

UNIVERSITY OF MUMBAI



Revised syllabus (Rev- 2016) from Academic Year 2016 -17

Under

FACULTY OF TECHNOLOGY

Production Engineering

Second Year with Effect from AY 2017-18

Third Year with Effect from AY 2018-19

Final Year with Effect from AY 2019-20

As per **Choice Based Credit and Grading System**
with effect from the AY 2016-17

Co-ordinator, Faculty of Technology's Preamble:

To meet the challenge of ensuring excellence in engineering education, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education. The major emphasis of accreditation process is to measure the outcomes of the program that is being accredited. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty of Technology, University of Mumbai, in one of its meeting unanimously resolved that, each Board of Studies shall prepare some Program Educational Objectives (PEOs) and give freedom to affiliated Institutes to add few (PEOs). It is also resolved that course objectives and course outcomes are to be clearly defined for each course, so that all faculty members in affiliated institutes understand the depth and approach of course to be taught, which will enhance learner's learning process. It was also resolved that, maximum senior faculty from colleges and experts from industry to be involved while revising the curriculum. I am happy to state that, each Board of studies has adhered to the resolutions passed by Faculty of Technology, and developed curriculum accordingly. In addition to outcome based education, semester based credit and grading system is also introduced to ensure quality of engineering education.

Choice based Credit and Grading system enables a much-required shift in focus from teacher-centric to learner-centric education since the workload estimated is based on the investment of time in learning and not in teaching. It also focuses on continuous evaluation which will enhance the quality of education. University of Mumbai has taken a lead in implementing the system through its affiliated Institutes and Faculty of Technology has devised a transparent credit assignment policy and adopted ten points scale to grade learner's performance. Credit assignment for courses is based on 15 weeks teaching learning process, however content of courses is to be taught in 12-13 weeks and remaining 2-3 weeks to be utilized for revision, guest lectures, coverage of content beyond syllabus etc.

Choice based Credit and grading system is implemented from the academic year 2016-17 through optional courses at department and institute level

Dr. S. K. Ukarande

Co-ordinator,

Faculty of Technology,

Member - Academic Council

University of Mumbai, Mumbai

Chairman's Preamble:

Engineering education in India is expanding and is set to increase manifold. The major challenge in the current scenario is to ensure quality to the stakeholders along with expansion. To meet this challenge, the issue of quality needs to be addressed, debated and taken forward in a systematic manner. Accreditation is the principal means of quality assurance in higher education and reflects the fact that in achieving recognition, the institution or program of study is committed and open to external review to meet certain minimum specified standards. The major emphasis of this accreditation process is to measure the outcomes of the program that is being accredited. Program outcomes are essentially a range of skills and knowledge that a student will have at the time of graduation from the program. In line with this Faculty of Technology of University of Mumbai has taken a lead in incorporating the philosophy of outcome based education in the process of curriculum development.

As the Chairman, Board of Studies in Mechanical Engineering of the University of Mumbai, I am happy to state here that, the Program Educational Objectives of the Undergraduate Program in Production Engineering, which comes under the same board, were finalized during the multiple brain storming sessions, which was attended by more than 25 members from different affiliated Institutes of the University. They are either Heads of Departments or their senior representatives from the Department of Production Engineering. The Program Educational Objectives finalized for the undergraduate program in Production Engineering are listed below;

1. To prepare the Learner with a sound foundation in the mathematical, scientific and engineering fundamentals related to Manufacturing and its strategies.
2. To motivate the Learner in the art of self-learning and to use modern tools for solving real life problems.
3. To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process.
4. To prepare the learner to face industrial challenges through practical exposure in an industrial environment.
5. To prepare the Learner for a successful career in Indian and Multinational Organizations.

In addition to Program Educational Objectives, for each course of the program, objectives and expected outcomes from a learner's point of view are also included in the curriculum to support the philosophy of outcome based education. I strongly believe that even a small step taken in the right direction will definitely help in providing quality education to the major stakeholders.

Dr. S. M. Khot

Chairman, Board of Studies in Mechanical Engineering, University of Mumbai

T.E. (Production) Sem.-V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned					
		Theory	Pract	Theory	Pract	Total			
PEC501	Design of Mold & Metal Forming Tools	04	--	04	--	04			
PEC502	Operations Research	03	--	03	--	03			
PEC503	Machine Design-I	04	--	04	--	04			
PEC504	CAD/CAM/CIM	04	--	04	--	04			
PEC505	Metrology & Quality Engineering	04	--	04	--	04			
PEDLO 501X	Department Level Optional Course I	03	--	03	--	03			
PEL501	Design of Mold & Metal Forming Tools Laboratory	--	02	--	01	01			
PEL502	Machine Design-I Laboratory	--	02	--	01	01			
PEL503	CAD/CAM/CIM Laboratory	--	02	--	01	01			
PEL504	Metrology & Quality Engg Laboratory	--	02	--	01	01			
PEL505	Business Communication & Ethics	--	02*+02	--	02	02			
	Total	22	12	22	06	28			
Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /Oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
PEC501	Design of Molds & Metal Forming Tools	20	20	20	80	03	--	--	100
PEC502	Operations Research	20	20	20	80	03	--	--	100
PEC503	Machine Design-I	20	20	20	80	03	--	--	100
PEC504	CAD/CAM/CIM	20	20	20	80	03	--	--	100
PEC505	Metrology & Quality Engg.	20	20	20	80	03	--	--	100
PEDLO 501X	Department Level Optional Course I	20	20	20	80	03	--	--	100
PEL501	Design of Mold & Metal Forming Tools Laboratory	--	--	--	--	--	25	25	50
PEL502	Machine Design-I Laboratory	--	--	--	--	--	25	25	50
PEL503	CAD/CAM/CIM Laboratory	--	--	--	--	--	25	25	50
PEL504	Metrology & Quality Engg Laboratory.	--	--	--	--	--	25	25	50
PEL505	Business Communication & Ethics Laboratory						50	--	50
	Total			120	480		150	100	850

* **Theory for entire class to be conducted.**

Course Code	Department Level Optional Course I
PEDLO5011	Internal Combustion Engines
PEDLO5012	Finite Element Analysis
PEDLO5013	Plastic Engineering
PEDLO5014	Micro and Nano Manufacturing
PEDLO5015	Sustainable Manufacturing

Course Code	Course Name	Credits
PEC501	Design of Mould & Metal Forming Tools	04

Objectives

1. To prepare the students study and analyze casting and forming processes like forging, rolling, extrusion and drawing of ferrous and non-ferrous metals.
2. To familiarize the students with the design of sand molds, die casting dies, roll grooves and multi impression forging die etc.

Outcomes: Learner will be able to...

1. Demonstrate the concepts of metal casting and metal forming processes.
2. Identify the equipment, machinery and tooling used for sand casting/die casting.
3. Identify equipment, machinery and tooling used for forming processes (such as forging, rolling and extrusion).
4. Illustrate the basic theory pertaining to plastic deformation of metal.
5. Develop skills in designing tools, the set up for the processing techniques pertaining to various metal casting and metal forming operations.
6. Analyze various defects, their probable causes and remedial measures confronted with metal casting and forming processes.

Module	Contents	Hrs.
01	Design of Sand moulds: 1.1 Design and drawing of gating system: Pouring basin, Sprue, Runners and Ingates. 1.2 Design of feeding system: Caine's method, Modulus method, Chvorinov's mould constant, Use of chills, padding and risering.	10
02	2.1 Melting & Pouring: Melting practices: Cupola, Arc and Induction furnaces. 2.2 Defects in cast components and their remedies.	02
03	Special Casting Processes 2.1 Die design and manufacture for pressure die casting of non-ferrous metals, Principle of Hot chamber and Cold chamber die casting processes, Design and manufacture of die-casting dies for Cold chamber die casting process. 2.2 Casting process used for composites. 2.3 Defects in die cast components and their remedies. 2.4 Lost Wax Process Investment Casting : Use of wax as the moulding material; Process description; Features and advantages; Fields of application; 2.5 Shell Mould casting: Working principle and application.	10
04	Forging of metals 4.1 Forging hammers, high speed forging machines, Presses and Horizontal upset forging machines: Construction and principle of operation. 4.2 Single and multi-impression closed die forging process; 4.3 Design and drawing of multi-impression drop forging, die set using fuller, edger, bender, blocker and finisher, cavities with flash and gutter. 4.4 Defects in forged products and their remedies.	12
05	Rolling of metals 5.1 Design and drawing of Continuous Billet Mill Roll grooves using diamond, square, oval and round passes. Roll passes for rolling rails, beams, angles and channels.	12

	5.2 Production of seamless tubes by rolling. 5.3 Defects in rolled products and their remedies.	
06	Extrusion of Metals and Miscellaneous Metal Forming Processes 6.1 Introduction to metal extrusion and basic concepts of extrusion dies. 6.2 Drawing of metals: Principle of operation and applications.	02

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Metal Casting: A Sand Casting Manual for the Small Foundry-Vol. 2*, Stephen D. Chastain.
2. *Principles of Metal Casting*, R W Heine, C R Loper, P. C. Rosenthal.
3. *Metal Casting*, T.V. Ramana Rao.
4. *Manufacturing Technology*, P.N. Rao.
5. *Foundry Engineering*, P.L.Jain.
6. *Die Casting*, H.H. Doehler
7. *The Diecasting Handbook*, A.C.Street , Portcullis Press, Redhill, U.K.
8. *Mechanical Metallurgy*, George E. Dieter.
9. *Metals Hand Book–Vol. 14 Forming and Forging*, ASM International.
10. *Forging Die Design*, Sharan, Prasad and Saxena.
11. *Forging Handbook-Forging Methods*, A. Thomas, Publisher-Drop Forging Research Association, Shepherd Street, Sheffield.

Course Code	Course Name	Credits
PEC502	Operations Research	03

Objectives:

1. To familiarize the students with various tools of optimization for management of various resources.
2. To acquaint the students with various simulation tools for optimization for various resources.

Outcomes: Learner will be able to:

1. Utilize the resources in various industries optimally.
2. Apply the concept of linear programming for solving specialized problems on transportation, assignments & sequencing.
3. Apply principles of queuing, replacement & game theory models to solve real life problems.
4. Demonstrate the concept of dynamic programming in modelling and solving problems.
5. Illustrate different types of simulation models applicable to Inventory/queuing.
6. Acquire skills in identifying & applying cost effective strategies in managing of manufacturing projects.

Module	Contents	Hrs.
01	<p>1.1 Linear Programming: Linear Programming Problem: Formulation, Graphical solution, Simplex method, Big-M method, Two-phase method, Principle of Duality, Dual Simplex, Sensitivity Analysis.</p> <p>1.2 Transportation problem: Formulation - Optimal solution, Degeneracy.</p> <p>1.3 Assignment problem: Formulation - Optimal solution, Traveling Salesman problem.</p> <p>1.4 Sequencing: Introduction – Flow Shop sequence. Sequencing – n jobs through two machines - n jobs through three machines – Job shop sequencing - two jobs through ‘m’ machines.</p>	15
02	<p>2.1 Queuing Models: Introduction - Single Channel - Poisson arrivals - exponential service times - with infinite population and finite population models – Multichannel - Poisson arrivals – exponential service times with infinite population single channel Poisson arrivals.</p> <p>2.2 Replacement: Introduction - Replacement of items that deteriorate with time - when money value is not counted and counted -Replacement of items that fail completely, group replacement</p>	06
03	<p>Game Theory: Introduction - Minimax (Maximin) - Criterion and optimal strategy - Solution of games with saddle points – Rectangular games without saddle points - 2 X 2 games - dominance principle – m X 2 & 2 X n games, Graphical method</p>	05
04	<p>Dynamic programming: Introduction – Bellman’s Principle of optimality - Applications of dynamic programming- capital budgeting problem - Shortest Path problem – Minimum Spanning Tree.</p>	04
05	<p>Simulation: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages.</p>	04
06	<p>Project Management: Programme Evaluation and Review Technique, Critical Path Method, Network Updating, Crashing of Network and Resources levelling.</p>	08

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Operations Research: Principle and Practices*, A. Ravindran, D. Phillips, Wiley India.
2. *Operations Research*, S. D. Sharma, Kedar Nath Ram Nath-Meerut.
3. *Operations Research*, R. Panneerselvam, PHI Publications.
4. *Operations Research*, Kanti Swarup, P. K. Gupta and Man Mohan, Sultan Chand & Sons.
5. *Operations Research*, A. M. Natarajan, P. Balasubramani, A. Tamilarasi, Pearson Education.
6. *Operations Research, An Introduction*, Hamdy A. Taha, Pearson Education
7. *Operations Research: Methods and Problems*, Maurice Saseini, Arthur Yaspan and Lawrence Friedman.
8. *Introduction to O.R.*, Hiller & Libermann (TMH).

Course Code	Course Name	Credits
PEC503	Machine Design – I	04

Objectives:

1. To prepare the students learn basic principles of engineering design.
2. To familiarise the students with the concepts of strength design related to various components.
3. To acquaint the students use design data books & various codes of practices.

Outcomes: Learner will be able to:

1. Apply basic principles of machine design.
2. Design joints such as knuckle joint/turn buckle.
3. Design machine elements such keys, shafts, couplings/springs.
4. Design pressure vessels.
5. Design weld joint.
6. Design rivet/bolt joints.

Module	Contents	Hrs.
01	1.1. Introduction - Steps involved in designing, types of designs, considerations in designing, Design–manufacturing interface, material selection, factor of safety and its implications. 1.2. Operational Joints - Introduction to cottered, pinned & threaded joints, & their applications. 1.3. Design of socket & spigot type 1.4. Design of Pinned Joints - Knuckle joint 1.5. Design of Turn Buckle	10
02	2.1 Determination of stresses in machine components with various cross sections. Circular, rectangular, triangular, trapezoidal, T & I sections subjected to direct & bending stresses. (Including stresses at critical sections) 2.1. Stresses in curved members- Design of crane hooks & C-clamps with various cross sections (Circular, triangular, square, rectangular, trapezoidal) (Circular & oval rings to be excluded).	06
03	3.1. Design of shafts 3.1.1. Design of shafts on the basis of strength. Shafts subjected to-bending alone, Torsion alone, combined action of torsion & bending, combined action of torsion & axial loads, combined action of torsion, bending & axial loads (Rankine’s and Guest’s equations) 3.1.2. Concepts about design of shafts based on rigidity (lateral & torsional rigidity)- only Implications 3.2. Design of keys 3.2.1. Different types of keys and applications. 3.2.2. Fitting of keys – types and effects of keyway on shaft 3.2.3. Stresses in keys and design of key dimensions. 3.3. Design of couplings: 3.3.1. Classification of couplings & application areas.	10

	3.3.2. Design of flanged couplings, muff couplings, bushed pin type flexible coupling.	
04	4.1. Design of welded joints - Types & classification of welded joints, applications. Familiarization of AWS code. Strength of welded joints- Transverse & parallel fillet welds. Welded joints subjected to torsion – circular fillet welds and adjacent fillet welds. 4.2. Design of welded joints subjected to eccentric loading.	06
05	5.1. Design of bolted joints - stresses in bolts, joints for leak proof fluid tight applications (like cylinder to cylinder cover fastening in an IC engine), bolts of uniform strength. 5.2. Design of riveted joints - Type of rivets and riveted joints. Failure modes of riveted joints & efficiency of riveted joints. Design of riveted joints for riveting longitudinal & circumferential seams of pressure vessels. Familiarization of Indian Boiler Regulation (IBR) 5.3. Design of bolted and riveted joints subjected to eccentric loading.	10
06	6.1. Design of Springs : Classification and applications, design of helical compression and tension springs (only circular cross-section), co-axial springs. Design of leaf springs–straight and semi elliptical laminated leaf springs. Strain energy of springs–design of buffer springs. 6.2. Design of Pressure Vessels : Design concepts of thick and compound cylinders, Stresses in thick & compound cylinders. Determination of wall thickness, hoop and radial stresses, nature of hoop and radial stress distribution on cylinder walls.	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

NOTE:

Use of standard design data books like PSG Data Book or Design Data by Mahadevan is permitted at the examination and shall be supplied by the college.

Reference Books:

1. *Design of machine elements* -- V. B. Bhandari. Tara Mc-Graw Hill Pub.
2. *Design of machine elements* -- Sharma, Purohit. Prentice Hall India Pub.
3. *Machine Design - An Integrated Approach* -- Robert L. Norton – Pearson Education.
4. *Machine Design* - Pandya & Shah- Charotar Publishing.
5. *Mechanical Engineering Design* - J. E. Shigley - McGraw Hill
6. *Recommended Data Books* - PSG, K. Mahadevan
7. *Machine Design* - Reshetov - Mir Publication
8. *Machine Design* - Black Adams-Mcgraw Hill
9. *Fundamentals of Machine Elements* - Hawrock, Jacobson McGraw Hill
10. *Design of Machine Elements* - V.M. Faires
11. *Design of Machine Elements* - Spotts.

Course Code	Course Name	Credits
PEC504	CAD/CAM/CIM	04

Objectives:

1. To familiarize the concepts of computer aided engineering for design & manufacturing.
2. To impart the knowledge on computer graphics used in engineering.
3. To familiarize the students with the concepts of computer aided manufacturing and its significance.
4. To familiarize the students with interfacing of drive systems with the machines.

Outcomes: Learner will be able to...

1. Use computer graphics in design.
2. Identify proper modeling techniques for geometric modeling.
3. Develop expertise in computer-aided manufacturing.
4. Illustrate basic concepts of control systems.
5. Write the appropriate code for performing particular tasks in a CNC.
6. Solve real life engineering problems using FEA.

Module	Contents	Hrs.
01	<p>Computer Aided Design:</p> <p>1.1 Introduction : Need and Utility of CAD systems in industry, Product Cycle, Definition of CAD tools based on their Constituents and Implementation in a design environment.</p> <p>1.2 CAD Hardware : Types of systems, system considerations, I/O devices, Hardware Integration & Networking.</p>	04
02	<p>Computer Graphics :</p> <p>Pixel plotting, Scan conversions of lines & circuits, 2D & 3D transformation, 2D Viewing and clipping. Parallel Projection. Elementary treatment of Hidden lines and surfaces. Cubic spines Bezier curves & B- spines, Animation and Color models.</p>	10
03	<p>Solid Modeling :</p> <p>Types of representation of solid models, interactive tools available with solid modeling software's. Introduction to surface modeling.</p> <p>CAD DATA Exchange : File Structure and format of IGES,STEP and DXF</p>	05
04	<p>Introduction :</p> <p>Elements of CAM system, Computer Numerical control of Machine Tools, Fundamental elements of CNC, Benefits of CNC, Computer control concepts, Data processing units & Binary calculation.</p> <p>Basics of control systems:</p> <p>Motion controller, Interpolation-Linear & Circular, Positioning & contouring control loops, Incremental & Absolute system, DNC & CNC systems and Adaptive control system.</p> <p>CNC Hardware Basics:</p> <p>CNC drives, Spindle design, Actuation and Feedback devices</p>	10

05	<p>CNC Programming : Introduction to CNC Lathe & Milling, Touch probe system, Tool length, nose radius & Diameter compensation, Turning & Machining centre programming, CNC part programming using ISO controllers, Canned cycles, Looping Jumping Subroutines Macros, Parametric programming, Computer aided part programming using APT and Post processing.</p>	11
06	<p>CIM : Computer applications in manufacturing, Automation and Integrated Production management systems. Automated Material handling systems, Conveyors, AVG, AS/RS, GT, FMS, Automated inspection procedure, Distributed Numerical control & Benefits of CIM and implementation & computer aided shop floor control system. Concept of “Ghost” factory.</p> <p>FEA: Introduction, Stress and Equilibrium, Boundary Condition, Strain – Displacement Relations, Stress Strain Relation, Potential Energy. One Dimensional Problem: Finite Element Modelling, Coordinate Potential Energy Approach, Galerkin Approach, Assembly of Global Stiffness Matrix, Properties of Stiffness Matrix, Finite Element Equations. Trusses: Introduction, 2D Trusses, Assembly of Global Stiffness Matrix.</p>	10

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *CAD/CAM* by Groover and Zimmers
2. *CAD Principles and Applications* by Barr, Krimger and Lazaer
3. William M Neumann and Robert F.Sproul “*Principles of Computer Graphics*”, Mc Graw Hill Book Co. Singapore, 1989.
4. Donald Hearn and M. Pauline Baker “*Computer Graphics*”, Prentice Hall, Inc., 1992.
5. Foley, Wan Dam, Feiner and Hughes – *Computer graphics principles & practices*, Pearson Education – 2003.
6. Reddy, J.N, “*An Introduction to the Finite element Method*”, McGraw – Hill, 1985.
7. Rao, “*Finite Element Method in Engineering*”, Pergammon Press, 1989.
8. CAD / CAM by P.N. Rao (Tata-Mcgraw- Hill) 2

9. *Mathematical and Procedural Elements for computer graphics* by Roger and Adams
10. *Computer Graphics* by Hearn and Baker (PHI)
11. *A first course in FEM* by daryl L.Logon(Cengage) 3
12. *Concepts and applications of FEA* by Cook, Malkus (Jhon-wiley)
13. *Mastering CAD – CAM* by Ibarahim Zeid (Tata-Mcgraw-Hill) 4

Course Code	Course Name	Credits
PEC505	METROLOGY AND QUALITY ENGINEERING	04

Objectives:

1. To acquaint with principles of precision measuring instruments & their significance.
2. To familiarize with the handling & use of precision measuring instruments/ equipment's.
3. To acquaint with key features and the basics of Total Quality Management philosophy.
4. To familiarize with various quality tools and their uses in solving problems.

Outcomes: Learner will be able to...

1. Handle & operate precision measuring instruments / equipment's.
2. Design Go and No Go gauges for a given assembly.
3. Analyze simple machined components for dimensional stability & functionality.
4. Identify and use proper quality tools in various manufacturing /service problems.
5. Integrate quality approaches for productivity improvement.
6. Comprehend and apply Quality standards in different situations.

Module	Contents	Hrs
01	1. Introduction to Metrology 1.1 Need for inspection, fundamental principles and definition, standards of measurement, Static characteristics of Measurements. 1.2 Limits, fits and Tolerances of interchangeable manufacture, Elements of Interchangeable System, hole based and shaft based systems IS 919 : 1963 tolerance grades, types of fits, General requirements of go & NO GO gauging, Taylor's principle, Design of go & no go gauges.	08
02	2.1 Comparators: Constructional features and operation of mechanical, optical, electrical/electronic and pneumatic comparators, advantages, limitations and field of Applications. 2.2 Principles of interference, concept of flatness, flatness testing, optical flats, optical Interferometer and laser interferometer. 2.3 Surface texture measurement: importance of surface conditions, roughness and waviness, surface roughness standards specifying surface roughness parameters- Ra, Ry, Rz, RMS value etc., surface roughness measuring instruments – Tomlinson and Taylor Hobson versions, surface roughness symbols	09
03	3.1 Screw Thread measurement: Two wire and three wire methods, fil carriage micrometer. 3.2 Gear measurement: Gear tooth comparator, Master gears, measurement using rollers and Parkinson's Tester. 3.3 Special measuring Equipment: Principles of measurement using Tool Maker's microscope, profile projector & 3D coordinate measuring machine.	07
04	Quality 1.1 Quality Control Evolution of Quality, Definition of Quality, Dimensions of Quality Planning, Principles of TQM, set up policy and objectives of quality control, quality of	08

	<p>design and quality of conformance, compromise between quality & cost, quality cost and planning for quality</p> <p>1.2 Cost of quality: prevention, appraisal & failure costs and Hidden cost of quality.</p> <p>1.2 Quality improvement</p> <p>Juran's trilogy, management of controllable defects, operator controllable defects, sporadic and chronic problems of quality. Bench Marking: Introduction, definition and its significance. Collection of data for bench marking and its use.</p>	
05	<p>SQC and SQC tools</p> <p>5.1 Process Data Collection & presentation – Bar Chart, Histogram and Run Charts.</p> <p>5.2 Process Variability – variables & Process Variation (Measures of accuracy & Centering, precision or spread, normal distribution and sampling averages).</p> <p>5.3 Process Control by Variable – using X bar and R Chart and control charts for standard deviation.</p> <p>5.4 Process Control by Attribute - for number of defectives or non-conforming units - np-charts, p-charts, c-charts and u-charts</p> <p>5.5 Process capability, OC curve, acceptance sampling AQL, LTPD, AOQL, producers and consumers risk (Single & Double sampling plan only). (Note: Emphasize the explanation with Numerical problems).</p>	08
06	<p>6.1 Sampling Techniques Sampling inspection and basic concepts, OC curves, consumer & Producer risk, single & double sampling plans and use of sampling tables.</p> <p>6.2 Quality standards</p> <p>a. The ISO9001:2000 Quality Management System Standard</p> <p>b. The ISO 14001:2004 Environmental Management System Standard</p> <p>c. ISO 27001:2005 Information Security Management System</p> <p>d. ISO/TS 16949:2002 for Automobile Industry</p> <p>e. Internal audit, surveillance audit, maintaining of certification</p>	08

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Engineering Metrology*, K. J. Hume, Kalyani publication
2. *Engineering. Metrology*, I.C. GUPTA, Dhanpat Rai Publications.
3. *Statistical quality control*, A.L. Grant, McGraw Hill International, New York.
4. *Engineering. Metrology*, R. K. Jain, Khanna Publisher.
5. *Engineering. Metrology*, Hume K.G., M C Donald, Technical &Scientific, London.
6. *Quality Control and Industrial Statistics*, Duncon A.J.,
D.B. Taraporevela & Co. Bombay.
7. *Statistical quality Control*, Mahajan M., DhanpatRai & Sons, Delhi.
8. *Introduction to Statistical Quality Control*, By Douglas C. Montgomery
wiley india publication
9. *Quality control* by D.H. Besterfield , Pearson education.
10. Juran's Quality Control Handbook.
11. *Metrology for Engineers* Charles Reginald Shotbolt, PublisherCassell,
12. *Understanding and Implementing ISO 9000 and ISO Standards* by David L. Goetsch,
Stanley Davis , Prentice Hall

Course Code	Course Name	Credits
PEDLO5011	Internal Combustion Engines	03

Objectives:

1. To familiarize with various types of internal combustion engines.
2. To impart knowledge about various systems/components of IC engines.
3. To impart knowledge about various engine performance characteristics and its testing.

Outcomes: Learner will be able to:-

1. Demonstrate working of different types of engines.
2. Analyze fuel supply systems and ignition systems of IC Engines.
3. Distinguish combustion process of SI and CI Engines.
4. Measure operating characteristics of IC Engines.
5. Analyze the impact of vehicular pollution and ways to reduce or control the pollution.
6. Illustrate various standard pollution norms like EURO, Bharat for I.C. engines.

Module	Contents	Hrs.
01	Introduction to IC Engines and cycle analysis: Basic of I.C. Engines, Details of two stroke and four stroke engines, Valve timing diagram, Air standard cycles, Fuel air cycle and actual cycle. Variation in specific heat, Dissociation and their effect on engine performance. Review of other losses in IC engines.	07
02	Spark Ignition Engines Fuel Supply System in S I Engines : Theory of Carburetion, Types of carburetors, Electronic fuel injection system (MPFI), Combustion in Spark Ignition Engines: Stages of combustion, ignition lag, flame propagation, factors affecting flame propagation, abnormal combustion, phenomenon of detonation in SI engines, effect of engine variables on detonation. Combustion chambers. Rating of fuels in SI engines.	07
03	Compression Ignition Engines Fuel supply system in CI Engine: Air injection systems, Airless/solid injection systems, individual pump, Common rail and distributor system, unit injector etc, types of fuel pump, injector and nozzles. Electronically controlled fuel injection system Combustion in compression ignition engines (CI): Stages of combustion, ignition delay, factors affecting delay period, phenomenon of knocking in CI engine, effect of engine variables on knocking, comparison of knocking in SI & CI engines, types of combustion chambers, rating of fuels in CI engines,	07
04	Engine systems and components Engine lubrication : Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems	07

	<p>Engine Cooling: Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling.</p> <p>Supercharging/Turbo-charging: Objectives, Effects on power output and engine efficiency, Methods, Types and Limitations.</p>	
05	<p>Testing and Performance of engines: Measurement of indicated power, brake power, fuel consumption and emission, Measurement of friction power by Willan's Line Method* and Morse Test*, calculation of brake thermal efficiency, brake power and brake specific fuel consumption of I.C Engines, variable compression ratio engines, heat balance sheet of I.C Engines (Numerical on Performance and Heat balance sheet of I.C Engine)</p>	08
06	<p>Engine Emission and Control S.I. engine emission (HC, CO, NO_x) Control methods- Evaporative (ELCD), Thermal, Catalytic converters, C.I. Engines Emission (CO, NO_x, Smog, Particulate), Control methods- Chemical, EGR. Standard pollution norms like EURO, Bharat, Introduction to alternative fuels for I.C. engines,</p>	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Internal Combustion Engines*, by Willard W. Pulkrabek, Pearson Education.
2. *Internal Combustion Engines*, by Shyam Agrawal, New Age International
3. *Internal Combustion Engines*, by Mathur and Sharma
4. *Internal Combustion Engines*, by Mohanty, Standard Book House
5. *Internal Combustion Engines*, by Gills and Smith
6. *Internal Combustion Engines Fundamentals*, by John B. Heywood
7. *Internal Combustion Engines*, by Gupta H N, 2nd ed, PHI
9. *Internal Combustion Engines*, by Richard Stone - Palgrave Publication
10. *Internal Combustion Engines*, by Domkundwar
11. *Internal Combustion Engines*, by V. Ganeshan

Course Code	Course Name	Credits
PEDLO5012	Finite Element Analysis	03

Objectives

1. To introduce the concepts of Mathematical Modelling of Engineering Problems.
2. To familiarize with the applicability of FEM to a range of Engineering Problems.
3. To acquaint with the applications of numerical techniques for solving problems.

Outcomes: Learner will be able to...

1. Solve ordinary and partial differential equations using the Galerkin method.
2. Develop the finite element equations to model engineering problems governed by 2nd order partial differential equations.
3. Apply the basic finite element formulation techniques to solve engineering problems.
4. Use commercial FEA software, to solve problems related to engineering.
5. Prepare Solutions of 2 -D Problems using FE Software.
6. Find solution techniques to Dynamic problems, longitudinal vibration, frequencies and mode shapes.

Module	Contents	Hrs.
01	<p>Introduction</p> <p>1.1. Introductory Concepts: Introduction to FEM, Historical Background, General FEM procedure. Applications of FEM in various fields. Advantages and disadvantages of FEM.</p> <p>1.2. Mathematical Modeling of field problems in Engineering, Governing Equations, Differential Equations in different fields.</p> <p>1.3 Approximate solution of differential equations-- Weighted residual techniques, Galerkin methods.</p>	09
02	<p>FEA Procedure</p> <p>2.1 Discrete and continuous models, Weighted Residual Methods –Ritz Technique –Basic concepts of the Finite Element Method.</p> <p>2.2. Definitions of various terms used in FEM like element, order of the element, internal and external node/s, degree of freedom, primary and secondary variables, boundary conditions.</p> <p>2.3. Minimization of a functional. Principle of minimum total potential. Piecewise Rayleigh-Ritz method. Formulation of “stiffness matrix”; transformation and assembly concepts.</p>	05
03	<p>One-Dimensional Problems</p> <p>3.1. One Dimensional Second Order Equations Discretization–Element types-Linear and Higher order Elements – Derivation of Shape functions and Stiffness matrices and force vectors.</p> <p>3.2. Assembly of Matrices -solution of problems in one dimensional structural analysis, heat transfer and fluid flow (Stepped and Taper Bars, Fluid Network, Spring-Cart systems)</p> <p>3.3. Analysis of Plane Trusses, Analysis of Beams.</p> <p>3.4. Solution of one Dimensional structural and thermal problems using FE Software, Selection of suitable Element Type, Modeling, Meshing,</p>	10

	Boundary Condition, Convergence of solution, Result analysis, Case studies.	
04	Two Dimensional Finite Element Formulations 4.1 Introduction, Three noded triangular element, four noded rectangular element, four noded quadrilateral element. 4.2 Natural coordinates and coordinates transformations: serendipity and Lagranges methods for deriving shape functions for triangular and quadrilateral element 4.3. Introduction to Sub parametric, Isoperimetric, super parametric elements. Compatibility, Patch Test, Convergence criterion, Sources of errors.	08
05	Two Dimensional Vector Variable Problems 5.1 Equations of elasticity –Plane stress, plane strain and axisymmetric problems. 5.2. Jacobian matrix, stress analysis of CST. 5.3. Solution of 2 -D Problems using FE Software (structural and Thermal), election of element type, meshing and convergence of solution. (Can be covered during practical hours).	05
06	Finite Element Formulation of Dynamics and Numerical Techniques: 6.1. Applications to free vibration problems of rod and beam. Lumped and consistent mass matrices. 6.2. Solutions Techniques to Dynamic problems, longitudinal vibration, frequencies and mode shapes. Fourth Order Beam Equation, Transverse deflections and Natural frequencies of beams. 6.3 Finding frequencies of beam using FE Software (Can be covered during practical hours).	05

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. Seshu. P. “*Textbook of Finite Element Analysis*” Prentice Hall of India, 2003.
2. J.N. Reddy, “*Finite Element Method*” Tata McGraw Hill, 2003.
3. Chandrupatla and Belegundu, “*Introduction to Finite Elements in Engineering*” PHI /Pearson Education, 2003.
4. Logan. D.L. “*A first course in Finite Element Method*”, Thomson Asia Pvt. Ltd., 2002.
5. Cook R.D., Malkus. D.S. Plesha, ME., “*Concepts and Applications of Finite Element Analysis*”, John – Wiley Sons 2003.
6. S.S. Rao, “*The Finite Element Method in Engineering*” Butter worth Heinemann, 2001.
7. M. Asghar Bhatti, “*FUNDAMENTAL Finite Element Analysis and Applications with Mathematica and MATLAB Computations*”, Wiley India Pvt. Ltd.

Course Code	Course Name	Credits
PEDLO5013	Plastics Engineering	03

Objectives

1. To familiarize with the vast potential of plastics materials in domestic engineering and specialty application areas.
2. To familiarize with the various processing techniques.
3. To familiarize with the design of moulds and dies.

Outcomes: Learner will be able to...

1. Illustrate the various applications of plastics.
2. Demonstrate applicability of plastics in place of conventional materials.
3. Design various tools for plastics processing.
4. Illustrate various plastic processing techniques.
5. Design different types of moulds with their application.
6. Demonstrate trouble shooting skills in manufacturing plastic parts.

Module	Contents	Hrs.
01	<p>Materials Brief introduction to plastics materials, their classifications, types important properties & fields of application. Introduction to plastics blends, alloys and composites. Principles of recycling of plastics and waste management</p>	04
	<p>Processing Techniques 2.1 Injection Moulding Moulding materials, moulding cycle-phases, and significance. Moulding Machinery: types, constructional and design features, plasticizing screw, injection and clamping units, Technical specifications and selection. Processing Techniques: Process parameters and their influence on product quality, trouble shooting. 2.2 Extrusion Process Constructional and design features of extrusion machinery plasticizing screw. Technical specification and selection. Extrusion lines for pipes, Films (monolayer and multilayer, blown and cast films), sheets, Extrusion coating, monofilaments, box strapping, cables/wires and profiles. [Coverage for the above should include materials, plant layouts, in line equipment, extrusion techniques, process parameter and their influence on extruded products and trouble shooting). 2.3 Blow Moulding Materials for blow moulding application, Types of Machinery, technical specifications and selection. (Extrusion Blow Moulding, Injection blow moulding and stretch Blow moulding). Processing Techniques: Process parameters and their influence on product quality, troubleshooting Comparison between types of Blow Moulding Processes.</p>	10

03	<p>Auxillary equipment for plastics processing Hopper dryers, Deccant dryers, Granulators, Mould temperature controllers, Proportionating devices, chilling units, automatic material conveying systems.</p> <p>Other Process: Brief coverage of the following processes with relevant details like machinery, materials, processing techniques and applications. Thermoset Mouldings, Thermoforming, Rotational Moulding, calendaring, fabrication and decorating with plastics.</p> <p>FRP Techniques: Raw materials and ancillaries used techniques like Hand lay-up, spray up and filament winding processes, applications.</p>	04
04	<p>Product designing with plastics Mechanical behaviour of plastics, creep data and its significance in designing. Product designing tips for designing articles to be manufactured by injection moulding, blow Moulding and Extrusion Processes.</p>	04
05	<p>Design of Moulds 5.1 Compression and transfer moulds: General arrangement of compression moulds-flash, semi positive and positive versions. General arrangement of transfer moulds-moulds for integral pot and auxillary transfer.</p> <p>5.2 Injection Moulds: General arrangement of two plate moulds. Design of mould components, design of feedings, cooling and ejection systems, three plate moulds, Designing for moulds for articles with undercuts-split moulds and moulds with side cores actuation techniques, moulds for internally threaded articles, fully automatic moulds, mould standardization and innovative mould components.</p> <p>5.3 Hot runner systems: General arrangement, design of manifold blocks, flow ways and nozzles, advantages and limitations.</p>	14
06	<p>Blow Moulds: General arrangement and mould components, design of neck and base pinch offs and flash pockets, Venting of moulds, selection of parting lines.</p> <p>Extrusion Dies: Design of extrusion dies for pipes, films, sheets, cables and profiles.</p> <p>Mould Materials of Construction: Characteristics, Tool steels and alloys, non-ferrous materials.</p>	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Moulding of Plastics*, Bickales.
2. *Design of Extrusion dies*, M. V. Joshi.
3. *Injection of Mould Design*, R. G. W. Pyre.
4. *Plastic Materials*, Brydson.
5. *Extrusion Technology* – Allen Griff.
6. *Practical guide to Blow Moulding*, Lee.
7. *Injection Moulding: Theory and Practice*, Rubin.
8. *Handbook of Composite fabrication*, Akovali.
9. *Plastic product materials and process selection Handbook*, Rosato.

Course Code	Course Name	Credits
PEDLO5014	Micro And Nano Manufacturing	03

Objectives:

1. To familiarize with the applications of various Micro and Nano manufacturing technologies.
2. To familiarize with traditional Micro and Nano machining.
3. To familiarize with Non-traditional Micro machining methods.
4. To familiarize with Micro Forming and Welding techniques.
5. To familiarize with various processes used for Nano finishing and carbon nano tube production.

Outcomes: Learner will be able to...

1. Demonstrate understanding of various traditional/non- traditional micro and nano machining methods.
2. Demonstrate understanding of various micro forming/welding techniques.
3. Demonstrate understanding of various nano finishing/carbon nano tube production methods.
4. Illustrate the details of various Micro Forming and Welding techniques.
5. Demonstrate various Nano Finishing Techniques used in industries.
6. Illustrate various Carbon Nanotube Production processes applicable in industries.

Module	Contents	Hrs.
01	Overview of Micro and Nano Manufacturing Introduction, Micro-Products And Design Considerations For Manufacturing, Material Factors, Considerations On Manufacturing Methods, Manufacturing Methods And Processes, Process Chains And Hybrid Processes, Transition from Nanotechnology to Nano manufacturing.	06
02	Traditional Micro and Nano Machining Mechanical micromachining: Introduction, Machining Effects at the Microscale, Shear Angle Prediction, Plastic Behavior at Large Strains, Langford and Cohen's Model, Walker and Shaw's Model, Usui's Model, Sawtooth Chip Formation in Hard Turning, Fluid-Like Flow in Chip Formation, Size Effects in Micromachining, Micromachining tool design, Nanomachining: Nanometric machining Theoretical basis of Nano machining Cutting force and energy, Cutting temperature, Chip formation and surface generation, Minimum undeformed chip thickness, Critical cutting edge radius, Properties of workpiece materials, Comparison of nanometric machining and conventional machining, Implementation of nanomachining - single point diamond turning.	12
03	Non-traditional Micro Machining Ultra Sonic Micro Machining, Chemical and Electro Chemical Micro Machining, Electric Discharge Micro Machining, Electron Beam Micro Machining, Laser Beam Micro Machining, Ion Beam Micro Machining.	06
04	Micro Forming and Welding	06

	Micro Blanking and Punching, Micro Embossing, Micro Extrusion, LASER Micro Welding, Electron Beam Micro Welding.	
05	Nano Finishing Techniques Abrasive Flow Machining (AFM), Magnetic Abrasive Finishing (MAF), Magneto rheological Finishing (MRF), Magneto rheological Abrasive Flow Finishing (MRAFF), Magnetic Float Polishing (MFP), Elastic Emission Machining (EEM), Chemical Mechanical Polishing (CMP).	06
06	Carbon Nanotube Production Chemical Vapour Deposition, Arc Discharge, Laser Ablation, Mechanisms of Growth, Purification of Carbon Nanotube.	06

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. Mark J. Jackson, *Micro and Nanomanufacturing*, Springer, 2007.
2. N. P. Mahalik, *Micromanufacturing and Nanotechnology*, Springer, 2006.
3. Yi Qin, *Micro-Manufacturing Engineering and Technology*, Elsevier, 2010.
4. Ming Wang Fu, Wai Lun Chan, *Micro-scaled Products Development via Microforming*, Springer, 2014.
5. Waqar Ahmed, Mark J. Jackson, *Emerging Nanotechnologies for Manufacturing*, 2nd Edition, Elsevier, 2015.
6. Joseph McGeough (Editor), *Micromachining of Engineering Materials*, Marcel Dekker, 2002.
7. V.K. Jain (Editor), *Micromanufacturing Processes*, Taylor and Francis, 2013.
8. Mark J. Jackson, *Microfabrication and Nanomanufacturing*, Taylor and Francis, 2006.

Course Code	Course Name	Credits
PEDLO5015	Sustainable Manufacturing	03

Objectives

1. To introduce basic concepts related to sustainability and sustainable development.
2. To get conversant with indigenous and global concerns about sustainability and its implications in manufacturing.
3. To familiarize with various technological innovations, approaches & environmental standards /legislations to promote sustainable development.

Outcomes: Learner will be able to...

1. Illustrate the agenda of indigenous and global sustainability to fulfil green expectations.
2. Demonstrate the knowledge about management of waste, pollution & energy conservation.
3. Demonstrate the knowledge of sustainability issues with its implementation in manufacturing.
4. Illustrate the relevance and implications of environment friendly materials.
5. Illustrate the implications of environment management in the context of modern industrial practices.
6. Develop the sustainability approach in environmental strategy and manufacturing.

Module	Contents	Hrs.
01	Sustainability: Basic concepts related to sustainability and sustainable development. Issues and challenges facing sustainable development. Global & indigenous sustainability agenda, green expectations & green movement.	04
02	Management of waste & pollution: Types, sources and nature of wastes, waste processing, green processing & engineering operations, Energy recovery, and 3 R principle. Types of pollution and management:-Anti pollution approaches & guide lines.	08
03	Management of Energy: Sources of energy, renewable energy, Innovations in generation, conservation, recycling and usage of energy. Energy audit and implications.	07
04	Environment friendly materials : Materials for sustainability , eco-friendly and new age energy efficient and smart materials , alternative manufacturing practices , materials and selection of manufacturing processes , control on use of renewable materials , Bio-degradable materials recycling of materials.	07
05	Environment Management : Innovations for reuse , bio-processing technology , sustainable loading on ecosystems , concept of eco-efficiency and its implementation , Environment analysis from raw materials to disposal (cradle to grave concept) sustainable design and materials for sustainable design , Environmental standards and legislations. ISO 14000, carbon foot print, anti-pollution boards, Environment management in business world, changing scenario in global perspective.	08

06	Integrating sustainability approach: Environmental issues in operating strategy, creating sustainable manufacturing, promoting sustainability awareness, sustainability rating schemes, eco-labelling programmes, human values and professional ethics in sustainable manufacturing. Encouraging innovations in sustainable manufacturing.	06
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Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

End Semester Examination:

Weightage of each module in end semester examination will be proportional to number of respective lecture hours mentioned in the curriculum.

1. Question paper will comprise of total **six questions, each carrying 20 marks**
2. **Question 1** will be **compulsory** and should **cover maximum contents of the curriculum**
3. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3)
4. Only **Four questions need to be solved**

Reference Books:

1. *Strategic Management of Sustainable manufacturing operations* (Advances in logistics operations & Management) By. Rameshwar Dubey & Angappa Gunabekaran by Imuste Productivity press.
2. *Analysis for Smart energy management: Tools and applications for sustainable manufacturing.* By Seog-chanoh and Alfred .J.Hildreth , Springer Series.
3. *Advances in sustainable Manufacturing* By Gunther Seliger and Marwan M.K. khraishah, Springer Series
4. *Green Management* by M.Karpagam, Geetha Jaikumar, Ane Books Pvt.Ltd.
5. *Design for Environment: A guide to sustainable Product Development.*
6. *Sustainable Development* By M.K. Ghosh Roy Ane Books Pvt.Ltd,

Course Code	Course Name	Credits
PEL501	Design of Mould & Metal Forming Tools Laboratory	01

Objectives

1. To prepare a study on sand moulds and pressure die casting dies.
2. To prepare a study on multi impression forging dies and roll passes.
3. To prepare a study on design & draw sand moulds and die casting dies.
4. To prepare a study on design & draw multi impression forging dies and roll pass grooves.

Outcomes: Learner will be able to...

1. Illustrate various forming and casting processes used in manufacturing of components.
2. Classify the equipment's and machines used in manufacturing processes, such as casting, rolling, forging, extrusion and wire drawing.
3. Design and draw the moulds required for castings/ pressure die casting processes.
4. Design and draw the dies required for forging processes.
5. Design and draw the grooves required for rolling processes.
6. Demonstrate various trends in the foundry/forging industries.

Sr.no	Design Exercise/Assignments
01	Assignment on Sand casting
02	Assignment on Special casting process.
03	Assignment on Extrusion process.
05	Design of sand casting moulds.
06	Design of Pressure die casting dies.
07	Design of Forging dies.
08	Design of Roll pass grooves.

Term Work

Term work shall consist of exercises listed in the above table and also a detailed report based on an Industrial visit to a Casting/Forging plant.

The distribution of marks for term work shall be as follows:

Assignments	: 07 marks
Industrial visit Report	: 03 marks
Design Exercises with Drawings (scaled model) on A4 size	: 15 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral Examination

1. Oral examination shall be conducted based on term work and syllabus content.
2. Examiners are expected to give a small task or ask questions either to evaluate understanding of basic fundamentals or to evaluate their capability of applying basic theory to practical applications.

Course Code	Course Name	Credits
PEL502	Machine Design – I Laboratory	01

Objectives

1. To familiarize with basic principles of engineering design and design various machine components.
2. To familiarize with the use of design data books & various codes of practice.
3. To familiarize with the preparation of working drawings based on designs.

Outcomes: Learner will be able to...

1. Demonstrate various design considerations.
2. Apply basic principles of machine design.
3. Design machine elements.
4. Use design data books and various standard codes of practices.
5. Prepare drawings pertaining to various designs.
6. Design various joints used in engineering applications.

Sr.no	Design Exercises/ Assignments
01	Design of Curved Beams
02	Design of Bolted, Welded and Riveted Joints
03	Design of Springs and Pressure Vessels
04	Design of Socket and Spigot type Cotter Joint, Knuckle Joint, Turnbuckle (Any Two)
05	Design of Shafts (Two Design Problems)
06	Design of Rigid Flange Coupling, Bush Pin Type of Flexible Coupling

Term Work

Term work shall consist of exercises listed in the above list

The distribution of marks for term work shall be as follows:

Assignments	: 10 marks
Design Exercises with Drawings on A4 size Paper	: 10 marks
Attendance	: 05 marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Oral Examination

1. Oral examination shall be conducted based on term work and syllabus content.
2. Examiners are expected to give a small task or ask questions either to evaluate understanding of basic fundamentals or to evaluate their capability of applying basic theory to practical applications.

Course Code	Course Name	Credits
PEL503	CAD/CAM/CIM Laboratory	01

Objectives

1. To introduce new and exciting field of Intelligent CAD/CAM/CAE with particular focus on engineering product design and manufacturing.
2. To develop a holistic view of initial competency in engineering design by modern computational methods.
3. To develop New API for CAD

Outcomes: Learner will be able to...

1. Identify proper computer graphics techniques for geometric modelling.
2. Transform, manipulate objects as well as store and manage data.
3. Create CAM Toolpath and prepare NC- G code
4. Apply rapid prototyping and tooling concepts in any real life applications.
5. Identify the tools for Analysis of a complex engineering component.

List of Exercises

1. Programming for transformations,
2. API on Creating As built joints, Slider Joint Motion
3. Get the physical Properties API
4. Get the circle and arc data from the edge
5. Sketch spline through points creation : API
6. Solid modeling using any 3D modeling software
7. Part programming and part fabrication on CNC trainer (Turning / Milling)
8. Geometrical optimization of any mechanical component using computer aided engineering concepts. (Shape optimization)
9. Development of physical 3D mechanical structure using any one of the rapid prototyping processes.

Term Work

Term work shall consist of

- a. Any four exercises from 1 to 6 of above list
- b. Part programming and part fabrication on CNC trainer
- c. A course project in a group of not more than four students based on 8 and 9 of above list

The distribution of marks for term work shall be as follows:

- Exercises : 15 Marks
- Course Project : 05 Marks
- Attendance : 05 Marks

Assessment:

End Semester Practical/Oral Examination:

1. Each student will be given a small task of design based on syllabus, which will be assessed by pair of examiners during the oral examination.
2. Distribution of marks for practical-oral examination shall be as follows:

Design Task:	15 marks
Oral:	10 marks
3. Evaluation of practical/oral examination to be done based on the performance of design task
4. Students work along with evaluation report to be preserved till the next examination

Course Code	Course Name	Credits
PEL504	Metrology And Quality Engineering Laboratory	01

Objectives

1. To acquaint with the principles of precision measuring instruments & their significance.
2. To familiarize with the handling & use of precision measuring instruments / equipments.
3. To acquaint with key features and basics of the Total Quality Management philosophy.
4. To familiarize with various quality tools and their uses in solving the problems.

Outcomes: Learner will be able to...

1. Handle & operate precision measuring instruments /equipment's.
2. Measure linear and angular measurements.
3. Measure thread and gear dimensions.
4. Design Go and Not Go gauge for given assembly.
5. Analyze simple machined components for dimensional stability & functionality.
6. Use proper quality tools in various manufacturing /service problems.
7. Use appropriate quality approaches for productivity improvement.
8. Comprehend and apply Quality standards in different situations.

Sr. No.	Experiments/Assignments
	Any Five experiments
01	Use of linear and angular measuring instruments
02	Use of Profile projector.
03	Use of comparator.
04	Measurement of surface roughness.
05	Measurement of flatness.
06	Thread measurement.
07	Gear measurement.
	Assignment on any Six assignments
01	Limits, Fits, Tolerance and Gauge Design.
02	Comparators and Interferometers
03	Surface Roughness Measurement.
04	Thread Measurement
05	Gear Measurement
06	Total Quality Management
07	Statistical Quality Control
08	Quality Standards

Term Work

Term work shall consist of at least 1 assignment on each module from syllabus and minimum 05 experiments as per above list to be conducted and presented with inferences.

The distribution of marks for term work shall be as follows:

Laboratory work (Experiment/ programs and journal):	10 Marks
Assignments:	10 Marks
Attendance (Theory and Practical):	05 Marks

The final certification and acceptance of term work ensures the satisfactory performance of laboratory work and minimum passing in the term work.

Practical / Oral Examination

1. Practical examination shall be conducted based on the list of experiments. Examination shall be based on actual handling of instruments and accurate measurement of given parameters.
2. Examiners are expected to evaluate learners' skill of handling the instruments and accurate measurement of asked parameters and conduct oral based on the syllabus.
3. The distribution of marks for practical/oral examination shall be as follows:
 - a. Practical performance 15 marks
 - b. Oral 10 marks
4. Students work along with evaluation report to be preserved till the next examination.

Subject Code	Subject Name	Credits
PEL505	Business Communication & Ethics	02

Objectives:

1. To inculcate professional and ethical attitude at the workplace
2. To enhance effective communication and interpersonal skills
3. To build multidisciplinary approach towards all life tasks
4. To hone analytical and logical skills for problem-solving

Outcomes: Learner will be able to...

1. Design a technical document using precise language, suitable vocabulary and apt style.
2. Develop the life skills/ interpersonal skills to progress professionally by building stronger relationships.
3. Demonstrate awareness of contemporary issues knowledge of professional and ethical responsibilities.
4. Apply the traits of a suitable candidate for a job/higher education, upon being trained in the techniques of holding a group discussion, facing interviews and writing resume/SOP.
5. Deliver formal presentations effectively implementing the verbal and non-verbal skills

Modules	Detailed Content	Hours
01	Report Writing 1.1 Objectives of Report Writing 1.2 Language and Style in a report 1.3 Types : Informative and Interpretative (Analytical, Survey and Feasibility)and Formats of reports (Memo, Letter, Short and Long Report)	05
02	Technical Writing 2.1 Technical Paper Writing (IEEE Format) 2.2 Proposal Writing	03
03	Introduction to Interpersonal Skills 3.1 Emotional Intelligence 3.2 Leadership and Motivation 3.3 Team Building 3.4 Assertiveness 3.5 Conflict Resolution and Negotiation Skills 3.6 Time Management 3.7 Decision Making	09
04	Meetings and Documentation 4.1 Strategies for conducting effective meetings 4.2 Notice, Agenda and Minutes of a meeting 4.3 Business meeting etiquettes	02
05	Introduction to Corporate Ethics 5.1 Professional and work ethics (responsible use of social media - Facebook, WA, Twitter etc. 5.2 Introduction to Intellectual Property Rights 5.3 Ethical codes of conduct in business and corporate activities (Personal ethics, conflicting values, choosing a moral response and making ethical decisions)	02

06	Employment Skills 6.1 Group Discussion 6.2 Resume Writing 6.3 Interview Skills 6.4 Presentation Skills 6.5 Statement of Purpose	07
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Assessment:

List of Assignments

1. Report Writing (Theory)
2. Technical Proposal
3. Technical Paper Writing (Paraphrasing a published IEEE Technical Paper)
4. Interpersonal Skills (Group activities and Role plays)
5. Interpersonal Skills (Documentation in the form of soft copy or hard copy)
6. Meetings and Documentation (Notice, Agenda, Minutes of Mock Meetings)
7. Corporate ethics (Case studies, Role plays)
8. Writing Resume and Statement of Purpose

Term Work

Term work shall consist of all assignments from the list.

The distribution of marks for term work shall be as follows:

Book Report	10 marks
Assignments:	10 marks
Project Report Presentation:	15 marks
Group Discussion:	10 marks
Attendance:	05 marks

References:

1. Fred Luthans, "Organizational Behavior", Mc Graw Hill,
2. Lesiker and Petit, "Report Writing for Business", Mc Graw Hill
3. R.Subramaniam, "Professional Ethics" Oxford University Press
4. Huckin and Olsen, "Technical Writing and Professional Communication", McGraw
5. Raman and Sharma, Fundamentals of Technical Communication, Oxford University Press
6. Hill Wallace and Masters, "Personal Development for Life and Work", Thomson Learning, 12th Edition
7. Heta Murphy, "*Effective Business Communication*", Mc Graw Hill, edition
8. R.C Sharma and Krishna Mohan, "*Business Correspondence and Report Writing*",
9. Raman Sharma, *Communication Skills*, Oxford University Press
10. B N Ghosh, "*Managing Soft Skills for Personality Development*", Tata McGraw Hill Lehman,
11. Dufrene, Sinha, "*BCOM*", Cengage Learning, 2nd edition
12. Bell . Smith, "Management Communication" Wiley India Edition, 3rd edition.
13. Dr. K. Alex , "Soft Skills", S Chand and Company
14. Robbins Stephens P., "Organizational Behavior", Pearson Education
15. <https://grad.ucla.edu/asis/agep/advsoystem.pdf>