NATIONAL INSTITUTE OF TECHNOLOGY DURGAPUR

DEPARTMENT OF MECHANICAL ENGINEERING

SYLLABI FOR THE CURRICULAM
OF UG COURSE W.E.F. 2018 ADMISSION BATCH
(B.TECH. in MECHANICAL ENGINEERING)

V0: Resolution of 50th Senate # 18-05-2018 # Item no: 50.7
Resolution of 51st Senate # 04-10-2018 # Item no: 51.2
Resolution of UGAC meeting # 10-05-2019
Final approval in 53rd Senate # 13-05-2019 # Item no: 52.3
Publication date # 30-05-2019

V1: Incorporation of new elective subjects: 27-06-2019

V2: Rectification of minor errors: 27-07-2022

First year common courses for first and second semester. The subjects may be interchanged due to section division.

FIRST SEMESTER

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC 01</td><td>Mathematics - I</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">Basic concepts of function, limit, differentiation and integration.</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Fundamentals of Differential Calculus
CO2: Fundamentals of Integral Calculus
CO3: Fundamentals of Vector Calculus
CO4: Basic Concepts of Convergence</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Functions of Single Variable: Rolle's Theorem and Lagrange's Mean Value Theorem (MVT), Cauchy's MVT, Taylor's and Maclaurin's series, Asymptotes & Curvature (Cartesian, Polar form). (8)

Functions of several variables: Function of two variables, Limit, Continuity and Differentiability, Partial derivatives, Partial derivatives of implicit function, Homogeneous function, Euler's theorem and its converse, Exact differential, Jacobian, Taylor's & Maclaurin's series, Maxima and Minima, Necessary and sufficient condition for maxima and minima (no proof), Stationary points, Lagrange's method of multipliers. (10)

Sequences and Series: Sequences, Limit of a Sequence and its properties, Series of positive terms, Necessary condition for convergence, Comparison test, D Alembert's ratio test, Cauchy's root test, Alternating series, Leibnitz's rule, Absolute and conditional convergence. (6)

Integral Calculus: Mean value theorems of integral calculus, Improper integral and it classifications, Beta and Gamma functions, Area and length in Cartesian and polar co-ordinates, Volume and surface area of solids of revolution in Cartesian and polar forms, (12)

Multiple Integrals: Double integrals, Evaluation of double integrals, Evaluation of triple integrals, Change of order of integration, Change of variables, Area and volume by double integration, Volume as a triple integral. (10)

Vector Calculus: Vector valued functions and its differentiability, Line integral, Surface integral, Volume integral, Gradient, Curl, Divergence, Green's theorem in the plane (including vector form), Stokes' theorem, Gauss's divergence theorem and their applications. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. E. Kreyszig, Advanced Engineering Mathematics: 10 th edition, Wiley India Edition.
2. Daniel A. Murray, Differential and Integral Calculus, Fb & c Limited, 2018.
3. Marsden, J. E; Tromba, A. J.; Weinstein: Basic Multivariable Calculus, Springer, 2013.
Reference Books:
1. Tom Apostal, Calculus-Vol-I & II, Wiley Student Edition, 2011.
2. Thomas and Finny: Calculus and Analytic Geometry, 11 th Edition, Addison Wesley.</td></tr>
</table>

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC01	**Physics**	PCR	2	1	0	3	3
Pre-requisites:		Course Assessment methods: (Continuous (CT), MID term and End Term Assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: To realize and apply the fundamental concepts of physics such as superposition principle, simple harmonic motion to real world problems. CO2: Learn about the quantum phenomenon of subatomic particles and its applications to the practical field. CO3: Gain an integrative overview and applications of fundamental optical phenomena such as interference, diffraction and polarization. CO4: Acquire basic knowledge related to the working mechanism of lasers and signal propagation through optical fibers.
Topics Covered	**Harmonic Oscillations** - Linear superposition principle, Superposition of two perpendicular oscillations having same and different frequencies and phases, Free, Damped and forced vibrations, Equation of motion, Amplitude resonance, Velocity resonance, Quality factor, sharpness of resonance, etc. [8] **Wave Motion** - Wave equation, Longitudinal waves, Transverse waves, Electro-magnetic waves. [3] **Introductory Quantum Mechanics** - Inadequacy of classical mechanics, Blackbody radiation, Planck's quantum hypothesis, de Broglie's hypothesis, Heisenberg's uncertainty principle and applications, Schrodinger's wave equation and applications to simple problems: Particle in a one-dimensional box, Simple harmonic oscillator, Tunnelling effect. [8] **Interference & Diffraction** - Huygens' principle, Young's experiment, Superposition of waves, Conditions of sustained Interference, Concepts of coherent sources, Interference by division of wavefront, Interference by division of amplitude with examples, The Michelson interferometer and some problems; Fraunhofer diffraction, Single slit, Multiple slits, Resolving power of grating. [13] **Polarisation** - Polarisation, Qualitative discussion on Plane, Circularly and elliptically polarized light, Malus law, Brewster's law, Double refraction (birefringence) - Ordinary and extra-ordinary rays, Optic axis etc.; Polaroid, Nicol prism, Retardation plates and analysis of polarized lights. [5] **Laser and Optical Fiber** - Spontaneous and stimulated emission of radiation, Population inversion, Einstein's A & B co-efficient, Optical resonator and pumping methods, He-Ne laser. Optical Fibre– Core and cladding, Total internal reflection, Calculation of numerical aperture and acceptance angle, Applications. [5]
Text Books, and/or reference material	**TEXT BOOKS**: 1. The Physics of Vibrations and Waves, H. John Pain, Willy and Sons 2. Vibrations and Waves in Physics, Iain G. Main, Cambridge University Press 3. Engineering Physics, H. K. Malik and A. K. Singh, McGraw-Hill. **REFERENCE BOOKS**: 1. Quantum Physics, R. Eisberg and R. Resnick, John Wiley and Sons 2. Fundamental of Optics, Jankins and White, McGraw-Hill 3. Optics, A. K. Ghatak, Tata McGraw-Hill 4. Waves and Oscillations, N. K. Bajaj, Tata McGraw-Hill 5. Lasers and Non-linear Optics, B. B. Laud , New Age International Pvt Lt

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYC 01	**Engineering Chemistry**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	CO1: Introduced to chemical thermodynamics, kinetics, electrochemistry, absorption and catalytic processes for engineering applications CO2: To learn fundamentals of polymer chemistry and petroleum engineering. CO3: Introduced to basic spectroscopic techniques for structure determination and characterization. CO4: To study few inorganic and bioinorganic compounds of industrial importance.
Topics Covered	**ORGANIC CHEMISTRY** i. Fundamentals of organic reaction mechanisms; Few important reactions and their mechanism along with their applications; Robinson annulation, Hydroboration reaction, Organometallic reagents (Gilman reagents), Metathesis using Grubb's catalyst and Wittig reaction. (3) ii. Fundamental concept on stereochemistry and application: Conformation and configuration of organic compounds, Diastereo-selective, enantio-selective, regio-selective, stereo-specific and stereo-selective reactions. (3) iii. Polymer chemistry and polymer engineering: Fundamental concept on polymer chemistry; synthesis and application of important polymers, Rubber and plastic materials. Conducting polymer. (2) iv. Petroleum Engineering and oil refinery: origin of mineral oils, separation principle and techniques of distillation of crude oil, Uses of different fractions, octane number, cetane number, Knocking, anti-knock compounds, and Bio-Fuel. (2) v. Structure elucidation of organic compounds by modern spectroscopic methods; Application of UV-Visible and FT-IR spectroscopy. (3) **INORGANIC CHEMISTRY** i. **Coordination Chemistry:** Crystal Field Theory of octahedral and tetrahedral complexes, colour and magnetic properties, Jahn-Teller distortion, pseudo Jahn-Teller distortion, Isomerism and stereochemistry.(5) ii. **Bioinorganic Chemistry:** Heme and non-heme O_2 transport protein (Haemoglobin, Myoglobin), Chlorophyll and photosynthesis. (3) iii. **Inorganic Materials:** Introduction towards industrially important inorganic materials like cementing material, refractory material, fertiliser, inorganic polymer. (2) iv. **Organometallic Chemistry:** π-acid ligands, stabilization of metal low oxidation state and 18 electron rules, metal carbonyls and nitrosyls, metal-alkene complexes. (4) **PHYSICAL CHEMISTRY** i. **Thermodynamics:** 2nd law of thermodynamics, entropy, free energy, Gibbs Helmholtz equation, change of phase. Cryogenics: joule Thomson experiment. (4) ii. **Chemical Kinetics:** 2nd and 3rd order rate expression, Reversible reaction, Chain reaction, Consecutive reaction, Temp effect on reaction rate. (4) iii. **Electrochemistry:** Electrochemical cell, Effect of pH, precipitation and complex formation on EMF of oxidation/reduction processes. (2) iv. **Absorption:** Physical and Chemical absorption, Absorption isotherms. (1) v. **Catalysis:** Types of catalysis, Rate expression for Catalysed reaction, Acid-base and Enzyme catalysis. (2)
Text Books, and/or reference	**Suggested Text Books:** (i) Physical Chemistry by P. Atkins, Oxford (ii) A guidebook to mechanism in Organic chemistry: Peter Sykes; Pearson Edu.

material	(iii) Inorganic Chemistry Part-I & II, R. L. Dutta, The new book stall **Suggested Reference Books:** **Organic Chemistry**: (i) Basic stereochemistry of organic molecules: S. Sengupta; Oxford University press (ii) Engineering Chemistry: Wiley (iii) Elementary Organic Spectroscopy: William Kemp, ELBS with Macmillan **Inorganic Chemistry:** (i) Inorganic Chemistry: Principle structure and reactivity, J. E. Huheey, E. A. Keiter and R. L. Keiter, Pearson Education (ii) Bioinorganic Chemistry -- Inorganic Elements in the Chemistry of Life: An Introduction and Guide, 2nd Edition, Wolfgang Kaim, Brigitte Schwederski, Axel Klein. (iii) Inorganic Chemistry Fourth Edition, Shriver & Atkins, Oxford **Physical Chemistry:** (i) Physical Chemistry by G.W Castellan (ii) Physical Chemistry by P. C. Rakshit

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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XEC01	**Engineering Mechanics**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Improves the knowledge of mechanics and ability to draw free body diagrams. CO2: Imparts knowledge on application of mechanics for special problems like truss and frame analysis. CO3: Builds up ability to calculate centroid and moments of inertia for various shapes and its application thereof. CO4: Enhances the idea on dynamics with different engineering applications using momentum and energy principles. CO5: Introduces with Virtual Work Principle and its simple application. CO6: Prepares the prerequisites for studying the subject Strength of Materials / Solid Mechanics.						
Topics Covered	Engineering Mechanics; measurement and SI units. [1] Vectors and force as a vector; Resultant of a system of forces on a particle; free body diagram and conditions of equilibrium of a particle; problems on particles; equilibrium of particles in space. [2] Resultant of a system of forces and couples on a rigid body; conditions of equilibrium of a rigid body; free body diagrams of rigid bodies subjected to different types of constraints; simple space problems of rigid bodies. [4] Coefficients of static and kinetic friction; problems involving friction; theories of friction on square threaded power screw and flat belt. [5] Simple trusses; analysis of trusses by method of joints and method of sections. [5] Centre of gravity and centre of mass; centroids of lines, curves and areas; first moment of area; second moment of area; polar moment of inertia; radius of gyration of an area; parallel axis theorem; mass moment of inertia. [4] Path, velocity, acceleration; rectilinear and curvilinear motion; motion of system of particles; introduction to the concept of plane kinematics of rigid bodies. [6] Newton's second law of motion; dynamic equilibrium and D'Alembert's principle; linear momentum; angular momentum; rectilinear and curvilinear motion; principles of work–energy and impulse–momentum; impact of system of particles; introduction to the concept of plane kinetics of rigid bodies. [12] Principle of Virtual Work, Solution of Problems on Mechanics using Principle of Virtual Work [3]						
Text Books, and/or reference material	1. S P Timoshenko and D H Young, Engineering Mechanics, 5th Edition 2. J L Meriam and L G Kraige, Engineering Mechanics, 5th Edition, Wiley India 3. F P Beer and E R Johnston, Vector Mechanics for Engineers 4. I H Shames, Engineering Mechanics						

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>ESC01</td><td>Environmental Science</td><td>PCR</td><td>2</td><td>0</td><td>0</td><td>2</td><td>2</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Understand the importance of environment and ecosystem.
CO2 Understand the fundamental aspect of pollutant tracking and its implementation in natural and anthropogenic pollution of air and water system.
CO3 Understand the scientific basis of local and as well as global issues.
CO4 Apply of knowledge to develop sustainable solution.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Multidisciplinary nature of Environmental Studies; Basic issues in Environmental Studies. [2]
Human population and the Environment. [1]
Social issues and the Environment. [1]
Constituents of our Environment & the Natural Resources: Atmosphere– its layers, their characters; Global warming, Ozone depletion, Acid rain, etc. [5]
Hydrosphere - Its constituents, Oceans, Groundwater, Surface waters; Hydrological cycle. [4]
Lithosphere - constituents of lithosphere; Rock and Mineral resources; Plate Tectonic Concept and its importance. [5]
Biosphere – its components; Ecosystems and Ecology; Biodiversity; Biomes. [5]
Natural disaster and their management – Earthquakes, Floods, Landslides, Cyclones. [3]
Pollution: Pollutants and their role in air and water pollution. [2]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">1. Environmental Studies – Benny Joseph – Tata McgrawHill-2005.
2. Environmental Studies – Dr. D.L. Manjunath, Pearson Education-2006.
3. Principles of Environmental Science and Engineering – P. Venugoplan Rao, Prentice Hall of India.
4. Environmental Science and Engineering – Meenakshi, Prentice Hall India.
5. Environmental studies – R. Rajagopalan – Oxford Publication - 2005.
6. Text book of Environmental Science & Technology – M. Anji Reddy – BS Publication.</td></tr>
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XES51	**Engineering Graphics**	PCR	1	0	3	4	2.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1 To develop the ability of mental visualization of different objects CO2 To impart knowledge regarding standard conventions on lettering, dimensioning, symbols etc CO3 To introduce with the theory of orthographic projection to solve problems on one/two/three dimensional objects CO4 To prepare for the higher semester departmental drawings CO5 To give exposure to read/interpret industrial drawing and to communicate with relevant people
Topics Covered	Graphics as language of communication; technical drawing tools and their up-keep; types of lines; construction of geometrical figures; lettering and dimensioning. [6] Construction and use of scales; construction of curves of engineering importance such as curves of conic section; spirals, cycloids, involutes and different loci of points; use of equations for drawing some curves. [9] Descriptive geometry: necessity and importance of orthographic projection; horizontal and vertical reference planes; coordinate of points; orthographic projection of points and lines situated in different quadrants, viz. 1st, 2nd, 3rd and 4th quadrants; traces of lines. First angle and third angle projection of lines and planes; views from top, front and left (or right); true length and true inclination of lines with planes of projections; primary auxiliary projection of points, lines and planes; auxiliary plan and auxiliary elevation. [9] Projection of simple regular solids, viz. prisms, cubes, cylinders, pyramids, cones, tetrahedrons, spheres, hemi-spheres etc. [6] Section of solids; section by perpendicular planes; sectional views; true shapes of sections. [6] Dimensional techniques; international and national standards (ISO and BIS). [3] Freehand graphics. [3]
Text Books, and/or reference material	1. Engineering Drawing and Graphics – K Venugopal 2. Engineering Drawing – N D Bhat 3. Practical Geometry and Engineering Graphics – W Abbott

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
HSS51	**Professional Communication Lab**	PCR	1	0	2	3	2
Pre-requisites		Course Assessment methods (Continuous Test (CT) and/or End Assessment (EA))					
None		CT					
Course Outcomes	CO1: Improvement in linguistic proficiency of the learners CO2: Improvement in communicative ability of the learners						
Topics Covered	1. Professional Communication: Introduction (1) 2. Technical Writing: Basic Concepts (2) 3. Style in Technical Writing (3) 4. Technical Report (2) 5. Recommendation Report (2) 6. Progress Report (1) 7. Technical Proposal (3) 8. Business Letters (3) 9. Letters of Job Application (2) 10. Writing Scientific and Engineering Papers (3) 11. Effective Use of Graphic Aids (2) 12. Presentation Techniques (6) 13. Group Discussion (6) 14. Interview Techniques (6)						
Text Books, and/or reference material	**Text Book:** 1. English for Engineers –Sudharshana & Savitha (Cambridge UP) **Reference Books:** 1. Technical Communication—Raman & Sharma (Oxford UP) 2. Effective Technical Communication—M A Rizvi (McGraw Hill Education)						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
PHS51	**Physics Laboratory**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))					
NIL		CE+EA					

Course Outcomes	CO1: To realize and apply different techniques for measuring refractive indices of different materials. CO2: To realize different types of waveforms in electrical signals using CRO. CO3: To understand charging and discharging mechanism of a capacitor. CO4: To understand interference, diffraction and polarization related optical phenomena. CO5: To acquire basic knowledge of light propagation through fibers.
Topics Covered	1. Find the refractive index of a liquid by a travelling microscope. 2. Determine the refractive index of the material of prism using spectrometer. 3. Determination of amplitude and frequency of electrical signals by oscilloscope. 4. To study the characteristics of RC circuits. 5. To study Brewster's law/Malus' law using laser light. 6. To study the diffraction of light by a grating. 7. To study the interference of light by Newton's ring apparatus. 8. To determine numerical aperture of optical fiber. 9. Determination of Planck constant.
Text Books, and/or reference material	**SUGGESTED BOOKS**: 1) A Text Book on Practical Physics – K. G. Majumdar. 2) Practical Physics – Worsnop and Flint **REFERENCE**: 1) Instruction sheets

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CYS51	**Chemistry Laboratory**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
None		CT+EA					

Course Outcomes	CO1: To learn basic analytical techniques useful for engineering applications. CO2: Synthesis and characterization methods of few organic, inorganic and polymer compounds of industrial importance. CO3: Learn chromatographic separation methods. CO4: Applications of spectroscopic measurements.
Topics Covered	i. Experiments based on pH metry: Determination of dissociation constant of weak acids by pH meter. ii. Experiments based on conductivity measurement: Determination of amount of HCl by conductometric titration with NaOH. iii. Estimation of metal ion: Estimation of Fe^{2+} by permangnomentry iv. Estimation of metal ion: Determination of total hardness of water by EDTA titration. v. Synthesis and characterization of inorganic complexes: e. g. $Mn(acac)_3$, $Fe(acac)_3$, cis-bis (glycinato)copper(II) monohydrate and their characterization by m. p. , FTIR etc. vi. Synthesis and characterization of organic compounds: e.g. Dibenzylideneacetone. vii. Synthesis of polymer: polymethylmethacrylate viii. Verification of Beer-Lamberts law and determination of amount of iron present in a supplied solution. ix. Chromatography: Separation of two amino acids by paper chromatography x. Determination of saponification value of fat/ vegetable oil
Text Books, and/or reference material	Suggested Text Books: 1. Vogel's Quantitative Chemical Analysis (6th Edition) Prentice Hall 2. Advanced Physical Chemistry Experiments: By Gurtu & Gurtu 3. Comprehensive Practical Organic Chemistry: Qualitative Analysis By V. K. Ahluwalia and S. Dhingra Suggested Reference Books: 1. Practical Chemistry By R.C. Bhattacharya 2. Selected experiments in Physical Chemistry By N. G. Mukherjee

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>WSS51</td><td>Workshop Practice</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Study and practice on machine tools and their operations
CO2: Practice on manufacturing of components using workshop trades including fitting, carpentry, foundry and welding
CO3: Identify and apply suitable tools for machining processes including turning, facing, thread cutting and tapping
CO4: Develop basic electrical engineering knowledge for house wiring practice</td></tr>
<tr><td>Topics Covered</td><td colspan="7">M/c shop & Carpentry shop -- 3X3= 9hrs.
• Introduction on machining process.
• Introduction to machine tools- Lathe, Shaper, Milling and Drill machine.
• Introduction to woods- Types, structure, disease and defect of wood.
• Introduction to wood working machines and tools.
• Making of dovetail joint and bridle joint.
Welding Shop & Sheet metal -- 3X3= 9hrs.
• Introduction to welding.Safety and precautions in welding.
• Formation of weld bead by SMAW on mild steel flat.
• Formation of weld bead by oxy-fuel welding on mild steel flat.
• Introduction to sheet Metal works.
• Tools and Machines used in sheet metal works.
• Concept of development, marking out of metal sheets.
• Cutting and joining of metal sheets.
• Safety precautions, General warning needed in the shop floor.
Black smithy & Foundry -- 3X3= 9hrs.
• Introduction Smithing and Forging- Tools, Machines, Furnaces and its accessories, fuels.
• Safety and precautions in blacksmithy.
• Making of bars of different cross-sections.
• Making of hexagonal headed bolts.
• Forge welding.
• Introduction to Foundry Technology.
• Preparation of sand mould using Solid/Split Pattern.
Fitting & Electrical shop -- 3X3= 9hrs.
• Introduction to hand metal cutting tools with specifications, nomenclature and their use.
• Marking tools, measuring tools and their use.
• Fitting of joints of mild steel flats.
• Introduction to electrical hazards and safety precaution.
• Wire jointing and soldering.
• PVC Conduit Wiring controlled by separate single way switches.
• PVC Cashing Capping Wiring for two way switches.
• Conduit wiring for the connection of a Calling Bell with In & Out Indicators.
• Batten Wiring and Cleat Wiring.
• Tube Light Connection.</td></tr>
</table>

	• Insulation Resistance Testing of 1ph / 3ph Motor and House Wiring. • Earth Resistance Testing. • DOL Starter Connection. **Viva voce -- 1X3= 3hrs.**
Text Books, and/or reference material	1. Workshop Technology Part I and Part II by W. A. J. Chapman 2. Elements of Workshop Technology S. K. Hazra Chowdhury, A. K. Hazra Chowdhury and Nirjhar Roy 3. Mechanical Workshop Practice by K. C. John

Co-curricular Activities (XXS51 and XXS52) are complimentary and divided in first and second semester. The total syllabus is given in XXS51.

<table>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>XXS51</td><td>Co-curricular Activities</td><td>PCR</td><td>0</td><td>0</td><td>2</td><td>2</td><td>1</td></tr>
<tr><td>Pre-requisites</td><td colspan="7">Course assessment methods: Continuous evaluation (CE) and end assessment (EA)</td></tr>
<tr><td>NIL</td><td colspan="7">CE + EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1: Social Interaction: Through the medium of sports
• CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them
• CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.
• CO4: Personality development through community engagement
• CO5: Exposure to social service</td></tr>
<tr><td>Topics Covered</td><td colspan="7">YOGA
• Introduction of Yoga.
• Sitting Posture/Asanas- Padmasana, Vajrasana, Ardha kurmasana, Ustrasana, Bakrasana, Sasankasana, Janusirshasana, Suryanamaskar.
• Mudra- Gyana mudra, Chin mudra, Shuni mudra, Prana mudra, Adi mudra, Anjali mudra.
• Laying Posture/Asanas- Pavana Muktasana, Uttana Padasana, Sarpasana, Bhujangasana (Cobra Pose), Eka Pada Śalabhāsana, Dhanurasana, Chakrasana, Viparitkarani.
• Meditation- Yog nidra, Om chant, Pray chant.
• Standing Posture/Asanas- Tadasana (Mountain Pose), Vrikshasana (Tree Pose), Ardha chandrasana, Trikonasana, Utkatasana, Padahastasana.
• Pranayama- Deep breathing, Anulom Vilom, Suryabhedi, Chandrabhedi.
• Kriya- Kapalbhati, Trataka.
ATHLETICS
• Introduction of Athletic.
• Starting Technique for Track events- Standing start, Crouch start & Block start.
• Finishing Techniques.
• Relay Race- 4×100m, 4×400m & Baton Exchange Technique & Rules.
• Track Marking with Fundamentals- 200m, 400m and Diagonal Distance Radius, Straight Distance, Staggers of Different Lanes & Curve Distance.
BASKETBALL
• Introduction and Players stance and ball handling.
• Passing- Two hand chest pass, Two hand bounce pass, One hand baseball pass, Side arm pass, Over head pass, Hook pass.
• Receiving- Two hand receiving, One hand receiving, Receiving in stationary position, Receiving while jumping and Receiving while running.
• Dribbling- Dribble, High dribble, Low dribble, Reverse dribble, Rolling dribble.
• Rules of Basketball.
• Basketball game.
VOLLEYBALL
• Introduction of Volleyball
• Service- Underarm service, Sidearm service, Tennis service, Floating service, Jump service.
• Pass: Underarm pass- Ready position, Teaching stage of underarm pass and Upper hand pass- Volley pass, Back pass, Short set, Jump set & Underarm set.</td></tr>
</table>

	• Rules and their interpretation. **FOOTBALL** • Introduction of Football • Push pass- Instep inside, Instep outer side. • Kicking- Spot kick, Instep kick, Lofted kick. • Dribbling- One leg, Both legs, Instep. • Trapping- Rolling ball sole trapping, High ball sole trapping, High ball chest trapping, High ball thigh trapping. • Throwing- Standing throw, Running throw, Seating throw. • Goal Keeping- Griping the ball, Full volley, Half volley, Drop Kick. • Rules and their interpretation. **CRICKET** • Introduction of Cricket • Batting gripping & Stance, Bowling gripping technique. • Batting front foot defense & Drive. • Batting Back foot defense & Drive. • Batting Square cut. • Bowling medium pace, Bowling off break. • Fielding drill, Catching (Short & High). • Rules & Regulation. **BADMINTON** • Basic introduction about Badminton and Badminton court. • Racket parts, Racket Grip, Shuttle Grip. • Basic stance, Basic Footwork, Shadow practice (Full court movement). • Strokes services: Forehand- Overhead & Underarm, Backhand- Overhead & Underarm. • Match practice (Single & Double). • Rules & Regulation. **TABLE TENNIS** • Introduction of Table Tennis. • Basic Stance and Grip (Shake hand & Pen hold). • Service Basic. • Stroke: Backhand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Stroke: Forehand- Push, Deep Push, Chop, Rally, Drive, Drop Shot, Flick, Block, Smash. • Rules and their interpretations. • Table Tennis Match (Singles & Doubles). **NCC** • FD-1 General Introduction and words of command. • FD-2 Attention, Stand at ease and Stand easy, Turning and inclining at the halt. • FD-3 Sizing, Forming up in three Ranks Numbering, Open and Close order March and Dressing. • FD-4 Saluting at the halt, Getting on parade, Dismissing and falling out. • FD-5 Marching, Length of pace and Time of Marching in quick time and Halt, Slow March and Halt. • FD-7 Turning on the March and Wheeling. • FD-12 Parade practice. **TAEKWONDO** • Introduction about Taekwondo- Meaning of Taekwondo, Korean language of dress, Fighting area, Punch, Block, Kicks etc. • Stance- Ready stance, Walking stance, Fighting stance, Front stance, Back stance, Cat stance etc. • Punch Technique- Front fist punch, Rear fist punch, Double fist punch, With stance etc. Blocks- Upper blocks, Middle block, Side block, Suto etc. • Foot Technique (Balgisul)- Standing kick (Saseochagi), Front kick (Abchagi), Doliyo (Chagi), Abdal chagi (Butterfly kick), Back kick etc.

	NSS • Swachha Bharat Mission • Free Medical Camp • Sanitation drive in and around the campus. • Unnat Bharat Abhiyaan • Matribhasha Saptah celebration

SECOND SEMESTER

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td>Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td><td></td></tr>
<tr><td>MAC 02</td><td>Mathematics - II</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods: (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Develop the concept of basic linear algebra and matrix equations so as to apply mathematical methods involving arithmetic, algebra, geometry to solve problems.
CO2: To acquire the basic concepts required to understand, construct, solve and interpret differential equations.
CO3: Develop the concepts of Laplace transformation & Fourier transformation with its property to solve ordinary differential equations with given boundary conditions which are helpful in all engineering & research work.
CO4: To grasp the basic concepts of probability theory</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Elementary algebraic structures: Group, subgroup, ring, subring, integral domain, and field. (5)
Linear Algebra: Vector space, Subspaces, Linear dependence and independence of vectors, Linear span, Basis and dimension of a vector space. Rank of a matrix, Elementary transformations, Matrix inversion, Solution of system of Linear equations, Eigen values and Eigen vectors, Cayley-Hamilton Theorem, Diagonalization of matrices. (15)
Ordinary Differential Equations: Existence and uniqueness of solutions of ODE (Statement Only), Equations of first order but higher degree, Clairaut's equation, Second order differential equations, Linear dependence of solutions, Wronskian determinant, Method of variation of parameters, Solution of simultaneous equations. (12)
Fourier series: Basic properties, Dirichlet conditions, Sine series, Cosine series, Convergence. (4)
Laplace and Fourier Transforms: Laplace transforms, Inverse Laplace transforms, Convolution theorem, Applications to Ordinary differential equations. Fourier transforms, Inverse Fourier transform, Fourier sine and cosine transforms and their inversion, Properties of Fourier transforms, Convolution. (10)
Probability: Historical development of the subject and basic concepts, Axiomatic definition of probability, Examples to calculate probability, Stochastic simulation, Random numbers. Random variables and probability distributions, Binomial distribution, Normal distribution. (10)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. E. Kreyszig, Advanced Engineering Mathematics: 9th edition, Wiley India Edition.
2. Gilbert Strang, Linear algebra and its applications (4th Edition), Thomson (2006).
3. Shepley L. Ross, Differential Equations, 3rd Edition, Wiley Student Edition.
Reference Books:
1. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000).
2. C. Grinstead, J. L. Snell, Introduction to Probability, American Mathematical Society</td></tr>
</table>

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSC01	**Introduction to Computing**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Basic knowledge of computer.		CT+EA					

Course Outcomes	CO1: Recognize the changes in hardware and software technologies with respect to the evolution of computers and describe the function of system software's (operating Systems) and application software's, languages, number system, logic gates. CO2: Illustrate the flowchart and inscribe an algorithm for a given problem Inscribe C programs using operators. CO3: Develop conditional and iterative statements to write C programs. CO4: Exercise user defined functions to solve real time problems CO5: Inscribe C programs that use Pointers to access arrays, strings and functions. CO6: Exercise user defined data types including structures and unions to solve problems..
Topics Covered	Fundamentals of Computer: History of Computer, Generation of Computer, Classification of Computers 2L Basic Anatomy of Computer System, Primary & Secondary Memory, Processing Unit, Input & Output devices [2] Languages: Assembly language, high level language, compiler and assembler (basic concepts) [1] Binary & Allied number systems representation of signed and unsigned numbers. BCD, ASII. Binary Arithmetic & logic gates [2] Basic concepts of operating systems like MS DOS, MS WINDOW, UNIX, Algorithm & flow chart [1] C Fundamentals: The C character set identifiers and keywords, data type & sizes, variable names, declaration, statements [2] Operators & Expressions: Arithmetic operators, relational and logical operators, type, conversion, increment and decrement operators, bit wise operators, assignment operators and expressions, precedence and order of evaluation. Input and Output: Standard input and output, formatted output -- printf, formatted input scanf. [8] Flow of Control: Statement and blocks, if - else, switch, loops - while, for do while, break and continue, go to and labels [5] Fundamentals and Program Structures: Basic of functions, function types, functions returning values, functions not returning values, auto, external, static and register Variables, scope rules, recursion, function prototypes, C pre-processor, command line arguments. [5] Arrays and Pointers: One dimensional, two dimensional arrays, pointers and functions, multi-dimensional arrays. [10] Structures Union and File: Structure, union , structures and functions, arrays of structures, file read, file write [5]
Text Books, and/or reference material	Text Books: 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie Reference Books: 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECC01	**Basic electronics**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Acquire idea about basic electronic circuit, construction, operation. CO2: Learn to use these Circuit elements for different applications.. CO3: Learn to analyze the circuits and to find out relation between input and output.						
Topics Covered	Semiconductors and its properties. (3) PN Junction formation and construction of Diode. (5) Diode circuits as rectifiers, Diode based waveform shaping circuits. (4) Bipolar Junction Transistor, construction and operation. (4) BJT Biasing circuits, different types. (3) Amplifier, Single stage, CE,CB, CC, operation and uses. (4) Feedback amplifier, advantages & disadvantages, basic closed loop analysis (3) Other Semiconductor Devices : Operation and use of LED, JFET, DIAC, MOSFET(2) Opamp: Characteristics of ideal operational amplifier Pin Configuration of IC 741, Analysis of simple operational amplifier circuits: concept of virtual ground; non-inverting amplifier and inverting amplifier Applications: voltage follower, summer, differentiator, integrator(6) Oscillator: Positive feedback and condition of oscillation R-C phase-shift oscillator, Wien bridge oscillator(3) Boolean Algebra : Boolean algebra, De Morgan's theorem, simplification of Boolean expression, Number system, range extension of numbers, Different codes: Gray code, ASCII code and different BCD codes and their uses(4) Logic Gates : NOT, OR, AND, NOR, NAND, EX-OR, EX-NOR gates Simplification of logic functions, Realizations of logic expressions using logic gates(4)						
Text Books, and/or reference material	Text Books: 1. Introduction Electronic Devices & Circuit Theory,11/e, 2012, Pearson: Boylestad & Nashelsky 2. Integrated Electronics: Millman & Halkias Reference Books: 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronics - Circuits and Systems, Fourth Edition by Owen Bishop 3. Electronics Fundamentals: Circuits, Devices & Applications (8e) by Thomas L. Floyd & David M. Buchla. 4. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bates 5. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul Malvino Dr., David J. Bates, et al.						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EEC01	**Electrical Technology**	PCR	2	1	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: To learn the fundamentals of Electric Circuits and Network theorems. CO2: To develop an idea on Magnetic circuits, Electromagnetism CO3: To learn about single phase and polyphase AC circuits. CO4: Introduction to single phase transformer. CO5: Introduction to the transient analysis of RLC circuits with DC excitation.						
Topics Covered	Fundamentals of Electric Circuits: Ohm's laws, Kirchhoff's laws, Independent and Dependent sources, Analysis of simple circuits. (3) Network theorems. (4) Magnetic field, Concept of magnetic circuits, Magnetomotive Force, Reluctance, Ampere's circuital law and Biot-Savart law, Determination of B/H curve, Comparison of electric and magnetic circuit, Electromagnetic induction, Faraday's laws of electromagnetic induction, Direction and Magnitude of induced E.M.F. (7) Self and mutual Inductance, Inductances in series and parallel, Energy stored in inductor, Capacitance, Capacitance in series and parallel, Relationship between charge, voltage and current, Energy stored in capacitor (5) Transients with D.C. excitation. (5) Generation of alternating voltage and current, E.M.F. equation, Average and R.M.S. value, Phase and phase difference, Phasor representation of alternating quantity, Behaviour of A.C. circuits, Resonance in series and parallel R-L-C circuits (7) Single-Phase Transformer , equivalent circuits, open circuit and short circuit tests (6) Polyphase system, Advantages of 3-phase system, Generation of 3-phase voltages, Voltage, current and power in a star and delta connected systems, 3-phase balanced and unbalanced circuits, Power measurement in 3-phase circuits. (5)						
Text Books, and/or reference material	**Text Books:** 1. Electrical & Electronic Technology by Hughes, Pearson Education India **Reference Books:** 1. Advanced Electrical Technology by H. Cotton, Reem Publication Pvt. Ltd 2. Electrical Engineering fundamentals by Vincent Deltoro, Pearson Education India						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
BTC01	**LIFE SCIENCE**	PCR	2	0	0	2	2
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: To be familiarized with the basic cellular organization of organisms and cellular communications. CO2: To impart an understanding about the basic structure and functions of the macromolecules and their biosynthesis and catabolism. CO3: To give an understanding of the key features of the structure, growth, physiology and behavior of bacteria, viruses, fungi and protozoa CO4: To introduce molecular biology to understand biological processes in various applications. CO5: To provide a foundation in immunological processes and an overview of the interaction between the immune system and pathogens. CO6: To provide knowledge about biological and biochemical processes that require engineering expertise to solve them						
Topics Covered	**1. Cell Biology (4)** Introduction to life science: prokaryotes & eukaryotes Definition; Difference Introduction to cells Define cell, different types of cell Cellular organelles All organelles and functions in brief Cellular communications Introduction to basic signaling; endocrine, paracrine signaling; concepts of receptor, ligand, on-off switch by phosphorylation/dephosphorylation **2. Biochemistry (4)** Biological function of carbohydrate and lipid Introduction, structure and function Biological function of nucleic acids and protein Introduction, structure and function Catabolic pathways of Macromolecules Introduction to catabolism, hydrolysis and condensation reactions; Catabolism of glucose-Glycolysis, TCA; overall degradation of proteins and lipids Biosynthesis of Macromolecules Generation of ATP (ETS), Generation of Glucose (Photosynthesis) **3. Microbiology (5)** Types of microorganisms and their general features Bacteria, Yeast, Fungi, Virus, Protozoa- general introduction with practical significance and diseases Microbial cell organization Internal and External features of cell- bacterial cell wall, viral capsule, pilus etc, Microbial nutritional requirements and growth Different Sources of energy; growth curve Basic microbial metabolism Fermentation, Respiration, Sulfur, N_2 cycle **4. Immunology (5)** Basic concept of innate and adaptive immunity Immunity-innate and adaptive, differences, components of the immune system Antigen and antibody interaction Antigen and antibody, immunogen, factors affecting immunogenicity, basic antigen-antibody mediated assays, introduction to monoclonal antibody Functions of B cell B cell, antibody production, memory generation and principle of vaccination Role of T cell in cell-mediated immunity						

	Th and Tc, functions of the T cell with respect to different pathogen and cancer cell **5. Molecular Biology (5)** Prokaryotic Genomes (Genome organization & structure) Nucleoid, circular or linear Eukaryotic Genomes (Genome organization & structure) Intron, exon, packaging, chromatin Central Dogma (Replication, Transcription and Translation) Applications of Molecular Biology (Diagnostics, DNA-fingerprinting, Recombinant products etc.) Introduction to Recombinant DNA, fingerprinting, cloning **6. Bioprocess Development (5)** Microbial growth kinetics Batch, fed-batch and continuous systems, Monod Equation Enzyme kinetics, including kinetics of enzyme inhibition and deactivation Definition of enzymes, activation energy, Concepts of Km, Vmax, Ki Microbial sterilization techniques and kinetics Introduction to sterilization, dry and moist sterilization Thermodynamics of biological system Concepts of Enthalpy, Entropy, favorable reactions, exergonic and endergonic reactions Material and energy balance for biological reactions Stoichiometry
Text Books, and/or reference material	Biotechnology 01 Edition, authored by U. Satyanarayana, Publisher: BOOKS & ALLIED (P) LTD.-KOLKATA Biochemistry by Lehninger. McMillan publishers Microbiology by Pelczar, Chan and Krieg, Tata McGraw Hill Brown, T.A., Genetics a Molecular Approach, 4th Ed. Chapman and Hall, 1992 Kuby J, Thomas J. Kindt, Barbara, A. Osborne Immunology, 6th Edition, Freeman, 2002. Bioprocess Engineering: Basic Concepts (2nd Edition), Shuler and Kargi, Prentice Hall International.

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
XES52	**Graphical Analysis Using CAD**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1 Introduction to graphical solution of mechanics problems CO2 Graphical solution of problems related to resultant/equilibrium in coplanar force system (Imparting knowledge on polar diagram, funicular polygon) CO3 Introducing Maxwell diagram and solution of plane trusses by graphical method CO4 Determination of centroid of plane figures by graphical method CO5 Exposure to AutoCAD software for computer aided graphical solution						
Topics Covered	• Graphical analysis of problems on statics. [14] • Graphical solution of engineering problems using CAD (with the help of "AutoCAD") [14]						
Text Books, and/or reference material	1. Engineering Drawing and Graphics – K Venugopal 2. AutoCAD — George Omura 3. Practical Geometry and Engineering Graphics – W Abbott						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
CSS51	**Computing Laboratory**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1: To understand the principle of operators. CO2: To understand the principle of loops, branching statements CO3: To understand the working principle of function, recursion CO5: To understand arrays , pointer, parameter passing techniques CO6: To detail out the operations of strings CO7: To understand structure, union CO7: Application of C-programming to solve various real time problems
Topics Covered	**List of Experiments:** Assignments on expression evaluation Assignments on conditional branching, iterations, pattern matching Assignments on function, recursion Assignments on arrays, pointers, parameter passing Assignments on string using array and pointers Assignments on structures, union
Text Books, and/or reference material	**Text Books:** 1. Let us C by Kanetkar 2. C Programming by Gottfried 3. Introduction to Computing by Balaguruswamy 4. The C-programming language by Dennis Ritchie **Reference Books:** 1. Computer fundamental and programming in C by P Dey and M. Ghosh 2. Computer fundamental and programming in C by Reema Thareja 3. programming with C by Schaum Series

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
ECS 51	**Basic electronics Lab**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: Acquire idea about basic electronic components, identification and behavior. CO2: To determine IV characteristics of these Circuit elements for different applications. CO3: Learn to analyze the circuits and observe and relate input and output signals.						
Labs Conducted.	1. To know your laboratory: To identify and understand the use of different electronic and electrical instruments. 2. To identify and understand name and related terms of various electronics components used in electronic circuits: Identify different terminals of components, fid their values and observe numbering associate with it. 3. Use of oscilloscope and function generator: Use of oscilloscope to measure voltage, frequency/time and Lissajous figures of displayed waveforms. 4. Study of half wave and Full-wave (Bridge) rectifier with and without capacitor filter circuit.: 5. Realization of basic logic gates: Truth table verification of OR, AND, NOT, NOT and NAND logic gates from TTL ICs 6. Regulated power supply: To study LM78XX and LM79XX voltage regulator ICs 7. Transistor as a Switch: To study and perform transistor as a switch through NOT gate 8. Zenner diode as voltage regulator 9. To study clipping and Clamping circuits 10. To study different biasing cirtis. 11. Study of CE amplifier and observe its frequency response.						
Text Books, and/or reference material	**Text Books:** 1. Experiments Manual for use with Electronic Principles (Engineering Technologies & the Trades) by Albert Paul Malvino Dr., David J. Bates, et al. **Reference Books:** 1. The Art of Electronics 3e, by Paul Horowitz, Winfield Hill 2. Electronic Principles, by Albert Paul Malvino Dr. and David J. Bates						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES51	**Electrical Technology Laboratory**	PCR	0	0	2	2	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1: To understand the principle of superposition. CO2: To understand the principle of maximum power transfer CO3: To understand the characteristics of CFL, incandescent Lamp, carbon lamp. CO4: To understand the calibration of energy meter. CO5: To understand open circuit and short circuit test of single phase transformer. CO6: To analyse RLC series and parallel circuits CO7: To understand three phase connections						
Topics Covered	**List of Experiments:** 1.To verify Superposition and Thevenin theorem 2. To verify Norton and Maximum power transfer theorem 3. Characteristics of fluorescent and compact fluorescent lamp 4. Calibration on energy meter 5. To perform the open circuit and short circuit test on single phase transformer 6. To study the balanced three phase system for star and delta connected load 7. Characteristics of different types of Incandescent lamps 8. Study of Series and parallel R-L-C circuit						
Text Books, and/or reference material	Suggested Text Books: Handbook of Laboratory Experiments in Electronics and Electrical Engineering by A M Zungeru, J M Chuma, H U Ezea						

Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
XXS52	**Co-curricular Activities**	PCR	**0**	**0**	**2**	**2**	**1**
Pre-requisites	Course assessment methods: (Continuous evaluation((CE) and end assessment (EA)						
NIL	CE + EA						
Course Outcomes	• CO1: Social Interaction: Through the medium of sports • CO2: Ethics: Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them • CO3: Self-directed and Life-long Learning: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes. • CO4: Personality development through community engagement • CO5: Exposure to social service						
Topics Covered	Complimentary to XXS51						

THIRD SEMESTER

<table>
<tr><td colspan="8">Department of Mathematics</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MAC331</td><td>Mathematics-III</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Basic knowledge of topics included in MAC01 & MAC02</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire the idea about mathematical formulations of phenomena in physics and engineering.
CO2: To understand the common numerical methods to obtain the approximate solutions for the intractable mathematical problems.
CO3: To understand the basics of complex analysis and its role in modern mathematics and applied contexts.
CO4: To understand the optimization methods and algorithms developed for solving various types of optimization problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Partial Differential Equations (PDE):</u> Formation of PDEs; Lagrange method for solution of first order quasilinear PDE; Charpit method for first order nonlinear PDE; Homogenous and Nonhomogeneous linear PDE with constant coefficients: Complimentary Function, Particular integral; Classification of second order linear PDE and canonical forms; Initial & Boundary Value Problems involving one dimensional wave equation, one dimensional heat equation and two dimensional Laplace equation. [14]
<u>Numerical Methods:</u> Significant digits, Errors; Difference operators; Newton's Forward, Backward and Lagrange's interpolation formulae; Numerical solutions of nonlinear algebraic/transcendental equations by Bisection and Newton-Raphson methods; Trapezoidal and Simpson's 1/3 rule for numerical integration; Euler's method and modified Eular's methods for solving first order differential equations. [14]

<u>Complex Analysis:</u> Functions of complex variable, Limit, Continuity and Derivative; Analytic function; Harmonic function; Conformal transformation and Bilinear transformation; Complex integration; Cauchy's integral theorem; Cauchy's integral formula; Taylor's theorem, Laurent's theorem (Statement only); Singular points and residues; Cauchy's residue theorem. [17]

<u>Optimization:</u>
Mathematical Preliminaries: Hyperplanes and Linear Varieties; Convex Sets, Polytopes and Polyhedra. [2]
Linear Programming Problem (LPP): Introduction; Formulation of linear programming problem (LPP); Graphical method for its solution; Standard form of LPP; Basic feasible solutions; Simplex Method for solving LPP. [9]</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. An Elementary Course in Partial Differential Equations-T. Amarnath
2. Numerical Methods for scientific & Engineering Computation- M.K.Jain, S.R.K. Iyengar & R.K.Jain.
3. Foundations of Complex Analysis- S. Ponnuswami
4. Operations Research Principles and Practices- Ravindran, Phillips, Solberg
5. Advanced Engineering Mathematics- E. Kreyszig
Reference Books:
1. Complex Analysis-L. V. Ahfors
2. Elements of partial differential equations- I. N. Sneddon
3. Operations Research- H. A. Taha</td></tr>
</table>

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 301</td><td>Solid Mechanics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">XEC01</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Knowledge on the analysis of stress, strains, elasticity properties of materials, strain energy principles
CO2 Exposure towards members subjected to shear force, bending moments, flexure loads, torsional loads
CO3 Idea about analyzing deflection of beams
CO4 Acquire the fundamentals about members subjected to compressive loads.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to stress and strains, Generalized Hooke’s Law, Relationship among different elastic coefficients. 4
Theory of Bending, Shearing Forces and Bending Moments in beams, SF and BM Diagrams. 6
Bending Stresses in Beams, Flexural rigidity, Section Modulus, Shear Flow, Shear Centre. 6
Deflection of Beams: Double-Integration method, Area-Moment method; Propped cantilever and Fixed beams. 6
Statically indeterminate beam problems. 4
Torsion of Circular shafts. 4
Analysis of bi-axial stress and Mohr’s Circle. 6
Combined Loading and Theories of Failure. 4
Columns: Buckling of columns, Euler’s formula for stability of column. 6
Stresses in Thin Cylinder 2
Strain Energy methods – Castigliano’s Theorem. 4</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Strength of Materials: Part I, II, S. Timoshenko, CBS Publishers, 1985.
2. Engineering Mechanics of Solids, E. P. Popov, PHI, 1993.</td></tr>
<tr><td colspan="7">Reference Books:
1. Introduction to Solid Mechanics, I. H. Shames and J. M. Pittariesi, PHI, 2003.
2. Strength of Materials, F. L. Singer and A. Pytel, Harper Collins Publishers, 1991</td></tr>
</table>

<table>
<tr><td colspan="7">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 302</td><td>Theory of Machines & Mechanisms</td><td>PCR)</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Mechanics</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1 Knowledge of dynamics of elementary mechanisms and machines
CO2 Knowledge of the fundamental of machine design</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Introduction to Mechanisms
Linkages, Mechanisms and machines; Kinematic pair, element, chains and inversions; degrees of freedom, mobility and Gruebler‘s criterion; four bar mechanisms and slidercrank mechanisms Special Mechanisms - Indicator Diagram Mechanisms, Steering Mechanism, Hookes Joint 4
Kinematics of Rigid Bodies Frame of reference in general motion, General plane motion, absolute and relative velocity in plane motion, Instantaneous center of rotation in plane motion 3
Kinetics of Rigid Bodies in 3D Plane motion of rigid bodies: Force and accelerations methods, Energy and momentum methods 3
Kinematic Analysis of Planar Linkages Position & displacement analysis, Velocity analysis, Acceleration analysis 9
Gears& Gear trains: Fundamental law of gearing, gear tooth terminology, gear type, contact ratio & Kinematics analysis, Kinematic analysis of Gear trains: Velocity ratio and sense of rotation; simple, compound and epicyclic gear trains 7
Cam Mechanisms: Cam terminology, displacement diagram, graphical layout of cam profile. 2
Kinematic Synthesis of Planar Linkages: Type, number and dimensional synthesis, Body guidance, path and function generation, Analytical linkage synthesis 4
Computer Aided Mechanism Analysis 1
Dynamic Force Analysis of Machines Dynamic force analysis for slider crank mechanism; inertia forces in reciprocating parts; primary and secondary inertia forces; simple engine mechanism – gas force, piston effort, gudgeon pin load, crank effort or turning moment; single and double acting engine; inertia force analysis
considering mass of the connecting rod; force analysis for a four bar mechanism 6
Flywheels: Turning moment diagram, indicator diagrams – mean effective pressures for suction, compression, expansion and exhaust strokes; overall mean effective pressure for the cycle; mean resisting torque; fluctuation of energy and speed; flywheel 6
Governor Mechanisms: Types, characteristics of centrifugal governors; conical pendulum type governors – Watt, Porter, and Proell; Spring loaded type of governors – Hartnell; controlling force, effort, power, sensitiveness, isochronism, stability and hunting of governors 5</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G.R., Shigley J.E.
2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K.</td></tr>
<tr><td colspan="6">Reference Books:
1. Introduction to the mechanics of machines, Morrison J.L.M., Crossland B.</td></tr>
</table>

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 303</td><td>Fluid Mechanics</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Fundamental of Engineering fluid mechanics</td></tr>
<tr><td>Topics Covered</td><td colspan="7">I. Introduction: 08
Definition of fluid; Concept of continuum and Knudsen number; Concept of velocity, pressure and stress fields; Stress tensor; Fluid properties; Slip and no-slip; Compressibility and bulk modulus; Vapour pressure; Surface tension; Capillary rise and depression.
II. Kinematics of flow and flow measurements: 08
Definition of flow field; Lagrangian and Eulerian description of fluid motion; Substantial derivative; Reynold's Transport Theorem; Integral form of conservation equations of fluid motion; Acceleration field; Pathline, streamsline, streakline, timeline and stream tube; Pure translation, rotation and linear and angular deformation of fluid element; angular velocity; vorticity and circulation; Free and forced vortex flows; Euler's equation along streamline; Bernoulli's Equation; Static, stagnation and dynamic pressures: Application of Bernoulli's Equation.
III. Differential analysis of fluid motions: Differential control volume: 08
Conservation of mass; conservation of momentum; Stokes's hypothesis; Navier-Stokes equation; Euler's equation of motion of an ideal fluid; Exact solutions of NS equations for steady incompressible flow: plane Poiseuille flow, Couette Flow, falling film flow,.
IV. Incompressible Flow through pipes and ducts: 06
Hagen-Poiseuille flow, Darcy Wesibach Equation, Major and minor losses, Surge control;
V. Dimensional Analysis: 04
Measurement and dimension; Variables and functions; Dimensional homogeneity; Pi Theorem; Dimensionless parameters; Scaling rules, dimensionless numbers; Similitude; Similarity solutions and transformations; Geometric and dynamic similitude.
VI. Boundary layer flows: 06
Boundary layer concepts; Prandtl's boundary layer equations; Blasius Equation for flow over a flat plate; Momentum integral equations for boundary layers; Wall shear stress; Separation of boundary layers; Fluid flows about immersed bodies.
VII. Potential flow: 06
Irrotational flow; Velocity potential and stream function; Stream function for two-dimensional incompressible flow; Laplace equation; Method of solution; Complex potential for fundamental flows; Superposition of elementary flows; Flow about a half body; Uniform flow past a source and a sink, a doublet, and a cylinder with circulation; Aerofoil theory.
VIII. Compressible flow: 06
Propagation of sound wave; Types of flow regimes: Mach cone; Stagnation and critical states; Isentropic flow of an ideal gas: area variation; Isentropic flow in converging and converging-diverging nozzle; normal shock.</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Introduction to Fluid Mechanics: Fox
2. Fluid Mechanics: Munson and Okiish
3. Fluid Mechanics: Robert Granger</td></tr>
<tr><td colspan="7">Reference Books:
1. Fluid Mechanics: Frank M. White
2. Mechanics of Fluids: B. S. Massey</td></tr>
</table>

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 304	**Engineering Thermodynamics**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Nil		CT+EA					

Course Outcomes	CO1 Knowledge of thermo-dynamical system CO2 Mastering laws of thermodynamics CO3 Study of air standard thermodynamic cycles CO4 Properties of pure substance CO5 Thermodynamic relations
Topics Covered	Reynolds transport theorem based reformulations of conservation principles 2 PVT and non-PVT equation of states, Important slopes and projections. 2 Zeroth law of thermodynamics: Concept of temperature 1 First law of thermodynamics: Concept of heat, work and energy 2 Second law of thermodynamics: Concept of Entropy 2 Gouy-Stodola theorem: Exergy analysis, Some aspects of entropy generation minimization 1 Third law of thermodynamics: Nernst heat theorem 1 Thermodynamic relations: Partial derivatives, Maxwell relations, Thermodynamic mnemonic diagram 2 Applications of SFEE 1 Heat engine, heat pump and refrigerators. First and second law based performances 2 Air standard cycles: Carnot, reversed Carnot, Otto, Diesel, dual, Joule-Brayton, reversed Joule-Brayton 5 Properties of pure substances: Steam table, Mollier diagram, P-h chart 6 Vapour power cycles: Rankine, reheat, regenerative, binary vapour cycles 6 Reciprocating air compressor: Single stage air compressor, isothermal efficiency, clearance and clearance volume, volumetric efficiency, two stage and multistage compression, Intercooler, heat rejected per kg. air, indicator diagram, mean effective pressure, Mechanical efficiency 4 Rotary compressor: Roots blower, vane type blower, rotary dynamic compressor, centrifugal compressor. Momentum principles and Euler's equation for energy transfer. Static and total head quantities, velocity diagrams 3
Text Books, and/or reference material	**Text Books:** 1. M. J. Moran, H. N. Shapiro, Fundamentals of Engineering Thermodynamics, Wiley. 2. R. E. Sonntag, C. Borgnakke, G. J. Van Wylen, Fundamentals of Thermodynamics, Wiley. 3. P. K. Nag, Engineering Thermodynamics, McGraw-Hill. 4. D. K. Kondepudi, I. Prigogine, Modern Thermodynamics, Wiley. 5. J. F. Lee, F. W. Sears, Thermodynamics, Addison Wesely
	Reference Books: 1. E. P. Gyftopoulos, G. P. Beretta, Thermodynamics: Foundations and Applications, Dover. 2. A. Thess, The Entropy Principle, Springer.

Department of Physics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC333	**Physics of Engineering Materials**	PCR	3	0	0	3	3
Course Outcomes	CO1: To understand fundamental theory of metal CO2: To comprehend theory and device applications of semiconductor materials CO3: To be familiar with fundamental of laser and its applications. CO4: To know about the super conductivity, dielectric and mechanical properties of material						
Topics Covered	Electron Theory of Metals Fermi-Dirac Statistics and Fermi energy, Density of states, Concept of density of states in nanomaterials, Electrical conduction in metals and alloys, Current density, Drift velocity, Mobility etc., Classical electron theory of metal (Drude-Lorentz Theory), Quantum mechanical consideration (Sommerfeld Model). Origin of band gap (Kronig-Penny Model), Brillouin zone, Resistivity of pure metals and alloys, Electronic specific heat of metals, Thermal conductivity of metals, Factors affecting electrical conductivity, Resistivity of pure metals and alloys, Solders, Soft and hard and the use of fluxes and their classifications. [12L] Semiconductors Intrinsic and extrinsic semiconductors, Fermi level, Calculation of number density of carriers and their temperature dependence, Conductivity, Mobility and its temperature dependence, Hall effect. Compound semiconductors, Direct and indirect bandgap semiconductors. Applications of semiconductor material; Semiconductor devices, p-n diode, Zener diode, Tunnel diode, Solar cell. Semiconductor device fabrication (Mention only techniques). Double hetrostructure LED (ILED). [10L] Materials for Optical Applications Optical materials for Light Emitting Diode, Laser- Solid-state lasers, Liquid & Gas lasers. Semiconductor Laser, Band diagram, Pumping mechanism, Operation. Examples of nonlinear optical materials [4L] Superconductors Superconductivity; Electrical & magnetic properties of superconducting materials, Zero resistance property, Meissner effect, A.C. resistance, BCS Theory (Qualitative), Josephson's junction, Engineering applications of superconducting materials. [5L] Dielectrics Definitions, The local field, The Clauius-Mossoti relation, Sources of polarizability, Dipolar polarizability, Debye equation and study of molecular structure, Electronic polarizability, Ionic polarizability (Brief), Measurement of dielectric constant, Electrets, Piezoelectricity, Ferroelectricity and comparison with piezoelectricity, Applications of ferroelectric materials. [5L] Mechanical Beheviour of Materials Bonding of solids, Crystal structure, Crystal imperfections, Estimation of theoretical strength, Introduction of stress and strain, Hooke's law, elasticity, plasticity, Fracture of materials, (Fracture, Fatigue, Creep), Strengthening mechanism, Composites. [6L]						
Text Books, and/or reference material	**TEXT BOOKS:** 1. Introduction to Modern Physics, H. S. Mani & G. K. Mehta 2. Solid State Electronic Devices, B. G. Streetman 3. Solid State Physics, S. O. Pillai **REFERENCE BOOKS:** 1. Introduction to Solid State Physics, C. Kittel 2. Introduction to Materials Science for Engineers, J. F. Shackelford & M. K. Muralidhara 3. Electronic Properties of Metals, E. Hamuel						

Department of Physics							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
PHC383	**Physics of Engineering Materials Laboratory**	PCR	0	0	3	3	2
Course Outcomes	CO1: To realize and apply different techniques for measuring characteristics of p-n junction and application of Zener diode as voltage regulator. CO2: To determine the properties (carrier concentration and type) of semiconductor by Hall-effect experiments. CO3: To apply the knowledge to determine the properties (bandgap and resistivity) of semiconductor materials by four-probe method at different temperatures. CO4: To determine the characteristics of solar cell. CO5: To determine the physical parameter such as e/m of an electron and Stefan's constant.						
Topics Covered	1. Determination of Stefan's constant. 2. Study of Hall voltage and Hall coefficient of a given material. 3. Measurement of electrical conductivity of a semiconductor. 4. To determine the energy bandgap of a semiconductor. 5. To study the variation of thermo emf of a thermo-couple with temperature and determine its thermo-electric power. 6. Determination of power conversion efficiency of a solar cell. 7. To study the quantization of energy (Frank Hertz Experiment). 8. To determine the value of e/m of an electron by using a cathode ray tube and a pair of bar magnet.						
Text Books, and/or reference material	Suggested Books: A Text Book on Practical Physics – K. G. Majumdar. Practical Physics – Worsnop and Flint						

FOURTH SEMESTER

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2"></td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 401</td><td>Design of Machine Elements</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 301</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Acquire an idea about engineering materials in machine design
CO2 To learn the basic design procedure for different elementary machine elements
CO3 To learn about design of bolt and welded joints, pressure vessels etc.
CO4 Introduction to fatigue design</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Review of stress analysis, Theories of failure, Machine Design in continuation of strength of materials. 5
Fundamentals of machine design - General Principles and Procedures of design of machine elements, Factor of safety and Service Factor Mechanical properties of Engineering Materials 3
Design under Static load: C-frames and Crane hooks 4
Design under variable loading and Impact loading 5
Design of Shaft under Torsion, Bending, Axial load and Combined loads, Design of Shafts under fatigue load. 10
Design of Keys, Splines, Rigid and flexible couplings 5
Design of Bolted joints 4
Design of Welded joints 4
Analysis and Design of thick cylinders and pressure vessels 5
Springs: Stress analysis and Design of Helical and Leaf springs. 4
Design of Connecting rods. 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Mechanical Engineering Design – J.E. Shigley
2. Design of Machine Elements – M.F. Spotts
3. Design of Machine Elements – V.B. Bhandari</td></tr>
<tr><td colspan="7">Reference Books:
Machine Design – Black and Adams</td></tr>
</table>

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 402	**Casting, Forming and Welding**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					

Course Outcomes	CO1. Learn different types of casting process. CO2. Select suitable manufacturing process for typical components. CO3. Learn the various welding process. CO4. Explain the concept of forging, rolling process and drawing.
Topics Covered	**Casting** (20 hrs) Foundry: foundry materials- moulding and core sand- binders – additives; sand preparation- sand control tests 2 pattern and pattern making 3 mould and core making, expendable and non-expendable moulds, 3 mould assembly; solidification of pure metals and alloys, grain growth. 1 Casting processes- sand casting, shell moulding, investment casting, slush casting, gravity and pressure die casting, centrifugal casting; continuous casting 5 casting design, gateway system design, riser design 3 casting defects- inspection, testing- destructive and non-destructive. 3 **Welding** (18 hrs) Metal joining- classification, welding heat sources, 1 arc welding machines, arc production, arc characteristics, metal transfer, welding electrode 5 resistance welding, thermit welding, soldering and brazing, 2 gas welding, 3 Welding metallurgy, weldability of ferrous and nonferrous metals, 1 Welding defects , testing of welded joints 3 Other nonconventional welding methods like, ultrasonic welding, electron beam welding, laser beam welding etc. 3 **Forming** (18 hrs) Metal forming- cold, warm and hot working. Forging: processes and its classification- drop forging and press forging, open die, impression die, closed die and precision forging processes. Grain flow in a forged product 4 Specific forging operations like, coining, piercing, hubbing, heading, Swaging, roll forging, orbital forging, incremental and isothermal forging. 2 Forging defects. 1 Rolling: Strip rolling- recrystallisation and process details, Rolling mills, ring rolling, gear and thread rolling, various rolled sections, defects in rolled products. 5 Drawing: drawing terms and their definitions, circular drawing die, rod and wire and tube drawing. 4 Extrusion: processes- direct and indirect extrusion, impact and hydrostatic extrusion, metal extrusion practice, metal flow during extrusion. 2
Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials - Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. Manufacturing Processes: H. S. Shan, Vol. 1 4. A textbook of Production Technology – P. C. Sharma
	Reference Books: 1. Manufacturing Science-- A. Ghosh, A.K.Mallik 2. Principles of Foundry Technology-- P.L.Jain

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 403</td><td>Heat and Mass Transfer</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 304</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Relation of thermodynamics and heat transfer
CO2 Knowledge of Conduction mode of heat transfer
CO3 Knowledge of Convection mode of heat transfer
CO4 Knowledge of radiation mode of heat transfer
CO5 Heat and mass transfer equipment's</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction, basic concepts and modes; relationship to thermodynamics. 1
Conduction: Mechanism; Fourier law of heat conduction in 3-D, 1-D steady state conduction with heat generation, composite plane wall, cylinders and spheres, thermal resistance network. Critical thickness of insulation; Use of analytical, numerical and graphical methods, thermal diffusivity, Fourier number, Heat Transfer from extended surface 12
Conservation principles: various conservation equations, Relation between system and control volume approach: Reynolds Transport Theorem, Entropy generation minimization as a general heat transfer objective, Basic convective configurations, Fluid flow and heat transfer aspect of internal flow, Fluid flow and heat transfer aspect of external flow, Visualization of convection, Flow over a flat plate, Concept of thermal and hydrodynamic boundary layers, Laminar and turbulent boundary layers, Scaling analysis, Natural, forced, mixed and turbulent convection, Dimensional analysis in correlations for convective heat transfer, Relation between fluid friction and heat transfer, Analysis of heat exchanger: LMTD, effectiveness-NTU method, Boiling and condensation mechanisms, Discrimination between diffusive and convective mass transfer, Fick's law of diffusion. 16
Radiation: physical mechanism, radiation properties, black body radiation, grey body, spectral dependence of radiation properties, Wien's displacement law, Kirchoff's law. Shape factor, heat exchange between infinite parallel planes, and Gray bodies; radiation shields, network representation. 7
Mass Transfer: Diffusive and Convective mass transfer, Evaporation process in the atmosphere, Fick's law and its applications. 6</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Heat Transfer-- J. P. Holman
2. Principles of Heat and Mass Transfer—F. P. Incropera, D. P. DeWitt, T.L. Bergan
3. A Heat Transfer Text Book, Dover - John H. Lienhard V, John H. Lienhard IV</td></tr>
<tr><td colspan="7">Reference Books:
1. Heat and Mass Transfer- Y. A. Cengel, A.J. Ghajar</td></tr>
</table>

Department of Mechanical Engineering							
(**For Electrical Engineering Students**)							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 431	**Fluid and Thermal Engineering**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
XEC01, MAC01, MAC02		CT+EA					
Course Outcomes	CO1: To learn the basics of Fluid Mechanics CO2: To learn the basics of Hydraulic machines CO3: To learn the basics of Thermodynamics CO4: To learn the basics of Power Plant Engineering						
Topics Covered	Definition of Fluid, Difference between fluid and solid, continuum concept, Knudsen No. density, specific volume ,bulk modulus, compressibility of fluid. (01) Viscosity, Newton,s law of viscosity , different types of fluid, Effect of pressure and temperature on viscosity, numerical problems (02) Fluid pressure, hydrostatic law of pressure,pressure variation with space in static fluid, abs. gauge and vacuum pressure, pressure measuring devices, numerical problems (03) Fluid kinematics, definition of flow field, Lagrangian and Eulerian approach of describing fluid motion. (01) Representatation of velocity and acceleration in ccartesian coordinate, temporal, convective and total acceleration. (01) Steady and unsteady flow, uniform and non uniform flow, laminar and turbulent flow, flow visualisation, stream line and path line. (01) Differential form of continuity equation in Cartesian form for compressible and incompressible flow. (01) Derivation of Euler's equation along a stream line, Benaullis equation, pressure head, kinetic head, datum head. (01) Application of Benaullis equation, flow measuring devices, venturimeter, orificemeter, pitot tube, numerical problems. (03) Hydraulic machines, dynamic force on fixed and moving vanes (01) Turbine and its classification, pelton turbine and its working principle, numerical problems (02) Pump and its classification, reciprocating pump and its working principle (01) Centrifugal pump-,working principle, velocity diagram, characteristics curve, numerical problem (03) Brief study of thermodynamics as a prerequisite for power plant engineering: Energy analysis of steady state flow system, example with mechanical power transfer to and from steady state flow devices like compressor, turbine, etc. System equilibrium, requirement for internal and total reversibility, causes of effect of irreversibility,concept of heat engine ,its working cycle, its efficiency with Carnot cycle, Effect of increase in saturation pressure on phase transformation, properties of steam, use of steam table, Mollier chart . (10) Basic devices in steam power plant and their schematic arrangement, fundamental concept of processes involved in them, simple rankine cycle with steady flow of working fluid (water and steam), performance parameter for efficient plant operation, effect of increase in boiler pressure on operating cycle performance, internal and external irreversibility associated with various practical processes during energy and mass transfer through the devices, Reheat, regeneration						

	and their combined application for improvement of plant operation, a few numerical problems, Brief description of super heater, economiser in power plant. (10) Introduction to gas turbine power plant: (01)
Text Books, and/or reference material	**Text Books:** 1. Hydraulics and Fluid Mechanics – Jagdish Lal 2. Hydraulic Machinery – Jagdish Lal 3.Introduction to Fluid Mechanics and Fluid Machines – S K Som and G Biswas 4. Engineering Thermodynamics – P K Nag 5. Introduction to Power Plant Engg- P K Nag
	Reference Books: 1. Introduction to Fluid Mechanics – Fox, Mcdonald and Pritchard

Department of Mechanical Engineering							
(for Chemical Engineering students)							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 432	**Mechanical Design of Equipment and Components**	PCR	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CT+EA					
Course Outcomes	CO1 System to control volume formulation CO2 Mathematical formulation of laws of thermodynamics CO3 Properties of pure substances CO4 Knowledge of stress and strain CO5 Principles of machine design						
Topics Covered	Relation between system and control volume approaches. 2 Equation of states. 2 Zeroth, first and second law of thermodynamics. 2 Gouy-Stodola theorem. (1) Applications of SFEE. 2 Carnot cycle, reversed Carnot cycle, Heat engine, heat pump and refrigerators. 2 First and second law based performances. 2 Properties of pure substances, Vapour power cycle—Rankine cycle. 4 Air standard cycles—Otto, Diesel, dual and Joule-Brayton cycles. 3 Review of stress, strain and deformation. 2 Engineering materials and their properties. 2 General principle of machine design. 2 Factor of safety. 2 Use of data book in mechanical design. 2 Design of shaft and key. 2 Mechanical drives: Introduction to simple gear drive and belt drive. 4 Types of pressure vessels: Thin cylinder and thick cylinder. 4						
Text Books, and/or reference material	**Text Books:** 1. P. K. Nag, Engineering Thermodynamics, McGraw-Hill. 2. E. Fermi, Thermodynamics, Dover. 3. V B Vhandari, Design of Machine elements [3rd edition]						
	Reference Books: 1. M. Planck. Treatise on thermodynamics. Dover. 2. E. P. Gyftopoulos, G. P. Beretta, Thermodynamics: Foundations and applications, Dover.						

<table>
<tr><td colspan="8">Department of Electrical Engineering</td></tr>
<tr><td colspan="8">(OFFERED FOR ME STUDENTS)</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>EEC432</td><td>Electrical Machines</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">EEC01</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Theory of electromechanical energy conversion, the concepts of voltage generation and fundamental torque equation.
CO2: Basic understanding of the principles of operation and construction of direct and alternating current machines and transformers.
CO3: A study of theory and concept of Electric Machines (AC & DC).
CO4: Deriving equivalent circuit of electrical machines.
CO5: Studying the performance and characteristics of Electrical machines (AC & DC).</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic principle of Faraday’s law of electro-magnetic induction, energy conversion and magnetic circuit. (4)

Transformer: Construction and principle of operation of single phase transformer, Step-up and Step-down transformer, E.M.F. equation, Equivalent circuits, phasor diagram, Open circuit and short circuit tests, losses and efficiency, All day efficiency, Auto transformer. (8)

D.C. Machines Construction, Methods of excitation and classifications, Simple lap and wave windings, emf equation, characteristics of different dc generator, armature reaction, Commutation, Back e.m.f in a d.c. motor, Motor Starter, Speed and torque equations, Speed vs torque characteristics and speed control of DC motors, losses in dc machines, Applications. (12)

Induction Motor: Pulsating and rotating magnetic field construction and principle of operation of Single and three phase induction motors, cage and wound rotor induction motors, comparison between them slip, equivalent circuits, No load and blocked rotor tests, Circle diagram, Torque/speed curve Starting and speed control, Applications of single phase and three phase induction motors. (12)

Synchronous Machines: Construction-alternators-turbo & hydro generators, principle of operation, emf equation, excitation control, synchronization load sharing synchronous motor operation, Synchronous condenser, applications of synchronous generator and motor. (6)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Electrical Machinery by P S Bimbhra
2. Electrical Technology Vol-II by B L Thereza
Reference Books:
1. Electrical Machines by J B Gupta</td></tr>
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<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 451</td><td>Solid Mechanics Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Engineering Mechanics, Solid Mechanics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Graphical and experimental verification of the solid Mechanics and Engineering mechanics</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Mohr’s Circle on strain Rosette- Graphical Solution.
Mohr’s Circle on Moment of Inertia - Graphical Solution.
Mechanical testing of Engineering Materials.
Experiments on the principles of strength of materials.
Instrumentation for measurement of deflection under loading.</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Strength of Materials – A. Pytel and F. L. Singer</td></tr>
<tr><td colspan="7">Reference Books:
1. Elements of Strength of Materials – S. P. Timoshenko and D. H. Young
2. Strength of Materials – S. S. Rattan</td></tr>
</table>

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 452	**Fluid Mechanics Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303 (Fluid Mechanics)		CT+EA					
Course Outcomes	CO1: Fundamentals of fluid mechanics.						
Topics Covered	Calibration of Venturimeter. Calibration of Orificemeter Determination of friction factor in flow through pipes. Determination of coefficient of bend loss in flow through pipes. Experiment on Impact of jet. Calibration of V-notch. Experiment on Bernoullie's Theorem.						
Text Books, and/or reference material	**Text Books:** 1. Mechanics of Fluids: Massey, B. S. 2. Fluid Mechanics – J. F. Douglas, J. M. Gasiorek, J. A. Swaffied, L. B. Jack 3. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, *et a*l. 4. Hydraulic Machinery - Jagdish Lal						
	Reference Books: Fluid Mechanics—F. M. White						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 453	**Mechanism Laboratory**	PCR	**0**	**0**	**3**	**3**	**1.5**
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Engineering Mechanics		CT+EA					
Course Outcomes	CO1: Students will be able to solve kinematics of mechanism by graphical method CO2: Students will be able to analyze mechanism by computer aided tools CO3: Students will be able to solve mechanism synthesis problems using computer aided tools CO4: Students will be able to demonstrate model of few planar mechanisms						
Topics Covered	Determination of velocity and acceleration of various mechanisms by semi graphical methods. Analysis of inertia forces. Computer Aided Kinematic Analysis of planar mechanisms Computer Aided Mechanism Synthesis of planar mechanisms Modeling & simulation of mechanisms using Computer Aided Tools Model making						
Text Books, and/or reference material	**Text Books:** 1. Theory of machines and mechanisms – Uicker, Penrock and Shigley 2. Theory of mechanisms and machines ---Ghosh & Mallick 3. Theory of machines – S S Rattan						
	Reference Books: 1. Theory of machines – Thomas Bevan 2. Introduction to the mechanics of machines – Morrison and Crossland						

Department of Electrical Engineering							
(OFFERED FOR ME STUDENTS)							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
EES482	**Electrical Machines Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
EEC01, EES51, EEC432		CT+EA					
Course Outcomes	CO1: Ability to determine the equivalent circuit parameters of a single-phase transformer CO2: Ability to determine the parameters of single-phase as well as three phase induction motor. CO3: Ability to determine the characteristics of dc shunt generator and series generator CO4: Ability to control the speed of a dc shunt motor CO5: Ability evaluate the voltage regulation of an alternator CO6: Ability to determine the efficiency of dc machines						
Topics Covered	**List of Experiments:** 1. Determination of equivalent circuit parameters of a single-phase transformer. 2. No-load and load characteristics of a dc shunt generator. 3. Speed control of a dc shunt motor. 4. Open-circuit and load characteristics of a dc series generator. 5. Voltage regulation of an alternator. 6. To perform no-load and blocked-rotor tests on a three-phase Induction Motor. 7. To perform no-load and blocked-rotor tests on a single-phase Induction Motor. 8. Swinburne's test of a dc machine.						
Text Books, and/or reference material	Text Books: 1. A. E. Fitzgerald, C. Kingsley and S. Umans, Electric Machinery, McGraw-Hill Co. Inc. 2. D. P. Kothari and I. J. Nagrath, Electrical Machines, Tata McGraw-Hill. Reference Books: 1. Laboratory manuals						

Department of Mechanical Engineering							
(for Electrical Engineering students)							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES 481	**Fluid and Thermal Engineering Sessional**	PCR	0	0	3	3	1.5
Pre-requisites		Theory of fluid machine and power plant engineering					
Course Outcomes	CO1: To understand the principle of calibration. CO2: To understand the major losses in pipe flow. CO3: To understand the principle of linear momentum. CO4: To understand the performance characteristics of various turbines. CO5: To understand the performance characteristics of centrifugal pump. CO6: To understand the function, construction of Lancashire Boiler. CO7: To understand the principle of diesel and petrol engine.						
Topics Covered	1.Calibration of venturimeter 2. Friction loss computation in pipe flow 3. Performance of Centrifugal Pump. 4. Performance Test of Pelton Wheel. 5. Performance Test of Francis Turbine. 6.Calibration of Vacuum gauge (Bourdon Gauge Tube) 7.Model study of Lancashire Boiler 8.To study the performance of four stroke petrol engine 9. To study the performance of diesel engine using rope brake dynamometer under variable load condition						
Text Books, and/or reference material	Suggested Text Books: 1) Introduction to Fluid Mechanics-R. W. Fox and A. T. McDonald. Pritchard 2) Introduction to Fluid Mechanics and Fluid Machines- S.K. Som and G. Biswas 3) Introduction to Power Plant Engg- P K Nag Suggested Reference Books: 1) Fluid Mechanics – J. F. Douglas, J. M. Gasiorek, J. A. Swaffied, L. B. Jack						

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td colspan="8">(for Chemical Engineering students)</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>WSS 481</td><td>Workshop Practice II</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Hands-on practice on Foundry
CO2: Hands-on practice on different job manufacturing in machine shop
CO3: Hands-on practice on Pattern Shop
CO4: Hands-on practice on welding Shop</td></tr>
<tr><td>Topics Covered</td><td colspan="7">M/c shop -- 3X6=18hrs.
• Mechanism and function of different parts of machine tool.
• Machining operations:
1) Machining of shaft and knurling by lathe.
2) Thread cutting by lathe.
3) Taper turning by lathe.
4) Machining of gear blank by lathe.
5) Making of Square Bar by shaper.
6) Machining of surface by shaper.
7) Spur gear cutting by milling.
• Introduction of two and three axis CNC m/cs.
• Explanation of ‘G’ and ‘M’ Codes.
Pattern shop -- 3X3=9hrs
• Description of wooden pattern.
• Types of pattern, pattern allowance.
• Layout and design of pattern making.
• Making of V-block.
Foundry shop -- 3X3= 9hrs
• Preparation of sand mould using Solid/Split Pattern.
• Aluminium casting using the prepared mould.
• Determination of properties of Green Moulding Sand using Sand Testing Equipments.
• Foundry Tooling Design.
Viva voce -- 1X3= 3hrs.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Manufacturing Science-- A. Ghosh, A. K. Mallik
Principles of Foundry Technology-- P. L. Jain</td></tr>
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FIFTH SEMESTER

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 501</td><td>Machining and Machine Tools</td><td>PCR</td><td>3</td><td>1</td><td>0</td><td>4</td><td>4</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Knowledge of fundamental machining processes and the underlying sciences of machining and the related processes
CO2 Various machine tools, their operations and the mechanisms in machine tools</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Machining</u> (28 hrs)
Introduction to Manufacturing processes and Metal cutting, Types of basic motions, Speed, feed and depth of cut, Shapes produced by different combination of motions, representation of chip formation in 3D. 2
Cutting Tools: Single point, Multi point, Left hand and Right hand cutting tool. Single point cutting tool nomenclature and representation in 3D, Tool geometry in ASA and ORS systems, Effect of tool geometry on performance. 2
Experimental observations in metal cutting- chip thickness, width of cut, primary deformation zone, shear angle concept, Piispanen's model, types of chips and the conditions of their formation, strain hardening, heat generation and dissipation, cutting fluid. Orthogonal and Oblique cutting- 2D and 3D representation, effect on chip formation and on mechanics of chip formation. Concept of undeformed chip thickness, chip reduction coefficient determination- experimentally from chip length. Analytical determination of shear angle and shear strain from simple geometry of chip formation. 4
Forces in Metal cutting: Free body diagram and mechanics of chip formation, direction and Representation of forces on basic plane and orthogonal plane, 3D representation of forces on cutting tool, Merchant's Circle Diagram representation of forces, transformation of forces, kinematic coefficient of friction, total work done and its distribution, different specific energies, power estimation, Merchant's first shear angle relationship and its deviation from experimental observations. 4
Tool life: Different way of tool failure, types of tool wear- their causes and remedies, features of flank and face wear, characteristic of wear growth, definition of tool life, factors affecting tool life, Taylor's tool life equation, effects of tool geometry on tool life. 4
Grinding- Machines and processes, Transverse grinding and plunge grinding, creep-feed grinding, 46hermos46ss grinding, truing and dressing of grinding wheels, balancing of grinding wheels, Details of grinding wheels- Manufacturing and specifications, grinding wheel wear, grinding temperature. 6
Nonconventional machining processes: Working principles, processes and mechanics of process parameters and applications. ECM, EDM, AJM, USM 6

<u>Machine tools</u> (28 hours)
Fundamental of Machine tools, Machine tool elements. 1
General feature of construction and working of Lathe, Different parts of a Lathe, Types of Lathe and specification. Back gear arrangement, Work holding devices. Screw cutting, Taper turning, Form turning and various other operations performed by a Lathe. Feed, speed, depth of cut and machining time calculation. 6
General feature of construction and working of Drilling machine, Different parts of a Drilling machine, Types of Drilling machine and Specification. Reaming, Threading and various other operations performed by a Drilling machine. Types of Drill bits. Feed, speed and machining</td></tr>
</table>

	time calculation. 4 General feature of construction and working of Milling machine, Different parts of a Milling machine, Types of Milling machine and Specification. Dividing head and Indexing method. Up milling, Down milling, Spiral milling and other operations performed by a Milling machine. Types and choice of Milling cutter. Machining time calculation. 6 General feature of construction and working of Shaping machine and Slotting machine. Quick return mechanism. Whitworth mechanism, Feed mechanism. Types of tools. Machining time calculation. 4 Gear manufacture- milling, hobbing and shaping, Gear finishing processes 4 Turret and Capstan Lathe: Types, parts, equipments and tools for use on turret and capstan lathe, operational planning and turret tool layout. 4
Text Books, and/or reference material	**Text Books:** 1. Theory of metal cutting – G. Kuppuswamy 2. Production Engineering Sciences – Pandey and Singh 3. Manufacturing Processes – H. S. Shan, Vol. 2 4. A textbook of Production Engineering – P. C. Sharma
	Reference Books: 1. Manufacturing Science – A. Ghosh, A.K.Mallik 2. Theory of metal cutting – Sen and Bhattacharya

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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 502</td><td>IC Engine and Gas Turbines</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 304, MEC 403</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Concept of internal combustion engines
CO2 Mechanism of internal combustion engines
CO3 Pollution from internal combustion engines
CO4 Mechanism of gas turbines
CO5 Outlines of alternative fuels</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Internal Combustion Engines: Basic engine types and their operation, construction and application. Engine design and operating parameters, 48hermos-chemistry of fuel air mixture, air-fuel cycle, properties of working fluids. Indicator diagrams, engine performance and output, compression ratio, air-fuel ratio, Ignition timing and other affecting variables on engine performance. Fuel and fuel rating. Charge motion within the cylinder, combustions in SI and CI engines. Detonation and Knock, Combustion chamber, Carburation and fuel injection systems. Scavenging, natural aspiration, turbo charging and super charging, Engine friction, lubrication and cooling. Operating variables Affecting SI and CI engine performance. Modern systems for controlling engine operation. Testing of IC engines. 27
Pollution from I. C. Engines and its control: Exhaust of IC engines, Composition of exhaust gases, Apparatus for exhaust gas analysis, Permissible limits and Remedial measures for control emissions. 5
Alternative fuels for I. C. Engines. 4
Gas Turbines: Application of gas turbines, analysis of open and closed cycles, Gas turbine combustion chamber. Single and multi-shell arrangements. Inter-cooling. Reheat and regeneration. Matching of turbine and compressor. Performance characteristics. Jet propulsion and application. 6</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Internal Combustion Engine – V Ganesan
2. A text book of Internal Combustion Engines—R. K. Rajput</td></tr>
<tr><td colspan="7">Reference Books:
1. I. C. Engines–P. W. Gill, Smith, Zury
2. I. C. Engine Fundamentals – Obert
3. I. C. Engine Fundamentals –Heywood</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEC 503	**Machine Design**	PCR	3	1	0	4	4
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 302, MEC 401		CT+EA					
Course Outcomes	CO1 Detail analysis of members under fatigue loads CO2 Design procedures for some machine elements used in mechanical drives CO3 Exposed to the importance of engineering tolerances and its use CO4 Introduction to different types of bearings and lubrications CO5 To understand the basics of gear mechanics						
Topics Covered	Manufacturing considerations in Design: Fits and Tolerances. 4 Belt drives: Flat belts and V-belts. 5 Power screw 5 Bearings: Sliding contact bearing; Rolling contact bearings -Construction, Types and selection, Constructional details, Types of lubrication. 7 Toothed Gear Drive: Spur gear- Contact forces, Materials, Static design by Lewis equation. 7 Dynamic loads on gears – Buckingham's method.Types, Terminology, Geometrical proportions, Analysis of contact, Materials, Analysis of Force, and Design of Helical, Bevel and Worm gears. Check for dynamic load and wear strength. Design of gear boxes. 15 Brakes: Band brakes and Shoe brakes 5 Clutch: Friction clutches and Jaw clutches. 4						
Text Books, and/or reference material	**Text Books:** 1. Mechanical Engineering Design – J.E. Shigley 2. Design of Machine Elements – M.F. Spotts 3. Design of Machine Elements – V.B. Bhandari						
	Reference Books: 1. Machine Design – Black and Adams						

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 504</td><td>Dynamics of Machinery</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 302</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Knowledge of gyroscopic motion of dynamic mechanical system
CO2 Knowledge of balancing of rotating and reciprocating machines
CO3 Knowledge of longitudinal, torsional and transverse vibration of mechanical system</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Gyroscope
Spinning, precession and gyroscopic couple; gyroscopic effect on ships and aeroplane; Application of Gyroscope 14
Balancing
Internal and external balancing; Balancing of rotating masses –single plane balancing and two plane balancing, Balancing of reciprocating masses – single cylinder engine, Vee cylinder engine, and multicylinder inline engine. 14
Vibration
Longitudinal vibration – free vibration, damped vibration, and forced damped vibration; Torsional vibration – free vibration of rotor system and torsionally equivalent shaft; Transverse vibration – vibration of shaft carrying uniformly distributed load and several concentrated load, and critical speed of shaft. 14</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Theory of Machines and Mechanisms, Uicker J.J., Pennock G
2. Theory of Mechanisms and Machines, Ghosh A., Mallik A.K.</td></tr>
<tr><td colspan="7">Reference Books:
1. Dynamics of machinery : Holowenko, Alfred R</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td colspan="8">OPEN ELECTIVE OFFERED FOR OTHER DEPARTMENTS</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEO 541</td><td>Experimental Methods in Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Nil</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire an idea about basic concepts of engineering measurements
CO2: To learn the basics of data analysis
CO3: To learn the fundamentals of data acquisition.
CO4: To learn the measurement techniques for electrical signals, pressure, temperature, flow, force, motion, vibration etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Basic concepts: Calibration, Standards, Dynamic Measurement, System response and Fourier Analysis 4
Data analysis: Error analysis, Uncertainty analysis, Statistical analysis, Curve fitting, Goodness of fit. 6
Measurement of electrical signals: Waveform measurements, Analog/digital meters, Amplifiers, Signal Conditioner, Oscilloscope, transducers 5
Measurements of physical variables: Pressure measurement 4
Flow measurement 6
Temperature measurement 4
Force/ torque/ strain measurement, motion and vibration measurement. 9
Data acquisition and processing: Signal conditioning, Data transmission, ADC and DAC 4</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Experimental Methods for Engineers – J. P. Holman</td></tr>
<tr><td colspan="7">Reference Books:
1. Instrumentation, measurements and experiments in Fluids by E. Rathakrishnan
2. Handbook of experimental fluid mechanics by Foss et al.
3. Measurement systems—application and design, Doebelin, E. O.</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 551</td><td>Design and Dynamics Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT))</td></tr>
<tr><td colspan="3">XEC01, MEC 302, MEC 401</td><td colspan="5">CT</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire basic idea about the machine component drawing, geometric profiles of gears and cams
CO2: To understand the use of gyroscope and governors
CO3: Understanding vibratory systems and mass balancing concept.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">• Drawings of the followings.
Assignment 1: Dimensioning concept and detail drawing of machine components. (3hrs x3)
Assignment 2: Generation of geometric profiles of gears and cams. (3hrs x 2)
• Motorized gyroscope – Study of gyroscopic effect and couple (3Hrs)
• Governor - Determination of range sensitivity, effort etc., for Watts / Porter / Proell / Hartnell Governors. (3Hrs)
• Single degree of freedom Spring Mass System – Determination of natural Frequency and verification of Laws of springs – Damping coefficient determination (3Hrs)
• Experiment on rotor balancing (3 Hrs x2)</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Theory of Mechanisms and Machines, Ghosh, Mallik
2. Theory of Machines and Mechanisms, Uicker J.J., Pennock G.R., Shigley J.E.</td></tr>
<tr><td colspan="7">Reference Books
1. Introduction to the mechanics of machines, Morrison J.L.M., Crossland B.
2. Dynamics of machinery : Holowenko, Alfred R</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 552</td><td>Heat Transfer Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 304, MEC 403</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Fundamental concepts of Temperature measurement systems
CO2: Test on heat transferring apparatus
CO3: Knowledge on conduction heat transfer
CO4: Knowledge on convection heat transfer
CO3: Knowledge on Radiation heat transfer</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Various types of temperature measuring and controlling instruments. Thermocouples, Thermostats etc.
Fundamental concept and function of Multi-channel temperature indicator,
<u>Experiments on-</u>
Determination of forced convection heat transfer coefficient through pin fin for variable flow rates of fluid at different inlet temperature.
Determination of LMTD and effectiveness for parallel and counterflow heat exchanger.
Verification of the laws of radiation with the help of radiation laboratory unit.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Heat Transfer-- J. P. Holman
2. A Course in Heat and Mass Transfer-- S.Domkundwar
3. A Course in Internal Combustion Engines-- R. P. Sharma, M. L. Mathur
4. I. C. Engines-- P. W. Gill, Smith, Zury</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 553</td><td>CAD/CAM Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 401</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Able to learn geometric modelling using CAD tools
CO2: Able to use MATLAB for solving computer graphics problem and engineering analysis problem
CO3: Exposed to CNC part programming</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Solid Modeling using software packages
Graphics programming using MATLAB
CNC part programming for Tool path generation & verification using CAM software</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Mastering CAD/CAM by I.Zeid
2. Getting started with MATLAB by Rudra Pratap</td></tr>
<tr><td colspan="7">Reference Books:
1. Computer Graphics by Roy A Plastock</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>WSS 581</td><td>Workshop Practice II</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2"></td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Hands-on practice on Foundry
CO2: Hands-on practice on different job manufacturing in machine shop
CO3: Hands-on practice on Pattern Shop
CO4: Hands-on practice on welding Shop</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Machine shop -- 3X6=18hrs.
• Mechanism and function of different parts of machine tool.
• Machining operations:
1) Machining of shaft and knurling by lathe.
2) Thread cutting by lathe.
3) Taper turning by lathe.
4) Machining of gear blank by lathe.
5) Making of Square Bar by shaper.
6) Machining of surface by shaper.
7) Spur gear cutting by milling.
• Introduction of two and three axis CNC m/cs.
• Explanation of ‘G’ and ‘M’ Codes.
• Introduction to non-conventional machining.
Welding shop -- 3X2= 6hrs.
• Welded joints- square butt joint & T-fillet joint by SMAW with mild steel flat.
• Types of electrodes and coding systems of electrodes.
• Types and functions of flux.
• Positions of welding, polarity in welding.
Pattern shop -- 3X2= 6hrs.
• Description of wooden pattern.
• Types of pattern, pattern allowance.
• Layout and design of pattern making.
Foundry -- 3X2= 6hrs.
• Preparation of sand mould using Solid/Split Pattern.
• Aluminium casting using the prepared mould.
• Determination of properties of Green Moulding Sand using Sand Testing Equipments.
Viva voce -- 1X3= 3hrs.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books: Reference Books:
1. Manufacturing Science-- A. Ghosh, A. K. Mallik
2. Principles of Foundry Technology-- P. L. Jain</td></tr>
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SIXTH SEMESTER

<table>
<tr><td colspan="8">Department of Humanities and Social Sciences</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>HSC 631</td><td>Principles of Economics</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To review basic economic principles with students;
CO2: To introduce students basic capital appraisal methods used for carrying out economic analysis of different alternatives of engineering projects or works;
CO3: To educate the students on how to evaluate systematically the various cost elements of a typical manufactured product, an engineering project or service, with a view to determining the price offer.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Group A: Microeconomics
Economics: Basic Concepts 3
Theory of Consumer Behaviour 3
Theory of Production, Cost and Firms 3
Analyses of Market Structures: Perfect Competition 3
Monopoly Market 3
General Equilibrium 3
Welfare Economics 3

Group B: Macroeconomics
Introduction to Macroeconomic Theory 3
National Income Accounting 3
Determination of Equilibrium Level of Income 3
Money, Interest and Income 3
Inflation 3
Unemployment 3
Multiplier 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Group A: Microeconomics
1. Koutsoyiannis: Modern Microeconomics
2. Maddala and Miller: Microeconomics
3. AnindyaSen: Microeconomics: Theory and Applications
4. Pindyck&Rubenfeld: Microeconomics</td></tr>
<tr><td colspan="7">Group B: Microeconomics
1. W. H. Branson: Macroeconomics – Theory and Policy (2nd ed)
2. N. G. Mankiw: Macroeconomics, Worth Publishers
3. Dornbush and Fisher: Macroeconomic Theory
4. SoumyenSikder: Principles of Macroeconomics</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 601</td><td>Power Plant Engineering</td><td>PCR</td><td>2</td><td>1</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 304, MEC 403</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 Study of power production
CO2 Study of some power plant related equipment’s</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Primary and Secondary sources of energy, Global trend for per capita consumption of energy, Demand of energy and future availability in usable form. Recent developments in renovation of energy sources. 2
Analysis of steam cycles: Steam power plant outline, effect of steam condition on thermal efficiency, regenerative feed heating, feed water heaters, optimum degree of regeneration, deaerator, co-generation of power and process heat 9
Fuels and combustion: Coal- ranking and analysis, fuel oil, natural and petroleum gas, Combustion reactions 2
Combustion equipment’s and firing methods: Fuel bed combustion, pulverized coal firing, Cyclone furnace, fluidized bed combustion-CFB and BFB, Coal gasifiers 7
Steam generator: High pressure boilers, Subcritical and Supercritical boilers, Calculation on economizer, Superheater, Reheater and Air preheater, Draught systems - FD, ID and balanced draught, calculation of fan power. Circulation- natural and Forced, circulation ratio, Performance rating of boilers. 8
Flow through nozzles and diffusers, Shocks, Super-saturation of steam through nozzle Flow. 3
Steam turbines: Machines working on impulse and reaction principles, Turbine blading, Velocity triangles, Blade speed ratio, Velocity and pressure compounding, Stage and overall efficiencies, Degree of reaction. 8</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Power Plant Engineering-P.K.Nag
2. Power Plant Technology — M.M. El.Wakil
3. A Course in Power Plant Engineering- S. Domkundwar, S.C. Arora</td></tr>
<tr><td colspan="7">Reference Books:
1. Power Plant Engineering- F.T. Morse
2. Steam Turbine Design and Practice- Kareton
3. Power Plant Engineering- Black and Veatch</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEC 602</td><td>Industrial Engineering and Measurement</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Basic knowledge of Engineering Mechanics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Knowledge on the structures of Engineering Organization in general.
CO2: Planning of manning and production line.
CO3: Ability for material management.
CO4: Indian standards of measurement.
CO5: Techniques of engineering measurements with its application.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Organization Structure: Classical principles, Different types of organization structure- Line, Staff, Line and staff, Committee organization, Case study. 3
Plant Location: Factors affecting plant location, Plant location theories- material index theory, location factor theory, Dimensional decision making model, Force analogy method, Specific site selection. 4
Plant layout: Different types of layout, Various flow patterns, Factory building construction, Travel chart. 2
Job evaluation, Merit rating and Wage incentive schemes: Methods of job evaluation- Ranking method, Classification method, Point method, Factor comparison method. Merit rating- Point rating scale, Employee comparison system. Different wage incentive schemes. 4
Work study: Operation process chart, Flow process chart, Flow diagram, String diagram, Multiple activity chart- Man-machine chart, Man-machine-helper chart, Left hand-right hand chart, Motion study, SIMO study, Cycle graph and chronocycle graph, Performance rating, Stop watch time study. 4
Production, planning and control: Routing and scheduling, Assignment problems- 2 machines and n jobs, 3 machines and n jobs, m machines and n jobs, n machines and n jobs, Gantt chart. 4

Generalised measurement systems- Calibration, Sensitivity, Damping, Characteristics of first order and second order systems, Dynamic response, Harmonic analysis. 5
Standards of linear measurements, Interferometric measurements. 2
Limit, Fit and Tolerances: Basis of a limit system, Unilateral and Bilateral systems. 2
Indian limit system IS 919:1993; Types of fits and selection of fits, IS 2709:1982 3
Dimension chain and Dimensional analysis, Design and use of limit gauges. 2
Error of flatness and straightness: Concept of mean true plane, Measurement of flatness error using Beam Comparator, Autocollimator and Precision Block Level. 3
Dynamometers for measuring 2-component and 3-component machining forces. 2
Surface roughness measurement. 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Industrial Engineering and Management—Dr. Ravishankar
2. Industrial Engineering and Production Management—M. Mahajan
3. A Text book of Engineering Metrology—I.C.Gupta
4. Engineering Dimentional Metrology—L.Miller</td></tr>
<tr><td colspan="7">Reference Books:
1. Management in Industry—C.S.George
2. Engineering Tolerences—H.W.Conway</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 610</td><td>Automobile Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 304, MEC403, MEC 502</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Classification and layouts of different vehicles
CO2: Different types of Engines in use
CO3: Different types of clutch, gear box and transmission used
CO4: Different types of brakes, drivelines and wheels and tyres.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Automotive engine: Construction, operation and service of automotive engine. 8
Bearing, lubrication and cooling system.
Fuel and exhaust, emission control. 6
Starting and charging system. Contact point and electronic ignition system. Other accessories with electrical and electronic devices. Engine trouble diagnosis and tune up. 10
Automotive power train: Transmission and transaxles, gear train, differentials and drive axles, drive lines and universal joints, clutches and brakes. 8
Automotive chassis: Springs and suspension system, steering system, wheels and tyres. 6
Automotive ventilation and air conditioning techniques. 4</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Suggested Text Books:
1. Automobile Engineering—K. Singh
2. Automotive mechanics—W. H. Crouse, D. L. Anglin
Suggested Reference Books:
1. Automotive mechanics—J. Heitner</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 611</td><td>Gas Dynamics and Propulsion</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">MEC303, MEC304</td><td colspan="6">Course Assessment methods (Continuous evaluation (CE) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CE+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn compressible flows with constant entropy only, with friction only and with heat transfer only.
CO2: To learn Normal shock, oblique Shock and Prandtl-Meyer Flow with real life applications.
CO3: To learn Performance analysis of Air Breathing Engines (Ramjet, Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet and Turbo prop.)
CO4: To learn Performance analysis of Non Air Breathing Engines (Solid Rocket Motors and Liquid Rocket Engines).</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Part-I: Gas Dynamics:</u>

Review of basic compressible flow e.g. sonic velocity, wave propagation. Flow with Variable area duct without normal shock and with normal shock. Fanno flow and Rayleigh flow. Solution of problems using gas table. 7
Moving Normal shocks and Oblique shocks: Normal velocity superposition for moving Normal shock and tangential velocity superposition for oblique shock, oblique shock analysis for perfect gas, oblique shock table and charts. Problems. 7
Prandtl-Meyer flow: Isentropic turn (either around expansion or compression corner) from infinitesimal shocks, Mach waves, Prandtl-Meyer flow analysis, Prandtl-Meyer function, over-expanded and under-expanded nozzles, boundary conditions for flow direction and pressure, shock diamond, supersonic aerofoils, Working of supersonic wind tunnel. 4
Correlation of Fanno flow, Rayleigh flow, and a normal shock 2
<u>Part-II: JET PROPULSION</u>
Air Breathing Engines: Derivation of generalized equation/ expressions for thrust, propulsion efficiency, thermal efficiency and overall efficiency. Relation between them, TSFC(Thrust specific fuel consumption); stoichiometry , equivalence ratio, mass fraction, mole fraction, partial pressure, mass balance in chemical equations, heat of reaction, heat balance in constant volume and constant pressure processes, fuel air ratio, variation of temperature with F/O and its stoichiometric value. Condition for maximum efficiency.
Performance analysis of the following:
(a) Ramjet, (b) Turbojet (standard): Fan exhausted turbojet & Fan mixed turbojet
I Turbo prop. Effect of after burner on all the above. Related problems 12
Non-air breathing engines: Performance of Rocket vehicles such as Thrust, specific Impulse (I_{sp}), vehicle acceleration, burning time. Type of chemical Rockets: Solid Rocket Motors and Liquid Rocket Engines. Elementary theory and performance characteristics of both types of chemical rockets. Related problems. 10</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Fundamentals of gas dynamics —R.D. Zucker & Oscar Biblarz.
2. Mechanics and thermodynamics of propulsion: P. G. Hill & C.R. Peterson.
Reference Books:
1. The Dynamics and Thermodynamics of Compressible Fluid Flow by A. H. Shapiro.
2. Aircraft Propulsion : V. Babu</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 612</td><td>Mechanics of Forming and Press Working</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 402</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Detailed and in depth analysis of the forming processes.
CO2: Specialized techniques in forming practiced in industry.</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Module 1:</u>
Stress-strain relationship: true stress true strain, elasticity, anelasticity, plasticity, work hardening, work done or strain energy. Complex Stress System, concept of absolute maximum shearing stress in a plane-stress system, three dimensional stress system and Mohr's circle for the general state of stress (3-D).
Plastic Deformation and Yield Criteria: maximum normal stress theory (Rankine's Theory), Tresca's maximum shear stress theory, Von Mises' maximum distortion energy theory, relation between tensile yield stress and shear yield stress, yielding under plane strain Graphical representation of Tresca's and Von Mises' theory.
Forging: processes and its classification- drop forging and press forging, open die, impression die, closed die and precision forging processes. Grain flow in a forged product. Forging die materials, lubrication, forging defects, forgeability of metals, die-manufacturing methods. Analysis of forging load: Low friction or sliding friction condition (as in cold forming); high friction condition; and, combined slipping and sticking friction condition.
Rolling: strip rolling- recrystallization and process details, conditions for biting, role of friction in rolling. Rolling mills, ring rolling, gear and thread rolling, various rolled sections, defects in rolled products. Determination of roll pressure: pressure distribution in rolling, determination of neutral point, front tension and back tension, force and power calculation. Roll deflections and roll flattening, spreading, methods of reduction of rolling force, roll materials, various rolled sections.
Drawing: drawing terms and their definitions, circular drawing die, drawing of wire and rod (homogeneous deformation), maximum possible reduction in a single pass, analysis of strip drawing, calculation of force and power, analysis of wire and rod drawing, calculation of force and power.
Extrusion: processes- direct and indirect extrusion, impact and hydrostatic extrusion, metal extrusion practice, metal flow during extrusion.
<u>Module 2:</u>
Sheet metal forming: characteristics; parameters affecting sheet metal forming process such as, yield point elongation, anisotropy, grain size, residual stresses, spring back, wrinkling, coated sheet. 1
Shearing, punching and blanking: punch force; shearing operations like, die cutting, fine blanking, slitting, steel rules, nibbling; Shearing dies: Punch and die shapes, compound dies, progressive dies, transfer dies, tool and die materials. 5
Bending of sheets and plates: minimum bend radius, factors affecting bendability, spring back, compensation for spring back, common bending operations. 3
Deep drawing: Characteristics of deep drawing, formability of sheet metal, design considerations
Miscellaneous forming processes: stretch forming, bulging, hydroforming, various spinning operations. 3
High energy rate forming: Explosive forming, electrohydraulic forming, magnetic pulse forming, superplastic forming etc. 3</td></tr>
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Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials — Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. Manufacturing Processes: H. S. Shan, Vol. 1 4. A textbook of Production Engineering – P. C. Sharma
	Reference Books: 1) Manufacturing Science—A. Ghosh, A.K.Mallik

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 613</td><td>Advanced Solids Mechanics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC301</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Three dimensional stress and strain analysis.
CO2: Development of solution procedures using energy method
CO3: Analysis of non-circular shafts and thick cylinders.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Mathematical preliminaries: Vector, Matrix, Index notation. 4
Analysis of stress: Three dimensional state of stresses, Equation of equilibrium in 63artesian and cylindrical coordinate system and equality of cross shear, plane state of stress, Principal stresses, Stress Invariants, Mohr’s circles, Mohr’s stress plane, Octahedral stresses. 10
Analysis of strain: State of strain, Green-Lagrange and infinitesimal strain in 63artesian and cylindrical coordinate system, Principal strain, Compatibility conditions, Airy’s stress function. 10
Energy methods: Elastic strain-energy for axial force, shear force, bending moment and torque, Theorem of virtual work and its application to derive governing equation of beam, Castigliano’s theorems. 10
Torsion of non-circular bar: Torsion of circular and elliptical bars, Torsion of rectangular bars. 8
Thick cylinders: Axisymmetric problems, Thick cylinder subjected to internal and external pressure, Composite cylinder. 6</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7"><u>Suggested Text Books:</u>
1. Theory of elasticity By Timoshenko and Goodier (Mc Graw Hill)
2. Advanced Mechanics of Solids by L. S. Srinath
<u>Suggested Reference Books:</u>
3. Elasticity theory, applications and numerics by M. H. Sadd (Academic Press)
4. Advanced mechanics of solids By O. T. Bruhns (Springer)
5. A treaties on the mathematical theory of elasticity A. E. H. Love (Dover Publications)</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 614</td><td>Advanced Machining and CNC Machine Tools</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 402</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand theory of machining, orthogonal cutting
CO2: To understand oblique cutting mechanics as applied to drilling and milling
CO3: To study other important aspects in machining related to cutting tools
CO4: Able to understand the fundamentals of CNC machine tools, Part programming, and Part programming languages</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Module 1 : Advanced Machining (21 hours)
Introduction: Characteristics and development of tool materials, cutting tool inserts and its geometry, cutting fluids 3
Mechanics of Metal Cutting, Shear angle relationships and Lee and Shaffer's Theory, Work hardening and Chip breakers. 3
Stress distribution on rake face of the tool 1
Thermal aspects of machining. 2
Mechanisms of tool wear, Surface Finish and Effects of cutting parameters and tool geometry on tool life. 4
Economics of machining. 1
Drilling: Geometry of drilling tools and mechanics of drilling. 3
Milling: Geometry of milling tools and mechanics of plain milling 4

Module 2 : CNC Machine Tools (21 hours)
CNC machine tools, constructional features, 2
Drives and controls, stepper motors, servo motors, hydraulic systems, 4
Feed back devices, 1
Counting devices, 1
Interpolators- linear, circular interpolation and other emerging techniques, 2
CNC part programming, post processors, 5
CNC programming with interactive graphics, 4
Use of various software packages, 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Theory of metal cutting – G. Kuppuswamy
2. Production Engineering Sciences – Pandey and Singh
3. A textbook of Production Engineering – P. C. Sharma
4. Computer Aided Manufacturing : P Rao, N Tewari, T.K. Kundra</td></tr>
<tr><td colspan="7">Reference Books:
1. Manufacturing Science – A. Ghosh, A.K.Mallik
2. Theory of metal cutting – Sen and Bhattacharya
3. Computer numerical control of machine tools: G. E. Thyer</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 615</td><td>Operation Research</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to discuss the history, concepts, formulations and applications of operations research.
CO2: Students will be able to analyze and solve conflicting problems on constrained linear optimization problems having single and multiple objectives.
CO3: Students will be able to apply integer, dynamic programming methods for solving relevant problems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Origin, growth, definition, methodology and application of OR. 2
Linear Programming, Mathematical Modelling, Graphical Method of Solution, Sensitivity Analysis. 8
Simplex Method, Big M and 2-Phase Methods, Duality in LP. 7
Transportation problem. 3
Assignment Problem 3
Sequencing problem. 2
Queuing model and Simulation. 3
Competitive Decision Making, Game Theory. 4
Duality Theory and Sensitivity Analysis. 3
Integer Programming, Binary Integer Programming. 4
Dynamic Programming. 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Hillier, Fredrick S. and Lieberman, Gerald J., Introduction to Operations Research, 7th Edition, TMH, 2001.
2. Basu, S. K., Pal, D. K., Bagchi, H., Operation Research for Engineers, 2nd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., 1998
3. Taha, H. A., Operation Research, McMillan Publishing Co., London, 1982.</td></tr>
<tr><td colspan="7">Reference Books:
1. Churchman, C. M., Ackoff, R. L., Arnoff, E.L., Introduction to Operation Research, Asia Publishing o., 1962
2. Hanssmann, F., Operations Research in Production and Inventory Control, John Wiley & Sons, Inc., London, 1962.</td></tr>
</table>

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 616	**Mechanical Equipment Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401, MEC 503		CT+EA					

Course Outcomes	CO1: Exposure to various types of mechanical elements and their design procedure. CO2: Ability to design different mechanical systems independently. CO3: Understand the working of various types of drive systems. CO4: Dealing with the case studies help develop self-confidence.
Topics Covered	Chain Drive 4 Rope Drive 4 Spiral Bevel Gear Drive 4 CVT Mechanism 4 Design of Pulley and Idlers 5 Design of Worm Gears 4 Cam Mechanisms 4 Disc Brakes 4 Selection of Single-Phase Induction Motors 3 Case Studies 6
Text Books, and/or reference material	**Text Books:** 1. Black and Adams, Machine Design, McGraw Hill Book Company Private Ltd., USA, 1973. 2. 2. Phelan R.M., Fundamentals of Mechanical Design, TMH, 2015. **Reference Books:** 1. Burr, Arthur H., and Cheatham, John B., Mechanical Analysis and Design, Prentice Hall, USA,1995 2. Norton, R.L. , Machine Design: An Integrated Approach

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 620</td><td>Advanced Foundry Engineering</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC402</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: At the end of the course student will be able to get the knowledge about various aspects of casting processes and the underlying science
CO2 : various types of casting methods
CO3 : Application fields of various casting processes</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Casting Processes: Classification, characteristics of sand casting processes, metal mould casting process, Pattern materials, types of patterns, Mould and core making materials and their characteristics. (12)
Solidification of metals: Nucleation and grain growth, solidification of pure metals, short and long freezing range alloys, Rate of solidification, macrostructure and microstructure. Solidification Contraction, Grain refinement (6)
Sand Casting Design: Gating and risering design calculations, Fluidity and its measurement. (6)
Investment casting, shell moulding, squeeze casting, vacuum casting, counter-gravity flow-pressure casting, Directional and monocrystal solidification, squeeze casting, semisolid metal casting, rheocasting. (8)
Family of cast iron – Ductile Iron, Malleable Cast Iron, (3)
Casting defects- inspection and testing , analysis of casting defects, nondestructive testing of casting- dye penetrant testing, magnetic flaw detection, radiography, ultrasonic testing, etc. (4)
Near net shape casting processes, Modern foundry practices and special casting method. Continuous casting (3)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. John Campbell, “Casting Practice” Elsevier Science Publishing Co.,2004
2. Scrope Kalpakjian, “Manufacturing processes for Engineering Materials”,Addision, Wesley, 1997.
3. P.C. Mukherjee, Fundamentals of metal casting technology — Oxford and IBH
4. Beely, Foundry Technology, Newnes-Butterworths, 1979
Reference Books:
1. Casting properties of metals and alloys —V. Korolkove.
2. ASM Hand Book “Casting”, ASM International 1998.</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 621</td><td>Mechanics of Composite and Functionally Graded Materials</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">XEC01,MEC301</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1:Concept of orthotropic materials
CO2:Analysis of composite structures
CO3:Concept of FGM</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Composites, various reinforcement and matrix materials. 3
Concept of orthotropic, transversely isotropic material, stress-strain relation for orthotropic and transversely isotropic material. Engineering constants for these materials. Transformation of stress and strain. 8
Micromechanical behavior of lamina. 6
Macro mechanical behavior of lamina, Classical lamination theory, Laminate stiffness of a few cases, Stress strain variation in a laminate. 8
Equation of equilibrium for laminated plates for bending, Solution technique for bending of simply supported laminated plates under uniformly distribute transverse load. 8
Failure criterion of composites. 4
Introduction to FGM. 5</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Mechanics of composite materials By R. M. Jones (Taylor and Francis)
2. Engineering mechanics of composite materials By I. M. Daniel , O. Ishai (Oxford University Press)</td></tr>
<tr><td colspan="7">Reference Books:
1. Mechanics of laminated composites plates and shells By J. N. Reddy (CRC Press)
2. The behavior of structures composed of composite materials By Jack R. Vinson and Robert L. Sierakowski</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 622</td><td>Engineering Optimization</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NIL</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to describe and formulate optimization problems
CO2: Students will be able to apply knowledge of different optimization methods for solving engineering problems
CO3: Students will be able to differentiate between optimization methods and suggest a suitable technique applicable for a specific problem.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Engineering Application, Statement and Classification of the Optimization Problem, Classification, formulation procedures. 4
Classical Methods: Single Variable Optimization; Multivariable Optimization without any Constraints with Equality and Inequality Constraints, Kuhn–Tucker Conditions; Linear Optimization Methods, One-Dimensional Minimization Method. Unimodal Function. 6
Elimination Methods: Exhaustive search, Fibonocci and Golden Method. 3
Interpolation Method – Quadratic and Cubic Interpolation Method. 2
Unconstrained Minimization Method — Univariate, Conjugate Directions, Steepest Descent (Cauchy) Method, Newton's Method, Marquardt Method, Quasi-Newton Method. 6
Constrained Minimization Method, Random Search Methods, Sequential Quadratic Programming. Basic Approach of the Penalty Function Method, Interior Penalty Function Method, Exterior Penalty Function Method. 5
Non-traditional Optimization Techniques — Genetic Algorithms. Simulated annealing. Particle swarm optimization. Ant Colony Optimization. Tabu search. 11
Reduction of size of an optimization problem. Scaling of design variables and constraints. 3
Introduction to optimization Toolbox in MATLAB. 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. S.S. Rao, Engineering Optimization, Theory and Practics, 3rd Enlarged Edition, New Age International Publishers, New Delhi, 2010.
2. Ashok D. Belegundu and Tirupathi R Chandrupatla, Optimization Concepts and Applications in Engineering, Pearson Education 1999, First India Reprint, 2002.</td></tr>
<tr><td colspan="7">Reference Books:
1. G. N. Vanderplaats, Numerical Optimization Techniques for Engineering Design with Applications, McGraw-Hill, New York, 1984.
2. R. L. Fox, Optimization Methods for Engineering Design, Addison- Wesley, Reading, Mass, 1971.</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 623	**Multi Phase Flow and Heat Transfer**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC303, MEC403		CT+EA					

Course Outcomes	CO1: Leads students toward a clear understanding and firm grasp of the basic principles of multi phase flow and heat transfer. CO2: Understands the fluid-dynamic involved in convection and multi-phase heat transfer. CO3: Performs elementary analysis of most gas-liquid two-phase systems and prepares to use more advanced models. CO4: Equips the student with the analytical model to apply the fundamentals to a wide variety of complex engineering problems, formulate them and interpret the results. CO5: Student can analyze Hydrodynamics of three phase flows and compare two phase flow situations.
Topics Covered	Introduction, Flow Regimes, 5 Homogeneous Flow, Separated Flow 4 Condensation, 2 One dimensional steady separated flow model, 6 Flow in which inertia effects dominate, energy equations, 3 The separated flow model for stratified and annular flow, 2 General theory of drift flux model, 3 Application of drift flux model to bubbly and slug flow, 4 Hydrodynamics of solid-liquid and gas-solid flow, 4 An introduction to three phase flow, 3 Fluid-Population Balance Technique, Volume of Fluid Method, Lattice Boltzmann Model. 6
Text Books, and/or reference material	**Text Books:** 1. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press. 2. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press 3. Wallis, G.B., One Dimensional Two Phase Flow, McGraw Hill Higher Education. 4. Hewitt, G.F., Measurement of Two Phase Flow Parameters. 5. Govier, G.W., and Aziz, k., Flow of Complex Mixtures. 6. Hetsroni, G., Handbook of Multiphase systems.

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 624</td><td>Tribology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 301, MEC 502, MEC 504</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces.
CO2: To learn the basic theory and application of friction and wear for different materials
CO3: To learn about lubricants and lubrication for different bearings
CO4: Introduced to Bio-tribology of human joints
CO5: Introduced to Micro-tribology for MEMS applications</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Surface topography: Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 3
Contact between surfaces: Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces. 6
Friction and Wear of contact surfaces: Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. 12
Lubricant and lubrication: Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications — Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. 12
Microtribology: Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS 7
Biotribology: Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements 8</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Engineering Tribology, Dr. Prasanta Sahoo
2. Introduction to Tribology of Bearings—B.C.Majumder
3. Principles of Tribology—J.Halling
4. Basic Lubrication Theory, Alastair Cameron</td></tr>
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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 625</td><td>Computer Aided Design and Manufacturing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MAC01, MAC02, MEC501</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Able to understand scope and application of CAD/CAM tools in industry
CO2: Able to learn geometric modelling and computer graphics concept in CAD tools
CO3: Able to understand the different design analysis and optimization tools in CAD.
CO4: Able to understand the fundamentals of Additive manufacturing, CNC machine tools, Part programming, FMS etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction: Current trends in Design & Manufacturing, Fundamental concept of CAD-CAM-CAE, Product Life-cycle, Overview of CAD-CAM system. 3
Computer Graphics: Fundamentals of Geometric transformations, Graphics standards, CAD-CAM Data Exchange 4
Geometric Modeling: Basics of Wire-frame entities, curve representation methods Surface entities, Solid modeling & concepts of B-rep and CSG representation scheme 5
5Engineering Analysis Tools: Fundamentals of Finite Element Modeling (FEM), Introduction to design optimization tools. 8
Virtual Prototyping & Rapid Prototyping: Introduction to Virtual Prototyping and its applications in Mechanical Engineering, Principles & applications of Additive manufacturing technologies. 5
Industrial Robotics: Classification, definition of industrial robot, Robot anatomy, Configuration of robots, Application of robot, Robotic end-effector, Robot programming language. 3
CNC Machine tools & CNC Programming: Structure of CNC machine tool & functional units, Designation of axes, Drives & actuation systems, Feedback devices, Automatic tool changer, Part programming fundamentals, Computer Aided Part Programming, APT language structure, CAD interface. 7
Group Technology: Part family, part classification and coding, benefits of group technology 3
Introduction to FMS & CIM: Introduction to FMS, Components of FMS, Fundamentals of CAPP, Introduction to Computer Integrated Manufacturing. 4</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. CAD/CAM: Theory & Practice by I.Zeid
2. CAD/CAM by P.N.Rao
3. Principles of Computer-Aided Design and Manufacturing by Farid Amirouche
4. Computer Graphics by Roy A Plastock</td></tr>
<tr><td colspan="7">Reference Books:
1. Mastering CAD/CAM by I.Zeid
2. Robotics by Fu, Gonzalez, Lee
3. Finite Element Method by J.N.Reddy</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 651	**Engineering Measurement Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 501		CT+EA					
Course Outcomes	CO1: Workshop and precision engineering measurement methods. CO2: Exposure to measuring instruments and their use.						
Topics Covered	Use of different basic measuring instruments. Measurement of external and internal radius. Measurement of external and internal taper. Measurement of bore diameter. Measurement of chordal gear tooth thickness. Measurement of angle of an angle plate. Measurement of diameters of a screw thread. Measurement of error of surface roughness using Talysurf. Measurement of different thread elements using optical projector. Measurement of composite error of gears using Roll Gear Tester.						
Text Books, and/or reference material	Hands out for each experiment. User manual for the instruments.						

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<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 652</td><td>Power Generation Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 304, MEC 403, MEC 502</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Experimentation of refrigerating systems
CO2: Experimentation on steam generators
CO3: Study of steam turbines
CO4: Test on diesel engine
CO5: Experimentation on steam nozzle</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Refrigeration and air-conditioning: Specification, performance test and loading of refrigerators. Concept of air conditioning. Types of air conditioning systems and their application.
Steam generators: Fundamental concept, types, application and performance data. Use of steam for power generation.
Fundamental concept and function of Turbines.
Study of-
Construction of fire tube and water tube boiler.
Starting and loading of fire tube boiler.
Construction of vapour compression refrigerator unit.
Experiments on-
Determination of dryness fraction of steam.
Efficiency test of a boiler.
Performance test of diesel engine using mechanical type dynamometer under variable speed conditions.
Determination of critical pressure ratio of a steam nozzle.
Effect of humidity and outside air temperature on cooling load of air conditioning machine.
Determination of output and back-work ratio of a gas turbine unit under variable load condition.</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Refrigeration and Air-conditioning—W. F. Stoecker, J. W. Jones
2. Refrigeration and Air-conditioning—C. P. Arora
3. Power Plant Engineering—P. K. Nag
4. Power Plant Engineering—F. T. Morse
5. Steam Turbine Design and Practice—Kaerton</td></tr>
<tr><td colspan="7">Reference Books:
1. Jeffrey M Gordon, Kim Choon Ng, Cool Thermodynamics, Viva Books, 2008.
2. Refrigeration and Air-conditioning—R. C. Jordon, G. B. Priester
3. Modern Air-conditioning, Heating and Ventilation—W. H. Carrier, R. E. Cherne</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 653</td><td>Machine Design Sessional - I</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 401, MEC 503, ME551</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Acquire basic idea about making the design and production drawing for simple and common mechanical assembly.
CO2: To understand the method of implementation of engineering tolerances.
CO3: To identify the importance of using the standards and use of catalogues in making the design.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Design and Drawing of Machine Elements:
Cotter joint, Flexible Coupling, Screw Jack. (36)
Problems as assigned by the concerned teacher (6)</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Design of Machine Elements – V.B. Bhandari
2. Design of Machine Elements – M.F. Spotts
3. Design Data Book – P.S.G. College of Technology, Coimbatore.</td></tr>
<tr><td colspan="7">Reference Books:
1. Mechanical Engineering Design – J.E. Shigley
2. Fundamentals of Mechanical Design – R.M. Phelan</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 654	**Manufacturing Laboratory**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
WSS51, MEC 402, WSS581		CT+EA					
Course Outcomes	CO1: Hands on practice on different job manufacturing by milling machine CO2: Understanding power transmission mechanism in lathe, drilling machine, Milling machine etc. CO3: Exposure to grinding machine and job practice CO4: Exposure to NC/CNC machines, part programming, and job practice CO5: Job practice in nonconventional machining, ECM, EDM etc.						
Topics Covered	Centre lathe — general features, parts and functions, Mechanism of power transmissions. Lathe operations — straight, taper and eccentric turning, thread cutting, drilling, boring, profile turning, knurling. Horizontal and Vertical milling machine – Spindle drives and feed motion — Milling cutters – indexing head – Simple, compound and differential indexing, Shaping machine – cutting motion and feed motion, slotting machine, Grinding machine – Cutting variables — selection of speeds, feeds and depth of cut — use of cutting fluids — Methods of holding work. Grinding machine – Surface grinding Unconventional machining, NC/CNC machine. **Exercises:** Shaping and slotting Exercises —Flat and bevel surfaces, grooves, Slots, guide ways, key ways etc. Exercises in horizontal and —surface, slot, key way and gear milling-Vertical milling machine. Grinding Exercises. Non – traditional Machining, NC/CNC Machining.						
Text Books, and/or reference material	**Text Books:** 1. Manufacturing Processes for Engg. Materials — Kalpakjian 2. Production Technology (vol I & II)—R. K. Jain and S.C. Gupta 3. A Course in Workshop Technology (vol I & II)—B.S.Raghuwanshi						
	Reference Books: 1. Manufacturing Science—A. Ghosh, A.K.Mallik 2. Principles of Foundry Technology—P.L.Jain						

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td colspan="8">OPEN ELECTIVE OFFERED FOR OTHER DEPARTMENTS</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEO 641</td><td>Tribology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NA</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn the basic knowledge of surface topography and contact between engineering surfaces.
CO2: To learn the basic theory and application of friction and wear for different materials
CO3: To learn about lubricants and lubrication for different bearings
CO4: Introduced to Bio-tribology of human joints
CO5: Introduced to Micro-tribology for MEMS applications</td></tr>
<tr><td>Topics Covered</td><td colspan="7"><u>Part I - Basic Tribology</u>

Surface topography: Measurement of surface topography; Quantifying surface roughness; The topography of engineering surfaces. 2
Contact between surfaces: Hertzian contact – sphere on sphere contact and cylinder on cylinder contact; Contact between rough surfaces. 4
Friction and Wear of contact surfaces: Laws and Theories of friction and wear; Friction and Wear of different materials; Application to friction materials. 8
Lubricants and lubrication: Viscosity of lubricants; Composition and properties of oils and greases; Reynolds equation; Type of lubrications - Hydrostatic lubrication, Hydrodynamic lubrication; Elastohydrodynamic lubrication; Boundary lubrication, and application to bearings. 14

<u>Part II - Advanced Tribology</u>

Microtribology: Surface forces and adhesion; Atomic force microscopy (AFM); Friction, wear and lubrication on atomic level; Applications to MEMS. 6
Biotribology: Natural human joints; Structure and properties of articular cartilage; Mechanism of synovial lubrication: Mechanism of articular cartilage damage; Artificial joint replacements; Skin Tribology 8</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Engineering Tribology - Dr. Prasanta Sahoo
2. Introduction to Tribology of Bearings-- B.C.Majumder
3. Principles of Tribology-- J.Halling
4. Basic Lubrication Theory - Alastair Cameron</td></tr>
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SEVENTH SEMESTER

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<tr><td colspan="8">Department of Management Sciences</td></tr>
<tr><td colspan="8">(FOR ME STUDENTS)</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MSC731</td><td>PRINCIPLES OF MANAGEMENT</td><td>PCR</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous assessment (CA) and end assessment (EA))</td></tr>
<tr><td colspan="3">NIL</td><td colspan="5">CA+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">• CO1:To make budding engineers aware of various management functions required for any organization
• CO2:To impart knowledge on various tools and techniques applied by the executives of an organization
• CO3:To make potential engineers aware of managerial function so that it would help for their professional career
• CO4:To impart knowledge on organizational activities operational and strategic both in nature
• C05: To impart knowledge on each functional area of management like Marketing, Finance, Behavioral Science, Quantitative Techniques and Decision Science</td></tr>
<tr><td>Topics Covered</td><td colspan="7">UNIT I: Management Functions and Business Environment: Business environment- macro, Business environment -micro; Porter's five forces, Management functions –overview, Different levels and roles of management, Planning- Steps, Planning and environmental analysis with SWOT, Application of BCG matrix in organization (8)
UNIT II: Quantitative tools and techniques used in management: Forecasting techniques, Decision analysis, PERT & CPM as controlling technique (7)
UNIT III: Creating and delivering superior customer value: Basic understanding of marketing, Consumer behavior-fundamentals, Segmentation, Targeting & Positioning, Product Life cycle. (8)
UNIT IV: Behavioral management of individual: Motivation, Leadership, Perception, Learning. (8)
UNIT V: Finance and Accounting: Basics of Financial management of an organization, Preparation of Final Accounts, Analysis of Financial statements, Cost Volume Profit (CVP) Analysis, An overview of financial market with special reference to India. (12)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Financial Management, 11th Edition, I M Pandey, Vikas Publishing House.
2. Marketing Management 15th Edition, Philip Kotler and Kelvin Keller, Pearson India
3. Management Principles, Processes and practice, first edition, Anil Bhat and Arya Kumar, Oxford Higher education
4. Organizational Behavior,13 th edition, Stephen P Robbins, Pearson Prentice hall India
5. Operations Management, 7th edition (Quality control, Forecasting), Buffa & Sarin, Willey</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 710</td><td>Finite Element Method</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Corse Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MAC01, MAC02, MEC 301</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To obtain an understanding of the fundamental theory of the FEA method
CO2: To develop the ability to generate the governing FE equations for systems governed by partial differential equations
CO3: To understand the use of the basic finite elements for analysis of bar, truss, beam etc.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Approximation Methods for solving Differential Equations, weak form of differential equation 8
One-dimensional FE formulation 6
FE formulation of truss and frames 5
Two dimensional FE formulation, Plane stress/ plane strain problem, Axisymmetric problem. 8
FE formulation for bending of beam 5
Free vibration of bar and beam 6
Concept of continuity and convergence criteria. 4</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Text book of Finite Element Analysis by P. Sesu (PHI)
2. Introduction to Finite Elements in Engineering by T. R. Chandrupatla, A. D. Belegundu (Prentice- Hall)
3. An Introduction to the Finite Element Method by J. N. Reddy (Tata McGraw Hill)
Reference Books:
1. Finite Element Procedures by K. J. Bathe (Prentice Hall)
2. Finite Element analysis Theory and Programming by C. S. Krishnamoorthy (Tata McGraw Hill)
3. Concepts and applications of finite element analysis by R. D. Cook, D. S. Malkus etc. (Wiley)</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE711</td><td>Computational Fluid Dynamics and Heat Transfer</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC303, MEC304</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn to model a physical Fluid Mechanical and Heat Transfer problem (both Laminar & Turbulent Flow) mathematically in terms of PDEs.
CO3: To learn discretization of the PDEs using Finite Difference and Finite Volume Methods
CO3: To learn R-K4 method to solve ODEs and Techniques to solve PDEs.
CO4: To learn to solve simple Heat transfer Problems and Viscous Incompressible Fluid Flow problems using MATLAB coding and checking the same by simulation using ANSYS-Fluent software.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Coservation equations of fluid flow and heat transfer:
Mass, momentum (NS-equation), energy conservation equation and equation of state, Stream function- Vorticity method and Laminar Boundary layer equations for Viscous and Thermal Boundary layer. Classification of PDEs: Elliptical, Parabolic and Hyperbolic PDEs, Initial and Boundary value problems, some examples. Numerical methods: (1) Jacobi Iteration, (2)Point Gauss Siedel iteration (3), Line Gauss Siedel iteration (4) Point Successive over / under relaxation method and (5) TDMA using Thomas Algorithm. 9
Turbulence modeling: (1) RANS equations with (a) Mixing length model, (b) The k-ε model and (c) k-ω model. (2) Large eddy Simulation (Concept only) and (3) Direct Numerical Simulation, DNS (Issues and concepts). 5
Discretization techniques of PDEs:
Finite Difference Methods: Central, Forward and Backward Differencing for both uniform and non-uniform grids. Numerical errors and accuracy; Consistency, Convergence and Stability of finite difference scheme. Grid generation, Discretization and solution using Matlab coding of both Steady and Unsteady Diffusion problems and Convetion-Diffusion problems.
Finite volume Method: Conservativeness, Boundedness and Transportiveness, Central differencing schemes, Upwind differencing schemes, Hybrid differencing schemes and Power law schemes, Quadratic Upstream Interpolation for Convective Kinetics (QUICK). 14
Numerical methods for Viscous Incompressible Fluid Flow:
Runge-Kutta methods and its application to solve Viscous Boundary layer equations (Blasius equation for flat plate) and Thermal boundary layer equations. Stream function- Vorticity method, MAC algorithm, SIPLE, SIMPLER, SIMPLEC and PISO to solve Viscous incompressible fluid flow. 14</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Pradip Neogy, S. K. Chakraborty and M. K. Laha: Introduction to Computational Fluid Dynamics;
2. H. K. Versteeg. And W. Malalasekera : An Introduction to Computational Fluid Dynamics: The Finite Volume Method.
3. P.S. Ghoshdastidar: Computational Fluid Dynamics and Heat Transfer.
Reference Books:
1. Tannehill, J. C., Anderson, D. A. and Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, McGraw Hill, 2002.
Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Ane Books-New Delhi, 1980.
2. Blazek, J., Computational Fluid Dynamics: Principles and Applications, 2nd Edition, Elsevier Science & Technology, 2006.
3. Chung, T. J., Computational Fluid Dynamics, Cambridge University Press, 2003.</td></tr>
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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 712	**Design and Optimization of Thermal Systems**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 304, MEC 403, MEC 502		CT+EA					

Course Outcomes	CO1: Latest methodologies for the design of thermal system CO2: Use of economics, system simulation and optimization method for thermal system CO3: Will learn exergy analysis and its application for thermal system CO4: Use of 81hermos-ecological parameters to assess various thermal system CO5: Modeling of energy system
Topics Covered	1..Introduction to Thermal System Design Introduction, Life cycle design Thermal system design aspects Computer aided thermal system design 2. Thermodynamics, Modelling, and Design Analysis Basic concepts and definition Control volume aspects Property relations Reacting mixtures and combustion Modelling and design of piping systems 3. Thermodynamic Modelling of Polygeneration System Modelling of Power Generation Modelling of Cogeneration Modelling of Polygeneration 4. Exergy Analysis Why exergy and energy analysis Balances for mass, energy and entropy Physical exergy Chemical exergy Exergy for systems and flows Exergy balance Reference environment Applications 5. Applications with Thermodynamics and Heat and Fluid Flow Heat transfer Heat exchangers Trade-off between thermal and fluid flow irreversibility Application to power generation and refrigeration 6. Economic Analysis Estimation of capital investment Principles of economic evaluation Cost of utility Profitability evaluation 7. Thermoeconomic Analysis and Evaluation Fundamental of thermoeconomics Thermoeconomic variable for component evaluation Costing considerations 8. Problem Formulation and Method for Optimization Introduction Optimization method Optimization of thermal systems

	Practical aspects 9. Thermoeconomic Optimization Introduction to optimization Cost optimal exergetic efficiency Optimization of heat exchanger networks Enhanced system optimization 10. Exergy Method: Ecological Applications Cumulative exergy consumption Thermo-ecological cost Applications
Text Books, and/or reference material	Text Books: 1. Bejan A., Tsatsaronis G., Moran M.; Thermal design and optimization. Wiley. 2. Jaluria Y., Design and optimization of thermal system. CRC Press. 3. Szargut J., Exergy method: Technical and ecological applications. WIT Press. 4. Dincer I., Rosen MA., Exergy: Energy, environment and sustainable development. Elsevier.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 713</td><td>Non-conventional Machining</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC501</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Cutting edge technology for nonconventional/ precision machining.
CO2: Emerging trend of metal removal process</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction 1
ECM: Working Principle; ECM Machine Tool; Process performances; Advantages, limitations and applications; ECG- Working Principles; ECG Machine Tool; Process performances; Advantages, limitations and applications; Electrochemical Debarring (ECDe), Shaped Tube Electrolytic Machining (STEM). 8
AJM, Water Jet Machining and Abrasive Water Jet Machining 8
USM: Working Principles, USM Machine Tool, Mechanics of cutting, Process capabilities, Advantages, limitations and applications. 4
FIB: Working Principles, Machine Tool , Mechanism of material removal and surface modification 4
EDM: Working Principles, EDM Machine Tool – Power Supply, Dielectric System, Electrodes, Servo-system, Pulse generating Circuits and analysis, Process Variables and Process Characteristics; Electrical Discharge Grinding; 4
Wire-cut EDM: Working Principles, EDM Machine Tool, Process Variables and Process Characteristics. 4
LBM: Production of LASERs, Working Principles of LBM, Types of LASERs, Process characteristics, Advantages, Limitations and Applications. 3
EBM: Production of Electron Beam, Working Principles of EBM, Focusing and control of electron beam, Process characteristics, Advantages, Limitations and Applications. 3
Chemical Machining, Micro fabrication and Micromachining 3</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Non-conventional Machining Process: V. K. Jain
2. Modern Machining Processes: Pandey and Shan</td></tr>
<tr><td colspan="7">Reference Books:
1. Manufacturing Science: Ghosh and mallik
2. Non-conventional Machining Process: P. K. Mishra</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE714</td><td>Advanced Welding Technology</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC402</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">• CO1 : To get the knowledge about newly developed welding process and its parameters
• CO2 : To learn various nonconventional welding methods
• CO3 : To learn various application fields of various welding processes</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Welding : Definition, requirements, Conditions for ideal weld, Classification of welding processes (1)
Arc Welding : Arc Initiation, Arc Physics, Arc Maintenance, Power Sources, Power Factor, Duty Cycle, SMAW, GMAW, GTAW, SAW, ESW, EGW, PAW, AHW (10)
Electrodes : Electrode Classification, Electrode Nomenclature, Electrode composition, Basicity Index, Role of different elements, Coating Factor, Selection of electrodes (3)
Weld design and associated symbols (5)
Shielding Gases: Types, roles, features, Selection (1)
Weld Metallurgy: Zones in a weld, HAZ and its calculation, Weld Decay, Weld Distortion, Residual Stresses – their causes, identification and remedy (3)
Solid State welding Processes – Forge Welding, Cold Welding, Friction Welding, Friction Stir Welding (6)
Thermo- Chemical Welding Processes – Thermite welding, etc (3)
Radiant Energy welding Processes – Electron Beam Welding, Laser Beam Welding, Ultrasonic Welding (5)
Welding at Micro and Nano Scale (3)
Automation in Welding (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1) Richard L. Little, Welding and Welding Technology, Tata McGraw Hill, 2004
2) J.F.Lancaster, Metallurgy of welding, Allen & Unwin, London, 1980

Reference Books:
1) V. Tsegelsky, The Electric Welder, Mir Publishers, Moscow, 1968</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 715</td><td>Robotics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC402, MES453</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to discuss the history, concepts and key components of robotics technologies.
CO2: Students will be able to analyse and solve problems spatial transformation, forward and inverse kinematics, dynamics of robot manipulators, jacobian and singularities, joint trajectory for motion planning.
CO3: Students will be able to describe and compare various robot grippers, sensors, actuators and controllers and their perception.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Robotics: Definition, Anatomy, Coordinate Systems, Work Envelopes, Basic structure, classification, applications of robots. 4
Robot Arm Kinematics: Frame transformation, Denavit-Hartenberg convention, Forward and Inverse kinematics of serial manipulator. 10
Linear and Angular Velocity of Links and Statics of Serial manipulator: Jacobians, Singularities. 6
Introduction to Dynamics of Serial Manipulators: Lagrange-Euler formulation. 5
Trajectory Planning of Manipulator: Joint space scheme, Cartesian space scheme. 5
Robot Sensors: Contact type, non-contact type, internal sensor, External sensor, Range sensor, Proximity sensor, touch sensor, Force and torque sensor, Encoders, etc. 7
Robot Grippers. 3
Robot Controllers 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Fu, K., Gonzalez, R. and Lee, C. S. G., Robotics: Control, Sensing, Vision and Intelligence, McGraw- Hill, 1987.
2. Craig, J. J., Introduction to Robotics: Mechanics and Control, 2nd Edition, Addison-Wesley, 1989.
3. Saha, S. K., Introduction to Robotics, TMH Publishing Company Ltd., New Delhi, 2008.
4. Pratihar, D. K., Fundamentals of Robotics, Narosa Publishing House, India, 2017.</td></tr>
<tr><td colspan="7">Reference Books:
1. Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2nd reprint, 2008.
2. Spong, M. W., Hutchison, S., and Vidyasagar, M., Robot Modeling and Control, Wiley India, New Delhi, 2006.</td></tr>
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 716	**Mechanical Equipment Design**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 401, MEC 503		CT+EA					
Course Outcomes	CO1: Exposure to various types of mechanical elements and their design procedure. CO2: Ability to design different mechanical systems independently. CO3: Understand the working of various types of drive systems. CO4: Dealing with the case studies help develop self-confidence.						
Topics Covered	Chain Drive 4 Rope Drive 4 Spiral Bevel Gear Drive 4 CVT Mechanism 4 Design of Pulley and Idlers 5 Design of Worm Gears 4 Cam Mechanisms 4 Disc Brakes 4 Selection of Single-Phase Induction Motors 3 Case Studies 6						
Text Books, and/or reference material	**Text Books:** 1. Black and Adams, Machine Design, McGraw Hill Book Company Private Ltd., USA, 1973. 2. Phelan R.M., Fundamentals of Mechanical Design, TMH, 2015.						
	Reference Books: 1. Burr, Arthur H., and Cheatham, John B., Mechanical Analysis and Design, Prentice Hall, USA,1995 2. Norton, R.L. , Machine Design: An Integrated Approach						

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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 717	**Control Systems**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
MEC 302, MEC 502	CT+EA

Course Outcomes	CO1: Will get exposure to the block diagram based formulations, behavior of linear time continuous control systems. CO2: Ability to analyze the system performance and relative stability information. CO3: Understand the relevance of characteristic roots in the behavior of various dynamic systems. CO4: Ability to design simple controllers for analog systems. CO5: To study and analyze state space methods, controllability and observability of control systems.
Topics Covered	Introduction to Control, Systems and Elements, Transducers, Feedbacks, Classification of systems 3 Mathematical modelling, Block Diagram and Transfer Functions 4 Analysis of Response of simple feedback control systems 5 Structure of Control systems and Control Laws 4 Root locus plot and analysis 5 Stability analysis by frequency response methods – Nyquist and Bode diagrams 5 State-space representations 5 PID controllers – Analysis and design 5 Digital Control Methods. 2 Design of Control Systems in Matlab Simulink Environment. 2 Examples of Control Systems, Laboratory Exercises. 2
Text Books, and/or reference material	**Text Books:** 1. Kuo, B. C., Automatic Control System, 3rd Edition, Prentice Hall Inc., New Jarsey, 1975. 2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011. **Reference Books:** 1. Raven, F. H., Automatic Control Engineering, McGraw Hill Book Company Private Ltd., USA, 1961.

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 718</td><td>Fundamentals of Combustion</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 304, MEC 403, MEC 502</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the physical process involved in combustion
CO2: To be able to model a process involving combustion.
CO3: To acquire an in-depth idea about laminar flames.
CO4: To understand partially premixed flames.
CO5: To learn the intricacies of turbulent flames.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Review of thermodynamics, Chemical kinetics, Mass transfer definitions: Fick’s law
Equations of conservation of species mass, momentum, and energy; multi-component diffusion equation
Schvab-Zel’dovich formulation, Rankine-Hugoniot relations.
Laminar premixed flames: Flame speed, flammability limits, flame stabilization, ignition and quenching.
Laminar diffusion flames: Burke-Schumann problem and droplet burning.
Partially premixed flames</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Principles of Combustion – K. K. Kuo
2. An introduction to combustion – S. R. Turns</td></tr>
<tr><td colspan="7">Reference Books:
Combustion Physics – C. K. Law</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 719</td><td>Modeling and Simulation of Dynamic Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">XEC01, MEC301, MEC504</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 By the end of the course students are able to know the fundamental of modeling and simulation and its usefulness.
CO2 Overview of various modeling software and its usefulness in development of mathematical model.
CO3 Modeling concept for electro-mechanical, mechatronics systems and feedback control.
CO4 Interpretation of simulation results and diagnosis of systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to system modeling 6
Introduction to modeling with examples, introduction to simulation, MATLAB and Simulink, bond graph and Adams multi-body simulation tools.
Modeling of dynamic systems 6
Introduction to dynamic systems with examples, bond graph modeling, causality, generation of system equations, Methods of drawing bond graph models of electrical and mechanical systems.
Modeling of systems (fundamental model) 8
Fundamental models of mechanical, electrical, hydraulic, pneumatic and thermal systems, hydraulic and thermal system modeling, examples of fundamental systems such as two-tank system, thermal damping, compressor-reservoir system, etc.
Modeling of systems (as a combination of subsystems) 10
Linear and nonlinear systems, modeling of systems: a combination of translational and rotational systems, hydro-mechanical systems and electro-mechanical systems, modeling of mechatronic systems and feedback control of mechanical systems.
Simulation and its applications 10
Simulation using Simulink, bond graph and Adams, simulation of simple and compound pendulum, simulation of planar mechanisms, validation of simulation results with examples.</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Bond graph in modeling simulation and fault identification, Amalendu Mukherjee, Arun Kumar Samantaray, and Ranjit Karmakar, CRC Press.
2. MATLAB for mechanical engineers, Rao V. Dukkipati, New age International.</td></tr>
<tr><td colspan="7">Reference Books:
1. Measurements, Modelling and Simulation of Dynamic Systems, Edward Layer, Krzystof Tomczyk, Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.
2. Modelling and simulation Exploring Dynamic System Behavior, Louis G. Birta, Gilbert Arbez, Springer London Ltd</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 720</td><td>Non-Linear Vibration</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 301, MEC 302, MEC 504</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Understanding the various characteristics of nonlinear dynamic system.
CO2: Development of solution procedures employing approximate methods.
CO3: Develop the concept of stability and different methods for stability and bifurcation analysis.
CO4: Analysis of nonlinear system employing numerical techniques and comparing the results with approximate methods.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction:
linear and nonlinear systems, conservative and non-conservative systems; potential well, Phase planes, types of forces and responses, fixed points, periodic, quasi-periodic and chaotic responses; Local and global stability; commonly observed nonlinear phenomena: multiple response, bifurcations, jump phenomena. 9
Analytical solution methods:
Harmonic balance, perturbation techniques (Linstedt-Poincare', method of Multiple Scales, Averaging method) 6
Stability and bifurcation analysis:
static and dynamic bifurcations of fixed point and periodic response, different routes to chaotic response. 6
Numerical techniques:
Time response, phase portrait, FFT, Poincare' maps, point attractors, limit cycles and their numerical computation, strange attractors and chaos; Lyapunov exponents and their determination, basin of attraction: point to point mapping and cell to cell mapping, fractal dimension. 9
Applications:
Single degree of freedom systems: Free vibration-Duffing's oscillator; primary-, secondary- and multiple- resonances; Forced oscillations: Van der Pol's oscillator; parametric excitation: Mathieu's and Hill's equations, Floquet theory; effects of damping and nonlinearity. Multi degree of freedom and continuous systems. 10</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Nayfeh, A. H., and Mook, D. T., Nonlinear Oscillations, Wiley-Interscience, 1979.
2. Hayashi, C. Nonlinear Oscillations in Physical Systems, McGraw-Hill, 1964.</td></tr>
<tr><td colspan="7">Reference Books:
1. Nonlinear Ordinary Differential Equations: An Introduction for Scientists and Engineers, D. Jordon and P. Smith, Oxford
2. Evan-Ivanowski, R. M., Resonance Oscillations in Mechanical Systems, Elsevier.
3. Nayfeh, A. H., and Balachandran, B., Applied Nonlinear Dynamics, Wiley.
4. Seydel, R., From Equilibrium to Chaos: Practical Bifurcation and Stability Analysis, Elsevier.</td></tr>
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<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 721</td><td>Convective Heat and Mass Transfer</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 303, MEC 304, MEC 403</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To acquire an idea about convective transport mechanism
CO2: To learn the basics of convective heat and mass transfer
CO3: To learn about internal and external convection
CO4: To learn about forced and natural convections
CO5: To learn about heat transfer in phase change</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Fundamental principles: Basic laws of fluid mechanics and thermodynamics, scale analysis 4
Laminar Boundary Layer: Concept of velocity and temperature boundary layers, integral solutions, similarity solutions, different wall heating conditions. 4
Laminar Duct Flow: Heat transfer to developed and developing duct flows. 4
External natural convection. 4
Internal natural convection. 4
Turbulent boundary layer flow and turbulent duct flow 5
Free turbulent flows: shear layer, jets and plumes. 4
Convection with change of phase. 6
Mass transfer. 7</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Convection Heat Transfer – A. Bejan
2. Convective Heat Transfer – L.C. Burmeister
3. Convective Heat and Mass Transfer – Kays and Crawford</td></tr>
<tr><td colspan="7">Reference Books:
1. Principles of Convective Heat Transfer – M. Kaviany
2. Convective Heat and Mass Transfer – S. M. Ghiaasiaan
3. Heat Convection – L. M. Jiji</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 722</td><td>Additive Manufacturing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC501</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Able to understand the principles of different additive manufacturing processes
CO2: Able to learn software's for additive manufacturing
CO3: Able to expose materials for Additive Manufacturing and it's selection
CO4: Able to know areas of usage, possibilities and limitations of the additive manufacturing technologies</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Introduction to Additive Manufacturing (AM), Overview, History, Need, Classification, Additive Manufacturing Technology in product development 2
CAD & Reverse Engineering, CAD model preparation – Part Orientation and support generation, Model Slicing, Tool path Generation, Software's for Additive Manufacturing Technology , Model Reconstruction – Data Processing for Additive Manufacturing Technology, Reverse engineering 6
Materials for Additive Manufacturing Technology 4
Different AM processes and relevant process physics, AM process chain 8
Sheet Lamination Processes 1
Photo-polymerization Processes 2
Extrusion-Based Systems 1
Powder Bed Fusion Processes 3
Binder jetting 1
Material jetting 2
Directed Energy Deposition Processes 3
Micro & Nano additive manufacturing processes 4
Design for Additive Manufacturing 3
Applications of Additive Manufacturing 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Ian Gibson, David W. Rosen and Brent Stucker, Additive manufacturing technologies: rapid prototyping to direct digital manufacturing, Springer.
2. C.K. Chua, K.F. Leong and C.S. Lim, 3D Printing and Additive Manufacturing: Principles and Applications, World Scientific.</td></tr>
<tr><td colspan="7">Reference Books:
1. Andreas Gebhardt, Understanding additive manufacturing: rapid prototyping, rapid tooling, rapid manufacturing, Hanser Publishers.</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 723	**Energy Conversion Systems**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 601		CT+EA					

Course Outcomes	CO1: Acquire an idea about different energy conversion technologies CO2: To learn the energy efficient, economically viable, and environmental friendly power generation technologies CO3: To learn about different conventional and non-conventional power generation systems. CO4: Introduced to different direct energy conversion systems
Topics Covered	Global and Indian Energy Scenario 3 Advanced Coal Technologies 6 Advanced Power generation Cycles-Supercritical Power plant, Cogeneration, Combined cycle power plants 7 Fluidized bed combustion 5 Gasification, Integrated Gasification Combined Cycle (IGCC) 6 Direct Energy Conversion: Fuel Cells: Proton Exchange Membrane (PEM) Fuel cells, Solid Oxide Fuel Cells (SOFC), Magneto-Hydro-Dynamic (MHD) Systems 7 Biomass based energy conversion 3 Nuclear Power generation 5
Text Books, and/or reference material	**Text Books:** 1. Principles of Energy Conversion-Archie W. Culp 2. Power Plant Engineering-P.K. Nag
	Reference Books: 1. Fluidized Bed Technology-J.R. Howard 2. PEM Fuel Cells: Theory and Practice- Frano Barbir

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 724</td><td>Hydraulic Machines</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 303</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: To acquire an in depth knowledge of hydraulic machines used in the Industry
CO2: To learn the basic design procedure for different hydraulic machines</td></tr>
<tr><td>Topics Covered</td><td colspan="6">Principles of Similarity, Specific Speed and Unit Quantities (4)
General classification of hydraulic machines – basic principles, torque, power and efficiency. (2)
A Brief introduction of 2 D Cascade Theory for Rotodynamic Machines (4)
Hydraulic Turbines: Classification and types of Turbines. Impulse Turbine:- Pelton Wheel;. Reaction Turbine:- Francis, Propeller and Kaplan turbines; Effective head, Available head and efficiency; Force, Torque, Power, Efficiency and Operation of Turbines; Principles of similarity; Specific speed; Cavitation; Setting of turbines; Draft tubes; Penstocks; Surge tanks; Performance characteristics curves; Selection of types and speeds of turbines; Governing of turbines. (12)
Pumps: Classification ; Rotodynamic pumps:- Centrifugal and Axial flow pumps ; Torque, Power, Efficiency and Operation; Performance Characteristics; Principles of Similarity and Specific speed; Energy losses in pumps; Cavitation; Priming; Power requirements; Homologous operation; Series and Parallel operation; Multistage pumps; Selection and installation of pumps of various duties; Testing of pumps. Cavitation and setting height of turbo machines Reciprocating pumps:- Types; Working principle; Instantaneous discharge and average discharge; Slip; Negative slip, Coefficient of discharge and volumetric efficiency; Work done and overall efficiency; Indicator diagram:- effect of inertia and friction on suction and delivery pipes; Separation head; Effect of bend on delivery pipe; Air vessels; Power saved by air vessels in overcoming pipe friction; Discharge in and out of air vessel. Hydraulic coupling; (12)
Torque converter (2)</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Mechanics of Fluids: Massey, B. S.
2. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, et al.
3. Hydraulic Machinery – Jagdish Lal</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MES 751</td><td>Hydraulic Machine Laboratory</td><td>PCR</td><td>0</td><td>0</td><td>3</td><td>3</td><td>1.5</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">Fluid Mechanics</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To understand the principle of linear momentum..
CO2: To understand the performance characteristics of various pumps.
CO3: To understand the performance characteristics of various turbines.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Performance of Centrifugal Pump.
Performance Test of Reciprocating pump.
Performance Test of Pelton Wheel.
Performance Test of Kaplan Turbine.
Performance Test of Francis Turbine.</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Mechanics of Fluids: Massey, B. S.
2. Fluid Mechanics – J. F. Douglas, J. M. Gasiorek, J. A. Swaffied, L. B. Jack
3. Introduction to Fluid Mechanics and Fluid Machines- S.K. Som, et al.
4. Hydraulic Machinery - Jagdish Lal</td></tr>
<tr><td colspan="7">Reference Books:
1. Fluid Mechanics—F. M. White</td></tr>
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Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MES 752	**Machine Design Sessional – II**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MEC 503		CT+EA					
Course Outcomes	CO1: Acquire basic idea about making the design and production drawing for relatively complicated mechanical systems for example gear boxes. CO2: To understand the method of implementation of engineering tolerances. CO3: To learn about economic design procedures.						
Topics Covered	Design and Drawing of Gear Box (36) Problems as assigned by the concerned teacher (6)						
Text Books, and/or reference material	**Text Books:** 1. Design of Machine Elements – V.B. Bhandari 2. Design of Machine Elements – M.F. Spotts 3. Machine Design: P. H. Black and O. E. Adams 4. Design Data Book – P.S.G. College of Technology, Coimbatore.						
	Reference Books: 1. Mechanical Engineering Design – J.E. Shigley 2. Fundamentals of Mechanical Design – R.M. Phelan 3. Machine Design: An Integrated Approach – R.L. Norton						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES753	**Vocational Training / Summer Internship and Seminar**	PCR	0	0	3	3	1.5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: Exposer to the professional world of engineering and research CO2: Interaction with the people of related field and community at large CO3: Correlation of the theoretical knowledge with the application practice CO4: Learning of technical report writing. CO5: Learning the way of oral presentation to audience.						
Topics Covered	Not required						
Text Books, and/or reference material	As applicable						

Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES754	**Project-I**	PCR	0	0	3	3	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NIL		CE+EA					
Course Outcomes	CO1: Identification of Industrial/ Academic / Engineering Problem CO2: To identify and utilize relevant previous work that supports their selected project problem. CO3: Identification and application of appropriate methodologies to solve the project problem. CO4: Formulation of the problem solution method and timeline. CO5: Meet the relevant field's standards CO6: Project report writing.						
Topics Covered	Related engineering and mathematical fundamentals. Application of the knowledge acquired from the engineering study. Practice of project report writing.						
Text Books, and/or reference material	As required to complete the project and suggested by the thesis supervisor.						

Department of Mechanical Engineering							
OPEN ELECTIVE OFFERED FOR OTHER DEPARTMENTS							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MEO 741	**Non-conventional Energy Systems**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
NA		CT+EA					

Course Outcomes	CO1: Identify and explain the use of non-conventional energy systems. CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development. CO3: Gain insight into the issues surrounding non-conventional energy sources development and use. CO4: Become knowledgeable about applications of non-conventional energy systems as they apply to commercial, residential and industrial markets.
Topics Covered	Traditional energy systems, Sources, Features and characteristics, applications 2 Component of solar energy systems, Collector types and performances, Radiation and meteorological data processing, Long term conversion factors, System conversion and system design procedures, Solar power generation, Solar heating and cooling, Solar passive systems: Solar still, Pond, Greenhouse, Dryer, Trombe wall, Overhangs and Wing walls. 13 Wind energy conversion systems, Estimate of wind energy potential, Aerodynamic and mechanical aspects of wind machine design. 4 Principles and applications of wave energy, Shoreline systems, Near shore systems, Off shore systems 3 Tidal energy, Biomass energy, Operating principle, Wood gassifier, Pyrolysis, Applications 4 Geothermal energy and OTEC. 4 Fuel cell: Types and technology status. 3 Hydel Power Plant: Introduction to hydro-electric power generation, Types of Hydel turbines, Layout and selection of turbines and installation, Geographic limitations, Turbine performance, Comparative analysis between thermal and hydel plants. 9
Text Books, and/or reference material	**Suggested Text Books:** 1) Solar Energy Fundamentals and Applications-- Garg and Prakash 2) Solar Energy-- S. P. Sukhatme **Suggested reference books:** 1) Fundamentals of Renewable Energy Systems-- D. Mukherjee and S. Chakrabarti 2) Non-conventional Energy Sources-- D. S. Chauhan and S. K. Srivastava

EIGHTH SEMESTER

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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)#</td><td>Total Hours</td></tr>
<tr><td>MEE 810</td><td>Solar Energy</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="3">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="3">MEC 304, MEC403, MEC 502, MEC 601</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="8">CO1: Identify and explain the use of active, passive solar thermal systems.
CO2: Develop an understanding that solutions to energy-related problems are complex involving sociological, economic, political and technological considerations, decisions and development.
CO3: Gain insight into the issues surrounding solar energy development and use.
CO4: Become knowledgeable about applications as they apply to commercial, residential and industrial markets.</td></tr>
<tr><td>Topics Covered</td><td colspan="8">Solar Radiation and Measurements: 7
Solar energy option - an overview, Fundamentals of solar radiation, Basic Earth sun-angles, Solar time and equation of time, measurements, Empirical equations for predicting the availability of solar radiation, Computation of radiation on a surface
Liquid Flat Plate Collectors: 8
Liquid flat plate collector design, Efficiency of flat plate collectors and performance analysis,
Flat plate solar air heaters, Other types of solar air heaters, some novel designs, Performance analysis and testing procedures.
Solar Concentric Collectors: 6
Cylindrical parabolic collectors, Performance analysis of cylindrical parabolic collectors, Compound parabolic concentrating collectors, Performance analysis of compound parabolic concentrating collectors, Paraboloid dish collectors.
Solar Thermal Energy Storage system: 5
Need of thermal energy storage, Size and duration of storage, Sensible heat storage, Latent heat storage, PCM, Thermo-chemical energy storage.
Solar Thermal Applications: 8
Solar space heating, active systems, passive system - Trombe wall, Solar refrigeration and air conditioning, Solar cookers, Solar desalination, Solar dryers, Solar ponds and its thermal performance, Solar energy for industrial process heat
Solar Thermo-Mechanical Power Generation: 8
Principles of solar engines, limitation of solar mechanical power conversion, Types of solar power plants, Solar chimney, Parabolic through power plants, Central receiver power plants. Solar furnaces.</td></tr>
<tr><td>Text Books, and/or reference material</td><td colspan="8">Suggested Text Books:
1. Sukhatme S. P., “Solar Energy: Principles of Thermal Collection and Storage,” 3rd Ed., Tata McGraw-Hill Publishing Company Ltd.
2. H. P. Garg and J. Prakash, Solar Energy: fundamentals and applications, 1st Ed., Tata McGraw-Hill Publishing Company Ltd.
Suggested Reference Books:
1. Solar energy Process – Duffie and Beckman, John Wiley</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 811</td><td>Mechatronics</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC 301, MEC 504</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: Students will be able to identify the importance of amalgamation between the electronics and electro-mechanical systems.
CO2: Students will be able to formulate and evaluate behavior of linear time continuous control systems.
CO3: Students will be able to formulate the procedure for converting analog signals to digital form and vice-versa.
CO4: Students will be able to describe signals and its processing by modern electronic methods.
CO5: Students will be able to identify and critically evaluate current developments and emerging trends within the field of mechatronic systems.</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Mechatronic Systems: Introduction, Application of Mechatronics. 2
Sensors and Transducers - Brief review, Simple electronic elements & Operational Amplifiers. 4
Actuators: Pneumatic, Hydraulic, Electrical & Mechanical actuation system, Micro-actuators. 3
Modelling and Simulation of Physical System: System models, Dynamic responses of the system, System transfer functions. 4
Digital logic: Number systems, Boolean algebra, Logic gates - Application gate, Design of logic of digital logic gates. 5
Microprocessors and Micro-Controllers: Introduction, Microprocessor Architecture, Instruction codes, General requirements for implementation issues, Examples. 6
Programmable Logic Controllers: Basic structure, I/O processing, Programming, Timer, Inter relays and Counters. 6
Signal conditioning & Digital communication system: Basics of signal conditioning, Filtering, Data acquisition and Digital signal processing, Digital communication and Communication interface. 6
Mechatronic Systems, Case Studies. 6</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Alciatore, D. G. and Histand, M. B., Introduction to Mechatronics and Measurement Systems, McGraw Hill Publications, 4th Edition, 2012.
2. Bolton, W., Mechatronics, Pearson Education India, 2008.
3. Gaonkar, R.S., Microprocessor Architecture, Programming and Applications with 8085, Penram Publishers India, 6th Edition, 2013.</td></tr>
<tr><td colspan="7">Reference Books:
1. Malvino, A. P., and Bates, D. J., Electronic Principles, TMH Publishing Company Ltd., New Delhi, 8th Edition, 2016.
2. Nise, N. N., Control Systems Engineering, 6th Edition, John Wiley & Sons, Inc., USA, 2011.</td></tr>
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<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 812</td><td>Micro and Nano Manufacturing</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">MEC402, MEC501</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1 : To understand the need for micro and nano scale fabrication
CO2 : To get acquainted with different micro and nano scale fabrication techniques and their characterization
CO3 : To be able to select a suitable micro or nano scale fabrication process based upon the requirement
CO4 : To compare and understand the differences between macro and nano scale fabrication processes</td></tr>
<tr><td>Topics Covered</td><td colspan="7">Need for Micro and Nano Scale Manufacturing Processes : Examples of micro and nano scale parts being used in various applications, How the performances of micro/nano scale components are better AFM, STM, SEM, TEM, XRD, 2
Photo Lithography : Historical perspective, Overview, Electromagnetic Spectrum
Clean Room – Classes, Features
Photoresist: Positive and Negative Photo resists; Glass Transition Temperature, Photoresist deposition: Spin coating, Spray coating, Electro-deposition; Baking, Masks, Exposure: Contact Printing, Projection Printing, Proximity Printing, Development, Critical Dimension, Overall Resolution, Line Width Metrology, Resist Profiles, Photolithography Resolution Enhancement Technology : through Improved Resist Performance, through Improved Mask Technology, through Improved Exposure Technology Reducing the minimum feature dimension in photolithography Examples 10
Dry Etching
Definitions, Plasma, Physics of plasma, Sputtering or Ion Etching, Ion Beam Milling, Plasma Etching, Deep Reactive Ion Etching (DRIE), ICP, Examples 3
Wet Etching
Chemical Milling, Photochemical Milling, Wet Isotropic and Anisotropic Etching, Etch Stop Techniques, 3
Moore's Law , Need for pushing the feature sizes to lower levels,
Next Generation Lithographic Techniques : EUV , XRL, LIGA, EBL : EBL Resists, electron emission, Ion Beam Lithography, Nano Imprint Lithography, Lithographic techniques still in research and developmental state Examples 12
Physical Vapor Deposition: Thermal evaporation, Sputtering– DC and RF Sputtering, Pulsed Laser Deposition – Laser sputtering, Aerosol Deposition Examples 4
Chemical Vapor Deposition: Overview, description, PVD vs CVD, APCVD, LPCVD, PECVD, ALD, Examples 4
Micro and Nano Scale Joining Techniques. 2</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Fundamental of Microfabrication and Nanotechnology Volume 2, by Prof Marc J Madou, CRC Press, Taylor and Francis Group
2. Micro and Nanomanufacturing, Mark J Jackson, Springerlink
3. Micro and Nanomanufacturing Volume 2, Mark J Jackson, Springerlink</td></tr>
<tr><td colspan="7">Reference Books:
Micro/Nano Manufacturing, Hans Nørgaard Hansen and Guido Tosello, MDPI Publishing (for application examples)</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 813	**Microfluidics**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
PHC01, CYC01, BTC01, MEC303, MEC304, MEC403		CT+EA					
Course Outcomes	CO1: To learn micro channel flows with heat transfer. CO2: To learn Surface Tension Driven Flows with real life applications. CO3: To learn Electro-hydro-dynamics fundamentals CO4: To learn Molecular Dynamics Simulations						
Topics Covered	Introduction to Microfluidics: Origin, Definition, Benefits, Challenges, Commercial activities, Physics of miniaturization, Scaling laws, Intermolecular forces, States of matter, Continuum assumption, Governing equations, Constitutive relations 1 Microfluidics- Some Application Examples: Drug delivery, Diagnostics, Bio-sensing 1 Equations of Conservation 1 Navier Stokes Equation 2 Energy Equation 2 Pressure –driven Micro flows: Exact solutions, Couette flow, Poiseuille flow 5 Some Examples of Unsteady Flows: Hydraulic resistance and Circuit analysis, Straight channel of different cross-sections, Channels in series and parallel. 3 Stokes Drag on a Sphere: Stokes drag on a sphere, Time-dependent flows, Two-phase flows 2 Lubrication Theory 2 Boundary Condition in Fluid Mechanics - Slip or No-slip: Gas and liquid flows, Boundary conditions, Slip theory, Transition to turbulence, Low Re flows, Entrance effects 2 Surface Tension Driven Flows: Surface tension and interfacial energy, Young-Laplace equation, Contact angle, Capillary length and capillary rise, Interfacial boundary conditions, Marangoni effect 6 Thin Film Dynamics 4 Introduction to Micro-fabrication: Materials, Clean room, Silicon crystallography, Miller indices. Oxidation, photolithography-mask, spin coating, exposure and development, Etching, Bulk and Surface micromachining, Wafer bonding. Polymer micro fabrication, PMMA/COC/PDMS substrates, micro molding, hot embossing, fluidic interconnections. Electrokinetics: Electrohydrodynamics fundamentals. Electro-osmosis, Debye layer, Thin EDL limit, Ideal electro-osmotic flow, Ideal EOF with back pressure, Cascade electro-osmotic micro pump, EOF of power-law fluids. Electrophoresis of particles, Electrophoretic mobility, Electrophoretic velocity dependence on particle size. Dielectrophoresis, Induced polarization and DEP, Point dipole in a dielectric fluid, DEP force on a dielectric sphere, DEP particle trapping, AC DEP force on a dielectric sphere. Electro-capillary effects, Continuous electro-wetting, Direct electro-wetting, Electro-wetting on dielectric 4 Dispersion, Introduction to Nano fluidics, Introduction to Molecular Dynamics Simulations, Bio microfluidics, Nano fluidic Energy Conversion 4						
Text Books,	**Text Books:** 1) Microfluidics - Stéphane Colin						

and/or reference material	2) Micro- and Nanoscale Fluid Mechanics, Transport in Microfluidic Devices- Brian Kirby, Cambridge University Press .
	Reference Books: 1) Theoretical Microfluidics- Henrik Bruus , Oxford University Press. 2) Fundamentals and Applications of Microfluidics: Nam- Trung Nguyen and Steven T. Wereley

<table>
<tr><td colspan="7">Department of Mechanical Engineering</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEE 814</td><td>Machine Tool Engineering and Automation</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="5">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">ME 402</td><td colspan="5">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="6">CO1: In depth study of mechanical machine tools construction and design.
CO2: Introduction to machine tools automation.</td></tr>
<tr><td>Topics Covered</td><td colspan="6">General principles of Machine Tool design, Machine Tool drives and mechanisms. 2
Design of speed and feed gear box, Optimum design principles for using double bound gears. 12
Design of Machine Tool structures: beds, slides and guides, selection of bearing for machine tools. 3
Hydrostatic and Hydrodynamic lubrication in Machine Tool slide ways and Guides, Stick-slip motion in Machine Tool slide ways. 3
Machine tool rigidity, system compliance and process capability of machine tools. 4
Machine tool inspection, testing and maintenance. 2
Overview on Automation: Definition, application, advantages and disadvantages. Types of automation: fixed automation (automatic machines, transfer devices and semi-automatics), Programmable automation (NC, CNC and machining centres, DNC, adaptive control machines, Industrial robots, CAD/CAM, CIM) and flexible automation (FMS). 5
CNC Hardware: Constructional features, operational characteristics of CNC machine tools, Machine tool drives, sensing devices, open and close loop control 3
CNC machining, part programming, NC tool path generation. 8</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="6">Text Books:
1. Principles of Machine Tools – Sen and Bhattacharya
2. Computer Controlled of Manufacturing Systems – Y. Koren</td></tr>
<tr><td colspan="6">Reference Books:
1. Machine Tool Engineering – N. K. Mehta
2. Numerical Control and Computer Aided Manufacturing – Kundra, Rao and Tiwari</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 815	**Theory of Plates**	PEL	3	0	0	3	3

Pre-requisites	Course Assessment methods (Continuous (CT) and end assessment (EA))
Engineering Mechanics, Strength of Materials	CT+EA

Course Outcomes	CO1:Concept of various plate theory CO2:Derivation of governing equation using virtual displacement theory CO3: Analysis of plates
Topics Covered	Stress strain relations, strain displacement relation, equations of equilibrium, virtual work principle, Classical plate theory, FSDT, HSDT. 8 Pure bending and cylindrical bending of isotropic rectangular plates, Navier and Levy solutions of rectangular plates. 8 Bending of circular plates. 6 Bending analysis of laminated composites plates. 8 Approximate solution methods for plate problems. 6 Dynamics of Plates. 6
Text Books, and/or reference material	**Text Books:** 1. Theory of plates By K. Chandrashekhara (Universities Press) 2. Theory and analysis of elastic plates and shells By J. N. Reddy(CRC Press) 3. Theory of plates and shells By S. P. Timoshenko and S. W. Krieger(Tata Mcgraw-Hill)
	Reference Books: 1. Theory and analysis of plates classical and numerical methods By R. Szilard (Prentice Hall)

Department of Mechanical Engineering							
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			Lecture (L)	Tutorial (T)	Practical (P)	Total Hours	
MEE 816	**Advanced Mechanical Vibration**	PEL	3	0	0	3	3
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
Fundamentals of Vibrations		CT+EA					

Course Outcomes	CO1: Understanding the fundamental material for a modern treatment of vibrations. CO2: Application of Lagrange equations for lumped and continuous systems CO3: Understanding fundamentals of beam theory; extensional, torsional, and flexural vibrations of beams. CO4: Understanding Self-excited vibration, nonlinear vibration etc.
Topics Covered	Review of relevant mathematics: linear algebra 3 Generalized co-ordinates, Lagrange's equations 3 Single-DOF and multi-DOF vibration 7 Vibration Absorber 2 Torsional vibration 4 Periodic excitation and Fourier series, impulse and step response 5 Vibration in continuous systems 4 Self-excited vibration, Criterion of stability; Effect of friction 5 Introduction to nonlinear vibration 7
Text Books, and/or reference material	**Text Books:** 1. Mechanical Vibrations, S. S. Rao, Pearson Education Inc. (4th Ed.), 2007. 2. Fundamental of Vibrations Leonard Meirovitch, Mc-Graw Hill Inc., 2001 3. Vibration and Control, D. J. Inman, John Willey & Sons Inc, 2002
	Reference Books: 1. Mechanical Vibrations, S. Tamadonni & Graham S. Kelly, Schaum's Out line Series, Mc-Graw Hill Inc, 1998. 2. Vibration Condition Monitoring of Machines, J. S. Rao, Tata Mc-Graw Hill, 2006.

<table>
<tr><td colspan="8">Department of Mechanical Engineering</td></tr>
<tr><td colspan="8">OPEN ELECTIVE OFFERED FOR OTHER DEPARTMENTS</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Title of the course</td><td rowspan="2">Program Core (PCR) / Electives (PEL)</td><td colspan="4">Total Number of contact hours</td><td rowspan="2">Credit</td></tr>
<tr><td>Lecture (L)</td><td>Tutorial (T)</td><td>Practical (P)</td><td>Total Hours</td></tr>
<tr><td>MEO 841</td><td>Nonlinear Dynamical Systems</td><td>PEL</td><td>3</td><td>0</td><td>0</td><td>3</td><td>3</td></tr>
<tr><td colspan="2">Pre-requisites</td><td colspan="6">Course Assessment methods (Continuous (CT) and end assessment (EA))</td></tr>
<tr><td colspan="2">NA</td><td colspan="6">CT+EA</td></tr>
<tr><td>Course Outcomes</td><td colspan="7">CO1: To learn stability analysis of nonlinear transient problems in all fields.
CO2: To learn Chaos of nonlinear transient problems using dynamical behaviors (Bifurcations, FFT, Poincare Maps, Lyapunav exponents, Henon maps and Fractals)</td></tr>
<tr><td>Topics Covered</td><td colspan="7">One- Dimensional Flow: Flows on the line, fixed points and stability, linear stability, real life problem and exercises; Flows on circle, Fixed points and stability, real life problem and exercises; Bifurcations: Types of bifurcations, Normal forms of saddle-node , transcritical, pitchfork, Supercritical and Subcritical bifurcations,and imperfect berfercations real life problem and exercises 12
Two -Dimensional Flows: Linear system, Definitions and examples, Classification of Linear system, Exercises, Phase plane, Phase portraits, Fixed points and Linearization of nonlinear systems, Exercises, Limit cycles, Definition and understanding with examples, Poincare theory, FFT of time series data, Exercises, Bifurcations of 2-D system, Saddle-node, Transcritical and Pitchfork Bifurcations, Hopf Bifurcations and its type with normal form, Hopf point and fold points, Hysteresis zone, Poincare map, FFT and phase portrait, Exercises 15
Chaos: Lorenz Equations, Properties of Lorenz Equations, Lorenz map, Exploring parameter Space, Exercises, One-Dimensional Maps, Fixed points and Cobwebs, Logistic maps, Lyapunov Exponent, Exercises, Fractals, Countable and uncountable sets, Cantor Sets, Dimension of a self, similar Fractals, Box dimension, Point wise Correlation Dimensions, Exercises, Strange attractor, Simplest examples, Henon map, Physical examples, Exercises. 15</td></tr>
<tr><td rowspan="2">Text Books, and/or reference material</td><td colspan="7">Text Books:
1. Nonlinear dynamics and Chaos by S. H. Strogatz</td></tr>
<tr><td colspan="7">Reference Books:
1. Chaos and nonlinear dynamics by R. C. Hilborn
2. Differential dynamical systems by J. D. Meiss</td></tr>
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Department of Mechanical Engineering							
Course Code	Title of the course	Program Core (PCR) / Electives (PEL)	Total Number of contact hours				Credit
			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES851	**Project-II**	PCR	0	0	15	15	5
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
All core courses taught up to 6th semester		CE+EA					
Course Outcomes	CO1: Review of project-I CO2: Additional literature survey on selection of the methodology CO3: Solution of the selected problem by using soft tools/ simulation/ model making CO4: To meet the relevant field's standards CO5: Analysis of the solution to arrive at the conclusion CO6: Thesis writing in standard format.						
Topics Covered	Related engineering and mathematical fundamentals. Application of the knowledge acquired from the engineering study and literature survey. Learning of thesis writing.						
Text Books, and/or reference material	As required to complete the project and suggested by the thesis supervisor.						

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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES852	**Project Seminar**	PCR	0	0	0	0	1
Pre-requisites		Course Assessment methods (Continuous (CT) and end assessment (EA))					
MES754 and MES851		CT + EA					
Course Outcomes	Not applicable						
Topics Covered	Work done in MES754 and MES851						
Text Books, and/or reference material	Not applicable						

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			Lecture (L)	Tutorial (T)	Practical (P)#	Total Hours	
MES853	**Viva Voce**	PCR	0	0	0	0	1
Pre-requisites							
NIL		EA					
Course Outcomes	Not applicable						
Topics Covered	All the courses of the B.Tech. Mechanical Engineering programme.						
Text Books, and/or reference material	Not applicable						