| COMPUTATIONAL MATHEMATICS | | | |
|---|---|---|---|
| Course Code | **1MMAT101** | Scheme | 2026 |
| Type of Course | **PCC/PEC/OEC (Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Illustrate the fundamental concepts of distributions, linear algebra, differential equations and optimization arising in various fields engineering.
2. Derive the solution by applying the acquired knowledge and skills of statistical/numerical/optimization techniques to solve problems of probability distributions, linear algebra and differential equations.
3. Evaluate the solution of the problems using appropriate statistical numerical and optimization techniques to the real world problems arising in many practical situations
4. Compile the overall knowledge of probability distributions, linear algebra and optimization methods gained to engage in life – long learning.

**Module-1**

**Vector Spaces and Orthogonality:** Vector spaces and subspaces, linear independence, basis and dimension, four fundamental subspaces, change of basis. Inner product, orthogonal vectors, orthogonal projections, orthogonal bases. Eigen subspaces, Gram-Schmidt orthogonalization process, QR factorization and singular value decomposition.

Number of Hours:08

**Module-2**

**Multiple Random variables**: Joint probability mass functions and probability density functions, marginal density function, conditioning of random variables, statistical independence, correlation and covariance functions, covariance and correlation matrices, transformation of random variables, Markov and Chebyshev inequalities, Gaussian distribution-Multivariate normal density and its properties

Number of Hours:08

**Module-3**

**Principal component analysis and Factor analysis:** Overview of principal component analysis and factor analysis, eigen structure of covariance or correlation matrix. Principal component-standardized variables, covariance matrices. Factor model-principal component method, maximum likelihood method, factor scores, factor rotation.

Number of Hours:08

**Module-4**

**Engineering optimization:** Engineering applications of optimization, statement of an optimization problem-design vector, design constraints, constraint surface, objective function and objective function surface. Multivariable optimization with inequality constraints-Kuhn-Tucker conditions, constraint qualification.

Number of Hours:08

**Module-5**

**Numerical solution of differential equations:** Boundary value problems–finite difference method for linear and nonlinear problems, shooting method and Galerkin method. Finite difference methods for parabolic, elliptic and hyperbolic partial differential equations.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Richard A Johnson and Dean W Wichern, “Applied Multivariate Statistical Analysis”, Pearson Prentice Hall, 6th Edition, 2007, , ISBN-13: 978-0-13-187715-3, ISBN-10: 0-13-187715-1.

2. Gilbert Strang, "Linear Algebra and its Applications", Cengage Learning, 4th Edition, 2006, ISBN 9780980232

**Reference books / Manuals:**

1. Edgar G. Goodaire "Linear Algebra: Pure & Applied Kindle Edition", World Scientific, 1st Edition, 2013, ISBN-13: 978-9814508360.
2. M K Jain, S. R. K. Iyengar, R. K. Jain; Numerical methods for scientific and engineering computation; New Age International Publishers; 6th edition; 2012; ISBN-13: 978-81-224-2001-2.
3. Singiresu S. Rao, Engineering Optimization Theory and Practice, New Age International (P)Ltd., 3rd edition, 2009, ISBN: 81-224-1149-5.

**Web links and Video Lectures (e-Resources):**

NPTEL courses on Computational Mathematics
ASM International Digital Library.

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| ADVANCED MATERIALS AND PROCESSING | | | |
|---|---|---|---|
| Course Code | **1MME102** | Scheme | 2026 |
| Type of Course | **PCC/PEC/OEC (Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the structure, properties, and applications of advanced engineering materials.
2. Analyze processing techniques for composites, ceramics, polymers, and smart materials.
3. Evaluate material selection criteria for engineering applications.
4. Apply advanced manufacturing methods for material shaping and property enhancement.
5. Integrate sustainability and innovation in material processing and usage.

**Module-1**

**Advanced Metallic Materials:** High-strength steels, superalloys, titanium alloys. Nanostructured metals and metallic glasses. Heat treatment and property tailoring.

Number of Hours:08

**Module-2**

**Polymers and Composites:** Engineering polymers: thermoplastics, thermosets, elastomers. Polymer processing techniques (extrusion, injection molding, additive manufacturing). Composite materials: fiber-reinforced plastics, laminates, hybrid composites. Applications in aerospace, automotive, biomedical.

Number of Hours:08

**Module-3**

**Ceramics and Advanced Inorganics:** Structural ceramics: alumina, zirconia, silicon carbide. Glasses and glass-ceramics. Processing methods: sintering, hot pressing, sol-gel. Properties: thermal resistance, wear resistance, biocompatibility.

Number of Hours:08

**Module-4**

**Smart and Functional Materials:** Shape memory alloys, piezoelectric materials, magnetostrictive materials. Conducting polymers, nanomaterials, graphene, carbon nanotubes. Applications in sensors, actuators, energy storage.

Number of Hours:08

**Module-5**

**Advanced Processing Techniques:** Powder metallurgy, additive manufacturing (3D printing). Surface engineering: coatings, cladding, laser processing. Sustainable processing and recycling of materials. Case studies on industrial applications.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Callister, W.D., *Materials Science and Engineering: An Introduction*, Wiley, 2018, 10th Edition, ISBN 9781119405498.
2. Ashby, M.F., *Materials Selection in Mechanical Design*, Butterworth-Heinemann, 2017, 5th Edition, ISBN 9780081005996.

**Reference books / Manuals:**

1. .Shackelford, J.F., *Introduction to Materials Science for Engineers*, Pearson, 2015, 8th Edition, ISBN 9780133826654.

2. Dieter, G.E., *Mechanical Metallurgy*, McGraw-Hill, 1986, 3rd Edition, ISBN 9780070168930.
3. Chawla, K.K., *Composite Materials: Science and Engineering*, Springer, 2012, 3rd Edition, ISBN 9780387743646.
4. Hull, D. and Clyne, T.W., *An Introduction to Composite Materials*, Cambridge University Press, 1996, 2nd Edition, ISBN 9780521388559.

**Web links and Video Lectures (e-Resources):**

NPTEL courses on Advanced Materials.
MIT OpenCourseWare: Materials Science.
ASM International Digital Library.

**Teaching-Learning Process (Innovative Delivery Methods):**
The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**
The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| INDUSTRIAL INTERNET OF THINGS | | | |
|---|---|---|---|
| Course Code | **1MME103** | Scheme | 2026 |
| Type of Course | **PCC/PEC/OEC (Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | 3: 0 : 0 : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the architecture and components of the Industrial Internet of Things.
2. Analyze communication protocols and networking technologies used in IIoT.
3. Apply sensor integration, data acquisition, and edge computing concepts in industrial systems.
4. Evaluate cloud platforms, big data analytics, and cybersecurity in IIoT applications.
5. Design IIoT solutions for smart manufacturing, predictive maintenance, and industrial automation

**Module-1**

**Introduction to IIoT:** Evolution from IoT to IIoT. IIoT architecture: perception, network, edge, and application layers. Key enabling technologies: sensors, actuators, embedded systems. Industrial applications and case studies.

Number of Hours:08

**Module-2**

**Communication and Networking in IIoT:** Industrial communication protocols: MQTT, CoAP, OPC-UA, Modbus, Profibus. Wireless technologies: Wi-Fi, Bluetooth, ZigBee, LoRaWAN, 5G. Edge computing and gateways. Interoperability challenges.

Number of Hours:08

**Module-3**

**Sensors, Data Acquisition, and Edge Processing:** Smart sensors and transducers. Data acquisition systems and signal conditioning. Edge analytics and real-time processing. Integration with PLCs and SCADA systems.

Number of Hours:08

**Module-4**

**Cloud Platforms, Big Data, and Cybersecurity:** Cloud computing for IIoT: AWS IoT, Azure IoT Hub, Google Cloud IoT. Big data analytics and machine learning in IIoT. Cybersecurity challenges: authentication, encryption, intrusion detection. Standards and frameworks for IIoT security.

Number of Hours:08

**Module-5**

**IIoT Applications and Case Studies:** Smart manufacturing and Industry 4.0. Predictive maintenance and asset management. Digital twins and simulation. Case studies: automotive, energy, healthcare, and logistics.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**


1. Gubbi, J., Buyya, R., Marusic, S., and Palaniswami, M., *Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions*, Elsevier, 2013, ISBN 9780128053959.
2. Al-Fuqaha, A., *Internet of Things: Applications and Protocols*, CRC Press, 2019, 1st Edition, ISBN 9780367331580.


**Reference books / Manuals:**

1. Da Xu, L., He, W., and Li, S., *Internet of Things in Industries: A Survey*, IEEE Transactions on Industrial Informatics, 2014, ISBN 9781119226079.
2. Gilchrist, A., *Industry 4.0: The Industrial Internet of Things*, Apress, 2016, ISBN 9781484220467.
3. Boyes, H., *Cybersecurity and the Internet of Things*, IET, 2019, ISBN 9781785616317.

**Web links and Video Lectures (e-Resources):**

NPTEL courses on IoT and IIoT.
MIT OpenCourseWare: IoT Systems.
IEEE Xplore Digital Library (Industrial IoT papers).

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| ADVANCED DESIGN AND STRUCTURAL ANALYSIS | | | |
|---|---|---|---|
| Course Code | 1MME104A | Scheme | 2026 |
| Type of course | **IPCC** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00 : 02 | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SL:TW | : : : : | SEE Marks | 50 |
| Credits | **04** | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Apply advanced design principles to mechanical and structural systems.
2. Analyze stresses, deflections, and stability in complex structures.
3. Use finite element methods for structural analysis and optimization.
4. Integrate design standards and codes in engineering practice.
5. Conduct laboratory experiments to validate theoretical models and design solutions.

**Module-1**

**Fundamentals of Advanced Design:** Review of stress-strain relationships. Failure theories and design criteria. Reliability-based design.

Number of Hours: 08

**Module-2**

**Structural Analysis Concepts:** Analysis of beams, frames, and trusses. Deflection methods and energy principles. Stability of columns and structural members.

Number of Hours: 08

**Module-3**

**Finite Element Analysis (FEA):** Introduction to FEA. Discretization, shape functions, and stiffness matrices. Applications in structural mechanics.

Number of Hours:08

**Module-4**

**Advanced Topics in Structural Design:** Dynamic analysis of structures. Vibration and fatigue considerations. Optimization in structural design.

Number of Hours: 08

**Module-5**

**Case Studies and Applications: Design of machine components under complex loading. Structural design in aerospace, automotive, and civil engineering. Integration of CAD/CAE tools. Number of Hours: 8–10**

Number of Hours: 10

## PRACTICAL COMPONENTS OF IPCC

**FIXED SET OF EXPERIMENTS**

1. Stress analysis of beams using strain gauges.
2. Deflection measurement in cantilever and simply supported beams.
3. Buckling test on columns.
4. Modal analysis of vibrating structures.
5. Finite element modeling and validation using ANSYS/ABAQUS.
6. Fatigue testing of structural specimens.
7. Case study-based mini project (design + analysis).

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Budynas, R.G. and Nisbett, J.K., *Shigley's Mechanical Engineering Design*, McGraw-Hill, 2015, 10th Edition, ISBN 9780073398211.
2. Logan, D.L., *A First Course in the Finite Element Method*, Cengage Learning, 2016, 6th Edition, ISBN 9781305635111.

**Reference books / Manuals:**

1. Timoshenko, S.P. and Gere, J.M., *Theory of Elastic Stability*, McGraw-Hill, 1961, 2nd Edition, ISBN 9780070858206.
2. Rao, S.S., *Mechanical Vibrations*, Pearson, 2017, 6th Edition, ISBN 9780134361307.
3. Cook, R.D., *Concepts and Applications of Finite Element Analysis*, Wiley, 2001, 4th Edition, ISBN 9780471356059.

**Web links and Video Lectures (e-Resources):**

1 **NPTEL – Advanced Structural Analysis**
2 **MIT OpenCourseWare – Structural Mechanics (ocw.mit.edu in Bing)**
3 **ANSYS Learning Hub (ansys.com in Bing)**
4 **IEEE Xplore – Structural Analysis and Design Papers**

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with real-world design problems.
3 Simulation and Virtual Labs using FEA software.
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**CIE Practical component:**

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Rubrics for CIE – Continuous assessment:**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Rubrics for SEE / CIE Test:**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested rubrics for Practical continuous assessment:**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |

| | | | | |
|---|---|---|---|---|
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Suggested Learning Activities may include (but are not limited to):**

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching

- Role Play

| Term Work (TW) and Self Learning (SL) components in Number of hours per semester | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

**(i)Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| Table – ICs/IPCCs 1 Distribution of marks | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |

| | | |
|---|---|---|
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |
| | **Subtotal** | **10** |
| | **Total** | **25** |
| | | |

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| ADVANCED MANUFACTURING PROCESS & DIGITAL FACTORY | | | |
|---|---|---|---|
| Course Code | 1MME104B | Scheme | 2026 |
| Type of course | **IPCC** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00 : 02 | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SL:TW | : : : : | SEE Marks | 50 |
| Credits | **04** | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain advanced manufacturing processes and their applications in modern industries.
2. Analyze digital factory concepts, Industry 4.0 technologies, and cyber-physical systems.
3. Apply additive manufacturing, micro/nano fabrication, and sustainable processing methods.
4. Integrate automation, robotics, and IoT in digital manufacturing environments.
5. Conduct laboratory experiments to validate advanced manufacturing techniques and digital factory models.

**Module-1**

**Advanced Manufacturing Processes:** Evolution of manufacturing technologies. Non-traditional machining: EDM, ECM, laser machining, ultrasonic machining. Hybrid processes.

Number of Hours: 08

**Module-2**

**Additive Manufacturing & Micro/Nano Fabrication:** Principles of additive manufacturing (3D printing). Materials for AM: polymers, metals, ceramics. Micro/nano fabrication techniques: lithography, MEMS, nanomaterials.

Number of Hours: 08

**Module-3**

**Digital Factory Concepts:** Industry 4.0 and cyber-physical systems. Digital twins and simulation. Smart sensors, IoT integration, and cloud manufacturing.

.Number of Hours:08

**Module-4**

**Automation and Robotics in Manufacturing:** CNC, robotics, and flexible manufacturing systems. Intelligent automation and AI in manufacturing. Case studies in automotive, aerospace, and healthcare.

Number of Hours: 08

**Module-5**

**Sustainable Manufacturing & Case Studies:** Green manufacturing and energy-efficient processes. Recycling and remanufacturing. Case studies: digital factory implementation in global industries.

Number of Hours: 10

## PRACTICAL COMPONENTS OF IPCC

**FIXED SET OF EXPERIMENTS**

1. EDM machining of a sample workpiece.
2. Laser cutting/engraving demonstration.
3. Additive manufacturing (3D printing of a prototype).
4. CNC machining and tool path simulation.
5. Digital twin modeling using CAD/CAE software.
6. IoT-enabled monitoring of a manufacturing process.
7. Mini project on digital factory integration.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Groover, M.P., *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, Wiley, 2019, 7th Edition, ISBN 9781119474234.
2. Kalpakjian, S. and Schmid, S.R., *Manufacturing Engineering and Technology*, Pearson, 2014, 7th Edition, ISBN 9780133128741.

**Reference books / Manuals:**

1. Gibson, I., Rosen, D.W., and Stucker, B., *Additive Manufacturing Technologies*, Springer, 2015, 2nd Edition, ISBN 9781493921133.
2. Xu, X., *Digital Factory for Industrial Production*, Springer, 2008, ISBN 9781848003010.
3. Bi, Z.M., Xu, L.D., and Wang, C., *Internet of Things for Industrial Automation*, Springer, 2014, ISBN 9783642549113.

**Web links and Video Lectures (e-Resources):**

NPTEL – Advanced Manufacturing Processes
NPTEL – Industry 4.0 and IIoT
MIT OpenCourseWare – Manufacturing Systems (ocw.mit.edu in Bing)
IEEE Xplore – Digital Factory and Industry 4.0 Papers

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with real-world design problems.
3 Simulation and Virtual Labs using FEA software.
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**CIE Practical component:**
The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.
The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for CIE – Continuous assessment:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for SEE / CIE Test:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested rubrics for Practical continuous assessment:**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |

| | | | | |
|---|---|---|---|---|
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Suggested Learning Activities may include (but are not limited to):**

- Course Project
- Case Study Presentation
- Programming Assignment
- Tool/Software Exploration
- Literature Review
- Open Book Test (preferably at RBL4 and RBL5 levels)
- GATE-based Aptitude Test
- Assignment (at RBL3, RBL4, or RBL5 levels)
- Any other relevant and innovative academic activity
- Use of MOOCs and Online Platforms

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching

- Role Play

| Term Work (TW) and Self Learning (SL) components in Number of hours per semester | | |
|---|---|---|
| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

**(i)Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| Table – ICs/IPCCs 1 Distribution of marks | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |

| | | |
|---|---|---|
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |
| | **Subtotal** | **10** |
| | **Total** | **25** |
| | | |

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| COMPUTATIONAL FLUID DYNAMICS & ENERGY SYSTEMS | | | |
|---|---|---|---|
| Course Code | 1MME104C | Scheme | 2026 |
| Type of course | **IPCC** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00 : 02 | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SL:TW | : : : : | SEE Marks | 50 |
| Credits | **04** | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Apply governing equations of fluid dynamics and energy systems to engineering problems.
2. Analyze fluid flow and heat transfer using numerical methods.
3. Implement CFD techniques for solving industrial problems.
4. Evaluate energy system performance using simulation tools.
5. Conduct laboratory experiments and simulations to validate CFD models.

**Module-1**

**Fundamentals of Fluid Dynamics & Energy Systems:** Governing equations: continuity, momentum, and energy. Boundary conditions and assumptions. Energy conversion systems overview.

Number of Hours: 08

**Module-2**

**Numerical Methods in CFD:** Discretization techniques: finite difference, finite volume, finite element. Grid generation and mesh quality. Stability and convergence analysis.

Number of Hours: 08

**Module-3**

**Applications in Heat Transfer & Energy Systems:** Conduction, convection, and radiation modeling. CFD in combustion and renewable energy systems. Case studies in power plants and HVAC systems.

Number of Hours:08

**Module-4**

**Turbulence Modeling & Advanced Topics:** Turbulence models: RANS, LES, DNS. Multiphase flows and reacting flows. Optimization in energy systems.

Number of Hours: 08

**Module-5**

**Simulation Tools & Case Studies:** Introduction to CFD software (ANSYS Fluent, OpenFOAM). Validation and verification of CFD models. Case studies: automotive aerodynamics, wind energy, thermal management.

Number of Hours: 10

## PRACTICAL COMPONENTS OF IPCC

**FIXED SET OF EXPERIMENTS**

1. Laminar flow simulation in a pipe using CFD software.
2. Heat transfer analysis in a finned surface.
3. Turbulent flow modeling using RANS.
4. Combustion simulation in an energy system.
5. CFD analysis of wind turbine blade.
6. Validation of CFD results with experimental data.
7. Mini project on energy system optimization.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Versteeg, H.K. and Malalasekera, W., *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, Pearson, 2007, 2nd Edition, ISBN 9780131274983.
2. Anderson, J.D., *Computational Fluid Dynamics: The Basics with Applications*, McGraw-Hill, 1995, ISBN 9780070016859.

**Reference books / Manuals:**

1. Patankar, S.V., *Numerical Heat Transfer and Fluid Flow*, CRC Press, 1980, ISBN 9780891165224.
2. Tannehill, J.C., Anderson, D.A., and Pletcher, R.H., *Computational Fluid Mechanics and Heat Transfer*, CRC Press, 1997, 2nd Edition, ISBN 9780891165224.
3. Blazek, J., *Computational Fluid Dynamics: Principles and Applications*, Elsevier, 2015, 3rd Edition, ISBN 9780080999951.

**Web links and Video Lectures (e-Resources):**

- NPTEL – Computational Fluid Dynamics
- NPTEL – Energy Systems Engineering
- MIT OpenCourseWare – CFD & Heat Transfer (ocw.mit.edu)
- ANSYS Learning Hub (ansys.com in Bing)
- IEEE Xplore – CFD and Energy Systems Papers

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with CFD case studies.
3 Simulation and Virtual Labs using ANSYS/OpenFOAM.
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks.**
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**CIE Practical component:**

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for CIE – Continuous assessment:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for SEE / CIE Test:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested rubrics for Practical continuous assessment:**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |

| | | | | |
|---|---|---|---|---|
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Suggested Learning Activities may include (but are not limited to):**

Course Project (CFD simulation of energy system).
Case Study (industrial CFD application).
Literature Review (emerging CFD techniques).
Open Book Test (RBL4/RBL5).
GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of hours per semester

| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

**(i)Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| **Table – ICs/IPCCs 1 Distribution of marks** | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |

| | |
|---|---|
| **Subtotal** | **10** |
| **Total** | **25** |
| | |

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| ADVANCED MATERIALS ENGINEERING & CHARACTERIZATION | | | |
|---|---|---|---|
| Course Code | 1MME104D | Scheme | 2026 |
| Type of course | **IPCC** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00 : 02 | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SL:TW | : : : : | SEE Marks | 50 |
| Credits | **04** | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the structure, properties, and classification of advanced engineering materials.
2. Apply characterization techniques to evaluate microstructure, mechanical, thermal, and electrical properties.
3. Analyze the role of nanomaterials, composites, and smart materials in engineering applications.
4. Use advanced instrumentation (SEM, TEM, XRD, DSC, etc.) for material characterization.
5. Conduct laboratory experiments to validate theoretical knowledge and material performance.

**Module-1**

**Fundamentals of Advanced Materials**: Classification: metals, ceramics, polymers, composites, nanomaterials. Structure-property relationships. Processing and applications.

Number of Hours: 08

**Module-2**

**Mechanical Characterization**: Tensile, compression, hardness, impact, fatigue, and creep testing. Fracture mechanics and failure analysis. Case studies in structural materials.

Number of Hours: 08

**Module-3**

**Thermal and Electrical Characterization:** Thermal conductivity, expansion, and DSC/TGA analysis. Electrical conductivity, dielectric properties, and impedance spectroscopy. Applications in energy systems and electronics.

Number of Hours:08

**Module-4**

**Microstructural Characterization**: Optical microscopy, SEM, TEM. X-ray diffraction (XRD) and crystallography. Spectroscopy techniques: FTIR, Raman, EDS.

.

Number of Hours: 08

**Module-5**

**Advanced Topics and Case Studies:** Nanomaterials and smart materials characterization. Surface engineering and coatings. Case studies: aerospace, biomedical, and automotive materials.

Number of Hours: 10

## PRACTICAL COMPONENTS OF IPCC

**FIXED SET OF EXPERIMENTS**

1. Tensile and hardness testing of metals.
2. Impact and fatigue testing.
3. Thermal analysis using DSC/TGA.
4. Microstructural analysis using optical microscopy.
5. SEM/TEM demonstration and analysis.
6. XRD analysis of crystalline materials.
7. Mini project on advanced material characterization.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Callister, W.D. and Rethwisch, D.G., *Materials Science and Engineering: An Introduction*, Wiley, 2018, 10th Edition, ISBN 9781119405498.
2. Cullity, B.D. and Stock, S.R., *Elements of X-Ray Diffraction*, Pearson, 2014, 3rd Edition, ISBN 9780131786622.

**Reference books / Manuals:**

1. Shackelford, J.F., *Introduction to Materials Science for Engineers*, Pearson, 2015, 8th Edition, ISBN 9780133826654.
2. Leng, Y., *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley, 2008, ISBN 9780470823040.
3. Williams, D.B. and Carter, C.B., *Transmission Electron Microscopy: A Textbook for Materials Science*, Springer, 2009, 2nd Edition, ISBN 9780387765006.

**Web links and Video Lectures (e-Resources):**

NPTEL – Materials Characterization
NPTEL – Advanced Materials
MIT OpenCourseWare – Materials Science and Engineering (ocw.mit.edu)
ASM International Digital Library (asminternational.org)
IEEE Xplore – Materials Engineering Papers

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with material case studies.
3 Simulation and Virtual Labs (XRD, SEM, TEM).
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks.**
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

**CIE Practical component:**

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Rubrics for CIE – Continuous assessment:**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Rubrics for SEE / CIE Test:**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested rubrics for Practical continuous assessment:**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |

| | | | | |
|---|---|---|---|---|
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Suggested Learning Activities may include (but are not limited to):**

Course Project (material characterization study).

Case Study (failure analysis of materials).

Literature Review (emerging characterization techniques).

Open Book Test (RBL4/RBL5).

GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Term Work (TW) and Self Learning (SL) components in Number of hours per semester**

| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

**(i)Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| **Table – ICs/IPCCs 1 Distribution of marks** | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |

| | |
|---|---|
| **Subtotal** | **10** |
| **Total** | **25** |
| | |

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| ROBOTICS, AI, AND MECHATRONIC SYSTEMS | | | |
|---|---|---|---|
| Course Code | 1MME104E | Scheme | 2026 |
| Type of course | **IPCC** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00 : 02 | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SL:TW | : : : : | SEE Marks | 50 |
| Credits | **04** | Total Marks | 100 |
| Type of Examination (IPCC): | Theory- CIE +SEE, and Lab- CIE only. | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of robotics, AI, and mechatronic systems.
2. Analyze kinematics, dynamics, and control of robotic manipulators.
3. Apply AI techniques (machine learning, computer vision, intelligent control) to robotics.
4. Integrate sensors, actuators, and embedded systems in mechatronic applications.
5. Conduct laboratory experiments and projects involving robotics and AI-enabled mechatronic systems

**Module-1**

**Fundamentals of Robotics and Mechatronics:** Introduction to robotics and mechatronic systems. Components: sensors, actuators, controllers. Applications in manufacturing, healthcare, and automation.

Number of Hours: 08

**Module-2**

**Kinematics and Dynamics of Robots:** Forward and inverse kinematics. Dynamics of robotic manipulators. Trajectory planning and motion control.

Number of Hours: 08

**Module-3**

**AI in Robotics:** Machine learning basics for robotics. Computer vision and image processing. Intelligent control and decision-making.

Number of Hours:08

**Module-4**

**Mechatronic System Design:** Embedded systems and microcontrollers. Integration of sensors and actuators. Case studies in mechatronic product design.

Number of Hours: 08

**Module-5**

**Advanced Applications and Case Studies:** Collaborative robots (cobots). Autonomous mobile robots and drones. AI-enabled predictive maintenance. Case studies in Industry 4.0.

Number of Hours: 10

## PRACTICAL COMPONENTS OF IPCC

**FIXED SET OF EXPERIMENTS**

1. Kinematic analysis of a robotic arm.
2. Path planning and trajectory control.
3. Vision-based object detection using AI.
4. Integration of sensors and actuators in a mechatronic system.
5. Programming a mobile robot for navigation.
6. Embedded system-based robotic control.
7. Mini project on AI-enabled mechatronic application.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Craig, J.J., *Introduction to Robotics: Mechanics and Control*, Pearson, 2017, 4th Edition, ISBN 9780133489796.
2. Bishop, R.H., *Mechatronics: Principles and Applications*, CRC Press, 2006, ISBN 9780849319862.

**Reference books / Manuals:**

1. Siciliano, B. and Khatib, O., *Springer Handbook of Robotics*, Springer, 2016, 2nd Edition, ISBN 9783319325521.
2. Russell, S. and Norvig, P., *Artificial Intelligence: A Modern Approach*, Pearson, 2021, 4th Edition, ISBN 9780134610991.
3. Bolton, W., *Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering*, Pearson, 2015, 6th Edition, ISBN 9781292077227.

**Web links and Video Lectures (e-Resources):**

NPTEL – Robotics
NPTEL – Mechatronics
MIT OpenCourseWare – Artificial Intelligence (ocw.mit.edu)
IEEE Xplore – Robotics and AI Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Problem-Based Learning (PBL) with robotics case studies.
3 Simulation and Virtual Labs (MATLAB, ROS, OpenCV).
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).
The CIE Theory component will be **25 marks** and CIE Practical component will be **25 marks.**

The CIE Theory component consists of IA tests for 25 marks. The CIE Practical component for continuous assessments will be for 15 marks through rubrics and for lab tests will be for 10 marks.

- To qualify and become eligible to appear for SEE, in the **CIE theory component**, a student must score at least **40% of 25 marks**, i.e., **10 marks**.
- To qualify and become eligible to appear for SEE, in the **CIE Practical component**, a student must secure **a minimum of 40% of 25 marks**, i.e., **10 marks**.
- To pass the **SEE**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks**.
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks**.

**CIE Practical component:**

The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. The summation of all the experiments marks to be scaled down to 15 marks.

The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and scaled down to 10 marks. For laboratory test, the student is required to conduct one experiment.

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for CIE – Continuous assessment:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

## Rubrics for SEE / CIE Test:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested rubrics for Practical continuous assessment:**

| Performance Indicators | Excellent | Very Good | Good | Satisfactory |
|---|---|---|---|---|
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |

| | | | | |
|---|---|---|---|---|
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output (3) | Student will be able to run the program but not able to analyze the output (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

**Suggested Learning Activities may include (but are not limited to):**

Course Project (robotic system design).

Case Study (AI-enabled robotics).

Literature Review (emerging mechatronic technologies).

Open Book Test (RBL4/RBL5).

GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Term Work (TW) and Self Learning (SL) components in Number of hours per semester**

| Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.) | | |
|---|---|---|
| **Sl. No.** | **Term Work (TW) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |
| SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc. | | |
| **Sl. No.** | **Self-Learning (SL) Activity** | **Number of Hours / Semester** |
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

**(i)Theory component**

The CIE marks of 25 shall be earmarked for two tests.

The first test shall be conducted after completing two modules of the syllabus and the second one after completing the rest three modules.

Each test shall be conducted for 25 marks. The average of the two tests scaled down to 25 marks shall constitute the test marks for a maximum of 25 marks.

**(ii) Laboratory component**

Out of 25 marks, 15 marks shall be assigned for assessment as per the rubrics listed in the course syllabus.

The remaining 10 marks shall be based on the practical test conducted by two Internal examiners appointed by the HoD. The allotment of marks shall be as per the rubrics defined for regular class work and practical test as indicated in the Table – ICs/IPCCs 1.

(i) To qualify and become eligible to appear for the SEE of the IC/IPCC, a student shall secure at least 40 % of 25 marks, i.e., 10 marks, in the CIE theory component, and at least 40 % of 25 marks, i.e., 10 marks in the CIE Practical component.

| **Table – ICs/IPCCs 1 Distribution of marks** | | |
|---|---|---|
| **Component** | **Description** | **Marks** |
| **Allotment of marks for regular class work** | | |
| Ability in Conducting Experiments | Initiative, skill, safety practices, teamwork, and independent handling of equipment during regular lab sessions. | 5 marks |
| Laboratory Record / Journal | Regular and neat maintenance of lab record, accuracy of results, and timely submission. | 10 marks |
| | **Subtotal** | **15** |
| **Allotment of marks for CIE practical test** | | |
| Laboratory Test / Experiment Performance | Ability to set up apparatus, follow procedure, take observations, and obtain correct results in the test experiment. | 5 marks |
| Viva-Voce | Understanding of theory, concepts, and experimental procedure; ability to explain results and answer related questions. | 5 marks |

| | |
|---|---|
| **Subtotal** | **10** |
| **Total** | **25** |
| | |

**Passing requirement in SEE**

For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.

For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.

If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

**Semester - I**

| PRESS TOOL DESIGN | | | |
|---|---|---|---|
| Course Code | 1MME104F | CIE Marks | 50 |
| Teaching Hours/Week (L:T: P) | 3:0:2 | SEE Marks | 50 |
| Total Hours of Pedagogy | 120 | Total Marks | 100 |
| Credits | 04 | Exam Hours | 3 |

**Course objectives:**

- Understand press tool types,
- Knowledge of design and press tool operations which makes them aware of type applications,
- To know the force calculations in drawing,
- Awareness' of lubrications in drawing
- Knowledge of typical design of form tools.

**MODULE-1 (08 Hrs)**

**Introduction**: Elements of press tools, classification of press, High speed presses, press brakes, shearing theory, cutting force, elements of press tool, clearance between punch and die, shut height and daylight, press tonnage calculation.

**Strip Layout**: Basic rules, economic layout, bridge size, calculation of plug point/center of pressure.

**Press Tool Operations**: Piercing, blanking, slitting, cropping, trimming, shaving, lancing, bending, curling, calibrating, drawing, embossing, coining, flanging, fine blanking.

**MODULE-2 (08 Hrs)**

**Design of Press Tool Elements**: Die plates, punches, punch holder plates, stripper plates, and calculation of stripping force, bolster plates, pilots, ejectors, shedders, materials ops, pillar, bush, slender punches, stock guides, stock feeding device and die sets.

**Types of Press Tools**: Progressive tools, stage tools, compound tools, combination tools, cam actuated die, horn dies, sub press dies, inverted dies, bulging dies, levering dies, trimming dies, shaving dies, riveting dies, assembly dies, lamination dies.

**Extrusion**: Forward, backward, combined extrusion, modem metal forming techniques.

**MODULE-3 (08 Hrs)**

**Bending and Forming Dies**: Theory of bending, development of bend, spring back, correcting spring back, bending tools, U - bending, V -bending, forming tools, bending on press brake, bending force calculation.

**MODULE-4 (08 Hrs)**

**Drawing:** Theory of drawing, blank development, strain factor, calculation of number of stages of drawing, circular draw, rectangular draw, draw force calculation, lubrication. Defects and remedies, ironing.

**MODULE 5 (08 Hrs)**

**Preparation and Presentation of Typical Designs in the Form of Drawings for the Following**

1. Piercing & blanking tool.
2. Progressive tool
3. Stage tool
4. Bending tool
5. Compound tool.

**PRACTICAL COMPONENT OF IPCC**

| Sl. No. | Experiments |
|---|---|
| 1. | Design, Assembly & Drafting of a Simple Stage Tool |
| 2. | Design, Assembly & Drafting of a Progressive Tool |
| 3. | Design, Assembly & Drafting of a Compound Tool |
| 4. | Design, Assembly & Drafting of a Bends & Forming Tool |
| 5. | Design, Assembly & Drafting of a Blank & Draw Tool |

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

**CIE**

Two Tests each of **25 Marks**

1. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
2. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

**SEE**

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

**Suggested Learning Resources:**

**Books**

1. Basic die design, D. Eugene Ostergaard, McGraw Hill, 1963
2. Die Design Fundaments, J. R. Paquin, R.E Crowley Industrial Press Inc. 2nd edition
3. Press Tools, Prakash. H Joshi Wheeler Publisher
4. Progressive Dies, Dallas B. Daniel,Springer, publication, 2005.
5. Mining Engineering Handbook, Michigan -SME 3rd Edition by peter darling, 2011.
6. Die Design Hand Book -SMITH A. DAVID.SME 3rd edition, 1990.

**Web links and Video Lectures (e-Resources):**

**Activity Based Learning (Suggested Activities in Class)/ Practical Based learning**

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Explain the press tool types, | L2 |
| CO2 | Discuss the press tool design and operations which makes them aware of type applications, | L2 |
| CO3 | Calculate the force in drawing | L3 |
| CO4 | Describe the awareness of lubrications in drawing | L2 |
| CO5 | Exhibit the knowledge of typical design of form tools. | L3 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

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

| ADVANCED STRUCTURAL DYNAMICS AND VIBRATION CONTROL | | | |
|---|---|---|---|
| Course Code | 1MME105A | Scheme | 2026 |
| Type of Course | PEC(Theory) | Semester | 01 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | 3 | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the structure, properties, and applications of advanced engineering materials.
2. Analyze processing techniques for composites, ceramics, polymers, and smart materials.
3. Evaluate material selection criteria for engineering applications.
4. Apply advanced manufacturing methods for material shaping and property enhancement.
5. Integrate sustainability and innovation in material processing and usage.

**Module-1**

**Advanced Metallic Materials:** High-strength steels, superalloys, titanium alloys. Nanostructured metals and metallic glasses. Heat treatment and property tailoring.

Number of Hours:08

**Module-2**

**Polymers and Composites:** Engineering polymers: thermoplastics, thermosets, elastomers. Polymer processing techniques (extrusion, injection molding, additive manufacturing). Composite materials: fiber-reinforced plastics, laminates, hybrid composites. Applications in aerospace, automotive, biomedical.

Number of Hours:08

**Module-3**

**Ceramics and Advanced Inorganics:** Structural ceramics: alumina, zirconia, silicon carbide. Glasses and glass-ceramics. Processing methods: sintering, hot pressing, sol-gel. Properties: thermal resistance, wear resistance, biocompatibility.

Number of Hours:08

**Module-4**

**Smart and Functional Materials:** Shape memory alloys, piezoelectric materials, magnetostrictive materials. Conducting polymers, nanomaterials, graphene, carbon nanotubes. Applications in sensors, actuators, energy storage.

Number of Hours:08

**Module-5**

**Advanced Processing Techniques:** Powder metallurgy, additive manufacturing (3D printing). Surface engineering: coatings, cladding, laser processing. Sustainable processing and recycling of materials. Case studies on industrial applications.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Callister, W.D., *Materials Science and Engineering: An Introduction*, Wiley, 2018, 10th Edition, ISBN 9781119405498.
2. Ashby, M.F., *Materials Selection in Mechanical Design*, Butterworth-Heinemann, 2017, 5th Edition, ISBN 9780081005996.

**Reference books / Manuals:**

1. .Shackelford, J.F., *Introduction to Materials Science for Engineers*, Pearson, 2015, 8th Edition, ISBN 9780133826654.

2. Dieter, G.E., *Mechanical Metallurgy*, McGraw-Hill, 1986, 3rd Edition, ISBN 9780070168930.
3. Chawla, K.K., *Composite Materials: Science and Engineering*, Springer, 2012, 3rd Edition, ISBN 9780387743646.
4. Hull, D. and Clyne, T.W., *An Introduction to Composite Materials*, Cambridge University Press, 1996, 2nd Edition, ISBN 9780521388559.

**Web links and Video Lectures (e-Resources):**

NPTEL courses on Advanced Materials.
MIT OpenCourseWare: Materials Science.
ASM International Digital Library.

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped Classroom with pre-class video lectures.
2. Case-Based Teaching (industrial applications).
3. Simulation and Virtual Labs for material processing.
4. Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| Performance Indicator- 1 (CO/PO Mapping) | | | | | |
| Performance Indicator-2 (CO/PO Mapping) | | | | | |
| ... | | | | | |
| Performance Indicator-n (CO/PO Mapping) | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

**Term Work (TW) and Self Learning (SL) components in Number of Hours per semester**

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

## Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

## Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| MICRO AND NANO MANUFACTURING TECHNOLOGIES | | | |
|---|---|---|---|
| Course Code | **1MME105B** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the principles of micro and nano manufacturing processes.
2. Analyze fabrication techniques for MEMS, NEMS, and nanostructures.
3. Apply lithography, etching, and deposition methods in micro/nano fabrication.
4. Evaluate applications of micro/nano manufacturing in electronics, biomedical, and energy systems.
5. Integrate sustainability and advanced instrumentation in micro/nano manufacturing.

**Module-1**

**Introduction to Micro and Nano Manufacturing:** Evolution of manufacturing technologies. Fundamentals of micro/nano scale physics. Applications in electronics, biomedical, and energy.

Number of Hours:08

**Module-2**

**Lithography and Patterning Techniques:** Photolithography, electron-beam lithography, nanoimprint lithography. Mask design and resolution limits. Case studies in semiconductor fabrication.

Number of Hours:08

**Module-3**

**Etching and Deposition Processes:** Wet and dry etching techniques. Chemical vapor deposition (CVD), physical vapor deposition (PVD). Atomic layer deposition (ALD).

Number of Hours:08

**Module-4**

**Micro/Nano Fabrication for MEMS and NEMS:** Fabrication of micro-electromechanical systems (MEMS). Nano-electromechanical systems (NEMS). Integration with sensors and actuators.

Number of Hours:08

**Module-5**

**Applications and Case Studies:** Nanoelectronics, nanophotonics, and nanomedicine. Energy harvesting and storage devices. Case studies: lab-on-chip, biomedical implants, nano-coatings.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Madou, M.J., *Fundamentals of Microfabrication and Nanotechnology*, CRC Press, 2018, 3rd Edition, ISBN 9781498717847.
2. Campbell, S.A., *The Science and Engineering of Microelectronic Fabrication*, Oxford University Press, 2008, 2nd Edition, ISBN 9780195330847.

**Reference books / Manuals:**

1. Rai-Choudhury, P., *Handbook of Microlithography, Micromachining, and Microfabrication*, SPIE Press, 1997, ISBN 9780819422526.
2. Bhushan, B., *Springer Handbook of Nanotechnology*, Springer, 2017, 4th Edition, ISBN 9783319472133.
3. Kovacs, G.T.A., *Micromachined Transducers Sourcebook*, McGraw-Hill, 1998, ISBN 9780071139465.

**Web links and Video Lectures (e-Resources):**

NPTEL – Micro and Nano Fabrication
NPTEL – Nanotechnology
MIT OpenCourseWare – Nanomanufacturing (ocw.mit.edu)
IEEE Xplore – Micro/Nano Manufacturing Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| ADVANCED COMBUSTION AND EMISSION CONTROL | | | |
|---|---|---|---|
| Course Code | **1MME105C** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain advanced combustion processes and their thermodynamic principles.
2. Analyze pollutant formation mechanisms in combustion systems.
3. Evaluate emission control technologies for IC engines, gas turbines, and industrial furnaces.
4. Apply computational and experimental methods for combustion diagnostics.
5. Integrate sustainable and clean combustion strategies in energy systems.

**Module-1**

**Fundamentals of Advanced Combustion:** Thermodynamics and chemical kinetics of combustion. Flame structure, ignition, and stability. Combustion in IC engines and gas turbines.

Number of Hours:08

**Module-2**

**Pollutant Formation in Combustion Systems:** Formation of NOx, CO, HC, SOx, and particulate matter. Mechanisms of soot and smoke formation. Environmental impact of emissions.

Number of Hours:08

**Module-3**

**Emission Measurement and Diagnostics**: Experimental techniques: gas analyzers, smoke meters, particle counters. Optical diagnostics: laser-induced fluorescence, spectroscopy. Computational modeling of combustion and emissions.

Number of Hours:08

**Module-4**

**Emission Control Technologies:** In-cylinder control: EGR, lean burn, stratified charge. After-treatment systems: catalytic converters, particulate filters, SCR. Emerging technologies: plasma-assisted combustion, low-temperature combustion.

Number of Hours:08

**Module-5**

**Sustainable Combustion and Case Studies:** Alternative fuels: biofuels, hydrogen, synthetic fuels. Combustion in renewable energy systems. Case studies: automotive emission control, power plant combustion optimization.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Turns, S.R., *An Introduction to Combustion: Concepts and Applications*, McGraw-Hill, 2012, 3rd Edition, ISBN 9780073380193.
2. Heywood, J.B., *Internal Combustion Engine Fundamentals*, McGraw-Hill, 1988, ISBN 9780070286374

**Reference books / Manuals:**

1. Glassman, I., Yetter, R.A., and Glumac, N.G., *Combustion*, Academic Press, 2014, 5th Edition, ISBN 9780124078383.
2. Kuo, K.K., *Principles of Combustion*, Wiley, 2005, 2nd Edition, ISBN 9780471727897.

3. Stone, R., *Introduction to Internal Combustion Engines*, Palgrave Macmillan, 2012, 4th Edition, ISBN 9780230576636.

**Web links and Video Lectures (e-Resources):**

NPTEL – Micro and Nano Fabrication
NPTEL – Nanotechnology
MIT OpenCourseWare – Nanomanufacturing (ocw.mit.edu)
IEEE Xplore – Micro/Nano Manufacturing Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

## Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

## Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| NANOSTRUCTURED MATERIALS AND SURFACE ENGINEERING | | | |
|---|---|---|---|
| Course Code | **1MME105D** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of nanostructured materials and their unique properties.
2. Analyze synthesis techniques for nanomaterials and thin films.
3. Apply surface engineering methods for wear resistance, corrosion protection, and functional coatings.
4. Evaluate characterization techniques for nanostructures and engineered surfaces.
5. Integrate nanostructured materials in advanced engineering applications

**Module-1**

**Introduction to Nanostructured Materials:** Fundamentals of nanoscience and nanotechnology. Classification: nanoparticles, nanowires, nanotubes, thin films. Structure-property relationships at the nanoscale

Number of Hours:08

**Module-2**

**Synthesis of Nanostructured Materials:** Physical methods: ball milling, vapor deposition. Chemical methods: sol-gel, hydrothermal, chemical vapor deposition. Biological and green synthesis approaches.

Number of Hours:08

**Module-3**

**Surface Engineering Techniques:** Surface modification: ion implantation, laser treatment. Coatings: PVD, CVD, thermal spraying, electroplating. Applications in tribology, corrosion resistance, and biomedical devices.

Number of Hours:08

**Module-4**

**Characterization of Nanostructures and Surfaces:** Microscopy: SEM, TEM, AFM. Spectroscopy: XPS, Raman, FTIR. X-ray diffraction and surface profilometry.

Number of Hours:08

**Module-5**

**Applications and Case Studies:** Nanostructured coatings in aerospace and automotive. Biomedical implants and drug delivery. Energy applications: batteries, fuel cells, solar cells.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Bhushan, B., *Springer Handbook of Nanotechnology*, Springer, 2017, 4th Edition, ISBN 9783319472133.
2. Ghosh, C.K., *Nanostructured Materials: Processing, Properties, and Applications*, CRC Press, 2019, ISBN 9780367331580.

**Reference books / Manuals:**

1. Cao, G., *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*, World Scientific, 2011, 2nd Edition, ISBN 9789814324557.
2. Ohring, M., *Materials Science of Thin Films*, Academic Press, 2001, 2nd Edition, ISBN 9780125249751.

3. Leng, Y., *Materials Characterization: Introduction to Microscopic and Spectroscopic Methods*, Wiley, 2008, ISBN 9780470823040.

**Web links and Video Lectures (e-Resources):**

NPTEL – Nanostructured Materials
NPTEL – Surface Engineering
MIT OpenCourseWare – Nanomaterials and Nanotechnology (ocw.mit.edu)
IEEE Xplore – Nanostructured Materials and Surface Engineering Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| CYBER-PHYSICAL SYSTEMS IN MECHANICAL ENGINEERING | | | |
|---|---|---|---|
| Course Code | **1MME105E** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of cyber-physical systems (CPS) and their role in mechanical engineering.
2. Analyze integration of sensors, actuators, and embedded systems in CPS.
3. Apply communication protocols, IoT, and cloud computing in CPS applications.
4. Evaluate CPS applications in smart manufacturing, robotics, and energy systems.
5. Design CPS solutions considering safety, reliability, and sustainability

**Module-1**

**Introduction to Cyber-Physical Systems:** Definition, architecture, and components of CPS. Role of CPS in mechanical engineering and Industry 4.0. Case studies in automation and robotics.

Number of Hours:08

**Module-2**

**Sensors, Actuators, and Embedded Systems:** Smart sensors and transducers. Actuator technologies and integration. Embedded controllers and real-time operating systems

Number of Hours:08

**Module-3**

**Communication and Networking in CPS:** IoT protocols: MQTT, CoAP, OPC-UA. Wireless communication: Wi-Fi, ZigBee, LoRaWAN, 5G. Edge computing and gateways.

Number of Hours:08

**Module-4**

**CPS Applications in Mechanical Engineering:** Smart manufacturing and digital factory. Robotics and autonomous systems. CPS in energy systems and predictive maintenance.

Number of Hours:08

**Module-5**

**Safety, Security, and Case Studies:** Cybersecurity in CPS. Reliability and fault-tolerant design. Case studies: automotive CPS, healthcare devices, smart grids.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Rajkumar, R., Lee, I., Sha, L., and Stankovic, J., *Cyber-Physical Systems: Foundations, Principles, and Applications*, Springer, 2016, ISBN 9783319331652.
2. Alur, R., *Principles of Cyber-Physical Systems*, MIT Press, 2015, ISBN 9780262029117.

**Reference books / Manuals:**

1. Lee, E.A., *Introduction to Embedded Systems: A Cyber-Physical Systems Approach*, MIT Press, 2017, 2nd Edition, ISBN 9780262533812.
2. Gilchrist, A., *Industry 4.0: The Industrial Internet of Things*, Apress, 2016, ISBN 9781484220467.
3. Baheti, R. and Gill, H., *Cyber-Physical Systems*, IEEE Press, 2011, ISBN 9781118009031.

**Web links and Video Lectures (e-Resources):**

NPTEL – Cyber-Physical Systems (nptel.ac.in in Bing)
NPTEL – Industry 4.0 and IIoT
MIT OpenCourseWare – Embedded Systems and CPS (ocw.mit.edu)
IEEE Xplore – Cyber-Physical Systems Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

**Semester - I**

| Jigs and Fixtures Design | | | |
|---|---|---|---|
| Course Code | 1MME105F | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 90 | Total Marks | 100 |
| Credits | 03 | Exam Hours | 3 |

**Course objectives:**

- Acquiring the knowledge on various jigs and fixtures,
- Understand the designs of clamping methods,
- Gaining the knowledge of indexing and methods,
- Study the different applications of fixtures and
- Drawing exercises of different typical jigs and fixtures.

**MODULE-1 (05 Hrs)**

**Introduction**: Definition of Jigs and Fixtures, Difference between jigs and fixtures, Advantages, Steps for design. Location Degree of freedom, 3-2-1 principles, Choice of location, redundant location, Diamond pin calculation, Locating methods and chip control.

**MODULE-2 (05 Hrs)**

**Locating Devices**: Surface location, Rest blocks, pins, V-blocks, Equalizers, Profile locators, Vee locaters, Nesting locaters, Diamond Pins, adjustable Locaters.

**Clamping Devices**: Basic principles, cutting forces, Rigid clamping, wedge clamping, cam clamping, quick action clamps, strap clamps, screw clamps, swing clamps, Toggle clamps, simultaneously acting clamps.

**MODULE-3 (05 Hrs)**

**Guiding Elements, Drill Bushings:** Standard Drill Bushing types**,** Jig bushes Installation, Standards, Tool Setting gauges. **Indexing Jigs and Fixtures:** Indexing methods, Linear, Rotary, Indexing jigs, Indexing fixtures. Assembly and Welding Fixture – Principles.

**MODULE-4 (05 Hrs)**

**Design of Jigs and Fixture Bodies, other Elements, types of Jigs and Fixtures:** Plate Jigs. Box Jigs, Indexing Jigs, Milling Fixtures and Indexing milling Fixtures, Turning Fixtures, Grinding Fixtures, Universal Jigs & Fixtures, Welding fixtures, Broaching fixtures and assembly fixtures, Modular Fixturing.

**MODULE-5 (05 Hrs)**

**Preparation and Presentation of typical designs in the form of drawings for the following**

1. Drill Jig
2. Drilling and Reaming Jigs
3. Milling Fixtures
4. Indexing Jigs
5. Indexing Milling Fixtures.
6. Turning Fixtures.

## Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

**CIE**

1. Two Tests each of **25 Marks**
2. Two assignments each of **25 Marks/One Skill Development Activity of 50 marks**
3. Total Marks of two tests and two assignments/one Skill Development Activity added will be CIE for 60 marks, marks scored will be proportionally scaled down to **30 marks**.

**SEE**

Theory SEE will be conducted by the University as per the scheduled timetable, with common question papers for the course (duration 03 hours)

1. The question paper will be set for 100 marks and marks scored will be scaled down proportionately to 50 marks.
2. The question paper will have ten questions. Each question is set for 20 marks.
3. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. The students have to answer 5 full questions, selecting one full question from each module.

SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50. (Student has to secure an aggregate of 50% of maximum marks of the course (CIE+SEE)

**Suggested Learning Resources:**

**Books**


1. Jigs & Fixtures - JOSHI P .H.- New Delhi -Tata McGraw Hill Pub. Co. Ltd., 11th print 1999.
2. Jigs. & Fixtures & Gauges -BOYES E. WILLIAM-Michigan -SME 1st Ed. 1986.
3. Jigs and Fixture Design Manual- by Erik k Henriksen, Industrial Press Inc.
4. An Introduction to Jig and Tool Design -KEMPSTER M.H.A.- Bristol- ELBS 3rd Ed. 1974.
5. Jigs and Fixture Hand book by A.K. Goroshkin, MIR publications.
6. Jigs and Fixture Hand book by Carr Lane Mfg Com.


**Course outcome (Course Skill Set)**

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

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Explain the acquired knowledge on various jigs and fixtures, | L2 |
| CO2 | Discuss the designs of clamping methods, | L2 |
| CO3 | Apply the knowledge for different indexing methods, | L3 |
| CO4 | Illustrate the different applications of fixtures and Jigs | L2 |
| CO5 | Demonstrate the different typical jigs and fixtures. | L2 |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | | | | | | | | | | |
| **CO2** | | | | | | | | | | |
| **CO3** | | | | | | | | | | |
| **CO4** | | | | | | | | | | |
| **CO5** | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| DESIGN FOR RELIABILITY AND LIFECYCLE ENGINEERING | | | |
|---|---|---|---|
| Course Code | **1MME106A** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of reliability engineering and lifecycle concepts.
2. Apply reliability modeling and prediction techniques to mechanical systems.
3. Analyze lifecycle costs, maintainability, and sustainability in engineering design.
4. Evaluate risk assessment and failure modes using FMEA, FTA, and reliability testing.
5. Integrate reliability and lifecycle engineering principles in product development and industrial applications.

**Module-1**

**Fundamentals of Reliability and Lifecycle Engineering:** Reliability concepts, definitions, and importance. Lifecycle phases: design, development, operation, maintenance, disposal. Case studies in mechanical engineering.

Number of Hours:08

**Module-2**

**Reliability Modeling and Analysis:** Reliability functions, hazard rate, MTBF. Reliability block diagrams and Markov models. Statistical distributions in reliability (exponential, Weibull, normal).

Number of Hours:08

**Module-3**

**Failure Analysis and Risk Assessment:** Failure modes and effects analysis (FMEA). Fault tree analysis (FTA). Risk assessment and mitigation strategies.

Number of Hours:08

**Module-4**

**Lifecycle Costing and Maintainability:** Lifecycle cost estimation methods. Maintainability analysis and design for serviceability. Sustainable design and circular economy concepts.

Number of Hours:08

**Module-5**

**Applications and Case Studies:** Reliability in aerospace, automotive, and energy systems. Reliability testing and accelerated life testing. Case studies: product lifecycle management (PLM), reliability-centered maintenance (RCM).

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. O'Connor, P.D.T. and Kleyner, A., *Practical Reliability Engineering*, Wiley, 2012, 5th Edition, ISBN 9780470979723.
2. Blanchard, B.S., *System Engineering and Analysis of Lifecycle Costing*, Pearson, 1991, ISBN 9780138812365.

**Reference books / Manuals:**

1. Modarres, M., *Reliability Engineering and Risk Analysis*, CRC Press, 2016, 3rd Edition, ISBN 9781439894149.
2. Kececioglu, D., *Reliability Engineering Handbook*, Prentice Hall, 1991, ISBN 9780137456119.

3. Dhillon, B.S., *Engineering Maintainability: How to Design for Reliability and Easy Maintenance*, Gulf Professional Publishing, 1999, ISBN 9780884152546.

**Web links and Video Lectures (e-Resources):**

NPTEL – Reliability Engineering
NPTEL – Product Lifecycle Management
MIT OpenCourseWare – Systems Engineering and Lifecycle Analysis (ocw.mit.edu)
IEEE Xplore – Reliability and Lifecycle Engineering Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks.**
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade 'F' (Fail).

| LEAN MANUFACTURING AND SUSTAINABLE PRODUCTION SYSTEMS | | | |
|---|---|---|---|
| Course Code | **1MME106B** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the principles of lean manufacturing and sustainable production systems.
2. Analyze waste elimination, value stream mapping, and continuous improvement strategies.
3. Apply lean tools (5S, Kaizen, Kanban, JIT, TPM) in manufacturing environments.
4. Evaluate sustainability metrics, green manufacturing practices, and lifecycle assessment.
5. Integrate lean and sustainable practices in modern production systems for efficiency and environmental responsibility.

**Module-1**

**Introduction to Lean Manufacturing:** Evolution of lean thinking. Principles of lean production. Waste identification and elimination (7 wastes).

Number of Hours:08

**Module-2**

**Lean Tools and Techniques:** 5S methodology, Kaizen, Kanban, Just-In-Time (JIT). Total Productive Maintenance (TPM). Value stream mapping and process improvement.

Number of Hours:08

**Module-3**

**Sustainable Production Systems:** Concepts of sustainability in manufacturing. Green manufacturing practices. Energy efficiency and resource optimization.

Number of Hours:08

**Module-4**

**Lifecycle Engineering and Assessment:** Product lifecycle management (PLM). Lifecycle costing and environmental impact assessment. Circular economy and sustainable supply chains.

Number of Hours:08

**Module-5**

**Case Studies and Applications:** Lean and sustainable practices in automotive, aerospace, and energy sectors. Industry 4.0 and digital sustainability. Case studies: zero-waste manufacturing, carbon footprint reduction.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**


1. Womack, J.P. and Jones, D.T., *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Free Press, 2003, ISBN 9780743231640.
2. Dalela, S. and Saurabh, S., *Sustainable Manufacturing: Principles, Tools, and Practices*, CRC Press, 2019, ISBN 9780367331580.


**Reference books / Manuals:**


1. Dennis, P., *Lean Production Simplified*, CRC Press, 2015, 3rd Edition, ISBN 9781498705301.
2. Jawahir, I.S. and Dillon, O.W., *Sustainable Manufacturing Processes, Systems, and Technologies*, Springer, 2013, ISBN 9783642298981.
3. Liker, J.K., *The Toyota Way: 14 Management Principles*, McGraw-Hill, 2004, ISBN 9780071392310.

**Web links and Video Lectures (e-Resources):**

NPTEL – Lean Manufacturing
NPTEL – Sustainable Manufacturing
MIT OpenCourseWare – Manufacturing Systems and Sustainability (ocw.mit.edu)
IEEE Xplore – Lean and Sustainable Production Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks**.

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks**.

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

## Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

## Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| HEAT TRANSFER IN MULTIPHASE AND MICRO-SCALE SYSTEMS | | | |
|---|---|---|---|
| Course Code | **1MME106C** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of heat transfer in multiphase and micro-scale systems.
2. Analyze boiling, condensation, and two-phase flow heat transfer mechanisms.
3. Apply micro-scale heat transfer principles in MEMS, micro-channels, and nanofluids.
4. Evaluate computational and experimental methods for multiphase heat transfer.
5. Integrate advanced heat transfer concepts in energy, electronics cooling, and biomedical applications.

**Module-1**

**Fundamentals of Multiphase Heat Transfer:** Review of conduction, convection, and radiation. Introduction to multiphase systems. Governing equations and boundary conditions.

Number of Hours:08

**Module-2**

**Boiling and Condensation Heat Transfer:** Pool boiling and flow boiling. Nucleate and film boiling regimes. Filmwise and dropwise condensation.

Number of Hours:08

**Module-3**

**Two-Phase Flow and Heat Transfer:** Flow regimes in two-phase systems. Pressure drop and heat transfer correlations. Applications in power plants and refrigeration.

Number of Hours:08

**Module-4**

**Micro-Scale Heat Transfer:** Heat transfer in micro-channels and MEMS. Nanofluids and enhanced thermal conductivity. Rarefied gas dynamics and slip flow

Number of Hours:08

**Module-5**

**Applications and Case Studies:** Electronics cooling and thermal management. Biomedical applications (micro-scale heat exchangers). Case studies: energy systems, aerospace, and micro-reactors.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Incropera, F.P., DeWitt, D.P., Bergman, T.L., and Lavine, A.S., *Fundamentals of Heat and Mass Transfer*, Wiley, 2011, 7th Edition, ISBN 9780470501978.
2. Kandlikar, S.G., Garimella, S., Li, D., Colin, S., and King, M.R., *Heat Transfer and Fluid Flow in Minichannels and Microchannels*, Elsevier, 2006, ISBN 9780080445274.

**<u>Reference books / Manuals:</u>**

1. Carey, V.P., *Liquid-Vapor Phase-Change Phenomena*, CRC Press, 2008, 2nd Edition, ISBN 9781560324785.
2. Kakac, S., Shah, R.K., and Aung, W., *Handbook of Single-Phase Convective Heat Transfer*, Wiley, 1987, ISBN 9780471829453.
3. Tiwari, A.K., *Nanofluids and Heat Transfer*, Springer, 2013, ISBN 9783642334979.

**Web links and Video Lectures (e-Resources):**

NPTEL – Heat Transfer
NPTEL – Micro and Nano Scale Heat Transfer
MIT OpenCourseWare – Heat Transfer in Micro-Scale Systems (ocw.mit.edu)
IEEE Xplore – Multiphase and Micro-Scale Heat Transfer Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class video lectures.
2 Case-Based Teaching (industrial applications).
3 Simulation and Virtual Labs for material processing.
4 Industry expert lectures and visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

**Continuous Internal Evaluation (CIE)**

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

**Passing requirement in SEE**

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| HIGH-TEMPERATURE MATERIALS AND CREEP MECHANICS | | | |
|---|---|---|---|
| Course Code | **1MME106D** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of high-temperature materials and their mechanical behavior.
2. Analyze creep mechanisms and deformation models under elevated temperatures.
3. Apply design principles for materials used in aerospace, automotive, and energy systems.
4. Evaluate experimental methods for creep testing and high-temperature characterization.
5. Integrate creep mechanics and material selection in lifecycle engineering.

**Module-1**

**Introduction to High-Temperature Materials:** Classification: superalloys, ceramics, composites. Thermo-mechanical properties and applications. Challenges in high-temperature environments.

Number of Hours:08

**Module-2**

**Fundamentals of Creep Mechanics:** Creep stages: primary, secondary, tertiary. Stress-strain-time relationships. Creep rate equations and models.

Number of Hours:08

**Module-3**

**Creep Mechanisms and Microstructural Effects:** Diffusion creep, dislocation creep, grain boundary sliding. Effect of microstructure on creep resistance. Role of alloying and heat treatment.

Number of Hours:08

**Module-4**

**Creep Testing and Characterization:** Experimental methods for creep testing. High-temperature tensile and fatigue testing. Non-destructive evaluation techniques.

Number of Hours:08

**Module-5**

**Applications and Case Studies:** Creep in turbine blades, boilers, and nuclear reactors. Design considerations for high-temperature components. Case studies: aerospace engines, power plants, automotive exhaust systems.

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Courtney, T.H., *Mechanical Behavior of Materials*, McGraw-Hill, 2000, 2nd Edition, ISBN 9780070132658.
2. Frost, H.J. and Ashby, M.F., *Deformation Mechanism Maps: The Plasticity and Creep of Metals and Ceramics*, Pergamon Press, 1982, ISBN 9780080293370.

**Reference books / Manuals:**

1. Evans, R.W. and Wilshire, B., *Creep of Metals and Alloys*, Institute of Metals, 1985, ISBN 9780904357197.
2. Reed, R.C., *The Superalloys: Fundamentals and Applications*, Cambridge University Press, 2006, ISBN 9780521859042.
3. Raj, R., *Creep in Ceramics*, Springer, 1986, ISBN 9780306424927.

**Web links and Video Lectures (e-Resources):**

NPTEL – Creep in Materials
NPTEL – Mechanical Behavior of Materials
MIT OpenCourseWare – High-Temperature Materials and Mechanics (ocw.mit.edu)
EEE Xplore – High-Temperature Materials and Creep Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with creep case studies.
3 Simulation and Virtual Labs (creep modeling software).
4 Industry expert lectures and industrial visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks.**

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students.** These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

### Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

### Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

| BIOMECHANICS AND BIOMEDICAL APPLICATIONS | | | |
|---|---|---|---|
| Course Code | **1MME106E** | Scheme | 2026 |
| Type of Course | **PEC(Theory)** | Semester | 01 |
| Teaching Hours/Week (L:T:P) | 03: 00:00 | CIE Marks | 50 |
| Total Hours of Pedagogy per semester L /T/P/SL&TW: | : : : : | SEE Marks | 50 |
| Credits | **3** | Total Marks | 100 |
| Examination type (SEE) | Theory | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Explain the fundamentals of biomechanics and its relevance to mechanical engineering.
2. Analyze the mechanics of biological tissues, joints, and musculoskeletal systems.
3. Apply engineering principles to biomedical devices and prosthetics.
4. Evaluate computational and experimental methods in biomechanics.
5. Integrate biomechanics concepts into healthcare, rehabilitation, and biomedical engineering applications.

**Module-1**

**Fundamentals of Biomechanics:** Introduction to biomechanics and biomedical engineering. Mechanical properties of biological tissues. Stress–strain behavior of bones, muscles, and ligaments.

Number of Hours:08

**Module-2**

**Musculoskeletal Mechanics:** Kinematics and dynamics of human motion. Joint mechanics and load distribution. Case studies in orthopedic biomechanics.

Number of Hours:08

**Module-3**

**Cardiovascular and Respiratory Biomechanics:** Hemodynamics: blood flow in arteries and veins. Respiratory mechanics and airflow modeling. Applications in medical devices (stents, ventilators).

Number of Hours:08

**Module-4**

**Biomedical Devices and Applications:** Prosthetics and orthotics design. Biomechanics of implants and biomaterials. Rehabilitation engineering and assistive devices.

Number of Hours:08

**Module-5**

**: Computational and Experimental Biomechanics:** Finite element modeling in biomechanics. Experimental techniques: motion capture, force plates, imaging. Case studies: sports biomechanics, injury prevention, rehabilitation

Number of Hours:10

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Fung, Y.C., *Biomechanics: Mechanical Properties of Living Tissues*, Springer, 1993, 2nd Edition, ISBN 9780387979472.
2. Nigg, B.M. and Herzog, W., *Biomechanics of the Musculoskeletal System*, Wiley, 2007, 3rd Edition, ISBN 9780470017677.

**Reference books / Manuals:**

1. Ozkaya, N. and Nordin, M., *Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation*, Springer, 2012, 3rd Edition, ISBN 9781441999996.
2. Bronzino, J.D., *The Biomedical Engineering Handbook*, CRC Press, 2018, 4th Edition, ISBN 9781439825334.

3. Humphrey, J.D. and Delange, S.L., *An Introduction to Biomechanics: Solids and Fluids, Analysis and Design*, Springer, 2004, ISBN 9780387954424.

**Web links and Video Lectures (e-Resources):**

NPTEL – Biomechanics
NPTEL – Biomedical Engineering
MIT OpenCourseWare – Biomechanics and Biomedical Applications (ocw.mit.edu)
IEEE Xplore – Biomechanics and Biomedical Engineering Papers (ieeexplore.ieee.org)

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1 Flipped Classroom with pre-class readings.
2 Problem-Based Learning (PBL) with biomedical case studies.
3 Simulation and Virtual Labs (ANSYS, COMSOL, motion analysis software).
4 Industry expert lectures and hospital/rehabilitation center visits.

**Assessment Structure:**

The assessment in each course is divided equally between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each carrying 50% weightage.

- To qualify and become eligible to appear for SEE, in the **CIE**, a student must score at least **40% of 50 marks**, i.e., **20 marks**.
- To pass the **SEE**, a student must score at least **35% of 50 marks**, i.e., **18 marks**.
- Notwithstanding the above, a student is considered to have **passed the course,** provided the combined total of **CIE and SEE** is at least **40 out of 100 marks**.

**Continuous Comprehensive Assessments (CCA)+ Internal Assessment Test (IA) = Continuous Internal Evaluation CIE [25+25=50 marks]**

A minimum of **two Internal Assessment Tests(IA)** shall be conducted, carrying a total of **25 marks.**

In addition, **Continuous Comprehensive Assessment (CCA)** shall be conducted for a total of **25 marks.**

It is recommended to include **a maximum of two learning activities** as part of the CCA to foster the **holistic development of students**. These activities shall be:

| Sl. No. | Name of the Learning activity | Maximum Marks |
|---|---|---|
| 1. | | |
| 2. | | |

**Rubrics for Learning Activity (Based on the nature of learning activity, design the rubrics for each activity):**

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

**Suggested Learning Activities may include (but are not limited to):**

- Course Project (material selection/design).
- Case Study (industrial application).
- Literature Review (emerging materials).
- Open Book Test (RBL4/RBL5).
- GATE-based Aptitude Test.

**Suggested Innovative Delivery Methods may include (but are not limited to):**

- Flipped Classroom
- Problem-Based Learning (PBL)
- Case-Based Teaching
- Simulation and Virtual Labs
- Partial Delivery of course by Industry expert/ industrial visits
- ICT-Enabled Teaching
- Role Play

## Term Work (TW) and Self Learning (SL) components in Number of Hours per semester

Term work (includes assignments, seminars, micro projects, industrial visits, any other student activities etc.)

| Sl. No. | Term Work (TW) Activity | Number of Hours / Semester |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

SL: Self Learning, MOOCs, spoken tutorials, online educational resources etc.

| Sl. No. | Self-Learning (SL) Activity | Number of Hours / Semester |
|---|---|---|

| | | |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | (Add rows if required) | |

## Continuous Internal Evaluation (CIE)

1. The CIE marks shall be decided based on internal tests and other outcome-based activities. The continuous internal evaluation shall be carried out by the teacher handling the course.
2. Out of 50 marks earmarked for CIE, 25 marks shall be assigned for internal tests. The first test shall be conducted after completing two modules of the syllabus and the second one after completing the remaining three modules.
3. The remaining 25 marks shall be assigned for Continuous Course Assessment (CCA), conducted as per the rubrics listed in the assessment section of the respective syllabus.
4. A student shall obtain a minimum of 40% marks or 20 out of 50 marks allotted to CIE to become eligible to appear for the SEE.

## Passing requirement in SEE

1. For a pass in the Semester End Examination (SEE), a student shall secure a minimum of 35 marks out of 100.
2. For the declaration of a pass grade, the sum of the Continuous Internal Evaluation (CIE) marks (out of 50) marks and the SEE marks scaled down to 50 shall be greater than or equal to 40 marks.
3. If the total (CIE + SEE) is less than 40 marks, the student shall be awarded the grade ‘F’ (Fail).

**Semester – I**

| Gauges and Measurements | | | |
|---|---|---|---|
| Course Code | 1MME106F | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P) | 3:0:0 | SEE Marks | 50 |
| Total Hours of Pedagogy | 90 hours | Total Marks | 100 |
| Credits | 3 | Exam Hours | 3 |

**Course objectives:**

- Understand specification of limits, fits and tolerance,
- Study the design knowledge of different gauges and their uses,
- Understand the Interference of fits and their needs in calculations,
- Know the different types of Geometric dimensioning and tolerance and
- Awareness of design knowledge in different gauges in manufacturing.

**MODULE-1 (05 Hrs)**

**Introduction:** Definition and objectives of metrology, Linear measurement: neutral axis significance, imperial standard yard, international standard meter, airy points, Basel points, Line, End & Wave length standards, Slip Gages.

**Angular Measurement:** introduction, comparisons with linear measurement, sine bar: principle, types, advantages & limitations, uses, problems on sine bar, practical uses, material, construction, limitations problems on angle blocks (angle gauges).

**MODULE-2 (05 Hrs)**

**Limits, Fits and Tolerance:** Definitions, need of tolerance, types of tolerance, tolerance analysis (addition & subtraction of tolerances) interchangeability & selective assembly, representation of holes & shaft as per I.S. class & grade of tolerance, -difference between allowance & tolerance.

**MODULE-3 (05 Hrs)**

**Fits:** Definition, types of fits, (clearance, interference & transition), tolerance disposition chart, problems (calculation of fits) hole base system & shaft base system, procedure for solving on finding the hole & shaft tolerance upper & lower limits.

**MODULE-4 (05 Hrs)**

**Design Of Gauges:** Taylor's principle, MMC & LMC of hole & shaft types of gauges (plain, threaded, limit, single end, double end, progressive, position, etc.,) important points for gauge design, limitations of gauges, - problems on gauge design.

**MODULE 5 (05 Hrs)**

**Geometric Dimensioning & Tolerancing (Gd&T)** Introduction, ANSI, ASME & ISO systems of Gd&T, functional dimensioning, feature & feature of size, advantages & limitations, feature control frame, fourteen characteristic symbols, form controls, profile controls, orientation controls, location controls, run-out controls, datum.

**Design Exercise:** Design of Plug Gauge, Ring Gauge, Snap Gauge, Indicator Gauge, Taper plate Gauge, Taper Plug Gauge, Thread Gauge and Position Gauge.

**Course outcome (Course Skill Set)**

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

| Sl. No. | Description | Blooms Level |
|---|---|---|
| CO1 | Explain the specification of limits, fits and tolerance, | L2 |
| CO2 | Discuss the design knowledge of different gauges and their uses, | L2 |
| CO3 | Apply the knowledge on the Interference of fits and their needs in calculations, | L3 |
| CO4 | Demonstrate the different types of Geometric dimensioning and tolerance | L3 |
| CO5 | Explain the design knowledge of different gauges in manufacturing. | L2 |

**Program Outcome of this course**

| Sl. No. | Description | POs |
|---|---|---|
| | | |
| | | |
| | | |

**Mapping of COS and POs**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | | | | | | | | | | |
| CO2 | | | | | | | | | | |
| CO3 | | | | | | | | | | |
| CO4 | | | | | | | | | | |
| CO5 | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

| AI AND ROBOTICS LABORATORY | | Scheme | 2026 |
|---|---|---|---|
| Course Code | **1MMEL107A** | Semester | 1 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SLTW | 0:0 :2 | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Examination type (SEE) | **Practical** | Exam Hours | 3 |

**Course outcome (Course Skill Set)**

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

1. Implement basic AI algorithms for robotics applications.
2. Design and simulate robotic motion planning and control.
3. Apply machine learning techniques for sensor data analysis.
4. Integrate vision systems for robotic perception.
5. Conduct open-ended experiments to explore AI-driven robotics solutions.

**Note:**

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

**PART – A**
**FIXED SET OF EXPERIMENTS**

1. Implementation of search algorithms (DFS, BFS, A*) for robot path planning.
2. Simulation of robotic arm kinematics using Python/Matlab.
3. Obstacle avoidance using sensor data (ultrasonic/IR).
4. Machine learning-based classification of sensor inputs.
5. Vision-based object detection using OpenCV.
6. Control of a mobile robot using reinforcement learning.

**PART – B**
**OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. **Concept 1:** Design and simulate a robot for warehouse automation.
2. **Concept 2:** Develop an AI-based predictive maintenance system for robots.
3. **Concept 3:** Implement swarm robotics algorithms for cooperative tasks.
4. **Concept 4:** Explore human-robot interaction using gesture recognition.
5. **Concept 5:** Integrate IoT with robotics for smart factory applications.
6. **Concept 6:** Prototype a vision-guided autonomous vehicle.

7.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Russell, S., Norvig, P., *Artificial Intelligence: A Modern Approach*, Pearson, 2021, 4th Edition, ISBN 9780134610993.
2. Siciliano, B., Khatib, O., *Springer Handbook of Robotics*, Springer, 2016, 2nd Edition, ISBN 9783319325521.

**Reference books / Manuals:**

1. Goodfellow, I., Bengio, Y., Courville, A., *Deep Learning*, MIT Press, 2016, ISBN 9780262035613.
2. Bishop, C.M., *Pattern Recognition and Machine Learning*, Springer, 2006, ISBN 9780387310733.

**Web links and Video Lectures (e-Resources):**

 NPTEL Course: *Artificial Intelligence for Robotics* – https://nptel.ac.in/courses/106/105/106105237

 MIT OCW: *Robotics: Science and Systems* – https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/

 IEEE Xplore Digital Library – https://ieeexplore.ieee.org/

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped classroom with robotics case studies.
2. Simulation and virtual labs using Python/ROS/Matlab.
3. Industry expert lectures and industrial visits.
4. Problem-based learning with open-ended robotics projects.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.
For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

Rubrics for SEE / CIE Test:

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

| Rubrics suggested for Practical continuous assessment | | | | |
|---|---|---|---|---|
| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

| MANUFACTURING AUTOMATION LAB (CNC/CIM) | | Scheme | 2026 |
|---|---|---|---|
| Course Code | **1MMEL107B** | Semester | 1 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SLTW | 0:0 :2 | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Examination type (SEE) | **Practical** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Operate CNC machines and understand their control systems.
2. Develop part programs for turning, milling, and drilling operations.
3. Apply CAD/CAM software for toolpath generation and simulation.
4. Integrate CNC with CIM systems for automated manufacturing.
5. Conduct open-ended experiments to explore automation and optimization in manufacturing

**Note:**

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

**PART – A**
**FIXED SET OF EXPERIMENTS**

1. Introduction to CNC machine tools and safety practices.
2. Part programming for CNC turning (linear and circular interpolation).
3. Part programming for CNC milling (pocketing, contouring).
4. Toolpath simulation using CAD/CAM software.
5. Machining of a component using CNC lathe/mill.
6. Demonstration of CIM system integration (robotics/AGV/automated storage).

**PART – B**
**OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. **Concept 1: Optimization of machining parameters for surface finish.**
2. **Concept 2: Development of complex toolpaths using CAD/CAM.**
3. **Concept 3: Integration of CNC with robotics for part handling.**
4. **Concept 4: Simulation of flexible manufacturing systems (FMS).**
5. **Concept 5: Case study on Industry 4.0 applications in CNC/CIM.**
6. **Concept 6: Prototype project on automated inspection using sensors.**

7.

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Groover, M.P., *Automation, Production Systems, and Computer-Integrated Manufacturing*, Pearson, 2018, 4th Edition, ISBN 9789332578329.
2. Kundra, T.K., Rao, P.N., *Numerical Control and Computer-Aided Manufacturing*, McGraw-Hill, 1998, ISBN 9780074621302.

**Reference books / Manuals:**

1. Mikell P. Groover, *Fundamentals of Modern Manufacturing*, Wiley, 2020, 7th Edition, ISBN 9781119722014.
2. Rao, P.N., *CAD/CAM: Principles and Applications*, McGraw-Hill, 2017, 3rd Edition, ISBN 9780070634459.

**Web links and Video Lectures (e-Resources):**

NPTEL Course: *CNC Technology and Automation* – https://nptel.ac.in/courses/112/107/112107083

MIT OCW: *Manufacturing Processes and Automation* – https://ocw.mit.edu/courses/mechanical-engineering/

SME (Society of Manufacturing Engineers) – https://www.sme.org/

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped classroom with CNC case studies.
2. Simulation and virtual labs using CAD/CAM software.
3. Industry expert lectures and industrial visits.
4. Problem-based learning with automation projects.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.
For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

Rubrics for SEE / CIE Test:

| | **Superior** | **Good** | **Fair** | **Needs Improvement** | **Unacceptable** |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

| Rubrics suggested for Practical continuous assessment | | | | |
|---|---|---|---|---|
| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

| PRODUCT DESIGN VISUALIZATION ENGINEERING LAB | | Scheme | 2026 |
|---|---|---|---|
| Course Code | **1MMEL107C** | Semester | 1 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SLTW | 0:0 :2 | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Examination type (SEE) | **Practical** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Operate CNC machines and understand their control systems.
2. Develop part programs for turning, milling, and drilling operations.
3. Apply CAD/CAM software for toolpath generation and simulation.
4. Integrate CNC with CIM systems for automated manufacturing.
5. Conduct open-ended experiments to explore automation and optimization in manufacturing

**Note:**

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

**PART – A**
**FIXED SET OF EXPERIMENTS**

1. Introduction to CAD software interface and basic sketching.
2. 2D drafting of mechanical components (orthographic and sectional views).
3. 3D modeling of simple parts using parametric features.
4. Assembly modeling of multiple components.
5. Generation of exploded views and bill of materials (BOM).
6. Rendering and visualization of product models with material and lighting effects.

**PART – B**
**OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. **Concept 1: Design and visualize a consumer product (e.g., bottle, chair, gadget).**
2. **Concept 2: Develop a 3D model of an automotive component with realistic rendering.**
3. **Concept 3: Create a product animation for assembly/disassembly visualization.**
4. **Concept 4: Explore simulation of product stress/thermal performance.**
5. **Concept 5: Prototype visualization for biomedical or aerospace applications.**
6. **Concept 6: Case study project on sustainable product design visualization.**

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Sham Tickoo, *Autodesk Inventor for Engineers and Designers*, CADCIM Technologies, latest edition.
2. Zeid, I., *Mastering CAD/CAM*, McGraw-Hill, 2005, ISBN 9780072868456.

**Reference books / Manuals:**

1. Kalpakjian, S., Schmid, S.R., *Manufacturing Engineering and Technology*, Pearson, 2014, 7th Edition.
2. P.N. Rao, *CAD/CAM: Principles and Applications*, McGraw-Hill, 2017, 3rd Edition.

**Web links and Video Lectures (e-Resources):**

NPTEL Course: *Computer Aided Design* – https://nptel.ac.in/courses/112/105/112105233

MIT OCW: *Product Design and Development* – https://ocw.mit.edu/courses/mechanical-engineering/

Autodesk Education – https://www.autodesk.com/education

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped classroom with CAD case studies.
2. Simulation and virtual labs for product visualization.
3. Industry expert lectures and industrial visits.
4. Problem-based learning with open-ended design projects.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.
For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

Rubrics for SEE / CIE Test:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

| Rubrics suggested for Practical continuous assessment | | | | |
|---|---|---|---|---|
| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

| ENGINEERING COMPUTATIONAL LAB | | Scheme | 2026 |
|---|---|---|---|
| Course Code | **1MMEL107D** | Semester | 1 |
| Teaching Hours/Week (L:T:P) | : : | CIE Marks | 50 |
| Total Hours of Pedagogy L:T:P:SLTW | 0:0 :2 | SEE Marks | 50 |
| Credits | 01 | Total Marks | 100 |
| Examination type (SEE) | **Practical** | Exam Hours | 03 |

**Course outcome (Course Skill Set)**

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

1. Apply computational tools (MATLAB, Python, Excel) for solving engineering problems.
2. Develop algorithms and programs for numerical methods and simulations.
3. Analyze engineering data using statistical and optimization techniques.
4. Visualize engineering solutions through graphs, plots, and computational models.
5. Conduct open-ended computational experiments integrating creativity and problem-solving.

**Note:**

1. The laboratory syllabus consists of PART-A and PART-B. While PART-A has 6 conventional experiments, PART-B has 6 typical open-ended experiments. The maximum marks for the laboratory course are 100.
2. Both PART-A and PART-B are considered for CIE and SEE.
3. Students have answer 1(one) question from PART-A and 1(one) question from PART-B.
   a. The questions set for SEE shall be from among the experiments under PART-A. It is evaluated for **70 marks** out of the maximum 100 marks.
   b. The open-ended question set for SEE shall be any other open-ended question and not selected from the experiments under PART-A. It shall be evaluated for **30 marks.**
4. For Continuous Internal Evaluation (CIE) during the semester, classwork shall typically include open-ended questions from **Part-B**, along with other similar questions designed to enhance the students' skills.

**PART – A**
**FIXED SET OF EXPERIMENTS**

1. Solving linear algebraic equations using matrix methods (Gauss elimination, LU decomposition).
2. Numerical solution of ordinary differential equations (Euler, Runge-Kutta methods).
3. Curve fitting and regression analysis using computational tools.
4. Root-finding methods (Bisection, Newton-Raphson).
5. Simulation of mechanical/thermal systems using MATLAB/Python.
6. Data visualization and plotting of engineering datasets.

**PART – B**
**OPEN ENDED EXPERIMENTS**

Open-ended experiments are a type of laboratory activity where the outcome is not predetermined and students are given the freedom to explore, design, and conduct the experiment based on the problem statements as per the concepts defined by the course coordinator. It encourages creativity, critical thinking, and inquiry-based learning.

1. **Concept 1: Optimization of engineering design parameters using computational methods.**
2. **Concept 2: Simulation of dynamic systems (mechanical/electrical).**
3. **Concept 3: Development of a computational model for heat transfer problems.**
4. **Concept 4: Case study on big data analytics in engineering.**
5. **Concept 5: Application of machine learning algorithms for engineering datasets.**
6. **Concept 6: Prototype project on computational modeling of sustainable energy systems.**

**Suggested Learning Resources: (Text Book/ Reference Book/ Manuals):**

**Text books:**

1. Chapra, S.C., Canale, R.P., *Numerical Methods for Engineers*, McGraw-Hill, 2015, 7th Edition.
2. Rao, S.S., *Engineering Optimization: Theory and Practice*, Wiley, 2019, 5th Edition.

**Reference books / Manuals:**

1. Mathews, J.H., Fink, K.D., *Numerical Methods Using MATLAB*, Pearson, 2004.
2. Hanselman, D., Littlefield, B., *Mastering MATLAB*, Pearson, 2011..

**Web links and Video Lectures (e-Resources):**

NPTEL Course: *Numerical Methods and Computational Techniques* – https://nptel.ac.in/courses/111/107/111107105

MIT OCW: *Computational Science and Engineering* – https://ocw.mit.edu/courses/mathematics/

Python Scientific Libraries – https://scipy.org/

**Teaching-Learning Process (Innovative Delivery Methods):**

The following are sample strategies that educators may adopt to enhance the effectiveness of the teaching-learning process and facilitate the achievement of course outcomes.

1. Flipped classroom with computational case studies.
2. Simulation and virtual labs using MATLAB/Python.
3. Industry expert lectures and industrial visits.
4. Problem-based learning with open-ended computational projects.

**Assessment Structure:**

The assessment for each course is equally divided between Continuous Internal Evaluation (CIE) and the Semester End Examination (SEE), with each component carrying **50% weightage** (i.e., 50 marks each).

The CIE marks awarded shall be based on the continuous evaluation of the laboratory report using a defined set of rubrics. Each experiment report can be evaluated for 30 marks. Total marks for the all report shall be scaled down to 30 marks. The laboratory test (duration 03 hours) at the end of the last week of the semester /after completion of all the experiments (whichever is early) shall be conducted for 50 marks and Marks scored shall be scaled down to 20 marks. Final average of marks for report and test shall be out of 50 marks.
For both CIE and SEE, the student is required to conduct one experiment each from both Part A and Part B.

Rubrics for CIE – Continuous assessment:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

Rubrics for SEE / CIE Test:

| | Superior | Good | Fair | Needs Improvement | Unacceptable |
|---|---|---|---|---|---|
| **Performance Indicator- 1 (CO/PO Mapping)** | | | | | |
| **Performance Indicator-2 (CO/PO Mapping)** | | | | | |
| **...** | | | | | |
| **Performance Indicator-n (CO/PO Mapping)** | | | | | |

- To qualify and become eligible to appear for SEE, in the **CIE component**, a student must secure **a minimum of 40% of 50 marks**, i.e., **20 marks.**
- To pass the **SEE component**, a student must secure **a minimum of 35% of 50 marks**, i.e., **18 marks.**
- A student is deemed to have **successfully completed the course** if the **combined total of CIE and SEE is at least 40 out of 100 marks.**

| Rubrics suggested for Practical continuous assessment | | | | |
|---|---|---|---|---|
| **Performance Indicators** | **Excellent** | **Very Good** | **Good** | **Satisfactory** |
| Fundamental Knowledge (4) (PO1) | The student has well depth knowledge of the topics related to the course (4) | Student has good knowledge of some of the topics related to course (3) | Student is capable of narrating the answer but not capable to show in depth knowledge (2) | Student has not understood the concepts clearly (1) |
| Design Of Experiment (5) (PO2 & PO3) | Student is capable of discussing more than one design for his/her problem statement and capable of proving the best suitable design with proper reason (5) | Student is capable of discussing few designs for his/her problem statement but not capable of selecting best (4) | Student is capable of discussing single design with its merits and de-merits (3) | Student is capable of explaining the design (1-2) |
| Implementation (8) (PO3 & PO8) | Student is capable of implementing the design with best suitable algorithm considering optimal solution. (7-8) | Student is capable of implementing the design with best suitable algorithm and should be capable of explaining it (5-6) | Student is capable of implementing the design with proper explanation. (3-4) | Student is capable of implementing the design. (1-2) |
| Result &Analysis (5) (PO4) | Student is able to run the program on various cases and compare the result with proper analysis. (5) | Student will be able to run the program for all the cases. (4) | Student will be able to run the code for few cases and analyze the output. (3) | Student will be able to run the program but not able to analyze the output. (1-2) |
| Demonstration (8) (PO9) | The lab record is well-organized, with clear sections (e.g., Introduction, Method, Results, Conclusion). Transitions between sections are smooth. (7-8) | The lab record is organized, with clear sections, but some sections are not well-defined. (5-6) | The lab record lacks clear organization or structure. Some sections are unclear or incomplete. (3-4) | The lab record is poorly organized, with missing or unclear sections. (1-2) |

Note: Can add Engineering & IT tool usage based on the nature of the course

| TOOL DESIGN ENGINEERING LAB-1 | | | |
|---|---|---|---|
| Course Code | 1MMEL107E | CIE Marks | 50 |
| Teaching Hours/Week (L:T:P) | 0:0:2 | SEE Marks | 50 |
| Total Hours of Pedagogy | 30 | Total Marks | 100 |
| Credits | 01 | Exam Hours | 03 |

**Course Objectives**

- Study the Design, Assembly and Drafting of Combination tool, simple drill jig, leaf jig.
- Study the Design, Assembly, Drafting and Analysis of Milling Fixture.
- Study the Design, Assembly and Drafting of Stage and Progressive Press Tool.
- Study the Design, Assembly and Drafting of Compound Tool and Bending Tool.
- Study the Design, Assembly and Drafting of a Cavity Injection Molding Tool for Simple Component.
- Learn to Design, Assembly, Drafting and Analysis of Cavity cold and hot chamber die casting tool.

| **Sl. No.** | **Experiments** |
|---|---|
| 1 | Design, Assembly and detail drawings of simple drill jig. |
| 2 | Design, Assembly, Drafting and Analysis of a leaf jig. |
| 3 | Design, Assembly, Drafting and Analysis of Milling & Turning Fixture. |
| 4 | Design, Assembly, Drafting and Analysis of Simple Stage Tool. |
| 5 | Design, Assembly, Drafting and Analysis of Progressive Press Tool. |
| 6 | Design, Assembly, Drafting and Analysis of a Compound Tool & Combination Tool. |
| 7 | Design, Assembly, Drafting and Analysis of a Single Cavity Injection Molding Tool for a given component. |
| 8 | Design, Assembly, Drafting and Analysis of a two cavity Injection molding tool for a given component. |
| 9 | Design, Assembly, Drafting and Analysis of a Single Cavity Cold Chamber die casting tool for a simple component. |
| 10 | Design, Assembly, Drafting and Analysis of a two cavity hot chamber die casting tool for a given component. |

**Assessment Details (both CIE and SEE)**

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

**Continuous Internal Evaluation (CIE)**

CIE marks for the practical course is **50 Marks.**

The split-up of CIE marks for record / journal and test are in the ratio **60:40.**

Each experiment to be evaluated for conduction with an observation sheet and record write-up. Rubrics for the evaluation of the journal/write-up for hardware/software experiments by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.

Record should contain all the specified experiments in the syllabus and each experiment write-up will be evaluated for 10 marks.

**Total marks scored by the students are scaled down to 30 marks** (60% of maximum marks)

Weightage to be given for neatness and submission of record / write-up on time.

Department shall conduct 01 testfor 100 marks, test shall beconducted after the 14$^{th}$ week of the semester.

In test, test write-up, conduction of experiment, acceptable result, and procedural knowledge wil carry a weightage of 60% and the rest 40% for Viva- Voce.

The suitable rubrics can be designed to evaluate each student’s performance and learning ability.

**The Test marks is scaled down to 20 Marks** (40% of the maximum marks)

The Sum of Scaled –down marks scored in the report write-up / journal and marks of test is the total CIE marks scored by the student.