STUDENT HANDBOOK

Applicable for students admitted into

M.TECH Program

2018-2019

Koneru Lakshmaiah Education Foundation
(Deemed to be University estd. u/s. 3 of the UGC Act, 1956)
Accredited by NAAC as 'A' Grade University ❖Approved by AICTE ❖ ISO 9001-2015 Certified
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M.TECH – ROBOTICS & MECHATRONICS
2018-19 Admitted Batch Structure & Syllabus

First Year (First Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5101	Fundamentals of Mechatronics	3	1	0	4	4
2	18 ME 5102	Advanced Engineering Mathematics	3	1	0	4	4
3	18 ME 5103	Sensors and Actuators	3	1	0	4	4
4	18 ME 5104	Modeling and Simulation of Mechatronic Systems	3	0	2	4	4
5		Elective – 1	3	0	0	3	3
6		Elective – 2	3	0	0	3	3
7	18 IE 5149	Seminar	0	0	4	4	2
		Total	**18**	**3**	**6**	**26**	**24**

First Year (Second Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5205	Robotics: Advanced Concepts and Analysis	3	1	0	4	4
2	18 ME 5206	Control of Mechatronic Systems	3	1	0	4	4
3	18 ME 5207	Mechatronics Product Design	3	1	0	4	4
4	18 ME 5208	Precision Engineering	3	1	0	4	4
5		Elective – 3	3	0	0	3	3
6		Elective – 4	3	0	0	3	3
7	18 IE 5250	Term Paper	0	0	4	4	2
		Total	**18**	**4**	**4**	**26**	**24**

Second Year (First & Second Semester):

S.No	Course code	Course Title	Periods			Credits
			L	T	P	
1	18 IE 6050	Dissertation	0	0	72	36

ELECTIVE COURSES

S.No	Course code	Course Title	Periods			Credits
			L	T	P	
Elective-1						
1	18 ME 51A1	Signal Processing in Mechatronic Systems	3	0	0	3
2	18 ME 51A2	MEMS and NEMS	3	0	0	3
3	18 ME 51A3	Vehicle Dynamics and Multi-body Systems	3	0	0	3
Elective-2						
1	18 ME 51B1	Emerging Smart Materials for Mechatronics Applications	3	0	0	3
2	18 ME 51B2	Intelligent Visual Surveillance	3	0	0	3
3	18 ME 51B3	Microprocessors and Embedded Systems	3	0	0	3
Elective-3						
1	18 ME 52C1	Computational Fluid Dynamics	3	0	0	3
2	18 ME 52C2	Nonlinear Optimization	3	0	0	3
Elective-4						
1	18 ME 52D1	Industrial Automation	3	0	0	3
2	18 ME 52D2	Fuzzy Sets and Artificial Intelligence	3	0	0	3

FUNDAMENTALS OF MECHATRONICS

Course Code: 18 ME 5101 **L-T-P: 3-1-0**

Pre-requisite: NIL **Credits: 4**

Syllabus:

Module I: Introduction: Definition of Mechatronics, Mechatronics in manufacturing, Products, and design. Comparison between Traditional and Mechatronics approach.

Module II: Review of fundamentals of electronics. Data conversion devices, sensors, microsensors, transducers, signal processing devices, relays, contactors and timers. Microprocessors controllers and PLCs.

Module III: Drives: stepper motors, servo drives. Ball screws, linear motion bearings, cams, systems controlled by camshafts, electronic cams, indexing mechanisms, tool magazines, transfer systems.

Module IV: Hydraulic systems: flow, pressure and direction control valves, actuators, and supporting elements, hydraulic power packs, pumps. Design of hydraulic circuits. Pneumatics: production, distribution and conditioning of compressed air, system components and graphic representations, design of systems. Description

Module V: Description of PID controllers. CNC machines and part programming. Industrial Robotics.

Text books:

1. HMT ltd. Mechatronics, Tata Mcgraw-Hill, New Delhi, 1988.
2. G.W. Kurtz, J.K. Schueller, P.W. Claar . II, Machine design for mobile and industrial applications, SAE, 1994.
3. T.O. Boucher, Computer automation in manufacturing - an Introduction, Chappman and Hall, 1996.
4. R. Iserman, Mechatronic Systems: Fundamentals, Springer, 1st Edition, 2005
5. Musa Jouaneh, Fundamentals of Mechatronics, 1st Edition, Cengage Learning, 2012.

ADVANCED ENGINEERING MATHEMATICS

Course Code: 18 ME 5102 **L-T-P: 3-1-0**

Pre-requisite: NIL **Credits: 4**

Syllabus:

Linear Algebra: Matrix algebra; basis, dimension and fundamental subspaces; solvability of Ax = b by direct Methods; orthogonality and QR transformation; eigenvalues and eigenvectors, similarity transformation, singular value decomposition, Fourier series, Fourier Transformation, FFT.
Vector Algebra & Calculus: Basic vector algebra; curves; grad, div, curl; line, surface and volume integral, Green's theorem, Stokes's theorem, Gauss-divergence theorem.
Differential Equations: ODE: homogeneous and non-homogeneous equations, Wronskian, Laplace transform, series solutions, Frobenius method, Sturm-Liouville problems, Bessel and Legendre equations, integral transformations; PDE: separation of variables and solution by Fourier Series and Transformations, PDE with variable coefficient.
Numerical Technique: Numerical integration and differentiation; Methods for solution of Initial Value Problems, finite difference methods for ODE and PDE; iterative methods: Jacobi, Gauss-Siedel, and successive over-relaxation.
Complex Number Theory: Analytic function; Cauchy's integral theorem; residue integral method, conformal mapping.
Statistical Methods: Descriptive statistics and data analysis, correlation and regression, probability distribution, analysis of variance, testing of hypothesis.

Text Books:

1. H. Kreyszig, "Advanced Engineering Mathematics", Wiley, (2006).
2. Gilbert Strang, "Linear Algebra and Its Applications", 4th edition, Thomson Brooks/Cole, India (2006).
3. J. W. Brown and R. V. Churchill, "Complex Variables and Applications", McGraw-Hill Companies, Inc., New York (2004).
4. J. W. Brown and R. V. Churchill, "Fourier Series and Boundary Value Problems", McGraw-Hill Companies, Inc., New York (2009).
5. G. F. Simmons, "Differential Equations with Applications and Historical Notes", Tata McGraw-Hill Edition, India (2003).
6. S. L. Ross, "Differential Equations" 3rd edition, John Wiley & Sons, Inc., India (2004).

SENSORS AND ACTUATORS

Course Code: 18 ME 5103 **L-T-P: 3-1-0**

Pre-requisite: NIL **Credits: 4**

Syllabus:

Brief overview of measurement systems, classification, characteristics and calibration of different sensors. Measurement of displacement, position, motion, force, torque, strain gauge, pressure flow, temperature sensor sensors, smart sensor. Optical encoder, tactile and proximity, ultrasonic transducers, opto-electrical sensor, gyroscope. Principles and structures of modern micro sensors, micro-fabrication technologies: bulk micromachining, surface micromachining, LIGA, assembly and packaging.

Pneumatic and hydraulic systems: actuators, definition, example, types, selection. Pneumatic actuator. Electro-pneumatic actuator. Hydraulic actuator, control valves, valve sizing valve selection. Electrical actuating systems: solid-state switches, solenoids, voice coil; electric motors; DC motors, AC motors, single phase motor; 3-phase motor; induction motor; synchronous motor; stepper motors. Piezoelectric actuator: characterization, operation, and fabrication;shapememoryalloys.

Text Books

1. John G. Webster, Editor-in-chief, “Measurement, Instrumentation, and Sensors Handbook”, CRC Press (1999).
2. Jacob Fraden, “Handbook of modern Sensors”, AIP Press, Woodbury (1997).
3. Nadim Maluf, “An Introduction to Microelectromechanical Systems Engineering”, Artech House Publishers, Boston (2000).
4. Marc Madou, “Fundamentals of Microfabrication”, CRC Press, Boca Raton (1997).
5. Gregory Kovacs, “Micromachined Transducers Sourcebook”, McGraw-Hill, New York (1998).
6. E. O. Deobelin and D. Manik, “Measurement Systems – Application and Design”, Tata McGraw-Hill (2004).
7. D. Patranabis, “Principles of Industrial Instrumentation”, Tata McGraw-Hill, eleventh reprint (2004).
8. B. G. Liptak, “Instrument Engineers’ Handbook: Process Measurement and Analysis”, CRC (2003).

MODELING AND SIMULATION OF MECHATRONIC SYSTEMS

Course Code: 18 ME 5104 **L-T-P: 3-0-2**

Pre-requisite: NIL **Credits: 4**

Syllabus:

Physical Modelling: Mechanical and electrical systems, physical laws, continuity equations, compatibility equations, system engineering concept, system modelling with structured analysis, modelling paradigms for mechatronic system, block diagrams, mathematical models, systems of differential-algebraic equations, response analysis of electrical systems, thermal systems, fluid systems, mechanical rotational system, electrical-mechanical coupling.

Simulation Techniques: Solution of model equations and their interpretation, zeroth, first and second order system, solution of 2nd order electro-mechanical equation by finite element method, transfer function and frequency response, non-parametric methods, transient, correlation, frequency, Fourier and spectra analysis, design of identification experiments, choice of model structure, scaling, numeric methods, validation, methods of lumped element simulation, modelling of sensors and actuators, hardware in the loop simulation (HIL), rapid controller prototyping, coupling of simulation tools, simulation of systems in software (MATLAB, LabVIEW) environment.

Modelling and Simulation of Practical Problems:

1. Pure mechanical models
2. Models for electromagnetic actuators including the electrical drivers
3. Models for DC-engines with different closed loop controllers using operational amplifiers
4. Models for transistor amplifiers
5. Models for vehicle system

Text Books:

1. L. Ljung, T. Glad, “Modeling of Dynamical Systems”, Prentice Hall Inc. (1994).
2. D.C. Karnopp, D.L. Margolis and R.C. Rosenberg, “System Dynamics: A Unified Approach”, 2nd Edition, Wiley-Interscience (1990).
3. G. Gordon, “System Simulation”, 2nd Edition, PHI Learning (2009).
4. V. Giurgiutiu and S. E. Lyshevski, “Micromechatronics, Modeling, Analysis, and Design with MATLAB”, 2nd Edition, CRC Press (2009).

SIGNAL PROCESSING IN MECHATRONIC SYSTEMS

Course Code: 18 ME 51A1 **L-T-P: 3-0-0**

Pre-requisite: NIL **Credits: 3**

Syllabus:

Discrete- Time Signals: Sequences; representation of signals on orthogonal basis; Sampling and Reconstruction of signals
Discrete systems: Z-Transform, Analysis of LSI systems, Frequency Analysis, Inverse Systems, Discrete Fourier Transform (DFT), Fast Fourier Transform algorithm, Implementation of Discrete Time Systems.
Frequency selective filters: Ideal filter characteristics, lowpass, highpass, bandpass and bandstop filters, Paley-Wiener criterion, digital resonators, notch filters, comb filters, all-pass filters, inverse systems, minimum phase, maximum phase and mixed phase systems.
Design of FIR and IIR filters: Design of FIR filters using windows, frequency sampling, Design of IIR filters using impulse invariance, bilinear transformation and frequency transformations, Butterworth, Chebyshev Filters.
Introduction to multi-rate signal processing: Decimation, interpolation, polyphase decomposition; digital filter banks: Nyquist filters, two channel quadrature mirror filter bank and perfect reconstruction filter banks, subband coding.
Introduction to DSP Processors: Introduction to various Texas processors such as TMS320C6713, TMS320C6416, DM6437 Digital Video Development Platform with Camera, DevKit8000 OMAP3530 Evaluation Kit.
Applications: Application of DSP to Speech and Radar signal processing, A few case studies of DSP applications in multimedia using TI DSP kits.

Text books:

1. S. K. Mitra, Digital Signal Processing: A computer-Based Approach, 3/e, TMcHl, 2006.
2. A. V. Oppenheim and R. W. Shafer, Discrete-Time Signal Processing, Prentice Hall India, 2/e, 2004.
3. J. G. Proakis and D. G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4/e, Pearson Education, 2007.

References:

1. V.K. Ingle and J.G. Proakis, “Digital signal processing with MATLAB”, Cengage, 2008.
2. T. Bose, Digital Signal and Image Processing, John Wiley and Sons, Inc., Singapore,04.

MEMS AND NEMS

Course Code: 18 ME 51A2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Micro and nano mechanics – principles, methods and strain analysis, an introduction to microsensors and MEMS, Evolution of Microsensors & MEMS, Microsensors & MEMS applications, Microelectronic technologies for MEMS, Micromachining Technology – Surface and Bulk Micromachining, Micromachined Microsensors, Mechanical, Inertial, Biological, Chemical,Acoustic, Microsystems Technology, Integrated Smart Sensors and MEMS, Interface Electronics for MEMS, MEMS Simulators, MEMS for RF Applications, Bonding & Packaging of MEMS, Conclusions & Future Trends.
Nanoelectromechanical systems (NEMS) – a journey from MEMS to NEMS, MEMS vs. NEMS, MEMS based nanotechnology – fabrication, film formation and micromachining, NEMS physics – manifestation of charge discreteness, quantum electrodynamical (QED) forces, quantum entanglement and teleportation, quantum interference, quantum resonant tunneling and quantum transport, Wave phenomena in periodic and aperiodic media – electronic and photonic band gap crystals and their applications, NEMS architecture, Surface Plasmon effects and NEMS fabrication for nanophotonics and nanoelectronics, Surface Plasmon detection – NSOM/SNOM

Text Books

1. Electromechanical Sensors and Actuators, Ilene J. Busch-Vishniac, Springer, 2008.
2. Introduction to Microelectronics Fabrication, Vol. V, G. W. Neudeck and R. F. Pierret (eds.), Addison – Wesley, 1988.
3. Introduction to Microelectromechanical Microwave Systems, H. J. De Loss Santos, 2nd edition, Norwood, MA: Artech, 2004.
4. Microsystems Design, S. D. Senturia, Kluwer – Academic Publishers, Boston MA, 2001.
5. Principles and Applications of Nano-MEMS Physics, H. J. Delos Santos, Springer, 2008.
6. Materials and Process Integration for MEMS Microsystems, Vol. 9, Francis E. H. Tay, Springer, 2002.

Reference Books

1. Quantum Mechanical Tunneling and its Applications, D. K. Roy, World Scientific, Singapore, 1986
2. Encyclopedia of Nanoscience and Technology, Vol. 5, H. S. Nalwa (ed.), American scientific Publishers, 2004
3. Carbon Nanotubes and Related Structures, P. J. F. Harris, Cambridge University Press, UK, 1986.

VEHICLE DYNAMICS AND MULTI-BODY SYSTEMS

Course Code: 18 ME 51A3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Introduction to vehicle dynamics: Vehicle coordinate systems; loads on axles of a parked car and an accelerating car. Acceleration performance: Power-limited acceleration, traction-limited acceleration.
Tire models: Tire construction and terminology; mechanics of force generation; rolling resistance; tractive effort and longitudinal slip; cornering properties of tire; slip angle; camber thrust; aligning moments.
Aerodynamic effects on a vehicle: Mechanics of airflow around the vehicle, pressure distribution, aerodynamic forces; pitching, rolling and yawing moments; crosswind sensitivity.
Braking performance: Basic equations for braking for a vehicle with constant deceleration and deceleration with wind-resistance; braking forces: rolling resistance, aerodynamic drag, driveline drag, grade, tire-road friction; brakes, anti-lock braking system, traction control, brakingefficiency.
Steering systems and cornering: Geometry of steering linkage, steering geometry error; steering system models, neutral steer, under-steer, over-steer, steering ratio, effect of under-steer; steering system force and moments, low speed and high speed cornering; directional stability of the vehicle; influence of front-wheel drive.
Suspension and ride: Suspension types—solid axle suspensions, independent suspensions; suspension geometry; roll centre analysis; active suspension systems; excitation sources for vehicle rider; vehicle response properties, suspension stiffness and damping, suspension isolation, active control, suspension non-linearity, bounce and pitch motion.
Roll-over: Quasi-static roll-over of rigid vehicle and suspended vehicle; transient roll-over, yaw-rollmodel,tripping.
Multi-body systems: Review of Newtonian mechanics for rigid bodies and system of rigid bodies; coordinate transformation between two set of axes in relative motion between one another; Euler angles; angular velocity, angular acceleration, angular momentum etc. in terms of Euler angle parameters; Newton-Euler equations of motion; elementary Lagrangian mechanics: generalised coordinates and constraints; principle of virtual work; Hamilton's principle; Lagrange's equation, generalized forces. Lagrange's equation with constraints, Lagrange's multiplier.

Text Books

1. T.D. Gillespie, "Fundamental of Vehicle Dynamics", SAE Press (1995)
.
2. J.Y. Wong, "Theory of Ground Vehicles", 4th Edition, John Wiley & Sons (2008).
3. Reza N. Jazar, "Vehicle Dynamics: Theory and Application", 1st Edition, 3rd Printing, Springer (2008).
4. R. Rajamani, "Vehicle Dynamics and Control", Springer (2006).
5. A.A. Shabanna, "Dynamics of Multibody Systems", 3rd Edition, Cambridge University Press (2005).

Reference Books

1. G. Genta, “Motor Vehicle Dynamics”, World Scientific Pub. Co. Inc. (1997).
2. H.B. Pacejka, “Tyre and Vehicle Dynamics”, SAE International and Elsevier (2005).
3. Dean Karnopp, “Vehicle Stability”, Marcel Dekker (2004).
4. U. Kiencke and L. Nielsen, “Automotive Control System”, Springer-Verlag, Berlin.
5. M. Abe and W. Manning, “Vehicle Handling Dynamics: Theory and Application”, 1st Edition, Elsevier (2009).
6. L. Meirovitch, “Methods of Analytical Dynamics”, Courier Dover (1970).
7. H. Baruh, “Analytical Dynamics”, WCB/McGraw-Hill (1999).

EMERGING SMART MATERIALS FOR MECHATRONICS APPLICATIONS

Course Code: 18 ME 51B1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Introduction: Smart materials and their application for sensing and actuation, Mechatronics aspects.

Piezoelectric materials: Piezoelectricity and piezoelectric materials, Constitutive equations of piezoelectric materials, Piezoelectric actuator types, Control of piezoelectric actuators, Applications of piezoelectric actuators for precise positioning and scanning.

Shape memory alloys (SMA): Properties of shape memory alloys, Shape memory effects, Pseudo-elasticity in SMA, Design of shape memory actuator, selection of materials, Smart actuation and control, Applications of SMA in precision equipments for automobiles, trains and medical devices.

Electro-active polymers (EAPs): Ionic polymer metal composites (IPMC), Conductive polymers, Carbon nanotubes, Dielectric elastomers, Design & control issues for EAP actuators, Applications of EAP for biomemetic, tactile display and medical devices.

Magnetostrictive materials: Basics of magnetic properties of materials, magnetostriction: constitutive equations, types of magnetostrictive materials, Design & control of magnetostrictive actuators, Applications of magnetostrictive materials for active vibration control. **Summary, conclusion and future outlook:** Comparative analysis of different smart materials based actuators, Conclusions, Future research trend and applications trends of smart materials and smart materials based actuator technology.

Text books:

1. Jose L. Pons, Emerging Actuator Technologies, a Micromechatronics Approach, John Wiley & Sons Ltd, 2005. .
2. Ralph Smith, Smart Material Systems: Model Development, SIAM, Society for Industrial and Applied Mathematics, 2005. .
3. F. Carpi, D. De Rossi, R. Kornbluh, R. Pelrine, P. Sommer-Larsen, Dielectric Elastomers as Electromechanical Transducers, Elsevier, Hungry, 2008. .
4. Y. B. Cohen, Electroactive Polymer (EAP) Actuators as Artificial Muscles Reality, Potential and Challenges, SPIE press, USA, 2004.

INTELLIGENT VISUAL SURVEILLANCE

Course Code: 18 ME 51B2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Basics of Image Processing: Introduction to Image Processing methods, Image Transforms, Wavelet Transform, JPEG Image Compression, Image Formats, Color Spaces- RGB, CMY, HSI.

Video Compression Standards: H. 261, H. 263, H.264, MPEG-1, MPEG-2, MPEG-4, MPEG-7, and MPEG-21, Video shot boundary detection, motion modeling and segmentation techniques.

Object Detection and Classification- Shape based object classification, motion based object classification, Silhouette-Based Method for Object Classification, Viola Jones object detection framework, Multiclass classifier boosting.

Multi-Object Tracking- Classification of multiple interacting objects from video, Region-based Tracking, Contour-based Tracking, Feature-based Tracking, Model-based Tracking, Hybrid Tracking, Particle filter based object tracking, Mean Shift based tracking, Tracking of multiple interacting objects.

Human Activity Recognition- Template based activity recognition, Sequential recognition approaches using state models (Hidden Markov Models), Human Recognition Using Gait, HMM Framework for Gait Recognition, Description based approaches, Human interactions, group activities, Applications and challenges.

Camera Network Calibration - Types of CCTV (closed circuit television) camera- PTZ (pan-tilt zoom) camera, IR (Infrared) camera, IP (Internet Protocal) camera, wireless security camera, Multiple view geometry, camera network calibration, PTZ camera calibration, camera placement, smart imagers and smart cameras.

Text Books

1. Murat A. Tekalp, “Digital Video Processing”, Prentice Hall, 1995.
2. Y. Ma and G. Qian (Ed.), “Intelligent Video Surveillance: Systems and Technology”, CRC Press, 2009.

MICROPROCESSORS AND IMBEDED SYSTEMS

Course Code: 18 ME 51B3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Introduction to Embedded Systems and microcomputers: Introduction to Embedded Systems, Embedded System Applications, Block diagram of embedded systems, Trends in Embedded Industry, Basic Embedded system Models, Embedded System development cycle, Challenges for Embedded system Design, Evolution of computing systems and applications. Basic Computer architecture: Von-Neumann and Harvard Architecture. Basics on Computer organizations. Computing performance, Throughput and Latency, Basic high performance CPU architectures, Microcomputer applications to Embedded systems and Mechatronics.

Microprocessor: 8086 Microprocessor and its Internal Architecture, Pin Configuration and their functions, Mode of Operation, Introduction to I/O and Memory, Timing Diagrams, Introduction to Interrupts.

Microprocessor Programming: Introduction to assembly language, Instruction format, Assembly language programming format, Addressing mode, Instruction Sets, Programming 8086 microprocessor.

Microprocessor Interfacing: Introduction to interfacing, Memory Interfacing, Programmable Peripheral Interfacing, Programmable I/O, Programmable Interrupt Controller, Programmable Timers, Programmable DMA Controller, Programmable Key board Controller, Data acquisition Interfacing: ADC, DAC, Serial and parallel data Communication interfacing.

Microcontroller: Introduction to Microcontroller and its families, Criteria for Choosing Microcontroller. Microcontroller Architecture, Programming model, Addressing modes, Instruction sets, Assembly and C programming for Microcontroller, I/O programming using assembly and C language, Interrupt Controller, I/O interfacing, Timers, Real Time Clock, Serial and parallel Communication protocols, SPI Controllers. LCD Controller.

Microcontroller Interfacing: Introduction to Microcontroller Interfacing and applications: case studies: Display Devices, controllers and Drivers for DC, Servo and Stepper Motor.

Introduction to Advanced Embedded Processor and Software: ARM Processor, Unified Model Language (UML), Embedded OS, Real Time Operating System (RTOS), Embedded C.

Microprocessor and Embedded system Laboratories: Basic assembly language programming implementation on Microprocessor and Microcontroller. Interfacing Displays, Key boards and sensors with Microprocessors and Microcontrollers, Data Acquisition using Microprocessor and Microcontroller, Implementation of Controlling schemes for DC, Servo, Stepper motor using assembly and C programming in microprocessors and Microcontrollers.

Text Books:

1. Introduction to Embedded Systems: Shibu K V, McGRAW Hill Publications.
2. Embedded Systems: Raj Kamal, TATA McGRAW Hill Publications.
3. Computer System Architecture: M. Morris Mano.

4. 8086 Microprocessors and Interfacings: D. Hall, TATA McGRAW Hill .
5. The Intel Microprocessors: B. Brey, Prentice Hall Publications.
6. PIC Microcontrollers and Embedded Systems: M. A. Mazidi, R.D. Mckinlay and D. Casey, Pearson Publications.
7. Programming and Customizing the PIC Microcontroller: M. Predko, McGRAW Hill Publications.
8. Embedded C Programming and Microchip PIC: R. Barnett, L. O'Cull and S. Cox

ROBOTICS: ADVANCED CONCEPTS AND ANALYSIS

Course Code: 18 ME 5205 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Introduction to robotics: brief history, types, classification and usage and the science and technology of robots.

Kinematics of robot: direct and inverse kinematics problems and workspace, inverse kinematics solution for the general 6R manipulator, redundant and over-constrained manipulators. **Velocity and static analysis of manipulators:** Linear and angular velocity, Jacobian of manipulators, singularity, static analysis.

Dynamics of manipulators: formulation of equations of motion, recursive dynamics, and generation of symbolic equations of motion by a computer simulations of robots using software and commercially available packages.

Planning and control: Trajectory planning, position control, force control, hybrid control Industrial and medical robotics: application in manufacturing processes, e.g. casting, welding, painting, machining, heat treatment and nuclear power stations, etc; medical robots: image guided surgical robots, radiotherapy, cancer treatment, etc;

Advanced topics in robotics: Modelling and control of flexible manipulators, wheeled mobile robots, bipeds, etc. Future of robotics.

Reference Books

1. M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, “Industrial Robotics-Technology, Programming and Applications”, McGraw-Hill Book and Company (1986).
2. S. K. Saha, “Introduction to Robotics”, Tata McGraw-Hill Publishing Company Ltd. (2008).
3. S. B. Niku, “Introduction to Robotics–Analysis Systems, Applications”, Pearson Education (2001).
4. . A. Ghosal, Robotics: “Fundamental Concepts and Analysis”, Oxford University Press (2008).
5. Pires, “Industrial Robot Programming–Building Application for the Factories of the Future”, Springer (2007).
6. Peters, “Image Guided Interventions – Technology and Applications”, Springer (2008).
7. K. S. Fu, R. C. Gonzalez and C.S.G. Lee, “ROBOTICS: Control, Sensing, Vision and Intelligence”, McGraw-Hill (1987).
8. J. J. Craig, “Introduction to Robotics: Mechanics and Control”, 2nd edition, Addison-Wesley (1989).

CONTROL OF MECHATRONIC SYSTEMS

Course Code: 18 ME 5206 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Time response design: Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, phase lead and phase-lag design, lag-lead design.

Frequency response design: Bode, polar, Nyquist, Nichols plot, lag, lead, lag-lead compensator, time delay, process plant response curve. PID controller design.

Modern control: Concept of states, state space model, different form, controllability, observability; pole placement by state feedback, observer design, Lunenburg observer, reduced order observer, observer based control.

Optimal control design: Solution-time criterion, control-area criterion, performance indices; zero steady state step error systems; modern control performance index: quadratic performance index, Ricatti equation.

Digital control: Sampling process, sample and hold, analog to digital converter, use of z-transform for closed loop transient response, stability analysis using bilinear transform and Jury method, digital control design using state feedback.

Non-Linear Control System: Common physical non-linear system, phase plane method, system analysis by phase plane method, stability of non-linear system, stability analysis by describing function method, Liapunov's stability criterion, Popov's stability criterion.

Text Books:

1. K. Ogata, "Modern Control Engineering", Prentice Hall India (2002).
2. Gene F. Franklin, J. D. Powell, A E Naeini, "Feedback Control of Dynamic Systems", Pearson (2008).
3. John Van De Vegte, "Feedback Control Systems", Prentice Hall (1993).
4. Thomas Kailath, "Linear Systems", Prentice Hall (1980).
5. Alok Sinha, "Linear Systems: Optimal and Robust Control", Taylor & Francis (2007).
6. Brian D. O. Anderson and John B. Moore, "Optimal Control: Linear Quadratic Methods", Dover Publications (2007).
7. K. Ogata, "Discrete-Time Control Systems", PHI Learning (2009).
8. H.K. Khalil, "Nonlinear Systems", Prentice Hall (2001).

MECHATRONICS PRODUCT DESIGN

Course Code: 18 ME 5207 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Introduction: Integrated Design issues in Mechatronics, Mechatronics Design process, Mechatronics Key Elements, Applications in Mechatronics.

Modeling and simulation of physical systems: Electrical systems, Mechanical systems-translational&rotational systems, fluid systems.

Sensors and Transducers: Introduction, sensor for motion and position measurement, force, torque and tactile sensors, vibration – Acceleration sensors, sensor for flow measurement, temperature sensing devices, sensor applications.

Actuating Devices:DC Motors, Stepper motors, fluid power Actuation, fluid power design elements, piezoelectric Actuators.

System Control – Logic Methods: Number Systems in Mechatronics, Binary Logic, Karnaugh Map Minimization, Programmable Logic Controllers.

Signal Conditioning and Real Time Interfacing: Elements of a Data Acquisition and Control System, Transducers and Signal Conditioning, Devices for Data Conversion, Data Conversion Process.

Case Studies

TEXT BOOKS:

1. DevdasShetty, Richard A.Kolk, “Mechatronics System Design”, PWS Publishing Company, 1997.

2. Boltan, “Mechatronics-Electronic Control Systems in Mechanical and Electrical Engineering”, 2nd Edition, Addison Wesley Longman Ltd., 1999

REFERENCE BOOK:

1. D.A Bradley, D.Dawson, N.C Burd and A.J.Loader, “Mechatronics” CRC Press, 2010.

PRECISION ENGINEERING

Course Code: 18 ME 5208 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Concept of Accuracy and Accuracy of NC Systems:

Introduction-General concept of accuracy of machine tool-spindle rotation accuracy-Displacement accuracy-Influence of Geometric Accuracy of Machine Tools on Work pieceAccuracy-Definition of Accuracy of NC system-Errors due to Numerical Interpolation-Errorsdue to displacement measurement system-Periodic errors-Errors due to velocity Lags-Transient Response.

Geometric Dimensioning and Tolerancing:

Tolerance Zone Conversions – Surfaces, Features, Features of Size, Datum Features – DatumOddly Configured and Curved Surfaces as Datum Features, Equalizing Datums – DatumFeature of Representation – Form Controls, Orientation Controls – Logical Approach toTolerancing.

Tolerances and Fits:

Sign convention-Tolerance zone-Fits-Basic Hole System of fits-Standards of Limits and Fits-Expected accuracy of a manufacturing process-Commonly used classification of types of fits-Tolerances and Fits for bearings-Methods of specifying Fits on splined shafts and holes-Selective assembly-Gauges for the control of distances between axes.

Surface Roughness and Micro finishing Processes:

Relation among the various indices of surface roughness-Ideal and Final Roughness inMachining-Influence of machining parameters on surface roughness-Ideal surface roughnessin slab milling-Bearing area curves-Micro finishing processes in the machining of metals.

Methods of Improving accuracy and surface finish:

Concept of precision Machining-Finish Turning, Boring and Grinding-Precision CylindricalGrinding-Internal Cylindrical Grinding-Errors in shape of surface grinding

Applications and Future Trends in Nano Technology:

Nano-grating system-Nanolithography, photolithography, electron beam lithography-Machining of soft metals, diamond turning, mirror grinding of ceramics-Devlopment ofintelligent products-Nano processing of materials for super high density Ics-Nano-mechanicalparts and micromachines.

TEXT BOOKS:

1. Precision Engineering in Manufacturing / murthy R. L., / New Age International(P)
2. limited,1996.
3. Geometric Dimensioning and Tolerancing / James D.Meadows / Marcel Dekker
4. Inc.1995.
5. Norio Taniguchi,- " Nano Technology ", Oxford university,Press,1996.

REFERENCE BOOKS:

1. Precision Engineering- V. C. Venkatesh, & Sudin Izman/ Tata McGraw-Hill

COMPUTATIONAL FLUID DYNAMICS

Course Code: 18 ME 52C1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Concept of Computational Fluid Dynamics: Different techniques of solving fluid dynamics problems, their merits and demerits, governing equations of fluid dynamics and boundary conditions, classification of partial differential equations and their physical behavior, Navier-Stokes equations for Newtonian fluid flow, computational fluid dynamics (CFD) techniques, different steps in CFD techniques, criteria and essentialities of good CFD techniques.

Finite Difference Method (FDM): Application of FDM to model problems, steady and unsteady problems, implicit and explicit approaches, errors and stability analysis, direct and iterative solvers. Finite Volume Method (FVM): FVM for diffusion, convection-diffusion problem, different discretization schemes, FVM for unsteady problems.
Prediction of Viscous Flows: Pressure Poisson and pressure correction methods for solving Navier-Stokes equation, SIMPLE family FVM for solving Navier-Stokes equation, modelling turbulence.
CFD for Complex Geometry: Structured and unstructured, uniform and non-uniform grids, different techniques of grid generations, curvilinear grid and transformed equations.
Lattice Boltzman and Molecular Dynamics: Boltzman equation, Lattice Boltzman equation, Lattice Boltzman methods for turbulence and multiphase flows, Molecular interaction, potential and force calculation, introduction to Molecular Dynamics algorithms.

Text Book/ Reference Books:

1. J. D. Anderson, “Computational Fluid Dynamics”, McGraw-Hill Inc. (1995).
2. S. V. Patankar, “Numerical Heat Transfer and Fluid Flow”, Hemisphere Pub. (1980).
3. K. Muralidhar, and T. Sundarajan, “Computational Fluid Flow and Heat Transfer”, Narosa (2003).
4. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, “Computational Fluid Mechanics and Heat Transfer”, Hemisphere Pub. (1984).
5. M. Peric and J. H. Ferziger, “Computational Methods for Fluid Dynamics”, Springer (2001).
6. H. K. Versteeg and W. Malalaskera, “An Introduction to Computational Fluid Dynamics”, Dorling Kindersley (India) Pvt. Ltd. (2008).
7. C. Hirsch, “Numerical Computation of Internal and External Flows”, Butterworth-Heinemann, (2007).
8. J. M. Jaile, “Molecular Dynamics Simulation: Elementary Methods”, Willey Professional, 1997.
9. A. A. Mohamad, “Lattice Boltzman Method: Fundamentals and Engineering Applications with Computer Codes”, Springer (2011).

NONLINEAR OPTIMIZATION

Course Code: 18 ME 52C2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Nonlinear programming: Convex sets and convex functions, their properties, convex programming problem, generalized convexity, Pseudo and Quasi convex functions, Invex functions and their properties, KKT conditions.

Goal Programming: Concept of Goal Programming, Model Formulation, Graphical solution method.

Separable programming. Geometric programming: Problems with positive coefficients up to one degree of difficulty, Generalized method for the positive and negative coefficients.

Search Techniques: Direct search and gradient methods, Unimodal functions, Fibonacci method, Golden Section method, Method of steepest descent, Newton-Raphson method, Conjugate gradient methods.

Dynamic Programming: Deterministic and Probabilistic Dynamic Programming, Discrete and continuous dynamic programming, simple illustrations.

Multi objective Programming: Efficient solutions, Domination cones.

Text Books:

1. Mokhtar S. Bazaaraa, Hanif D. Shirali and M.C.Shetty, Nonlinear Programming, Theory and Algorithms, John Wiley & Sons, New York (2004).

Reference Books:

1. D. G. Luenberger, Linear and Nonlinear Programming, Second Edition, Addison Wesley (2003).
2. R. E. Steuer, Multi Criteria Optimization, Theory, Computation and Application, John Wiley and Sons, New York (1986).

INDUSTRIAL AUTOMATION

Course Code: 18 ME 52D1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Automation: Introduction, automation principles and strategies, basic elements of advanced functions, levels modeling of manufacturing systems.

Material handling: Introduction, material handling systems, principles and design, material transport system: transfer mechanisms automated feed cut of components, performance analysis, uses of various types of handling systems including AGV and its various guiding technologies.

Storage system: Performance, location strategies, conventional storage methods and equipments, automated storage systems.

Automated manufacturing systems: Components, classification, overview, group technology and cellular manufacturing, parts classification and coding, product flow analysis, cellular manufacturing, application considerations in G.T.

FMS: Introduction, components, application, benefits, planning and implementation, transfer lines and fundamentals of automated production lines, application, analysis of transfer line without internal storage (numerical problems).

Inspection Technology: Introduction, contact and non-contact conventional measuring, gauging technique, CMM, surface measurement, machine vision, other optical inspection techniques, non-contact non-optical inspection technologies versus.

Manufacturing support system: Process planning and concurrent engineering- process planning, CAPP, CE and design for manufacturing, advanced manufacturing planning, production planning and control system, master production schedule, MRP.

Capacity planning, shop floor control, inventory control, MRP-II, J.I.T production systems. lean and agile manufacturing.

Text Books

1. M.P. Groover, Automation, “Production Systems and Computer Integrated manufacturing”, 2nd Edition, Pearson Education (2004).

References Books

1. Vajpayee, “Principles of CIM”, PHI, 1992.
2. Viswanathan and Narahari, “Performance Modeling of Automated Manufacturing Systems”, PHI, 2000.
3. R.S. Pressman, “Numerical Control and CAM, John Wiley , 1993.

FUZZY SETS AND ARTIFICIAL INTELLIGENCE

Course Code: 18 ME 52D2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Basic Concepts of Fuzzy Sets, Fuzzy Logic, Zadeh's Extension Principle, Operations on Fuzzy Sets, Fuzzy Measures, Probability and Possibility Measures, Fuzzy Inference Methodologies, Fuzzy Relations, Applications of Fuzzy Sets in Management, Decision Making, Medicine and Computer Science.

Introduction to Artificial Intelligence, Production System and Artificial Intelligence, Problem Solving by Search, Predicate Calculus, Knowledge Representation, Semantics Nets, Frames, Conceptual Dependencies, Knowledge Bases and Expert Systems, Fuzzy Rule, Neuro Fuzzy Approaches, Case Studies in Various Domain.

Text books:

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003.
2. H.J.Zimmermann, Fuzzy Set Theory and Its Applications, 2nd Ed., Kluwer Academic Publishers, 1996.
3. D.Dubois and H. Prade, Fuzzy Sets and Systems: Theory and Applications, Academic Press, 1980.

Reference books:

1. E. Charniak and D. McDermott, Introduction to Artificial Intelligence, Addison-Wesley, 1985.
2. E. Rich, Artificial Intelligence, McGraw-Hill, 1983.
3. P. H. Winston, Artificial Intelligence, Addison Wesley, 1993.
4. J.Yen and R.Langari, Fuzzy Logic Intelligence, Control, and Information, Pearson Education, 2005.
5. T.J.Ross, Fuzzy Logic with Engineering Applications, McGraw-Hill, 1997.
6. J.Kacprzyk, Multistage Fuzzy Control, Wiley, 1997.

M.TECH - THERMAL ENGINEERING
2018-19 Structure & Syllabus

First Year (First Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5109	Numerical Methods in Thermal engineering	3	1	0	4	4
2	18 ME 5110	Advanced Thermodynamics	3	1	0	4	4
3	18 ME 5111	Design of Thermal Systems	3	1	0	4	4
4	18 ME 5112	Advanced Heat and Mass Transfer	3	1	0	4	4
5		Elective – 1	3	0	0	3	3
6		Elective - 2	3	0	0	3	3
7	18 IE 5149	Seminar	0	0	4	4	2
		Total	**18**	**4**	**4**	**26**	**24**

First Year (Second Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5213	Incompressible and Compressible Flows	3	1	0	4	4
2	18 ME 5214	Computational Fluid Dynamics	3	0	2	5	4
3	18 ME5215	Refrigeration and Cryogenics	3	1	0	4	4
4	18 ME 5216	Measurements in Thermal Engineering	3	1	0	4	4
5		Elective – 3	3	0	0	3	3
6		Elective - 4	3	0	0	3	3
7	18 IE 5250	Term Paper	0	0	4	4	2
		Total	**18**	**3**	**6**	**27**	**24**

Second Year (First & Second Semester):

S.No	Course code	Course Title	Periods			Credits
			L	T	P	
1	18 IE 6050	Dissertation	0	0	72	36

ELECTIVE COURSES

S.No	Course code	Course Title	Periods	Credits

			L	T	P	
Elective-1						
1	18 ME 51E1	Heat Exchanger Design	3	0	0	3
2	18 ME 51E2	Convection and Two-Phase Flow	3	0	0	3
3	18 ME 51E3	Compact Heat Exchangers	3	0	0	3
Elective-2						
1	18 ME 51F1	Engine Systems and Performance	3	0	0	3
2	18 ME 51F2	IC Engine Combustion and Pollution	3	0	0	3
3	18 ME 51F3	Alternative Fuels	3	0	0	3
Elective-3						
1	18 ME 52G1	Principles of Turbo-machinery	3	0	0	3
2	18 ME 52G2	Gas Turbine Engineering	3	0	0	3
3	18 ME 52G3	Turbo-Compressors	3	0	0	3
Elective-4						
1	18 ME 52H1	Energy Conservation, Management & Audit	3	0	0	3
2	18 ME 52H2	Renewable Energy Technology	3	0	0	3
3	18 ME 52H3	Solar Energy and Wind Energy	3	0	0	3

NUMERICAL METHODS IN THERMAL ENGINEERING

Course Code: 18 ME 5109 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Mathematical Description of the Physical Phenomena: Governing equations—mass, momentum, energy, species, General form of the scalar transport equation, Elliptic, parabolic and hyperbolic equations, Behavior of the scalar transport equation with respect to these equation type; **Discretization Methods:** Methods for deriving discretization equations-finite difference, finite volume and finite element method, Method for solving discretization equations, Consistency, stability and convergence; **Diffusion Equation:** 1D-2D steady diffusion, Source terms, non-linearity, Boundary conditions, interface diffusion coefficient, Under-relaxation, Solution of linear equations (preliminary), Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme, Two dimensional conduction, Accuracy, stability and convergence revisited; **Convection and Diffusion:** Steady one-dimensional convection and diffusion, Upwind, exponential, hybrid, power, QUICK scheme,Two-dimensional convection-diffusion, Accuracy of Upwind scheme; false diffusion and dispersion, Boundary conditions; **Flow Field Calculation:** Incompressibility issues and pressure-velocity coupling, Primitive variable versus other methods, Vorticity-stream function formulation, Staggered grid, SIMPLE family of algorithms; **Numerical Methods for Radiation:** Radiation exchange in enclosures composed of diffuse gray surfaces, Finite volume method for radiation, Coupled radiation-conduction for participating media

TEXT BOOKS:

1. Numerical heat transfer and fluid flow, S. V. Patankar, Hemisphere publishing company (1980)
2. Computational Fluid Mechanics and Heat Transfer, J. C. Anderson, D. A. Tanehil and R. H. Pletcher, Taylor & Francis publications, USA (1997)

REFERENCE BOOKS:

1. Advances in numerical heat transfer, (Eds.) W. J. Minkowycz, E. M. Sparrow, Taylor & Francis publications (1997)
2. Heat Transfer - Mathematical Modelling, Numerical Methods and Information Technology, (Ed.) A. Belmiloudi, InTech Publications (2011)
3. Numerical heat transfer by T. M. Shih, Hemisphere publications company (1984)
4. Numerical methods in thermal problems: Proceedings of seventh international conference held in Staford, USA, Volumes 1-2, (Eds.) K. Morgan (1991)
5. Computational Heat Transfer, Mathematical Modelling, A. A. Samarskii, P. N. Vabishchevich, John Wiley & Sons (1995)
6. Hand book of numerical heat transfer, W. J. Minkowycz, E. M. Sparrow, G. E. Schneider, R. H. Pletcher, Wiley publishers (2001)

ADVANCED THERMODYNAMICS

Course Code: 18 ME 5110 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Review of first and second law of thermodynamics, Maxwell equations, Joule-Thompson experiment, irreversibility and availability, exergy analysis, phase transition, types of equilibrium and stability, multi-component and multi-phase systems, equations of state, chemical thermodynamics, combustion. Third law of thermodynamics, Kinetic theory of gases- introduction, basic assumption, molecular flux, equation of state for an ideal gas, collisions with a moving wall, principle of equi-partition of energy, classical theory of specific heat capacity. Transport phenomena-intermolecular forces, The Vander Waals equation of state, collision cross section, mean free path, Statistical thermodynamics- introduction, energy states and energy levels, macro and micro-scales, thermodynamic probability, Bose-Einstein, Fermi-Dirac, Maxwell-Boltzmann statistics, distribution function, partition energy, statistical interpretation of entropy, application of statistics to gases-mono-atomic ideal gas.

TEXT BOOKS:

1. Advanced Engineering Thermodynamics, A. Bejan, Wiley and sons, (2006)
2. Thermodynamics, J. P. Holman, McGraw-Hill Inc., (1998)

REFERENCE BOOKS:

1. Advanced Thermodynamics for Engineers, Kenneth Wark, McGraw-Hill
2. Thermodynamics, Kinetic theory, and Statistical thermodynamics, F. W. Sears, and G. L. Salinger, Narosa Publishing House (1998)
3. Fundamentals of Engineering thermodynamics, M. J. Moron, and H. N. Shapiro, John Wiley& Sons
4. Heat and thermodynamics, M. W. Zemansky, and R. H. Dittman, Mc_Graw Hill International (2007)

DESIGN OF THERMAL SYSTEMS

Course Code: 18 ME 5111 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Modeling of Thermal Systems: types of models, mathematical modeling, curve fitting, linear algebraic systems, numerical model for a system, system simulation, methods for numerical simulation; Acceptable Design of a Thermal System: initial design, design strategies, design of systems from different application areas, additional considerations for large practical systems; Economic Considerations: calculation of interest, worth of money as a function of time, series of payments, raising capital, taxes, economic factor in design, application to thermal systems; Problem Formulation for Optimization: optimization methods, optimization of thermal systems, practical aspects in optimal design, Lagrange multipliers, optimization of constrained and unconstrained problems, applicability to thermal systems; search methods: single-variable problem, multivariable constrained optimization, examples of thermal systems; geometric, linear, and dynamic programming and other methods for optimization, knowledge-based design and additional considerations, professional ethics. Optimization, Objective function formulation, Constraint equations, Mathematical formulation, Calculus method, Dynamic programming, Geometric programming, linear programming methods, solution procedures. Equation fitting, Empirical equation, best fit method, method of least squares. Modeling of thermal equipments such as turbines, compressors, pumps, heat exchangers, evaporators and condensers

TEXT BOOKS:

1. W.F. Stoecker, Design of Thermal Systems - McGraw-Hill
2. Y. Jaluria, Design and Optimization of Thermal Systems –CRC Press

REFERENCE BOOKS:

1. Bejan, G. Tsatsaronis, M.J. Moran, Thermal Design and Optimization – Wiley.
2. R. F. Boehm, Developments in the Design of Thermal Systems – Cambridge University Press.
3. N.V. Suryanarayana, Design & Simulation of Thermal Systems – MGH.

ADVANCED HEAT AND MASS TRANSFER

Course Code: 18 ME 5112 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Introduction - review of heat transfer Fundamentals - transient conduction and extended surface Heat Transfer, Unsteady heat conduction. Lumped capacity model, awareness of one-dimensional unsteady results (charts; Biot and Fourier numbers), Brief review of Steady Laminar and Turbulent Heat Transfer in External and Internal Flows - Heat Transfer at High Speeds - Unsteady Laminar and Turbulent Forced Convection in Ducts and on Plates - Convection with body forces, Boundary layers and internal flows. Awareness of these configurations, some knowledge of internal flow energy balances, Convection correlations. Finding heat transfer coefficients from Reynolds numbers and Rayleigh numbers, Heat Exchangers. Typical configurations and epsilon-NTU analysis, phase-change heat transfer. General awareness of processes of condensation and boiling in a pure substance, some use of correlations, Quenching of metals, Leidenfrost problem, heat transfer of sprays, jets and films, Radiation basics - Radiation in Enclosures - Gas Radiation - Diffusion and Convective Mass Transfer - Combined Heat and Mass Transfer from Plates and in Pipes.

TEXT BOOKS:

1. Heat transfer, A. Bejan, John Wiley & Sons (1993)
2. Advanced Heat and Mass Transfer, A. Faghri, Y. Zhang, J. Howell, Global Digital Press (2010)

REFERENCE BOOKS:

1. A Heat Transfer Text Book, J. H. Lienhard iv, and J. H. Lienhard V, Phlogiston Press (2008)
2. Heat and Mass Transfer, H. D. Baehr, and K. Stephan, Springer-Verlag (1998)
3. Heat transfer, F. M. White, Addision-Wesley (1984)
4. Basic heat and mass transfer, K. C. Rolle, Prentice-Hall (2000)
5. Heat Transfer – A practical approach, Y. A. Cengel, Tata McGraw-Hill (2002)

HEAT EXCHANGER DESIGN

Course Code: 18 ME 51E1 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Heat Exchangers-Introduction, C1assfication, and Selection. Heat Exchanger Thermo-Hydraulic Fundamentals. Heat Exchanger Design. Compact Heat Exchangers. Shell and Tube Heat Exchanger Design. Regenerators. Plate Heat Exchangers and Spiral Plate Heat Exchangers. Heat-Transfer Augmentation. Fouling; Flow-Induced Vibration of Shell and Tube Heat Exchangers. Mechanical Design of Shell and Tube Heat Exchangers. Corrosion; Material Selection and Fabrication. Quality Control and Quality Assurance and Nondestructive Testing. Heat Exchanger Fabrication.

TEXT BOOKS

1. Heat Exchanges: Selection, Design and Construction, E. A. Saunders, Longman Scientific and Technical (1988)
2. Fundamentals of Heat Exchanger Design, Ramesh K. Shah, Dusan P. Sekulic, Wiley (2002)

REFERENCES

1. Heat Transfer, J. P. Holman, McGraw Hill, New York (1989)
2. Process Heat Transfer, CRC Press, G.F. Hewitt, G.L. Shires, T.R. Bott (1994)
3. Fluid Dynamics and Heat Transfer, J.G. Knudsen and D.L. Katz, McGraw Hill, New York (1958)
4. Heat Exchanger Design Handbook, K. Thulukkanam, CRC Press (2013)
5. Heat Exchangers: Selection, Rating and Thermal Design, S. Kakaç and H. Liu, CRC Press (2002)
6. Fluid Mechanics and Transfer Processes, Cambridge University Press, J. M. Kay, and R. M. Nedderman (1985)
7. Heat exchanger design handbook, Hemisphere publishing corp., (1981)

CONVECTION AND TWO-PHASE FLOW

Course Code: 18 ME 51E2 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Introduction to two-phase flow and heat transfer technology, Liquid-vapor phase change phenomena, Interfacial tension, Wetting phenomenon, Contact angles, Transport effects, Dynamic behavior of interfaces, Phase stability and nucleation, Two-phase flow fundamentals, Flow patterns and map representation, Development of homogeneous, separated flow and drift flux models, Flooding mechanisms, Boiling Fundamentals, Homogeneous and heterogeneous nucleation, Pool boiling and convective flow boiling, Heat transfer and CFH mechanisms, Enhancement techniques, Condensation fundamentals, External and internal condensation, Film condensation theory, Drop-wise condensation theory, Enhancement techniques, Application of two-phase flow and heat transfer, Electronics thermal management, Latent heat storage devices, Gravity assisted thermo-siphons/Vapor chambers, Theory and operation of Conventional heat pipes, Micro heat pipes, Pulsating heat pipes, Capillary pumped loops/ Loop heat pipes, Micro two-phase heat exchangers, Static and dynamic instabilities, micro-scale boiling and condensation, atomistic nucleation models.

TEXT BOOKS

1. Liquid Vapor Phase Change Phenomena, Van P. Carey, Taylor & Francis
2. Boundary layer theory, H. Schlichting, Springer (2002)

REFERENCES

1. Heat Transfer - Incropera and Dewitt, John Wiley and Sons
2. One Dimensional Two-Phase Flow, G. B. Wallis, McGraw Hill (1969)
3. Heat transfer, McGraw Hill book, C. Gebhart (1961)
4. Convective Boiling And Condensation by Collier John (Oxford Engineering Science)
5. Two-phase Flow and Heat Transfer - P. B. Whalley (Oxford Engineering Science)
6. Heat Transfer Characteristics in Boiling and Condensation by Karl Stephan (Springer)
7. Heat Pipe Technology and Applications by J. P. Peterson (John Wiley & Sons)

COMPACT HEAT EXCHANGERS

Course Code: 18 ME 51E3 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Classification of heat exchangers - compactness - heat transfer correlation for laminar and turbulent flow through channels, fins their geometries and efficiently. Applications and selection of compact heat exchangers. Basic heat exchangers theory related to compact heat exchangers - Definition of important HX parameters - ε NTU, F - LMTD, P-NTU, P-θ and combination charts. Coupling of heat exchangers, effect of longitudinal conduction in compact heat exchangers, effects of variable property and heat transfer coefficient, core pressure drop and velocity distribution in compact heat exchangers. Contraction and expansion pressure loss. Compact recuperators - Advantages and disadvantages of plates fin and tube fin heat exchangers - fin configuration, heat transfer and pressure drop data in finned heat exchangers, importance of laminar flow in finned recuperators and entry length effect. Plate and frame heat exchangers - Advantages of PHE, Plate geometry and flow configurations, effectiveness and pressure drop in PHE, Fouling in PHE. Thermal regenerations - working principle of periodic flow and rotary regenerators, transient temperature profile, Hausen's chart, optimization of thermal storage. Heat Pipe Heat Exchangers - Working principles, Wick types, various operating limits of heat pipes, pressure gradient and heat transfer requirements in heat pipe heat exchangers. Use of compact heat exchangers in multiphase applications.

TEXT BOOKS:

1. Heat Exchangers Selection, Rating and Thermal design, Sadik Kakac, Hongtan Liu,CRC Press (2002)
2. Heat Exchanger Design, P Arthur. Frass, John Wiley & Sons (1988)

REFERENCE BOOKS:

1. Heat Exchangers, Theory and Practice, Taborek.T, Hewitt.G.F and Afgan.N, McGraw-Hill Book Co. (1980)
2. Fundamentals of Heat Exchanger Design, Ramesh K. Shah, Dusan P. Sekulic, Wiley (2002)
3. Process Heat Transfer, Hewitt.G.F, Shires.G.L, Bott.T.R, CRC Press (1994)

ENGINE SYSTEMS AND PERFORMANCE

Course Code: 18 ME 51F1 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Working principle; Constructional details; Classification and application of different types of I.C. Engines; Wankel and other rotary engines; Operation of the Stirling engine; Mixture preparation systems for SI and CI engines; Combustion chambers; Ignition, lubrication and cooling systems; Speed governing systems; Intake and exhaust systems; Supercharging methods; Turbocharger matching; Aero-thermodynamics of compressors and turbines; Engine Testing and performance; Effects of engine design and operating parameters on performance and emissions

TEXT BOOKS

1. John B Heywood, Internal Combustion Engine Fundamentals, Tata McGraw-Hill (1988)
2. Elements of gas turbine technology, J. D. Mattingly, Tata McGrawHill (2005)

REFERENCE BOOKS:

1. Ganesan V, Internal Combustion Engines , Third Edition, Tata Mcgraw-Hill , 2007
2. Gas turbine theory, Cohen, Rogers, Saravanamutto, Pearson education (2001)
3. Patterson D.J. and Henein N.A, "Emissions from combustion engines and their control" Ann Arbor Science publishers Inc, USA, 1978
4. Gupta H.N, "Fundamentals of Internal Combustion Engines" ,Prentice Hall of India,
   2006
5. Ultrich Adler ," Automotive Electric / Electronic Systems, Published by Robert Bosh, GmbH,1995

IC ENGINE COMBUSTION AND POLLUTION

Course Code: 18 ME 51F2 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Role of fuel in engine combustion, selection of fuels, Basic combustion processes for SI and CI engines - Factors affecting combustion in these engines - Combustion chambers - Instrumentation to study the combustion process in engines. Pollution formation in SI and CI engines - Factors affecting emissions - Control measures for evaporative emissions - Thermal reactors and catalytic converters - Engine modifications to reduce emissions - Instrumentation to measure pollutants - Emission standards and testing.

TEXT BOOKS:

1. Internal Combustion Engines Fundamentals- John B. Heywood, Pub.-McGraw Hill, New York
2. Engineering fundamental of the I.C.Engine – Willard W. Pulkrabek Pub. PHI, India

REFERENCE BOOKS:

1. Fundamentals of I.C. Engines - P.W. Gill, J.H. Smith & Ziurys- IBH & Oxford pub.
2. Internal Combustion Engines –V. Ganesan, Pub.-Tata McGraw-Hill.
3. Internal Combustion Engines & Air pollution- Obert E.F, Pub.-Hopper & Row Pub., New York

ALTERNATIVE FUELS

Course Code: 18 ME 51F3 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Fossil fuels and their limitations; Engine requirements; Potential alternative liquid and gaseous fuels; Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di-methyl and Di-ethyl ether etc., their use in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance; Use of gaseous fuels like biogas, LPG, hydrogen, natural gas, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels. Different approaches like dual fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

TEXT BOOKS:

1. Richard.L.Bechfold – Alternative Fuels Guide Book - SAE International Warrendale
   - 1997.
2. Handbook of Alternative Fuel Technologies, Sungyu Lee, CRC Press

REFERENCE BOOKS:

1. Alternative Fuels: Emissions, Economics, and Performance**,** Timothy T. Maxwell, Jesse C. Jones, SAE International (1991)
2. Nagpal - "Power Plant Engineering" - Khanna Publishers – 1991
3. Maheswar Dayal - Energy Today & Tomorrow - I & B Horishr India - 1982.
4. "Alcohols as motor fuels progress in technology" - Series No.19 - SAE Publication
   USE – 1980
5. SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA.

INCOMPRESSIBLE AND COMPRESSIBLE FLUID FLOWS

Course Code: 18 ME 5213 **L-T-P : 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Definition and properties of Fluids, Fluid as continuum, Langragian and Eulerian description, Velocity and stress field, Fluid statics, Fluid Kinematics, Reynolds transport theorem, Integral and differential forms of governing equations: mass, momentum and energy conservation equation, Couette flows, Poiseuille flows, Fully developed flows in non-circular cross-sections, Unsteady flows, Creeping flows, Revisit of fluid kinematics, Stream and Velocity potential function, Circulation, Irrotational vortex, Basic plane potential flows: Uniform stream; Source and Sink; Vortex flow, Doublet, Superposition of basic plane potential flows, Flow past a circular cylinder, Magnus effect; Kutta-Joukowski lift theorem; Concept of lift and drag, Boundary layer equations, Boundary layer thickness, Boundary layer on a flat plate, similarity solutions, Integral form of boundary layer equations, Approximate Methods, Flow separation, Entry flow into a duct, Basic concepts of thermodynamics, governing equations in various forms, concept of Mach number, one dimensional flows and normal shock wave, Rayleigh and Fanno flows, Two dimensional flows and oblique shock waves, θ-B-M relations, understanding of shock interaction and shock reflection with various graphs, Prandtl- Mayer expansion, shock-expansion theory, quasi one dimensional flows, method of characteristics and, unsteady wave motion and introduction to various experimental facilities for these speed ranges.

TEXT BOOKS:

1. Boundary layer theory, H. Schlichting, and K. Gersten, Springer (2000)
2. Elements of gas Dynamics, H. W. Liepmann & A. Roshko, Dover Publications (2002)
3. Viscous fluid flow, F. M. White, Mc-Graw Hill (2005)

REFERENCE BOOKS:

1. Introduction to Fluid Mechanics, E. J. Shaughnessy, I. M. Katz and J. P. Schaffer, Oxford University Press (2004)
2. Compressible fluid flow, M. A. Saad, Prentice Hall (1985)
3. Incompressible flow, R. L. Panton, John Wiley & Sons (2005)
4. Advanced Fluid Mechanics, Som, and Biswas, Tata McGraw Hill (2008)
5. The dynamics and thermodynamics of compressible fluid flow, Vol. 1 & 2, A. H. Shapiro, Ronald Press (1954)

COMPUTATIONAL FLUID DYNAMICS

Course Code: 18 ME 5214 **L-T-P : 3-0-2**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Introduction: Conservation equation; mass; momentum and energy equations; convective forms of the equations and general description, Classification and Overview of Numerical Methods: Classification into various types of equation; parabolic elliptic and hyperbolic; boundary and initial conditions; over view of numerical methods, Finite Difference Technique: Finite difference methods; different means for formulating finite difference equation; Taylor series expansion, integration over element, local function method; treatment of boundary conditions; boundary layer treatment; variable property; interface and free surface treatment; accuracy of FD method, Finite Volume Technique: Finite volume methods; different types of finite volume grids; approximation of surface and volume integrals; interpolation methods; central, upwind and hybrid formulations and comparison for convection-diffusion problem, Finite Element Methods: Finite element methods; Rayleigh-Ritz, Galerkin and Least square methods; interpolation functions; one and two dimensional elements; applications, Methods of Solution: Solution of finite difference equations; iterative methods; matrix inversion methods; ADI method; operator splitting; fast Fourier transform, Time integration Methods: Single and multilevel methods; predictor-corrector methods; stability analysis; Applications to transient conduction and advection-diffusion problems, Numerical Grid Generation: Numerical grid generation; basic ideas; transformation and mapping, Navier-Stokes Equations: Explicit and implicit methods; SIMPLE type methods; fractional step methods, Turbulence modeling: Reynolds averaged Navier-Stokes equations, RANS modeling, DNS and LES.

TEXT BOOKS:

1. Numerical Computation of Internal and External Flows, C. Hirsch, Vols. I & II, John Wiley & Sons (2004)
2. An Introduction to Computational Fluid Dynamics, H. K. Versteeg & W. Malalasekera, Longman Scientific & Technical (1995)

REFERENCE BOOKS:

1. Computational Fluid Mechanics and Heat Transfer, J. C. Anderson, D. A. Tannehil and R. H. Pletcher, Taylor & Francis publications, USA (1997)
2. Fundamentals of CFD, T. K. Sengupta, Universities Press (2004)
3. Computational Fluid Dynamics, T. J. Chung, Cambridge University Press (2002)
4. Computational Methods for Fluid Dynamics, J. H. Ferziger and M. Peric, Springer (1997)
5. Computational Techniques for Fluid Dynamics, C. A. J. Fletcher, Vols. I & II, Springer-Verlag (1996)

REFRIGERATION AND CRYOGENICS

Course Code: 18 ME 5215 **L-T-P : 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Review of Basic Thermodynamics, Properties of Cryogenic fluids, First and Second Law approaches to the study of thermodynamic cycles, Isothermal, Adiabatic and Isenthalpic processes. Production of Low Temperatures: Liquefaction systems, ideal, Cascade, Linde Hampson and Claude cycles and their derivatives; Refrigerators: Stirling, Gifford-McMahon cycles and their derivatives. Cryogenic Insulations: Foam, Fibre, powder and Multilayer. Applications of Cryogenics in Industry, Space Technology, Nuclear Technology, Biology and Medicine, Matter at low temperatures: specific heat, thermal conductivity, electrical conductivity, magnetic and mechanical properties; Review of free electron and band theory of solids: Basic properties of Superconductors; out lines of Ginzbarg Landau and Bardeen-Cooper-Schrieffer theories of superconductivity: Super-conducing tunneling phenomena; Introduction to type II superconductivity including flux flow and critical current density: High temperature superconductivity. Properties of liquid ^{4}He and ^{3}He; Production of very low temperatures by Adiabatic demagnetization, dilution refrigeration and nuclear demagnetization and their measurements.

TEXT BOOKS:

1. Refrigeration and Air conditioning, Stoecker, and Jones ()
2. Cryogenics Systems, R. F. Barron, Oxford Univesity Press (1985)
3. Cryogenics: Theory, Processes and Applications, Allyson E. Hayes, Nova Science Pub Incorporated (2010)

REFERENCE BOOKS:

1. Refrigeration and Air Conditioning, Jordan, and Priester, Prentice Hall India ()
2. A text book of Cryogenics, V. V. Kostionk, Discovery publishing house pvt. Ltd. (2003)
3. Principles of Refrigeration by Dossat. , Thomas J. Horan: Books.
4. Heating, Ventilating, Air-Conditioning and Refrigeration by Billy C. Langley, Prentice Hall
5. Haselden, G. G. (1971) *Cryogenic fundamentals* Academic Press, New York

MEASUREMENTS IN THERMAL ENGINEERING

Course Code: 18 ME 5216 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

Introduction to measurements for scientific and engineering applications - need and goal - broad category of methods for measuring field and derived quantities; Principles of measurement - parameter estimation - regression analysis - correlations - error estimation and data presentation - analysis of data; Measurement of field quantities - thermometry - heat flux measurement - measurement of force, pressure, flow rate, velocity, humidity, noise, vibration - measurement of the above by probe and non intrusive techniques; Measurement of derived quantities - torque, power, thermo-physical properties - radiation and surface properties; Analytical methods and pollution monitoring - mass spectrometry -chromatography - spectroscopy.

TEXT BOOKS:

1. Measurement in fluid mechanics, S. Tauvulorais, Cambridge University Press (2009)
2. Experiments and Uncertainty Analysis for Engineers, H.W. Coleman and W.G. Steele Jr., Wiley & Sons, New York, (1989)
3. Fundamentals of temperature, pressure and flow measurement, R. P. Benedict, John Wiley and Sons (2003)

REFERENCE BOOKS:

1. Fluid mechanics and measurements, R. J. Goldstein, Taylor & Francis (1996)
2. Hand book of experimental fluid mechanics, C. Tropea, Y. Alexander, J. F. Foss, Springer (2007)
3. The measurement of turbulent fluctuations, Smolyakov, and Tkachenko, Springer-Verlag (1983)
4. Thermal and flow measurements, T. W. Lee, CRC Press (2008)

PRINCIPLES OF TURBO MACHINERY

Course Code: 18 ME 52G1 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Classification - Specific work - Representation of specific work in T-s and h-s diagrams - Internal and external losses - Euler's equation of turbo-machinery - Ideal and actual velocity triangles - Slip and its estimation - Impulse and reaction type machines - Degree of reaction - Effect of outlet blade angle on blade shape - Model laws, specific speed and shape number - Special features of hydro, steam and gas turbines - Performance characteristics of turbo-machines - Cavitation, Surge and Stall - Thin aerofoil theory - Cascade mechanics. Use of CFD for Turbo-machinery analysis and design.

TEXT BOOKS:

1. Fundamentals of Turbomachinery by William W. Peng, John Wiley & Sons
2. Principles of turbomachinery, D. G. Shepherd, Macmilan, 1969

REFERENCE BOOKS:

1. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press, 2008.
2. Turbine, Compressors and Fans by S.M.Yahya, TMH
3. Hydraulic and Compressible Flow Turbomachines by A.T.Sayers, Mc-Graw Hill
4. Principles of Turbomachinery by Seppo A. Korpella, John Wiley & Sons
5. Nicholas Cumpsty, Compressor Aerodynamics, 2004, Kreiger Publications, USA.
6. Elements of gastubine technology, J. D. Mattingly, Tata McGrawHill (2005)

GAS TURBINE ENGINEERING

Course Code: 18 ME 52G2 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Thermodynamics of gas turbines: Cycle analysis; Gas Turbine Components: compressor, combustor, heat exchangers, turbine - description: analytical considerations, performance; Matching of compressor and turbine: cooling of turbine blades. Compressor and turbine impeller construction, blade fixing details, sealing; Material selection for components, Protective coating for hot turbine parts, Components fabrication techniques, Gas turbine turbocharger, gas turbine power generation, turbo expander, gas turbine application, Closed cycle gas turbines, Co-generation - Introduction, Thermodynamics of co-generation, Criteria for component performance, Some practical schemes.

TEXT BOOKS:

1. Elements of gas turbine technology, J. D. Mattingly, Tata McGrawHill (2005)
2. Gas turbine theory, Cohen, Rogers, Saravanamutto, Pearson education (2001)

REFERENCE BOOKS:

1. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press, 2008.
2. Turbine, Compressors and Fans by S.M.Yahya, TMH

TURBO COMPRESSORS

Course Code: 18 ME 52G3 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Thermodynamics of fluid flow and thermodynamic analysis of compression and expansion processes: Sonic velocity and Mach number; Classification of fluid flow based on Mach number; Stagnation and static properties and their relations; Compression process – Overall isentropic efficiency of compression; Stage efficiency; Comparison and relation between overall efficiency and stage efficiency; Polytropic efficiency; Preheat factor; Expansion Process – Overall isentropic efficiency for a turbine; Stage efficiency for a turbine; Comparison and relation between stage efficiency and overall efficiency for expansion process; polytropic efficiency of expansion; Reheat factor for expansion process. Axial flow compressors, propellers, centrifugal compressors. Equations of motion in axial and radial turbomachines. Operation and performance of compressors. Compressor cascades and loss correlations. Compressor instrumentation and testing. Supersonic compressors. Special aspects. Future trends.

TEXT BOOKS:

1. Hydraulic and Compressible Flow Turbomachines by A.T.Sayers, Mc-Graw Hill
2. Aerodynamics of turbines and compressors, (Ed.) W. R. Hawthorne, Vol. 10, Princeton university press, 1964

REFERENCE BOOKS:

1. Turbine, Compressors and Fans by S.M.Yahya, TMH
2. Theory of turbo machinery, G.T. Csandy, McGrawHill, 1964
3. J H Horlock, Axial Flow Turbines, Butterworths, 1965, UK.

ENERGY CONSERVATION, MANAGEMENT AND AUDIT

Course Code: 18 ME 52H1 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Energy Scenario - Basics of Energy and its various forms - Energy Management and - Audit - Material and Energy Balance - Energy Action Planning - Financial Management –Project Management - Energy Monitoring and Targeting - Global Environmental Concerns. Energy Efficiency in Thermal Utilities - Fuels and Combustion – Boilers - Steam System - Furnaces - Insulation and Refractory - FBC Boilers -Cogeneration - Waste heat recovery. Energy Efficiency in Electrical Utilities - Electrical Systems - Electric Motors - Compressed Air System - HVAC and Refrigeration System - Fans and Blowers - Pumps and Pumping System - Cooling Tower - Lighting System - Diesel Generating System - Energy Efficient Technologies in Electrical Systems
Energy Performance Assessment for Equipment and Utility systems – Boilers – Furnaces - Cogeneration, Turbines (Gas, Steam) - Heat Exchangers - Electric Motors and Variable Speed Drives - Fans and Blowers - Water Pumps – Compressors. HVAC Systems - Lighting Systems - Performing Financial Analysis - Applications of Non - Conventional and Renewable Energy Sources - Waste Minimization and Resource Conservation

TEXT BOOKS

1. CB Smith, Enegy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management & Case study, Hemisphere, Washington, 1980

REFERENCES:

1. Trivedi, PR, Jolka KR, Energy Managemnent, Commonwealth Publication, NewDelhi, 1997
2. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington,1988
3. Diamant, RME, Total Energy, Pergamon, Oxford, 1970.
4. Guide book for National Certification Examination for Energy Managers and Energy Auditors, Bureau of energy efficiencies, 2005.

RENEWABLE ENERGY TECHNOLOGY

Course Code: 18 ME 52H2 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Sources: Renewable Energy Sources in India - Potential sites, availability. Solar Energy: Measurement and collection, flat plate collectors, concentrating collectors, solar ponds, photovoltaic conversion, Thermal energy storage. Ocean Energy: Principles of OTEC; wave energy, tidal energy, energy conversion systems. Wind Energy: Principle, potential and status; Wind Characteristics; National Wind Atlas; Theory of wind turbine blades; Types of wind turbines and their characteristics. Biofuels: Sources and potential, properties and characterization; Biogas generation through aerobic and anaerobic digestion; Thermochemical methods of biofuel utilization: Combustion and gasification; Status of biofuel technology. Geothermal Energy-Nature, types and utilization. Applications: Applications of renewable energy sources - Typical examples.

TEXT BOOKS

1. Renewable Energy Resources, Twidell & Wier, CRC Press
2. Godfrey Boyle, Renewable Energy, Power for a Sustainable Future, Oxford University Press, U.K., 1996.

REFERENCE BOOKS:

1. L.L. Freris, Wind Energy Conversion systems, Prentice Hall, UK, 1990
2. Renewable energy resources - Tiwari and Ghosal - Narosa.
3. Renewable Energy Technologies - Ramesh & Kumar - Narosa
4. Non-Conventional Energy Systems / K Mittal /Wheeler
5. Renewable energy sources and emerging technologies by D.P.Kothari,K.C.Singhal, P.H.I
6. Non-Conventional EnergySources - G.D.Rai, KhannaPublishers

SOLAR ENERGY AND WIND ENERGY

Course Code: 18 ME 52H3 **L-T-P : 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

Solar Radiation: Availability - Measurement and Estimation - Isotropic and an Isotropic Models – Introduction to Solar Collectors (Liquid Flat - Plate Collector, Air Heater and Concentrating Collector) and Thermal Storage - Steady State Transient Analysis - Solar Pond - Solar Refrigeration. **Modeling of Solar Thermal Systems And Simulations In Process Design:** Design of Active Systems by f-chart and Utilizability Methods - Water Heating Systems - Active and Passive - Passive Heating and Cooling of Buildings - Solar Distillation - Solar Drying. **Photovoltaic Solar Cell:** P-N Junction - Metal - Schottky Junction, Electrolyte - Semiconductor Junction, Types of Solar Cells - their Applications - Experimental Techniques to determine the Characteristics of Solar Cells - Photovoltaic Hybrid Systems Photovoltaic Thermal Systems – Storage Battery - Solar Array and their Characteristics Evaluation - Solar Chargeable Battery. **Wind:** Its Structure - Statistics - Measurements and Data Presentation - Wind Turbine Aerodynamics - Momentum Theories - Basics Aerodynamics - Airfoils and their Characteristics - HAWT - Blade Element Theory - Prandtl's Lifting Line Theory (prescribed wake analysis) - VAWT Aerodynamics - Wind Turbine Loads - Aerodynamic Loads in Steady Operation - Wind Turbulence - Yawed Operation and Tower Shadow. **Wind Energy Conversion System (WECS):** Siting - Rotor Selection - Annual Energy Output - Horizontal Axis Wind Turbine (HAWT) Vertical Axis Wind Turbine - Rotor Design Considertions - Number of Blades – Blade Profile -2/3 Blades and Teetering - Coning - Upwind/Downwind - Power Regulation - Yaw System - Tower - Synchronous and Asynchronous Generators and Loads – Integration of Wind Enengy Converters to Electrical Networks - Inverters - Testing of WECS - WECS Control System - Requirements and Startegies - Miscellaneous Topics - Noise etc - Other Applications.

TEXT BOOKS:

1. L.L.Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
2. J.A.Duffie and W.A.Beckman-Solar Engineering of Thermal Processes-John Wiley (1991).

REFERNECE BOOKS:

1. S.P.Sukhatme-Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
2. J.F.Kreider and F.Kreith-Solar Energy Handbook McGraw-Hill (1981).
3. D.A.Spera, Wind Turbine Technology: Fundamental concepts of Wind Turbine Engineering, ASME Press.

M.Tech – Machine Design

2018-19 Course Structure & Syllabus

First Year (First Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5117	Design Methods	4	0	0	4	4
2	18 ME 5118	Design with Advanced materials	3	0	0	3	3
3	18 ME 5119	Theory of Elasticity and Plasticity	3	1	0	4	4
4	18 ME 5120	Modeling & Analysis-1 (CAD)	4	0	2	6	5
5		Elective-1	3	0	0	3	3
6		Elective-2	3	0	0	3	3
7	18 IE 5149	Seminar	0	0	4	4	2
		Total	**20**	**1**	**6**	**27**	**24**

First Year (Second Semester):

S. No.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1	18 ME 5221	Mechanical Vibrations	3	0	0	3	3
2	18 ME 5222	Design for Optimization	3	1	0	4	4
3	18 ME 5223	Advanced strength of materials	3	1	0	4	4
4	18 ME 5224	Modeling & Analysis-2 (FEM)	4	0	2	6	5
5		Elective-3	3	0	0	3	3
6		Elective-4	3	0	0	3	3
7	18 IE 5250	Term Paper	0	0	4	4	2
		Total	**19**	**2**	**6**	**27**	**24**

Second Year (Third Semester & Fourth Semester)

S.NO.	Course Code	Course Title	Periods			Contact Hours	Credits
			L	T	P		
1.		Major Project	0	0	72	-	36
		Total Credits	0	0	72	-	**36**

ELECTIVE COURSES:

Elective – 1						
1	18 ME 51I1	Precision and Quality Engineering	3	0	0	3
2	18 ME 51I2	Advanced Mechanisms	3	0	0	3
3	18 ME 51I3	Concurrent Engineering	3	0	0	3
Elective – 2						
1	18 ME 51J1	Design of Pressure Vessels and Plates	3	0	0	3
2	18 ME 51J2	Tribological System Design	3	0	0	3
3	18 ME 51J3	Product Design and Development	3	0	0	3
Elective – 3						
1	18 ME 52K1	Mechanics of Composite Materials	3	0	0	3
2	18 ME 52K2	Machine Tool Design	3	0	0	3
3	18 ME 52K3	Fracture Mechanics	3	0	0	3
Elective – 4						
1	18 ME 52L1	Engineering Noise & Control	3	0	0	3
2	18 ME 52L2	Engineering Failure Analysis and prevention	3	0	0	3
3	18 ME 52L3	Design for Manufacturing, Assembly and Environment	3	0	0	3

DESIGN METHODS

Course Code: 18 ME 5117 **L-T-P: 4-0-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

THE DESIGN PROCESS

The design process – Morphology of design – Design Drawings – Computer Aided Engineering - Design of Standards – Concurrent Engineering – Product Life Cycle – Technological Forecasting – Market Identification – Competition bench marking – System engineering – Life Cycle Engineering – Human Factors in Design – Industrial Design.

DESIGN METHODS

Creativity and Problem Solving – Product Design Specification – Conceptual Design – Decision Theory – Decision Tree – Embodiment Design – Detail Design – Mathematical Modeling – Simulation – Geometric Modeling – Fine Element Modeling – Optimization – Search Methods – Geometric Programming – Structural and shape Optimization.

MATERIAL SELECTION PROCESS AND DESIGN

Material Selection Process – Economics – Cost Vs Performance – Weighted Property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design of Manufacture – Design of Assembly – Design for Casting, Forging, Metal Forming, Machining and Welding – Residual Stresses – Fatigue, Fracture and Failure.

ENGINEERING STATISTICS AND RELIABLITY

Probability – Distributions – Test of Hypothesis – Design of Experiments – Reliability Theory – Design for Reliability – Reliability Centered Maintenance.

LEGAL AND ETHICAL ISSUES IN DESIGN AND QUALITY ENGINEERING

Introduction- the Origin of Laws – Contracts – Liability – Tort Law – Product Liability – Protecting Intellectual Property – Legal and Ethical Domains – Codes of Ethics – Solving Ethical Conflicts – Case Study.

Total Quality Concept – Quality Assurance – Statistics Processes Control – Taguchi Methods – Robust Design – Failure Model Effect Analysis.

Text Books

1. Dieter, George E, Engineering Design – “A Material and Processing Approach” McGraw Hill, International Editions, Singapore, 2000.
2. Karl T. Ulrich and Steven D. Eppinger “Product Design and Development” McGraw Hill Edition 2000.

Reference books:

1. Pahl, G, and Betiz, W., ”Engineering Design”, Springer – Verlag, NY 1984.
2. Ray, MS, “Elements of Engg. Design”, Prentice Hall Inc. 1985.
3. Suh, N.P., “The Principles of Design”, Oxford University Press, NY 1990.

DESIGN WITH ADVANCED MATERIALS

Course Code: 18 ME 5118 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**
Syllabus:

FERROUS MATERIALS AND ALLOYS:

Aluminum: Wrought and cast aluminum alloys- Properties.

Copper: Propertied of wrought copper alloys and copper alloy casting. Selection and application of copper alloys.

Zinc and Tin: Properties, selection and application.

PLASTICS:

General properties of plastic: Introduction, Polymeric materials to designer and selection of Plastics. Plastic additives, Mechanical behavior of plastic.

COMPOSITES:

Introduction; conventional engineering materials, what are composites? Function of fiber and matrix special features, drawbacks, procession, product fabrication, application.

INTERMETALLIC:

Properties and application of titanium aluminides, Nickel aluminides, Iron Luminides, Beryllides and silicides.

SUPER ALLOYS:

Properties, Selection and Engineering application of Nickel based super alloy, cobalt based super alloy and iron based super alloy.

CERAMICS:

Oxides surfaces, Ceramic forming and metal ceramic interface.

TEXT BOOK:

1. Engineering materials, properties and selection- Ken Budinski and Michael K. Budinski, Prentice Hall.

REFERENCE BOOK:

1. Material selction in machine design- Michael Ash by Butterworth- Heinemann.
2. Material selection and application in Machanical Engineering – Dr. A. Raman, Industrial Press Inc.
3. Selection and use of Engineering Materials – F.A.A. Crane, J.A.Charles and Justin Furness, Butterworth – Heinemann.

THEORY OF ELASTICITY AND PLASTICITY

Course Code: 18 ME 5119 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**
Syllabus:

ELASTICITY: Two dimensional stress analysis - Plane stress - Plane strain – Equations of compatibility - Stress function - Boundary conditions.

PROBLEM IN RECTANGULAR COORDINATES - Solution by polynomials - Saint Venent'sprinciples - Determination of displacement - Simple beam problems.

PROBLEMS IN POLAR COORDINATES - General equations in polar coordinates – Stressdistribution symmetrical about axis - Strain components in polar coordinates - Simple andsymmetric problems.

ANALYSIS OF STRESS AND STRAIN IN THREE DIMENSIONS: Principle stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain.
General theorems: Differential equations of equilibrium and compatibility - Displacement - Uniqueness of solution - Reciprocal theorem.

BENDING OF PRISMATIC BARS: Stress function - Bending of cantilever beam - Beam ofrectangular cross-section - Beams of circular cross-section.

PLASTICITY: Plastic deformation of metals - Structure of metals - Deformation - Creep stressrelaxation of deformation - Strain rate condition of constant maximum shear stress - Condition ofconstant strain energy - Approximate equation of plasticity.

METHODS OF SOLVING PRACTICAL PROBLEMS: The characteristic method – Engineeringmethod - Compression of metal under press - Theoretical and experimental data drawing.

REFERENCE BOOKS:

1. Theory of Elasticity/Timoshenko S.P. and Goodier J.N./Koakusha Publishers
2. An Engineering Theory of Plasticity/E.P. Unksov/Butterworths
3. Applied Elasticity/W.T. Wang/TMH
4. Theory of Plasticity for Engineers/Hoffman and Sacks/TMH
5. Theory of Elasticity and Plasticity/Sadhu Singh/ Khanna Publishers
6. Theory of Elasticity and Plasticity/Harold Malcolm Westergaard/Harvard University Press

MODELING AND ANLALYSIS – I (CAD)

Course Code: 18 ME 5120 **L-T-P: 4-0-2**
Pre-requisite: NIL **Credits: 5**
Syllabus:

CAD TOOLS:
Definition of CAD Tools, Types of System, CAD/CAM system evaluation criteria, brief treatment of input an output devices. Graphics standards, functional areas of CAD, Modeling and Viewing, Software documentation efficient use of CAD Software.

GEOMETRIC MODELING:
Types of Mathematical representation of curves, wire frame models, wire frame entities, parametric representation of synthetic curves hermit cubic splines, Bezier curves, B-Splines rational curves.

SURFACE MODELING:
Mathematical representation surfaces, surface model, surface entities, surface representation, parametric representation of surfaces, plane surface, rule surface, surface of revolution, tabular cylinder.

PARAMETRIC REPRESENTATION OF SYNTHETIC SURFACES:
Hermit Bi-Cubic surface, Bezier curve surface, B-Spline surface, COONs, Blending Surface, Sculptured surface, Surface Manipulation- Displaying, segmentation, trimming, intersection, Transformations (2D and 3D).

GEOMETRIC MODELING 3D:
Solid modeling, solid representation, Boundary Representation (B-Rep), Constructive Solid Geometry.

CAD/CAM DATA EXCHANGE:
Evaluation of data – Exchange format, IGES Data representations and structure, STEP Architecture, Implementation, ACIS and DXF.

DESIGN APPLICATIONS:
Finite Element Modeling and Analysis and Mechanical Assembly.

COLLABORATIVE ENGINEERING:
Collaborative Design, Principles, Approaches, tools, designs system.

Reference books:

1. CAD/CAM Theory and Practice/Ibrhim Zeid/Mc Graw Hill International.
2. MASTERING CAD/CAM / Ibrahim Zeid / Mc Graw Hill International.
3. CAD/CAM PN Rao / TMH.

4. CAD/CAM Principles, Practice and Manufacturing Management / Chris Mc. Mohan, Jimmie Browne / Pearson edu. (LPE)
5. Concurrent Engineering Fundamentals: Integrated Product Development/ Prasad / Prentice Hall.
6. Successful implementation of concurrent Product and Process / Sammy G Sinha / Wiley John and Sons Inc.

MODELING AND ANLALYSIS – I (CAD)

LIST OF EXPERIMENTS

1. Introduction to CAD Modeling
2. Basics of 2D modeling using solid works – Sketcher Module
3. Part modeling using Extrude
4. Part modeling using Revolve
5. Part modeling using Rib
6. Part modeling of symmetric object using Mirror
7. Part modeling using Sweep and Loft
8. Part modeling and assembly of Screw jack
9. Part modeling and assembly of Pipe vice
10. Part modeling and assembly of Crane hook
11. Part modeling and assembly of Swivel bearing
12. Surface modeling using Extrude feature
13. Surface modeling using Swept feature
14. Surface modeling using Loft feature
15. Part Modeling using Surface Module

MECHANICAL VIBRATIONS

Course Code: 18 ME 5221 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

Review of Mechanical Vibrations: Basic concepts; Free vibration of single degree of freedom systems with and without damping, Forced vibration of single DOF-systems. Force and motion isolation. Two DOF-system: natural frequency.

Transient Vibration of single Degree-of freedom systems: Impulse excitation, arbitrary excitation, Laplace transforms formulation, Pulse excitation and rise time, Shock response spectrum, Shock isolation, Finite difference numerical computation.

Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations.

Random Vibrations : Random phenomena, Time averaging and expected value, Frequency response function, Probability distribution, Correlation, Power spectrum and power spectral density, Fourier transforms, FTs and response.

Continuous Systems : Vibrating string, Longitudinal vibration of rods, Torsional vibration of rods, Suspension bridge as continuous system, Euler equation for beams, Vibration of membranes.

Vibration Control: Introduction, Vibration isolation theory, Vibration isolation theory for harmonic excitation, practical aspects of vibration analysis, shock isolation, Dynamic vibration absorbers, and Vibration dampers.

Vibration Measurement and applications: Introduction, Transducers, Vibration pickups, Frequency measuring instruments, Vibration exciters, Signal analysis.

Modal analysis & Condition Monitoring: Dynamic Testing of machines and Structures, Experimental Modal analysis, Machine Condition monitoring and diagnosis.

Text Books:

1. Theory of Vibration with Application, - William T. Thomson, Marie Dillon Dahleh, Chandramouli Padmanabhan, 5th edition Pearson Education.
2. Fundamentals of Mechanical Vibration. - S. Graham Kelly. 2nd edition McGraw Hill.
3. Mechanical Vibrations, - S. S. Rao., 4th edition Pearson Education.

Reference Books:

1. Mechanical Vibrations - S. Graham Kelly, Schaum's Outlines, Tata McGraw Hill, 2007

DESIGN FOR OPTIMIZATION

Course Code: 18 ME 5222 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**

Syllabus:

INTRODUCTION
General Characteristics of mechanical elements, adequate and optimum design, principles of optimization, formulation of objective function, design constraints- Classification of Optimization problem.

OPTIMIZATION TECHNIQUES
Single variable and multivariable optimization, techniques of unconstrained minimization- Golden selection, Random, Patter and Gradient search methods- interpolation methods, Optimization with equality and inequality constraints.

MULTI OBJECTIVE OPTIMIZATION
Direct methods – Indirect methods using penalty functions, Lagrange multipliers, Geometric programming and stochastic programming, multi objective optimization, Genetic algorithms and stimulated Annealing techniques.

STATIC APPLICATION
Structural applications – Design of simple truss members, Design applications – Design of simple axial, transvers loaded members for minimum cost, maximum weight- Design of shafts and torsion ally loaded members- Design of springs.

DYNAMIC APPLICATION
Dynamic applications- Optimum design of single, two degree of freedom systems , vibration absorbers. Application in mechanisms – Optimum design of simple linkage mechanisms.

Text Books:

1. Sigeresus S.Rao "Engineering Optimization – Theory and Practice" New age lntl. Ltd., Published, 2000.

Reference books:

1. Johnson Ray. C., "Optimum Design of mechanical elements", Wiely, John &sons, 1990.

2. Goldberg. D.E., “Genetic algorithms in search optimization and machines”, Barnen, Addison Wesley, New York, 1989.
3. Kalyanamoy Deb, “Optimization for Engineering Design algorithm and Examples”, Prentice Hall of India Pvt. 1995.

ADVANCED STRENGTH OF MATERIALS

Course Code: 18 ME 5223 **L-T-P: 3-1-0**
Pre-requisite: NIL **Credits: 4**

Syllabus:

SHEAR CENTER
Bending axis and shear center- shear center of axisymmetric and unsymmetrical sections.

UNSYMMETRICAL BENDING:
Bending stress in beams subjected to non-symmetrical bending, deflection of straight beams due to non symmetrical bending.

CURVED BEAM THEORY:
Winkler Bach formula for circumferential stress- limitation – correct factors- radial stress in curved beams – closed ring subjected to concentrated and uniform loads- stress in chain links.

Torsion: Linear elastic solution, Pradtl elastic membrane (Soap-Film) Analogue, Narrow rectangular cross section, Hollow thin wall torsion members, multiply connected cross section.

CONTACT STRESS:
Introduction, problem of determining contact stresses, assumptions on which a solution for contact stresses is based, expression for principle stresses, method of computing contact stresses, deflections of bodies in point contact, stresses for tow bodies in contact over narrow rectangular area (Line of contact). Loads normal to area, stressed for two bodies in line contact normal and tangent to contacts area.

TWO DIMENSIONAL ELASTICITY PROBLEMS:
Plane stress and plain strain – problems in rectangular Coordinates bending of cantilever beam loaded at the end, bending of a beam by uniform load.

TWO DIMENSIONAL ELASTICITY PROBLEMS:
In polar coordinates, general equations in polar coordinates, stress distribution symmetrical about the axis, pure bending of curved bars, and displacements for symmetrical stress distributions, rotating discs.

INTRODUCTION TO THREE DIMENSIONAL PROBLEMS:

Uniform stress stretching of a prismatic bar by its own weight, twist o circular shafts of constant cross section, pure bending of plates.

Reference books:

1. Advanced Mechanics of materials by Boresi and Sidebottom- Wiely International.
2. Theory of Elasticity by Timoschenko S.P. and Goodier J.N Mc Grawhill Publishers.
3. Advanced strength of material by Den Hortog J.P..
4. Theory of plates- Timoshenko.
5. Strength of Materials and Theory of Structures (Vol I&II) by B.C Punmai.

MODELING AND ANALYSIS- 2 (ADVANCED FEM)

Course Code: 18 ME 5224 **L-T-P: 4-0-2**
Pre-requisite: NIL **Credits: 5**

Syllabus:

BENDING OF PLATES AND SHELLS
Review of Elasticity equation – Bending of plates and shells – Finite Element formulation of plates and shell elements – Conforming and Non-Conforming elements- C_0 and C_1 Continuity elements – application and examples.

NON-LINEAR PROBLEM:
Introduction- Iterative Techniques – Material Non- Linearity – Elasto Plasticity – Plasticity – Viscos Plasticity – Geometric Non linearity – Large displacement formulation – application in metal forming process and contact problems.

DYNAMIC PROBLEMS:
Direct formulation- free, transient and forced response – Solution procedures- Subspace iterative Techniques – Houbot, Wilson, Newmark – Methods – Examples.

FLUID MECHANICS AND HEAT TRANSFER:
Governing equations of fluid mechanics – in viscid and incompressible flow – Potential formulations – Slow Non- Newtonian Fluid Flow – Metal and Polymer forming – Navier stocks equation – Steady and Transient solution.

ERROR ESTIMATES AND ADAPTIVE REFINEMENT:
Error norms and convergence rates- N Refinement with adaptively – Adaptive refinement.

Text Books:

1. Zienkiewicz, O.C. and Taylor, R.L., “The Finite Element Method”, Fourth Edition, Volume I and 2, McGraw Hill International Edition, Physics services, 1991.

Reference books:

1. Cook R.D., “Concept and Applications of Finite Element Analysis:, John Wiely and Sons Inc., New York 1989.
2. Bathe K.J., “Finite Element Procedure in Engineering Analysis”, Prentice Hall, 1990.

MODELING AND ANALYSIS- 2 (ADVANCED FEM)

LIST OF EXPERIEMENTS

A Introduction to ANSYS using APDL

1. Static analysis on Beams subjected to Angular loads
2. Static analysis on Flat Plate and Flat Plate with Hole
3. Static analysis of thin Cylindrical Shell subjected to Internal Pressure
4. Static Analysis on an Airplane wing model
5. Non-linear Analysis on Cantilever Beam
6. Application of Non-linear Materials
7. Modal analysis on cantilever Beam
8. Dynamic analysis on beam subjected to force function
9. Thermal Analysis - Solidification of metal Casting
10. Thermal analysis - Heat flow through furnace wall
11. Thermal analysis – Heat flow through composite wall
12. Thermal analysis on plane wall
13. CFD Analysis - Pressure distribution along transition duct

PRECISION AND QUALITY ENGINEERING

Course Code: 18 ME 51I1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

INTRODUCTION:
Importance of Precision Engineering, Tolerance and Technology, Definition of Tolerance, Impact of specifying Tolerance.

MEASUREMENT OF PRECISION:
Application of displacement transducers to machines and instruments, introduction to Precision Machine Design, Principles of Precision of Machine Design, Principle of Accuracy, Repeatability and resolution.

INTRODUCTION TO QUALITY:
Quality of design, Quality of Conformance to Design, Quality of Performance, Growth of Quality Control, Process Monitoring, Acceptance Sampling, Quality of Performance Reliability, Management of Quality, Quality and Productivity.

FUNDAMENTAL OF STATISTICS AND PROBABILITY IN QUALITY CONTROL:
Events and Probability, Laws of Probability, Distribution and Frequency, Binomial Distribution, Normal Distribution, Poisson's Distribution, Exponential and Weibull and Distribution, Random Experiments, Probability, Random Variable, Distribution Functions, Discrete Distributions, Continuous Distribution, Uniform Distribution, Numerical Characteristics of Random Variables.

STATISTICAL QUALITY CONTROL:
Variability in Materials, Machines and people, Statistical Understanding of Variability, Basic form of control chart, use of Control charts, Development of a Control Chart, Control charts for Variable and attributes.

BASIC CONCEPT OF RELIABILITY:
Introduction, Reliability and Quality, Failures and Failure Modes, Causes of Failures and Un reliability, maintainability and Availability, History of Reliability, Reliability literature.

TOTAL QUALITY MANAGEMENT:
Objectives of TQM, Management in TQM, Implementation of TQM.
I.S.O 9000 Series.
Introduction Characteristics, Area covered in ISO 9000

ADVANCED MECHANISMS

Course Code: 18 ME 51I2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

Introduction: Elements of Mechanisms; Mobility Criterion for Planar mechanisms and manipulators; Mobility Criterion for spatial mechanisms and manipulators. Spherical mechanisms-spherical trigonometry.

Advanced Kinematics of plane motion- I: The Inflection circle ; Euler – Savary Equation; analytical and graphical determination of di ; Bobillier's Construction; collineastion axis ; Hartmann's Construction ;Inflection circle for the relative motion of two moving planes; Application of the Inflection circle to kinematic analysis**Advanced Kinematics of plane motion - II:** Polode curvature; Hall's Equation; Polode curvature in the four bar mechanism; coupler motion; relative motion of the output and input links; Determination of the output angular acceleration and its Rate of change; Freudenstein's collineation –axis theorem; Carter – Hall circle; The circling – point curve for the Coupler of of a four bar mechanism.

Introduction to Synthesis-Graphical Methods - I: The Four bar linkage; Guiding a body through Two distinct positions; Guiding a body through Three distinct positions; The Rotocenter triangle; Guiding a body through Four distinct positions; Burmester's curve.

Introduction to Synthesis-Graphical Methods - II: Function generation- General discussion; Function generation: Relative– Rotocenter method, Overlay's method, Function generation- Velocity – pole method; Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem.

Introduction to Synthesis - Analytical Methods: Function Generation: Freudenstien's equation, Precision point approximation, Precision – derivative approximation; Path Generation: Synthesis of Fourbar Mechanisms for specified instantaneous condition; Method of components; Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link; Method of components.

Manipulator kinematics – I: D-H notation, D-H convention of assignment of co-ordinate frames and link parameters table; D-H transformation matrix; Direct and Inverse kinematic analysis of Serial manipulators: Articulated ,spherical & industrial robot manipulators-PUMA, SCARA,STANFORD ARM, MICROBOT.

Manipulator kinematics – II: Differential kinematics Formulation of Jacobian for planar serial manipulators and spherical manipulator; Singularity analysis.

Text Books:

1. Jeremy Hirschhorn, Kinematics and Dynamics of plane mechanisms,McGraw-Hill,1962.
2. L.Sciavicco and B.Siciliano, Modelling and control of Robot manipulators,Second edition, Springer -Verlag,London,2000.
3. Amitabh Ghosh and Ashok Kumar Mallik, Theory of Mechanisms and Machines. E.W.P.Publishers.

Reference Books:

1. Allen S.Hall Jr., Kinematics and Linkage Design, PHI,1964.
2. J.E Shigley and J.J . Uicker Jr., Theory of Machines and Mechanisms , McGraw-Hill, 1995.
3. Mohsen Shahinpoor, A Robot Engineering Text book,Harper & Row Publishers, New York,1987.

CONCURRENT ENGINEERING

Course Code: 18 ME 51I3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

Concurrent Engineering Definitions
Introduction. Basic Principles of CE. Components of CE. Concurrency and Simultaneity. Modes of Concurrency. Modes of Cooperation. Benefits of Concurrent Engineering. References. Test Problems: CE Definitions.

Cooperative Work Teams
Introduction. Cooperative Concurrent Teams. Program Organization. Supplier Rationalization. Types of CE Organization. Management Styles or Philosophies. Workplace Organization and Visual Control. Employee Excellence Development (New Technologies and Team Capabilities). References. Test Problems: Cooperative Work Teams.

System Engineering
Introduction. An Automobile Manufacturing Process. System Engineering. Systems Thinking. Approaches to System Complexity. Sharing and Collaboration in CE 300. System Integration. Management and Reporting Structure. Agile Virtual Company. References. Test Problems: System Engineering.

Information Modeling- Introduction
Information Modeling. Modeling Methodology. Foundation of Information Modeling. Concurrent Engineering Process Invariant. Enterprise Model-Class. Specification Model-Class. Product Model-Class. Process Model- Class. Cognitive Models. Merits and Demerits. Summary. References. Test Problems: Information Modeling.

The Whole System
Introduction. Conventional Design and Development Process. A Transformation Model for a Manufacturing System. CE Enterprise System Taxonomy. Integrated Product and Process Development. Transformation System for Product Realization. Key Dimensions of a CE Specification Set. Artifact's Intent Definitions. References. Test Problems: The Whole System.

REFERENCES:

1. Biren Prasad – "Concurrent Engineering Fundamentals: Integrated Product and Process Organization" Volume I - Prentice Hall, 1996

DESIGN OF PRESSURE VESSELS AND PLATES

Course Code: 18 ME 51J1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

INTRODUCTION
Methods for determining stresses – Terminology and Ligament Efficiency – Applications.
STRESSES IN PRESSURE VESSELS
Introduction – Stresses in a circular ring, cylinder – Membrane stress Analysis of Vessel Shell components – Cylindrical shells, spherical Heads, conical heads – Thermal Stresses – Discontinuity stresses in pressure vessels.
DESIGN OF VESSELS
Design of Tall cylindrical self supporting process columns – supports for short vertical vessels – stress concentration – at a variable Thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design.
BASIC EQUATIONS OF THIN PLATE THEORY
Introduction-assumptions-slopes and curvatures of bent plate-strain curvature relations-moment curvature relations-equilibrium equations-rectangular plate, circular plate-boundary conditions- rectangular plate, circular plate-summery of basic equations-basic equations in Cartesian coordinate system-basic equations in polar co-ordinate system.
Bending of plates
Introduction-pure bending and cylindrical bending of rectangular plates-navier solution for an all-round simply supported rectangular plate-levy solution for rectangular plates- Method of superposition for the analysis of rectangular plates with arbitrary boundary conditions.
BENDING OF CIRCULAR PLATES:
Circular plates subjected to an arbitrary load- Symmetric bending of circular plates, circular plate subjected to asymmetric load.

TEXT BOOKS

1. John F. Harvey, Theory and Design of Pressure Vessels, CBS Publishers and Distributors, 1987.
2. K Chandrashekara, “Theory of plates”, University Press, 2001

REFERENCES

1. Henry H. Bedner, “Pressure Vessels, Design Hand Book, CBS publishers and Distributors, 1987.
2. Stanley, M. Wales, “Chemical process equipment, selection and Design. Butterworth series in Chemical Engineering, 1988.

3. William. J., Bees, “Approximate Methods in the Design and Analysis of Pressure Vessels and Piping”, Pre ASME Pressure Vessels and Piping Conference, 1997.
4. Timoshenko S.P. and Goodier J.N, “Theory of elasticity” McGraw-Hill Publishers
5. Timoshenko S, “ Theory Of Plates And Shells” McGraw-Hill Publishers.

TRIBOLOGICAL SYSTEM DESIGN

Course Code: 18 ME 51J2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

SURFACES, FRICTION AND WEAR
Topography of Surfaces – Surface features – Surface interaction – Theory of Friction – Sliding and Rolling Friction, Friction properties of metallic and non-metallic materials – friction in extreme conditions – wear, types of wear – mechanism of wear – wear resistance materials – surface treatment – Surface modifications – surface coatings.

LUBRICATION THEORY
Lubricants and their physical properties lubricants standards – Lubrication Regimes Hydrodynamic lubrication – Reynolds Equation, Thermal, inertia and turbulent effects – Elasto hydrodynamic and plasto hydrodynamic and magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication.

DESIGN OF FLUID FILM BEARINGS
Design and performance analysis of thrust and journal bearings – Full, partial, fixed and pivoted journal bearings design – lubricant flow and delivery – power loss, Heat and temperature rotating loads and dynamic loads in journal bearings – special bearings – Hydrostatic Bearing design.

ROLLING ELEMENT BEARINGS
Geometry and kinematics – Materials and manufacturing processes – contact stresses – Hertzian stress equation – Load divisions – Stresses and deflection – Axial loads and rotational effects, Bearing life capacity and variable loads – ISO standards – Oil films and their effects – Rolling Bearings Failures.

TRIBO MEASUREMENT INSTRUMENTATION
Surface Topography measurements – Electron microscope and friction and wear measurements – Laser method – instrumentation - International standards – bearings performance measurements – bearing vibration measurement.

REFERENCES:

1. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., OK, 1981
2. Hulling, J. (Editor) – “Principles of Tribology “, Macmillian – 1984.
3. Williams J.A. “ Engineering Tribology”, Oxford Univ. Press, 1994.
4. Neale, M.J. “Tribology Hand Book”, Butterworth Heinemann, 1995.

WEB REFERENCES:

1. http://www.csetr.org/link.htm
2. http://www.me.psu.edu/research/tribology.html

PRODUCT DESIGN & DEVELOPMENT

Course Code: 18 ME 51J3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

COLLABORATIVE PRODUCT DESIGN: Product lifecycle management-concepts, benefits, value addition to customer. Lifecycle models-creation of projects and roles, users and project management, system administration, access control and its use in life cycle. Product development process and functions. Data transfer. Variants of e-commerce. Multi system information sharing. Workgroup collaboration. Development of standard classification for components and suppliers. Model assembly process-link product and operational information. Customization factors-creation of business objects, user interfaces, search facile ties as designed by the enterprise. Software-PDM/PLM and their comparison.

PRODUCT DEVELOPMENT: Quality function deployment-quality project approach and the problem solving process. Design creativity-innovations in design alternatives. Concurrent engineering, industrial design principles. Product development versus design, types of design and redesign, modern production development process, reverse engineering and redesign product development process, examples of product development process, scoping product development – S-curve, new product development.

UNDERSTANDING CUSTOMER NEEDS: Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality.

PRODUCT TEAR DOWN AND EXPERIMENTATION: Tear down method, post teardown report, benchmarking and establishing engineering specifications, product portfolios.

GENERATING CONCEPTS: Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection, technical feasibility, ranking, measurement theory, DFMA, design for robustness.

PHYSICAL PROTOTYPES: Types of prototypes, use of prototypes, rapid prototyping technique scale, dimensional analysis and similitude, physical model and experimentation-design of experiments, statistical analysis of experiments.

REFERENCE BOOKS:

1. John W Gosnay and Christine M Mears, Business Intelligence with Cold Fusion , Prentice Hall India, New Delhi, 2000.
2. David S Linthicum, "B2B Application Integration", Addison Wesley, Boston, 2001.
3. Alexis Leon,Enterprise Resource Planning, Tata McGraw Hill, New Delhi, 2002.
4. David Ferry and Larry Whipple,Building and Intelligent e-business, Prima Publishing, EEE Edition, California, 2000.
5. David Bedworth, Mark Hederson and Phillip Wolfe, Computer Integrated Design and Manufacturing, McGraw Hill Inc., New York, 1991.
6. Kevin Otto and Kristin Wood, Product Design – Techniques in Reverse Engineering and New Product Development, Pearson Education, New Delhi.
7. Karl T Ulrich and Stephen D Eppinger, Product Design and Development, McGraw Hill, New York, 1994.

MECHANICS OF COMPOSITE MATERIALS

Course Code: 18 ME 52K1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

Basic concepts and characteristics: Geometric and Physical definitions, natural and man-made composites, Aerospace and structural applications, types and classification of composites,

Reinforcements: Fibres- Glass, Silica, Kevlar, carbon, boron, silicon carbide, and born carbide fibres. Particulate composites, Polymer composites, Thermoplastics, Thermosetts, Metal matrix and ceramic composites.

Micromechanics: Unidirectional composites, constituent materials and properties, elastic properties of a lamina, properties of typical composite materials, laminate characteristics and configurations.

Characterization and Testing of Composite Materials

Characterization of Constituent Materials, Physical Characterization of composite materials, Determination of Tensile, Compressive and shear properties of Uni-dimensional lamina, Inter Lamina Fracture Toughness, Bi-Axial Testing, Characterization of Composites with Stress Concentration, Structural Testing.

Elastic Behavior of Composite Lamina- Macro mechanics

Stress Strain Relations, Relations between Mathematical and Engineering constants, Stress-strain Relations for a thin Lamina (Two-Dimensional), Transformation of Stress and Strain (Two-Dimensional), Transformation of Elastic Parameters (Two-Dimensional), Transformations of stress-strain Relations in Terms of Engineering Constants (Two-Dimensional)

Strength of Uni Directional Lamina

Introduction, Longitudinal tension- Failure Mechanisms and strength, Longitudinal Compression, Transverse Tension and compression, In-plane shear, Out-of-plane Loading,

Strength of Composite Lamina

Failure Theories, Maximum Stress theory, Max Strain theory, Tsai-Hill, Tsai-Wu, Hashin-Rotem Failure theories, Evaluation and Applicability of Lamina Failure Theories.

Text Books:

1. Isaac M Daniel and Ishai, “Engineering Mechanics of Composite Materials”, Oxford University Press, 1994.
2. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, WileyInter-science, New York, 1980.

Reference Books:

1. R. M. Jones, Mechanics of Composite Materials, Mc Graw Hill Company, New York, 1975.
2. L. R. Calcote, Analysis of Laminated Composite Structures, Van Nostrand Rainfold, New York, 1969.

MACHINE TOOL DESIGN

Course Code: 18 ME 52K2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

FUNDAMENTALS OF MACHINE TOOL DESIGN: Introduction, working motions in machine tools, machine tool drives: electric motor, transmission arrangement, Hydraulic transmission of elements: pumps, hydraulic cylinders, throttles.
General requirements of machine tool design: Productivity, accuracy, simplicity of design, safety, low cost of manufacturing, engineering process applied to machine tools.
DESIGN OF SPEED & FEED RATES: Aim of speed & feed rate regulation; various laws of stepped regulation of speed-Design of speed box, Design of feed box, classification of speed & feed boxes. Step less regulation of speed & feed rates for hydraulics.
DESIGN OF MACHINE TOOL STRUCTURES: Functions of machine tool structures & their requirements, Design criteria for machine tool structures, Basic design procedure of machine tool structures.
DESIGN OF BEDS, TABLES, COLUMNS: Various types of beds used in machine tools- their construction & design feature; Determination of forces acting on horizontal table, Column design of milling machine & maximum deflection error in milling machine.
DESIGN OF GUIDE WAYS & HOUSINGS: Functions & types of guide ways, Design of guide way- shapes, materials. Design of guide ways for wear resistance, stiffness. Design of housings- solid.
DESIGN OF POWER SCREWS OF MACHINE TOOLS: Types & classifications, Design of sliding friction power screws, Design of rolling friction power screws.
DESIGN OF SPINDLE UNITS IN MACHINE TOOLS: Functions, requirements, materials for spindles, Design calculations of spindles: deflection of spindle axis due to bending, due to compliance of spindle supports.
NUMERICAL CONTROL OF MACHINE TOOLS: Fundamentals, classification & structure of NC systems, Program readers, Decoder, Buffer storage, comparators.
Extension of numerical control systems: Introduction to DNC, CNC, Machining centers.

Text Books:

1. NK Mehta," Machine Tool Design and Numerical Control', second Edition, Tata McGraw Hill book Company, (1997)
2. Gopal Chandra sen & Amitabha Bhattacharya,"Principles of Machine Tools", New Central Book agency, Calcutta,(1998)

Reference Books :

1. SK Basu, DK Pal," Design of Machine Tools", Oxford & IBH Publication Co Pvt Ltd, New Delhi (1995)
2. CMTI "Machine Tool design Course , Vol 4,5 & 6, Central Machine Tool Institute, Bangalore. (1997)

FRACTURE MECHANICS

Course Code: 18 ME 52K3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

ELEMENTS OF SOLID MECHANICS
The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation - limit analysis.

STATIONARY CRACK UNDER STATIC LOADING
Two dimensional elastic fields – Analytical solutions yielding near a crack front – Irwin's approximation - plastic zone size – Dugdale model – J integral and its relation to crack opening displacement.

ENERGY BALANCE AND CRACK GROWTH
Griffith analysis – Linear Fracture Mechanics-Crack Opening displacement – Dynamic energy balance – crack arrest.

FATIGUE CRACK GROWTH CURVE
Empirical Relation describing crack growth by fatigue – Life calculations for a given load amplitude – effects of changing the load spectrum – Effects of Environment.

ELEMENTS OF APPLIED FRACTURE MECHANICS

Examples of crack-growth Analysis for cyclic loading - leak before break – crack Initiation under large scale yielding – Thickness as a Design parameter – crack instability in Thermal or Residual – stress fields.

REFERENCES:

1. David Broek, "Elementary Engineering Fracture Mechanics", Fifthoff and Noerdhoff International Publisher, 1978.
2. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
3. Preshant Kumar, "Elements of Fracture Mechanics", Wheeler Publishing, 1999.

WEB REFERENCES:

1. www.elsevier.com/locate/engfracmech

ENGINEERING NOISE AND CONTROL

Course Code: 18 ME52L1 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

FUNDAMENTALS AND BASIC TERMINOLOGY:
Introduction, Noise-Control Strategies, Acoustic Field Variables and the Wave Equation, Plane and Spherical Waves, Mean Square Quantities, Energy Density, Sound Intensity, Sound Power, Units, Spectra, Combining Sound Pressures, Impedance, Flow Resistance

INSTRUMENTATION FOR NOISE MEASUREMENT AND ANALYSIS:
Microphones, Weighting Networks, Sound Level Meters, Grades of Sound Level Meter, Sound Level Meter Calibration, Noise Measurements Using Sound Level Meters, Time-Varying Sound, Noise Level Measurement, Statistical Analyzers, Noise Dosimeters, Tape Recording of Noise, Spectrum Analysers, Intensity Meters, Energy Density Sensors

CRITERIA:
Introduction, Hearing Loss, Hearing Damage Risk, Hearing Damage Risk Criteria, Implementing a Hearing Conservation Program, Speech Interference Criteria, Psychological Effects of Noise, Ambient Noise Level Specification, Environmental Noise Level Criteria, Environmental Noise Surveys

SOUND POWER AND SOUND PRESSURE LEVEL ESTIMATION PROCEDURES:
Introduction, Fan Noise, Air Compressors, Compressors for Refrigeration Units, Cooling Towers, Pumps, Jets, Control Valves, Pipe Flow, Boilers, Turbines, Diesel and Gas-Driven Engines, Furnace Noise, Electric Motors, Generators, Transformers, Gears, Transportation Noise

ACTIVE NOISE CONTROL
Introduction, Active Control of Sound Propagation in Ducts, Active Control of Sound Radiation From Vibrating Structures, Sound Transmission into Enclosed Spaces, Active Vibration Isolation, Electronic Controller Design

Text books:

1. David A. Bies and Colin H. Hansen; “Engineering noise control: theory and practice”

ENGINEERING FAILURE ANALYSIS AND PREVENTION

Course Code: 18 ME 52L2 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus:

Common causes of failure.
Principles of failure analysis.
Fracture mechanics approach to failure problems.
Techniques of failure analysis.
Service failure mechanisms ductile and brittle fracture, fatigue fracture, wear failures, fretting failures, environment induced failures, high temp. failure.
Faulty heat treatment and design failures, processing failures (forging, casting, machining etc.), failure problems in joints and weldments.
Case studies for ferrous and non-ferrous metallic parts and parts made from polymers and ceramic.

Text Books:

1. Metals Hand Book, Vol.10, “Failure Analysis and Prevention ", (10th Edition), 1994.
2. Failure Analysis of Engineering Structures: Methodology and Case Histories- **V. Ramachandran**
3. Practical Engineering Failure Analysis by Hani M. Tawancy, Anwar Ul-Hamid, Nureddin M. Abbas.

DESIGN FOR MANUFACTURING, ASSEMBLY AND ENVIRONMENT

Course Code: 18 ME 52L3 **L-T-P: 3-0-0**
Pre-requisite: NIL **Credits: 3**

Syllabus

INTRODUCTION
General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric tolerances - Assembly limits -Datum features - Tolerance stacks.

FACTORS INFLUENCING FORM DESIGN
Working principle, Material, Manufacture, Design- Possible solutions - Materials choice - Influence of materials on form design - form design of welded members, forgings and castings.

COMPONENT DESIGN - MACHINING CONSIDERATION
Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clamp ability - Design for accessibility - Design for assembly.

COMPONENT DESIGN - CASTING CONSIDERATION
Redesign of castings based on Parting line considerations - Minimizing core requirements, machined holes, redesign of cast members to obviate cores.
Identification of uneconomical design - Modifying the design - group technology - Computer Applications for DFMA

DESIGN FOR THE ENVIRONMENT
Introduction – Environmental objectives – Global issues – Regional and local issues – Basic DFE methods – Design guide lines – Example application – Lifecycle assessment – Basic method – AT&T's environmentally responsible product assessment - Weighted sum assessment method – Lifecycle assessment method – Techniques to reduce environmental impact – Design to minimize material usage – Design for disassembly – Design for recyclability – Design for remanufacture – Design for energy efficiency – Design to regulations and standards.

REFERENCE BOOKS:

1. Boothroyd, G, 1980 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Bralla, Design for Manufacture handbook, McGraw hill, 1999.
3. Boothroyd, G, Heartz and Nike, Product Design for Manufacture, Marcel Dekker, 1994.
4. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 1995.
5. Fixel, J. Design for the Environment McGraw hill., 1996.

6. Graedel T. Allen By. B, Design for the Environment Angle Wood Cliff, Prentice Hall. Reason Pub., 1996.
7. Kevien Otto and Kristin Wood, Product Design. Pearson Publication, 2004.