UNIVERSITY OF MUMBAI

Bachelor of Engineering

Production Engineering (Second Year – Sem. III & IV)

Revised course (REV- 2012) from Academic Year 2012 -13,

Under

FACULTY OF TECHNOLOGY

(As per Semester Based Credit and Grading System)

S. E. (Production) Sem.-IV

Course Code	Course Name	Teaching Scheme (Contact Hours)		Credits Assigned		
		Theory	Pract.	Theory	Pract.	Total
PEC401	Applied Mathematics-IV[@]	4	--	4	--	4
PEC402	Theory of Machines	4	2	4	1	5
PEC403	Manufacturing Engineering-II	3	--	3	--	3
PEC404	Electrical and Electronics Engineering	4	2	4	1	5
PEC405	Applied Thermodynamics	3	--	3	--	3
PEC406	Materials Technology	4	2	4	1	5
PEL307	Workshop Practice-IV	--	4	--	2	2
Total		**22**	**10**	**22**	**5**	**27**

Course Code	Course Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (in Hrs)			
		Test1	Test 2	Avg.					
PEC401	Applied Mathematics-IV[@]	20	20	20	80	03	--	--	100
PEC402	Theory of Machines	20	20	20	80	03	25	--	125
PEC403	Manufacturing Engineering-II	20	20	20	80	03	--	--	100
PEC404	Electrical and Electronics Engineering	20	20	20	80	03	25	25	150
PEC405	Applied Thermodynamics	20	20	20	80	03	--	--	100
PEC406	Materials Technology	20	20	20	80	03	25	--	125
PEL307	Workshop Practice-IV	--	--	--	--	--	50	50	100
Total		**--**	**--**	**120**	**480**	**--**	**125**	**75**	**800**

[@] Course common to Mech/Auto/Prod/Civil

Course Code	Course/Subject Name	Credits
PEC401	**Applied Mathematics –IV@**	**4**

Objectives:

1. To inculcate an ability to relate engineering problems to mathematical context.
2. To provide a solid foundation in mathematical fundamentals required to solve engineering problems.
3. To study the basic principles of Vector analyses, statistics and probability and complex integration.
4. To prepare the students with a strong foundation for competitive exams/professional practices.

Outcomes: Learner should be able to:-

1. Use matrix algebra with its specific rules to solve the system of linear equations.
2. Understand and apply the concept of probability distribution and sampling theory to engineering problems.
3. Apply principles of vector differential and integral calculus to the analysis of engineering problems.
4. Identify, formulate and solve engineering problems.

Module	Details	Hrs
01	**Matrices:** 1.1 Brief revision of vectors over a real field, inner product, norm, Linear Dependance and Independence and orthogonality of vectors. 1.2 Characteristic polynomial, characteristic equation, characteristic roots and characteristic vectors of a square matrix, properties of characteristic roots and vectors of different types of matrices such as orthogonal matrix, Hermitian matrix, Skew-Hermitian matrix, Cayley Hamilton theorem (without proof) Functions of a square matrix, Minimal polynomial and Derogatory matrix.	09
02	**Vector calculus:** 2.1 Brief revision of Scalar and vector point functions, Gradient, Divergence and curl. 2.2 Line integrals, Surface integrals, Volume integrals. Green's theorem(without proof) for plane regions and properties of line integrals, Stokes theorem(without proof), Gauss divergence theorem (without proof) related identities and deductions.(No verification problems on Stoke's Theorem and Gauss Divergence Theorem)	11
03	**Non Linear Programming:** 3.1 Unconstrained optimization, problems with equality constraints Lagranges Multiplier method. 3.2 Problem with inequality constraints Kuhn-Tucker conditions.	06
04	**Probability Distributions:** 4.1 Discrete and Continuous random variables, Probability mass and density function, Probability distribution for random variables, Expected value, Variance. 4.2 Probability Distributions: Binomial, Poisson and Normal Distributions. For detailed study.	10
05	**Sampling Theory:** 5.1 Sampling distribution. Test of Hypothesis. Level of significance, critical region. One tailed and two tailed tests. Interval Estimation of population parameters. Large and small samples.	10

	5.2 Test of significance for Large samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two samples. 5.3 Student's t-distribution and its properties. Test of significance of small samples: Test for significance of the difference between sample mean and population means, Test for significance of the difference between the means of two Samples, paired t-test. 5.4 Analysis of Variance(F-Test): One way classification, Two-way classification(short-cut method) 5.5 Chi-square distribution and its properties, Test of the Goodness of fit and Yate's correction.	
06	**Correlation and Regression:** 6.1 Correlation, Co-variance, Karl Pearson Coefficient of Correlation & Spearman's Rank Correlation Coefficient (non-repeated & repeated ranks) 6.2 Regression Coefficients & lines of regression	06

[@] Course common to Mech/Auto/Prod/Civil

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Reference Books:

1. *Fundamentals of Mathematicals Statistics*, S C Gupta & V K Kapoor, S. Chand & Co.
2. *Higher Engineering Mathematics*, Dr B. S. Grewal, Khanna Publication.
3. *Elements of Applied mathematics*, P N & J N Wartikar, Pune VidyarthiGruhaPrakashan.
4. *Advanced Engineering Mathematics*, E Kreyszing, Wiley Eastern Limited.
5. *Operations Research*, S.D. Sharma, S. Chand & CO.
6. *Vector Analysis*, Murray R. Spiegel, Shaum Series.
7. *Operations Research*, Kantiswarup, Manmohan and P K Gupta, S. Chand & CO.

Course Code	Course/Subject Name	Credits
PEC402	**Theory of Machines**	**4+1**

Objectives:

1. To study Mechanics of machines, principles and also it's related application areas.
2. To familiarize with various types of Mechanisms and Motion analysis.
3. To develop problem solving capabilities in the topics of velocity and acceleration.
4. To study kinematics and kinetics of simple machine elements and devices.
5. To provide an understanding and appreciation of the variety of mechanisms employed in modern complex machines, such as automobiles, machine tools etc.

Outcomes: The learner should able to:-

1. Understand the rigid body dynamics (kinematics) of linkages, design of four bar mechanisms, gyroscopic devices etc.
2. Understand the direct relevance of problems discussed in engineering practice.
3. Understand validation of certain theoretical models thorough laboratory experiments.

Module	Details	Hrs.
01	**Basic Concepts:** Links, kinematics pairs, kinematics pairs giving one, two and three degrees of freedom, kinematics chains, degree of freedom and mobility criterion. Constrained kinematics chains as mechanism. Inversions of four bar, single and double slider crank chains and their applications. Introduction to simple mechanisms− pantograph, straight line motion mechanism, automobile steering mechanism; Introduction to gyroscope (no numerical problems).	06
02	**Motion Characteristics of Mechanisms:** Velocity and acceleration analysis of mechanisms with single degree of freedom system with Coriollis component using graphical method. Instantaneous centre, Kennedy's theorem; analysis of velocities of mechanism using instantaneous centre method.	09
03	**CAMS:** Introduction to types of cams, types of followers. Follower motions. viz. simple harmonic motions, constant velocity, uniform and constant acceleration and retardation and cycloidal motion, layout of cam profile for specified displacement characteristics. Cams with oscillating follower systems.	08
04	**GEARS :** Introduction: Types of gears and applications, Gear terminology, condition for constant velocity ratio−conjugate profiles, profiles used in gears. Interference of involute teeth, methods of preventing interferences through undercutting, length of path of contact and contact ratio, no of teeth to avoid interference. Gear trains: Simple, compound, planetary and epicyclic gear trains (with numericals).	09
05	5.1 **Balancing:** Introduction. Rotary masses: several masses in same plane, several masses in different planes. Balancing of reciprocating masses, primary balancing and secondary balancing. Balancing of locomotives− Variation of Tractive Effort, Swaying Couple and Hammer Blow 5.2 **Vibrations:** Introduction−free vibrations; longitudinal, transverse and torsional vibrations. Dunkerly's equation, critical or whirling speed of shaft. Torsional vibrations of two rotor system-torsionally equivalent shaft. Free torsional vibrations of a geared system. (Damped and forced vibrations are excluded)	12

06	**Clutches Brakes and Dynamometers:** Study and analysis of single plate clutch, multiple plate clutches and cone clutches. Types of brakes. viz. block and shoe brakes, band brake, band and block brakes, braking of vehicles. Types of dynamometers, classification, Prony brake, Rope brake belt transmission dynamometers	08

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Term Work:

Term work shall consist of

1. Assignments: On topics drawn from syllabus [at least 1 from each module].
2. Practical: Based on topics from syllabus, experiments are to be conducted and presented with inferences.

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

Laboratory work (Experiments and Assignments): 20Marks.
Attendance (Theory and Practicals): 05 Marks.

Reference Books:

1. *Theory of Machines*, 3rd edition by Thomas Bevan, Pearson publication.
2. *Theory of Machines*, 11th Edition by P.L. Ballaney, Khanna Publications (1980).
3. *Theory of Machines*, 2nd Edition by S.S.Ratan, Tata McGraw Hill (2005)
4. *Theory of Machines and Mechanisms*,3rd Edition by John, J Shighley, Oxford University.
5. *Theory of Machines*, Pandya& Shah.
6. *Mechanisms of Machines*, J. Hannah & RC Stephen.
7. *Theory of Machines*,V.Ravi, PHI Learning publication (2011).

Course Code	Course/Subject Name	Credits
PEC403	**Manufacturing Engineering – II**	**3**

Objectives:

1. To study machine tools and basic machining processes.
2. To know the fundamentals of metal cutting.
3. To familiarize with modern machine tools & manufacturing practices.
4. To study manufacturing processes for polymeric composites.

Outcomes: Learner should be able to:-

1. Understand features and applications of automats, NC & CNC turning and machining centers.
2. Understand gear and thread production processes.
3. Understand and distinguish between the conventional and unconventional machining processes.

Modules	Details	Hrs.
01	1.1 **Automats:** Major classification, horizontal and vertical, single spindle and multi-spindle, bar type and chuck type, screw type and Swiss type, tools and tool holders, typical tooling setup for simple work pieces, chutes, magazines, and hoppers for feeding. 1.2 **Numerically Controlled Machines:** Difference between NC and CNC machine tools, CNC turning centers, Machining centers- horizontal spindle, vertical spindle, universal, three axis, five axis, and seven axis. Characteristics and capabilities of machining centers. Special purpose machines. Working principles and applications only.	10
02	2.1 **Grinding Machines:** Grinding process, grinding machines−cylindrical, centre type, universal, plain, plunge, centre type, chucking type, centre less grinding machines−through feed, in feed, end feed, internal grinding machines− horizontal, vertical spindle-rotary/reciprocating types, tool and cutter grinders, special grinding machines. 2.2 **Grinding Wheels:** Types of abrasives−natural, artificial, grain size, types of bonds, grade, structure, shapes and sizes, marking system of grinding wheel, selection of grinding wheels, balancing of grinding wheels, truing, dressing and mounting of grinding wheels. 2.3 **Finishing Processes:** Reaming process, Honing process, machine, honing stone and tools, abrasive, grit size. Lapping−process, hand and machine lapping, flat internal and external cylindrical lapping, lap materials, medium, vehicles. Super finishing process- equipment, stones and fluids. Roller burnishing-process, tools and applications.	08
03	**Screw Thread Cutting Machines:** Thread production process, thread chasing, thread milling, thread whirling, die threading & tapping, thread rolling, thread grinding, self opening die heads, chasers -radial and tangential (tool geometry omitted).	03
04	**Gear Teeth Cutting Machines:** Gear milling, gear hobbing, principles of hobbing (kinematics omitted). Hobbing techniques, hob size, material (tool geometry omitted) and gear shaping process (tool geometry omitted). Gear finishing processes-gear shaving, gear lapping, gear grinding and gear burnishing.	04

05	**Unconventional machining processes:** Classification according to type of energy used for machining, basic principles, machines, applications of Electrical discharge machining (EDM), Electron beam machining (EBM), Plasma arc machining (PAM), Laser beam machining (LBM), Electrochemical machining (ECM), Chemical machining (CHM), Ultrasonic machining (USM), Abrasive jet machining (AJM), Water jet machining (WJM) and Abrasive water jet machining (AWJM).	08
06	**Polymeric composites manufacturing processes:** Basic steps in composite manufacturing process, advantages and disadvantages of thermoset & thermoplastic composite processing. Manufacturing process for thermoset composites- (**major applications, raw material, basic processing steps, advantages and limitations only**) prepeg layup, wet layup, spray up, filament winding, pultrusion and resin transfer moulding.	06

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question one will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Reference Books:

1. *Elements of Workshop Technology: Machine Tools (Volume - 2)***,** S. K. HajraChoudhary, A. K. HajraChoudhary, Nirjhar Roy, Media promoters (2010).
2. *A Course in Workshop Technology Vol. II (Machine Tools)*, B. S. Raghuwanshi, DhanpatRai& CO. (2001).
3. *Workshop Technology Part 1, 2 and 3*, W. A. J. Chapman, Taylor & Francis (1972)
4. *Production Technology – HMT* , Tata McGraw-Hill (1980).
5. *Composites Manufacturing – Materials, product, and Process Engineering* by Sanjay K. Muzumdar, CRC Press (2002).
6. *Manufacturing, Engineering and Technology, 4thEdition* bySeropeKalpakjian, Steven R. Schmid, published by Pearson (2005).
7. *A Text Book Of Production Technology Vol. II* , O. P. Khanna, DhanpatRai Publication (2000).
8. *Fundamentals of Modern Manufacturing- Materials, Processes and Systems, 3rd Edition* by Mikell P. Groover, Wiley India (2002).
9. *Manufacturing Processes for Engineering Materials, 4th Edition* bySeropeKalpakjian, Steven R. Schmid, published by Pearson (2007).

Course Code	Course/Subject Name	Credits
PEC404	**Electrical & Electronics Engineering**	**4+1**

Objectives:

1. To acquaint the students with the basic concepts involved in electrical machines and their control circuits.
2. To expose the students to domain knowledge in various applications of Production engineering.

Outcomes: Learner should be able to:-

1. Develop basic understanding of Electrical and Electronics Engineering concepts: with this, students should be able to utilize their knowledge in the future to interact with the Electrical & Electronics Engineering personnel in Manufacturing Industries.

Modules	Details	Hrs.
01	1.1 **DC Generator**: Construction, working principle and EMF equation. 1.2 **DC motor**: Working principle, types torque equation, Characteristics curves, speed control of DC motor, starting methods. Stepper Motor – construction, working principle, types, and applications. (Selection of various Motors for different applications)	06
02	2.1 **Three Phase Induction Motor**: Construction, working principle, Torque, speed characteristics. Torque equation 2.2 **Single phase Induction Motor**: Working principle type (Problem of DC Motor speed torque characteristics and 3 phase Induction Motor Torque speed characteristics only).	06
03	**Transformers:** Single Phase, Three Phase – construction, working principle, use of Equivalent circuit. Efficiency and regulation calculation methods. (Problems). (Equivalent circuit. Development not necessary). Transmission and distribution of electric power (scope limited to preliminary expose to the topics e.g. 11KV, 33KV Lines. Circuit breakers, Isolators, Distribution transformers and Distribution Network like Ring Bus System). Basic utility services network.	08
04	**Operational Amplifiers**: Basics- ideal OP –AMP. OP-AMP Applications (elementary configurations). Introduction to BOOLEAN ALGEBRA Digital IC's, registers, timers, counters, multiplexers, de-multiplexers, encoder, decoders (Internal Architecture not necessary, only functions). Introduction to microprocessor 8085. Functions of micro-controllers and their applications. Introduction to PLC and applications.	14
05	Solid state controls and application timers, relays and overload protection devices. SCR working principle. SCR characteristics curve. SCR Application in DC & AC motor control and welding.	10
06	Single Phase A.C. commutator Motors working principle. Performance curves. Area of application in industry (Mathematical Derivations not necessary also problems excluded).	08

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Term work:

Term work shall consist of

1. Assignments: On topics drawn from syllabus.
2. Practical's: Based on topics from syllabus, experiments can be conducted and presented with inferences.
3. Three experiments covering module no. 1 and 2.
4. From module 4 and 5, suggested experiments (any three of the following).
   i. SCR characteristics.
   ii. Speed control of DC motor by SCR.
   iii. OP Amp used as differentiator and integrator.
   iv. Multiplexers.
5. Factory report: Preparation of equipment, process, quality control and failure analysis of engineering components reports after visit to important industrial plants.

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

- Laboratory work (assignments, Practicals and Factory report): 20 Marks.
- Attendance (practicals & theory): 05 Marks.

Reference Books:

1. *Electrical Technology*, 4th Edition by Cotton , Pitman (1939)
2. *Electric Machines*, 4th Edition by Kothari and I. J. Nagrath, McGraw Hill Publication.
3. *Electrical Machines and transformers*, 2nd Edition by Anderson Leonar and Jack Macneil, Prentice Hall (1988).
4. *Design with Operational Amplifiers and Analog Circuits*, 3rd Edition by Sergio Franco,Tata McGraw Hill (2002).
5. *Digital principles & Applications*, 4th Edition by Malvino& D Leach, McGraw Hill (1986).
6. *Modern digital electronics*, 4th Edition by R. P. Jain, Tata McGraw Hill (2010).
7. *SCR- General Electric Manual*, 5th Edition by D R Grafham (1972).
8. *Electronic Devices and Circuit Theory*, 9th Edition by Boylestad and Nashelsky, Pearson Publication (2006).
9. *Single phase commutator Motor*, by Frederick Creedy ,Ulan press.

Course Code	Course/Subject Name	Credits
PEC405	**Applied Thermodynamics**	**3**

Objectives*:*

1. To study the basic concepts and definitions used in engineering thermodynamics and applications of engineering thermodynamics in real life situations.
2. To broaden an understanding of Work, Heat, Energy, First Law & Second Law of Thermodynamics and their analysis in different applications.
3. To study the properties of pure substances.
4. To develop the students for a systematic approach to thermodynamic cycle analysis - Gas and Vapour power cycle.
5. To gain knowledge of application of mathematical skills to solve engineering thermodynamic problems.

Outcomes: Learner should be able to:-

1. Define heat, work, thermal efficiency and the difference between various forms of energy.
2. Identify and describe energy exchange processes (in terms of various forms of energy, heat and work).
4 Understand the steady-flow energy equation or the First Law of Thermodynamics to a system of thermodynamic components to estimate required balances of heat, work and energy flow.
5 Understand the importance of the second law of thermodynamics in the characterization of the processes and recognize the importance of entropy in the performance of the devices.
6 Characterize the different thermodynamic cycles of generating power, identifying the conditions of application of each.

Module	Details	Hrs.
01	1.1**Thermodynamic concepts**: Microscopic and Macroscopic viewpoints in thermodynamics, System, surrounding, state, path, property, Internal energy and Enthalpy, Reversible and irreversible process, thermodynamic work, heat, temperature, thermodynamic equilibrium and Zeroth law of thermodynamics. 1.2 **First law of Thermodynamics:** Statement. First law applied to non-cyclic process, Application to non flow processes viz. Constant volume, constant Pressure, and constant temperature, adiabatic and polytrophic processes. Heat and work calculations.	08
02	**First law applied to open systems:** Flow work, Steady flow energy equation, Work done in steady flow processes in terms of pressure and volume. Throttling process. Joule's porous plug experiment. Joule-Thompson coefficient, SFEE applied to nozzle, turbine, compressor, boiler, condenser etc.	04
03	**Second law of thermodynamics**: Limitations of first law of Thermodynamics. Heat engine, thermal efficiency, reversed heat engine, coefficient of performance, Kelvin-Planck and Clausius statements and their equivalence. PMM I and PMM II, Carnot cycle, Carnot's theorem its Corollaries and Thermodynamic temperature scale.	06
04	**Entropy**: Entropy, temperature – entropy diagram Clausius inequality, Entropy changes for an ideal gas during reversible process, Principle of increase of entropy. Introduction to availability and irreversibility	06

05	**Properties of steam**: Dryness fraction, enthalpy, internal energy and entropy. Steam table and Mollier chart and First law applied to steam processes.	05
06	6.1 **Power Cycles** (**Vapour power)**: Rankine cycle, Modified Rankine cycle, Reheat Rankine Cycle and Regenerative Rankine cycle. 6.2 **Gas power:** Thermodynamics of Otto, Diesel, Dual and Brayton cycle. Comparison and representation on P-V and T-S diagram.	10

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Reference Books:

1. *Engineering Thermodynamics*,4th Edition *by* P. K. Nag, Tata Macgraw Hill (2008).
2. *Engineering Thermodynamics*, 4th Edition by R K. Rajput, Lakshmi Publication (2010).
3. *Applied Thermodynamics*, 5th Edition by T. D. Eastop and A. McConkey, Pearson (2009).
4. *Fundamentals of Compressible flow*, 3rd Edition by S. M. Yahya, New Age Publication
5. *Thermodynamics*, 2nd Edition by J. P. Holman, Macgraw Hill (1974).
6. *Thermodynamics for Engineers*, M. A. Saad, Prentice Hall publication.
7. *Fundamentals of Thermodynamics*, 8th Edition by Sonntag, Wiley India (2012).
8. *Thermodynamics*, 2nd Edition by W. C. Raynold, Macgraw Hill and NY (1977).
9. *Engineering Thermodynamics*, 4th Edition *by* Mayhew Y R and Rogers GFC, Pearson (1992).
10. *Engineering Thermodynamics*, 2nd Edition by M. Achutan, PHI (2009).
11. *Engineering Thermodynamics*, J. B. Jones and Dugan, PHI (1996).
12. *Thermal Engineering*, 20th Edition by P.L.Ballaney, Khanna Publication (1994).
13. *Thermodynamics and Engg. Approach*, 7th Edition by Yunus and Cengel, McGraw Hill (2012).
14. *Engineering Thermodynamics*, Lyndd Russell and George A Adebiyi ,Oxford Press (2007).

Course Code	Course/Subject Name	Credits
PEC406	**Materials Technology**	**4+1**

Objectives:

1. To understand basic engineering materials, their properties & selection and applications.
2. To understand types and causes of failure of components in various Engineering applications.

Outcomes: Learner should be able to:-

1. Distinguish different types of materials and composites used in Manufacturing.
2. Demonstrate a deeper understanding of materials in engineering applications.

Module	Details	Hrs.
01	1.1 **Solidification of metals:** Formation of solids from liquids of pure metals and alloys. Ingot defects and their remedies. Single crystal and polycrystalline structure. 1.2 **Crystal imperfection:** Definition, classification, Point defects: their formation and effects. Dislocations: Edge and screw dislocations, their significance. Surface defects: Grain boundary, sub-angle grain boundary, stacking fault, and their significance. Dislocation generation by Frank Reed sources. Dislocation interactions. 1.3 **Deformation:** Mechanisms of deformation; Critical resolved shear stress. Slip systems of FCC, BCC, HCP metals. Deformation in Single and Polycrystalline materials. Strain Hardening and its significance. Necessity of Process Annealing. Recovery, Recrystallization and Grain Growth; Factors affecting Recrystallization.	10
02	2.1 **Fracture:** Definition and types of facture. Brittle fracture and Ductile fracture. Ductility transition. Definition and signification (fundamental understanding only). 2.2 **Fatigue Failure:** Definition of fatigue and significance of cyclic stress. Mechanism of fatigue. Fatigue testing. Test data presentation. S.N. Curve and its interpretation. Influence of important factors on fatigue. 2.3 **Creep:** Definition and significance of creep. Effect of temperature and creep on mechanical behavior of materials. Creep testing and data presentation & analysis. Mechanism and types of creep.	08
03	3.1 **Theory of Alloying:** Significance of alloying, Definition. Classification and properties of different types of alloys. 3.2 **Alloy Phase Diagrams:** Different types of alloy diagrams and their analysis. Tie bar and lever rules and their application. Dispersion hardening / age hardening 3.3**The Iron-Iron Carbide Phase Diagram**: Importance of Iron as engineering material, Allotropic forms of Iron. Iron-Iron carbide diagram and its analysis. Classification of Plain Carbon Steels and Cast Irons.	10

04	4.1 **Principles of Heat treatment:** Technology of heat treatment. Classification heat treatment process. TTT Diagram. CT Diagram and Superimposition of cooling curves on Diagram. 4.2 **Heat treatment Process:** **Annealing**: Principle, process, and properties developed on Full Annealing; Spheroidizing; **Normalizing**: The process and its applications **Hardening:** Hardening media, Salt baths, Hardenabilitiy. Tempering, Subzero treatment, Austempering, Martempering, Maraging and Ausforming process. **Surface hardening**: Surface Hardening methods. Their significance and applications. Carburizing, Nitriding, Cyaniding, Carbon-nitriding. Induction hardening and Flame hardening processes.	10
05	5.1 **Effect of Alloying Elements in Steels**: Limitation of plain carbon steels. Significance of alloying elements. Effects of major and minor constituents, Effect of alloying elements on ferrite, carbide, austenite, Effect of alloying elements on phase transformation, decomposition, hardening and tempering. **Tool steels**: Important compositions and applications. **Stainless steels** : Important compositions and applications 5.2 **Non Ferrous Metals and their Alloys:** Basic Treatment Only. Important non-ferrous materials like Aluminium, Copper, Nickel, Tin, Zinc – Their alloys, properties and applications. 5.3 **Powder Metallurgy:** Powder manufacturing methods; Powder Metallurgy Process. Applications such as Oil Impregnated Bearings and Cemented Carbides. Limitations of Powder Metallurgy.	08
06	6.1 **Composites:** Definition; Classification; Particle-reinforced Composites and Fibre-**r**einforced Composites. Rule of Mixtures; Sandwich structures. Classification of Composites on basis of Matrix materials. 6.2 **Nano-structured Materials:** Definition and Introduction to Nano-Technology. Unique features of Nano-structured Materials. Typical applications. **(Fundamental understanding only).** 6.3 **Ceramics:** Definition, Comparative Study of Structure and Properties of Engineering Ceramics with reference to Metallic Materials. Toughening Mechanisms in Ceramics.Engineering application of Ceramics.	06

Theory Examination:

1. Question paper will comprise of total 6 questions, each of 20 Marks.
2. Only 4 questions need to be solved.
3. Question 1 will be compulsory and based on maximum part of the syllabus.
4. Remaining questions will be mixed in nature (for example suppose Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).

In question paper, weightage of each module will be proportional to the number of respective lecture hours as mentioned in the syllabus.

Internal Assessment:

Assessment consists of two tests out of which; one should be a compulsory class test (on minimum 40% of curriculum) and the other is either a class test (on minimum 70% of curriculum) or assignment on live problems or course project.

Term Work:
Term work shall consist of

1. Assignments: On topics drawn from syllabus.
2. Factory report: Preparation of equipment, process, quality control and failure analysis of engineering components reports after visit to important industrial plants.
3. All experiments below mentioned below have to be performed.

List of Experiments: (Term Work sr. no.3):

1. Preparation of specimen (minimum two metals/alloys) for microscopic examination.
2. Heat treatment process (Annealing, Normalizing and Hardening).
3. Jominy end Quench test for hardenability.
4. NDT (at least two).

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

• Laboratory work (assignments, Practicals/Factory report): 20 Marks.
• Attendance (practicals & theory): 05 Marks.

Reference Books:

1. *Materials Science and Engineering: An Itroduction*, 8th Edition by William D. Callister, Jr. – Adapted by R. Balasubramaniam. Wiley India (P) Ltd (2010).
2. *The Structure and Properties of Materials*, Vol I by M. G. Moffet, G. T. W. Pearsall & J. Wulff.
3. *Material Science and Metallurgy*, 12th Edition by V.D. Kodgire,Everest Publication (2002).
4. *Metallurgy for Engineer*s, 4th Edition by E.C. Rollason - ELBS SOC. And Edward Arnold, London (1973).
5. *Mechanical Behaviour of Materials*, 2nd Edition by Courtney, Waveland Press (2005).
6. *Introduction of Engineering Materials*, B.K. Agrawal, McGraw Hill Publishing Co. ltd.
7. *Mechanical Metallurgy*, 3rd Edition by G.E. Dieter, McGraw Hill International New Delhi (1988).
8. *Engineering Metallurgy Part I&II*, 6th Edition by R. A. Higgins & Hodder Stoughlon, London, Viva Books (P) Ltd. (1998).
9. *A text book of Metallurgy, 2nd*Edition by A.R.Bailey, Macmillan & Co. Ltd., London (1960).
10. *Introduction to solids*, L.V.Azaroff, McGraw Hill International New Delhi (1977).
11. *The Structure and Properties of Engineering Alloys*, 2nd Edition by W.F. Smith-McGraw hill International, New Delhi (1993).
12. *Strengthening of Metals*,Packner – Reinhild Puplishing Corporation, New Delhi.
13. *Engineering Physical Metallurgy*, Y. Lakhtin , University Press of the Pacific (2000).
14. *Physical Metallurgy for Engineers*, Donald S. Clarke and Wibur R. Varney, D. Van Nostrand Co.INC (1962).
15. *Structure and Properties of Alloys*, Robert M, Brick, Robert B and Gordon , McGraw Hill International Book Co (1965).
16. *The Science and Engineering of Materials*, 6th Edition by Donald R. Askeland- PWS Publishing Co. (2011).
17. *Introduction to Physical Metallurgy*, 2ndEdition by S H Avner, Tata McGraw Hill (1997).
18. *Corrosion Engineering*, 3rd Edition by M.G. Fontana, McGraw-Hill (2005).

Course Code	Course/Subject Name	Credits
PEL407	**Workshop Practice-IV**	**2**

Objectives:

1. To practice machining of flat surfaces on shaping and grinding machines.
2. To practice milling, boring and thread cutting operations.

Outcomes: Learner should be able to:-

1. Understand the difference between metal machining and composite machining.
2. Understand different practical aspects involved in operation and applications of milling, shaping, grinding, boring etc.

Term Work:

1. One composite job consisting of minimum four parts, employing operations on lathe, precision turning, screw cutting, boring etc. and involving the use of shaping, milling and grinding operations.
2. Demo on machining of Glass Fiber Reinforcement Plastic (GFRP) composite material, Drilling and edge milling operation are to be studied (Any of the commercial available GFRP/Epoxy plates are to be used).

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

- Laboratory work (workshop practicals): 40 Marks.
- Attendance (practicals): 10 Marks.

Practical Examination:

Practical examination will be held for 4 hours and shall consist of minimum 4 operations such as precision turning, boring, screw cutting, Drilling, milling, shaping, grinding etc.