UNIVERSITY OF MUMBAI

Bachelor of Engineering

in

Production Engineering

Second Year with Effect from AY 2020-21

Third Year with Effect from AY 2021-22

Final Year with Effect from AY 2022-23

(REV- 2019 'C' Scheme) from Academic Year 2019 – 20

Under

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2019–2020)

AC- 29/06/2021
Item No. 6.6

UNIVERSITY OF MUMBAI

Syllabus for Approval

Sr. No.	Heading	Particulars
1	Title of the Course	Third Year B.E. Production Engineering
2	Eligibility for Admission	After passing second year Engineering as per Ordinance 0.6243
3	Passing Marks	40%
4	Ordinances / Regulations (if any)	Ordinance 0.6243
5	No. of Years / Semesters	8 semester
6	Level	U.G.
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic Year	With effect from Academic Year: 2021-22

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Associate Dean
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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 Science and Technology (in particular Engineering)of University of Mumbai has taken a lead in incorporating philosophy of outcome based education in the process of curriculum development.

Faculty 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. 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. 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.

There was a concern that the earlier revised curriculum more focused on providing information and knowledge across various domains of the said program, which led to heavily loading of students in terms of direct contact hours. In this regard, faculty of science and technology resolved that to minimize the burden of contact hours, total credits of entire program will be of 170, wherein focus is not only on providing knowledge but also on building skills, attitude and self learning. Therefore in the present curriculum skill based laboratories and mini projects are made mandatory across all disciplines of engineering in second and third year of programs, which will definitely facilitate self learning of students. The overall credits and approach of curriculum proposed in the present revision is in line with AICTE model curriculum.

The present curriculum will be implemented for Third Year of Engineering from the academic year 2021-22. Subsequently this will be carried forward for Final Year Engineering in the academic year 2022-23.

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Incorporation and implementation of Online Contents from NPTEL/ Swayam Platform

The curriculum revision is mainly focused on knowledge component, skill based activities and project based activities. Self learning opportunities are provided to learners. In the revision process this time in particular Revised syllabus of 'C ' scheme wherever possible additional resource links of platforms such as NPTEL, Swayam are appropriately provided. In an earlier revision of curriculum in the year 2012 and 2016 in Revised scheme 'A' and 'B' respectively, efforts were made to use online contents more appropriately as additional learning materials to enhance learning of students.

In the current revision based on the recommendation of AICTE model curriculum overall credits are reduced to 171, to provide opportunity of self learning to learner. Learners are now getting sufficient time for self learning either through online courses or additional projects for enhancing their knowledge and skill sets.

The Principals/ HoD's/ Faculties of all the institute are required to motivate and encourage learners to use additional online resources available on platforms such as NPTEL/ Swayam. Learners can be advised to take up online courses, on successful completion they are required to submit certification for the same. This will definitely help learners to facilitate their enhanced learning based on their interest.

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Preface By BoS

Engineering education in India is changing fast and is set to face multiple challenges in the near future. Academic institutes are expected to prepare good quality engineers and Industries are expected to come goodwith the wealth generation activity. Manufacturing, among the industry sectors, is currently emerging as oneof the high growth sectors in India. Government of India (GOI) has launched the 'Make in India' program to place India on the world map as a manufacturing hub. The GOI has set an ambitious target of increasing the contribution of manufacturing output to 25% of GDP by 2022, from the current 16 %. In this context, the major challenge is to ensure high quality in all aspects related to education & industry practices. Accreditation of the program is one of the principal ways, by which the quality can be assured. The major emphasis of the 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. Keeping this in mind, the Faculty of Science and Technology of the University of Mumbai has taken the lead in ensuring that the outcome based education is stressed upon in the curriculum development.

At the Board of Studies (Adhoc) in Production Engineering of the University of Mumbai, we are happy to statethat, the Program Educational Objectives (PEOs) of the UG Program in Production Engineering, were discussed in detail and finalized during the multiple brain storming sessions, attended by more than 20 members from different colleges affiliated to the University of Mumbai. Experts from the industry were also invited for their inputs and suggestions. Thus the PEOs were finalized as follows:

To prepare the Learner with sound foundation in STEM subjects, related to Manufacturing and its strategies.

To motivate the Learner for self-learning and to use modern tools for solving real life problems.

To inculcate a professional and ethical attitude, good leadership qualities and commitment to social responsibilities in the Learner's thought process.

To prepare the learner to face industrial challenges through practical exposure in an industrial environment.To prepare the Learner for a successful career in Indian and Multinational Organizations.

In addition to PEOs, for each course of the program, objectives and expected outcomes from a learner's point of view are also included in the curriculum to achieve the goal of outcome based education. We hopeto achieve the desired goals in our efforts to prepare high quality Production Engineers. Thank you very much.

Board of studies (Adhoc) in Production Engineering
Dr. Hari Vasudevan – Chairman
Dr. Arun Rane – Member
Dr. Yogesh Padia – Member
Dr. K. H. Inamdar

Program Structure for Third Year Engineering
Semester V & VI
UNIVERSITY OF MUMBAI
(With Effect from 2021-2022)

Semester V

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
PEC501	Production Tooling	3	--	3	--	3
PEC502	Machine Design - I	3	--	3		3
PEC503	Machining Science and Technology	3	--	3	--	3
PEC504	Metrology & Quality Engineering.	3	--	3	--	3
PEDO501X	Department Optional Course – 1	3	--	3	--	3
PEL501	Production Tooling Lab.	--	2	--	1	1
PEL502	Machine Design - I Lab.	--	2	--	1	1
PEL503	Machining Science and Technology Lab.	--	2	--	1	1
PEL504	Metrology & Quality Engineering Lab.	--	2	--	1	1
PEL505	Professional Communication & Ethics-II	--	2*+2	--	2	2
PEM501	Mini Project – 2 A	--	4$	--	2	2
Total		**15**	**16**	**15**	**08**	**23**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac/ oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
PEC501	Production Tooling	20	20	20	80	3	--	--	100
PEC502	Machine Design - I	20	20	20	80	3	--	--	100
PEC503	Machining Science and Technology	20	20	20	80	3	--	--	100
PEC504	Metrology & Quality Engineering	20	20	20	80	3	--	--	100
PEDO501X	Department Optional Course – 1	20	20	20	80	3	--	--	100
PEL501	Production Tooling Lab.	--	--	--	--	--	25	25	50
PEL502	Machine Design - I Lab.	--	--	--	--	--	25	--	25
PEL503	Machining Science and Technology Lab.	--	--	--	--	--	25	--	25
PEL504	Metrology & Quality Engineering Lab.	--	--	--	--	--	25	25	50
PEL505	Professional Communication & Ethics-II	--	--	--	--	--	50	--	50
PEM501	Mini Project – 2 A	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	--	**200**	**50**	**750**

* Theory class to be conducted for full class
$ indicates work load of Learner (Not Faculty) for Mini Project

Students group and load of faculty per week.

Mini Project 2A:
Students can form groups with minimum 2 (Two) and not more than 4 (Four).
Faculty Load: 1 hour per week per four groups.

PEDO501X	**Department Optional Course – 1**
PEDO5011	Thermal Engineering
PEDO5012	Plastic Engineering
PEDO5013	Industrial Robotics
PEDO5014	Sustainable Manufacturing
PEDO5015	Hydraulic Machinery

Semester VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract. Tut.	Theory	Pract.	Total
PEC601	Process Engineering	3	--	3	--	3
PEC602	Machine Design - II	3	--	3		3
PEC603	Industrial Engineering	3	--	3	--	3
PEC604	Operation Research	3	--	3	--	3
PEDO601X	Department Optional Course – 2	3	--	3	--	3
PEL601	Process Engineering lab.	--	2	--	1	1
PEL602	Machine Design - II Lab.	--	2	--	1	1
PEL603	Additive Manufacturing Lab.	--	2	--	1	1
PEL604	Data Analytics Lab.		2	--	1	1
PEM601	Mini Project – 2 B	--	4$	--	2	2
Total		**15**	**12**	**15**	**06**	**21**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Prac /oral	Total
		Internal Assessment			End Sem Exam	Exam. Duration (in Hrs)			
		Test1	Test2	Avg					
PEC601	Process Engineering	20	20	20	80	3	--	--	100
PEC602	Machine Design - II	20	20	20	80	3	--	--	100
PEC603	Industrial Engineering	20	20	20	80	3	--	--	100
PEC604	Operation Research	20	20	20	80	3	--	--	100
PEDO6PEX	Department Optional Course – 2	20	20	20	80	3	--	--	100
PEL601	Process Engineering lab.	--	--	--	--	--	25	25	50
PEL602	Machine Design - II Lab.	--	--	--	--	--	25	25	50
PEL603	Additive Manufacturing Lab.	--	--	--	--	--	25	--	25
PEL604	Data Analytics Lab.	--	--	--	--	--	25	--	25
PEM601	Mini Project – 2 B	--	--	--	--	--	50	--	50
Total		**--**	**--**	**100**	**400**	**--**	**150**	**50**	**700**

$ indicates work load of Learner (Not Faculty) for Mini Project.

Students group and load of faculty per week.

Mini Project 2B:
Students can form groups with minimum 2 (Two) and not more than 4 (Four).
Faculty Load: 1 hour per week per four groups.

PEDO601X	**Department Optional Course – 2**
PEDO6011	Internal Combustion Engineering
PEDO6012	Refrigeration & Air Conditioning
PEDO6013	Rapid prototyping & Manufacturing
PEDO6014	Logistics and Supply Chain Management
PEDO6015	Maintenance Engineering.

Course Code	Course Name	Credits
PEC501	Production Tooling	03

Objectives:

1. To acquaint with the concepts pertaining to planning and sequencing of operations.
2. To familiarize with the capabilities of designing a simple productive and cost effective jigs and fixtures.
3. To acquaint with the various press working operations for mass production of sheet metal components.
4. To familiarize with the sheet metal working techniques for design of press tools.

Outcomes: Learner will be able to:

1. Select location and clamping faces/points on jobs.
2. Design and develop simple productive and cost effective jigs.
3. Design and develop simple productive and cost effective fixtures.
4. Identify press tool requirements to build concepts pertaining to design of press tools.
5. Prepare working drawings and setup for economic production of sheet metal components.
6. Develop blank size in bent and drawn components.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Introduction to Jigs and Fixture:** Introduction to Jigs and Fixtures, their difference and Significance. Material used for different elements of jigs/fixtures and recommended hardness where necessary **Location & Locating Devices:** Locating principles, Degrees of freedom, redundant location, Fool proofing, nesting, Locators: location from Flat and cylindrical surfaces, conical locators, centralizers. **Clamping & clamping Devices:** Clamping Principle, Examples of typical clamps such as multiple clamping and equalizing devices, quick acting clamping mechanisms such as link, toggle, cam, eccentric, pneumatic &hydraulic devices.	**08**
02	**Construction of Drill Jig** Introduction, Selection of location, supporting and clamping faces/points. Various types of Jig Bushes, Commonly used Drill jigs. Case Study on Drill Jig Design.	**08**
03	**Construction of Milling fixture** Introduction, Selection of location, supporting and faces/points. Tool setting &cutter guiding (Tenon & Setting block), Case Study on Milling Fixture design.	**06**
04	**Introduction to Press Working** Classification of common Press working operations, Benefits and limitations of using Press tools. Applications of pressed parts/components. Theory of Shearing in Press Working, Optimum Cutting clearance, Construction of Basic shearing die. Functions of different elements of a press tool. Methods of feeding the strip/coil material.	**05**
05	**Design and Calculations for Piercing & Blanking Die** Different types of Dies, Die sets and its selection, Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force. Recommending minimum tonnage of a	**06**

	press, Centre of Pressure (its importance and calculation).Design aspects of Press tool elements viz. Punches & methods of retaining punches, Die block, Stripper, Pilot, etc. Methods of reducing cutting loads on press tools. Selection of materials and its hardness for different elements of Press tools.	
06	**Bending & Drawing Dies** Theory of Bending. Spring back and measures to control it. Calculations for bending force & Blank development of Simple Bent components. Types of Bending die. Minimum bend radius. Theory of Drawing. Metal flow in Drawing & forming operations; reduction ratio and redrawing limits, draw clearance, drawing and blank holding forces for cylindrical draws only. Blank development of Cup. Defects in drawn as well as bent parts. Presses selection for drawing/bending operations. Basic construction and working of Bending and Drawing dies.	**08**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I)
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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. *Production Engineering* –P. C. Sharma, S. Chand, New Delhi.
2. *Jig and Fixture Design* Manual - Erik K. Henrikson, Industrail Press, New York.
3. *Jigs and Fixture* - P.H. Joshi, Tata McGraw Hill, New Delhi.
4. *Non- Standards Calming Devices* - Hiran E. Grant TMH, New Delhi.
5. *Die Design Fundamentals* –J. R. Paquin, Industrail Press, New York.
6. *Techniques of Press Working Sheet Metal* –Eary & Reed, Prentice Hall, New Jersey.
7. *Press Tools Design and Construction* –P. H. Joshi, S. Chand, New Delhi.
8. *Tool Design* –C. Donaldson, Tata McGraw Hill, New Delhi.
9. *Introduction to Jig and Tool Design*– M. H. A. Kempster, Edward Arnold, London.

Course Code	Course Name	Credits
PEC502	Machine Design – I	03

Objectives:

1. To prepare the students learn basic principles of engineering design.
2. To familiarize 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/cotter joint.
3. Design machine elements such keys, shafts, couplings/springs.
4. Design pressure vessels.
5. Design welded joint.
6. Design riveted and bolted joints.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Introduction** - Steps involved in designing, types of designs, considerations in designing, Design−manufacturing interface, material selection, factor of safety and its implications. **Operational Joints** - Introduction to cotter, pinned & their applications. Design of socket & spigot type cotter joint, Design of Pinned Joints – Knuckle joint	**08**
02	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) **Stresses incurved members** – Design of crane hooks & C-clamps with various cross sections (Circular, triangular, square, rectangular, trapezoidal) (Circular & oval rings to be excluded).	**05**
03	**Design of shafts:** Design of shafts on the basis of strength. Shafts subjected to- bending, Torsion, combined action of torsion & bending, Concepts about design of shafts based on rigidity (lateral & torsional rigidity)- only Implications **Design of keys:** Different types of keys and applications, Fitting of keys – types and effects of keyway on shaft, Stresses in keys and design of key dimensions. **Design of couplings:** Classification of couplings & application areas, Design of flanged couplings, bushed pin type flexible coupling.	**08**
04	**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. Design of welded joints subjected to eccentric loading.	**05**
05	**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. **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) **Design of bolted and riveted joints** subjected to eccentric loading.	**08**

06	**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. **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.	**05**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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. Tata Mc-Graw Hill Education.
2. *Design of machine elements* -- Sharma, Purohit. Prentice Hall India Education.
3. *Machine Design* - An Integrated Approach -- Robert L. Norton –Pearson Education.
4. *Machine Design* - Pandya & Shah- Charotar PI/blishing.
5. *Mechanical Engineering Design* - J. E. Shigley - Mc-Graw Hill Publication.
6. *Recommended Data Books* - PSG, K.Mahadevan
7. *Machine Design* - Reshetov – Mir Publication.
8. *Machine Design* - Black Adams- Mc-Graw Hill Publication.
9. *Fundamentals of Machine Elements* - Hawrock, Jacobson Mc-Graw Hill Publication.
10. *Design of Machine Elements* - V.M.Faires
11. *Design of Machine Elements* -Spotts.

Course Code	Course Name	Credits
PEC 503	Machining Science and Technology	03

Objectives:

1. To familiarize with the theory of metal cutting and its application to compute various machining parameters, thermal aspects of machining, selection and application of cutting tool materials and cutting fluid, tool wear, tool life and surface roughness.
2. To learn the economics of machining process and control machining parameters.
3. To familiarize with various design aspects of single and multipoint cutting tools.

Outcomes: Learner will be able to:

1. Explain the mechanics of metal cutting and working principles of tool dynamometer and calculate the values of various forces, velocities, power consumption and other parameters in machining operation.
2. Understand the need of temperature measurement and know various coolants, their properties and selection.
3. Select the appropriate cutting tool materials to meet specific machining application and analyses work piece surface quality after post machining.
4. Understand the effect of cutting parameters, work piece material on tool life, tool wear mechanism and select the optimum cutting parameters for given job.
5. Understand ASA, ORS and NRS systems of tool designation and their interrelation, tool holder designation and design aspects of tool shank, tool inserts and chip breakers.
6. Design single point and multipoint cutting tools.

Module No.	Description	Duration
01	**Theory of Metal Cutting and Tool Dynamometry:** Introduction, machining parameters, orthogonal and oblique cutting, mechanism of metal cutting, types of chips, shear plane angle, friction angle, analysis of cutting forces and velocity, Merchant's circle diagram, calculation of cutting forces, shear stress and strain, strain rate, power requirement, Merchant's original and modified theory for orthogonal cutting, lee and Schaffer relation, dynamometry, construction and working principles of strain gauge type lathe dynamometer, piezoelectric, milling and drilling dynamometer.	08
02	**Temperature measurement in Metal Cutting:** Significance of measuring temperature in metal cutting , sources of heat generation and temperature distribution, temperature of chip, analytical and experimental determination of chip tool interface temperature- measurement by direct thermocouple, tool work thermocouple, radiation method and temperature measurement by hardness and microstructural changes. **Cutting Fluids:** Function, properties, types and selection of cutting fluids.	05
03	**Cutting Tool Materials:** Requirements of cutting tool material, essential properties, types, applications and composition of major cutting tool material – plain carbon steel, high speed steel, cast alloys, cemented tungsten carbide, titanium carbides, ceramics and cermet tools, synthetic and polycrystalline demand, cubic boron nitride and coated tools. **Surface Integrity in Machining:** Surface roughness, factors affecting surface quality, measurement and specification of surface finish, built up edge formation and its effect on surface finish	05
	Tool Life: Definition, factors influencing tool life, Taylor's tool life equation, experimental methods to determine to find Taylor's exponent, machinability, machinability index/rating.	

04	**Tool Wear:** Mechanism of tool wear: flank and crater wear. **Machining Economics:** Components of product cost, determination of optimum cutting velocity and tool life based on minimum cost of production, maximum production rate criteria.	**06**
05	**Design of Single Point Cutting Tools:** Geometry of Single point cutting tool (SPTT), Significance of various angles of SPTT. Tool nomenclature systems: MRS, ORS and NRS, conversion between different systems of nomenclature by analytical method, Master line method, circle diagram and slope method. Constructional features of solid tool, tipped tool, mechanically clamped regrind able tools and throw type of tools. Design of tool shank, chip breakers. ISO coding for tipped tools and tool holders.	**06**
06	**Design of Multi Point Cutting Tools:** Form tools: Introduction, constructional details and profile design of flat and circular form tool and related fields of application. Broach: Broach nomenclature, types of broaches, design procedure for circular and key way broaches, Design and Mechanics of Milling process.	**09**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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. *"Fundamentals of Metal Machining and Machine Tools", Third Edition,* Winston A .Knight, Geoffrey Boothroyd, CRC press, Taylor and Francis group (2006).
2. *"Metal Cutting Principles",* Second Edition, by Milton Clayton Shaw, Oxford University Press, 2005.
3. *"Cutting Tools",* P. H. Joshi, A. H. Wheeler Publishing Co. Ltd., 1991.
4. *"ASM Handbook",* Vol. 16, Machining, Ninth Edition, Joseph R. Davis, ASM International, 1989.
5. *"Fundamentals of Metal Cutting and Machine Tools",* Second Edition ,B. L. Juneja, G. S. Sekhon and Nitin Seth, New Age International Pvt. Ltd.,2003.
6. *"Metal Cutting Theory and Cutting Tool Design",* V. Arshinov and G. Alekseev, Mir publishers, Moscow, 1976.
7. *"Typical Examples and Problems in Metal Cutting and Tool Design",* N. Nefedov and K. Osipov, Mir publishers, Moscow, 1986.
8. *"METAL CUTTING Theory and practices",* Amitabh Bhattacharya, New Central book agency (P) ltd, Kolkata, 2011.
9. *"A Textbook of Production Engineering",* Dr. P.C. Sharma, S. Chand publications, 2015.

10. *"Principles of Metal Cutting",* G. Kuppuswami, Universities Press (India) Limited, 1996.
11. *"Manufacturing Science",* Ghosh A., Mallik A. K, East-West Press Private .Ltd, 2001.
12. *"Manufacturing, Engineering & Technology,* Kalpakjain, S. and Steven R. Schmid, Person, 2007.

Course Code	Course Name	Credits
PEC504	Metrology And Quality Engineering	03

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.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Introduction to Metrology** Definition of Metrology. Scope of Engineering Metrology. Standards of Measurements. Static Characteristics of Measurements. **Limits, fits and Tolerances** Basic Definitions, Taylor's principle, Hole Basis and Shaft Basis System, Design of Go & No-Go gauges for Hole and Shaft using Tolerance Disposition Diagram (refer PSG Data book).	07
02	**Comparators**: Understanding of features and operation of mechanical, optical, electrical/electronic and pneumatic comparators, advantages, limitations and field of Applications. **Principles of interference**, concept of flatness, flatness testing, optical flats, optical Interferometer and laser interferometer. **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.	07
03	**Screw Thread measurement**: Two wire and three wire methods, floating carriage micrometer. **Gear measurement:** Gear tooth comparator, measurement using rollers and Parkinson's Tester. **Special measuring Equipment:** Principles of measurement using Tool Maker's microscope, profile projector & 3D coordinate measuring machine.	06
04	**Quality** Evolution of Quality, Definition of Quality, Dimensions of Quality Planning, Principles of TQM, setup policy and objectives of quality control, quality of design and quality of conformance, compromise between quality & cost, quality cost and planning for quality, Costs of Quality	03

05	**SQC and SQC tools** **Process Data Collection & presentation** – Bar Chart, Histogram and Run Charts. **Process Variability** – variables & Process Variation (Measures of accuracy & Centering, precision or spread, normal distribution and sampling averages). **Process Control by Variable** – using X bar and R Chart and control charts for standard deviation. **Process Control by Attribute** - for number of defectives or non- conforming units - np-charts, p-charts, c-charts and u-charts. **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).	**10**
06	**Sampling Techniques** Sampling inspection and basic concepts, OC curves, consumer & Producer risk, single & double sampling plans and use of sampling tables. **Quality standards** The ISO9001:2000 Quality Management System Standard, The ISO 14001:2004 Environmental Management System Standard	**06**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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 publications.
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., Dhanpat Rai & 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* by Charles Reginald Shotbolt, Publisher Cassell,
12. *Understanding and Implementing ISO 9000 and ISO Standards* by David L. Goetsch, Stanley Davis , Prentice Hall.

Course Code	Course Name	Credits
PEDLO5011	Thermal Engineering	03

Objectives:

1. To prepare the students learn about various modes of heat transfer and their governing laws.
2. To impart the ability to analysis the performance of compressors, gas turbine.
3. To develop the knowledge of working principle of Internal Combustion Engine.
4. To develop the knowledge of working principle of Refrigeration and Air Conditioning Systems.

Outcomes: Learner will be able to:

1. Apply heat transfer principles to solve problems related to composite wall and heat exchangers.
2. Apply thermodynamics and fluid mechanics principles to evaluate the performance of compressors.
3. Apply thermodynamics and fluid mechanics principles to evaluate the performance gas turbine.
4. Apply thermodynamics and fluid mechanics principles to evaluate the performance of Internal Combustion Engine.
5. Apply thermodynamics and fluid mechanics principles to evaluate the performance of Refrigeration.
6. Apply thermodynamics and fluid mechanics principles to evaluate the performance of Air Conditioning.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	Heat Transfer: Modes of heat transfer, Conduction: Fourier's Law of heat conduction, thermal conductivity, Convection: heat transfer coefficient, overall heat transfer coefficient, One Dimensional Steady Steady State heat conduction through composite wall and hollow cylinder, Forced and Free Convection. Heat Exchangers: Classification, LMTD for parallel flow and counter flow. (Numerical only on One Dimensional heat conduction and LMTD of heat exchanger)	**07**
02	Reciprocating Air Compressors Classification, Terminology, Work and power calculations with and without clearance for single and two stage compression, volumetric efficiency and FAD, Intercooling and advantages of Multistage compression.	**06**
03	Gas Turbines Classification, Application, open cycle and closed cycle gas turbine. Calculation of thermal efficiency. Methods for improvements of thermal efficiency of gas turbine plants (Numerical only on calculating thermal efficiency and work ratio).	**07**
04	I.C. Engines Classification, components of engines, 2 stroke and 4 stroke engine, SI & CI engine. Study of simple carburettor, fuel injection systems, ignition system, combustion process in SI and CI engines. Cooling and lubrication systems. Testing &Performance of IC engines and Heat Balance Sheet.	**07**
05	Refrigeration Applications of refrigeration, terminology, Bell Colemann cycle, Vapour compression refrigeration cycle. Calculations for COP, power capacity and mass flow rate. Vapour Absorption System (Ammonia water system) (Numerical only on VCR).	**06**
06	Air conditioning Properties of moist air, basic psychometric processes. Introduction to air conditioning, applications, comfort air conditioning, summer, winter and year round air conditioning system.	**06**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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. Heat Transfer, D. K. Dixit, Tata Mc Graw Hill Publications.
2. Thermal Engineering, Mahesh Rathore, Tata Mc Graw Hill Publications.
2. Thermal Engineering, R. K. Rajput, Laxmi Publications.
3. Thermal Engineering, Ballaney, Khanna Publications.
4. A Course in Thermal Engineering, Domkundwar, Kothoraman and Khaju.

Course Code	Course Name	Credits
PEDLO5012	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.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Materials** 1.1 Brief introduction to plastics materials, their classifications & types. 1.2 Important properties of plastics & fields of application. 1.3 Overview of additives for plastics processing & their significance. 1.4 Introduction to plastics blends, alloys and composites. 1.5 Principles of recycling of plastics and waste management.	**05**
02	**Processing Techniques - Injection Moulding, Compression & Transfer Moulding.** 2.1 Injection Moulding: Moulding materials, moulding cycle-phases, and significance. 2.2 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, troubleshooting. 2.3 Compression Moulding - Moulding equipment, Moulding cycle, Material Bulk Factor - implications, Moulding Techniques- process parameters and their influence. Trouble shooting. 2.4 Transfer Moulding: Integral Pot &Auxiliary Ram, Transfer processes, Techniques and comparison, process Parameters and their influence. Trouble shooting.	**06**
03	**Processing Techniques - Extrusion & Blow Moulding** 3.1 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 parameters and their influence on extruded products and trouble shooting).	**06**

	3.2 Blow Moulding: Materials for blow moulding, 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.	
04	**Other Processing Techniques** 4.1 **Auxiliary equipment for plastics processing**: **Oven driers,** Hopper dryers, Dececant dryers, Granulators, mould temperature controllers, proportionating devices, chilling units, automatic material conveying systems. Significance of auxiliary equipment for plastics processing. 4.2 **Other Process**: Brief coverage of the following processes with relevant details like machinery, materials, processing techniques and applications. Thermoforming, Rotational Moulding, calendaring, Fabrication and decorating with plastics. 4.3 **FRP Processing**: Raw materials and ancillaries used, Techniques like hand lay-up, spray up and filament winding processes, applications. Applications of FRP.	**06**
05	**Design of Moulds – Compression & Transfer Moulds, Injection 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 auxiliary transfer techniques. 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 of moulds for articles with undercuts- split moulds, split actuation techniques, moulds with side cores, moulds for internally threaded articles, Fully automatic moulds, standard and innovative mould components. 5.3 Hot runner systems: General arrangement, design of manifold blocks, flow ways and nozzles, advantages and limitations.	**10**
06	**Design of Moulds - Blow Moulds, Extrusion Dies and mould materials.** 6.1 **Blow Moulds:** General arrangement and mould components, design of neck and base pinch off sand flash pockets, Venting of moulds, selection of parting lines. 6.2 **Extrusion Dies**: Design of extrusion dies for pipes, films, sheets, cables and profiles. 6.3 **Mould Materials of Construction**: Characteristics, Tool steels and alloys, non-ferrous materials, Mould Polishing and surface treatments.	**06**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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*, Ros

Course Code	Course/Subject Name	Credits
PEDO5013	Industrial Robotics	03

Objectives

1. To acquaint with the significance of robotic system in agile and automated manufacturing processes.
2. To familiarize with the robotic elements/ peripherals, their selection and interface.
3. To familiarize with the basics of robot kinematics.

Outcomes: Learner will be able to:

1. Illustrate the importance of robot in automation.
2. Acquire skills in robot language and programming.
3. Acquire skill in robot task planning for problem solving.
4. Demonstrate the concepts of kinetics and dynamics of robot.
5. Select various sensors/robot peripherals for deployment in a manufacturing system.
6. Identify an application of robots in manufacturing.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Introduction** Automation, robotics, Robotic system & Anatomy, Classification and Future Prospects.	**02**
02	**2.1 Drives** Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators and Power Transmission system. **2.2 Robot & its Peripherals** **2.3 End Effecters:** Type mechanical and other grippers, Tool as end effecter. **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment.	**08**
03	**3.1 Machine vision** Introduction, Low level & High level Vision, Sensing & Digitizing, Image Processing & analysis, Segmentation, Edge detection, Object Description & recognition, interpretation and Applications. **3.2 Programming for Robots** Method, Robot programme as a path in space, Motion interpolation, motion& task level Languages, Robot languages, Programming using Python and characteristics of robot.	**09**
04	**4.1 Robot Kinematics** Forward, reverse & Homogeneous Transformations, Manipulator Path control and Robot Dynamics.	**08**
05	**5.1 Root Intelligence & Task Planning** Introduction, State space search, Problem reduction, use of predictive Logic, Means. Ends Analysis, Problem solving, Robot learning and Robot task planning.	**07**
06	**6.1 Robot application in manufacturing** Material transfer, machine loading & un loading, processing operation, Assembly & inspectors, robotic Cell design & control, Social issues & Economics of Robotics.	**05**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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. *Industrial Robotics, Technology, Programming & Applications,* Grover, Weiss, Nagel, Ordey, McGraw Hill.
2. *Robotics: Control, Sensing, Vision & Intelligence,* Fu, Gonzalex, Lee, McGraw Hill.
3. *Robotic technology & Flexible Automation,* S R Deb. Tata McGraw Hill.
4. *Robotics for Engineers,* Yoram Koren, McGraw Hill.
5. *Fundamentals of Robotics,* Larry Health.
6. *Robot Analysis & Control*, H Asada, JJE Slotine.
7. *Robot Technology,* Ed. A Pugh, Peter Peregrinus Ltd. IEE, UK.
8. *Handbook of Industrial Robotics,* Ed. Shimon.John Wiley.

Course Code	Course Name	Credits
PEDLO5014	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 fulfill green expectations.
2. Demonstrate the know ledge 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.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
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, 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.	**05**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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 opreations & 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
PEDO5015	Hydraulic Machinery	03

Objectives:

1. To evaluate the performance of hydraulic turbines.
2. To understand the functioning and characteristic curves of pumps.
3. To study about hydroelectric power plant and estimation of hydropower potential.
4. To make the student is expected to have thorough knowledge on the selection of turbines and pumps for practical purposes

Outcomes: Learner will be able to:

1. Estimate the efficiency and performance of the turbine with the study of characteristics curves.
2. Estimate the efficiency of different pumps and performance of the pumps with the study of characteristics curves.
3. Select the type of turbine required with reference to available head of water and also Identify the type of turbine with estimated specific speed.
4. To estimate performance parameters of a given Centrifugal and Reciprocating pump.
5. Prepare the models for prototypes of hydraulic structures.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Basics of the turbo machines:** Hydrodynamic force of jets on stationery and moving flat, inclined and curved vanes, jet striking centrally and at tip, velocity triangles at inlet and outlet, expressions for work done and efficiency, angular momentum principle, applications to radial flow turbines.	**08**
02	**Hydraulic turbines:** General Layout of Hydroelectric Power Plant, Classification of turbines, Definition of various heads and efficiencies of a turbine. **Impulse turbines:**Pelton Wheel (Turbine), Constructional details, Velocity triangles, Work done and efficiency calculations, Governing of Pelton wheel. **Reaction Turbine:** Francis, Kaplan and Propeller turbines, Constructional details, Velocity triangles, Work done and efficiency calculations, Degree of reaction, Draft tube, Governing of turbines, Surge tanks.	**08**
03	**Performance of turbines:** Unit quantities, Specific speed, performance characteristics curves, Model testing of turbines, Cavitation.	**06**
04	**Centrifugal pumps:** Classification, Working, Work done, Head and efficiencies, Specific speed, Pumps in series and parallel, Priming of pump, Performance characteristic curves, NPSH.	**07**
05	**Reciprocating Pumps:** Main components and working of a reciprocating pump, types of reciprocating pumps, power required to derive the pump, coefficient of discharge and slip, indicator diagram, air vessels, performance characteristics, Comparison of centrifugal and reciprocating pumps.	**06**
06	**Hydraulic devices:** Hydraulic accumulator, Hydraulic intensifier, Hydraulic Press, Hydraulic crane, Hydraulic lift, Hydraulic ram, Hydraulic coupling, Hydraulic torque converter, Air lift pump, Jet pump.	**04**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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.**

Text books:

1. Hydraulic Machines by R.K. Rajput, S Chand Publication.
2. Hydraulics and Fluid Mechanics including Hydraulic Machines by Modi & Seth, Raj sons Publication Pvt. Ltd.
3. Hydraulic Machines by Benga & Sharma, Khanna Publishers.

Reference Book:

1. Hydraulic Machines by Jagdish Lal, Metropolitan book Co. Pvt Ltd.
2. Fluid Machanics & fluid power engineering by D.S. Kumar, S.K. Katiria & Sons publications.
3. Fluid Mechanics & Turbo Machines by M. M. Das, PHI.
4. Fluid Mechanics & Machinery by R. K. Bansal, Luxmi Publications.
5. Fluid Mechanics & Machinery by C. Ratnam, A. V. Kothapalli, I.K. International Publishing House Ltd.
6. Introduction to Fluid Mechanics & Fluid Machines by Som & Biswas, Tata McGraw Hill.
7. Fluid Mechanics & Machinery – C. S. P Ojha, R. Berndtsson, P. N. Chandramouli, OUP.
8. Hydraulic Machines: Theory & Design, V .P. Vasandhani, Khanna Publication.
9. Introduction to Fluid Mechanics – Fox & Macdonald, Wiley.
10. Fluid Mechanics – Fundamentals & Applications – Cengel & Cimbala, Tata McGraw Hill.

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Course Code	Course Name	Credits
PEL501	**Production Tooling Lab.**	**01**

Objectives:

1. To acquaint with the concepts pertaining to planning and sequencing of operations.
2. To prepare for designing of simple productive and cost effective jigs and fixtures.
3. To familiarize with the various press working operations for mass production of sheet metal components.
4. To acquaint with the sheet metal working techniques for design of press tools.

Outcomes: Learner will be able to:

1. Identify and select location and clamping faces/points on jobs.
2. Design and develop simple productive and cost effective jigs.
3. Design and develop simple productive and cost effective fixtures.
4. Identify press tool requirements to build concepts pertaining to design of press tools.
5. Prepare working drawings, including bill of materials and setup for economic production of sheet metal components.
6. Demonstrate the principles of blank development.

Term Work

Term work shall consist of:

A : Design of

1. Simple Progressive Die with minimum three stages. (Assembly & BOM)
2. Drill Jig (Assembly & BOM).
3. Milling fixture (Assembly & BOM).

Preparation of 3D assembly model of either a Jig or a Fixture or a Press Tool on any 3D modeling software like Solid works, Autodesk Inventor, Unigraphics NX, Pro-E etc.

B : Assignments on topics drawn from the syllabus.

C : A detailed report based on an Industrial visit to a manufacturing firm, covering the topics mentioned in subject of Production Tooling.

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

Part A**:** Design	**: 12 marks**
Part B: Assignments	: **05 marks**
Industrial Visit Report	: 03 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

Each student will be given a small task of design based on syllabus, which will be assessed /verified by examiners during the oral examination.

The distribution of marks for oral-practical examination shall be as follows:

Design Task : 15 marks
Oral : 10 marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Student's work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Credits
PEL502	**Machine Design – I Lab.**	**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.
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.

Course Code	Course Name	Credits
PEL 503	**Machining Science and Technology Lab.**	**01**

Objectives

1. To familiarize with the methods of force measurement during machining.
2. To familiarize with the methods of temperature measurement during machining.
3. To familiarize with the cutting tool materials, cutting fluids, tool life, wear mechanism and machining economics.
4. To familiarize with the Taguchi's Design of Experiments and ANOVA.
5. To familiarize with the design procedures for various single point and multipoint cutting tools.

Outcomes:-The learner will be able to:

1. Understand the machining operation and select a proper force measurement method for the required machining operation.
2. Select a proper temperature measurement method, cutting tool and cutting fluids for the give machining operation.
3. Distinguish surface integrity after parametrical changes in machining operation.
4. Apply Taguchi's Design of Experiments and ANOVA for various machining operations.
5. Design simple Flat Form Tool, Circular Form Tool and circular broach.

Sr. No.	Design Exercise/Assignment
01	Assignment on theory of metal cutting and dynamometry.
02	Assignment on Temperature Measurement in metal cutting and cutting fluids.
03	Assignment on cutting tool materials, cutting fluids and surface roughness.
04	Assignment on cutting tool life, tool wear and machining economics.
05	Assignment on single point cutting tool geometry and interaction between MRS, ORS tool designation system.
06	Any Two Case Studies on application of Taguchi Design of Experiments and ANOVA in machining.
07	Design of Circular Form Tool.
08	Design of Flat Form Tool.
09	Design of Circular Broach.

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 A4sizePaper	: **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.

Course Code	Course Name	Credits
PEL504	**Metrology And Quality Engineering Lab.**	**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 /equipment.
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.
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.
08	3D Coordinate Measuring Machine (Demo / Industry Visit)
	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. Practicalexaminationshallbeconductedbasedonthelistofexperiments.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.

Course Code	Course Name	Credits
PEL 505	Professional Communication & Ethics-II	**02**

Objectives: Learners should be able to:

1. discern and develop an effective style of writing important technical/business documents.
2. investigate possible resources and plan a successful job campaign.
3. understand the dynamics of professional communication in the form of group discussions, meetings, etc. required for career enhancement.
4. develop creative and impactful presentation skills.
5. analyse personal traits, interests, values, aptitudes and skills.
6. understand the importance of integrity and develop a personal code of ethics.

Outcomes: learner will be able to:

1. plan and prepare effective business/ technical documents which will in turn provide solid foundation for their future managerial roles.
2. strategize their personal and professional skills to build a professional image and meet the demands of the industry.
3. emerge successful in group discussions, meetings and result-oriented agreeable solutions in group communication situations.
4. deliver persuasive and professional presentations.
5. develop creative thinking and interpersonal skills required for effective professional communication.
6. apply codes of ethical conduct, personal integrity and norms of organizational behavior.

Module	Contents	Hours
1	**ADVANCED TECHNICAL WRITING : PROJECT/PROBLEM BASED LEARNING (PBL)** **1.1 Purpose and Classification of Reports:** **Classification on the basis of:** • Subject Matter (Technology, Accounting, Finance, Marketing, etc.) • Time Interval (Periodic, One-time, Special) • Function (Informational, Analytical, etc.) • Physical Factors (Memorandum, Letter, Short & Long) **1.2. Parts of a Long Formal Report:** ● Prefatory Parts (Front Matter) ● Report Proper (Main Body) ● Appended Parts (Back Matter) **1.3. Language and Style of Reports** ● Tense, Person & Voice of Reports ● Numbering Style of Chapters, Sections, Figures, Tables and Equations ● Referencing Styles in APA & MLA Format ● Proofreading through Plagiarism Checkers **1.4. Definition, Purpose & Types of Proposals** • Solicited (in conformance with RFP) & Unsolicited Proposals • Types (Short and Long proposals) **1.5. Parts of a Proposal**	**06**

	• Elements • Scope and Limitations • Conclusion **1.6. Technical Paper Writing** • Parts of a Technical Paper (Abstract, Introduction, Research Methods, Findings and Analysis, Discussion, Limitations, Future Scope and References) • Language and Formatting • Referencing in IEEE Format	
2	**EMPLOYMENT SKILLS** **2.1. Cover Letter & Resume** • Parts and Content of a Cover Letter • Difference between Bio-data, Resume & CV • Essential Parts of a Resume • Types of Resume (Chronological, Functional & Combination) **2.2 Statement of Purpose** • Importance of SOP • Tips for Writing an Effective SOP **2.3 Verbal Aptitude Test** • Modelled on CAT, GRE, GMAT exams **2.4. Group Discussions** • Purpose of a GD • Parameters of Evaluating a GD • Types of GDs (Normal, Case-based & Role Plays) • GD Etiquettes **2.5. Personal Interviews** • Planning and Preparation • Types of Questions • Types of Interviews (Structured, Stress, Behavioural, Problem Solving & Case-based) • Modes of Interviews: Face-to-face (One-to one and Panel) Telephonic, Virtual	**06**
3	**BUSINESS MEETINGS** **1.1. Conducting Business Meetings** • Types of Meetings • Roles and Responsibilities of Chairperson, Secretary and Members • Meeting Etiquette **3.2. Documentation** • Notice • Agenda • Minutes	**02**
4	**TECHNICAL/ BUSINESS PRESENTATIONS** **1.1 Effective Presentation Strategies** • Defining Purpose • Analysing Audience, Location and Event • Gathering, Selecting &Arranging Material	**02**

	• Structuring a Presentation • Making Effective Slides • Types of Presentations Aids • Closing a Presentation • Platform skills **1.2 Group Presentations** • Sharing Responsibility in a Team • Building the contents and visuals together • Transition Phases	
5	**INTERPERSONAL SKILLS** **1.1. Interpersonal Skills** • Emotional Intelligence • Leadership & Motivation • Conflict Management & Negotiation • Time Management • Assertiveness • Decision Making **5.2 Start-up Skills** • Financial Literacy • Risk Assessment • Data Analysis (e.g. Consumer Behaviour, Market Trends, etc.)	**08**
6	**CORPORATE ETHICS** **6.1 Intellectual Property Rights** • Copyrights • Trademarks • Patents • Industrial Designs • Geographical Indications • Integrated Circuits • Trade Secrets (Undisclosed Information) **6.2 Case Studies** • Cases related to Business/ Corporate Ethics	**02**

List of assignments:

(In the form of Short Notes, Questionnaire/ MCQ Test, Role Play, Case Study, Quiz, etc.)

1. Cover Letter and Resume
2. Short Proposal
3. Meeting Documentation
4. Writing a Technical Paper/ Analysing a Published Technical Paper
5. Writing a SOP
6. IPR
7. Interpersonal Skills
8. Aptitude test (Verbal Ability)

Note:

1. The Main Body of the project/book report should contain minimum 25 pages (excluding Front and Back matter).
2. The group size for the final report presentation should not be less than 5 students or exceed 7 students.

3. There will be an end–semester presentation based on the book report.

Assessment:

Term Work:

Term work shall consist of minimum 8 experiments.

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

Assignment : 10 Marks
Attendance : 5 Marks
Presentation slides : 5 Marks
Book Report (hard copy) : 5 Marks

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

Internal oral:

Oral Examination will be based on a GD & the Project/Book Report presentation.

Group Discussion : 10 marks
Project presentation
Individual Presentation : 10 Marks
Group Dynamics : 5 Marks

Books Recommended:

Textbooks and Reference books:

1. Arms, V. M. (2005). *Humanities for the engineering curriculum: With selected chapters from Olsen/Huckin: Technical writing and professional communication, second edition*. Boston, MA: McGraw-Hill.
2. Bovée, C. L., &Thill, J. V. (2021). *Business communication today*. Upper Saddle River, NJ: Pearson.
3. Butterfield, J. (2017). *Verbal communication: Soft skills for a digital workplace*. Boston, MA: Cengage Learning.
4. Masters, L. A., Wallace, H. R., & Harwood, L. (2011).*Personal development for life and work*. Mason: South-Western Cengage Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T. (2017). *Organizational behaviour*. Harlow, England: Pearson.
6. Meenakshi Raman, Sangeeta Sharma (2004) Technical Communication, Principles and Practice. Oxford University Press
7. Archana Ram (2018) Place Mentor, Tests of Aptitude For Placement Readiness. Oxford University Press
8. Sanjay Kumar & PushpLata (2018). Communication Skills a workbook, New Delhi: Oxford University Press.

Course	Course Name	Credits
PEM501	**Mini Project - 2A**	**02**

Objectives:

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to:

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyse the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project:

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problems in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty may give inputs during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

- Distribution of Term work marks for both semester shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

- In this semester students shall present a seminar on Mini project and demonstrate their understanding of need/problem.
- Term work shall be assessed by review/progress monitoring committee appointed by the Head of the Department/Institute of respective Programme.
- In this semester entire theoretical solution shall be ready, including components/system selection and cost analysis.

Mini Project A shall be assessed based on following points

1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness
6. Societal impact

Course Code	Course Name	Credits
PEC 601	Process Engineering	03

Objectives

1. To familiarize with the significance of process engineering with its relevance to manufacturing operations.
2. To prepare a skills in preparing machining sequence and estimate manufacturing time.
3. To acquaint with the significance and control of tolerance in design & manufacturing.
4. To appraise with basics of process and operation planning.

Outcomes: Learner will be able to:

1. Determine machine sequences to cater to the manufacturing requirements.
2. Analyse part prints.
3. .Prepare tolerance control charts with its balancing.
4. Design work holding devices for consistent positioning of work piece in relation to the tool.
5. Prepare process picture, process routing/process sheets.
6. Design cams for part production on single spindle automats.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Process Engineering** Differentiation between Product Engineering and Process Engineering. Role of process engineering in a manufacturing setup, organization chart, functions of process engineering. Determining machining sequences - criteria and manufacturing sequence.	**04**
02	**2.1Preliminary Part Print Analysis** General characteristics, determining the principal processes, alternate processes, functional surfaces of the work piece, areas for processing, nature of work to be performed, finishing and identifying operations, case study for understanding preliminary part print analysis. **2.2 Work piece control** Causes of work-piece variations, variables influencing work-piece control, work piece control techniques - Equilibrium theories, concept of location, geometric control, dimensional control, mechanical control, alternate location theory.	**08**
03	**Tolerance Design** **Dimensional Analysis:** Types of dimensions, concept of baseline dimension, basic geometric dimensioning and tolerance (GD & T). **Tolerance Analysis**: Rules for adding and subtracting tolerance, tolerance stacks, design and process tolerance stacks, tolerance chart, purpose and use of tolerance chart, definitions and symbols, determining lay−out of tolerance chart, stock removal, constructing and balancing of tolerance chart.	**06**

04	**Process planning** 4.1 Classifying operations (Study of Basic Processes Operations, Principal Processes and Auxiliary Processes, identification of major, critical, qualifying, re-qualifying and supporting operations), product and process critical area, selection of equipment and Tooling. **4.2 Computer Aided Process Planning (CAPP):** CAPP -variant approach and generative approach.(Detail)	**06**
05	**5.1 Operation Planning** Process plan sheet design for complete manufacturing part with details of sequence of operations, machine or equipment used, Process pictures, machining parameters i.e. cutting speed, feed, depth of cut, tooling and gauge details, cutting tools specifications and gauge details, machining time calculations. Tool layout for turning on production lathe. **5.2 Other aspects of Process Engineering** Introduction to high speed machines, SPM, transfer line and other mass production machines-Elementary treatment only, in-process gauging and multiple gauging. ERP SOFTWARE (PPC module -only introduction).	**09**
06	**Cam Design for Automat** Automats major classification and types, tools and tool holders. Single spindle automats and its tooling, tool layout and cam design for part production on Single spindle automat.	**06**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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. Process Engineering for Manufacturing, Donald F. Eary and Gerald E. Johnson, Prentice-Hall, Inc
2. Production Technology, HMT.
3. Manufacturing Engineering. Danilevsky, Mir publication.
4. Tolerance Design and Analysis, Wade.
5. Fundamentals of Manufacturing Engineering, V.M. Kovan et al, Mir Publications.
6. HSS and Carbide Tool Catalogues for Turning, Drilling, Milling etc. from Tool manufacturer.
7. Westerman Tables for the Metal Trade, Wiley, Eastern Limited.
8. PMT Catalogue Traub Automat.

Course Code	Course Name	Credits
PEC 602	Machine Design - II	03

Objectives:

1. To familiarize with the constructional & design features of machine tool structures like bed, columns, slide ways/guideways and mechanical drives.
2. To prepare for skills in designing variable speed gear boxes, bearings, power screws, clutches etc. used in machine tools.
3. To acquaint with the usage of standards & hand books and retrieve relevant data from these for designing/selection of machine tool components.
4. To appraise about safety and safety standards pertaining to machine tools.
5. To acquaint with the recommended procedure of carrying out acceptance tests on machine tools & their significance.

Outcomes: Learner will be able to:

1. Design machine tool structures, drive elements/drives.
2. Design speed and feed gear boxes.
3. Design power screws and clutches.
4. Design bearings.
5. Demonstrate the requirements like maintaining of expected accuracy levels, parametric optimization, managing wear and tear problems.
6. Illustrate the safety aspects/ acceptance tests in machining tools.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**ELEMENTS OF MACHINE TOOLS** **1.1**Types and capabilities of various machine tools. General purpose and special purpose machine tools. Design requirements of machine tools. **1.2. Design of machine tool structures :-** **1.2.1Bed and Columns**- Design criteria for machine tool structures, Materials of construction, Profiles, Factors affecting Static and dynamic stiffness. Methods of enhancing rigidity. Design considerations for beds. .Machine tool bed cross-sections like lathe bed. Design considerations for columns, column sections. **1.2.2 Machine tool guideways** - Classification of guideways, Materials of construction, Slideway profiles, Clearance adjustment and wear compensation techniques, Fundamentals of hydrostatic guideways. Types of antifriction guideways. Design of guideways for wear and stiffness. **1.3 Design of Power Screws** Design of power screws- Materials of construction, power screw profiles and selection, backlash adjustments, design of machine tool power screws based on strength, buckling and stiffness, power requirements and efficiency, mounting of power screws, Elementary treatment on ball recirculating power screws.	**08**

02	**DESIGN OF MECHANICAL DRIVES:** **2.1 Design of belt drives** - Design of belts, belt materials, belt types:- specification and selection, types of pulleys and design of pulleys. *(Only design procedure)* **2.2 Design of gear drives** - Types of gears, materials, application, and selection. Design of spur gears - Design on the basis of beam strength (Lewis's equation), Design on the basis of wear and fatigue (Buckingham's Equation) **2.3 Design of chain drives**- Types of chains and sprockets. Principles of designing sprockets and roller chains. Design of chain drives- Types of chains and sprockets. Principles of designing sprockets and roller chains. *(Only design procedure)*	**06**
03	**DESIGN OF SPEED AND FEED BOXES** **3.1 Design of gear boxes**: Stepped and Stepless speed outputs, selection of spindle speed ranges, construction of structural, speed, gearing & deviation diagrams, layout of speeds on geometric progression, kinematic advantages of geometric progression series, selection of values of common ratio, Design of gear boxes for feed and speeds having 2−3 stages and 4−12 speeds. **3.2 Stepless drives** : Mechanical stepless drives − single disc, double disc and cone disc transmissions, speed regulation by epicyclic gear train, positive infinitely variable drives (PIV drives) − Kopp's , Meander and Svetozarav'sdrives. **3.3 Feed boxes**: Quadrant change gear mechanism, speed boxes with gear cone and sliding key, Norton gear drive, Meander gear drives, gear boxes with clutched drive, Schopke drive and Ruppert drive.	**12**
04	**DESIGN OF CLUTCHES** Design considerations, materials of clutch plates & linings. Running conditions- wet & dry. Design of plate clutches. Single and multi-plate clutches involving design of clutch plates, springs & operating lever.	04
05	**DESIGN OF MACHINE TOOL BEARINGS** Bearing materials & their characteristics. Types of bearings- selection & application. **5.1 Design of ball & roller bearings**: Bearing designation (ISI, ISO, SAE, and SKF). Calculation of equivalent load, cubic mean load, static & dynamic load bearing capacities. Selection of ball & roller bearing from handbook. Mounting & maintenance of bearings. **5.2 Design of journal bearings:** Terminology. Theory of lubrication, bearing characteristic Number, Sommerfield Number, calculations involving bearing dimensions, clearance, coefficient of friction, heat generated, and heat dissipated and power lost in friction. Mounting & maintenance of bearings.	**06**
06	**SAFETY OF MACHINE TOOLS & ACCEPTANCE TESTS** **6.1Safety of machine tools:** Concepts, various safety devices incorporated in machine tools to safeguard safety of man, tools and equipment. Interlocked, fool proof safety systems. Introduction to safety standards. **6.2 Acceptance tests on machine tools:** Significance, performance and geometrical tests on machine tools. **6.3 Vibrations in machine tools:** Elementary concepts about factors contributing to vibrations, vibration detection and measurement, remedial approaches	**03**

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

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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. Principles of machine tools, Sen and Bhattacharya, New Central Book Agency.
2. Machine tool design and Numerical Control, N. K. Mehta, Tata McGraw Hill.
3. Machine tool Engineering, G R Nagpal, Khanna Publishers.
4. Design of Machine tool, S.K. Basu and D. K. Pal, Oxford and IBH publishing Co.
5. The design and construction of machine tools, H. C. Town.
6. Machine tool design hand book: Central Machine Tool Research Institute, Bangalore. Tata McGraw Hill.
7. PSG Design Data book: PSG College of engineering and technology, Coimbatore.
8. Machine Tool Design (Volume 3), (English, Paperback, V. Vermakov, N. Acherkan, Nicholas Weinstein).
9. Machine Tool Structures: Vol.1, by F. Koenigsberger, J. Tlusty .

Course Code	Course Name	Credits
PEC 603	Industrial Engineering	03

Objectives:

1. To prepare for understanding of the role of Industrial Engineering in the overall business strategy of the firm.
2. To prepare for understanding of the interdependence of the operating system with other key functional areas of the firm.
3. To familiarize with the key factors and interdependence of these factors in the design of effective operating systems.
4. To prepare for identification and evaluation of tools appropriate for analysis of operating systems of the firm.
5. To familiarize with the application of production and operations management policies and techniques to the service sector as well as manufacturing firms.

Outcomes: Learner will be able to...

1. Analyze implications of Industrial Engineering in industries.
2. Demonstrate the role of Production Management in creating competitive advantage for business organizations.
3. Analyze various constituents of production operations in manufacturing and service.
4. Plan and control various production related activities.
5. Illustrate various inventory management procedures with the tools employed there in.
6. Demonstrate role of JIT, MRP, and ERP with their contribution towards Industrial Engineering.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration Hrs**
01	**Introduction to Industrial Engineering:** Industrial Engineering in the modern world, techniques and objectives of Industrial Engineering. **Production and Productivity:** Definition and comparison, productivity measurements, factors influencing productivity. Productivity Improvement techniques likes 5s, Poka-Yoke, Kaizen, Kanban, Quality Improvement Techniques like QFD, FMEA, Ishikawa diagram, SMED, SQC tools.	**05**
02	**Work System Design:** Inter disciplinary nature of ergonomics, modern ergonomics, human performance, information processing, factors affecting human performance, physical workload and energy expenditure. Workspace Design, Anthropometry, workspace design for standing and seated workers, Arrangements of components within a physical space, Application of Ergonomics in automobiles **Job Evaluation and Wage Plan:** Objective, Methods of job evaluation, job evaluation procedure, merit rating (performance appraisal), method of merit rating, wage and wage incentive plans.	**07**
03	**Value Engineering and Value Analysis:** Distinction between value engineering & value analysis and their Significance. Steps in value engineering & analysis, function analysis system techniques- FAST diagram with Case studies.	**06**
04	**Facility Location:** The need for location decision, Procedure for making location decisions, Factors affecting location decisions, Methods of evaluating location decisions. **Facility Layout / Plant Layout:** Types of Layout, Significance and Factors influencing layout choices, Principles of Plant layout, Concepts of Group Technology and Cellular Manufacturing, Computerized Layout Techniques.	**07**

	Materials Handling: Function, Importance and Objectives of Material Handling, Material handling Principles, Types of Material Handling Systems, Selection of Material Handling Equipment.	
05	**Inventory Management:** Nature, Importance, Classification and Functions of Inventory, Inventory Costs, Importance of Inventory Management, Inventory Control System for Dependent Demand and Independent Demand, Inventory Ordering Systems. Inventory Control subject to Known Demand. The EOQ Model, Extension to Finite Production Rate, Quantity Discount Model**.**	**08**
06	Material Requirement Planning (MRP), Manufacturing Resource Planning (MRP II), Enterprise Resource Planning (ERP), Just in Time Manufacturing, Lean Production, Agile Manufacturing, Line Balancing, Sustainable Production and Green Manufacturing.	**06**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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. *Production and Operations analysis by Steven Nahmia , McGraw-Hill / Irwin publication*
2. *Facilities Planning* 4th Edition by James A. Tompkins, John Wiley and Sons Inc.
3. *Elements Of Production Planning And Control* by Eilon, Samuel, New York: Macmillan
4. Production Planning and Control by Prof. Jhamb L.C. by Everest Publishing House
5. *Production (Operations) Management* by Prof. Jhamb L.C. by Everest Publishing House
6. *Inventory Management* Prof. Jhamb L.C. by Everest Publishing House
7. *Operations Management*- an Integrated Approach 5th Edition by R. Dan Reid, Wiley
8. *Production and Operations Management* by R. Panneer selvam, Prentice-Hall Of India
9. *Operations Management for Competitive Advantage* by Richard B. Chase, MGH
10. *Orlicky's Material Requirements Planning*, by Carol Ptak, McGraw Hill.
11. *Enterprise resource planning*: *concepts and practice* by Vinod kumar Garg PHI Learning
12. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, by James P. Womack, Free Press
13. *Toyota Production System: An Integrated Approach to Just-In-Time,* by Yasuhiro Monden ,CRC PRESS

Course Code	Course Name	Credits
PEC 604	Operation 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 modeling 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.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
01	**Linear Programming:** Linear Programming Problem: Formulation, Graphical solution, Simplex method, Big−M method, Two−phase method, Principle of Duality, Dual Simplex, and Sensitivity Analysis. **Transportation problem:** Formulation - Optimal solution, Degeneracy. **Assignment problem:** Formulation - Optimal solution, Traveling Salesman problem. **Sequencing:** Introduction – Flow Shop sequence. Sequencing – n jobs through two machines - n jobs through three machines – Job shop sequencing - two jobs through 'm' machines.	**13**
02	**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. **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	**06**
03	**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 X2 & 2 X n games, Graphical method	**05**
04	**Dynamic programming**: Introduction – Bellman's Principle of optimality - Applications of dynamic programming- capital budgeting problem - Shortest Path problem – Minimum Spanning Tree.	**04**
05	**Simulation**: Definition - Types of simulation models - phases of simulation - applications of simulation - Inventory and Queuing problems - Advantages and Disadvantages - Simulation Languages.	**04**
06	**Project Management:** Programme Evaluation and Review Technique, Critical Path Method, Network Updating, Crashing of Network and Resources leveling.	**07**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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, Arhur Yaspan and Lawrence Friedman.
8. *Introduction to O.R*, Hiller & Libermann (TMH).

Course Code	Course Name	Credits
PEDO6011	Internal Combustion Engine	03

Objectives:

1. To understand the working and basic components of IC engine.
2. To understand the basis performance measuring parameters of IC engine.

Outcomes: learner will be able to:

1. Understand the working concept of IC Engine and its classifications.
2. Understand the working of fuel supply system of Spark Ignition Engine.
3. Understand the working of fuel supply system of Compression Ignition Engine.
4. Understand the lubrication and cooling system of SI and CI Engine.
5. Analyze the performance parameters like Indicated power, brake power and fuel consumption of the engine.
6. Understand the use of non-conventional fuel like Alcohol - Hydrogen - Natural Gas and Liquefied Petroleum Gas – Biodiesel- Biogas and its merits and demerits as fuels.

Detailed Syllabus: (Module wise)

Module No.	Description	Duration Hrs
01	**Introduction** Classification of I.C. Engines; Parts of I.C. Engine and their materials, Cycle of operation in Four stroke and Two-stroke IC engines and their comparative study; Fuel air cycles and their analysis, Actual working cycle, Valve Timing Diagram. LHR Engines, Homogeneous charge compression Ignition, Rotary engine-Six stroke engine concept	06
02	**S.I. Engines** **Fuel Supply System**: Spark ignition Engine mixture requirements, Fuel-Air ratio, Simple carburettor and auxiliary circuits (excluding mathematical analysis of carburetors). **Injection systems:** Single-point and Multipoint injection, Gasoline Direct Injection. Ignition System: Battery Ignition System, Magneto Ignition System, Functions and working of ignition coil, spark plug, contact breaker point, Requirements and working of Ignition advance mechanisms; mechanical and vacuum, Electronic Ignition Systems; Capacitor Discharge Ignition System, Transistorized Coil Assisted Ignition System, Transistor Ignition system with contactless breaker. **Combustion :** Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure Crank angle diagram, Abnormal combustion, Auto ignition, Detonation and Knocking, Factors affecting combustion and detonation, Types of combustion chambers	07
03	**Compression Ignition Engines** **Fuel Injection Systems:** Air injection systems, Airless/solid injection systems, Common rail, individual pump, distributor and unit systems. Injection pumps, Fuel injector, Types of nozzle, Electronically controlled unit fuel injection system. **Combustion:** Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers.	07
04	**Engine lubrication:** Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems.	06

	Engine Cooling: Necessity of engine cooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling. **Supercharging/Turbo-charging:** Objectives, Limitations, Methods and Types, Different arrangements of turbochargers and superchargers.	
05	**Engine Testing and Performance** Measurement of Brake Power, Indicated Power, Frictional Power, Fuel Consumption, Air flow, BMEP, Performance characteristic of SI and CI Engine Effect of load and speed on Mechanical, Indicated Thermal, Brake Thermal and Volumetric efficiencies, Heat balance sheet. **Engine Exhaust Emission and its control** Constituents of exhaust emission at its harmful effect on environment and human health, Formation of NOx, HC, CO and particulate emissions, Methods of controlling emissions; Catalytic convertors, particulate traps, Exhaust Gas Recirculation, EURO and BHARAT norms.	**07**
06	**Alternative Fuels** Alcohol - Hydrogen - Natural Gas and Liquefied Petroleum Gas – Biodiesel- Biogas - Producer Gas - Properties - Suitability - Engine Modifications - Merits and Demerits as fuels. **Basics of Electronic Engine Controls:** Electronic Control module (ECM), Inputs required and output signals from ECM, Sensors: Throttle Position, Inlet Air Temperature, Coolant Temperature, Crankshaft Position, Camshaft Position, Mass Air flow and Exhaust Gas Oxygen sensors, their construction and importance in ECM. Electronic Spark control, Air Management system, Idle speed control.	**06**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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.**

Books Recommended:

Text books:

1. Internal Combustion Engine, Mathur and Sharma.
2. Internal Combustion Engines, Shyam Agrawal, New Age International.
3. Internal Combustion Engine by Domkundwar.

Reference Books:

1. Internal Combustion Engines, Willard W. Pulkrabek, Pearson Education.
2. Internal Combustion Engines, Mohanty, Standard Book House.
3. Internal Combustion Engine, Gills and Smith.
4. Internal Combustion Engines Fundamentals, John B. Heywood, Tata McGraw Hill.
5. Internal Combustion Engines, Gupta H N, 2nd ed, PHI.
6. Internal Combustion Engine, V Ganesan, Tata McGraw Hill.
7. Introduction to Internal Combustion Engines, Richard Stone, Palgrave Publication, 4th Edition.
8. Internal Combustion Engine, S.L. Beohar.

Course Code	Course Name	Credits
PEDO6012	Refrigeration and Air-conditioning	03

Objectives:

1. To familiarize with the working and operating principles of Vapour Compression and Vapour Absorption systems.
2. To familiarize with the components of refrigeration and air conditioning systems.
3. To familiarize with the design air conditioning systems using cooling load calculations.

Outcomes: Learner will able to:

1. Demonstrate fundamental principles of refrigeration and air conditioning.
2. Locate various important components of the refrigeration and air conditioning system.
3. Illustrate the properties of refrigerants.
4. Use psychometric chart.
5. Design and analyze complete air conditioning systems.
6. Design ducts for conditioning system.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration**
1	**Introduction to Refrigeration:** Methods of refrigeration, First and Second Law applied to refrigerating machines, Carnot refrigerator, Carnot heat pump, unit of refrigeration, Coefficient of Performance, Energy Efficiency Ratio (EER), BEE star rating.	3
2	**Vapour Compression Refrigeration System:** Simple vapour compression cycle, Effect of liquid sub cooling & superheating, effect of evaporator and condenser pressures, methods of sub cooling, use of P-h charts, Actual VCR cycle. Types of condensers, evaporators, expansion devices and Compressors. Use of enhanced surface tubes in Heat Exchangers. **Refrigerants-** Desirable properties of refrigerants, ASHRAE numbering system for refrigerants. Thermodynamic, Chemical and Physical properties. Secondary refrigerants, ODP and GWP, Montreal protocol and India's commitment, Recent substitutes for refrigerants.	10
3	**Vapour Absorption Refrigeration:** Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system. **Nonconventional Refrigeration Systems:** Thermoelectric Refrigeration, Thermoacoustic Refrigeration, Vortex Tube Refrigeration.	4
4	**Psychrometry**: Need for air conditioning, Principle of psychromerty, Psychometric properties, chart and processes, air washers, requirements of comfort air conditioning, summer and Winter Air conditioning.	6
5	**Cooling load calculations and design of air-conditioning systems:** Different Heat sources,- Adiabatic mixing of two air streams, Bypass factor, sensible heat factor, RSHF, GSHF, ERSHF, Room apparatus dew point and coil apparatus dew	10

	point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation. **Requirements of comfort air-conditioning**: Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone.	
6	**Applications of Refrigeration and Air-conditioning Systems:** Introduction to Unitary Products viz. Room/Split and Packaged Air Conditioners, Introduction to recent developments viz. Variable Refrigerant Flow systems, VAV control systems, Inverter Units. Applications Refrigeration & A/C Ice plant – food storage plants – dairy and food processing plants, Food preservation, Freeze Drying, A/c in textile, printing pharmaceutical industry and Hospitals.	6

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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. *Refrigeration and air-conditioning* – C P Arora, Tata McGraw Hill.
2. *Principles of refrigeration* – R J Dossat, Willey Eastern Publication.
3. *Refrigeration and air-conditioning* – W F Stoker and J W Jones, Tata McGraw Hill.
4. *Modern Air-conditioning practice* – C P Arora, Tata McGraw Hill.
5. *Refrigeration and air-conditioning*- Manohar Prasad, New Age Int (P) Ltd.
6. *Basic Refrigeration and air-conditioning*- P.Ananthanarayana, Tata McGraw Hill.
7. *Refrigeration and air-conditioning*- V. M. Domkundwar.

Course Code	Course/Subject Name	Credits
PEDO6013	Rapid Prototyping and Manufacturing	03

Objectives:

1. To acquaint with various rapid prototyping and additive manufacturing technologies.
2. To familiarize with the concept of Direct Digital Manufacturing.
3. To familiarize with the various Rapid tooling and Reverse engineering techniques.
4. To introduce the concept of Digital Manufacturing.

Outcomes: Learner will be able to:

1. Demonstrate an importance of rapid prototyping/additive manufacturing techniques.
2. Design and develop of products using rapid manufacturing technology.
3. Design and develop of products using additive manufacturing technology.
4. Illustrate the concept of Direct Digital Manufacturing.
5. Select appropriate Reverse engineering techniques for a particular case.
6. Select appropriate Rapid tooling techniques for a particular case.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration Hrs**
01	**Introduction to Rapid Prototyping (RP) and Additive Manufacturing (AM)** Prototype Fundamentals, Historical Development, Fundamentals of Rapid Prototyping, Advantages of Rapid Prototyping, Commonly Used Terms, Additive Manufacturing (AM) Definition, Applications of AM parts, The Generic AM process, Why use the term Additive Manufacturing, The Benefits of AM, Distinction Between AM and CNC Machining Other Related Technologies: Reverse Engineering, CAE, Haptic based CAD. Classifications of AM / RP System: Liquid polymer Systems, Discrete Particle Systems, Molten Material Systems, Solid Sheet Systems New AM Classification Schemes as per ASTM F42 and ISO TC 261: Vat photo polymerization, Powder bed fusion, Material extrusion, Material jetting, Binder jetting, Sheet lamination and Directed energy deposition	**06**
02	**Additive Manufacturing / Rapid Prototyping Systems** **Vat Photo Polymerization based AM / RP Systems**: Principle of operation, Process, materials advantages, disadvantages, and applications of 3D Systems' stereo lithography (SLA), CMET'S Solid Object Ultraviolet-Laser Printer (SOUP). **Powder Bed Fusion based AM / RP Systems**: Principle of operation, Process, materials, advantages, disadvantages, and applications of 3D Systems' Selective Laser Sintering (SLS), EOS's EOSINT Systems, ARCAM's Electron Beam Melting (EBM). **Material Extrusion based AM / RP Systems**: Principle of operation, Process, advantages, disadvantages and applications of STRATASYS' Fused Deposition Modeling (FDM). **Material Jetting based AM / RP Systems:** Principle of operation, Process, advantages, disadvantages and applications of 3D Systems' Multi-jet Modeling System (MJM). **Binder Jetting based AM / RP Systems**: Binder jetting principle, materials, Z Corporation's Three Dimensional Printing (3DP) machine, process benefits and drawbacks. **Sheet lamination based AM / RP Systems:** Principle of operation, Process, materials, advantages, disadvantages, and applications of CUBIC Technologies Laminated Object	**10**

	Manufacturing (LOM), CAM-LEM's (Computer Aided Manufacturing of Laminated Engineering Materials) CL 100. **Directed Energy Deposition based AM / RP Systems**: Principle of operation, Process, materials, advantages, disadvantages, and applications of OPTOMEC's Laser Engineered Net Shaping (LENS).	
03	**Direct Digital Manufacturing** Concept of Direct Digital Manufacturing (DDM), Application Case Studies, DDM Drivers, Manufacturing Versus Prototyping, Cost Estimation: Cost Model, Build Time Model, Life-Cycle Costing, 3.6 Future of DDM	**05**
04	**Design for Additive Manufacturing** **AM Unique Capabilities**: Shape Complexity, Hierarchical Complexity, Functional Complexity, And Material Complexity. **Core DFAM Concepts and Objectives:** Complex Geometry, Integrated Assemblies, Customized Geometry, Multifunctional Designs, Elimination of Conventional DFM Constraints	**05**
05	**Rapid Tooling** Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling **Reverse Engineering (RE):** Introduction, RE generic process, RE hardware and software, Integration of RE and RP for Layer-based Model Generation, Applications and case studies of RE in automotive, aerospace and medical device industry, Barriers for adopting RE.	**06**
06	**Digital Manufacturing** Definition of digital manufacturing, Digital manufacturing idea taking control for center, Digital manufacturing idea taking design for center, Digital manufacturing idea taking management as its center, The 10 disruptive principles of digital manufacturing processes. **Key Technologies of Digital Manufacturing**: Various Digital Technologies in Product Life Cycle, Resource and Environment, Management, Control and Product Recognition.	**07**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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. *Fundamentals of Digital Manufacturing Science*, Zude Zhou, Shane (Shengquan) Xie, Dejun Chen, Springer, 2012.

2. *Rapid Manufacturing: An Industrial Revolution for the Digital Age,* N. Hopkinson, R.J.M. Hague and P.M. Dickens (Eds.), John Wiley & Sons, 2006.

3. *Rapid Tooling: Technologies and Industrial Applications*, Peter D. Hilton and Paul F. Jacobs (Eds.), Marcel Dekker, 2000.

4. *Collaborative Design and Planning for Digital Manufacturing* Lihui Wang, Andrew Y.C. Nee. (Eds.), Springer, 2009.

5. *Rapid Prototyping Principles and Applications*, Chua C.K., Leong K.F., and Lim C.S 2nd Edition, World Scientific, 2003.

6. *Additive Manufacturing Technologies*, Ian Gibson, D.W. Rosen, and B. Stucker, 2nd Edition, Springer, 2015.

7. *Rapid Prototyping Theory and Practice*, Ali Kamrani, and EmadAbouel Nasr (Eds.), Springer, 2006.

8. *Understanding Additive Manufacturing*, Andreas Gebhardt, Hanser, 2011.

9. *Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling*, D. T. Pham and S.S. Dimov, Springer, 2001.

10. *Rapid Prototyping Technology Selection and Application*, Kenneth G. Cooper, Marcel Dekker Inc, 2001.

11. Reverse Engineering: An Industrial Perspective, Vinesh Raja and Kiran J. Fernandes (Eds.), *Springer*, 2008.

Course Code	Course Name	Credits
PEDO6014	Logistics and Supply Chain Management	03

Objective:

1. To acquaint with concepts, analytical and problem solving skills and design skills to develop an understanding of information technology in supply chain optimization.
2. To acquaint with the complexity of inter-firm and intra-firm coordination in implementing programs such as e-collaboration, quick response, jointly managed inventories and strategic alliances.

Outcomes: Learner will be able to:

1. Demonstrate the functional strategy map of supply chain management.
2. Design supply chain strategy of a firm.
3. Demonstrate concepts and ideas related to Materials management.
4. Illustrate various aspects pertaining to logistics and analysis of logistic systems.
5. Demonstrate activities of warehouse and transport management.
6. Demonstrate the use of emerging technology in logistics and supply chain management.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration Hrs**
01	**Supply Chain & Framework** Objective of a Supply Chain, Decision Phases in a Supply Chain, Process Views of a Supply Chain, Examples of Supply Chains **Supply Chain Strategic Fit** Competitive and Supply Chain Strategies, Achieving Strategic Fit, Expanding Strategic Scope, Challenges to Achieving and Maintaining Strategic Fit, Drivers of Supply Chain Performance, Framework for structuring drivers: inventory, transportation facilities, information, sourcing, pricing, Obstacles to achieving fit.	**05**
02	**Supply Chain Network** Role of Network Design in the Supply Chain, Factors Influencing Network Design Decisions, Framework for Network Design Decisions.	**05**
03	**Materials Management** Scope, Importance, Classification of materials, Procurement, Purchasing policies, Vendor development and evaluation, Inventory control systems of stock replenishment, Cost elements, EOQ and its derivative modules.	**05**
04	**Dimensions of Logistics** Macro and Micro Dimensions of logistics, Logistics and interfaces with other areas, Approach to analyzing logistics system, Techniques of logistics system analysis, Factors affecting the cost and Importance of logistics.	**06**
05	**Warehouse and Transport Management** Warehouse functionality, Warehouse operating principles, Developing warehouse resources, Material handling and packaging in warehouses, Transportation Management, Transport functionality and principles, Transport infrastructure, Transport economics and Pricing, Transport decision making	**06**

06	**IT in Supply Chain** The Supply Chain IT Framework, Customer Relationship Management(CRM), Internal Supply chain management(ISCM), Supplier Relationship Management(SRM), Transaction management, Risk Management in IT **Coordination in A Supply Chain** Lack of supply chain coordination and the Bullwhip effect, Obstacle to coordination, Managerial levers to achieve coordination, Building partnerships and trust, **Emerging Trends and Issues** Vendor managed inventory (VMI), Co-managed Inventory (CMI), Third- and Fourth-Party Logistics Providers (3PL-4PL), Reverse logistics: Reasons, Role and activities of RFID systems in Supply chain: Lean supply chain, Implementation of Six Sigma in supply chain, Green supply chain.	**12**

Assessment:
Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:
Weightage of each module in end semester examination will be proportional to the 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.**

References

1. *Supply Chain Management Strategy, Planning, and operations*, Sunil Chopra and Peter Meindl.
2. *Materials Management & Purchasing*, Ammer D.S. Taraporawala.
3. *Designing & Managing Supply chain*, David Simchi Levi, Philip Kaminsky & Edith Smichi Levi.
4. *Supply Chain Redesign: Transforming Supply Chains into Integrated Value Systems*, Robert B Handfield, Ernest L Nicholas.
5. *The Management of Business Logistics: A Supply Chain Perspective*, Coyle, Bardi, Langley.

Course Code	Course Name	Credits
PEDO6015	Maintenance Engineering	03

Objectives

1. To acquaint with various principles, functions and practices adopted in industry for the successful management of maintenance activities.
2. To appraise with the importance of maintenance in productivity enhancement and cost reduction.
3. To make conversant with preventive maintenance and breakdown maintenance functions.
4. To appraise with modern approaches in the field of maintenance.

Outcomes: Learner will be able to:

1. Acquire awareness and interest about the significance of maintenance function.
2. Develop skills to diagnose and trace the faults.
3. Keep pace with the ongoing and emerging trends in the field of maintenance engineering.
4. Plan and implement maintenance management strategies & functions.

Detailed Syllabus: (Module wise)		
Module No.	**Description**	**Duration Hrs**
01	**Principles of Maintenance & Maintenance Planning** Introduction to maintenance, Types of maintenance, Basic Principles of maintenance planning, Objectives of planned maintenance activity, Importance and benefits of sound Maintenance systems, Reliability, Maintainability and machine availability trade off, concepts of MTBF, MTTR and MWT and factors of availability.	**06**
02	**Preventive Maintenance** Significance of Preventive maintenance, maintenance planning & schedules, repair cycle, Concepts of lubrication & lubricants, Types of lubricants & selection Techniques of lubrication.	**06**
03	**Breakdown Maintenance** Logical fault location methods, Sequential fault location, Repair methods for machine beds, columns, and slide and guide ways. Repair methods for drive elements like shafts, spindles, couplings, gears and gear box, lead screw, bearings, keys, belts, chains, sprockets etc. maintenance of pneumatic and hydraulic components values and actuators and similar drive elements.	**08**
04	**Condition Monitoring** Condition Monitoring, Cost comparison with and without condition monitoring, On load testing and offload testing, Methods and instruments for condition monitoring, Temperature sensitive tapes, Pistol thermometers and wear debris analysis	**06**
05	**Maintenance of Machine Tools & Material Handling Equipment** Maintenance of Material handling equipment like crane, fork lift and conveyors, Maintenance of machine tools like lathes, shaping, milling & drilling machines.	**06**
06	**Maintenance Management** Maintenance strategies, Types and techniques, planned and unplanned maintenance, Computer aided maintenance, maintenance scheduling, spare part management, inventory control, maintenance records and documentation. Concepts of Total Productive Maintenance (TPM).Predictive maintenance techniques.	**07**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

1. First test based on approximately 40% of curriculum contents and second test based on remaining contents (approximately 40%, but excluding contents covered in Test I).
2. Total duration allotted for writing each of the paper is 1 hr.
3. Average of the marks scored in both the two tests will be considered for final grading.

End Semester Examination:

Weightage of each module in end semester examination will be proportional to the 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.**

References

1. *Industrial Maintenance Management*, Srivastava S.K., S. Chand and Co.
2. *Installation, Servicing and Maintenance*, Bhattacharya S.N., S. Chand and Co.
3. *Maintenance Planning*, White E.N., I Documentation, Gower Press.
4. *Industrial Maintenance*, Garg M.R., S. Chand & Co.
5. *Maintenance Engineering Hand book*, Higgins L.R., McGraw Hill.
6. *Condition Monitoring*, Armstrong, BSIRSA.
7. *Handbook of Condition Monitoring*, Davies, Chapman &Hall.
8. *Advances in Plant Engineering and Management*, Seminar Proceedings–IIPE.

Course Code	Course Name	Credits
PEL 601	**Process Engineering Lab.**	**01**

Objectives:-

1. To familiarize with the significance of process engineering and its relevance to manufacturing operations.
2. To prepare for developing a skills in preparing machining sequence and estimating manufacturing time.
3. To acquaint with the significance and control of tolerance in design & manufacturing.
4. To appraise a basics of process and operation planning.

Outcomes: Learner will be able to…

1. Develop capability to prepare part prints.
2. Develop work piece control system.
3. Develop tolerance control charts and process sheets.
4. Develop tool layout for production Lathe.
5. Develop process picture, process routing, process sheets.
6. Design cams for part production on single spindle automats.

Sr. no	Design Exercise /Assignment.
01	Assignment on introduction to process engineering.
02	Assignment on Part print analysis.
03	Assignment on Work piece control.
04	Prepare Tolerance Chart Design for one component.
05	Design of Tool Layout for production lathe.
06	Design process planning sheet with process picture.
07	Design of Cams for Traub Automat.

Term Work

Term work shall consist of assignments based on the syllabus and exercises as mentioned in the table above as well as a detailed report, based on an Industrial visit to a manufacturing firm, covering few of the essential concepts mentioned in subject of Process Engineering and Tooling. The report should cover the importance of optimization of various resources like Time, Material etc. in today's manufacturing firms.
The distribution of marks for term work shall be as follows:

Design Exercise : 12 marks
Assignments : 05 marks
Industrial Visit Report : 03 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

Each student will be given a small exercise based on syllabus, which will be assessed /verified by examiners during the oral examination.

The distribution of marks for oral-practical examination shall be as follows:

Exercise	: 15 marks
Oral	: 10 marks

1. Evaluation of practical/oral examination to be done based on the performance of design task.
2. Student's work along with evaluation report to be preserved till the next examination.

Course Code	Course Name	Credits
PEL 602	Machine Design – II Lab.	01

Objectives:

1. To familiarize with the concept of design features of machine tool structures.
2. To acquaint with design principles of feed gear boxes, bearings, power screws, clutches etc. used in machine tools.
3. To acquaint with the standards & hand books to retrieve relevant data for designing/selection of machine tool components.
4. To acquaint with the acceptance tests on machine tools & their significance.

Outcomes: Learner will be able to:

1. Use codes and hand books to retrieve relevant data for design and selection.
2. Design machine tool structures.
3. Select drive elements and drives for machine tools.
4. Design feed gear boxes for a machine tool.
5. Design bearings and clutches for a machine tool.
6. Design power screws for a machine tool.

Sr. no	Design Exercise/ Assignment
01	Design of mechanical drives (At least one design and drawing)
02	Design and drawing of machine tool guide ways, slide ways profiles, wear compensation techniques.
03	Design and drawing of machine tool structure profiles.
04	Demonstration of acceptance test on at least one machine tool.
04	Assignment on power screws.
05	Assignment on clutches.
06	Assignment each on anti-friction bearing & journal bearing.

Term Work:

Term work shall consist of design exercises and assignments as per the list given above The distribution of marks for term work shall be as follows:

Laboratory work (Experiments/ design and drawings):	15 marks
Assignments:	05marks
Interest & involvement:	05marks
TOTAL:	25Marks**.**

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
PEL 603	Additive Manufacturing Lab.	01

Objective:

1. To acquaint with various rapid prototyping and additive manufacturing technologies.
2. To familiarize with the concept of Direct Digital Manufacturing.
3. To familiarize with the various Rapid tooling and Reverse engineering techniques.
4. To introduce the concept of Digital Manufacturing.

Outcomes: Learner will be able to:

1. Demonstrate an importance of rapid prototyping/additive manufacturing techniques.
2. Illustrate the concept of Direct Digital Manufacturing.
3. Select appropriate Rapid tooling techniques for a particular case.

Sr. no	Experiments
01	Basic Design / Modelling Introduction
02	Introduction to 3D Printing Machine and Software
03	Injection Mould Prototype - Modelling and Printing
04	Assembly Modelling and Printing (Separate Components)
05	Reverse Engineering of Model
06	Working Model Print
07	Study the workflow, material requirements, design consideration, post processing of Fused Deposition Modelling FDM 3D Printer.
08	Design for Additive Manufacturing: One or two experiments

Assessment:

Term Work:

Term work shall consist of any six experiments from Sr.No 1 to 8. In all total 6 experiments.

Experiments (1to 8): …… 10 marks

Assignments: ……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.

Course Code	Course Name	Credits
PEL 604	**Data Analytics Lab.**	**01**

Objective: Students will try to learn:

1. To introduce students to the basic concepts and techniques Data Preparation.
2. To become familiar with regression methods, classification methods, clustering methods.
3. To become familiar with Model Comparison.

Outcomes: Learner will be able to:

1. Develop relevant programming abilities.
2. Demonstrate proficiency with statistical analysis of data.
3. Develop the ability to build and assess data-based models.
4. Apply data science concepts and methods to solve problems in real-world contexts and will communicate these solutions effectively.

Module No.	Detailed Contents
01	Introduction to Data Analytics, Data Summarization and Visual Analytics (At least two programs on Central tendency, depression and data visualization)
02	Data Preparation: Data Cleaning, Data Integration, Data Transformation and Data Reduction (One program which includes all the above. Consider an uncleaned dataset for the same.)
03	Data Modelling: Fundamentals of modelling (Creating Training and Validation data), Decision Tree (Construction of Decision Tree and assessing the results) and K nearest neighbour (Perform KNN with different K values and analyse the results). For result analysis: confusion matrix, accuracy, misclassification, precision, recall, F score, ROC curve. (At least two programs one on decision tree and another on KNN. Consider a categorical class label data set.)
04	Data Modelling: Linear regression for continuous class label data set and Logistic regression for binary class label dataset. (At least two programs one on linear regression and another on logistic regression)
05	Data Modelling: Artificial neural network and Support Vector machine for Non Linear dataset, Ensemble model: Boosting. (At least two programs one on Neural Network and another on Support Vector machine. One program can be implemented on Random Forest.)
06	Data Modelling: Introduction to Pattern Discovery for dataset without class labels. K means clustering. Model comparison for same data sets. (At least one program on K means clustering. One program can be a comparison of two or more models on same dataset.)

Assessment:

Term Work:

Distribution of Term work Marks

Laboratory work	20 Marks
Attendance	05 Marks

Reference Books:

1. Data Mining: Concepts and Hierarchy by ByJiawei Han, Jian Pei, Micheline Kamber, Maurgan Kaufmann publisher.
2. Machine Learning by Tom Mitchell, McGraw Hills publisher.
3. Data Mining and Predictive Analytics by Danial T Larose and Chantal D Larose, Wiley.
4. Python for Data Analysis by Wes McKinney, O'Reilly publisher.
5. R for Data Science by Hadley Wickham and Garrett Grolemund, O'Reilly publisher.

Course	Course Name	Credits
PEM601	Mini Project – 2B	02

Objectives

1. To acquaint with the process of identifying the needs and converting it into the problem.
2. To familiarize the process of solving the problem in a group.
3. To acquaint with the process of applying basic engineering fundamentals to attempt solutions to the problems.
4. To inculcate the process of self-learning and research.

Outcome: Learner will be able to:

1. Identify problems based on societal /research needs.
2. Apply Knowledge and skill to solve societal problems in a group.
3. Develop interpersonal skills to work as member of a group or leader.
4. Draw the proper inferences from available results through theoretical/ experimental/simulations.
5. Analyze the impact of solutions in societal and environmental context for sustainable development.
6. Use standard norms of engineering practices
7. Excel in written and oral communication.
8. Demonstrate capabilities of self-learning in a group, which leads to lifelong learning.
9. Demonstrate project management principles during project work.

Guidelines for Mini Project :

- Students shall form a group of 3 to 4 students, while forming a group shall not be allowed less than three or more than four students, as it is a group activity.
- Students should do survey and identify needs, which shall be converted into problems in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty may give inputs during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert best solution into working model using various components of their domain areas and demonstrate.
- The solution to be validated with proper justification and report to be compiled in standard format of University of Mumbai.

Guidelines for Assessment of Mini Project:

Term Work

- The review/ progress monitoring committee shall be constituted by head of departments of each institute. The progress of mini project to be evaluated on continuous basis, minimum two reviews in each semester.
- In continuous assessment focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.

- Distribution of Term work marks for both semester shall be as below;
    - Marks awarded by guide/supervisor based on log book : 10
    - Marks awarded by review committee : 10
    - Quality of Project report : 05

- In this semester expected work shall be procurement of component's/systems, building of working prototype, testing and validation of results based on work completed in an earlier semester.
- First review is based on readiness of building working prototype to be conducted.
- Second review shall be based on poster presentation cum demonstration of working model in last month of the said semester.
- Term work shall be assessed by review/progress monitoring committee appointed by the Head of the Department/Institute of respective Programme.

Mini Project B shall be assessed based on following points

1. Innovativeness
2. Cost effectiveness and Societal impact
3. Full functioning of working model as per stated requirements
4. Effective use of skill sets
5. Effective use of standard engineering norms
6. Contribution of an individual's as member or leader
7. Clarity in written and oral communication

Guidelines for Assessment of Mini Project Practical/Oral Examination in Even semester:

- Report should be prepared as per the guidelines issued by the University of Mumbai.
- Mini Project shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners approved by the University of Mumbai
- Students shall be motivated to publish a paper based on the work in Conferences/students competitions.

Mini Project shall be assessed based on following points;

1. Quality of problem and Clarity
2. Innovativeness in solutions
3. Cost effectiveness and Societal impact
4. Full functioning of working model as per stated requirements
5. Effective use of skill sets
6. Effective use of standard engineering norms
7. Contribution of an individual's as member or leader
8. Clarity in written and oral communication