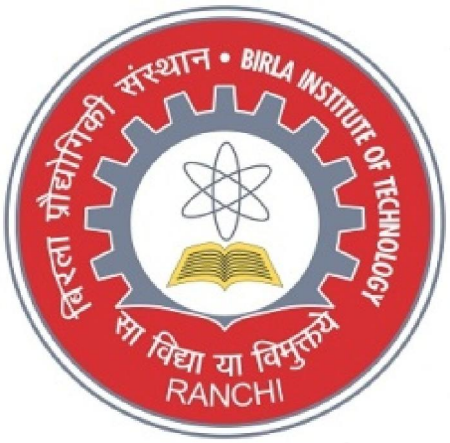
BIRLA INSTITUTE OF TECHNOLOGY



CHOICE BASED CREDIT SYSTEM (CBCS) CURRICULUM

(Effective from Academic Session: Monsoon 2018)

6th Semester Syllabus

BACHELOR OF TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

SIXTH SEMESTER

COURSE INFORMATION SHEET

Course code: ME 305
Course title: Automobile Engineering
Credits: 3 (L: 3, T:0, P: 0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Automotive Electrical and Electronics System: Introduction to electrical system, Battery and Cranking Motor, The charging circuit, the starting and ignition system, Electronically assisted ignition system, Capacitive discharge ignition, Distributor-less ignition, Sensors and applications in automobiles, Pressure sensors, temperature sensors, Position sensors, Lambda sensors, Air flow sensors, Knock sensors, Actuators, Solenoids, stepper motors.	8
Module –II Mechanics of Motor Vehicle: Power for propulsion, rolling, air and grade resistance, traction and tractive effort, road performance curves, Acceleration, gradeability and draw par pull , calculation of maximum acceleration, maximum tractive effort and reactions for different drives.	8
Module – III Power Transmission Systems: General Arrangement of clutch, friction clutch, gear box, torque transmission. Fluid flywheel, sliding, constant and synchromesh type gear box, epicyclic gear box, live axle transmission, rear engine vehicles, type of axles, axle less transmissions, four wheel drive, torque converter, turbo transmitter converter, automatic transmission, Borg-Warner transmission, Automatic control.	8
Module - IV Drive Lines, Brakes and tyres: Universal Joint, Propeller shaft, Live rear axle, final drive, torque reaction, thrust systems, differentials, wheel bearing, front Axle and rear axle, Steering Mechanism and carriage unit, primary construction, Ackerman linkage, centre point steering, Axle construction, wheel alignments, independent and dead axle suspension, frame design, types and action of springs and dampers, chassis lubrication, Brakes, functions and methods of operation, types, linkages, hydraulic mechanism servo and power brakes, types of tyres and tubes.	8
Module –V Modern Technology and Microprocessors in Automobiles: Introduction to hybrid vehicles, components, applications, Introduction to electrical components used in hybrid and electric vehicles, configurations, introduction to energy storage requirements in hybrid and electric vehicles, battery based energy storage, fuel cell based energy storage, hybridization of different energy storage devices, Microprocessor and Microcomputer controlled devices in automobiles, instrument cluster, Voice warning system, travel information system, keyless entry system.	8

TEXT BOOKS:

T1. Automotive Mechanic by W.H. Course.
T2. Automotive Mechanics by Heitner.
T3. Electric and Hybrid Vehicles: Design and Fundamental by Iqbal Hussein

4. Modern Electrical Equipment of Automobiles by Judge A.W

REFERENCE BOOKS :

1. The Motor Vehicles by D.S. Newton and Steeds.
2. Fundamental of motor vehicle technology by Hillier and Peter Coobes.
3. Propulsion System for Hybrid Vehicle by John M. Miller.
4. Automotive Electrical Equipments by Kohli P L

COURSE INFORMATION SHEET

Course code: ME 307
Course title: Robotics Engineering
Credits: 3 (L: 3, T: 0, P: 0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Introduction to Robotics Engineering. Degrees of Freedom for Open and Closed loop systems, Serial robot kinematics: Transformation matrices and homogeneous coordinates, Composite rotation matrix, Rotation about an arbitrary axis, Euler angle representation. Links, Joints and their parameters, Denavit-Hartenberg representation, Forward kinematics.	8
Module –II Inverse kinematics of serial robot: Geometrical and Algebraic Approach. Velocity analysis: Jacobian matrix, Acceleration analysis. Role of Jacobian in robot Statics. Gravity compensation. Trajectory planning: Cartesian and Joint space trajectories, Cubic, cosine, quintic and cycloidal trajectories, Path primitives: Line and Circle in space, Point to point and Continuous path trajectories.	8
Module – III Dynamics of serial robots: Lagrange-Euler formulation, Newton Euler approach, Motion equations of a manipulator. Inverse and Forward dynamics approaches.	8
Module - IV Parallel robot structures, Inverse kinematics of parallel robots, 3-RPS, 6-RPS and 6-RUS structures. Forward kinematics of parallel robot approaches, Introduction to Wheeled mobile robot and Ariel robot subsystems.	8
Module –V Classical Industrial robot systems, PUMA, and SCARA configurations, Robotic system integration, Industrial applications of robotics: Case studies. Advanced concepts: Compliant structures and Force control applications, Redundant systems and associated challenges, System Identification.	8

TEXT BOOKS:

1. Subir Kumar Saha, Introduction to Robotics, TMH, New Delhi, 2014.
2. John J. Craig, Introduction to Robotics, Pearson Education, 2011.
3. J. P. Marlett, Parallel Robots, Springer, 2006.

REFERENCE BOOKS:

1. Dilip K. Pratihar, Fundamentals of Robotics, Narosa Publishing House, 2016.
2. KS Fu, C. S. G Lee, R. Gonzalez, Robotics: Control, Sensing, Vision and Intelligence, McGraw-Hill Education, 1987.
3. Bruno Siciliano and OussamaKhatib, Handbook of Robotics, Springer, 2016.
4. Saeed B. Niku, An Introduction to Robotics Analysis, Systems, Applications, Prentice-Hall, 2001.

COURSE INFORMATION SHEET

Course code: ME359 (Program Elective-3)
Course title: Power Plant Engineering
Credits: 3 (L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Introduction: Principal types of power plants, special features, Advantages and Limitations. Elements of Modern Power Station, Importance of central power station, Review of electricity generation and energy scenario in Indian as well as world context. Application and future trend of developments.	8
Module –II **Thermal Power Plants:** Major components, fuels and their properties, storage, preparation, handling and burning, Ash handling and dust collection, Air pre-heater, Feed water treatment plants, insulation, Heat balance of power plant, Modern development in steam boiler.	8
Module – III **Diesel and Gas Turbine Power Plants:** Introduction, various system required for operation of Diesel Power Plant. Components of gas turbine power plant, different arrangements, optimum design of Gas turbine unit for combined cycle plant, comparative study of diesel and gas turbine plants. **Hydraulic Power Plants:** Different types of hydraulic power plants, rain fall and run-off measurements and plotting of various curves for estimating power available with or without storage.	8
Module - IV **Nuclear Power Plants:** Nuclear Reactors, Types of reactors, Pressurized water reactors, boiling heater reactors, Heavy water-cooled and moderated (CANDU) reactor, Gas-cooled reactors, Liquid metal cooled reactors, Indian Nuclear power installations. **Non-Conventional Power Plants:** Geothermal power plants, Tidal power plants, Wind power plants, solar power plants	8
Module –V **Combined operation of different power plants:** Introduction, Advantages of combined working, load division between power stations, storage type hydro-electric power plant in combination with steam plant, Instrumentation and control. **Economic Analysis:** Difference between Base load and peak load plants, Different terms and definitions, Performance and operating characteristics of power plants, Load division, Tariff method for Electrical Energy.	8

Text Books:

1. Power Plant Engineering: by F.T. Morse.
2. P. K. Nag, Power Plant Engineering, Tata McGraw-Hill, 2008.
3. Power Plant Technology: by M.M.E. Wakil, McGraw Hill Publication.

Reference Books:

1. Power Plant Engineering: by Arora&Domkundwar, Dhanpatrai Publication
2. Power Plant Engineering: by K.K. Ramalingam, Scitech Publications.

COURSE INFORMATION SHEET

Course code: ME 361(Program Elective-3)
Course title: Combustion
Credits: 3 (L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I **Introduction:** Importance of combustion, combustion equipment hostile fire problems,pollution problems arising from combustion. **Thermodynamics of Combustion:** Enthalpy of formation, enthalpy of reaction, heating values, first and second law analysis of reacting systems, chemical equilibrium, equilibrium composition, adiabatic and equilibrium flame temperature.	8
Module –II **Kinetics of Combustion:** Law of mass action, reaction rate, simple and complex reactions, reaction order and molecularity, Arhenius Law, activation energy, Chain reaction steady state and partial equilibrium approximations. Chain explosion, Explosion limits and oxidation characteristics of hydrogen, carbon monoxide and hydrocarbons.	8
Module – III **Flames: Premixed Flames:** structure and propagation of flames in homogeneous gas mixtures; simplified RankineHugoniot relations; properties of hugoniot curve; analysis of deflagration and detonation branches, properties of Chapman Jouguet wave. Laminar flame structure; theories of flame propagation and calculation of flame speeds, flame speed measurements. Stability limits of laminar flames; flammability limits and quenching distance; bumer design. Mechanisms of flame stabilization in laminar and turbulent flows; flame quenching. Diffusion flames; comparison of diffusion with premixed flame. Combustion of gaseous fuel jets Burke and shumann development.	8
Module - IV **Burning of Condensed Phase:** General mass burning considerations, combustion of fuel droplet in a quiescent and convective environment. Introduction to combustion of fuel sprays. **Ignition:** Concepts of ignition, chain ignition, thermal spontaneous ignition, forced ignition.	8
Module –V **Combustion Generated Pollution & its Control:** Introduction, nitrogen oxides thermal fixation of atmospheric nitrogen prompt NO, thermal NOxformation and control in combustors Fuel NOxand control , post-combustion destruction of NOx, Nitrogen dioxide carbon monoxide oxidation -quenching , hydro carbons, sulphur oxides	8

Text books:

1. An Introduction to Combustion, concepts and applications by S. R.Turns, McGraw Hill (2000).
2. Principles of Combustion by K. K. Kuo, John Wiley (2005).

Reference books:

1. Combustion Physics by C.K. Law, Cambridge University Press (2010).
2. Combustion Theory by F.A., Williams Addison Wesley (2007).

COURSE INFORMATION SHEET

Course code: ME 363(Program Elective-3)
Course title: Vehicle Dynamics
Credits: 3 (L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Longitudinal dynamics: An introduction to vehicle dynamics, Vehicle Load Distribution – Acceleration and Braking -Brake Force Distribution, Braking Efficiency and Braking Distance - Longitudinal dynamics of a Tractor-Semi Trailer.	8
Module –II Tire mechanics and a simple tire model: An Introduction: Mechanical Properties of Rubber - Slip, Grip and Rolling Resistance - Tire Construction and Force Development – Contact Patch and Contact Pressure Distribution, Lateral Force Generation - Ply Steer and Conicity -Tire Models – Magic Formula - Classification of Tire Models and Combined Slip.	8
Module – III Lateral Dynamics: Bicycle Model - Stability and Steering Conditions -Understeer Gradient and State space Approach – Handling Response of a Vehicle - Mimuro Plot for Lateral Transient Response - Parameters affecting vehicle handling characteristics.	8
Module - IV Vehicle Handling and Vertical Dynamics: Subjective and Objective Evaluation of Vehicle Handling, Rollover Prevention - Half Car Model - Quarter Car Model.	8
Module –V Vehicle Vibration: Basics of vibration, Lagrange's method and dissipation function, Bicycle, car and body pitch mode, Full car vibrating model, Suspension optimization.	8

Text books:

1. H. B. Pacejka, Tyre and Vehicle Dynamics, Elsevier, 2nd Ed.
2. R. N. Jazar, Vehicle Dynamics: Theory and Application, Springer.
3. T. D. Gillespie, Fundamentals of Vehicle Dynamics, Society of Automotive Engineers.
4. K. Popp and W. Schiehlen, Ground vehicle Dynamics, Springer-Verlag Berlin Heidelberg.

Reference books:

1. J. Reimpell, H. Stoll, and J. W. Betzler, The Automotive Chassis: Engineering Principles,

COURSE INFORMATION SHEET

Course code: ME367 (Programme Elective -3)
Course title: Industrial Tribology
Credits: 3 (L:3,T:0,P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I **Tribology** Introduction and historical background, nature of engineering surfaces, Role of tribology in MEMS/NEMS, factors influencing tribological phenomena. Engineering surfaces- Surface characterization, Computation of surface parameters, Surface measurement techniques, Introduction to micro and nano tribology, Industrial significance and economic aspects.	8
Module –II **Contact of engineering surfaces** Hertzian and non-hertzian contact. Contact pressure and deformation in non-conformal contacts, Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Atomic scale understanding of friction, Surface forces (van der Waals, electrostatic, hydrogen bonding etc.), stick-slip phenomenon, friction anisotropy.	8
Module – III **Wear** Wear and wear types, Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage, wear controlling techniques.	7
Module - IV **Lubrication** Lubricant composition, lubricants types, physical and chemical properties, effect of temperature and pressure on viscosity, additive role and types, elements of lubrication,Lubrication regimes-Boundary Lubrication, Mixed Lubrication, Hydro dynamic lubrication.	9
Module –V **Industrial applications** Solution of tribological problems and recent developments,an overview of engineering materials having potential for tribological application, rolling element bearings, gears, crank shafts, piston rings, cylinder liners etc.	11

Text Book

1. M. Hutchings, Tribology: Friction and Wear of Engineering Materials, Edward Arnold, 1992.
2. K. C. Ludema, Friction, Wear, Lubrication: A Textbook in Tribology, CRC Press, 1996.
3.R. D. Arnell, P. Davies, J. Halling, and T. Whomes, Tribology Principles and Design Applications, MacMillan, 1991.

Reference Book

1. G Bayer, Mechanical wear prediction and prevention- Marcel Dekkar. Inc., New York.
2. B. Bhushan, Principles and Applications of Tribology, Willey –IEEE, 1999.
3. P. Sahoo. Industrial Tribology, Tata McGraw Hill.

COURSE INFORMATION SHEET

Course code: ME365 (Program Elective-3)
Course title: Design of Mechanisms
Credits: 3 (L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Introduction to Mechanisms and number synthesis: Mechanisms, Kinematic pairs, Plane and space mechanisms, Kinematic chains, Kinematic diagram, Kinematic Inversions, Equivalent linkage, Mobility and range of movement, Four and six link mechanisms.	8
Module –II Kinematic Synthesis 1: (Graphical methods) Motion generation with two and three prescribed points, Path generation with three and four points, Function generation with three precession points, The Overlay Method, (Analytical Methods) Complex number modelling in kinematic synthesis, The Dyad, Motion path and function generation with three prescribed points, Three precession point synthesis for multiloop mechanisms, Freudenstein's equation for three point function generation, Loop-closer equation technique.	8
Module – III Kinematic Synthesis 2 and Curvature Theory: Motion generation with four prescribed points, Special cases of four position synthesis, Five position motion generation, Extensions of Burmester point theory for path and function generation, Geared linkages. Curvature theory: Fixed and moving centroide, Velocity and Acceleration, Inflection points and inflection circles, The Euler-Savary Equation, Bobillier's construction, Hartmann's construction, Cusp points.	8
Module - IV Dynamics of Mechanisms: Review kinetostatics using matrix method, Lagrange equation of motion, Force and moment balancing of linkages, Shaking moment balancing, Effect of moment balance on input torque, Analysis of high speed elastic mechanism.	8
Module –V Synthesis of Spatial Linkages: Matrix method for translation and rotation, Modelling and kinematic analysis of spatial mechanisms, Kinematic analysis of industrial robot.	8

Text books:

1. G. N. Sandor and A. G. Erdman, Advanced Mechanism Design: Analysis and Synthesis - Volume 2, Prentice Hall, New Jersey.
2. R. S. Hartenberg and J. Denavit, Kinematic Synthesis of Linkages, McGraw-Hill Book Company.
3. A. K. Mallik, A. Ghosh and G. Dittrich, Kinematic Analysis and Synthesis of Mechanisms, CRC Press.

Reference book:

1. A. G. Erdman, G. N. Sandor and S. Kota, Mechanism Design: Analysis and Synthesis - Volume 1, Prentice Hall, New Jersey.

COURSE INFORMATION SHEET

Course code: ME69 (Program Elective-3)
Course title: GAS DYNAMICS
Credits: 3 **(**L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Fundamental of Gas Dynamics-energy equation, stagnation state and stagnation properties, bulk modulus of elasticity, sound velocity, Mach number, Mach angle, Bernoulli equation, isentropic flow with variable area , flow with variable area in adiabatic processes, area ratio as a function of Mach number, flow through convergent nozzles, divergent nozzle, numerical examples.	8
Module –II Flow with Normal Shock Waves- development of a normal shock wave, governing equations, mach number downstream of the normal shock wave, static pressure ratio across the shock, temperature ratio across the shock, density ratio across the shock (or) Rankine-Hugoniot equation, stagnation pressure ratio across the shock, change in entropy across the shock, impossibility of rarefaction shock wave, strength of a shock wave, numerical examples.	8
Module – III Fanno flow: Fanno curves, Fanno flow equations, solution of Fanno flow equations, variation of flow properties, change of entropy, variation' of mach number with duct length. Rayleigh flow: Rayleigh line, constant entropy lines, constant enthalpy lines, general equations in Rayleigh flow process, Rayleigh flow relations, variation of flow properties, maximum heat transfer. numerical examples.	8
Module - IV Jet Propulsion: Turbo jet, turbo prop engine, pulse jet engine, entropy relations and efficiencies of a turbo jet engine, thrust, propulsive, thermal and overall efficiencies, specific fuel consumption, specific thrust and specific impulse, effect of altitude, effect of forward speed, thrust augmentation, numerical examples.	8
Module –V Comparison between air breathing engines and rocket engines, classification of rocket engines, solid propellant rockets, liquid propellant rockets, hybrid rockets, mono propellants, fuel, oxidizer, properties of liquid and solid propellants, restricted burning, thrust and specific impulse, specific propellant consumption, weight flow coefficient, thrust coefficient, impulse to weight ratio, propulsive, thermal, overall efficiency, application of rocket engines, numerical examples.	8

TEXT BOOKS:

1. Gas Dynamics and Jet Poropulsion, S.L. Somasundaram,, New Age International Publishers.
2. Aircraft Propulsion and Gas Turbine Engines, Ahmed F. El-Sayed, CRC Press.
3. Fundamentals of Compressible Flow, S. M. Yahya, New Age International Publishers.

4. Fundamentals of Gas Dynamics, V. Babu, Ane Books India.

REFERENCE BOOKS:

1. Fluid Mechanics, Fundamentals and Applications(S I Unit), Youns A. Cengel and John M. Cimbala, Tata Mc-Graw Hills Education Pvt. Ltd.
2. Rocker Propulsion Elements, G. P. Sutton, John Wiley, NY.
3. Elements of Gas Dynamics, H.W. Liepmann and A. Roshko, Dover Publications, New York.

COURSE INFORMATION SHEET

Course Code: ME 393(Open Elective -3)
Course Title: Elements of Hydel and Thermal Power plants
Credits: 3 **(**L: 3 T:0 P: 0)
Class schedule per week: 3
Class: B. Tech.
Semester / Level: 6
Branch: Mechanical Engineering
SYLLABUS

MODULE	HOURS
Module – I **Hydel Power plants:** Introduction, Classification of Hydropower plants, Pump Storage power plants, Combine Hydro and Steam turbine Power Plants, essential features of Hydro-electric power plants.	**8**
Module – II **Components of Hydro- electric power plants**: Hydraulic turbines, draft tube, Surge Tanks. Run- off measurements, Hydrograph and Flow duration curve, Mass curve.	**8**
Module – III **Thermal Power Plants:** General layout of thermal power plant, Site selection, Major components. Steam Generators: Boiler mounting and accessories, Different types of super-heaters, Re-heaters, economizers, Air preheaters, Methods of superheat control, Corrosion in boilers and its prevention.	**8**
Module – IV **Coal & Ash Handling Systems:** Coal handling storage of coal, Burning systems, Pulverized fuel handling systems, Unit and central systems, Pulverized mills- ball mill, Bowl mill, Ball &race mill, Impact or hammer mill, Pulverized coal burners, Oil burners. Necessity of ash disposal with respect to state and central pollution control rules, Mechanical, Hydraulic, pneumatic and steam jet ash handling system, Dust collection and its disposal, Mechanical dust collector, Electrostatic precipitator.	**8**
Module – V **Condensers and Cooling Towers:** Types of condensers, sources of air in condenser, Effects of air leakage, Necessity of cooling towers, Types of cooling towers. **Draught System**: Natural draught- estimation of height of chimney, Maximum discharge, Condition, Forced, Induced and balanced draught, Power requirement by fans.	**8**

Text Books:

1. Power Plan tEngineering: by Arora & Domkundwar, DhanpatraiPublication (2016).
2. Power Plant Engineering by P.K.Nag, Tata McGraw Hill Publishing Company Ltd. (2017).
3. Power Plant Engineering by P.C. Sharma, S.K. Kataria & Sons (2015).

Reference Books:

1. Power Plant Engineering: by F.T.Morse. Van Nostrand Reinhold; 3rd edition (1953).
2. Power Plant Technology: by M.M.E.Wakil, McGrawHill Publication (1988).

COURSE INFORMATION SHEET

Course code: ME 373(Program Elective-4)
Course title: Design, Modelling and Application of Solar Energy
Credits: 3 (L:3, T: 0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I **Design concepts of solar systems**: System conceptual design, design of major components, overall system, design of physical principles to the solar system based on application. The process includes idea generation, concepts election and estimation, design of major components, and overall system design, solar radiation data.	8
Module –II **Mathematical Modeling**: overview of modelling – Types, stages, selection of modeling, Renewable Energy Devices and Systems equations, levels of analysis, steps in model development, solving and testing of models.	8
Module – III **Computational Modeling**: Computational modeling overview – Types, stages, selection of the modeling equations, levels of analysis, and steps in model development, solving and testing of models.	8
Module - IV **Solar thermal energy storage**: Design aspects of solar thermal energy storage systems. Selection criteria of storage materials for heating and cooling applications, selection of heat transfer fluid for heating and cooling applications. Case study of design and modelling of solar thermal energy storage-based system.	8
Module –V **Solar photovoltaic system**: Design of photovoltaic off-grid and grid- connected power systems. Design of system components - PV modules, batteries, charge controllers, inverters, auxiliaries. Case study of design and modelling of solar photovoltaic system.	8

Text Book

1. Solar Energy: Fundamentals and Applications by Garg&Prakash, H. P. Garg TMH Publication 2000.
2. Modelling and optimization of renewable energy systems. ArzuSencan. 2012. Intech publication ISBN : 978-953-51-0600-5

Reference Books:

1. Da Rosa. A.V, "Fundamentals of Renewable Energy Processes", 2nd ed., Academic Press, 2009.
2. Bender. E.A, "Introduction to Mathematical Modeling", Dover Publ., 2000
3. Fluid dynamics computational modeling and applications. Edited by L. Hector Juarez February 24th 2012 ISBN: 978-953-51-0052-2

COURSE INFORMATION SHEET

Course code: ME 375(Program Elective-4)
Course title: Power Gear Train
Credits: 3 **(**L:3, T: 0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Gear Drive: Principle of Transmission and Conjugate Action, Gear Materials, Spur Gear, Types of Gear Teeth, Beam Strength of Spur Gear, Effective tooth load, Contact stress and surface Durability	8
Module –II Helical Gears: Parameters of a Helical Gear, Virtual number of teeth on Helical Gears, Force components on a tooth of Helical Gear, Different strengths of Helical Gear tooth.	8
Module – III Straight Bevel Gears: Bevel Gear basic rack, spiral Bevel gears, Virtual no of teeth, Force analysis of Bevel gears, beam strength of Bevel gear tooth, wear strength of Bevel gear tooth, effective tooth load on Bevel gear, Spotts's Equation for dynamic tooth load.	8
Module - IV Worm and Worm Wheel Set: Parameters of Worm gear set, Worm gear proportions, Force analysis in Worm and wheel set, Effect of rubbing velocity on friction in Worm wheel drive, Materials, Temperature rise of lubricating, Beam and wear strengths of worm wheel set.	8
Module –V Gearbox: Introduction, Resistance to vehicle motion, Types of gearboxes, sliding-mesh gear box, contact-mesh gearbox, synchromesh gearbox, epicyclic gearbox, Wilson gearbox, overdrive, five speed sliding mesh gearbox. Spread sheet applied to the design of Gear train, Gear train diagnostics based on noise and vibration.Case studies of power gear train in Automobiles & Overhead Cranes.	8

TEXT BOOK :
1. Machine Design by U. C. Jindal.

REFERENCE BOOK :
1. Julian Happian-Smith, Introduction to Modern Vehicle Design, Butterworth Heinemann..

COURSE INFORMATION SHEET

Course code: ME 377(Program Elective-4)
Course title: Mechatronics
Credits: 3 (L:3, T:0, P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Introduction : Definition of Mechatronics, Mechatronics in manufacturing products and design, Review of fundamentals of electronics, Gates and K map Minimization ,JK Flip Flop	8
Module –II Signal Conditioning :Mechatronics elements, Data Conversion Devices, Sensors and transducers, Microsensors, Signal processing Devices, Relays, Comparators, Filters, Timers, Transfer Systems , PLC's programming	8
Module – III Processors Controllers and Drives: Microprocessors, Microcontrollers, Drives, Linear motion bearings, cams and ball screws, PID controllers, Closed Loop and Open loop	8
Module - IV Actuators : Servo motors, Stepper motors, Hydraulic actuators, Flow, Pressure and Direction control valves, Pneumatic Actuators, Distribution and conditioning of Compressed air, sytem components and graphic representations	8
Module –V CNC Technology and Robotics : CNC Machines and Part programming, Real time Systems, Industrial Robotics, Case Studies	8

Text book:

1. Introduction to Mechatronics and Measurement System by David G. Alciatore, Michael B. Histamd, McGraw Hill
2. Mechatronics by Bolton, Pearson Education

Reference books:

1. Mechatronics System Design by Devdas and Shetty, Pearson Education
2. CNC TECHNOLOGIES BY HMT LTD MGH

COURSE INFORMATION SHEET

Course code: ME 383(Program Elective-4)
Course title: Automation in Manufacturing
Credits: 3 **(**L: 3,T:0,P:0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Manufacturing automation, components and types of automation, CAD,CAM, Computer Control of Manufacturing Systems. Mechatronics in Manufacturing Systems. Modeling of Mechanical Systems for Mechatronics Applications, Automation Strategies in manufacturing industries.	8
Module –II Basic Principle, classification and structure of NC systems, NC-coordinate system, Constructional features and feedback devices for CNC machine tools, part programming (Fanuc), DNC and adaptive control.	8
Module – III Sensors, Actuators,Control System in manufacturing: Mechanical & Electric mechanical system, Pneumatics and hydraulics and servo control in CNC machine tools, Illustrative examples and case studies.	8
Module - IV Assembly Automation: Automatic Assembly Transfer Systems, Transfer mechanism, buffer storage and control functions for transfer devices, feeding mechanism definition and concept, AGV, AS/RS.	8
Module –V Flexible automation: Flexible manufacturing systems: concept, need, structure & operation, objectives and benefits. Quantitative Analysis of Flexible Manufacturing Systems, Quantitative Analysis in Cellular Manufacturing,CIM.	8

Text Books:

1. Automation, Production System, and CIM,M.P. Groover
2. CNCMachines,P. Radhakrishnan
3. System approach to Computer Integrated Design and Manufacturing: Nanua Singh

References Books:

1. Numerical Control of Machine Tools, Y. Koren
2. Manufacturing Technology II, P.N. Rao
3. Performance Modeling of Automated Manufacturing System : N. Viswannadham& Y Narhari

COURSE INFORMATION SHEET

Course code: ME 385(Program Elective-4)
Course title: Theory of Elasticity
Credits: 3 **(**L: 3, T:0, P: 0)
Class schedule per week: 3
Class: B.Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Fundamentals of stress and strain: Introduction; Body force, surface force and stress vector; The state of stress at a point; Principal stresses; Mohr's circle; Stress invariants; Octahedral stresses; Hydrostatic and deviator stresses; The state of strain at a point; Cubical dilatation; Principal Strains; Generalised Hooke's law.	8
Module –II Derive governing equations of equilibrium; Boundary value problems; Equilibrium equations in cylindrical coordinates; Compatibility Equations.	8
Module – III Methods of Solution of Elasticity Problems – Plane Stress-Plane Strain Problems; Polar coordinates; Axisymmetric problems.	8
Module - IV Two dimensional problems: Airy's stress functions in rectangular coordinates; Investigation of Airy's Stress function for simple beam problems	8
Module –V Energy methods: Castigliano's theorem; approximate solution using Ritz method. Applications of energy methods to various problems.	8

TEXT BOOKS:

1. S.P Timoshenko, J.N. Goodier, Theory of Elasticity, 3rd Ed., McGraw-Hill Book Company, 1970.

REFERENCE BOOKS:

1. L.S. Srinath,Advanced Mechanics of Solids, 3rd Ed., Tata McGraw-Hill Ed. Pvt. Ltd., 2009.

COURSE INFORMATION SHEET

Course code: ME387(Program Elective-4)
Course title: Advanced Heat Transfer
Credits: 3 **(**L: 3, T:0, P: 0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Basic concepts and laws of Heat Transfer, Two-Dimensional Steady-State Conduction, Method of Separation of Variables, Conduction Shape Factor and the Dimensionless Conduction Heat Rate, Finite-Difference Equations, Transient Conduction: General Lumped Capacitance Analysis, Plane Wall with Convection, Radial Systems with Convection, Semi-Infinite Solid, Objects with Constant Surface Temperatures or Surface Heat Fluxes, Periodic Heating, Finite-Difference Methods	8
Module –II Extended surfaces (Fins), Fins of Non-uniform Cross-Sectional Area, circumferential fins. Radiation: Fundamental Concepts, radiation heat transfer by electrical analogy approach, Shape factor, Triangular enclosure, Applications.	8
Module – III Convection Boundary Layers, Boundary Layer Equations, Normalized Boundary Layer Equations, Boundary Layer Analogies, Flat Plate in Parallel Flow, Cylinder in Cross Flow, Sphere, Flow Across Banks of Tubes, Impinging Jets, Packed Beds, Convection Correlations: Noncircular Tubes and the Concentric Tube Annulus, Turbulent Flow in Circular Tubes, Flow in Small Channels, Combined Free and Forced Convection.	8
Module - IV Boiling and Condensation, Dimensionless Parameters, Boiling Modes, Pool Boiling, Pool Boiling Correlations, Forced Convection Boiling, Condensation: Physical Mechanisms, Laminar Film Condensation on a Vertical Plate, Turbulent Film Condensation, Film Condensation on Radial Systems, Condensation in Horizontal Tubes, Drop wise Condensation.	8
Module –V Mass Transfer: Introduction to Diffusion and Convective mass transfer: Significant parameters in convective mass transfer, application of dimensional analysis to Mass Transfer, Analogies among mass, heat, and momentum transfer, Convective mass transfer correlations, Mass transfer between phases, Simultaneous heat and mass transfer.	8

TEXT BOOKS:

1. Fundamentals of Heat and Mass Transfer by Incropera, F. P. and De Witt, D. P
2. Heat and Mass Transfer by P.K. Nag
3. Fundamentals of Engineering Heat and Mass transfer by R. C. Suchdeva
4. Heat and Mass Transfer by Yunus A. Cengel.
5. Data Book: Heat and Mass Transfer by C.P. Kothandraman

REFERENCE BOOKS:

1. Whitaker, S., Fundamental Principles of Heat Transfer, New York, Pergammon, 1997
2. Heat and Mass Transfer by F. Kids
3. Heat and Mass Transfer by J.P. Holman

COURSE INFORMATION SHEET

Course code: ME 381(Program Elective-4)
Course title: Design of Brake System
Credits: 3 **(**L: 3, T:0, P: 0)
Class schedule per week: 3
Class: B. Tech
Semester / Level: 6
Branch: Mechanical Engineering

Syllabus

Module	Hours
Module -I Types of brakes, Friction materials in brakes and their characteristics, Design of Brakes in Passenger cars / Vans: Weight transfer, effect of tire / road adhesion, wheel lock, brake efficiency / adhesion utilization.	8
Module –II Design of Brakes in Vehicle – trailer combinations: in light trailers, overrun brakes, centre axle trailer, chassis trailer.	8
Module – III Brake design Analysis: Brake and shoe Factors in different types of brakes, estimation by analytical methods, Thermal Effects in Friction Brakes (Thermal analysis and Heat Dissipation).	8
Module - IV Electronic brake systems: Features of Anti-lock brake system (ABS), Traction Control System, Electronic Stability Control, Adaptive Cruise Control, trailer Sway Control, Electronic Brake force Distribution (EBD).	8
Module –V Brake Noise: Sources, its analysis (using analytical approaches) and control, system response, modal analysis and variability in brake noise.	8

Text Books

1. Day A, Braking of Road Vehicles, Butterworth Heinmann (Elsevier).
2. Julian Happian-Smith, Introduction to Modern Vehicle Design, Butterworth Heinemann.

Reference Books

1. UweDausend, Bert J. Breuer, Advanced Brake Technology, SAE International.

   Ronald W. Walker, High-Performance Brake Systems, Car Tech Incoporated.

Department of Production Engineering
Birla Institute of TechnologyMesra

Course No.:	**PE324**
Course Title:	Surface Engineering and Laser Additive Manufacturing
Type:	Elective to BTechin Production and Mechanical Engineering
Units:	3-0-0, 3 credits
Instructor:	Indranil Manna
Prerequisites:	none
Aim and Outcome:	The course will train the students about the science and importance of surfaces, surface dependent properties of engineering interest and evaluation, techniques to improve surface dependent properties - conventional and advanced methods, and end with laser assisted additive manufacturing techniques and its application.

Lecture Plan – 40 contact hour (55 min each):

Module I

- Introduction to structure of solids: structure, morphology, energy, types and classification (2 lectures)
- Surface dependent engineering properties: physical, chemical and mechanical – their definition, origin and importance (2 lecture)

Module II

- Common surface initiated engineering degradation/failures and their mechanism: wear, friction,fatigue, corrosion, oxidation (4 lectures)
- Importance of surface engineering (SE), Classification and scope of surface engineering of alloys and components, Methods and principles of surface modification of materials; Strengthening mechanism of engineering materials – metallic and non-metallic (4 lectures)

Module III

- Conventional surface modification methods: shot peening, flame and induction hardening, carburizing, nitriding, diffusion aided surface alloying (8 lectures)

- Surface coating techniques by chemical/electro-chemical routes: electro/electroless deposition, anodizing, galvanizing, etc. (4 lectures)

- Surface coating by physical routes: thermal/plasma spray, physical/chemical vapor deposition, sputtering, etc. (4 lectures)

Module IV

- Advanced surface modification methods: laser, plasma, ion and electron beam assisted surface engineering (6 lectures)

Module V

- Additive manufacturing vis-à-vis subtractive manufacturing, Advantages and challenges, recent trend and innovation, laser assisted additive manufacturing of polymers, metals and alloys, characterization and testing (6 lectures)

TOTAL = 40 lectures

Text Books and References:

1. Surface Engineering for Wear Resistances (Introduction and classification of Wear), By: K.G. Budinski, Prentice Hall, Englewood Cliffs, 1988
2. Corrosion Engineering (classification of Corrosion), By: M.G. Fontana, M.C. Graw Hill, N. York, 1987
3. Materials Science and Engineering by W. D. Callister
4. Introduction to Surface Engineering and Functionally Engineered Materials, by Peter Martin, WILEY, 2011
5. Surface Engineering of Metals: Principles, Equipment, Technologies, by: TadeuszBurakowski, TadeuszWierzchon, CRC Press, 1988
6. Surface Engineering for Corrosion and Wear Resistance, by JR Davis, ASM International, 2001
7. Additive Manufacturing by Andreas Gebhardt and Jan-Steffen Hötter, Springer, 2016
8. Additive Manufacturing of Metals by John O. Milewski, Springer, 2017

COURSE INFORMATION SHEET

Course code:	ME 306
Course title:	Robotics and Automation Lab.
Credits: 1.5	(L:0, T:0, P:3)
Class schedule per week:	3
Class:	B. Tech
Semester / Level:	6
Branch:	Mechanical Engineering

List of experiments:

1. Introduction to Industrial Robot (KUKA KR5 Arc): Frames, Safety, Teach Pendant, etc.
2. Identification of DH Parameters of KUKA KR5 Arc Robot from Technical Specifications and physical and software verification using RoboAnalyzer.
3. End-effector tool calibration and manual/CAD verification.
4. Robot Workspace/Base Calibration.
5. Robot programming for a pick and place operation.
6. Pneumatic Circuit Design for Automated Single Cylinder Reciprocating action.
7. Reciprocating Single Cylinder action using Electro-Pneumatic circuit.
8. Sequential Double Cylinder Reciprocating action using Electro-Pneumatic circuit.
9. PLC: Introduction to Ladder Logic Programming.
10. Programming PLC for Pick and Place Task.
11. Using MATLAB/SimMechanics for perform mechanical simulation.
12. Create and simulate a 2R robot in MATLAB/SimMechanics and control its position.

COURSE INFORMATION SHEET

Course code:	ME 310
Course title:	Automobile Engineering Lab
Credits: 1.5	**(**L: 0, T:0, P:3)
Class schedule per week:	3
Class:	B. Tech
Semester / Level:	6
Branch:	Mechanical Engineering

List of experiments:

1. To study the construction details and general principles of two- stroke and four stroke CI and SI engines.
2. To study the fuel system of engines (carburettor and injector, injection pump, fuel pump, MPFI, SPFI and CRDi).
3. To study the engine lubrication and cooling system.
4. To study the super charging, electrical system and equipment's of an automobile.
5. To study the clutch, gearbox, torque converters.
6. To study the universal joint, back axle construction, propeller shaft and differential.
7. To study the mechanical hydraulic Servo and power operated braking systems.
8. To study the front axle, steering geometry and wheel alignment of a 4 wheel vehicle.
9. To study the springs, torsion bars, independent suspension and shock absorbers (coil leaf and dampers).
10. To study the tyres and wheel balancing.
11. Performance of a power steering system.
12. To study the charging and ignition system of an automobile.
13. Assembly and disassembly of 6-cylinder Diesel engine.