PG Syllabus

For

Mechanical System Design & Innovation Technology

Under the Department of

Mechanical Engineering

NATIONAL INSTITUTE OF TECHNOLOGY

(Established by Ministry of Human Resource Development, Govt. of India**)**

Yupia, District: Papum Pare, Arunachal Pradesh- 791112

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DIRECTOR

FOREWORD

To **achieve the target of being a global leader in the field of Technical Education**, there is some sort of time bound urgency **to work quickly, massively and strongly**, in respect of National Institute of Technology, Arunachal Pradesh being an **" Institute of National Importance"** (by an Act of Parliament) and being **established only in five years back in 2010**. I have therefore adopted a **'B' plan** as stated below to achieve the primary goal of producing world class visionary engineers and exceptionally brilliant Researchers and Innovators:

B- Plan

- **Best Teaching**
- **Best Research**
- **Best Entrepreneurship & Innovation practices**
- **Best Services to Society**

In implementing the **'B' plan** in letter and spirit, the framing of syllabi has been taken **as an important legitimate parameter**. Therefore, extraordinary **efforts and dedications were directed for the last few years to frame** syllabi **in a framework which is perhaps not available in the country as of today, with an Indian perspective in a Global context**.

Besides attention on **'B' plan** institute has given considerable importance to the major **faults of current Technical Education while framing the syllabus**. The major stumbling blocks in Technical Education today are:

I. The **present system is producing "Academic Engineers" rather than "Practical Engineers".**
II. The present system of education makes the **students to run after jobs rather than making them competent to create jobs.**
III. There is lack of **initiative to implement the reality of "Imagination is more important than knowledge".**

Taking due consideration of the findings made above, to my mind credible syllabi has been framed in the institute in which the major innovations are introduction of:

I. **I-Course (Industrial Course) one in each semester at least one, which is targeted to be taught by the Industrial Expert at least up to 50% of its component.**
II. **Man making and service to society oriented compulsory credit courses of NCC/NSS, values & ethics.**
III. **Compulsory audit course on Entrepreneurship for all branches.**
IV. **Many add-on courses that are (non-credit courses) to be offered in vacation to enhance the employability of the students.**
V. **Many audit courses like French, German, and Chinese to enhance the communication skill in global scale for the students.**
VI. **Research and imagination building courses such as Research Paper Communication.**
VII. **Design Course as "Creative Design".**

Further, the syllabi are framed **not to fit in a given structure as we believe structure is for syllabus and syllabus is not for structure. Therefore, as per requirement of the courses, the structure, the credit and the contact hours have been made available** in case to case.

The syllabus is also innovative as it includes:

I. **In addition to the list of text and reference books, a list of journals and magazines for giving students a flexibility of open learning.**
II. **System of examination in each course is conventional examination, open book examination and online examination.**

Each course has been framed with definite objectives and learning outcomes. The Syllabus has also identified the courses to be taught either of two models of teaching:

I. **J. C. Bose model of teaching where practice is the first theory.**
II. **S. N. Bose model of teaching where theory is the first practice.**

Besides the National Institute of Technology, Arunachal Pradesh has initiated a scheme of **simple and best teaching** in which for example:

I. **Instead of teaching RL, RC and RLC circuit separately, only RLC circuit will be taught and with given conditions on RLC circuits, RL and RC circuits will be derived and left to the students as interest building exercise.**
II. **Instead of teaching separately High Pass Filter, Band Pass Filter and Low Pass Filter etc.; one circuit will be taught to derive out other circuits, on conditions by the students.**

I am firmly confident that the framed syllabus will result in **incredible achievements, accelerated growth and pretty emphatic win over any other systems** and therefore **my students will not run after jobs rather jobs will run after them.**

For the framing of this excellent piece of syllabus, **I like to congratulate all members of faculty, Deans and HODs in no other terms but "Sabash!".**

Prof. Dr. C.T. Bhunia
Director, NIT, (A.P.)

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Proposed Course Structure for M.Tech In

Mechanical System Design & Innovation Technology

Under Mechanical Engineering Department

(2 YEARS COURSE)

First Semester

Subject Code	Subject	P	T	L	Credit
MAS 901	Advanced Engineering Mathematics	2	0	3	4
ME- 911	Advanced Fluid Mechanics & Heat transfer	0	0	3	3
ME-912	Solid Mechanics	0	0	3	3
ME- 913	Elective-I	0	0	3	3
ME 914	Elective-II	0	0	3	3
ME 915	Lab-I	3	0	0	2
Total		**5**	**0**	**15**	**18**

Second Semester

Subject Code	Subject	P	T	L	Credit
ME -921	Mechanics and Automation	0	0	3	3
ME-922	Computer Aided Design and Manufacturing	0	0	3	3
ME 923	Research Methodology & Experimental Method	0	0	3	3
ME 924	Elective-III	0	0	3	3
ME 925	Elective-IV	0	0	3	3
ME 926	Lab-II	3	0	0	2
ME 927	Seminar-I	3	0	0	3
Total		**6**	**0**	**15**	**20**

Third Semester

Subject Code	Subject	P	T	L	Credit
ME 931	Seminar-II	0	0	3	3
ME 932	Elective-V	0	0	3	3
ME 933	Dissertation Phase-I	28	0	0	14
Total		**28**	**0**	**6**	**20**

Fourth Semester

Subject Code	Subject	P	T	L	Credit
ME 941	Dissertation Phase-II	40	0	0	20
Total		**40**	**0**	**0**	**20**

Electives:-

1. Design and analysis of IC engines
2. Design of Heat Exchangers.
3. Steam power generation and performance analysis.
4. Design and analysis of mini and micro hydro system.

5. Design of Refrigeration and Air-conditioning Systems.
6. Wind energy conversion system.
7. Road vehicle System Design.
8. High pressure Equipment design and analysis.
9. Optimization Techniques.
10. Creative Design.
11. Gas turbine power plant system.
12. Finite Element Methods.
13. Mechanical Vibrations.
14. Mechanical Power Systems.
15. Computational Fluid Mechanics and Heat Transfer.
16. Robotics.
17. Control Systems.
18. Materials and Manufacturing Process.

First Semester

Subject Code	Subject	P	T	L	Credit
MAS 901	Advanced Engineering Mathematics	2	0	3	4
ME- 911	Advanced Fluid Mechanics & Heat transfer	0	0	3	3
ME-912	Solid Mechanics	0	0	3	3
ME- 913	Elective-I	0	0	3	3
ME 914	Elective-II	0	0	3	3
ME 915	Lab-I	3	0	0	2
Total		**5**	**0**	**15**	**18**

Name of the Module: Advanced Engineering Mathematics
Module Code: MAS 901
Semester: 1st
Credit Value: 4 [P=2, T=0, L=3]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. Introduce students to the fundamentals of vector and tensor algebra; and expose students to mathematical applications of vector and tensor algebra to handle diverse problems which occur in real life situations.
2. Introducing the basic notions of probability theory and develops them to the stage where one can begin to use probabilistic ideas in statistical inference and modeling, and the study of stochastic processes.
3. Providing confidence to students in manipulating and drawing conclusions from data and provide them with a critical framework for evaluating study designs and results.
4. Injecting future scope and the research directions in the field of stochastic process.
5. Demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems.

B. Learning outcomes:

Upon Completion of the subjects:

1. Know the fundamental mathematics of vector and tensor that are important for higher learning.
2. Provide working tools for students in some branches of applied mathematics, physics and geophysics.
3. Students will add new interactive activities to fill gaps that we have identified by analysing student log data and by gathering input from other college professors on where students typically have difficulties.
4. Students will add new simulation-style activities to the course in Inference and Probability.

5. Students will be substantially prepared to take up prospective research assignments.

C. Subject Matter:

Unit I:

Vectors: Vector and Tensor Analysis in Cartesian system; effect of rotation of coordinate systems; Review of ODEs; Laplace & Fourier methods; series solutions; and orthogonal polynomials; Sturm-Liouville problem. Complex Variable.

Unit II:

PDE: Review of 1st and 2nd order PDEs; Linear systems of algebraic equations; Gauss elimination; LU decomposition; Matrix inversion; ill-conditioned systems; Numerical Eigen solution techniques (Power, Householder, QR methods etc.).

Unit III:

Numerical solution of systems of nonlinear algebraic equations: Newton-Raphson method; Numerical integration: Newton-Cotes methods; error estimates; Gaussian quadrature. Numerical solution of ODEs: Euler; Adams; Runge-Kutta methods and predictor-corrector procedures; stability of solutions; solution of stiff equations.
Solution of PDEs: finite difference techniques.

Unit IV:

Probability and Statistics: Probability Distribution; Bay's Theorem; Parameter Estimation; Testing of Hypothesis; Goodness of Fit.
Laboratory: Basics of programming; Numerical experiments with algorithms.

D. Teaching/ Learning/ Practice Pattern:

Teaching: 60%
Learning: 40%
Practice: 0%

E. Examination Pattern:

1. Theoretical Examination

F. Reading List:

Books:

1. *E. Kreyzig, Advanced Engineering Mathematics, New Age International, 1996.*
2. *D. S. Watkins, Fundamentals of Matrix Computations, John Wiley, 1992.*
3. *M. K. Jain, S. R. K. Iyengar, and R. K. Jain, Numerical Methods for Scientific and Engineering Computation, 3rd Ed., New Age International, 1993*

4. *D.S. Chandrashekaraiah and L. Debnath, Continuum Mechanics, Academic Press, 1994.*
5. *M.K. Jain, S.R.K. Iyenger and R.K. Jain, Computational Methods for Partial Differential Equations, New Age International, 1994*
6. *R. Courant and D. Hilbert, Methods of Mathematical Physics, Wiley, 1989.*
7. *P.V. O'Neil, Advanced Engineering Mathematics, Cengage Learning, 2007.*
8. *G. B. Arfken, H. J. Weber and F.Harris, Mathematical Methods for Physicists, 5th Ed., Academic Press,*

Magazines:

1. *Current Science (Indian Academy of Science)*
2. *The Mathematics Student (Math Student) (Indian Mathematical Society)*
3. *Mathematical Spectrum(The University of Sheffield)*
4. *Mathematics Magazine (Mathematical Association of America)*
5. *Plus magazine (University of Cambridge)*
6. *Ganithavahini (Ramanujan Mathematical Society)*
7. *Mathematics Today, London Metropolitan University.*

Journals:

1. *Journal of Engineering Mathematics, Springer.*
2. *Journal of Computational and Applied Mathematics, London Metropolitan University.*
3. *The Journal of Indian Academy of Sciences.*
4. *Bulletin of Pure and Applied Sciences.*

Name of the Module: Advanced Fluid Mechanics and Heat Transfer
Module Code: ME 911
Semester: 1^{st}
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

Advanced Fluid Mechanics is one of the major courses for graduate students in the study of the flow of fluids. The course focuses on the internal flow in equipment, such as pipes, power machinery, fluid machinery and vessels, etc. The relative reactions between fluids and equipment will also be discussed in the course. The focus of the course is a central theme of modern applied mathematics. Based on mathematical concepts of gradient, divergence, vorticity and tensor, the basic properties normally ascribed to fluids such as density, compressibility and dynamic viscosity will be introduced. Then general equations, including continuous equation, momentum equation and energy equation are derived. In general, the motion of fluids is extremely complicated, including highly nonlinear phenomena like turbulence, and cannot be described exactly. Therefore the course is used to model a vast range of physical phenomena and plays a vital role in science and engineering.

B. Learning outcomes:

Upon Completion of the subjects:

The focus of the course is to solve problems in industry. The course is intended to provide students with the following benefits:

1. Understanding the concept of fluid and the models of fluids
2. Understanding the basic physical meaning of general equations
3. Understanding the concept of stream function and potential function
4. Ability to derive the equation for viscous flow, including laminar flow and turbulent flow.
5. Ability to address such problems in engineering, and to solve the problems

Subject Matter:

Unit-I

Concepts of fluids: Definitions of fluids, concept of continuum, different types of fluid, tensor analysis, governing laws of fluid mechanics in integral form, Reynold’s transport theorem, mass, momentum and energy equations in integral form and their applications, differential fluid flow analysis, continuity equation, Navier-Stokes equation and exact solutions. Potential flow analysis: Two-dimensional flow in rectangular and polar coordinates, continuity equation and the stream function, irrotationality and the velocity potential function, vorticity and circulation. Introduction to turbulent Flow Theory.

Unit-II

Flow over immersed bodies and D' Alembert's paradox, aerofoil theory and its application. Viscous flow analysis: Low Reynold's number flow, approximation of Navier-stokes equation, approximate solutions of Navier-Stokes equation, Prandtl's boundary layer equations, Compressible fluid flow: One dimensional isentropic flow, Fanno and Rayleigh flows, choking phenomenon, normal and oblique shocks. Micro and nano flow: Physical aspects of micro and nano flows, governing equations, surface tension driven flows, modeling of micro and nano flows.

Unit-III

Conduction: Equations and boundary conduction in different coordinate systems; Analytical Solutions: separation of variables, Laplace Transform, Duhamel's theorem: Non-impulse initial conditions; Numerical Methods: Finite difference and flux conservation; Interfacial heat transfer. Convection: Conservation equations and boundary conditions; Heat transfer in laminar developed and developing boundary layers: duct flows and external flows, analytical and approximate solutions, effects of boundary conditions;

Unit-IV

Heat transfer in turbulent boundary layers and turbulent duct flows; Laminar and turbulent free convection, jets, plumes and thermal wakes, phase change. Radiation: Intensity, radiosity, irradiance, view factor geometry and algebra; formulations for black and non–black surfaces, spectrally–selective surfaces (solar collectors); Monte Carlo methods for radiation exchange; The radiative transfer equation, extinction and scattering properties of gases and aerosols, overview of solution methods and applications. Interaction between conduction, convection and radiation: Coupled problems; Examples in manufacturing and electronic cooling applications; Micro channels and micro fins.

Text Books:

1. White, F.M., Viscous Fluid Flow, McGraw-Hill, New York, 3rd edition 2006.
2. Bachelor G. K. An introduction to Fluid Dynamics , Cambridge University Press, 2007.
3. Streeter V.L. and Wylie E. B., Fluid Mechanics , Tata McGraw-Hill, Delhi 2001.
4. Shames I. H., Mechanics of Fluids , Tata McGraw Hill, Delhi, 4th edition 2003.
5. Douglas and Swaffield, Fluid Mechanics , Prentice Hall, 5th edition 2006.
6. Yahya S. M., Fundamentals of Compressible Flow , Tata McGraw Hill, Delhi, 3rd edition 2003.
7. Karniadakis G., Beskok, A., and Narayan A. Microflows and Nanoflows , Springer, 1st edition 2005.
8. Journal of Fluid Mechanics,Cambridge University Press.
9. Physics of Fluids , , American Institute of Physics.
10. M N Ozisik, *Heat Conduction*, 2nd ed, John Wiley & Sons, 1993
11. Kakaç, S., Yener, Y., Heat Conduction, 3rd edition, Taylor & Francis, 1993.
12. F P Incropera and D P Dewitt, *Introduction to Heat Transfer*, 3rd ed, John Wiley & Sons, 1996
13. W. M. Kays and E. M. Crawford, *Convective Heat and Mass Transfer*, Mc Graw Hill,1993.
14. Adrian Bejan, *Convective Heat Transfer*, John Wiley and Sons, 1995.

15. M F Modest, *Radiative Heat Transfer*, McGraw-Hill, 1993
16. R Siegel and J R Howell, *Thermal Radiation Heat Transfer*, 3rd ed, Taylor & Francis, 1992
17. Numerical Heat Transfer (Part A & Part B)

Journals:-

1. International journal of Heat and Mass Transfer.

Name of the Module: Solid Mechanics
Module Code: ME 912
Semester: 1st
Credit Value: 3[P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. To establish an understanding of the fundamental concepts of mechanics of deformable solids; including static equilibrium, geometry of deformation, and material constitutive behaviour.
2. To provide students with exposure to the systematic methods for solving engineering problems in solid mechanics.
3. To discuss the basic mechanical principles underlying modern approaches for design of various types of structural members subjected to axial load, torsion, bending, transverse shear, and combined loading.
4. To build the necessary theoretical background for further structural analysis and design courses.

B. Learning Outcome:

Upon completion of the subject:

1. Understand the concepts and principles applied to members under various loadings and the effects of these loadings.
2. Analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.
3. Analyze columns and pressure vessels under various loadings.

C. Subject Matter:

Unit-I

Analysis of Stresses and Strains in rectangular and polar coordinates: Cauchy's formula, Principal stresses and principal strains, 3D Mohr's Circle, Octahedral Stresses, Hydrostatic and deviatoric stress, Differential equations of equilibrium, Plane stress and plane strain, compatibility conditions.

Unit-II

Introduction to curvilinear coordinates. Generalized Hooke's law and theories of failure. Energy Methods. Bending of symmetric and asymmetric straight beams, effect of shear stresses, curved beams, Shear center and shear flow, shear stresses in thin walled sections, thick curved bars.

Unit-III

Torsion of prismatic solid sections, thin walled sections, circular, rectangular and elliptical bars, membrane analogy. Thick and thin walled cylinders, Composite tubes, Rotating disks and cylinders.

Unit-IV

Euler's buckling load, Beam Column equations. Strain measurement techniques using strain gages, characteristics, instrumentations, principles of photo-elasticity.

D. Teaching/Learning/Practice Pattern:

Teaching: 70 %
Learning: 30 %
Practice: 0 %

(Teacher is to divide components for T/R/P)

E. Examination Pattern:

1. Theoretical Examination

F. Reading List:

Books

1. *L. S. Srinath, Advanced Mechanics of Solids, 2nd Edition, TMH Publishing Co. Ltd., New Delhi, 2003.*
2. *R. G. Budynas, Advanced Strength and Applied Stress Analysis, 2nd Edition, McGraw Hill Publishing Co, 1999.*
3. *A. P. Boresi, R. J. Schmidt, Advanced Mechanics of Materials, 5th Edition, John Willey and Sons Inc, 1993.*
4. *S. P. Timoshenko, J. N. Goodier, Theory of Elasticity, 3rd Edition, McGraw Hill Publishing Co. 1970.*
5. *P. Raymond, Solid Mechanics for Engineering, 1st Edition, John Willey & Sons, 2001.*
6. *J. W. Dally and W. F. Riley, Experimental Stress Analysis, 3rd Edition, McGraw Hill Publishing Co., New York, 1991.*

Magazine

1. *Popular Mechanics.*
2. *Everyday Engineering Magazine*

Journals

1. *Journal of Mechanical Engineering, Editorial Office Of Chinese Journal Of Mechanical Engineering.*
2. *International Journal of Plasticity, Elsevier Ltd.*

Name of the Module: Lab-I
Module Code: ME 915
Semester: 1st
Credit Value: 2 [P=3, T=0, L=0]
Module Leader:

A. Objectives:

To familiarize students to the application/practical side of the theories and principles of thermal sciences so as to enable them to design, analyze and take up development activities of similar systems /allied applications.

B. Learning Outcomes:

Upon completion of the subject:

1. Students will acquire hands on experience on the various test-rigs, Experimental set up.
2. Students should able to measure the various technical parameters by instrument and by mathematical relationship.
3. Students will able to identify the effect of various parameters on the system and able to co-relate them.

The lab practice consists of the tutorials and experiments as decided by the course supervisors.

C. Subjects Matter:

1. Forced Convection Heat Transfer.
2. Boiling Heat Transfer
3. To study the complex fluid flow phenomena by using Particle Image Velocimetry.
4. Calibration of different measuring instruments.
5. Measurement and Analysis of combustion parameters in I.C. engines.
6. To estimate the COP of a vapour compression refrigeration system.
7. Hot wire anemometer.
8. Turbine and pump characteristics.

D. Teaching/Learning/Practice Pattern:

Teaching: 0%
Learning: 30%
Practice: 70%

E. Examination Pattern:

1. Practical Examination

Second Semester

Subject Code	Subject	P	T	L	Credit
ME -921	Mechanics and Automation	0	0	3	3
ME-922	Computer Aided Design and Manufacturing	0	0	3	3
ME 923	Research Methodology & Experimental Method	0	0	3	3
ME 924	Elective-III	0	0	3	3
ME 925	Elective-IV	0	0	3	3
ME 926	Lab-II	3	0	0	2
ME 927	Seminar-I	3	0	0	3
Total		**6**	**0**	**15**	**20**

Name of the Module: Mechatronics and Automation
Module Code: ME921
Semester: 2nd
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is designed to meet with the following objectives:
1. To understand the concepts of mechatronics, its importance in Industries
2. To understand sensors and transducers and its applications in various fields.
3. To understand PLDs, micro-processors and micro-controllers.
4. To understand the importance of different Drives and Mechanisms.
5. To understand Robotics and its applications in Industries.

B. Learning Outcomes:

Upon completion of the subject, students will be able to:
1. Implement mechatronics in manufacturing industries.
2. Identify different sensors and actuators used in industries.
3. Classify different drives and mechanisms used in automations.
4. Compare Hydraulic and Pneumatic systems as used in industries.
5. Execute CNC programming and understand the fundamentals of robotics.

C. Subject Matter:

Unit I: Introduction to Mechatronics: Defination, mechatronics in manufacturing, products and design, mechatronics elements, data conversion devices, sensors, microsensors, displacement, position and proximity sensors, velocity, motion, force and pressure sensors, temperature and light sensors, transducers, signal processing devices, relays, contactors and timers, data conversion devices.

Unit II: Programmable Logic Devices (PLDs): Introduction to micro-processors and micro-controllers, microprocessor programming, Programmable Logic Controllers (PLC), PID controllers.

Unit III: Drives and Mechanisms: Elements of CNC machine tools, electric motors, stepper motors and servo motors, cams, linear motion drives, indexing mechanisms, tool magazines and transfer systems.

Unit IV: Hydraulic and Pneumatic Systems: Introduction to hydraulic systems, hydraulic pumps, control valves, pressure relief valves, graphical representation of hydraulic and pneumatic elements, design of hydraulic circuit, introduction to Pneumatic systems, compressors, air treatment and pressure regulation, actuators, pneumatic controllers, application of pneumatic systems.

Unit V: CNC Programming and Industrial Robotics: CNC programming fundamentals, CNC machines and part programming, CNC programming- drilling, milling, turning operations, Industrial robotics, types of Industrial robots, classification based on work envelope, Generations configurations and control loops, co-ordinate systems, need for robot, basic parts and functions, specifications.

D. Teaching/Learning/Practice pattern:

Teaching: 70%
Learning: 30%
Practice: 0%

(Teacher is to divide components for T/L/P)

E. Examination Pattern:

Theoretical Examination

F. Reading List:

Books:

1. Boucher, T.O., **Computer Automation in Manufacturing: An Introduction**, Chapman and Hall, 1996.
2. Deb, S.R., **Robotics Technology and Flexible Automation**, Tata McGraw Hill, 1994.
3. Boltan, W., **Mechatronics: electronic control systems in Mechanical and Electrical Engineering**, Longman, 1999.
4. Groover M.P., **Industrial Robotics: Technology, programming and application**, McGraw Hill, 2012.

5. Fu. K.S., Gonzalac R.C., Lee C.S.G., **Robotics Control, sensing, vision and Intelligence**, McGraw Hill, 2011.
6. Saeed B.Niku, **Introduction to Robotics, analyses, systems, applications**, Prentice Hall Pvt. Ltd., 2005.

Magazine:

1. The Mechatronics Zone
2. IEEE Robotics and Automation Magazine
3. Vision Systems Design
4. Robot Magazine
5. Robotic Magazine
6. Servo Magazine

Name of the Module: Computer Aided Design and Manufacturing
Module Code: ME922
Semester: 2nd
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is designed to meet with the following objectives:
1. Explain how computer technology is revolutionizing drafting, design and manufacturing.
2. Describe the basic features and operations of a CAD program.
3. Explain the importance of CAD file management.
4. Identify the basic features and operations of a CAM program.
5. Understand the different types of CAD/CAM software and their applications.

B. Learning Outcomes:

Upon completion of the subject, students will be able to:
1. Define different CAD tools and functional areas of CAD.
2. Understand the principles, approaches, tools and design systems in CAD.
3. Use CAD software for wire frame, surface and solid modeling.
4. Classify NC/CNC/DNC systems and its relevance in the modern world.
5. Understand the concepts of FMS and CIM in manufacturing.

C. Subject Matter:

Unit I: CAD Tools: Definition of CAD tools, types of systems, CAD/CAM system evaluation criteria, graphics standards, functional areas of CAD, modeling and viewing, software documentation, efficient use of CAD software.

Unit II: Wire frame, Surface and Solid Modeling: Types of mathematical representation of curves, wire frame models, wire frame entities, parametric representation of synthetic curves-Hermite cubic splines, Bezier curves, B-splines. Mathematical representation of surfaces, surface model, surface entities, surface representation, parametric representation of surfaces, plane surface, ruled surface, surface of revolution, tabulated surface. Solid Representation: boundary representation (B-rep), Constructive Solid Geometry (CSG), Design applications, mechanical tolerances, mass property calculations, CAD database structure. CAD/CAM data exchange formats and evaluation.

Unit III: Numerical Control (NC), Computer Numerical Control (CNC): Introduction to automation, types of automation, basic components of an NC system, classification, applications, NC motion control, part programming formats, NC part programming (APT), NC positioning systems. Computer Numerical Control (CNC) and Direct Numerical Control

(DNC), features of CNC/DNC, elements of CNC/DNC machines, machine control unit for CNC, CNC software.

Unit IV: Flexible Manufacturing Systems (FMS) & Computer Integrated Manufacturing (CIM): Introduction to FMS, components, applications, benefits, FMS layout, FMS planning and implementation issues, quantitative analysis of FMS, applications of FMS, FMS optimization. Computer Integrated Manufacturing (CIM): evaluation of CIM, CIM hardware and software, nature and role of the elements of CIM system, development of CIM, different concepts of CIM (IBM, Siemens, Digital equipment corporation).

D. Teaching/Learning/Practice pattern:

Teaching: 70%
Learning: 30%
Practice: 0%

(Teacher is to divide components for T/L/P)

E. Examination Pattern:

Theoretical Examination

F. Reading List:

Books:

1. Ibrahim Zeid, **CAD/CAM Theory and Practice**, 1st edition, McGraw Hill International.
2. Foley, Van Dam, Feiner and Hughes, **Computer Graphics Principles and Practice**, 2nd edition, Addison-Wesley, 2000.
3. Hans B, Kief and J. Frederick Waters, **Computer Numerical Control**, Glencae Macmillan/McGraw Hill.
4. Steve Krar and Arthar Gill, **CNC Technology and Programming**, McGraw Hill.
5. P.N.Rao, N.K.Tewari, **Computer Aided Manufacturing**, Tata McGraw Hill.
6. Mikell P. Grover, **Automation, Production Systems and Computer-Integrated Manufacturing**, Pearson Education.
7. P. Radhakrishnan & S. Subramanyan, **CAD/CAM/CIM**, Willey Eastern Limited.

Magazine:

1. CADALYST
2. CAD-CAM Net (online)
3. CAD user (UK based)
4. Multi-CAD (Australia based)
5. CAD DIGEST
6. AutoCAD Magazine (Spain based)

Name of the Module: **Research Methodology and Experimental Method**
Module Code: ME 923
Semester: 2nd
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

A. Objectives:

The course is design to meet with the following objectives:

1. To learn basic Concept of research methodology.
2. To learn techniques involve in measurement.
3. To learn report/paper writing and art of oral presentation.

B. Learning Outcome:

Upon completion of the subject, students will be able to:

1. Understand the basics of research and methodology.
2. Different mathematical and experimental techniques.

C. Subject Matter:

Unit I:

Introduction- Defining Research, Scientific Enquiry, Hypothesis, Scientific Method, Types of Research, Research Process and steps in it.

Unit II:

Research Design and Modeling Literature Survey and Review, -Mathematical - Classification of Models, Development of Models, Stages in Model building, Principles of Modeling, Use of Analogy, Models as Approximations, Data consideration and Testing of Models.

Unit III:

Experimentation-General measurement system, Signal flow diagram of measurement system, Inputs and their methods of correction - broad category of methods for measuring field and derived quantities; Principles of measurement - Causes and types of errors in measurement, Propagation of errors, Uncertainty analysis, Regression analysis, Statistical analysis of Experimental data.

Unit IV:

Analysis - Analysis of Variance and Co-variance, Hypothesis Testing – Parametric. Report Writing: Prewriting Considerations, Principles of Thesis Writing, Format of Report Writing, Format of Publication in Research Journals, Oral Presentations (Briefing).

D. Teaching/Learning/Practice Pattern:

Teaching: 50 %

Learning: 50 %

Practice: 0%

(Teacher is to divide components for T/R/P)

E. Examination Pattern:

1. Theoretical Examination and Open book examination.

G. Reading List:

Books:

1. Krishnaswamy, K.N., Sivakumar, AppaIyer&Mathirajan M., (2006) -Management Research Methodology: Integration of Principles, Methods & Techniques (New Delhi, Pearson Education)

2. Wheeler, A.J. and Ganji, A.R. Introduction to Engineering Experimentation (Prentice Hall, 2003).

3. Holman, J. P., Experimental Methods for Engineers (McGraw Hill).

Magazine:

1. Research Methods and Techniques.

2. Gear Solution.

3. Machine Design.

Journals:

1. Journal of Mechanical Design, ASME.

2. Journal of experimental thermal and fluid science, Elsevier.

3. journal of experimental nanoscience, Taylor & Francis.

Name of the Module: Lab-II
Module Code: ME 926
Semester: 2^{nd}
Credit Value: 2 [P=3, T=0, L=0]
Module Leader:

List:

1. Determination of chip reduction coefficient
2. Fabrication single point cutting tool
3. Re-sharpening of twist drill
4. Cutting force measurement using DAQ and Labview & Measurement of cutting temperature using DAQ and Labview
5. Estimation of tool life, optimal design of chip breaker, study on Machinability
6. Experiments on Vibrations.
7. Experiments on surface characterizations.

Name of the Module: Seminar I
Module Code: ME927
Semester:
Credit Value: 2 [P=3, T=0, L=0]
Module Leader:

Objective: To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

• Individual students are required to choose a topic of their interest preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Third Semester

Subject Code	Subject	P	T	L	Credit
ME 931	Seminar-II	0	0	3	3
ME 932	Elective-V	0	0	3	3
ME 933	Dissertation Preliminaries	28	0	0	14
Total		**28**	**0**	**6**	**20**

Name of the Module: Seminar II
Module Code: ME931
Semester:
Credit Value: 2 [P=3, T=0, L=0]
Module Leader:

Objective: To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.

• Individual students are required to choose a topic of their interest preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Fourth Semester

Subject Code	Subject	P	T	L	Credit
ME 941	Dissertation Phase-II	40	0	0	20
Total		**40**	**0**	**0**	**20**

Electives:

1. Name of the Module: Design and Analysis of IC Engines
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. To make students familiar with the basic thermodynamic cycles - ideal, fuel-air and real cycles
2. To describe the engine friction and heat transfer issues of modern Internal Combustion Engine
3. To make the students to present the design considerations for engine components like valves, piston, cylinder, rings.
4. To apply modelling and simulation techniques to the complex phenomenon of engine combustion
5. To introduce students the importance of gas exchange processes
6. To introduce students the balancing and vibrations issues in an engine

B. Learning Outcomes:

Upon completion of the subject:

1. Student will be able to develop an appreciation for theoretical and practical limits to engine performance and fuel economy
2. Students will be able to find out the maximum possible engine efficiency and ways to minimise losses from actual engine
3. Students will be able to address the issue of effective heat transfer from engine with suitable material for better heat transfer and compatibility
4. Students will be able to work out engine friction by different methods and will be able to learn that it is an important parameter to address engine efficiency
5. Students will be able to work out the material property requirement on to the part of each component to suit the design requirement
6. Students will be able to address real world engine design issues.
7. Students will be able to develop an ability to optimize future engine designs for specific sets of constraint like efficiency, ecology and economy
8. Develop skill to compare and contrast simulated results with experimental results
9. Able to appraise an understanding of suction and exhaust processes, flow through valves

C. Subjects Matter:

Unit I

Introduction: Historical review, Engine types, Design and operating parameters, Thermo chemistry of fuel, Air mixtures, Properties, Cycle analysis, Models of engine cycles, Real engine cycles, Differences and factors responsible for computer modeling.

Gas exchange processes: Volumetric efficiency, Flow through ports, Supercharging and Turbo charging, Mean velocity and turbulent characteristics, Swirl, Squish, Pre-chamber engine flows.

Unit II:

Fuel air cycles, Actual cycles and Their analysis: Combustion and speed, Cyclic variations, Ignition, Abnormal combustion, Fuel factors, MPFI, S. I. engine testing, Essential features, Types of cycles, Practical data, Fuel spray behaviour, Ignition delay mixing formation and control, Common rail fuel injection system.

Unit III:

Pollutant formation and control: Nature and extent of problems, Nitrogen oxides, Carbon monoxide, Unburnt hydrocarbon and particulate, Emissions, Measurement, Exhaust gas treatment, Catalytic converter, SCR, Particulate traps, Lean, NOx, Catalysts.

Unit IV:

Fuel supply systems for S. I. engines: Fuel supply systems for S. I. and C. I. engines using gaseous fuels like LPG, CNG and Hydrogen.

Modern trends in I. C. engines: Lean burning and Adiabatic concepts, Rotary engines, Modification in I. C. engines to suit bio fuels, HCCI and GDI concepts, Electronic control in I. C. engine.

D. Teaching/Learning/Practice Pattern:

Teaching: 60%
Learning: 40%
Practice: 0%

E. Examination Pattern:

1. Theoretical Examination.

F. Reading List:

Books:

1. *Maleev, "I. C. Engines: Theory and Practice", Mc-Graw Hill2000.*
2. *Heywood, J. B., "Internal Combustion Engine Fundament als", Mc-Graw Hill International Edition, 2002.*
3. *Richard, Stone, "Introduction to Internal Combustion Engines", 2nd Edn. McMillan Press, 2003.*
4. *Taylor, C. F., "Internal Combustion Engine in Theory and Practice", Vol. 1 & 2, M. I. T. Press, Cambridge, USA, 2003.*
5. *Juvinall, R. C., and Marshek, K. M., "Fundamental of Machine Component Design", John Wiley & Sons, N.Y., 2001.*

Journals:

1. *International Journal of Engine research*
2. *The International Journal of Advanced Manufacturing Technology*

2. Name of the Module: Design of Heat Exchangers
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. To introduce different kind of Heat Exchangers used in industry.
2. To introduce the preliminary design and selection of Heat exchanger based on application.
3. To encourage the student to modify and analyse the existing design procedure in the field of Heat Exchanger.
4. To learn the thermal and stress analysis on various parts of the heat exchangers
5. To analyze the sizing and rating of the heat exchangers for various applications

B. Learning Outcomes:

Upon completion of the subject:

1. Apply the fundamental principles of heat transfer and associated correlations to heat exchangers.
2. List different types of heat exchangers based on different attribute.
3. Select and design various types of heat exchangers as per standard design methodology.
4. Able to design the heat exchanger based on the information provided for a particular application and do the cost economic analysis

C. Subjects Matter:

Unit I:

FUNDAMENTALS OF HEAT EXCHANGER: Review of heat transfer principles & convection correlation. Introduction to heat exchangers and classification.

Temperature distribution and its implications types – Design of double pipe heat exchangers. Shell & tube type heat exchangers, nomenclature, J-factors, conventional design methods, bell, Delware method – regenerators and recuperators – analysis of heat exchangers. – LMTD and effectiveness method.

Unit II:

FLOW AND STRESS ANALYSIS: Effect of turbulence – friction factor – pressure loss – stress in tubes – header sheets and pressure vessels – thermal stresses, shear stresses - types of failures.

Unit III:

DESIGN ASPECTS: Heat transfer and pressure loss – flow configuration – effect of baffles – effect of deviations from ideality – design of double pipe - finned tube - shell and tube heat exchangers - simulation of heat exchangers.

Unit IV:

COMPACT AND PLATE HEAT EXCHANGERS: Types – merits and demerits – design of compact heat exchangers, plate heat exchangers – performance influencing parameters - limitations.

CONDENSERS AND COOLING TOWERS: Design of surface and evaporative condensers – cooling tower – performance characteristics**.** Plate type Heat exchangers

D. Teaching/Learning/Practice Pattern:

Teaching: 60%
Learning: 40%
Practice: 0%

E. Examination Pattern:

1. Theoretical Examination.

F. Reading List:

Books:

1. *Saunders, E.A.D., "Heat Exchangers Selection Design and Construction", Longmann*
2. *Scientific and Technical, N.Y., 2001.*
3. *Kays, V.A. and London, A.L., "Compact Heat Exchangers" , McGraw Hill, 2002.*
4. *Holger Martin, "Heat Exchangers" Hemisphere Publ. Corp. , Washington, 2001.*
5. *Kuppan, T., "Heat Exchanger Design Handbook", Macel Dekker, Inc., N.Y. , 2000*
6. *Seikan Ishigai, "Steam Power Engineering , Thermal and Hydraulic Design Principles",*
7. *Cambridge Univ. Press, 2001.*

Magazine:

Journals:

1. *International Journal of Heat and Mass Transfer*
2. *Journal of Enhanced Heat Transfer*
3. *Journal of Heat Transfer*

3. Name of the Module: Steam Power Generation and performance analysis

Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

Objectives:-

The course objective is to introduce students to the various components of thermal power plants and the related thermal and economical tools for effective engineering analysis of such plants.

Learning Outcome:-

1. Understanding of different types of thermal power systems and their components.
2. Ability to analyze and evaluate the performance of thermal power plants.
3. Ability to select and rate the different components of a thermal power plant.

Unit –I

Steam Turbine –

Superheater, reheater and partial condenser vacuum cycles and classifications. Regenerative Heat Exchangers

Unit –II

Power plant Accessories –

Turbine characteristics. Auxiliaries - Water Treatment Systems, Electrostatic Precipitator / Flue gas Desulphurization, Coal crushing / Preparation - Ball mills / Pulverisers, ID/FD Fans, Chimney, Cooling Towers.

Unit –III

Power plant control systems –

Review of control principles, Combustion control, pulveriser control, control of air flow, Furnace pressure and feed water, steam temperature control, Safety provisions / Interlocks.

Unit –IV

Analysis of System load curve –

Plant load factor, availability, Loss of load Probability calculations for a power system, Maintenance Scheduling Pricing of Power – Project cost components, Analysis of Power Purchase Agreements (PPA), Debt/Equity Ratio and effect on Return on Investment, Environmental Legislations/Government Policies Optimal Dispatch Scheduling of Hydro-Thermal plants.

Load Forecasting –

Time series, Econometric, end use techniques. Least Cost Power Planning - Integration of DSM, Renewable into supply.

Books:-

1. R.W.Haywood, Analysis of Engineering Cycles, 4th Edition, Pergamon Press,
2. Oxford, 1991.
3. D. Lindsay, Boiler Control Systems, Mcgraw Hill International, London, 1992.
4. H.G. Stoll, Least Cost Electrical Utility / Planning, John Wiley & Sons, 1989.

Journals:-

1. Journal of Engineering for Gas Turbines and Power
2. International Research Journal of Engineering and Technology
3. Journal of Thermal Science

4. **Name of the Module: Design and analysis of mini and micro hydro system**
   Module Code:
   Semester:
   Credit Value: 3 [P=0, T=0, L=3]
   Module Leader:

Learning Objectives:-

1. To develops an idea of effectively generating electrical energy from hydraulic energy using micro/ mini hydropower system.
2. To become familiar with technical aspects of the plant which includes civil components, mechanical components, electrical components and transmission system.
3. To become familiar with management and various application of the plant, failure as well as sustainability of the plant.
4. To give concepts for the evaluation of the plant, basic concepts of financial analysis.

Unit-I

Hydro power scenario in India and world, its development and future prospect.

Hydrology – hydrological cycle, precipitation, run-off and its measurement, hydrograph, unit hydrograph, flow duration and mass curve.

Site selection–Preparation of DPR, Clearance from various agencies, funding agencies, government rules and subsidies for SHP.

Unit-II

Classification of hydro electric power plants, pondage and storage, Operating principles of different types hydro plants like run-off river, dam toe type and canal base type,

Design, construction and operation of different components of a hydro plant like dam, spillways, canals (power canal), penstocks (economical diameter, embedded and exposed type, short and long penstock), surge tank, draft tubes, etc. Power house structure, overhead crane, auxiliary power supply

Unit-III

Selection of hydro-turbines – impulse, reaction and propeller turbines, hydroturbines. Kaplan, Bulb/tubular, cross flow and Deriaz turbine. Accessories, torque, power efficiency, water turbine design, installation, operation and maintenance, characteristics curves. Speed and pressure regulation of various hydro turbines.

Unit-IV

Tidal Power – power from sea waves and its machinery. Pumped storage plant, multipurpose projects and effects on environment.

Methods of governing of impulse and reaction turbine, starting and stopping of water turbines, operation of hydro turbines, machine loading and frequency control, maintenance of hydropower plants.

Need for testing of SHP, testing methodology and instruments used.

Text Books:-

1. Water Power Engineering- M M Dandekar & K N Sharma, Vikash Publishing
2. Engineering Hydrology – K Subramanya, Tata McGraw-Hill
3. Water Power Engineering - Barrows, Tata McGraw-Hill
4. Hydroelectric Hand Books – Creager and Justin, John Wiley and Sons

Journals:-

1. International Journal Of Electrical Power & Energy Systems
2. Journal Of Fluid Engineering

5. Name of the Module: Design of Refrigeration and Air-conditioning System

Module Code:

Semester:

Credit Value: 3 [P=0, T=0, L=3]

Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. To enable students select alternate new azeotrope and mixed refrigerants based on application in a various refrigeration system.
2. To enable students to analyse low temperature refrigeration systems
3. To enable students to present design aspects of various refrigeration systems and its components
4. To enable students to evaluate refrigeration systems to improve the performance
5. To enable students to assess psychometrics of various air conditioning processes, determination and calculation of various cooling loads and heating loads for air conditioning systems, cold storage plants etc.
6. To enable students use design aspects air distribution system components for air conditioning plants.

B. Learning Outcomes:

Upon completion of the subject:

1. Select appropriate new eco friendly refrigerants according to application in various types of refrigeration systems.
2. Design and analyze low temperature refrigeration systems.
3. Design and analyze the refrigeration systems for various applications
4. Evaluate the refrigeration systems to improve the performance
5. Compute various cooling loads and heating loads for air conditioning systems, cold storage plants etc.
6. Design the residential, commercial and industrial air conditioning plants.
7. Design air distribution systems for air conditioning plants.

C. Subjects Matter:

Unit I

Review of basic principles of refrigeration -Vapour compression and vapour absorption cycles, Ecofriendly refrigerants. Low temperature refrigeration, Martinovesky, Dubinsky machine, Capitza air liquifier; Cap Phillips machines, Gifford models.

Unit II:

Refrigerator using solid CO_2as working media. Magnetic refrigeration systems. Design aspects of refrigeration system components. Design of water coolers, Ice plant, Cold storage plants

Unit III:

Review of air conditioning principles. Psychrometry of various air conditioning processes. Cooling load calculations for air conditioning systems. Design aspects of various components of an air conditioning system such as fans, Cooling coils, Heating coils, Ducts and air, Distribution system.

Unit IV:

Analysis and design of air Washers and cooling towers. Design of residential, commercial and industrial air conditioning plants.

D. Teaching/Learning/Practice Pattern:

Teaching: 70%
Learning: 30%
Practice: 0%

E. Examination Pattern:

1. Theoretical Examination.
2. Practical Examination.

F. Reading List:

Books:

1. *Stocker, W. F. and Jones, J. W., "Refrigeration and Air Conditioning" , McGraw Hill, N. Y. 1986.*
2. *Dossat, R. J., "Principles of Refrigeration", John Wiley and Sons, 1988.*
3. *Threlked, J.L., "Thermal Environmental Engineering", Prentice Hall, N. Y. , 1970.*
4. *Baron, R. F., "Cryogenics Systems", Oxford Press, USA, 1985.*
5. *ASHRAE Fundamentals, Applications, Systems and Equipment, 1999*

Magazine:

Journals:

1. *International Journal of Refrigeration and Air Conditioning*

6. Name of the Module: Wind Energy Conversion Systems
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

Objectives:-

1. To learn the design and control principles of Wind turbine
2. To understand the concepts of fixed speed and variable speed, wind energy
3. conversion systems
4. To analyze the grid integration issues.

Unit I:
Introduction

Components of WECS-WECS schemes-Power obtained from wind-simple momentum theory-Power coefficient- Sabinin‟s theory-Aerodynamics of Wind turbine

Wind Turbines

HAWT-VAWT-Power developed-Thrust-Efficiency-Rotor selection-Rotor design considerations-Tip speed ratio-No. of Blades-Blade profile-Power Regulation-yaw control-Pitch angle control-stall control-Schemes for maximum power extraction. Power transmission system for turbines.

Unit II:
Fixed Speed Systems

Generating Systems- Constant speed constant frequency systems -Choice of Generators-Deciding factors-Synchronous Generator-Squirrel Cage Induction Generator- Model of Wind Speed- Model wind turbine rotor - Drive Train model Generator model for Steady state and Transient stability analysis.

Unit III:
Variable Speed Systems

Need of variable speed systems-Power-wind speed characteristics-Variable speed constant frequency systems synchronous generator- DFIG- PMSG - Variable speed generators modeling - Variable speed variable frequency schemes.

Unit IV:
Grid Connected Systems

Wind interconnection requirements, low-voltage ride through (LVRT), ramp rate limitations, and supply of ancillary services for frequency and voltage control, current practices and industry trends wind interconnection impact on steady-state and dynamic performance of the power system including modeling issue.

Books:

1. L.L.Freris "Wind Energy conversion Systems", Prentice Hall, 1990

2. S.N.Bhadra, D.Kastha,S.Banerjee,"Wind Electrical Sytems",Oxford University Press,2010.

3. Ion Boldea, "Variable speed generators", Taylor & Francis group, 2006.

4. E.W.Golding "The generation of Electricity by wind power", Redwood burn Ltd., Trowbridge,1976.

5. N. Jenkins," Wind Energy Technology" John Wiley & Sons,1997

6. S.Heir "Grid Integration of WECS", Wiley 1998.

Journals:-

1. Journal of Engineering Science and Technology
2. International Journal of Environmental Science and Development

7. Name of the Module: Road Vehicle System Design

Module Code:

Semester:

Credit Value: 3[P=0, L=3, T=0]

Module Leader:

Learning Objectives:-

- Be able to give an overview of the functions of main components of a modern road vehicle
- Be able to provide an individual written explanation of the propulsion system in road vehicles and how these are influenced by various operating and design parameters at a detailed conceptual level
- Be able to perform analysis of the propulsion system and road vehicle efficiency
- Be able to describe the usefulness of road vehicles as well as their safety issues and impact on the environment

Learning Outcome:-

- Be able to use comparative factors to analyse, select and design propulsion systems (engine - transmission) and brake systems for a given simple vehicle application
- Be able to calculate vehicle efficiency based on the design of the vehicle and its components
- Be able to apply simplified models to analyse a vehicles chassis dynamics
- Be able to, group wise with supervision, conduct performance measurements on a modern personal car

Subject Matter:

Unit I:
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.

Unit II:
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.

Unit III:
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, braking efficiency.

Unit IV:
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-roll model, tripping.

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.

Journals:-

1. Journal of Engineering Science and Technology
2. International Journal of Environmental Science and Development

8. Name of the Module: High Pressure Equipment Design

Module Code:

Semester:

Credit Value: 3[P=0, T=0, L=3]

Module Leader:

A. Objectives:

The course is design to meet with the following objectives:

1. To be able to apply the requirements of the relevant industry standards to the mechanical design of equipments used in the process industry and above ground atmospheric storage.
2. To specify appropriate physical property models to simulate processes.

B. Learning Outcome:

Upon completion of the subject, students will be able to:

1. Identify the elements of the design process.
2. Identify or define the yield stress and the ultimate stress of a material.
3. Calculate the endurance limit of a material with appropriate corrections.
4. Identify the stresses acting on a surface and find principal stresses.
5. Evaluate loading and stress results using principal shear stress criterion.
6. Evaluate loading and stress results using maximum distortion energy criterion.
7. Create a Soderberg endurance failure line.
8. Calculate stresses and loads involved with fatigue effect.
9. Devise a list of concepts for a design application using idea-generation techniques.
10. Determine the speeds of gears in spur gear systems including planetary systems.
11. Determine stresses in a gear using the Lewis equation or the AGMA equation.
12. Calculate the life of ball or roller bearings.
13. Determine shaft parameters so that design conditions for performance are met.
14. Calculate bounds on parameters in design.

C. Subject Matter:

Unit I:

Design Considerations: Preliminary considerations, Design construction and features, Stress analysis of components shells. Thick and thin shells.

Unit II:

Ends, flanges, local attachments, etc.

Unit III:

Material selection, Special type of vessels-high pressure applications.

Unit IV:

Externally loaded vessels, etc. Design system, Use of Codes for typical applications.

D. Teaching/Learning/Practice Pattern:

Teaching: 70 %

Learning: 30 %

Practice: 0 %

(Teacher is to divide components for T/R/P)

E. Examination Pattern:

1. Theoretical Examination

F. Reading List:

Books:

1. Van Nostand, Pressure vessel Design, MGH.
2. M. V. Joshi, Process equipment design,3rd edition , McMillan India.
3. Material Handling equipment Hand book, MGH.

Magazine:

1. Wireless Design & Development.
2. Product Design & Development magazine.
3. Vision Systems Design.

Journals:

1. Journal of Mechanical Engineering, Editorial Office of Chinese Journal of Mechanical Engineering.
2. International Journal for Engineering Modelling, University of Split.
3. Advances in Modelling and Analysis A, ASME.
4. Advances in Modelling and Analysis B, ASME.
5. Journal of Ergonomics
6. An International Journal for Fusion Energy and Technology devoted to Experiments, Theory, Methods and Design
7. Journal of Engineering, Design and Technology
8. Journal of Mechanical Design

9. Name of the Module: Optimization Techniques
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. To comprehend the governing equation pertinent to the fluid flow and Heat Transfer field.
2. To develop the numerical skill towards the understanding and solution of fluid flow and heat transfer field.
3. To encourage the student to take a complex problem based on the numerical solution techniques

B. Learning Outcomes:

Upon completion of the subject:

1. Solve the basic governing equations and significance of these equations in the field of fluid flow and heat transfer.
2. Implement different techniques and solution procedure using different discretization schemes for real field complex problem.
3. Modify the available schemes and methods for multi-physics problem.

C. Subjects Matter:

Unit I:
Single and multivariable optimization methods, constrained optimization methods, Kuhn, tucker conditions, necessary& Sufficiency theorems.

Unit II:
Linear programming, Traveling salesman problem and transshipment problems, Post optimization analysis.

Unit III:
Integer programming all integer, Mixed integer and zero, one programming

Unit IV:
Geometric programming - concept - degree of difficulty - solution of unconstrained & constrained non linear problems by geometric programming. Dynamic programming.

D. Teaching/Learning/Practice Pattern:

Teaching: 60%
Learning: 40%
Practice: 0%

E. Examination Pattern:

1. Theoretical Examination.

F. Reading List:

Books:

1. *Rao S.S., "Optimization Theory &Applications", Wiley Eastern 2000.*
2. *Deb. K, "Optimization for Engineering Design", Prentice Hall of India, 2002*
3. *Reklaitis G.V., Ravindram A., Ragsdell K.M., "Engineering Optimization Methods &*
4. *Application", Wiley, 2001.*
5. *Verma, A. P,. "Operation Research", S. K. Kataria and Sons, 2007.*
6. *Vora, N. D, "Quantitative techniques", Tata Mc-Graw Hill, 2006.*

Journals:

1. *Journal of optimization theory and application*
2. *International journal of Mathematical modelling and Numerical optimization*

10. Name of the Module: Creative Design

Module Code:
Semester:
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

A. Objectives:

The course is design to meet with the following objectives:

1. To learn basic Concept Mechanical systems design.
2. To learn basic consideration of safety factor in designing.
3. To learn design optimization with respect to efficient material and performance.

B. Learning Outcome:

Upon completion of the subject, students will be able to:

1. Understand safety factor in designing.
2. Optimize design for efficient performance.

C. Subject Matter:

Unit I:

Introduction to Design: Design, Design Process, Creative Design, Concept of Mechanical System Design.

Unit II:

Creative Problem Solving Techniques: Creative Process, Creativity Characteristics, Analysis of existing Design, Mathematical & Experimental Analysis.

Unit III:

Creative Design Methodology: Introduction, generalization, specialization, particulization, Atlas of new Design.

Unit IV:

Fine arts: Introduction, Free Hand sketching, Computer graphics, 3D modelling.

D. Teaching/Learning/Practice Pattern:

Teaching: 50 %
Learning: 50 %
Practice: 0%

(Teacher is to divide components for T/R/P)

E. Examination Pattern:

1. Theoretical Examination and Open book examination.

G. Reading List:

Books:

1. *Simant, Mishra, Ramesh Chandra, "Mechanical System Design", PHI.*
2. *Farazdak Haideri, "Mechanical System Design", Nirali Prakashan.*
3. *S. P. Patil , "Mechanical System Design", Jaico Publishing House,*
4. *J. E. Shigley, " Mechanical Engineering Design", McGraw-Hill. 2nd edition*
5. *Hong-sen-yan, "Creative Design of Mechanical Devices", Springer,1st edition*

Magazine:

1. *ES Engineering System.*
2. *Gear Solution.*
3. *Machine Design.*

Journals:

1. *Journal of Mechanical Design, ASME.*
2. *Journal of Advanced Mechanical Design, Systems, and Manufacturing, JSME.*
3. *Journal of Advanced Mechanical Design, Systems, and Manufacturing, J-stage.*

11. Name of the Module: Gas Turbine Power Plant System
Module Code:
Semester:
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

Subject Matter:

Unit I:

Fundamentals of Turbo Machines:

Classification, Applications Thermodynamic analysis; Isentropic flow, Energy transfer; Efficiency; static and Stagnation conditions; continuity equation; Euler's flow through variable cross sectional area; unsteady flow in turbo machines.

Gas Dynamics:

Fundamentals thermodynamic concepts; Isentropic conditions; Mach number and Area – Velocity relation; Dynamic pressure; normal shock relations for perfect gas; supersonic flow, oblique shock waves; normal stock recovery; detached shocks.

Unit II:

Steam Nozzles and Turbines:

Convergent nozzles – Convergent-divergent nozzles – Energy balance – Effect of backpressure – Design aspects of nozzles - Types of steam turbines, Flow through impulse and reaction turbine stages, Impulse Turbines: Work done and stage velocity triangles; Blade and stage Efficiencies; Constant Reaction stages and Blading; Design of blade passages, angles and height; Secondary flow; leakage losses - Key elements of steam turbines.

Unit III:

Centrifugal compressors:

Elements of compressor stage, Velocity triangles and efficiencies; Blade passage design; Diffuser and pressure recovery; slip factor; Stanitz and Stodolas formulae; Compressor performance - Stall and surge, Performance characteristicsAxial Flow Compressors : Flow analysis, work and velocity triangles; Efficiencies; Thermodynamic analysis; stage pressure rise; Degree of reaction; stage loading; Free and forced vortex blades, Effect of axial velocity and incidence on velocity triangles - Performance characteristics.

Unit IV:

Axial Flow Gas Turbines:

Work done; velocity triangles and efficiencies; thermodynamic flow analysis; degree of reaction; Zweifels relation; Free-vortex blades; Blade angles for variable degree of reaction; Actuator disc theory; stresses in blades, Blade assembling; materials and cooling of blades; performance; Matching of compressor and turbine; off-design performance.

Books:

1. Axial Turbines / Horlock
2. Turbines, Compressors and Fans / Yahya
3. Axial Flow Compressors / Horlock.
4. Gas Turbines – Theory and practice / Zucrow
5. Elements of Gas Dynamics / Liepman and Roshkow
6. Elements of Gas Dynamics / Yahya
7. Gas Turbines - Dr V Ganesan, TMH

Journals:-

1. Journal of Engineering for Gas Turbines and Power
2. Energy
3. Applied Energy

12. Name of the Module: Finite Element Method
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

A. Objectives:

The objectives of the course are as follows:
1. To develop the Finite Element formulation for a model one-dimensional problem (i.e., linear approximation).
2. To discuss the possible refinements of the simplest approximation.
3. To develop the frame work of a finite element code to solve the one-dimensional problem.
4. To extend the finite element formulation to other one-dimensional problems.
5. To develop the two-dimensional finite element formulation for a model 2-D problem.

B. Learning Outcomes:

Upon completion of the course, students will be able to:
1. Develop FEM model for 1-D problem.
2. Compare between Finite Element and Finite Difference Method.
3. Implement FEM model to different fluid and heat transfer problem.
4. Explore other fields for possible application of FEM model.
5. Distinguish between mesh-free and FEM methods.

C. Subject Matter:

Unit I: Introduction to FEM: Introduction to Finite Element Method, difference between Finite Element and Finite Difference Methods, method of weighted residuals, collocation, method of least squares, Galerkin's method, elements of calculus of variations, Ritz method, equivalence of Ritz and Galerkin method for some cases.

Unit II: Linear and Quadratic 1D Elements: Linear quadratic and higher order elements, application to solutions of OED, assembly and solution of banded system.

Unit III: Finite Element to 2D Problems: Introduction, difference between 1D and 2D approach, types of 2D elements, local coordinates, global coordinates, triangular elements, linear and quadratic elements with area coordinates, rectangular elements, general quadrilateral elements, serendipity elements, linear and higher order shape functions.

Unit IV: Solution to Fluid Flow and Heat Transfer problems: Assembly of element equations, solution of equations, application to flow and heat transfer problems, higher order differential equations.

Unit V: Mesh-less Finite Element Methods: Introduction to Mesh-less Galerkin methods, difference between meshfree and FEM methods, choice of approach, interpolating polynomials, variational formulation, application to some simple problems.

D. Teaching/Learning/Practice pattern:

Teaching:	70%
Learning:	30%
Practice:	0%

(Teacher is to divide components for T/L/P)

E. Examination Pattern:

Theoretical Examination

F. Reading List:

Books:

1. J.N.Reddy, **An Introduction to Finite Element Method**, McGraw Hill, 2003.
2. L.S.Segerlind, **Applied Finite Element Analysis**, John Wiley & Sons, 1998.
3. S.S.Rao, **The Finite Element Method in Engineering**, Pergamon, 2004.
4. K.J.Bathe, **Finite Element Procedures**, Prentice Hall, 1996.
5. U.S.Dixit, **Finite Element Methods for Engineers**, Cengage Learning Asia, 2009.

Journals:

1. Computer Methods in applied Mechanics and Engineering, Elsevier
2. Journal of Computational and Applied Mathematics, Elsevier
3. Finite Elements in Analysis and Design, Elsevier
4. Applied Mathematics and Computation, Elsevier
5. Applied Numerical Mathematics, Elsevier
6. Applied Thermal Engineering, Elsevier
7. Advanced Modeling and Simulation in Engineering Sciences, Springer

13. Name of the Module: Mechanical Vibration
Module Code:
Semester:
Credit Value: 3 [P=0, T=0, L=3]
Module Leader:

Objectives:-

1. Fully understand and appreciate the importance of vibrations in mechanical design of machine parts that operate in vibratory conditions,
2. Be able to obtain linear vibratory models of dynamic systems with changing complexities (SDOF, MDOF),
3. Be able to write the differential equation of motion of vibratory systems,
4. Be able to make free and forced (harmonic, periodic, non-periodic) vibration analysis of single and multi degree of freedom linear systems.

Learning Outcomes:-

1. Appreciating the need and importance of vibration analysis in mechanical design of machine parts that operate in vibratory conditions
2. Ability to analyze the mathematical model of a linear vibratory system to determine its response
3. Ability to obtain linear mathematical models of real life engineering systems
4. Ability to use Lagrange's equations for linear and nonlinear vibratory systems
5. Ability to determine vibratory responses of SDOF and MDOF systems to harmonic, periodic and non-periodic excitation
6. General notion on frequency and time response of vibratory systems

Subject Matters:

Unit-I
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;

Unit-II
Elementary Lagrangian mechanics: generalized coordinates and constraints; principle of virtual work; Hamilton's principle; Lagrange's equation, generalized forces. Lagrange's equation with constraints, Lagrange's multiplier. Nonlinear effects in Dynamics.

Unit-III
Review of the single DOF system and simple Multi-DOF lumped parameter systems. Equations of motion for free and forced vibration of distributed parameter systems: axial vibration of a bar, transverse vibration of a string, torsional vibration of a shaft, transverse vibration of beams.

Unit-IV
Boundary-value problem and boundary conditions. Differential eigenvalue problem, eigenfunction and natural modes. Orthogonality of eigenfunctions and expansion theorem.

Rayleigh quotient. Response to initial conditions and external excitations. Discretization of distributed parameter system: Algebraic eigenvalue problem, eigenvalue and eigenvectors. Introduction to Modal analysis.

Books:

1. H. Baruh, Analytical Dynamics, McGraw-Hill (1999).
2. L. Meirovitch, Methods of Analytical Dynamics, Dover Publication, 2010.
3. D.T. Greenwood, Principles of Dynamics, Prentice-Hall International, 1988.
4. A.A. Shabana, Dynamics of Multibody Systems, 4th Cambridge University Press, 2013.
5. L. Meirovitch, Fundamentals of Vibration, McGraw Hill, 2000.
6. W.T. Thompson, M.D. Dahleh, C. Padmanabhan, Theory of Vibration with Application, 5th Ed., Pearson, 2008.
7. S.S. Rao, Mechanical Vibration, 4th Ed., Pearson, 2004.
8. W. Weaver, Jr., S.P. Timoshenko, D.H. Young, Vibration Problems in Engineering, 5th Ed., John Wiley and Sons, 1990.

Journal:-

1. Journal of Vibration and Control.
2. Journal of Vibration and Acoustics.

14. Name of the Module: Mechanical Power Systems

Module Code:

Semester:

Credit Value: 3 [P=0, T=0, L=3]

Module Leader:

Objectives:-

1. Understand the working principles of components of fluid power systems and their use.
2. Appreciate the working of control valves and their application
3. Describe the operation of pneumatic and hydraulic actuators.
4. Design fluid power circuit diagrams for control action of cylinders.

Learning Outcomes:-

At the end of this module students should be able to:

- Understand drive system components and their capabilities and limitations.
- Design selection of drive system equipment.
- Design / specify spur and helical gears.
- Understand available alternative drive systems.
- Understand basic hydraulic (hydrostatic) drive systems.
- Matching of prime mover to driven load
- Understand techniques & features needed in the detail design of mechanical power transmissions & components

Subject Matter:

Unit-I:-

Introduction:-

Fluid properties, hydraulic fluids, hydraulic and pneumatic systems.

Unit-II:-

Different elements of hydraulic system:-

Constructional and working details of each component; Pumps and motors, characteristics, Maintenance of hydraulic system, Selection criteria for cylinders, valves, pipes etc.

Unit-III:-

Elements of pneumatic system:

Constructional and working details of each component; air compressor, air motor, control valves, actuators and mountings, filter, regulator and lubricator.

Unit-IV:-

Applications of Mechanical Power Systems:

Hydro-Mechanical servo systems, Electro pneumatics, ladder diagram, Servo and Proportional valves, PLC-construction, Hydraulic tipping mechanism, power steering, fork lift hydraulic gear, hydro-pneumatic suspension, air brake, maintenance and trouble shooting of pneumatic circuits. Introduction to electro-mechanical power system.

Books:-

1. Anthony Espisito, " Fluid Power with Application", Pearson Education (Singapore) Pte.Ltd, Delhi, India, Fifth Edition, First Indian Reprint, 2003

2. Werner Deppert and Kurt Stoll, "Pneumatic Controls: An introduction to principles", Vogel-Druck Wurzburg, Germany, 1975.

3. Pippenger, J.J, "Industrial Hydraulic & Pneumatics", McGraw Hill, 2002.

4. Anderson B W "The analysis and design of pneumatic systems", John Wiley.

5. A. B. Goodwin, "Fluid Power Systems", Mc Millan Pub. Co.

Journals:-

1. Journal of Power and Energy
2. Journal on Mechanical Engineering

15. Name of the Module: Computational Fluid Mechanics and Heat Transfer

Module Code:
Semester:
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

A. Objectives:

The course is design to meet with the objectives of:

1. This course brings together the knowledge gained in fluid mechanics, thermodynamics, heat transfer and numerical methods in order to develop computational techniques for the engineering analysis of heat and fluid flow processes.
2. This course also intends to provide the students with sufficient background to understand the mathematical representation of the governing equations of fluid flow, discretization techniques, grid generation, transformation equations and to numerically solve the flow field problems.
3. The student will be introduced to the modeling and computational techniques that are incorporated in current computational fluid dynamics (CFD) software.
4. The student will also have the opportunity to use a standard CFD software package to analyze some complex flow situations.

B. Learning outcomes:

Upon Completion of the subjects:

Student will be able to

1. Understand the governing of fluid flow, heat transfer and numerical solution.
2. Numerically solve the fluid flow field using some popular CFD techniques. Model fluid flow problems and heat transfer.

C. Subject Matter:

Unit I:

Mathematical Description of the Physical PhenomenaGoverning 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.

Unit II:

Diffusion Equation- 1D-2D steady diffusion, Source terms, nonlinearity, Boundary conditions, interface diffusion coefficient, Underrelaxation, Solution of linear equations (preliminary), Unsteady diffusion, Explicit, Implicit and Crank-Nicolson scheme, Two dimensional conduction, Accuracy, stability and convergence revisited.

Unit III:

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.

Unit IV:

Flow Field Calculation- Incompressibility issues and pressurevelocity coupling, Primitive variable versus other methods, Vorticitystream 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.

Reference Books

1. K. Muralidhar, T. Sundarajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, New Delhi, 1997.
2. Veersteeg .H.K. & Malaseekara, "Introduction to CFD, The Finite Volume Method, Longman Scientific & Technical, 1995.
3. John, D. Anderson.J R., Computational Fluid Dynamics, McGraw Hill, 1995.
4. C.T.Shaw, Computational Fluid Dynamics, Prentice Hall, 1992.
5. S.V.Patankar, Numerical Heat Transfer and Fluid Flow, McGraw Hill, 1993.

Journal:-

1. International Journal of Computational Fluid Dynamics
2. Journal of Fluid Science and Technology

16. Name of the Module: Robotics

Module Code:

Semester:

Credit Value: 3[P=0, L=3, T=0]

Module Leader:

Subject Matter:

Unit I:-

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

Unit II:-

Kinematics of robot: direct and inverse kinematics problems and workspace, inverse kinematics solution for the general 6R manipulator, redundant and over-constrained manipulators.

Unit III:-

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.

Unit IV:-

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:

- M. P. Groover, M. Weiss, R. N. Nagel and N. G. Odrey, “Industrial Robotics-Technology, Programming and Applications”, McGraw-Hill Book and Company (1986).
- S. K. Saha, “Introduction to Robotics”, Tata McGraw-Hill Publishing Company Ltd. (2008).
- S. B. Niku, “Introduction to Robotics–Analysis Systems, Applications”, Pearson Education (2001).
- . A. Ghosal, Robotics: “Fundamental Concepts and Analysis”, Oxford University Press (2008).
- Pires, “Industrial Robot Programming–Building Application for the Factories of the Future”, Springer (2007).
- Peters, “Image Guided Interventions – Technology and Applications”, Springer (2008).

- K. S. Fu, R. C. Gonzalez and C.S.G. Lee, “ROBOTICS: Control, Sensing, Vision and Intelligence”, McGraw-Hill (1987).
- J. J. Craig, “Introduction to Robotics: Mechanics and Control”, 2nd edition, Addison-Wesley (1989).

Journals:-

1. Robotics and Autonomous Systems
2. International Journal of Computational Vision and Robotics

17. Name of the Module: Control Systems

Module Code:
Semester:
Credit Value: 3[P=0, L=3, T=0]
Module Leader:

Course Outcome:

On completion of this course students will:

1. Understand the methodology for modelling dynamic systems with concept of stability

2. Know the transfer function, signal flow graph representation of linear systems & their controlling actions

3. Understand concept of time, frequency response as well as concept of state-space models and their relation to frequency domain models

4. Control system of hydraulic and pneumatic system

Subject Matter:-

Unit-I

Basic concepts of control system:
Terminology - plant, process, system, disturbances, controlled variable, manipulated variable etc., Block diagram of basic control system, application areas with examples. Classifications of control systems, Concept of superposition for linear systems with examples.

Mathematical modeling of systems:
Translational and rotational mechanical, electrical, thermal, hydraulic and pneumatic systems, Force voltage and force current analogy, Position servo mechanism. Block diagram and signal flow graph representation of physical systems along with rules, properties, comparison and limitation, Mason's gain formula

Unit-II

Time response analysis:
Standard test signals along with examples of their usage, steady state errors for step, ramp and parabolic inputs, analysis of first and second order systems, Transient response specifications with numerical examples, Basic control actions and two position, proportional, PI, PID and rate feedback controllers, Limitations of time domain analysis.

Frequency response analysis:

Need of frequency response analysis, Sinusoidal response of linear system, methods used in frequency response, Frequency domain specifications.

Unit-III

Stability:

Concept of stability, types of stability, Routh's stability criterion, special cases with numerical examples, stability of closed loop system, concept of root locus, open loop and closed loop transfer poles, step by step procedure for root loci, numerical examples

Hydraulic control system:

Basic elements of hydraulic circuit, Principle used in hydraulic circuit, Sources of hydraulic power, Integral, Derivative, PD & PID controller with its transfer function, Comparison between hydraulic and electrical control system.

Unit-IV

Pneumatic control system:

Basic elements of pneumatic circuit, Difference between pneumatic and hydraulic control systems, Force balance and force distance type controllers, Nozzle-flapper amplifier, PD, PI and PID control system along with its transfer function.

State space analysis:

State space representation, state variables, state, state vector, state space, formulation of state space equations for mechanical and electrical systems, advantages over classical technique.

Books:

1. Modern control theory, Katsuhiko Ogata, Pearson Education International, Fifth edition.
2. Control system engineering, Norman S Nise, John Wiley & Sons, Inc., Sixth edition.
3. Modern control systems, Richard C. Dorf, Robert H Bishop, Pearson Education International, Twelfth edition.
4. Automatic control systems, Farid Golnaraghi, Benjamin C Kuo, John Wiley & Sons, Inc., Nineth edition.
5. J.Nagrath and M.Gopal," Control System Engineering", New Age International Publishers, 5th Edition, 2007

Journals:-

1. Mechanical Systems and Signal Processing
2. Journal of Dynamical and Control Systems
3. International Journal of Control, Automation, and Systems

18. Name of the Module: Materials and Manufacturing Process

Module Code:

Semester:

Credit Value: 3 [P=0, T=0, L=3]

Module Leader:

A. Objectives:

The course is designed to meet with the following objectives:
1. To make them aware of the various materials available and used in industries
2. To understand the importance of materials and its selection for design
3. To understand the conventional and non-conventional manufacturing process
4. To understand the importance of manufacturing process based on material selection
5. To make them aware of the correlations between materials and manufacturing process.

B. Learning Outcomes:

Upon completion of the subject, students will be able to:
1. Identify different materials and its importance in design and industries.
2. Classify different materials based on its applications.
3. Compare conventional and non-conventional manufacturing techniques.
4. Select suitable manufacturing process for a given material.
5. Relate materials with manufacturing process for better material selection and design.

C. Subject Matter:

Unit I: Fundamental review & Mechanical behavior of metals and alloys: Covalent, Ionic, Metallic, Vander Walls Bond, Bond strength and melting point, crystalline structures, vacancies, dislocations and other crystal defects, metals & alloys, micro structural characteristics, tensile and compressive stress-strain relations, fracture toughness, fatigue, creep, wear and abrasion.

Unit II: Materials: HSLA steels, tool and die materials, alloy cast irons, stainless steels, materials for low temperature applications, refractory metals and super alloys, ball bearing steels and bearing metals, automobile alloys and aerospace alloys, Ni and Ti aluminides, smart materials, shape memory alloys, ceramics, crystal structures, mechanical behavior of ceramics, toughening mechanisms in ceramics, ceramics for engineering applications, composites, classification, mechanics of load transfer from matrix to fiber, toughening mechanisms in composites, comparative study of PMCs, CMCs and MMCs.

Unit III: Conventional Machining processes: Metal removal process, chip formation, forces acting on cutting tool and their measurement, Merchant’s theory, tool wear & tool life, surface finish, thermal aspects, friction in metal cutting and testing of machine tools, abrasive processes, grinding wheel designation and selection, creep feed grinding, honing, lapping and other finishing processes, sheet metal forming, high speed machining, economics of high speed machining.

Unit IV: Unconventional Machining process (UCMP): Need for unconventional processes, classification of UCMP based on energy types, AJM, WJM, AWJM, USM, Electro-chemical and chemical Metal Removal Processes, Thermal Metal Removal Processes, EDM, LBM, Plasma Arc Machining, EBM, PAM.

Additive Manufacturing: General features and classification, overviews of generative manufacturing processes, two dimensional layer-by-layer techniques and direct three-dimensional techniques for Rapid Prototyping (RP), 3D printing, laminated object manufacturing, laser engineering net shaping, selective laser sintering, stereo-lithography.

D. Teaching/Learning/Practice pattern:

Teaching: 70%
Learning: 30%
Practice: 0%

(Teacher is to divide components for T/L/P)

E. Examination Pattern:

Theoretical Examination

F. Reading List:

Books:

1. Thomas H. Courtney, **Mechanical Behavior of Materials**, McGraw Hill.
2. Michael F. Ashby, **Material Selection in Mechanical Design**, Butterworth-Heinemann Ltd.
3. Flinn, R.A and Trojan, P.K., **Engineering Materials and their Applications**, Wiley 1995.
4. Issac Daniel, Ori Ishai, **Engineering Mechanics of Composite Materials**, Oxford University Press, 2006.
5. G. Boothroyd and W. A. Knight, **Fundamentals of Machining and Machine Tools**, CRC Press.
6. E.M. Trent and P.K.Wright, **Metal Cutting**, Butterworth-Heinemann, Boston.
7. D.A.Stephenson and J.S.Agapiou, **Metal Cutting Theory and Practice**, CRC Press.
8. Kalpak Jain S. and Schmid S.R., **Manufacturing Processes for Engineering Materials**, Wesley.
9. Mikell P.Groover, **Fundamentals of Modern Manufacturing: Materials, Processes and Systems**, John Wiley & Sons.

Magazine:

1. Engineering Materials
2. Modern Materials Handling
3. Assembly
4. Scientific American
5. Aerospace Manufacturing
6. Net Composites Now

Journals:

1. Materials and Design, Elsevier
2. Additive Manufacturing, Elsevier
3. Composite Structures, Elsevier
4. Measurement, Elsevier
5. Green and Sustainable Manufacturing of Advanced Material, Elsevier
6. International Journal of Production Economics, Elsevier
7. Computers and Industrial Engineering, Elsevier
8. Journal of Materials Processing Technology, Elsevier
9. Journal of Materials Science & Technology, Elsevier
10. Journal of Manufacturing Systems, Elsevier
11. International Journal of Mechanical and Materials Engineering, Springer
12. Journal of Industrial Engineering International, Springer
13. Journal of Remanufacturing, Springer
14. Mechanics of Advanced Materials and Modern Processes, Springer