Lean Servicing  | Betsi Harris Ehrlich | St. Lucie Press       | 1 <sup>st</sup> Edition, 2002  |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://nptel.ac.in/courses/110104080">https://nptel.ac.in/courses/110104080</a> |

**SEMESTER S6**

**QUALITY MANAGEMENT**

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>OEIET612</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

**Course Objectives:**

1. To enable the students to understand the fundamentals of quality management and its importance in organisations.
2. To apply quality management principles to real world scenarios.

**SYLLABUS**

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Introduction to Quality Management:</b> definitions of the terms - quality, quality planning, quality control, quality assurance, quality management. Total Quality Management (TQM) - overview on TQM, TQM axioms, consequences of total quality, barriers to TQM, Deming approach to TQM, Juran's quality trilogy, Crosby's fourteen steps for quality improvement. | <b>9</b>             |
| <b>2</b>          | <b>Strategic quality management:</b> cost of quality, customer satisfaction, quality function deployment (QFD), integrating quality into strategic management, quality and the management cycle, obstacles to achieving successful strategic quality management, supplier selection, concepts of 5S, six sigma and Kaizen. Lean principles.                              | <b>9</b>             |
| <b>3</b>          | <b>Human dimensions of TQM:</b> top management commitment, leadership for TQM, change management, resources for quality activities, training for quality, employee involvement, motivation, empowerment, team work, self managing teams, role of the quality director.   | <b>9</b>             |

|          |   |          |
|----------|---|----------|
| <b>4</b> | <b>Supporting tools, activities and techniques in TQM projects:</b> affinity diagram, brainstorming, cause and effect analysis, process flow chart, check sheets, scatter diagram, Pareto chart, histogram, control charts, process capability, Taguchi's robust design, total productive maintenance, failure mode and effect analysis. Quality systems: ISO 9000 family of standards, ISO 14000 standards, quality auditing - types and benefits. | <b>9</b> |
|----------|---|----------|

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| <b>Part A</b>  | <b>Part B</b>  | <b>Total</b> |
|--|--|--------------|
| <ul style="list-style-type: none"> <li>• 2 Questions from each module.</li> <li>• Total of 8 Questions, each carrying 3 marks</li> </ul> <p><b>(8x3 =24 marks)</b></p> | <ul style="list-style-type: none"> <li>• Each question carries 9 marks.</li> <li>• Two questions will be given from each module, out of which 1 question should be answered.</li> <li>• Each question can have a maximum of 3 sub divisions.</li> </ul> <p><b>(4x9 = 36 marks)</b></p> | <b>60</b>    |

### Course Outcomes (COs)

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

| Course Outcome |   | Bloom's Knowledge Level (KL) |
|----------------|---|------------------------------|
| <b>CO1</b>     | Explain the fundamentals of quality management and its importance in organizations. | <b>K2</b>                    |
| <b>CO2</b>     | Explain the strategic management principles and its implementation.                 | <b>K2</b>                    |
| <b>CO3</b>     | Demonstrate the various human dimensions of TQM.                                    | <b>K2</b>                    |
| <b>CO4</b>     | Apply quality improvement tools and techniques in industries.                       | <b>K3</b>                    |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 2   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO2</b> | 2   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO3</b> | 2   | 2   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| <b>CO4</b> | 3   | 3   | 3   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |                          |                            |                       |                               |
|------------|--------------------------|----------------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book        | Name of the Author/s       | Name of the Publisher | Edition and Year              |
| <b>1</b>   | Total Quality Management | Besterfield Dale H, et al. | Pearson Education     | 5 <sup>th</sup> Edition, 2018 |
| <b>2</b>   | Total Quality Management | Subburaj Ramasamy          | McGraw Hill Education | 4 <sup>th</sup> Edition, 2017 |



| Reference Books |  |                          |                       |                               |
|-----------------|--|--------------------------|-----------------------|-------------------------------|
| Sl. No          | Title of the Book  | Name of the Author/s     | Name of the Publisher | Edition and Year              |
| 1               | Total Quality Management   | K.C. Arora               | S K Kataria and Sons  | 4 <sup>th</sup> Edition, 2016 |
| 2               | Juran on "Leadership for Quality" An Executive Handbook              | Juran J. M.              | The Free Press        | 1 <sup>st</sup> Edition, 1989 |
| 3               | Managing for Total Quality - From Deming to Taguchi and SPC          | Logothetics N.           | Prentice Hall Ltd     | 1 <sup>st</sup> Edition, 1993 |
| 4               | Quality Planning and Analysis - From Product Development through Use | Juran J. M., Gryna F. M. | Tata McGraw Hill      | 3 <sup>rd</sup> Edition, 2004 |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/110/104/110104080/">https://archive.nptel.ac.in/courses/110/104/110104080/</a> |

## SEMESTER S6

### MAINTENANCE ENGINEERING AND MANAGEMENT

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>OEIET613</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To enable students to acquire knowledge in theory and practical application of Maintenance Engineering
2. To equip students in various tools and strategies for effective maintenance of a system.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Maintenance and reliability concepts:</b> Maintenance - need/purpose, basic and composite functions of maintenance, principles, objectives and benefits of maintenance. Defects and failures - definitions, basics of failures, sources of defects, failure rate, causes and types of failures. Reliability - basic concepts, bathtub curve. MTTF, MTBF, MTTR, MTBM, maintainability, availability, inter-relationship between productivity, quality, reliability, availability and maintainability in maintenance.   | <b>9</b>             |
| <b>2</b>          | <b>Maintenance strategies and classifications:</b> Maintenance strategies/ systems/ types – classifications, basis/factors considered for selection. Breakdown maintenance, corrective maintenance - concept, features. Routine maintenance and opportunistic maintenance - concept, features. Proactive maintenance - concept, features. Preventive maintenance- basics. Predictive maintenance - basics, advantages and disadvantages. Condition based maintenance - features. Merits and demerits of maintenance strategies. Condition monitoring concepts, monitoring systems (offline and online) and techniques/methods. | <b>9</b>             |

|          |   |          |
|----------|---|----------|
| <b>3</b> | <b>Tools, strategies and methods for effective maintenance:</b> Reliability centred maintenance (RCM) and its advantages. Fault tree analysis (FTA) - steps, features and merits. Event tree analysis (ETA) - features, merits and procedure. Root cause analysis (RCA), cause and effect analysis. Failure modes and effects analysis (FMEA). Failure mode effect and criticality analysis (FMECA). Six sigma maintenance, lean maintenance concept – features and benefits. zero maintenance concept, 5-S maintenance concept, maintenance effectiveness, overall equipment effectiveness (OEE).  | <b>9</b> |
| <b>4</b> | <b>Maintenance planning, scheduling, cost and budgeting:</b> Maintenance planning, procedure/steps in maintenance planning. Maintenance scheduling - basic techniques. Maintenance organization - factors affecting size and type of maintenance organization, objectives and characteristics, types of maintenance organisation - formal and informal organisation, classifications of maintenance organisation - line & staff, functional, centralized and decentralized maintenance organisation, merits and demerits. Maintenance costs - classification of maintenance costs, maintenance cost analysis. Maintenance Budget - types of maintenance budget, preparation of maintenance budget (basics). | <b>9</b> |

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| <b>Attendance</b> | <b>Assignment/<br/>Microproject</b> | <b>Internal<br/>Examination-1<br/>(Written)</b> | <b>Internal<br/>Examination- 2<br/>(Written)</b> | <b>Total</b> |
|-------------------|-------------------------------------|---|--|--------------|
| <b>5</b>          | <b>15</b>                           | <b>10</b>                                       | <b>10</b>  | <b>40</b>    |

### End Semester Examination Marks (ESE)

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A   | Part B  | Total     |
|--|---|-----------|
| <ul style="list-style-type: none"><li>2 Questions from each module.</li><li>Total of 8 Questions, each carrying 3 marks</li></ul> <p>(8x3 =24 marks)</p> | <ul style="list-style-type: none"><li>Each question carries 9 marks.</li><li>Two questions will be given from each module, out of which 1 question should be answered.</li><li>Each question can have a maximum of 3 sub divisions.</li></ul> <p>(4x9 = 36 marks)</p> | <b>60</b> |

### Course Outcomes (COs)

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

| Course Outcome |  | Bloom's Knowledge Level (KL) |
|----------------|--|------------------------------|
| CO1            | Explain the concept of maintenance and reliability and their inter-relationship.                                     | K2                           |
| CO2            | Demonstrate the different types and strategies of maintenance and different techniques used in condition monitoring. | K2                           |
| CO3            | Explain the tools, strategies and methods for assessing and ensuring effective maintenance .                         | K2                           |
| CO4            | Apply planning, scheduling, costing & budgeting in maintenance and preparation of maintenance budget.                | K3                           |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

### CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1 | 3   | 3   | 1   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| CO2 | 3   | 3   | 1   | -   | -   | -   | -   | -   | -   | -    | -    | 2    |
| CO3 | 3   | 3   | 1   | 1   | -   | -   | -   | -   | -   | -    | -    | 2    |
| CO4 | 3   | 3   | 1   | 2   | -   | -   | -   | -   | -   | -    | -    | 2    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |   |                      |                       |                               |
|------------|---|----------------------|-----------------------|-------------------------------|
| Sl. No     | Title of the Book   | Name of the Author/s | Name of the Publisher | Edition and Year              |
| 1          | Reliability, Maintenance and Safety Engineering, 1st edition, | Gupta A. K.          | Laxmi Publications    | 1 <sup>st</sup> Edition, 2009 |
| 2          | Reliability-Based Design                                      | Rao S. S.            | McGraw-Hill           | 1 <sup>st</sup> Edition, 1992 |
| 3          | Maintenance Engineering and Management                        | Srivastava, S.K.     | S. Chand              | Reprint Edition, 2020         |
| 4          | Maintenance Engineering and Management                        | Venkataraman.        | Prentice-Hall         | 4 <sup>th</sup> Edition, 2010 |

| Reference Books |  |                         |                         |                               |
|-----------------|--|-------------------------|-------------------------|-------------------------------|
| Sl. No          | Title of the Book  | Name of the Author/s    | Name of the Publisher   | Edition and Year              |
| 1               | Industrial Maintenance                                       | Brumbach M., Clade J.   | Delmar Cengage Learning | 2 <sup>nd</sup> Edition, 2013 |
| 2               | Handbook of Condition Monitoring: Techniques and Methodology | Davies A.               | Springer                | 8 <sup>th</sup> Edition, 1997 |
| 3               | Maintenance Engineering and Management                       | Mishra R. C., Pathak K. | PHI Learning.           | 2 <sup>nd</sup> Edition, 2012 |
| 4               | Maintenance Engineering Handbook                             | Mobley K.               | McGraw-Hill             | 8 <sup>th</sup> Edition, 2008 |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/112/105/112105232/">https://archive.nptel.ac.in/courses/112/105/112105232/</a> |
|                                | <a href="http://vlabs.iitkgp.ac.in/mssp/exp9/index.html">http://vlabs.iitkgp.ac.in/mssp/exp9/index.html</a>                 |

## SEMESTER S6

### HEURISTICS SOLUTION TECHNIQUES

|  |                 |                    |                |
|--|-----------------|--------------------|----------------|
| <b>Course Code</b>                         | <b>OEIET614</b> | <b>CIE Marks</b>   | 40             |
| <b>Teaching Hours/Week<br/>(L: T:P: R)</b> | 3:0:0:0         | <b>ESE Marks</b>   | 60             |
| <b>Credits</b>                             | 3               | <b>Exam Hours</b>  | 2 Hrs. 30 Min. |
| <b>Prerequisites (if any)</b>              | None            | <b>Course Type</b> | Theory         |

#### Course Objectives:

1. To provide basic understanding of various meta-heuristic solution algorithms.
2. To enable students to apply heuristic algorithms for solving optimization problems.

### SYLLABUS

| <b>Module No.</b> | <b>Syllabus Description</b>  | <b>Contact Hours</b> |
|-------------------|--|----------------------|
| <b>1</b>          | <b>Basic concepts &amp; Evolutionary algorithms:</b> Genetic algorithm (GA), basic concepts, types of encoding, selection, crossover and mutation, binary, continuous, hybrid and parallel GA, application of GA in solving constrained and combinatorial optimization problems, sequencing and scheduling problems and transportation problems.   | <b>8</b>             |
| <b>2</b>          | <b>Ant Colony Algorithms:</b> Overview, basic algorithm, variants, formalization and properties of ant colony optimization, applications in scheduling and vehicle routing problem.<br><b>Particle Swarm Optimization (PSO):</b> Basic concepts, swarm intelligence principles, computational characteristics, parameter selection, discrete PSO, variants and applications.   | <b>10</b>            |
| <b>3</b>          | <b>Search based algorithms:</b> Scatter search - Components, algorithm, applications, greedy randomized adaptive search procedure, Tabu Search (TS) - principles, neighbourhood, candidate list, short - term and long - term memory, threshold accepting, application of TS in decision making.<br><b>Simulated Annealing:</b> Main components of simulated annealing, homogeneous vs. in-homogenous simulated annealing, annealing schedules, applications in sequencing and scheduling, travelling salesman problem, variants of simulated annealing. | <b>10</b>            |

|          |  |          |
|----------|--|----------|
| <b>4</b> | <b>Artificial Neural Networks (ANN):</b> Basic concepts, biological and artificial neurons, learning rules and activation functions, ANN architecture, single layer and multi layer feed forward networks, back propagation networks and applications.<br><br><b>Fuzzy Systems:</b> Crisp logic, predicate logic, fuzzy logic, fuzzy rule based system, defuzzification methods, applications. | <b>8</b> |
|----------|--|----------|

**Course Assessment Method**  
(CIE: 40 marks, ESE: 60 marks)

**Continuous Internal Evaluation Marks (CIE):**

| Attendance | Assignment/<br>Microproject | Internal<br>Examination-1<br>(Written) | Internal<br>Examination- 2<br>(Written) | Total     |
|------------|-----------------------------|--|---|-----------|
| <b>5</b>   | <b>15</b>                   | <b>10</b>                              | <b>10</b>                               | <b>40</b> |

**End Semester Examination Marks (ESE)**

*In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions*

| Part A  | Part B  | Total     |
|---|---|-----------|
| <ul style="list-style-type: none"> <li>2 Questions from each module.</li> <li>Total of 8 Questions, each carrying 3 marks<br/>(8x3 = 24 marks)</li> </ul> | <ul style="list-style-type: none"> <li>Each question carries 9 marks.</li> <li>Two questions will be given from each module, out of which 1 question should be answered.</li> <li>Each question can have a maximum of 3 subdivisions.<br/>(4x9 = 36 marks)</li> </ul> | <b>60</b> |

**Course Outcomes (COs)**

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

| Course Outcomes |   | Bloom's<br>Knowledge<br>Level (KL) |
|-----------------|---|------------------------------------|
| <b>CO1</b>      | Apply evolutionary algorithms for decision making.  | <b>K3</b>                          |
| <b>CO2</b>      | Solve combinatorial optimization problems using nature inspired algorithms.   | <b>K3</b>                          |
| <b>CO3</b>      | Make use of effective searches to arrive at smart solutions to complex decision problems in engineering and management. | <b>K3</b>                          |
| <b>CO4</b>      | Apply artificial neural network and fuzzy logic concepts to solve complex problems.                                     | <b>K3</b>                          |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

**CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)**

|            | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| <b>CO1</b> | 3   | 3   | -   | 3   | 3   | -   | -   | 2   | 3   | 3    | -    | 3    |
| <b>CO2</b> | 3   | 3   | -   | 3   | 3   | -   | -   | 2   | 3   | 3    | -    | 3    |
| <b>CO3</b> | 3   | 3   | -   | 3   | 3   | -   | -   | 2   | 3   | 3    | -    | 3    |
| <b>CO4</b> | 3   | 3   | -   | 3   | 3   | -   | -   | 2   | 3   | 3    | -    | 3    |

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| <b>Text Books</b> |  |   |  |                               |
|-------------------|--|---|--|-------------------------------|
| <b>Sl. No</b>     | <b>Title of the Book</b>                               | <b>Name of the Author/s</b>                                 | <b>Name of the Publisher</b>               | <b>Edition and Year</b>       |
| <b>1</b>          | Modern Heuristic Techniques for Combinatorial Problems | Colin R. Reeves   | Orient Black Swan                          | 1 <sup>st</sup> Edition, 1993 |
| <b>2</b>          | Metaheuristics for Hard Optimization                   | Johann Dréo, Alain Pétrowski, Patrick Siarry, Eric Taillard | Springer-Verlag Berlin and Heidelberg GmbH | 1 <sup>st</sup> Edition, 2010 |

| <b>Reference Books</b> |  |   |  |                                |
|------------------------|--|---|--|--------------------------------|
| <b>Sl. No</b>          | <b>Title of the Book</b>   | <b>Name of the Author/s</b>   | <b>Name of the Publisher</b>                   | <b>Edition and Year</b>        |
| <b>1</b>               | Metaheuristic Search Concepts-A Tutorial with Applications to Production and Logistics | Günther Zäpfel , Roland Braune, Michael Bögl                        | Springer-Verlag Berlin and Heidelberg GmbHGmbH | 20 <sup>th</sup> Edition, 2014 |
| <b>2</b>               | Meta-Heuristics: Theory and Applications   | Ibrahim H. Osman, James P. Kelly                                    | Springer                                       | 1 <sup>st</sup> Edition, 1996  |
| <b>3</b>               | Meta-Heuristics: Advances and Trends in Local Search Paradigms for optimization        | Stefan Voß, Silvano Martello, Ibrahim H. Osman, Cathérine Roucairol | Springer                                       | 1 <sup>st</sup> Edition, 1998  |
| <b>4</b>               | Genetic Algorithms + Data Structures = Evolution Programs                              | Z. Michalewicz  | Springer-Verlag Berlin and Heidelberg GmbH     | 2 <sup>nd</sup> Edition, 1994  |

| <b>Video Links (NPTEL, SWAYAM...)</b> |   |
|---------------------------------------|---|
| <b>Link ID</b>                        | <a href="https://archive.nptel.ac.in/courses/106/106/106106226/">https://archive.nptel.ac.in/courses/106/106/106106226/</a> |
|                                       | <a href="https://archive.nptel.ac.in/courses/110/106/110106134/">https://archive.nptel.ac.in/courses/110/106/110106134/</a> |



## SEMESTER S6

### MODELLING AND SIMULATION LAB

|  |                 |                    |               |
|--|-----------------|--------------------|---------------|
| <b>Course Code</b>                     | <b>PCIEL607</b> | <b>CIE Marks</b>   | 50            |
| <b>Teaching Hours/Week (L: T:P: R)</b> | 0:0:3:0         | <b>ESE Marks</b>   | 50            |
| <b>Credits</b>                         | 2               | <b>Exam Hours</b>  | 2 Hrs 30 Min. |
| <b>Prerequisites (if any)</b>          | None            | <b>Course Type</b> | Lab           |

#### Course Objectives:

1. To make the students gain practical skills in applying system simulation techniques in various industrial and interdisciplinary areas.
2. To provide hands-on training on system modelling and behaviour.

| <b>Expt. No.</b> | <b>Experiments</b>   |
|------------------|--|
| <b>1</b>         | Exercise on random number generation and test of fitness using Excel and Statistical softwares |
| <b>2</b>         | Exercise on statistical distribution fitting using SPSS/ Minitab / Systat etc.                 |
| <b>3</b>         | Exercise on Monte-Carlo simulation using Excel.  |
| <b>4</b>         | Simulation of queuing systems using Simio / Arena / Promodel / Witness etc.                    |
| <b>5</b>         | Simulation of manufacturing systems using Simio / Arena / Promodel / Witness etc.              |
| <b>6</b>         | Simulation of healthcare systems using Simio / Arena / Promodel / Witness etc.                 |
| <b>7</b>         | Simulation of biological systems using Vensim / Powersim / Stella etc.                         |
| <b>8</b>         | Simulation of social systems using Vensim / Powersim / Stella etc.                             |
| <b>9</b>         | Simulation of industrial systems using ensim / Powersim / Stella etc.                          |
| <b>10</b>        | Apply system dynamics models for forecasting, financial analysis and decision making.          |

#### Course Assessment Method (CIE: 50 marks, ESE: 50 marks)

#### Continuous Internal Evaluation Marks (CIE):

| <b>Attendance</b> | <b>Preparation/Pre-Lab Work experiments, Viva and Timely completion of Lab Reports / Record (Continuous Assessment)</b> | <b>Internal Examination</b> | <b>Total</b> |
|-------------------|---|-----------------------------|--------------|
| <b>5</b>          | <b>25</b>   | <b>20</b>                   | <b>50</b>    |

**End Semester Examination Marks (ESE):**

| Procedure/<br>Preparatory<br>work/Design/<br>Algorithm | Conduct of experiment/<br>Execution of work/<br>troubleshooting/<br>Programming | Result with valid<br>inference/<br>Quality of Output | Viva<br>voce | Record | Total |
|--|---|--|--------------|--------|-------|
| 10   | 15  | 10   | 10           | 5      | 50    |

- *Submission of Record: Students shall be allowed for the end semester examination only upon submitting the duly certified record.*
- *Endorsement by External Examiner: The external examiner shall endorse the record*

**Course Outcomes (COs)**

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

| Course Outcome |  | Bloom's<br>Knowledge<br>Level (KL) |
|----------------|--|------------------------------------|
| CO1            | Apply the system concepts to understand a real world system.                         | K3                                 |
| CO2            | Distinguish a discrete and continuous system with respect to modelling.              | K4                                 |
| CO3            | Build various scenarios for a discrete system and simulate the same.                 | K3                                 |
| CO4            | Develop cause and effect relationships for continuous systems and simulate the same. | K3                                 |

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

**CO- PO Mapping (Mapping of Course Outcomes with Program Outcomes)**

|     | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|
| CO1 | 2   | 2   | 2   | 2   | 2   | 3   | -   | -   | 1   | 1    | -    | 2    |
| CO2 | 2   | 1   | 2   | 1   | 2   | 1   | -   | -   | 1   | 1    | -    | 2    |
| CO3 | 2   | 2   | 3   | 2   | 3   | 2   | -   | -   | 1   | 1    | -    | 2    |
| CO4 | 2   | 2   | 3   | 2   | 3   | 2   | -   | -   | 1   | 1    | -    | 2    |

1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

| Text Books |   |                                     |                         |                               |
|------------|---|-------------------------------------|-------------------------|-------------------------------|
| Sl. No     | Title of the Book                                       | Name of the Author/s                | Name of the Publisher   | Edition and Year              |
| 1          | Excel Data Analysis : Modeling and Simulation           | Hector Guerrero                     | Springer                | 2nd Edition, 2019             |
| 2          | Simio and Simulation - Modeling, Analysis, Applications | Jeffrey S. Smith, David T. Sturrock | Simio LLC               | 7 <sup>th</sup> Edition, 2024 |
| 3          | System Dynamics Modelling with Vensim                   | Juan Martin Garcia                  | Independently published | 1 <sup>st</sup> Edition, 2018 |

| Reference Books |   |                      |  |                                |
|-----------------|---|----------------------|--|--------------------------------|
| Sl. No          | Title of the Book   | Name of the Author/s | Name of the Publisher                                      | Edition and Year               |
| 1               | Simulation Modeling and Analysis                                      | A. M. Law            | McGraw Hill  | 6 <sup>th</sup> Edition, 2024  |
| 2               | System Simulation   | Geoffrey Gordon      | Prentice Hall India  | 2 <sup>nd</sup> Edition, 1979  |
| 3               | Discrete Event Simulation: Modeling, Programming and Analysis         | George Fishman       | Springer series in Operations Research and Financial Engg. | 1 <sup>st</sup> Edition, 2001  |
| 4               | System Simulation with Digital Computer                               | Deo Narsingh         | Prentice Hall India  | 24 <sup>th</sup> Edition, 2011 |
| 5               | Simulation  | Sheldon M Ross       | Elsevier   | 6 <sup>th</sup> Edition, 2023  |
| 6               | Business Dynamics – Systems Thinking and Modeling for a Complex World | John D Sterman       | McGraw Hill  | 1 <sup>st</sup> Edition, 2000  |

| Video Links (NPTEL, SWAYAM...) |   |
|--------------------------------|---|
| Link ID                        | <a href="https://archive.nptel.ac.in/courses/112/107/112107220/">https://archive.nptel.ac.in/courses/112/107/112107220/</a> |
|                                | <a href="https://archive.nptel.ac.in/courses/112/107/112107214/">https://archive.nptel.ac.in/courses/112/107/112107214/</a> |
|                                | <a href="https://archive.nptel.ac.in/courses/110/101/110101142/">https://archive.nptel.ac.in/courses/110/101/110101142/</a> |
|                                | <a href="https://archive.nptel.ac.in/courses/110/107/110107157/">https://archive.nptel.ac.in/courses/110/107/110107157/</a> |

## Continuous Assessment (25 Marks)

### 1. Preparation and Pre-Lab Work (7 Marks)

- Pre-Lab Assignments: Assessment of pre-lab assignments or quizzes that test understanding of the upcoming experiment.
- Understanding of Theory: Evaluation based on students' preparation and understanding of the theoretical background related to the experiments.

## **2. Conduct of Experiments (7 Marks)**

- Procedure and Execution: Adherence to correct procedures, accurate execution of experiments, and following safety protocols.
- Skill Proficiency: Proficiency in handling equipment, accuracy in observations, and troubleshooting skills during the experiments.
- Teamwork: Collaboration and participation in group experiments.

## **3. Lab Reports and Record Keeping (6 Marks)**

- Quality of Reports: Clarity, completeness and accuracy of lab reports. Proper documentation of experiments, data analysis and conclusions.
- Timely Submission: Adhering to deadlines for submitting lab reports/rough record and maintaining a well-organized fair record.

## **4. Viva Voce (5 Marks)**

- Oral Examination: Ability to explain the experiment, results and underlying principles during a viva voce session.

***Final Marks Averaging: The final marks for preparation, conduct of experiments, viva, and record are the average of all the specified experiments in the syllabus.***

## **Evaluation Pattern for End Semester Examination (50 Marks)**

### **1. Procedure/Preliminary Work/Design/Algorithm (10 Marks)**

- Procedure Understanding and Description: Clarity in explaining the procedure and understanding each step involved.
- Preliminary Work and Planning: Thoroughness in planning and organizing materials/equipment.
- Algorithm Development: Correctness and efficiency of the algorithm related to the experiment.
- Creativity and logic in algorithm or experimental design.

### **2. Conduct of Experiment/Execution of Work/Programming (15 Marks)**

- Setup and Execution: Proper setup and accurate execution of the experiment or programming task.

**3. Result with Valid Inference/Quality of Output (10 Marks)**

- Accuracy of Results: Precision and correctness of the obtained results.
- Analysis and Interpretation: Validity of inferences drawn from the experiment or quality of program output.

**4. Viva Voce (10 Marks)**

- Ability to explain the experiment, procedure results and answer related questions
- Proficiency in answering questions related to theoretical and practical aspects of the subject.

**5. Record (5 Marks)**

- Completeness, clarity, and accuracy of the lab record submitted