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UNIVERSITY OF MUMBAI

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

FACULTY OF TECHNOLOGY

Production Engineering

Second Year with Effect from AY 2017-18
Third Year with Effect from AY 2018-19
Final Year with Effect from AY 2019-20

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

Co-ordinator, Faculty of Technology's Preamble:

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

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

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

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

Dr. S. K. Ukarande
Co-ordinator,
Faculty of Technology,
Member - Academic Council
University of Mumbai, Mumbai

Chairman's Preamble:

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

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

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

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

Dr. S. M. Khot

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

T.E. (Production) Sem.-VI

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract	Theory	Pract	Total
PEC601	Machining Science and Technology.	04	--	04	--	04
PEC602	Process Engineering and Tooling.	04	--	04	--	04
PEC603	Production Tooling.	04	--	04	--	04
PEC604	Machine Design – II	04	--	04	--	04
PEC605	Production and Operation Management	04	--	04	--	04
PEDLO 601X	Department Level Optional Course II	03	--	03	--	03
PEL601	Machining Science and Technology Laboratory	--	02	--	01	01
PEL602	Process Engineering and Tooling Laboratory	--	02	--	01	01
PEL603	Production Tooling Laboratory	--	02	--	01	01
PEL604	Machine Design-II Laboratory	--	02	--	01	01
	Total	**23**	**08**	**23**	**04**	**27**

		Examination Scheme							
		Theory							
Course Code	Course Name	Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)	Term Work	Pract. /Oral	Total
		Test1	Test 2	Avg					
PEC601	Machining Science and Technology	20	20	20	80	03	--	--	100
PEC602	Process Engineering and Tooling	20	20	20	80	03	--	--	100
PEC603	Production Tooling	20	20	20	80	03	--	--	100
PEC604	Machine Design-II	20	20	20	80	03	--	--	100
PEC605	Production and Operation Management	20	20	20	80	03	--	--	100
PEDLO 601X	Department Level Optional Course II	20	20	20	80	03	--	--	100
PEL601	Machining Science and Technology Laboratory	--	--	--	--	--	25	--	25
PEL602	Process Engineering and Tooling Laboratory	--	--	--	--	--	25	25	50
PEL603	Production Tooling Laboratory	--	--	--	--	--	25	25	50
PEL604	Machine Design-II Laboratory	--	--	--	--	--	25	--	25
	Total			**120**	**480**		**100**	**50**	**750**

Course Code	Department Level Optional Course II
PEDLO6011	Manufacturing Planning and Control
PEDLO6012	Refrigeration and Air Conditioning
PEDLO6013	Reliability Engineering
PEDLO6014	Industrial Robotics
PEDLO6015	Rapid Prototyping and Manufacturing

Course Code	Course Name	Credits
PEC601	**Machining Science and Technology**	**04**

Objectives:

1. To familiarize with the basic concepts of machining science like mechanics of machining, tool wear, tool life and surface roughness.
2. To familiarize with various single and multipoint cutting tools designing processes
3. To prepare for understanding the economics of machining process.

Outcomes: Learner will be able to…

1. Calculate the values of various forces involved in the machining operations.
2. Analyse the effect of temperature and cutting fluids in metal cutting.
3. Analyse the surface integrity after post machining.
4. Design various single/multipoint cutting tools.
5. Select an appropriate tool material for particular machining application.
6. Demonstrate the interrelationship between cutting parameters and machining performance measures.

Module	Contents	Hrs.
01	**Metal Cutting Theory:** Orthogonal and oblique cutting, various types of chips ,Mechanics of orthogonal steady state metal cutting ,shear plane and shear plane angle, Merchant's force circle, stresses, shear strain, velocity relations, rate of strain, energy considerations ,Concept of specific power consumption in machining, Ernst and Merchant's model& modified model for orthogonal cutting, Lee and Shaffer model. Analytical modelling of machining operations, mechanistic modelling of machining, slip line field analysis, finite element analysis, modelling of material properties. **Dynamometry:** Dynamometer requirements, force measurement, electric transducers, strain gage lathe dynamometer, strain rings, milling dynamometer, drilling dynamometer, surface grinding dynamometer, piezoelectric dynamometry.	**10**
02	**Temperatures in metal cutting and cutting fluids:** Heat generation in metal cutting, heat transfer in a moving material, temperature distribution in metal cutting, temperature in primary deformation zone, temperature in secondary deformation zone, effect of cutting speed on temperature, prediction of temperature distribution in machining, measurement of cutting temperature, work-tool thermocouple, direct thermocouple measurement, radiation methods, hardness and microstructure changes in steel tools. Cutting fluid types, the action of coolants, the action of lubricants, characteristics of an efficient lubricant in metal cutting, application methods of cutting fluid, cutting fluid maintenance and environmental considerations, disposal of cutting fluids, dry cutting and minimum quantity lubrication, cryogenic cooling.	**06**
03	**Cutting tool materials and machining induced Surface Integrity** Properties of cutting tool materials. Major tool material types. Plain carbon steel, high speed steel, cast alloys, cemented tungsten carbide, titanium	**06**

	carbides, ceramic and cermet tools, synthetic diamond, polycrystalline diamond (PCD), cubic boron nitride (CBN), coated tools. Measurement and specification of surface finish, primary cutting edge finish, fracture roughness, BUE formation and its influence on finish, secondary cutting edge finish, geometrical contribution to roughness, edge finishing, residual stress and microhardness.	
04	**Tool life and machining economics:** Definition, flank wear and crater wear, criteria for tool failure, effect of cutting parameters and tool geometry on tool life. Taylor's tool life equation. Experimental methods to find Taylor exponents. Components of product cost, Optimum cutting velocity for minimum cost of production and maximum production rate.	**06**
05	**Design of single point cutting tools** : Different systems of tool nomenclature like MRS, ORS and NRS. Interrelationship among different systems of nomenclature for tool angles. Constructional features of solid tool, tipped tools, mechanically held regrind able insert type tools and throw away tip type tools. Design of shanks, cutting tip and chip breakers for HSS and Carbide tools. ISO coding system for tipped tools and tool holders.	**08**
06	**Design of Multi point cutting tools:** Various types such as flat form tool, tangential form tool, circular form tool, constructional details and fields of application. Profile design of flat and circular form tools. Broach nomenclature, design steps for circular pull type, key way and spline broaches. Design of face and peripheral milling cutters.	**12**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Fundamentals of Metal Machining and Machine Tools, Third Edition* by Winston A. Knight, Geoffrey Boothroyd, CRC press Taylor and Francis group (2006).
2. *Metal Cutting Principles (2nd Edition),* by Milton Clayton Shaw, Oxford University Press (2005).
3. *Cutting Tools,* by P. H. Joshi, A. H. Wheeler Publishing Co. Ltd. (1991).
4. *ASM Handbook, Vol. 16: Machining (9th Edition),*by Joseph R. Davis, ASM International(1989).

5. *Fundamentals of Metal Cutting and Machine Tools (2nd Edition),* by B. L. Juneja, G. S. Sekhon and Nitin Seth, New Age International Pvt. Ltd. (2003).
6. *Metal Cutting Theory and Cutting Tool Design,* by V. Arshinov and G. Alekseev, Mir publishers, Moscow (1976).
8.*Typical Examples and Problems in Metal Cutting and Tool Design,* by N. Nefedov and K. Osipov, Mir publishers, Moscow (1986).

Course Code	Course Name	Credits
PEC602	**Process Engineering and Tooling**	**04**

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.

Module	Contents	Hrs.
01	**Process Engineering** Differentiation between Product Engg and Process Engg. 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.	**08**
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).	**12**
06	**Cam Design for Automat** Automats major classification& types, tools and tool holders, magazines, and hoppers for feeding. Single spindle automats and its tooling, tool layout and cam design for part production on Single spindle automat.	**10**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. Process Engineering for Manufacturing, Donald F. Eary and Gerald E.Johnson,Prentice-Hall, Inc.
2. Production Technology, HMT.
3. Manufacturing Engineering,V. Danilevsky, Mir publication.
7. Tolerance Design and Analysis,Wade.
8. Fundamentals of Manufacturing Engineering, V.M. Kovan et al, Mir Publications.
9. HSS and Carbide Tool Catalogues for Turning, Drilling, Milling, Boring etc. from Tool manufactures.
10. Westerman Tables for the Metal Trade, Wiley, Eastern Limited.
11. PMT Catalogue Traub Automat

Course Code	Course Name	Credits
PEC603	**Production Tooling**	**04**

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. Demonstrate the principles of blank development in bent & drawn components.

Module	Contents	Hrs
01	**Introduction to Jigs and Fixture:** **1.1**Introduction to Jigs and Fixtures, their difference and Significance. Material used for different elements of jigs/fixtures and recommended hardness where necessary. **1.2Location & Locating Devices:** Locating principles, Degrees of freedom, Redundant location, Fool proofing, nesting, Locators: location from Flat and cylindrical surfaces, conical locators, centralizers. **1.3Clamping & 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** 2.1 Introduction, Selection of location, supporting and clamping faces/points**.** 2.2 Various types of Jig Bushes. 2.3 Commonly used Drill jigs. Case Study on Drill Jig Design.	**08**
03	**Construction of Milling fixture** 3.1 Introduction, Selection of location, supporting and clamping faces/points. 3.2 Tool setting &cutter guiding (Tennons & Setting block). 3.3 Case Study on Milling Fixture Design.	**08**

04	**Introduction to Press Working** 4.1Classification of common Press working operations, Benefits and limitations of using Press tools. Applications of pressed parts/components. 4.2 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.	**06**
05	**Design and Calculations for Piercing & Blanking Die** 5.1 Different types of Dies, Die sets and its selection. 5.2 Calculations for Economic Strip Layout, Calculations of Cutting force and Stripping force. Recommending minimum tonnage of a press. Centre of Pressure (its importance and calculation). 5.3 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. 5.4 Selection of materials and its hardness for different elements of Press tools.	**10**
06	**Bending & Drawing Dies** 6.1 Theory of Bending. Spring back and measures to control it. Calculations for bending force & Blank development of Simple Bent components. Types of Bending dies. Minimum bend radius. 6.2 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. 6.3 Defects in drawn as well as bent parts. Presses selection for drawing/bending operations. 6.4 Basic construction and working of Bending and Drawing dies.	**08**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Production Engineering* – P. C. Sharma
2. *Jig and Fixture Design* Manual, Erik K. Henrikson, Industrail Press.
3. *Jigs and Fixture,* P.H. Joshi, THM. .
4. *Non- Standards Calming Devices,* Hiran E. Grant TMH, New Delhi.
5. *Die Design Fundamentals* – J. R. Paquin
6. *Techniques of Press Working Sheet Metal* – D. F. Eary& E. A. Reed
7. *Press Tools Design and Construction* – P. H. Joshi
8. *Tool Design* – C.Donaldson

Course Code	Course Name	Credits
PEC604	**Machine Design - II**	**04**

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 a skills in designing feed 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 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.

Module	Contents	Hrs.
01	**ELEMENTS OF MACHINE TOOLS** 1.1Types and capabilities of various machine tools. General purpose, and special purpose machine tools. 1.2. **Design of machine tool structures** :- 1.2.1 **Design of bed & columns-** Materials of construction, Profiles, Static and dynamic stiffness. Designing for strength and rigidity. Methods of enhancing rigidity. Design of machine tool bed cross-section like lathe bed. Design of simple machine tool columns like pillar drill column etc. on the basis of strength and rigidity. **1.2.2 Machine tool guideways -** Materials of construction, Classification of guideways, Types of slideways, Clearance adjustment and wear compensation techniques, Fundamentals of hydrostatic guideways. Design of guideways for wear and stiffness. **1.3 Design of mechanical drives:** **1.3.1 Design of belt drives -** Design of belts, belt materials, belt types:- specification and selection, types of pulleys and design of pulleys. **1.3.2 Design of gear drives** - Types of gears, materials, application, and selection. Design of spur gears - Design on the basis of beam strength (W. Lewis equation), Design on the basis of wear and fatigue (Buckingham's Equation) 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.	**12**

02	**DESIGN OF SPEED AND FEED BOXES** 2.1Stepped and Stepless speed outputs, selection of spindle speed ranges, construction of structural, speed, gearing & deviation diagrams, layout of speeds on arithmetic and geometric progression, kinematic advantages of geometric progression series, selection of values of common ratio. **2.2Stepless 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's drives. **2.3Feed 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. **2.4Design of gear boxes** for feed and speeds having 2−3 stages and 4−12 speeds.	**16**
03	**DESIGN OF POWER SCREWS** **3.1 Design of power screws**: Materials of construction. Power screw profiles and selection, 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.	**04**
04	**DESIGN OF CLUTCHES** 4.1 Design considerations, materials of clutch plates & linings. Running conditions- wet & dry. 4.2 Design of plate clutches. Single and multiplate 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, Sommerfeld Number, calculations involving bearing dimensions, clearance, coefficient of friction, heat generated, heat dissipated and power lost in friction. Mounting & maintenance of bearings.	**07**
06	**SAFETY OF MACHINE TOOLS & ACCEPTANCE TESTS** 6.1 Safety 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 lathe, milling, drilling and shaping machines. 6.3 Vibrations in machine tools:- Elementary concepts about factors contributing to vibrations, vibration detection and measurement, remedial approaches	**05**

NOTE:
Use of standard design data books like PSG data book is permitted at the examination and shall be supplied by the college.

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Principles of machine tools, Sen and Bhattacharya*, New Central Book Agency.
2. *Machine tool design and Numerical Control*, N.K.Mehta, Tata MGH
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 MGH
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:* v. 1, by F. Koenigsberger (Author), J. Tlusty (Author)

Course Code	Course Name	Credits
PEC605	**Production and Operations Management**	**04**

Objectives:

1. To prepare for understanding of the role of production and operations management 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 Production and Operations Management 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 production and operations management.

Module	Contents	Hrs.
01	**Introduction** An overview of Production and Operations Management (POM), Managing a Production System, Types of Production Systems, Significance of Productivity, Decision making in POM, Problems in POM, Sub functional areas of POM, Recent trends in POM.	**06**
02	**Product Planning and Development (PPD)** What is a Product?, Need, Objectives and Challenges of PPD, characteristics of Successful Product Development, New Product development Strategy and Process, Factors to be considered in Product Development, The Product Life Cycle Concept, Factors affecting Product Design and Product Development, Stages in Product Design and Product Development.	**06**
03	**3.1 Facility Location** The need for location decision, Procedure for making location decisions, Factors affecting location decisions, Methods of evaluating location decisions **(numerical on this topic)**	**08**

	3.2 Facility Layout / Plant Layout Types of Layout, Significance and Factors influencing layout choices, Principles of Plant layout, Computerised Layout Techniques. **3.3 Materials Handling** Function, Importance and Objectives of Material Handling, Material handling Principles, Types of Material Handling Systems, Selection of Material Handling Equipments, Evaluation of Material handling Performance Relationship with Plant layout **(numerical on this topic).**	
04	**Production Planning and Control** Classification of PPC functions, Factors determining PPC, procedure Role of PPC in POM, Principles of PPC, PPC in different Production System, Organisation of PPC department.	**06**
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 **(numerical on this topic).**Inventory Control subject to Uncertain Demand, The Newsboy Model, Service Levels in Q and R Systems, **(numerical on this topic)**	**12**
06	**Advance Topics in POM** Material Requirement Planning (MRP) **(numerical on this topic)**, Manufacturing Resource Planning (MRP II), Enterprise Resource Planning (ERP), Just in Time Manufacturing, Lean Production, Agile Manufacturing, Line Balancing **(numerical on this topic)**, Line of Balance **(numerical on this topic)**, Sustainable Production and Green Manufacturing.	**12**

Assessment:

Internal Assessment for 20 marks:
Consisting **Two Compulsory Class Tests**
First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I)

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

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

Reference Books:

1. *Production and Operations analysis by Steven Nahmias , 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. Panneerselvam, Prentice-Hall Of India
9. *Operations Management for Competitive Advantage* by Richard B. Chase, MGH
10. *Orlicky's Material Requirements Planning*, by Carol Ptak , MGH
11. *Enterprise resource planning: concepts and practice* by Vinodkumar 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
PEDLO6011	**Manufacturing Planning and Control**	**03**

Objectives

1. To provide a profound insights into how to coordinate the supply, production and distribution functions.
2. To provide an insight in knowhow to balance a conflicting objectives to minimize the total costs involved and maximize customer service.
3. To prepare for analytical abilities to formulate, solve and analyze problems arising in modern production and inventory systems.

Outcomes: Learner will be able to…

1. Analyze all aspects of a successful manufacturing planning and control infrastructure.
2. Design demand management scheme.
3. Illustrate the significance of sales and operations planning.
4. Design and oversee an effective master production schedule.
5. Design materials requirements planning.
6. Analyze capacity planning and management.

Module	Contents	Hrs.
01	**MPC concept and Significance** Typical MPC support activities. An MPC system framework matching, MPC system with the needs of the firm, Evaluation of the MPC system.	**06**
02	**2.1 Demand Management in MPC system** Demand management and the MPC environment, Sales and Operations planning, Information Use in Demand management. **2.2 Forecasting** The time Horizon in Forecasting, characteristics of Forecast, Subjective Forecasting Methods, Objective Forecasting Mehods, Methods for Forecasting Stationery Series, Trend Based Mthods, Method for Seasonal Series, Evaluating Forecasts, Practical Considerations.	**10**
03	**3.1 Aggregate Planning** Overview of the Aggregate Planning Problem, Costs in Aggregate Planning, Evaluation of various strategy, Modelling Management behaviour, Disaggregating Aggregate Plans, Practical Considerations **3.2 Master Production Scheduling** The MPS activity, The MPS techniques, Bill of Materials Structuring for the MPS, The final assembly schedule, MPS stability.	**06**
04	**4.1 Capacity Planning and Utilisation** The role of Capacity Planning in MPC, Capacity Planning and control Techniques, Rough-cut Capacity Planning, Scheduling Capacity and Materials, Management and Capacity Planning Utilisation. **4.2 Production Activity and Control (PAC)** A framework for PAC, PAC Techniques.	**08**

05	**Strategy and MPC System Design** MPC Design options, Choosing the Options, Integrating MRP and JIT, Extending MPC integration to customers.	**06**
06	Advanced concepts in MRP, ERP, JIT and Scheduling, MPC implementation.	**06**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Manufacturing planning and control systems* by Thomas E. Vollmann, MGH.
2. *Master production scheduling: principles and practice,* William L. Berry, MGH.
3. *Operations management: a systems model-building approach,* Thomas E. Vollmann, Addison-Wesley Pub. Co.
4. *Manufacturing Planning and Control: Beyond MRP II*, P. Higgins, P. Le Roy, Springer Science & Business Media.
5. *Manufacturing Planning Systems,* Bill Scott McGraw-Hill.
6. *Supply Chain Focused Manufacturing Planning and Control* By W. C. Benton Cengage Learning.
7. *Dynamic Analysis of Agile Manufacturing Planning and Control (MPC) Systems Using Control Theory* by Ahmed Mahmoud Deif, University of Windsor (Canada).
8. *Planning and Control of Manufacturing Operations* by By John Kenworthy, Woodhead Publishing.
9. *Production Planning and Inventory Control*, Seetharama L. Narasimhan, Prentice Hall.
10. *Distribution Planning and Control*: Managing in the Era of Supply Chain management By David Frederick Ross, Kluwer Academic Publisher.

Course Code	Course Name	Credits
PEDLO6012	**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 analyse complete air conditioning systems.
6. Design ducts for conditioning system.

Module	Contents	Hrs.
01	**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	**04**
02	**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. Cooling tower: Types of cooling towers, tower approach, tower range, tower efficiency, tower losses, tower maintenance. **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.	**08**
03	**Vapour Absorption Refrigeration:** Importance of VAR system, COP of ideal VAR system, Ammonia-water VAR system, Lithium Bromide – Water VAR system, Single and double effect, Electrolux refrigeration system. Solar VAR system. **Nonconventional Refrigeration Systems :** Thermoelectric Refrigeration, Thermoacoustic Refrigeration, Vortex Tube Refrigeration	**06**

04	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.	**06**
05	**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 point, Ventilation and infiltration, Inside and Outside Design condition, Cooling Load estimation , 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. Human Comfort, Thermal exchange of body with environment, Effective temperature, Comfort chart, Comfort zone.	**10**
06	**Duct Design and Applications**: Friction chart for circular ducts. Equivalent diameter of a circular duct for rectangular ducts, Static pressure regain and equal pressure drop methods of duct design, Factors considered in air distribution system, Air distribution systems for cooling & heating. Controls – LP/HP cutoff, Thermostats, Humidistats, Interlocking control, Electronic Controllers. 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	**08**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Refrigeration and air-conditioning* – C P Arora, TMH
2. *Principles of refrigeration* – R J Dossat, Willey Eastern Publication
3. *Refrigeration and air-conditioning* – W F Stoker and J W Jones, TMH
4. *Modern Air-conditioning practice* – C P Arora, TMH
5. *Refrigeration and air-conditioning*- Manohar Prasad, New Age Int (P) Ltd.
6. *Basic Refrigeration and air-conditioning*- P.Ananthanarayana, TMH
7. *Refrigeration and air-conditioning*- V. M. Domkundwar

Course Code	Course Name	Credits
PEDLO6013	**Reliability Engineering**	**03**

Objective:

1. To introduce the basic concepts of Reliability Engineering for ensuring sustainable product management.
2. To familiarize with the application of engineering knowledge and statistical techniques to prevent or to reduce the likelihood of frequency of failure.
3. To familiarize with the reliability of new designs and its analysis based on data.
4. To familiarize the concept of reliability testing and simple calculations.

Outcomes: Learner will be able to…

1. Analyze different modes of failure with its interpretations.
2. Demonstrate an integrated approach for achieving optimum product reliability.
3. Select appropriate reliability testing method/report failure.
4. Demonstrate the concept of reliability predication and analysis techniques.
5. Illustrate the concept of maintainability and availability related to reliability.
6. Illustrate the different corporate strategies for product reliability management.

Module	Contents	Hrs.
01	**Reliability and Failure Concept:** Definition, Role of reliability functions in the organization, Quality and reliability, Significance and importance of reliability. Concept of Failure, Causes of failures, Failure and hazard rate, Reliability expressions for constant, increasing and decreasing hazard rates, Component Reliability, Mean Time To Failure (MTTF), Mean Time Between Failure (MTBF), Time dependent and Stress dependent hazard models, Numerical based on calculations of failure rate and hazard rate.	**08**
02	**System Reliability:** Basic Probability concept, Introduction to independence, mutually exclusive, conditional probability, Discrete and continuous probability distributions, Data analysis based on Probability distributions (Exponential, Wei-bull, Normal, Gamma, Poisson, Lognormal and extreme value), Conditional Probability. Analysis of Series, parallel, series-parallel, standby and k-out of-m modelling. System reliability evaluation technique including methods of bounds, decomposition and transformation techniques. Single and Multiple variable inversion techniques for minimizing system reliability expression. Tie-set and cut- set method.	**08**
03	**Reliability Design** : Functional Designs, Designing for reliability, Design process, Optimal reliability and redundancy techniques, Failure and repair rate allocation, Various design problems and their relevant solution techniques, Reliability improvements.	**04**
04	**Reliability Predication and Analysis:** Reliability predication methodology, System reliability analysis techniques – Failure Mode Effects Analysis (FMEA), Failure Mode effects and critically analysis (FMECA)-Case studies, Basic symbols, Fault tree construction and	**10**

	analysis, Failure Mechanism- Types, Introduction to computer aided reliability.	
05	**Maintainability and Availability:** Maintainability: Concepts, Allocation, Predication and Design aids. Availability: Function and Analysis. Trade-off between reliability, Maintainability and Availability, Planning for safety.	**04**
06	**Reliability Testing and Management** Introduction to Reliability Testing, Stress strength interaction, Testing for reliability and Durability-Accelerated Life Testing and Highly Accelerated Life Testing (HALT), Highly accelerated stress screening (HASS). Objective of reliability management, Typical reliability control organization, Integrated reliability programs, Costs and productivity, Reliability audit, Customer involvement, Reliability considerations in production, Reliability specifications and contracts, Reliability data system and data bank.	**08**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *"An Introduction to Reliability and Maintainability Engineering"*, Ebeling Charles E, Tata McGraw-Hill.
2. *"Reliability in Engineering Design"* Kapur K.C., and Lamberson L.R., John Wiley and Sons.
3. *"Quality and Reliability in Engineering"* Chandrupatla, Cambridge University Press, India.
4. *"Reliability Based Designs"* S. S. Rao, Tata McGraw-Hill.
5. *"Concept in Reliability with an introduction to Maintainability and Availability"*, L. S. Srinath East-West Press Pvt. Ltd.
6. *"Accelerated Testing—Statistical Models, Test Plans, and Data Analysis"*, Nelson, Wayne , John Wiley & Sons.
7. *"Reliability Engineering Handbook Vol. I and II"*, Kececioglu Dmitri, Prentice-Hall, Englewood Cliffs, New Jersey.
8. *"Reliability Engineering and Life Testing",* V.N.A. Naiken, PHI Learning.
9. *"Reliability Engineering"* E. Balagurusamy, Tata McGraw-Hill.

10. *"Maintenance Theory of Reliability"* Toshio Makagawa, Springer Series.
11. *"Practical Reliability Engineering and Analysis for System Designs a Life Cycle Sustainment"* William Wessels , C R C Press.
12. *"Recent Advances in Reliability and Quality"*, Hoang Pham, World Scientific Technology.

Course Code	Course/Subject Name	Credits
PEDLO6014	**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.

Module	Contents	Hrs.
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 endeffecter. **Sensors:** Sensors in Robotics, Tactile Sensors, Proximity & Range Sensors, Sensor Based Systems, Vision systems and Equipment. Introduction to the Microcontroller (Arduino) and interfacing with a sensor	**10**
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 in suitable languages and characteristics of robot.	**10**
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.	**06**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *Industrial Robotics, Technology, Programming & Applications*, Grover, Weiss, Nagel, Ordey, Mc Graw Hill.
2. *Robotics: Control, Sensing, Vision & Intelligence,* Fu, Gonzalex, Lee, Mc Graw Hill.
3. *Robotic technology & Flexible Automation,* S R Deb. TMH.
4. *Robotics for Engineers,* Yoram Koren , Mc Graw 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
PEDLO6015	**Rapid Prototyping and Digital 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.

Module	Contents	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). 2.1 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). 2.2 Material Extrusion based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of STRATASYS' Fused Deposition Modeling (FDM).	**10**

	2.3 Material Jetting based AM / RP Systems: Principle of operation, Process, advantages, disadvantages and applications of 3D Systems' Multi-jet Modeling System (MJM). 2.4 Binder Jetting based AM / RP Systems: Binder jetting principle, materials, Z Corporation's Three Dimensional Printing (3DP) machine, process benefits and drawbacks. 2.5 Sheet lamination based AM / RP Systems: Principle of operation, Process, materials, advantages, disadvantages, and applications of CUBIC Technologies Laminated Object Manufacturing (LOM), CAM-LEM's (Computer Aided Manufacturing of Laminated Engineering Materials) CL 100. 2.6 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 3.3 Manufacturing Versus Prototyping 3.4 Cost Estimation: Cost Model, Build Time Model 3.5 Life-Cycle Costing 3.6 Future of DDM	**05**
04	**Design for Additive Manufacturing** 4.1 AM Unique Capabilities: Shape Complexity, Hierarchical Complexity, Functional Complexity, Material Complexity. 4.2 Core DFAM Concepts and Objectives: Complex Geometry, Integrated Assemblies, Customized Geometry, Multifunctional Designs, Elimination of Conventional DFM Constraints	**05**
05	**Rapid Tooling and Reverse Engineering** 5.1 Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling 5.2 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.	**07**
06	**Digital Manufacturing** 6.1 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. 6.2 Key Technologies of Digital Manufacturing: Various Digital Technologies in Product Life Cycle, Resource and Environment, Management, Control and Product Recognition.	**08**

Assessment:

Internal Assessment for 20 marks:

Consisting **Two Compulsory Class Tests**

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

End Semester Examination:

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

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

Reference Books:

1. *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 Emad Abouel 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**
PEL601	**Machining Science and Technology Laboratory**	**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 Taguchi's Design of Experiments and ANOVA.
4. To familiarize with the design procedures for various cutting tools.

Outcomes:-The learner will be able to…

1. Select a proper force measurement method for the required machining operation.
2. Select a proper temperature measurement method for the required 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 multi point cutting tool like Broach.
6. Design of Flat Form Tool and Circular Form Tool.

Sr. No.	**Design Exercise/Assignment**
01	Assignment on Dynamometry and Metal Cutting Theory
02	Assignment on Temperature Measurement in metal cutting and cutting fluids
03	Assignment Introduction to Taguchi Design of Experiments and ANOVA. – Two Case Studies on applications in machining.
04	Design of Circular Broach.
05	Design of Flat Form Tool.
06	Design of Circular Form Tool.

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
PEL602	**Process Engineering and Tooling Laboratory**	**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 workpiece 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 optimisation 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
PEL603	**Production Tooling Laboratory**	**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 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: The students 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 and setup for economic production of sheet metal components.
6. Prepare bill of materilas..

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).

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

Assignments on topics drawn from the syllabus are as follows-

One assignment/module on module nos. 1, 2, 3 and 1 physical model/prototype (by a group of 4 students) on module 4, 5 or 6. OR

One assignment/module on module nos. 4, 5, 6 and 1 physical model/prototype (by a group of 4 students) on module 1, 2 or 3.

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

Part A**:** Design task	**: 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
Oral	…	10

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
PEL604	**Machine Design – II Laboratory**	**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 guideways, slideway 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 antifriction 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:	05 marks
Interest & involvement	05 marks
TOTAL:	25 Marks**.**

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