# SEMESTER 4

## INDUSTRIAL ENGINEERING

## SEMESTER S4

## MATHEMATICS FOR PHYSICAL SCIENCE– 4

## (C Group)

| | | | |
|---|---|---|---|
| **Course Code** | **GCMAT401** | **CIE Marks** | 40 |
| **Teaching Hours/Week (L: T:P: R)** | 3:0:0:0 | **ESE Marks** | 60 |
| **Credits** | 3 | **Exam Hours** | 2 Hr. 30 Min. |
| **Prerequisites (if any)** | Basic calculus. | **Course Type** | Theory |

**Course Objectives:**

1. To familiarize students with the foundations of probabilistic and statistical analysis mostly used in varied applications in engineering and science.
2. To provide the students with the basics of various numerical methods to develop problem solving skills used in various engineering disciplines.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | Random variables, Discrete random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Binomial distribution, Poisson distribution, Poisson distribution as a limit of the binomial distribution, Joint pmf of two discrete random variables, Marginal pmf, Independent random variables, Expected value of a function of two discrete variables.<br>**[Text 1: Relevant topics from sections 3.1 to 3.4, 3.6, 5.1, 5.2]** | **9** |

| | | |
|---|---|---|
| **2** | Continuous random variables and their probability distributions, Cumulative distribution function, Expectation, Mean and variance, Uniform, Normal and Exponential distributions, Joint pdf of two Continuous random variables, Marginal pdf, Independent random variables, Expectation value of a function of two continuous variables. **[Text 1: Relevant topics from sections 3.1, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2]** | **9** |
| **3** | Confidence Intervals, Confidence Level, Confidence Intervals and One-side confidence intervals for a Population Mean for large and small samples (normal distribution and *t*-distribution), Hypotheses and Test Procedures, Type I and Type II error, *z* Tests for Hypotheses about a Population Mean (for large sample), *t* Test for Hypotheses about a Population Mean (for small sample), Tests concerning a population proportion for large and small samples. **[Text 1: Relevant topics from 7.1, 7.2, 7.3, 8.1, 8.2, 8.3, 8.4]** | **9** |
| **4** | Newton-Raphson Method, Gauss Elimination Method ,Gauss - Jordan Method, Numerical solution of ordinary differential equations-Euler's method, Modified Euler's method, Runge - Kutta method of $2^{nd}$ Order, Numerical solution of Laplace equation –Jacobi's Method, Curve Fitting by Method of Least Squares - Straight lines, Parabola. **(Text 2: Relevant topics from sections 2.5,4.2,7.5,8.4,8.5,9.4)** | **9** |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 =24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the concept, properties and important models of discrete random variables and to apply in suitable random phenomena. | **K3** |
| **CO2** | Understand the concept, properties and important models of continuous random variables and to apply in suitable random phenomena. | **K3** |
| **CO3** | Estimate population parameters, assess their certainty with confidence intervals, and test hypotheses about population means and proportions using *z*-tests and the one-sample *t*-test. | **K3** |
| **CO4** | Apply numerical methods to find solutions of linear system of equations, ordinary differential equations and Laplace equations. | **K3** |

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

**CO-PO Mapping Table:**

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Probability and Statistics for Engineering and the Sciences | Devore J. L | Cengage Learning | 9th edition, 2016 |
| **2** | Introductory Methods of Numerical Analysis | S SSastry | PHI Learning Pvt Limited | 5th edition, 2012 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Probability, Random Variables and Stochastic Processes, | Papoulis, A. &Pillai, S.U., | McGraw Hill. | 4th edition, 2002 |
| **2** | Introduction to Probability and Statistics for Engineers and Scientists | Ross, S. M. | Academic Press | 6th edition, 2020 |
| **3** | Numerical methods for Engineers | Steven C. Chapra, Raymond P. Canale | McGraw Hill Education | 8th edition, 2021 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://archive.nptel.ac.in/courses/117/105/117105085/ |
| **2** | https://archive.nptel.ac.in/courses/117/105/117105085/ |
| **3** | https://archive.nptel.ac.in/courses/117/105/117105085/ |
| **4** | https://archive.nptel.ac.in/courses/111/107/111107105/ |

## SEMESTER S4

# MACHINE TOOLS AND DIGITAL MANUFACTURING

| Course Code | PCIET402 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L:T:P: R) | 3:1:0:0 | ESE Marks | 60 |
| Credits | 4 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To equip students with the foundational knowledge of metal cutting processes, including tool nomenclature, chip formation, and cutting force analysis.
2. To provide hands-on experience and theoretical understanding of operating conventional machine tools and CNC machines, emphasizing their construction, operation, and programming.
3. To familiarize students with the architecture and functions of digital manufacturing systems, Programmable Logic Controllers (PLCs), and the key principles of Industry 4.0, fostering their ability to implement advanced manufacturing strategies

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Metal Cutting:** Overview of metal cutting processes, Tool Nomenclature, Attributes of each tool nomenclature, Standardised systems of nomenclature of single point cutting tool like ASA, ORS, Case studies and examples with varying tool attributes to analyse their impact on surface roughness and material removal rate (MRR), Orthogonal and Oblique Cutting. Mechanism of metal removal, Primary and secondary deformation shear zones, Mechanism of chip formation, Types of chips and types of chip breakers.<br><br>Merchant's theory Friction forces in metal cutting, Analysis of cutting | 11 |

| | | |
|---|---|---|
| | forces (simple problems), Work done and power required.<br><br>Cutting Tool Materials, Properties and applications of various tool materials, Advanced tool materials and coatings, Thermal Aspects of Machining, Techniques for thermal management in machining.<br><br>Tool Wear and Mechanisms of tool wear, Types of tool wear, Role and types of cutting fluids. Tool life, Factors affecting tool life, Taylor's tool life equation (simple problems), Economics of Machining, case studies on machining economics. | |
| **2** | **Conventional Machine Tools:** Lathes Machine– Types of lathes and size, specification and parts, Work holding devices. Types of operations in a lathe, plain turning, taper turning, thread cutting and facing operations. Turning Centres, C axis machining, Vertical/Inclined turrets.<br><br>Milling machines - Types of milling machines, Milling operations, end milling and slot milling. Types of milling cutters, up milling and down milling. Work holding devices, Indexing and indexing heads, 5 and 6 axis milling.<br><br>Reciprocating machines- shapers, planers, slotting machines, broaching machines, uses and specific applications.<br><br>Grinding machines – Classification – Operations – Surface, cylindrical and centreless grinding machines. | **11** |
| **3** | **Computer Numeric Controlled Machines:** NC and CNC machines, classification and principle, Point to point, straight cut and contouring positioning - incremental and absolute systems – open loop and closed loop systems -Parts: Positional Encodes, axis and spindle drives, LM Guideways, ball screws, automatic tool changer(ATC).<br><br>**NC part programming:** part programming fundamentals - manual | **11** |

| | | |
|---|---|---|
| | programming –NC coordinate systems and axes – sequence number, preparatory functions, dimension words, speed word, feed world, tool world, miscellaneous functions, Tool nose radius compensation and constant surface speed control, Canned cycles and Multiple repetitive cycles.<br><br>**Programmable Logic Controllers (PLC):** Need – relays - logic ladder program –timers, simple problems only. | |
| **4** | **Digital Manufacturing:** Definition and Illustration of Digital Manufacturing, Operation reference mode of digital manufacturing system, Architecture of digital manufacturing system, General function structure model of digital manufacturing system.<br><br>Core pillars of Computer Integrated Manufacturing, Flexible manufacturing Cell (FMC), Automated Guided vehicles (AGV), Automated Storage and Retrieval Systems (ASRS), Industrial robots-major configurations and applications.<br><br>PLM and its implementation, Steps in PLM, manufacturing data and its use, Overview of Industry 4.0. | **11** |

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

### Continuous Internal Evaluation Marks (CIE):

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the different types of conventional and CNC machine tools, their parts, and their specific applications. | **K2** |
| **CO2** | Explain the mechanisms of metal removal, chip formation, tool wear and the role of tool angles in determining surface roughness and material removal rate (MRR). | **K2** |
| **CO3** | Apply knowledge to create and interpret part programs for CNC machines, including manual programming, canned cycles, and multiple repetitive cycles. | **K3** |
| **CO4** | Evaluate the economics of machining through case studies, considering factors such as cutting forces, tool life, and material costs to make informed decisions on machining strategies. | **K4** |

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 | 3 | - | | - | - | - | - | - | - | - | - | 2 |
| CO2 | 3 | 3 | | - | - | - | - | - | - | - | - | 2 |
| CO3 | 3 | 3 | 3 | - | 3 | - | - | - | - | - | - | 2 |
| CO4 | 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** |
| **1** | Manufacturing Process | H. N. Gupta, R.C. Gupta Arun Mittal | New Age International | 2nd Edition, 2009 |
| **2** | Computer control of manufacturing systems | Yoram Koren | TATA McGraw-Hill | 1st Edition, 1983 |
| **3** | Fundamentals of Digital Manufacturing Science | Zude Zhou, Shane (Shengquan) Xie, Dejun Chen | Springer London | 1st Edition, 2023 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Fundamentals of Machining and Machine Tools | Geoffrey Boothroyd, Winston A. Knight | CRC Press Inc. | 3rd Edition, 2005 |
| **2** | CAD/CAM Computer Aided Design and Manufacturing | P.Groover, E. M. Zimmers | Pearson Education | 1st Edition, 2014 |
| **3** | Programmable logic controllers | Petruzella Frank. D | McGraw-Hill | 2nd Edition, 2006 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Link ID** | https://onlinecourses.nptel.ac.in/noc24_me123/preview |
| | https://onlinecourses.nptel.ac.in/noc24_me100/preview |

## SEMESTER S4

## WORK SYSTEM DESIGN

| | | | |
|---|---|---|---|
| **Course Code** | **PCIET403** | **CIE Marks** | 40 |
| **Teaching Hours/Week (L:T:P: R)** | 3:1:0:0 | **ESE Marks** | 60 |
| **Credits** | 4 | **Exam Hours** | 2 Hrs. 30 Min. |
| **Prerequisites (if any)** | None | **Course Type** | Theory |

**Course Objectives:**

1. To familiarise concepts of work system design in organisations.
2. To enable students to utilize techniques in work system design for productivity improvement in organisations.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| **1** | **Productivity and Work Systems:** Concepts, definition and importance of productivity, holistic approach to productivity, productivity and living standards, measuring productivity, fractional and multifactor productivity, work systems and productivity, techniques for productivity improvement, techniques in work study for productivity improvement, effect of workplace environment and workplace design in productivity improvement. | **11** |
| **2** | **Method Study:** Definition and objectives of method study, procedure of method study, selection of work, recording the work and activities, classification of activities, representation of activities, use of different charts and diagrams, examining the work, developing methods, evaluation and implementation of method study. | **11** |

| | | |
|---|---|---|
| **3** | **Work Measurement and Standard Time:** Definition and objectives of work measurement, basic procedure of stop watch time study, classification of elements, breaking the job into elements, determination of sample size, performance rating systems, calculation of allowances and estimation of standard time, development of incentive schemes with examples. | **11** |
| **4** | **Indirect methods of work measurement:** Work sampling, determination of sample size, conducting work sampling study, calculation procedures, MTM and MOST in work measurement.<br>**Micro motion study:** Therbligs, film analysis and SIMO chart preparation, principles of motion economy pertaining to worker, workplace and tools, worker, applications of these principles in design. | **11** |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 =24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Make use of productivity concepts in an industry and identify the importance of work study and workplace environment | **K3** |
| **CO2** | Apply method study concepts and identify its use in productivity improvement | **K3** |
| **CO3** | Apply time study concepts of work measurement and identify the use of standard time in development of incentive schemes | **K3** |
| **CO4** | Utilize PMTS and Work sampling concepts in work measurement and identify the role of principles of motion economy in workplace design | **K3** |

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** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO2** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO3** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO4** | **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** |
| **1** | Introduction to work study | ILO | Oxford and IBH | 3rd Edition, 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Motion and time study design and measurement of work | Ralph M.Barnes | Wiley India Private Limited | 7th Edition, 2013 |
| **2** | Work systems: The Methods, Measurements and Management of works | Mikell P. Groover | Pearson International | 1st Edition, 2013 |
| **3** | Niebel's Methods, Standards and Work Design | Andris Freivalds, Benjamin Niebel | McGraw Hill | 13th Edition, 2013 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Link ID** | https://archive.nptel.ac.in/courses/112/107/112107249/ |

## SEMESTER S4

# THEORY OF MACHINES AND DESIGN

| Course Code | PBIET404 | CIE Marks | 60 |
|---|---|---|---|
| Teaching Hours/Week (L:T:P: R) | 3:0:0:1 | ESE Marks | 40 |
| Credits | 4 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To introduce different mechanisms and enable the students to do the kinematic analysis of planar mechanisms.
2. To discuss the theory of different machine elements in order to carry out the design.
3. To discuss the theories of failure and enable the students to do the strength based design for some practical applications such as shafts, gears and structural joints viz. riveted, bolted and weld joints at the basic level.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Kinematics and Mechanisms:** Mechanisms such as Quick return motion, steering mechanism, universal coupling.<br><br>**Kinematic analysis of planar mechanisms:** Kinematic chain, kinematic diagrams, Degrees of freedom, Grashof's condition, mechanical advantage; Position vector loop, velocity and acceleration diagrams of four bar chain and slider crank mechanisms. | **10** |

| | | |
|---|---|---|
| **2** | **Cams:** Radial cam- terminology; displacement, velocity, acceleration diagrams- for uniform velocity, uniform acceleration and SHM. Cam profile synthesis (knife edge follower).<br><br>**Friction clutch**- Design of plate friction clutch; Belt drive power transmission - open and crossed belt.<br><br>**Brakes and dynamometers (no derivations):** simple band brake, block brake, disk brake; Rope brake dynamometer. | **11** |
| **3** | **Introduction to stress analysis:** Behaviour of materials- elastic and plastic, Concept of Stress and Strain, Hooke's law (2D), principal stresses, maximum shear stress, bending and torsional stresses, combining stresses (2D), Mohr's circle, stress concentration factor; Stresses in pressure vessels.<br><br>**Design for strength:** Theories of failure- Max. normal stress, Max. shear stress theory and von Mises theory; factor of safety. Failure criteria for fatigue, endurance limit. Design of Shafts (with single pulley/gear mounted on it), key. | **12** |
| **4** | **Gears:** Types, Gear terminology, pressure angle, law of gearing, Gear trains- simple, compound and planetary, Lewis equation. Design of spur gears.<br><br>**Design of structural joints:** riveted joints, bolted joints and weld joints- butt and lap fillet welds. | **11** |

**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:

- Development and kinematic analysis of simple mechanisms.
- Cam profile synthesis.
- Design of a brake, clutch, shaft or spur gear using a design data book.
- Design of structural joints for some simple practical applications.
- Some simple case studies to understand and apply the theory/concepts discussed and learned during the lecture hours.

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 2 marks<br>**(8x2 =16 marks)** | • 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks.<br>**(4x6 = 24 marks)** | **40** |

**Course Outcomes (COs)**

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Analyse simple mechanisms using principles of kinematics. | **K4** |
| **CO2** | Execute the synthesis of radial cam profile and design of machine elements working on dry friction. | **K3** |
| **CO3** | Apply the principles of stress analysis to design components to resist failure by static loads. | **K3** |
| **CO4** | Apply principles of design for spur gear and structural joints. | **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 | 2 | 2 | - | 2 | - | - | - | 2 | 2 | - | 1 |
| **CO2** | 3 | 2 | 3 | - | - | - | - | - | 2 | 2 | - | 1 |
| **CO3** | 3 | 2 | 3 | - | 2 | 3 | - | - | 2 | 2 | - | 3 |
| **CO4** | 3 | 2 | 3 | - | 2 | 2 | - | - | 2 | 2 | - | 1 |

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Theory of machines and mechanisms | Ballaney. P. L. | Khanna Publishers | 21st Edition, 2020 |
| **2** | Theory of Machines | S. S. Rattan | Tata McGraw-Hill Education | 5th Edition, 2019 |
| **3** | Design of Machine Elements | Bhandari. V. B. | Tata McGraw-Hill Education | 5th Edition, 2020 |

| Design Data Books (Permitted for reference in the university examination) | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Design Data Handbook.; Mechanical Engineers in SI and Metric Units. | Mahadevan, K., and K. Balaveera Reddy | CBS Publishers & Distributors | 4th Edition, 2013 |
| **2** | Design Data: Data Book of Engineers | Faculty in ME, PSG College | Kalaikathir Achchagam | 4th Edition, 2020 |
| **3** | Machine Design Data Handbook | NarayanaIyengar B.R & Lingaiah K | Tata McGraw Hill/Suma Publications | 4th Edition, 2006 |

| Reference Books | | | | |
|---|---|---|---|---|
| **1** | Theory of Mechanisms and Machines | Amithabha Ghosh and Asok Kumar Malik | East West Press | 3rd Edition, 2011 |
| **2** | Theory of Machines: Kinematics and Dynamics | Sadhu Singh | Pearson Education | 3rd Edition, 2011 |
| **3** | Theory of Machines | John J. Uicker Gordon R. Pennock, Joseph E. Shigley | Oxford University Press | 5th Edition, 2017 |
| **4** | Machine Design | P C Sharma and D K Aggarwal | S K Kataria & Sons | 1997 |
| **5** | Design of Machinery | Robert L Norton | Tata McGraw-Hill | 2005 |
| **6** | Shigley's Mechanical Engineering Design | Richard G. Budynas, J. Keith Nisbett, Kiatfa Tangchaichit | The McGraw-Hill companies | 11th Edition, 2020 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/112104121 (Kinematics of Machines by Prof. Ashok K Mallik, IIT Kanpur) |
| **2** | https://archive.nptel.ac.in/courses/112/105/112105124/ (Design of Machine Elements-I, IIT Kharaghpur) |
| **3** | https://archive.nptel.ac.in/courses/112/105/112105124/ (Design of Machine Elements-I, IIT Kharaghpur) |
| **4** | https://archive.nptel.ac.in/courses/112/105/112105124/ (Design of Machine Elements-I, IIT Kharaghpur) |

## PBL Course Elements

| **L: Lecture** | **R: Project (1 Hr.), 2 Faculty Members** | | |
|---|---|---|---|
| **(3 Hrs.)** | **Tutorial** | **Practical** | **Presentation** |
| Lecture delivery | Project identification | Simulation/ Laboratory Work/ Workshops | Presentation (Progress and Final Presentations) |
| Group discussion | Project Analysis | Data Collection | Evaluation |
| Question answer sessions/ Brainstorming Sessions | Analytical thinking and self-learning | Testing | Project Milestone Reviews, Feedback, Project reformation (If required) |
| Guest Speakers (Industry Experts) | Case Study/ Field Survey Report | Prototyping | Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 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 |
| **Total** | | **30** |

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 S4

## ROBOTICS AND AUTOMATION

| Course Code | PEIET411 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L:T: P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To familiarise the concepts and applications of hydraulic and pneumatic automation.
2. To enable students to develop automation logic using PLC and other techniques.
3. To familiarise the basics of robotics and its applications.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to automation**: classification of drives-hydraulic and pneumatic-comparison. ISO symbol of fluid power generating elements-hydraulic pumps and motor gears, vane pumps, piston pumps.<br><br>**Control and regulating elements**: Pressure, flow and direction control valves, spool valves, electro hydraulic servo valves. | 9 |
| 2 | **Electrical control of pneumatic and hydraulic circuits:** interfacing with PLC, ladder diagrams, use of relays, timers and counters.<br><br>Typical Design methods of automation-ladder diagram, circuit sequencing, combinational logic design, cascading, Karnaugh map method. | 9 |

| | | |
|---|---|---|
| **3** | **Introduction to robotics:** Drive systems: AC and DC servo and stepper motors. Actuators: Pneumatic and hydraulic actuators, Sensors: Proximity and range sensors, force and torque sensors, velocity sensors, encoders, vision sensors.<br><br>**Classification of robots:** Work envelope, Classification of work cell layout. Consideration in work cell design. Flexible automation vs robotic technology. | **9** |
| **4** | **Industrial application of robots:** Spray painting, spot-welding, arc welding, drilling, assembly operation, loading unloading, role of a robot in a manufacturing cell. Safety considerations. | **9** |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 = 24marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the basics of hydraulic and pneumatic automation. | **K2** |
| **CO2** | Develop automation circuits for various industrial applications using control valves. | **K3** |
| **CO3** | Develop automation logic using PLC and other techniques. | **K3** |
| **CO4** | Understand the basics of Robotics. | **K2** |
| **CO5** | Understand the application of robotics in various industries. | **K2** |

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** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** |
| **CO2** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | | **-** | **-** | **-** | **3** |
| **CO3** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | | **-** | **-** | **-** | **3** |
| **CO4** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | | **-** | **-** | **-** | **3** |
| **CO5** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | | **-** | **–** | **-** | **3** |

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** | Hydraulics and Pneumatics | Jagadeesha T. | I K International Publishing House | 10th Edition, 2015 |
| **2** | Fluid Power with application | Antony Esposito | Prentice-Hall | 7th Edition, 2008 |
| **3** | Fluid power transmission a and control | Alavudeen A. | Charotar Publishing House | 1st Edition, 2008 |
| **4** | Introduction to Robotic Mechanic and Control | John J. Craig | Pearson Education International | 4th Edition, 2017 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Fluid Power Logic Circuit Design | Peter Rohner | MacMillan Press | 1st Edition,1994 |
| **2** | Introduction to Fluid Logic | E.C.Fitch and J.B.Surjaatmadja | McGrawHill | 1st Edition,1978 |
| **3** | Robot Dynamics and Control | Mark.W.Spong&M.Vidyasagar | John Wiley and Sons | 1st Edition, 2004 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/108105063 |
| **2** | https://nptel.ac.in/courses/108105088 |
| **3** | https://nptel.ac.in/courses/112105249 |
| **4** | https://onlinecourses.nptel.ac.in/noc23_de12 |

## SEMESTER S4

# INDUSTRIAL REFRIGERATION AND AIR CONDITIONING

| | | | |
|---|---|---|---|
| **Course Code** | **PEIET412** | **CIE Marks** | 40 |
| **Teaching Hours/Week (L:T:P: R)** | 3:0:0:0 | **ESE Marks** | 60 |
| **Credits** | 3 | **Exam Hours** | 2 Hrs. 30 Min. |
| **Prerequisites (if any)** | None | **Course Type** | Theory |

**Course Objectives:**

1. To provide students with a comprehensive understanding of the principles and applications of refrigeration and air conditioning systems.
2. To familiarise fundamental concepts of refrigeration systems, psychrometry, and air conditioning system design.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Refrigeration**: History, applications, and importance of refrigeration.<br><br>**Thermodynamics of Refrigeration**: Reversed Carnot cycle, heat pumps, refrigeration machines, limitations of the reversed Carnot cycle. Units of Refrigeration: Definition and practical examples.<br><br>**Air Refrigeration Systems**: Reversed Joule cycle, aircraft refrigeration systems (simple, bootstrap, regenerative, and reduced ambient systems).<br><br>**Special Refrigeration Systems**: Vortex tube refrigeration, Thermoelectric Refrigeration (Peltier Effect), Magnetic Refrigeration, Steam Jet Refrigeration. | 9 |

| | | |
|---|---|---|
| **2** | **Vapour Compression Systems**: Simple cycle, representation on T-s and P-h diagrams, Coefficient of Performance (COP), and methods to improve COP (superheating, undercooling, liquid suction heat exchanger).<br><br>**Multi-pressure Systems**: Multi-compression and multi-evaporator systems, inter-cooling, flash intercooling, flash gas removal, cascade systems.<br><br>**Refrigerants**: Properties, eco-friendly refrigerants, mixed refrigerants, selection criteria for different applications. | **9** |
| **3** | **Vapour Absorption Systems**: Ammonia-water system, Lithium bromide-water systems, Electrolux systems, comparison with vapour compression systems and drawbacks.<br><br>**Applications of Refrigeration**: Domestic refrigerators, water coolers, ice plants, cold storage, food preservation (plate freezing, quick-freezing).<br><br>**Refrigeration System Components**: Compressors, condensers, expansion devices, evaporators, cooling towers (types and applications), refrigerant leakage detection, refrigerant charging, and system controls. | **8** |
| **4** | **Psychrometry**: Properties of air (saturated, unsaturated, dry, wet, dew point, humidity levels), thermodynamic equations, adiabatic saturation process, psychrometric charts, processes (sensible heating/cooling, humidifying/dehumidifying), air washers, bypass factors, sensible heat factor, RSHF, GSHF.<br><br>**Air Conditioning Design**: Comfort and Industrial air conditioning. Comfort air conditioning factors, effective temperature, comfort charts, cooling load estimation, design conditions, supply conditions, fresh air supply.<br><br>**Air Conditioning Systems**: Room air conditioners, split systems, packaged systems, all-air systems, chilled water systems, winter and summer air conditioning, heating systems, humidifiers, year-round AC system and controls (thermostat, humidistat), air distribution systems (duct design), air conditioning for various environments (restaurants, hospitals, retail outlets, computer centers, theaters, industrial applications). | **10** |

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

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

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

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 = 24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

**Course Outcomes (COs)**

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Explain the fundamentals and thermodynamic principles of refrigeration systems. | **K3** |
| **CO2** | Analyse vapour compression systems and select appropriate refrigerants for various applications. | **K4** |
| **CO3** | Understand the working of vapour absorption refrigeration and to explore the various applications of refrigeration, and study the components of refrigeration systems. | **K3** |
| **CO4** | Apply psychrometric principles to analyse and design air conditioning systems. | **K3** |

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** | **3** | **2** | **2** | **1** | **1** | **-** | **-** | **-** | **-** | **-** | **2** | **3** |
| **CO2** | **3** | **2** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **2** | **3** |
| **CO3** | **3** | **2** | **3** | **2** | **1** | **-** | **-** | **-** | **-** | **-** | **2** | **3** |
| **CO4** | **3** | **3** | **2** | **2** | **1** | **2** | **-** | **-** | **-** | **2** | **3** | **3** |

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** | Refrigeration and Air Conditioning Technology | Bill Whitman, Bill Johnson, John Tomczyk | Cengage Learning | 8th Edition, 2023 |
| **2** | Refrigeration and Air Conditioning | G.F. Hundy, A.R. Trott, T.C. Welch | Butterworth-Heinemann | 5th Edition, 2021 |
| **3** | Refrigeration and Air Conditioning | C.P. Arora | McGraw Hill Education | 5th Edition, 2017 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Modern Refrigeration and Air Conditioning | Andrew D. Althouse, Carl H. Turnquist, Alfred F. Bracciano | Goodheart-Willcox | 21st Edition, 2022 |
| **2** | Air Conditioning Engineering | W.P. Jones | Arnold | 5th Edition, 2013 |
| **3** | Refrigeration and Air Conditioning Technology Handbook | J. Whitfield, P. Dincer | CRC Press | 2nd Edition, 2020 |
| **4** | Handbook of Air Conditioning and Refrigeration | Shan K. Wang | McGraw-Hill | 3rd Edition, 2017 |
| **5** | Practical Guide to Refrigeration and Air Conditioning | Minnick & Associates | Delmar Cengage Learning | 2nd Edition, 2016 |

| | | | | |
|---|---|---|---|---|
| **6** | Fundamentals of HVACR | Carter Stanfield, David Skaves | Pearson | 3rd Edition, 2016 |
| **7** | Air Conditioning and Refrigeration Repair | Roger A. Fischer, Ken Chernoff | McGraw-Hill | 2nd Edition, 2014 |
| **8** | Textbook of Refrigeration and Air Conditioning | R.K. Rajput | S. Chand Publishing | 6th Edition, 2016 |
| **9** | Principles of Refrigeration | Roy J. Dossat | Pearson Education | 5th Edition, 2019 |
| **10** | Air Conditioning Principles and Systems | Edward G. Pita | Prentice Hall | 4th Edition, 2017 |

| **Video Links (NPTEL, SWAYAM…)** | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | http://nptel.ac.in/courses/112105128/ |
| **2** | https://onlinecourses.nptel.ac.in/noc24_me77/preview |
| **3** | https://nptel.ac.in/courses/112105129 |
| **4** | https://archive.nptel.ac.in/courses/112/107/112107208/ |

## SEMESTER S4

# DYNAMICS OF MACHINERY

| Course Code | PEIET413 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To familiarise the rigid- body dynamics of kinematically driven machine components and perform the force analysis
2. To equip the students to analyze the effects of gyroscopic forces on vehicle stability, to control power and speed fluctuations in IC engines, and reduce machinery vibrations.
3. To outline the theoretical concepts of vibrations and to enable the students to perform the vibration analysis of single degree of freedom (SDOF) systems.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Introduction to Mechanisms and machines:** Mechanisms such as four bar chain, slider crank, quick return motion, steering mechanism, universal coupling.<br><br>**Static & Dynamic Force analysis:** Static equilibrium conditions, Two & three force members, four bar and slider crank mechanisms, method of virtual work; Force & moment equilibrium, Inertial forces, D' Alembert's principle. Dynamic analysis of four-bar and slider-crank mechanisms. | 9 |

| | | |
|---|---|---|
| **2** | **Gyroscopic couple:** gyroscopes, effect of gyroscopic couple on - bearings, stability of two wheel and four wheel vehicles.<br><br>**Balancing of rotating masses:** single mass, several masses in same and in different planes; Balancing of reciprocating masses, partial balancing of single cylinder and multi-cylinder inline engines | **9** |
| **3** | **Flywheels:** Applications in punching press, IC engines; turning moment diagrams-for four stroke IC engines; Coefficient of fluctuation of energy, speed; design of flywheels.<br><br>**Governors:** Types of governors, Watt, Porter and Proell governors-Isochronism, sensitivity and stability | **9** |
| **4** | **Free vibrations:** Undamped free vibrations of SDOF systems - natural frequency of longitudinal, transverse and torsional vibrations by Newton's method and energy method; Damped systems and critical damping, logarithmic decrement.<br><br>**Forced vibrations:** Forced harmonic vibration, rotating unbalance, magnification factor, resonance; whirling of rotating shafts, vibration isolation and transmissibility**.** | **9** |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 = 24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

**Course Outcomes (COs)**

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the functions of mechanisms and execute the force analysis of kinematic systems. | **K3** |
| **CO2** | Examine the balancing of rotating and reciprocating masses in machines; determine the gyroscopic effect on stability of vehicles. | **K3** |
| **CO3** | Understand the principle of governors/ flywheel for the control of speed/power fluctuation in engines or machines and execute its analysis and design. | **K3** |
| **CO4** | Determine the natural frequencies and examine free or harmonically excited vibration response of damped and undamped vibration. | **K3** |

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** | **3** | **2** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** |
| **CO2** | **3** | **2** | **3** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **3** |
| **CO3** | **3** | **2** | **3** | **-** | **-** | **2** | **-** | **-** | **-** | **-** | **-** | **3** |
| **CO4** | **3** | **2** | **3** | **-** | **3** | **2** | **-** | **-** | **-** | **-** | **-** | **3** |

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Theory of Machines and Mechanisms | Ballaney P. L. | Khanna Publishers | 21st Edition, 2020 |
| **2** | Theory of Machines | S. S. Rattan | Tata McGraw-Hill Education | 4th Edition, 2017 |
| **3** | Theory of vibration with applications | W. T Thomason | CBS Publishers | 1st Indian Edition, 1990 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Theory of Mechanisms and Machines | Amithabha Ghosh and Asok Kumar Malik | East West Press | 3rd Edition, 2011 |
| **2** | Kinematics and dynamics of machinery | Robert L Norton | McGraw-Hill Education | 1st Edition in SI units 2009 |
| **3** | Theory of Machines | Thomas Bevan | Pearson Education Ltd. | 3rd Edition, 2010 |

| | | | | |
|---|---|---|---|---|
| **4** | Theory of Machines and Mechanisms | John J. Uicker<br>Gordon R. Pennock,<br>Joseph E. Shigley | Oxford University Press | 5th Edition, 2017 |
| **5** | Mechanical vibrations and Industrial noise control | Lasithan L G | PHI Learning | 1st Edition, 2014 |

| **Video Links (NPTEL, SWAYAM…)** | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://nptel.ac.in/courses/112104121<br>https://archive.nptel.ac.in/courses/112/104/112104114/ |
| **2** | https://archive.nptel.ac.in/courses/112/104/112104114/ |
| **3** | https://archive.nptel.ac.in/courses/112/104/112104114/ |
| **4** | https://archive.nptel.ac.in/courses/112/107/112107212/ |

## SEMESTER S4

# MODERN AUTOMOTIVE TECHNOLOGIES

| Course Code | PEIET414 | CIE Marks | 40 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 3:0:0:0 | ESE Marks | 60 |
| Credits | 3 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Theory |

**Course Objectives:**

1. To provide a comprehensive understanding of modern automotive technologies, focusing on electric and hybrid vehicles and recent advancements in automotive power plants.
2. To familiarise advanced developments in autonomous vehicle technologies and fuel cells.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| 1 | **Electric and Hybrid Vehicle Technology:** Introduction to Vehicle Electrification: Low Emission Vehicle (LEV), Transitional Low Emission Vehicle (TLEV), Ultra Low Emission Vehicle (ULV), and Zero Emission Vehicle (ZEV).<br><br>**Basic components of electric vehicles:** Inverters, battery packs, battery management systems, motors, and electronic power control units.<br>**Electric wiring harness:** CAN Bus, Multiplex wiring. Regenerative braking. Factors to consider for converting automobiles to electric vehicles<br>**Hybrid Electric Vehicles:** Types: Series and parallel hybrid layouts, Comparison of power systems and control systems, Different modes of operation for best performance, Wireless Charging, Battery Recycling and Lifecycle Management | 8 |

| | | |
|---|---|---|
| **2** | **Recent Trends in Automotive Power Plants:** Stratified charge engines, Reactivity Controlled Compression Ignition engines (RCCI), Hydrogen engines, Flex fuel vehicles. Biofuels and synthetic fuels<br><br>**Vehicle Operation and Engine Control Systems*:*** Application of sensors, actuators, and microprocessors for optimal fuel economy and performance, electronic engine management systems, electronic cruise control; and chassis control systems<br><br>**Integrated Control Systems (Basics):** Advanced integration of vehicle control systems for enhanced performance and safety, AI and Machine Learning in engine control, Predictive maintenance systems. | **9** |
| **3** | **Autonomous Vehicle Technologies:** Autonomous vehicle levels (0-5), Sensor technologies (LiDAR, radar, cameras, ultrasonic sensors)<br><br>**Driver Assistance Systems (ADAS):** Vision systems in cars, Comprehensive driver assistance: lane recognition, traffic sign recognition, road recognition, and object recognition.<br><br>**Connected Vehicles and IoT (Basics):** Vehicle-to-Vehicle (V2V) communication, Telematics and applications, Cybersecurity in connected vehicles, Over-the-air (OTA) updates, 5G in automotive communication, Human-Machine Interfaces (HMI), Role of AI and ML in autonomous vehicles | **9** |
| **4** | **Advanced Electronics and Microcontroller Systems in Modern Vehicles*:*** Electronically controlled systems: Headlights, Sunroofs, Electro chromic mirrors, Head-up displays, Navigation systems, Automatic climate control, Anti-theft systems, Automatic door locks, Tyre pressure sensing, Automated wipers, Anti Lock braking system (ABS), Electronic Stability Control (ESP).<br><br>**Fuel Cells and Alternative Energy Systems:** Introduction to fuel cells: Operational voltages, types (Proton Exchange membrane fuel | **10** |

| | | |
|---|---|---|
| | cells, Alkaline fuel cells, Medium and High temperature fuel cells), Fuel choices, Fuel Processing, Fuel Stacks, Air supply, Auxiliary systems.<br><br>**Advanced Battery Technologies:** Solid-state batteries, Fast-charging technologies, Second-life applications of EV batteries.<br><br>**Sustainable Automotive Materials*:*** Use of lightweight materials, Recycling and end-of-life vehicle strategies, Vehicle-to-Grid (V2G) technology | |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

**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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br><br>**(8x3 = 24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the basic concepts and identify the components of electric and hybrid vehicles. | **K3** |
| **CO2** | Analyze advanced automotive power plants, control systems, and integrated vehicle control technologies to enhance performance, safety, and fuel economy. | **K4** |
| **CO3** | Apply the technologies used in autonomous and connected vehicles and their impact on vehicle safety and efficiency. | **K3** |
| **CO4** | Apply knowledge of modern automotive electronics and alternative energy systems to innovate and improve vehicle systems. | **K3** |

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** | **3** | **2** | **-** | **-** | **2** | **-** | **1** | **-** | **-** | **-** | **-** | **1** |
| **CO2** | **3** | **3** | **2** | **2** | **3** | **-** | **-** | **-** | **-** | **-** | **-** | **-** |
| **CO3** | **3** | **3** | **3** | **2** | **3** | **2** | **1** | **2** | **-** | **-** | **-** | **2** |
| **CO4** | 3 | 2 | 2 | **-** | 3 | 2 | 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** |
| **1** | Electric and Hybrid Vehicles: Design Fundamentals | Iqbal Husain | CRC Press | 3rd Edition, 2021 |
| **2** | Advanced Engine Performance Diagnosis | James D. Halderman | Pearson | 6th Edition, 2020 |
| **3** | Automotive Embedded Systems Handbook | Nicolas Navet, Francoise Simonot-Lion | CRC Press | 1st Edition, 2017 |
| **4** | Automotive Handbook | Bosch | Robert Bosch GmbH | 10th Edition, 2018 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Electric Vehicle Engineering | Perry MacMullen | McGraw-Hill Education | 1st Edition, 2021 |
| **2** | Build Your Own Electric Vehicle | Bob Brant, Seth Leitman | McGraw-Hill | 3rd Edition, 2013 |
| **3** | Modern Electric, Hybrid Electric, and Fuel Cell Vehicles | Mehrdad Ehsani, Yimin Gao, Stefano Longo, Kambiz Ebrahimi | CRC Press | 3rd Edition, 2018 |

| | | | | |
|---|---|---|---|---|
| **4** | Electric and Hybrid Vehicles: Technologies, Modeling, and Control - A Mechatronic Approach | Amir Khajepour, M. Saber Fallah, Avesta Goodarzi | Wiley | 1st Edition, 2014 |
| **5** | Automotive Control Systems: For Engine, Driveline, and Vehicle | Uwe Kiencke, Lars Nielsen | Springer | 2nd Edition, 2020 |
| **6** | Understanding Automotive Electronics | William B. Ribbens | Butterworth-Heinemann | 8th Edition, 2017 |
| **7** | Automotive Electrical and Electronic Systems | Tom Denton | Routledge | 5th Edition, 2019 |
| **8** | Automotive Mechatronics: Operational and Practical Issues | Bosch (Editor) | Springer | 1st Edition, 2018 |
| **9** | Connected and Autonomous Vehicles: Technologies, Applications, and Challenges | Rajkumar Buyya, Amir Vahid Dastjerdi | Springer | 1st Edition, 2021 |
| **10** | Autonomous Driving: Technical, Legal and Social Aspects | Markus Maurer, J. Christian Gerdes, Barbara Lenz, Hermann Winner | Springer | 1st Edition, 2016 |
| **11** | Automotive Electricity, Electronics and Computer Controls | Barry Hollembeak | Cengage Learning | 6th Edition, 2018 |
| **12** | Fuel Cell Fundamentals | Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz | Wiley | 3rd Edition, 2016 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | http://nptel.ac.in/courses/108103009/<br>https://onlinecourses.nptel.ac.in/noc23_ee01/preview<br>https://archive.nptel.ac.in/courses/108/106/108106170/ |
| **2** | https://archive.nptel.ac.in/courses/106/106/106106139/<br>https://onlinecourses.nptel.ac.in/noc21_ee32/preview<br>https://archive.nptel.ac.in/courses/108/108/108108123/ |
| **3** | https://archive.nptel.ac.in/courses/108/108/108108098/<br>http://www.digimat.in/nptel/courses/video/108108123/L18.html<br>https://onlinecourses.nptel.ac.in/noc23_ee61/preview |
| **4** | https://archive.nptel.ac.in/courses/108/106/108106170/<br>https://archive.nptel.ac.in/courses/103/102/103102015/<br>https://onlinecourses.nptel.ac.in/noc21_mm34/preview<br>https://nptel.ac.in/courses/108106182 |

## SEMESTER S4

# COMPUTER AIDED DESIGN AND ANALYSIS

| | | | |
|---|---|---|---|
| **Course Code** | **PEIET415** | **CIE Marks** | 40 |
| **Teaching Hours/Week (L:T:P:R)** | 3:0:0:0 | **ESE Marks** | 60 |
| **Credits** | 5/3 | **Exam Hours** | 2 Hrs. 30 Min. |
| **Prerequisites (if any)** | None | **Course Type** | Theory |

**Course Objectives:**

1. To initiate ideas for innovative designs and design modifications.
2. To use computer aided 3D modelling packages for demonstrating new designs.
3. To familiarize Engineering analysis of systems using software.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| **1** | **Introduction to Design:** Introduction to various stages of the design process: Formulation of problem, Generation of alternatives, Evaluation, Guided Redesign. Component design, product design and system design approaches and examples. Structural, thermal, flow kinematic and dynamic design considerations and software packages. Preliminary design and detailed design Practicing sessions for creating primary designs of components, products, and systems. | **9** |

| | | |
|---|---|---|
| **2** | **Introduction to computer Aided 3D Modelling:** Historical Development, Industrial Look at CAD/CAM, Application of computers in design, Benefits of CAD. CAD Environment, Packages, and Architectures. Basics of geometric and solid modelling. Geometric Features. Two dimensional and Three-Dimensional Operations. Degree of freedom and assembly constraints. Comparison of commercial packages advantageous and limitations. (Pro-E, Fusion 360, Catia, AutoCAD inventor, Solid works). Open-source packages. Practicing sessions for creating 3D models using any 3D modelling software package. | 9 |
| **3** | **Introduction to Structural Analysis:** Engineering Analysis, History, Advantages, Classification, Basic steps, 3D modelling and mesh generation. Role of finite element analysis in computer-aided design. Material properties for structural analysis. Boundary conditions and initial conditions. Analysis methods and convergence criteria. Post processing: representation, interpretation, and evaluation methods. Practicing sessions for structural analysis using any FEM package. Comparison of analytical solutions in the text books with simulation results. | 9 |
| **4** | **Heat Transfer and Fluid Flow Analysis:** Material properties for thermal and fluid analysis, Different types of boundary conditions and initial values for thermal and fluid flow problems. Solution methods and convergence criteria. Examples for Multiphysics problems and solution strategies. Solution procedure for thermo- mechanical and fluid structure interaction problems. Practicing sessions on heat transfer and fluid flow analysis using any FEM package. Comparison of analytical solutions in the text books with simulation results. | 9 |

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

### Continuous Internal Evaluation Marks (CIE):

| *Attendance* | *Internal Examination* | *Analyse* | *Evaluate* | *Total* |
|---|---|---|---|---|
| **5** | **15** | **10** | **10** | **40** |

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

| Phases | Assessment Criteria | Marks |
|---|---|---|
| **Analyse** | ***Problem Definition***<br>*a. Clearly defines the real-world quality issue.*<br>*b. Examine and identify relevant contextual factors.* | **5** |
| | ***Problem Analysis***<br>*a. Present a structured realistic solution methodology.*<br>*b. Compare and justify the proposed solutions with evidence and logical reasoning* | **5** |
| **Evaluate** | ***Validation of Results***<br>*a. Thoroughly evaluate the proposed solutions.*<br>*b. Compares trade-offs, advantages, and disadvantages.*<br>***c.*** *Considers feasibility, scalability, and practical implications.* | **5** |
| | ***Conclusion and Report Writing***<br>*a. Summarizes procedure, findings and insights, limitation, and scope for future work.*<br>*b. Preparation of Report with all components of project report.* | **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 |
|---|---|---|
| • 2 Questions from each module.<br>• Total of 8 Questions, each carrying 3 marks<br>**(8x3 = 24 marks)** | • Each question carries 9 marks.<br>• Two questions will be given from each module, out of which 1 question should be answered.<br>• Each question can have a maximum of 3 sub divisions.<br>**(4x9 = 36 marks)** | **60** |

## Course Outcomes (COs)

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

| Course Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Develop preliminary designs with understanding of structural, thermal, kinematic and dynamics engineering concepts. | **K3** |
| **CO2** | Develop engineering skills in the design using model generation. | **K3** |
| **CO3** | Analyse engineering designs using fundamental concepts of Engineering. | **K4** |
| **CO4** | Evaluate engineering designs using fundamental concepts of solid mechanics, fluid mechanics and heat transfer. | **K5** |

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** | **3** | **-** | **3** | **2** | **3** | **-** | **-** | **-** | **2** | **-** | **-** | **-** |
| **CO2** | **3** | **-** | **3** | **2** | **3** | **-** | **-** | **-** | **2** | **-** | **-** | **3** |
| **CO3** | **3** | **-** | **3** | **2** | **3** | **-** | **-** | **-** | **2** | **-** | **-** | **3** |
| **CO4** | **3** | **-** | **3** | **3** | **3** | **-** | **-** | **-** | **2** | **3** | **-** | **3** |

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** | Design and Engineering | Jayasree P. K. | CBS Publishers | 2nd Edition, 2020 |
| **2** | CAD/ CAM Theory and Practice | Ibrahim Zeid | McGraw Hill | 2nd Edition, 2007 |
| **3** | Introduction to Finite Elements in Engineering | T. R. Chandrupatla and A. D. Belegundu, | Pearson Education | 3rd Edition, 2001 |
| **4** | Computer Aided Design and Manufacturing, | M.P. Groover | Prentice Hall of India | 2nd Edition, 2016 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Engineering Design a project Based Approach | Dym C. L. | Wiley | 4th Edition, 2013 |
| **2** | A First course in Finite Element Method | Daryl Logan | Thomson Learning | 6th Edition, 2016 |
| **3** | Strength of Materials | Rattan | McGraw Hills | 3rd Edition, 2017 |
| **4** | Fluid Mechanics: Fundamentals and Applications | John. M. Cimbala | SIE Publishers | 4th Edition, 2019 |

| Video Links (NPTEL, SWAYAM…) | |
|---|---|
| **Module No.** | **Link ID** |
| **1** | https://archive.nptel.ac.in/courses/107/101/107101087/ |
| **2** | https://archive.nptel.ac.in/courses/112/102/112102101/ |
| **3** | https://archive.nptel.ac.in/courses/112/107/112107214/ |
| **4** | https://archive.nptel.ac.in/courses/103/107/103107096/ |

## SEMESTER S3/S4

# ECONOMICS FOR ENGINEERS

## (Common to All Branches)

| | | | |
|---|---|---|---|
| **Course Code** | **UCHUT346** | **CIE Marks** | 50 |
| **Teaching Hours/Week (L: T:P: R)** | 2:0:0:0 | **ESE Marks** | 50 |
| **Credits** | 2 | **Exam Hours** | 2 Hrs. 30 min. |
| **Prerequisites (if any)** | None | **Course Type** | Theory |

**Course Objectives:**

1. Understanding of finance and costing for engineering operation, budgetary planning and control
2. Provide fundamental concept of micro and macroeconomics related to engineering industry
3. Deliver the basic concepts of Value Engineering.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| **1** | Basic Economics Concepts - Basic economic problems – Production Possibility Curve – Utility – Law of diminishing marginal utility – Law of Demand - Law of supply – Elasticity - measurement of elasticity and its applications – Equilibrium- Changes in demand and supply and its effects<br>Production function - Law of variable proportion – Economies of Scale – Internal and External Economies – Cobb-Douglas Production Function | **6** |

| | | |
|---|---|---|
| **2** | Cost concepts – Social cost, private cost – Explicit and implicit cost – Sunk cost - Opportunity cost - short run cost curves - Revenue concepts<br>Firms and their objectives – Types of firms – Markets - Perfect Competition – Monopoly - Monopolistic Competition - Oligopoly (features and equilibrium of a firm) | **6** |
| **3** | Monetary System – Money – Functions - Central Banking –Inflation - Causes and Effects – Measures to Control Inflation - Monetary and Fiscal policies – Deflation<br>Taxation – Direct and Indirect taxes (merits and demerits) - GST<br>National income – Concepts - Circular Flow – Methods of Estimation and Difficulties - Stock Market – Functions- Problems faced by the Indian stock market-Demat Account and Trading Account – Stock market Indicators-SENSEX and NIFTY | **6** |
| **4** | Value Analysis and value Engineering - Cost Value, Exchange Value, Use Value, Esteem Value - Aims, Advantages and Application areas of Value Engineering - Value Engineering Procedure - Break-even Analysis - Cost-Benefit Analysis - Capital Budgeting - Process planning | **6** |

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

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

| Attendance | Assignment/ Microproject | Internal Examination-1 (Written) | Internal Examination- 2 (Written ) | Total |
|---|---|---|---|---|
| **10** | **15** | **12.5** | **12.5** | **50** |

**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 |
|---|---|---|
| • Minimum 1 and Maximum 2 Questions from each module.<br>• Total of 6 Questions, each carrying 3 marks<br>**(6x3 =18marks)** | • 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 8 marks.<br>**(4x8 = 32 marks)** | **50** |

## Course Outcomes (COs)

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

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand the fundamentals of various economic issues using laws and learn the concepts of demand, supply, elasticity and production function. | **K2** |
| **CO2** | Develop decision making capability by applying concepts relating to costs and revenue, and acquire knowledge regarding the functioning of firms in different market situations. | **K3** |
| **CO3** | Outline the macroeconomic principles of monetary and fiscal systems, national income and stock market. | **K2** |
| **CO4** | Make use of the possibilities of value analysis and engineering, and solve simple business problems using break even analysis, cost benefit analysis and capital budgeting techniques. | **K3** |

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

**CO-PO Mapping Table:**

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

| **Text Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Managerial Economics | Geetika, Piyali Ghosh and Chodhury | Tata McGraw Hill, | 2015 |
| **2** | Engineering Economy | H. G. Thuesen, W. J. Fabrycky | PHI | 1966 |
| **3** | Engineering Economics | R. Paneerselvam | PHI | 2012 |

| **Reference Books** | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Engineering Economy | Leland Blank P.E, Anthony Tarquin P. E. | Mc Graw Hill | 7TH Edition |
| **2** | Indian Financial System | Khan M. Y. | Tata McGraw Hill | 2011 |
| **3** | Engineering Economics and analysis | Donald G. Newman, Jerome P. Lavelle | Engg. Press, Texas | 2002 |
| **4** | Contemporary Engineering Economics | Chan S. Park | Prentice Hall of India Ltd | 2001 |

## SEMESTER S3/S4

# ENGINEERING ETHICS AND SUSTAINABLE DEVELOPMENT

| | | | |
|---|---|---|---|
| **Course Code** | **UCHUT347** | **CIE Marks** | 50 |
| **Teaching Hours/Week (L: T:P: R)** | 2:0:0:0 | **ESE Marks** | 50 |
| **Credits** | 2 | **Exam Hours** | 2 Hrs. 30 Min. |
| **Prerequisites (if any)** | None | **Course Type** | Theory |

**Course Objectives:**

1. Equip with the knowledge and skills to make ethical decisions and implement gender-sensitive practices in their professional lives.
2. Develop a holistic and comprehensive interdisciplinary approach to understanding engineering ethics principles from a perspective of environment protection and sustainable development.
3. Develop the ability to find strategies for implementing sustainable engineering solutions.

## SYLLABUS

| Module No. | Syllabus Description | Contact Hours |
|---|---|---|
| **1** | **Fundamentals of ethics** - Personal vs. professional ethics, Civic Virtue, Respect for others, **Profession and Professionalism,** Ingenuity, diligence and responsibility, Integrity in design, development, and research domains, Plagiarism, a balanced outlook on law - challenges - case studies, **Technology and digital revolution**-Data, information, and knowledge, Cybertrust and cybersecurity, Data collection & management, **High technologies: connecting people and places**-accessibility and social impacts, **Managing conflict**, Collective bargaining, **Confidentiality**, Role of confidentiality in moral integrity, **Codes of Ethics**.<br>**Basic concepts in Gender Studies** - sex, gender, sexuality, gender spectrum: beyond the binary, gender identity, gender expression, gender stereotypes, **Gender disparity and discrimination in education**, | **6** |

| | | |
|---|---|---|
| | employment and everyday life, History of women in Science & Technology, Gendered technologies & innovations**, Ethical values and practices in connection with gender** - equity, diversity & gender justice, **Gender policy and women/transgender empowerment initiatives.** | |
| **2** | **Introduction to Environmental Ethics:** Definition, importance and historical development of environmental ethics, key philosophical theories (anthropocentrism, biocentrism, ecocentrism). **Sustainable Engineering Principles:** Definition and scope, triple bottom line (economic, social and environmental sustainability), life cycle analysis and sustainability metrics. **Ecosystems and Biodiversity:** Basics of ecosystems and their functions, Importance of biodiversity and its conservation, Human impact on ecosystems and biodiversity loss, An overview of various ecosystems in Kerala/India, and its significance. **Landscape and Urban Ecology:** Principles of landscape ecology, Urbanization and its environmental impact, Sustainable urban planning and green infrastructure. | **6** |
| **3** | **Hydrology and Water Management:** Basics of hydrology and water cycle, Water scarcity and pollution issues, Sustainable water management practices, Environmental flow, disruptions and disasters. **Zero Waste Concepts and Practices:** Definition of zero waste and its principles, Strategies for waste reduction, reuse, reduce and recycling, Case studies of successful zero waste initiatives. **Circular Economy and Degrowth:** Introduction to the circular economy model, Differences between linear and circular economies, degrowth principles, Strategies for implementing circular economy practices and degrowth principles in engineering. **Mobility and Sustainable Transportation:** Impacts of transportation on the environment and climate, Basic tenets of a Sustainable Transportation design, Sustainable urban mobility solutions, Integrated mobility systems, E-Mobility, Existing and upcoming models of sustainable mobility solutions. | **6** |
| **4** | **Renewable Energy and Sustainable Technologies:** Overview of renewable energy sources (solar, wind, hydro, biomass), Sustainable technologies in energy production and consumption, Challenges and opportunities in renewable energy adoption. **Climate Change and Engineering Solutions:** Basics of climate change science, Impact of climate change on natural and human systems, Kerala/India and the Climate crisis, Engineering solutions to | **6** |

| | | |
|---|---|---|
| | mitigate, adapt and build resilience to climate change. **Environmental Policies and Regulations:** Overview of key environmental policies and regulations (national and international), Role of engineers in policy implementation and compliance, Ethical considerations in environmental policy-making. **Case Studies and Future Directions:** Analysis of real-world case studies, Emerging trends and future directions in environmental ethics and sustainability, Discussion on the role of engineers in promoting a sustainable future. | |

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

### Continuous Internal Evaluation Marks (CIE):

Continuous internal evaluation will be based on individual and group activities undertaken throughout the course and the portfolio created documenting their work and learning. The portfolio will include reflections, project reports, case studies, and all other relevant materials.

- The students should be grouped into groups of size 4 to 6 at the beginning of the semester. These groups can be the same ones they have formed in the previous semester.
- Activities are to be distributed between 2 class hours and 3 Self-study hours.
- The portfolio and reflective journal should be carried forward and displayed during the 7th Semester Seminar course as a part of the experience sharing regarding the skills developed through various courses.

| Sl. No. | Item | Particulars | Group/Individual (G/I) | Marks |
|---|---|---|---|---|
| 1 | Reflective Journal | Weekly entries reflecting on what was learned, personal insights, and how it can be applied to local contexts. | I | 5 |
| 2 | Micro project<br><br>(Detailed documentation of the project, including methodologies, findings, and reflections) | 1 a) Perform an Engineering Ethics Case Study analysis and prepare a report<br><br>1 b) Conduct a literature survey on 'Code of Ethics for Engineers' and prepare a sample code of ethics | G | 8 |
| | | 2. Listen to a TED talk on a Gender-related topic, do a literature survey on that topic and make a report citing the relevant papers with a specific analysis of the Kerala context | G | 5 |
| | | 3. Undertake a project study based on the concepts of sustainable development* - Module II, Module III & Module IV | G | 12 |
| 3 | Activities | 2. One activity* each from Module II, Module III & Module IV | G | 15 |
| 4 | Final Presentation | A comprehensive presentation summarising the key takeaways from the course, personal reflections, and proposed future actions based on the learnings. | G | 5 |
| | | Total Marks | | **50** |

*Can be taken from the given sample activities/projects

**Evaluation Criteria:**

- **Depth of Analysis**: Quality and depth of reflections and analysis in project reports and case studies.
- **Application of Concepts**: Ability to apply course concepts to real-world problems and local contexts.
- **Creativity**: Innovative approaches and creative solutions proposed in projects and reflections.
- **Presentation Skills**: Clarity, coherence, and professionalism in the final presentation.

## Course Outcomes (COs)

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

| Course Outcome | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Develop the ability to apply the principles of engineering ethics in their professional life. | **K3** |
| **CO2** | Develop the ability to exercise gender-sensitive practices in their professional lives | **K4** |
| **CO3** | Develop the ability to explore contemporary environmental issues and sustainable practices. | **K5** |
| **CO4** | Develop the ability to analyse the role of engineers in promoting sustainability and climate resilience. | **K4** |
| **CO5** | Develop interest and skills in addressing pertinent environmental and climate-related challenges through a sustainable engineering approach. | **K3** |

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

**CO-PO Mapping Table:**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | 3 | 2 | 3 | 3 | 2 | | 2 |
| **CO2** | | 1 | | | | 3 | 2 | 3 | 3 | 2 | | 2 |
| **CO3** | | | | | | 3 | 3 | 2 | 3 | 2 | | 2 |
| **CO4** | | 1 | | | | 3 | 3 | 2 | 3 | 2 | | 2 |
| **CO5** | | | | | | 3 | 3 | 2 | 3 | 2 | | 2 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Ethics in Engineering Practice and Research | Caroline Whitbeck | Cambridge University Press & Assessment | 2nd edition & August 2011 |
| **2** | Virtue Ethics and Professional Roles | Justin Oakley | Cambridge University Press & Assessment | November 2006 |
| **3** | Sustainability Science | Bert J. M. de Vries | Cambridge University Press & Assessment | 2nd edition & December 2023 |
| **4** | Sustainable Engineering Principles and Practice | Bhavik R. Bakshi, | Cambridge University Press & Assessmen | 2019 |
| **5** | Engineering Ethics | M Govindarajan, S Natarajan and V S Senthil Kumar | PHI Learning Private Ltd, New Delhi | 2012 |
| **6** | Professional ethics and human values | RS Naagarazan | New age international (P) limited New Delhi | 2006. |
| **7** | Ethics in Engineering | Mike W Martin and Roland Schinzinger, | Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi | 4" edition, 2014 |

**Suggested Activities/Projects:**

**Module-II**

- Write a reflection on a local environmental issue (e.g., plastic waste in Kerala backwaters or oceans) from different ethical perspectives (anthropocentric, biocentric, ecocentric).
- Write a life cycle analysis report of a common product used in Kerala (e.g., a coconut, bamboo or rubber-based product) and present findings on its sustainability.
- Create a sustainability report for a local business, assessing its environmental, social, and economic impacts
- Presentation on biodiversity in a nearby area (e.g., a local park, a wetland, mangroves, college campus etc) and propose conservation strategies to protect it.
- Develop a conservation plan for an endangered species found in Kerala.
- Analyze the green spaces in a local urban area and propose a plan to enhance urban ecology using native plants and sustainable design.
- Create a model of a sustainable urban landscape for a chosen locality in Kerala.

**Module-III**

- Study a local water body (e.g., a river or lake) for signs of pollution or natural flow disruption and suggest sustainable management and restoration practices.
- Analyse the effectiveness of water management in the college campus and propose improvements - calculate the water footprint, how to reduce the footprint, how to increase supply through rainwater harvesting, and how to decrease the supply-demand ratio
- Implement a zero waste initiative on the college campus for one week and document the challenges and

outcomes.

- Develop a waste audit report for the campus. Suggest a plan for a zero-waste approach.
- Create a circular economy model for a common product used in Kerala (e.g., coconut oil, cloth etc).
- Design a product or service based on circular economy and degrowth principles and present a business plan.
- Develop a plan to improve pedestrian and cycling infrastructure in a chosen locality in Kerala

**Module-IV**

- Evaluate the potential for installing solar panels on the college campus including cost-benefit analysis and feasibility study.
- Analyse the energy consumption patterns of the college campus and propose sustainable alternatives to reduce consumption - What gadgets are being used? How can we reduce demand using energy-saving gadgets?
- Analyse a local infrastructure project for its climate resilience and suggest improvements.
- Analyse a specific environmental regulation in India (e.g., Coastal Regulation Zone) and its impact on local communities and ecosystems.
- Research and present a case study of a successful sustainable engineering project in Kerala/India (e.g., sustainable building design, water management project, infrastructure project).
- Research and present a case study of an unsustainable engineering project in Kerala/India highlighting design and implementation faults and possible corrections/alternatives (e.g., a housing complex with water logging, a water management project causing frequent floods, infrastructure project that affects surrounding landscapes or ecosystems).

## SEMESTER S4

# MACHINE TOOLS LAB

| Course Code | PCIEL407 | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L: T:P: R) | 0:0:3:0 | ESE Marks | 50 |
| Credits | 2 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Lab |

**Course Objectives:**

1. To impart hands-on training on conventional and advanced machine tools.
2. To provide training in conventional and advanced welding technologies.

| Expt. No. | Experiments (Minimum 10 experiments should be completed) |
|---|---|
| 1 | Exercises on lathe: - Plain and step turning. |
| 2 | Exercises on lathe: Ball & curve, and Taper turning. |
| 3 | Exercises on lathe: - Thread cutting. |
| 4 | Exercises on shaping machine: machining of flat surfaces. |
| 5 | Exercises on shaping machine: machining of grooves and key ways. |
| 6 | Exercises on drilling machine: drilling, boring, reaming, tapping and countersinking etc. |
| 7 | Exercises on cylindrical grinding machine: Grinding of a plain cylindrical surface. |
| 8 | Exercises on surface grinding machine: Grinding of a flat surface. |
| 9 | Exercises on tool and cutter grinding machine: Grinding of a single-point cutting tool. |
| 10 | Exercises on milling machine: Plane and pocket milling operations. |
| 11 | Exercises on milling machine: Spur gear cutting operation. |
| 12 | Study and preparation of program, simulation and exercise on CNC lathe: turning, step turning, taper turning, thread cutting, ball and cup turning etc. |
| 13 | Study and preparation of program, simulation and exercise on CNC milling machine: surface milling, pocket milling, contour milling etc. |
| 14 | Exercises on arc welding: butt welding and lap welding of M.S. plates. |

| | |
|---|---|
| **15** | Exercises on gas welding: butt welding and lap welding of M.S. plates. |
| **16** | Exercises on TIG welding: butt welding and lap welding of M.S. plates. |

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

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

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

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

| Procedure/ Preparatory work/Design/ Algorithm | Conduct of experiment/ Execution of work/ troubleshooting/ Programming | Result with valid inference/ Quality of Output | Viva 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 Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Understand and recall the fundamental operations, processes, and safety practices of various machining tools such as lathes, shaping machines, drilling machines, and grinding machines. | **K2** |
| **CO2** | Apply their knowledge to perform practical machining tasks, such as turning, thread cutting, grinding, milling, and welding on different machines as per manufacturing drawings. | **K3** |
| **CO3** | Analyze machining processes to identify and troubleshoot potential issues, ensuring precision and efficiency in operations. | **K4** |
| **CO4** | Apply their skills to set up and operate CNC lathe and CNC machining centre, preparing programs, and conducting simulations for precise machining operations. | **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** | **3** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO2** | **3** | **-** | **-** | **3** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO3** | **3** | **-** | **-** | **2** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO4** | **3** | **-** | **-** | **1** | **-** | **-** | **-** | **-** | **-** | **-** | **-** | **2** |
| **CO5** | **3** | **-** | **-** | **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** | Production Technology | HMT | Tata McGraw Hill | 1st Edition, 2017 |
| **2** | Workshop Technology Part I | W. A. J. Chapman | ELBS & Edward Arnold Publishers | 5th Edition, 1972 |
| **3** | Numerical Control of Machine Tools | Yoram Koren | McGraw-Hill | 1st Edition, 2014 |

## 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

## SEMESTER S4

# WORK SYSTEM DESIGN LAB

| Course Code | PCIEL408 | CIE Marks | 50 |
|---|---|---|---|
| Teaching Hours/Week (L:T:P: R) | 0:0:3:0 | ESE Marks | 50 |
| Credits | 2 | Exam Hours | 2 Hrs. 30 Min. |
| Prerequisites (if any) | None | Course Type | Lab |

**Course Objectives:**

1. To equip students to carry out method study and work measurement in organisations.
2. To enable students to gain practical knowledge to improve productivity by optimising the attributes of the workplace and work environment.

| Expt. No. | Experiments (Minimum 10 experiments should be completed) |
|---|---|
| 1 | Method analysis on assembly tasks. |
| 2 | Micromotion study on recorded tasks. |
| 3 | Determination of standard time with time study. |
| 4 | Work sampling on recorded tasks. |
| 5 | Determination of standard time with methods time measurement. |
| 6 | Application of principles of motion economy in the workplace. |
| 7 | Determination of eye fatigue after tasks. |
| 8 | Determination of visual reaction time for various tasks. |
| 9 | Determination of auditory reaction time for various tasks. |
| 10 | Determination of energy expenditure for different activities. |
| 11 | Determination of performance with variation in workplace lighting. |
| 12 | Determination of static anthropometry in standing postures. |

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

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

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

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

| Procedure/ Preparatory work/Design/ Algorithm | Conduct of experiment/ Execution of work/ troubleshooting/ Programming | Result with valid inference/ Quality of Output | Viva 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 Outcomes | | Bloom's Knowledge Level (KL) |
|---|---|---|
| **CO1** | Apply method and motion study concepts in organizations | **K3** |
| **CO2** | Apply work measurement concepts in organizations | **K3** |
| **CO3** | Evaluate workers cognitive and physiological responses | **K4** |
| **CO4** | Analyse working environment and its effects in work places | **K4** |

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 | 3 | 2 | 3 | - | - | - | - | - | 2 | 2 | - | 2 |
| CO2 | 3 | 2 | 3 | - | - | - | - | - | 2 | 2 | - | 2 |
| CO3 | 3 | 2 | 3 | - | - | - | - | - | 2 | 2 | - | 2 |
| CO4 | 3 | 2 | 3 | - | - | - | - | - | 2 | 2 | - | 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** | Introduction to work study | ILO | Oxford and IBH | 3rd Edition 2015 |

| Reference Books | | | | |
|---|---|---|---|---|
| **Sl. No** | **Title of the Book** | **Name of the Author/s** | **Name of the Publisher** | **Edition and Year** |
| **1** | Motion and time study design and measurement of work | Ralph M.Barnes | Wiley India Private Limited | 7th Edition 2013 |
| **2** | Work systems: The Methods, Measurements and Management of works | Mikell P. Groover | Pearson International | 1st Edition 2013 |
| **3** | Niebel's Methods, Standards and Work Design | Andris Freivalds, Benjamin Niebel | McGraw Hill | 13th Edition 2013 |

## 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.***

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    - 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