DR B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY

JALANDHAR

DEPARTMENT OF MECHANICAL ENGINEERING

SCHEME OF INSTRUCTION AND SYLLABI

FOR B. TECH. PROGRAM IN

MECHANICAL ENGINEERING

Effective from 2014

DR B R AMBEDKAR NATIONAL INSTITUTE OF TECHNOLOGY

JALANDHAR

VISION

To build a rich intellectual potential embedded with interdisciplinary knowledge, human values and professional ethics among the youth, aspirant of becoming engineers and technologists, so that they contribute to society and create a niche for a successful carrer.

MISSION

To become a leading and unique institution of higher learning, offering state-of-the art education, research and training in engineering and technology to students who are able and eager to become change agents for the industrial and economic progress of the nation. To nurture and sustain an academic ambience conducive to the development and growth of committed professionals for sustained development of the nation and to accomplish its integration into the global economy.

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

The department accomplishes to be recognized nationally and internationally for exceptionally good engineering education and research producing well-qualified engineers, who are innovators, leaders and can serve the society.

MISSION

1. To impart utmost quality technical education to the students for their capacity building and skill enhancement so that they become globally competitive mechanical engineers.
2. To provide conducive environment and state-of-art facilities for carrying out research.
3. To widen the treaty with world class R&D organizations, premiere educational institutes and industries for excellence in teaching, research and consultancy services.
4. To provide a conducive academic environment to the students coupled with ethics and leadership traits.

GRADUATE ATTRIBUTES

Graduate Attributes are the knowledge skills and attitudes, which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

1. **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem Analysis:** Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.
6. **The Engineer & Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment & Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual & Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management & Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in team, to manage projects and in multidisciplinary environments.
12. **Lifelong Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

DEPARTMENT OF MECHANICAL ENGINEERING
B. TECH. IN MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES:

The educational objectives of the undergraduate program are in alignment with the mission and vision of the Institute as well as the Department of Mechanical Engineering. The existing Mechanical Engineering program educational objectives were developed as part of the programs in progress efforts to maintain through innovation the needs of our constituents. The existing educational objectives of the Mechanical Engineering program are as following:

PEO 1. To train graduates with a firm basis in engineering, Science and Technology for a thriving career in Mechanical Engineering.

PEO 2. To prepare graduates to develop into effective collaborators/innovators in efforts to address social, technical and engineering challenges.

PEO 3. To prepare graduates to engage in professional development through self-study, graduate and professional studies in engineering and business.

PEO 4. To equip graduates with integrity and ethical values so that they become responsible engineers.

PROGRAM OUTCOMES

(a) Ability to apply knowledge of mathematics, science and engineering for the solution of mechanical engineering problems.
(b) Ability to formulate and analyse complex mechanical engineering problems.
(c) Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social and public health.
(d) Ability to design and conduct experiments, and to analyse and interpret data.
(e) Ability to use techniques, skills, and modern engineering tools necessary for mechanical engineering practice.
(f) Ability to include social, cultural, ethical issues with engineering solutions.
(g) Ability to consider the impact of engineering solutions on environment and the need for sustainable development.
(h) Ability to function effectively on multidisciplinary teams.
(i) Ability to communicate effectively.
(j) Knowledge and understanding of principles of management and finance in relation to engineering projects.
(k) Appreciation of technological change and the need for independent life-long learning.

Mapping of Program Outcomes with Graduate Attributes

Graduate Attributes (GAs)	Program Outcomes (Pos)										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
1. Engineering Knowledge	**X**										
2. Problem Analysis		**X**									
3. Design/Development of Solutions			**X**								
4. Conduct Investigations of Complex Problems		**X**		**X**							
5. Modern Tool Usage					**X**						
6. The Engineer & Society						**X**					
7. Environment & Sustainability							**X**				
8. Ethics						**X**					
9. Individual & Team Work								**X**			
10. Communication									**X**		
11. Project Management & Finance										**X**	
12. Lifelong Learning											**X**

Mapping of the Program Educational Objectives with Program Outcomes

Program Educational Objectives		Program Outcomes (Pos)										
		a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**K**
1. To prepare graduates with a solid foundation in engineering, science & technology for a successful career in Mechanical Engineering.	PEO 1	**X**	X	X	X	X				X		X
1. To prepare graduates to become effective collaborators/innovators in efforts to address social, technical and engineering challenges.	PEO 2	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
2. To prepare graduates to engage in professional development through self-study, graduate and professional studies in engineering and business.	PEO 3	**X**	**X**		**X**	**X**			**X**	**X**	**X**	**X**
3. To equip graduates with integrity and ethical values so that they become responsible engineers.	PEO 4			**X**			**X**	**X**			**X**	

SCHEME OF INSTRUCTION
B. Tech. (Mechanical Engineering) Course Structure

B. Tech. I – Year I – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	PHX-101	Physics	3	1	0	4
2	ICX-101	Electrical Sciences	2	0	0	2
3	CSX-101	Computer Programming	2	0	0	2
4	BTX-101	Introduction to Bio Sciences	3	0	0	3
5	HMX-101	Introduction to Management and Human Values	3	0	0	3
6	MEX-101	Engineering Graphics	1	0	4	3
7	PHX-102	Physics Lab	0	0	2	1
8	ICX-102	Electrical Science Lab	0	0	2	1
9	CSX-102	Computer Programming Lab	0	0	2	1
Total			**14**	**1**	**10**	**20**

B. Tech. I – Year II – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MAX-101	Mathematics-I	3	1	0	4
2	CHX-101	Chemistry	3	1	0	4
3	MEX-102	Elements of Mechanical Engineering	3	1	0	4
4	HMX-102	English Communication	3	0	0	3
5	IDX-101	Environmental Science and Technology	2	0	0	2
6	INX-101	Manufacturing Process	1	0	4	3
7	ECX-101	Basic Electronics	2	0	0	2
8	HMX-104	English Communication Lab	0	0	2	2
9	ECX-102	Basic Electronics Lab	0	0	2	1
10	CHX-102	Chemistry Lab	0	0	2	1
Total			**17**	**3**	**10**	**26**

B. Tech. II – Year III – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-201	Strength of Materials	3	1	0	4
2	MEX-203	Theory of Machines	3	1	0	4
3	MEX-205	Machine Drawing	1	0	6	4
4	MEX-207	Applied Thermodynamics-I	3	1	0	4
5	MEX-209	Material Science and Technology	3	0	0	3
6	MAX-201	Mathematics-II	3	1	0	4
7	MEX-211	Material Characterization Lab	0	0	2	1
Total			**16**	**4**	**8**	**24**

B. Tech. II – Year IV – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MAX-202	Mathematics-III	3	0	2	4
2	MEX-202	Applied Thermodynamics-II	3	1	0	4
3	MEX-204	Dynamics of Machines	3	1	0	4
4	MEX-206	Mechanics of Deformable Bodies	3	1	0	4
5	MEX-208	Production Processes	3	1	0	4
6	MEX-210	Production Processes Lab	0	0	2	1
7	MEX-212	Fluid Mechanics-I	3	1	0	4
Total			**18**	**5**	**4**	**25**

B. Tech. III – Year V – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-301	Design of Machine Elements	3	0	2	4
2	MEX-303	Heat Transfer	3	1	0	4
3	MEX-305	I. C. Engines and Control	3	0	0	3
4	MEX-307	Mechanical Measurement & Metrology	3	0	0	3
5	MEX-309	Mechatronics	3	0	0	3
6	MEX-311	Fluid Mechanics-II	3	1	0	4
7	MEX-313	Heat Transfer Lab	0	0	2	1
8	MEX-315	Thermal Engineering Lab	0	0	2	1
9	MEX-317	Mechanical Measurement & Metrology Lab	0	0	2	1
Total			**18**	**2**	**8**	**24**

B. Tech. III – Year VI – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-302	Fluid Machinery	3	1	0	4
2	MEX-304	Industrial Automation	3	0	0	3
3	MEX-306	Production Management	3	0	0	3
4	MEX-308	Fluid Machinery Lab	0	0	2	1
5	MEX-310	Industrial Automation & Mechatronics Lab	0	0	2	1
6	MEX-XXX	Department Elective-I	3	0	0	3
7	MAX-206	Numerical Methods	3	1	0	4
8	MEX-XXX	Department Elective-II	3	0	0	3
9	MEX-300	Industrial Practical Training	-	-	-	4
Total			**18**	**2**	**4**	**26**

B. Tech. IV – Year VII – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-401	Refrigeration and Air Conditioning	4	0	0	4
2	MEX-403	CAD/CAM	2	0	0	2
3	MEX-405	System Design	3	0	0	3
4	MEX-407	Metal Cutting and Machine Tools	3	0	0	3
5	MEX-409	Refrigeration and Air Conditioning Lab	0	0	2	1
6	MEX-411	Project Phase-I and Seminar	0	0	4	2
7	MEX-413	CAD/CAM Lab	0	0	4	2
8	MEX-415	System Design Lab	0	0	2	1
9	MEX-417	Metal Cutting and Machine Tools Lab	0	0	2	1
10	MEX-XXX	Department Elective-III	3	0	0	3
11		Open Elective-I	3	0	0	3
Total			**18**	**0**	**14**	**25**

B. Tech. IV – Year VIII – Semester

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-400	Project Phase-II	0	0	8	4
2	MEX-402	Vibrations and Control	3	0	0	3
3	MEX-404	Vibrations and Control Lab	0	0	2	1
4	MEX-XXX	Department Elective-IV	3	0	0	3
5	MEX-XXX	Department Elective-V	3	0	0	3
6	MEX-XXX	Department Elective-VI	3	0	0	3
7		Open Elective-II	3	0	0	3
Total			**15**	**0**	**10**	**20**

LIST OF DEPARTMENT ELECTIVES

S. No.	Course Code	Course Title	L	T	P	C
1	MEX-330	Unconventional Methods of Machining	3	0	0	3
2	MEX-331	Design for Production	3	0	0	3
3	MEX-332	Solar Thermal Process	3	0	0	3
4	MEX-333	Advances in Metal Forming	3	0	0	3
5	MEX-334	Numerical Control for Machine Tool	3	0	0	3
6	MEX-335	Tool Design	3	0	0	3
7	MEX-336	Flexible Manufacturing System	3	0	0	3
8	MEX-430	Total Quality Management	3	0	0	3
9	MEX-431	Operation Management	3	0	0	3
10	MEX-432	Non Conventional Energy	3	0	0	3
11	MEX-433	Automobile Engineering	3	0	0	3
12	MEX-530/MEX-675	Mechanics of Composite Material	3	0	0	3
13	MEX-531	Lubrication and Wear	3	0	0	3
14	MEX-532	Industrial Safety and Environment	3	0	0	3
15	MEX-533	Cryogenics	3	0	0	3
16	MEX-534	Power Plant Engineering	3	0	0	3
17	MEX-535/MEX-677	Finite Element Methods	3	0	0	3
18	MEX-536	Experimental Stress Analysis	3	0	0	3
19	MEX-630/MEX-687	System Dynamics & Control	3	0	0	3
20	MEX-631	Robotics: Mechanics and Control	3	0	0	3
21	MEX-632	Computational Fluid dynamics	3	0	0	3
22	MEX-633	Operations Research	3	0	0	3
23	MEX-634	Fundamentals of Combustion	3	0	0	3

DETAILED SYLLABUS

			L	T	P	Credit
PHX-101	**Physics**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	After completing the course PHX-101, students should be familiar with basics of electricity and magnetism. They should have knowledge of four Maxwell equations and their Physical significances.
CO 2	Students should have the knowledge about the basics phenomenon's related to physical optics i.e. interference, diffraction and polarisation. They should know about how interference patterns are formed in thin films and how the diffraction patterns are formed in diffraction grating.
CO 3	Students should know about the basic properties of Laser beams. They should know the basic physical principle behind the working of laser, different types of lasers and their applications.
CO 4	Students should know about the special theory of relativity and how it is different from Newtonian theory. They should have knowledge about various interesting consequences of special theory of relativity and about Einstein mass energy relationship.
CO 5	After completing the course students should know about the need of quantum mechanics. They should know about dual character of radiations as well as matter. They should know the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equations and their applications to simple one dimensional potential problem.

Detailed Syllabus:

Electrostatics: Gradient of a scalar, divergence and curl of a vector, Gauss's law and its applications; electric potential and electric field (in vector form); potential due to a monopole, dipole and multipoles (multipole expansion); work and energy in electrostatics; dielectrics; polarization, electric displacement, susceptibility & permittivity, Clausius Mossotti equation.

Magnetostatics and Electrodynamics: Lorentz Force Law; magnetic field of a steady current (Biot –Savart law); ampere's law and its applications; ampere's law in magnetized materials; electromotive force; Faraday's law; Maxwell's Equations, Wave Equation.

Optics: Interference: Conditions for Interference of light, Fresnel biprism experiment; displacement of fringes, Interference in thin films-wedge shaped film; Newton's rings; Diffraction: Single & N- Slit; Diffraction grating, Grating spectra; Rayleigh's criterion and resolving power of grating; Polarization: Phenomena of double refraction, Nicol prism; Production and analysis of plane; circular and elliptical polarized light; Fresnel's theory of optical activity, Polarimeters.

Lasers: Spontaneous and stimulated emission; Einstein's coefficients, population inversion and optical pumping; three and four-level lasers; Ruby, He-Ne, Nd: Yag, CO2, semiconductor lasers. Industrial and medical applications of lasers.

Theory of Relativity: Invariance of an equation and concept of ether; Michelson-Morley experiment; Einstein's postulates and Lorentz transformation equations, length, time and simultaneity in relativity; addition of velocity, variation of mass with velocity, mass-energy relation, energy-momentum relation.

Quantum Theory: The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, orthogonal wave functions; applications of Schrödinger wave equation (particle in a box and harmonic oscillator).

Text Books:

1. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall of India, New Delhi, 2nd Ed. (1998).
2. Ajoy Ghatak, "Optics" , McGraw Hill Companies, 3rd Ed.
3. K. Thyagarajan and A. K. Ghatak, "Lasers, - Theory and Applications", Macmilan India Ltd., New Delhi, (2000).
4. A. Beiser, "Concepts of Modem Physics", McGraw Hill, New Delhi, 6th Ed. (2002).

Reference Books:

1. Eugene Hecht, "Optics" , Addison Wesley (2002).
2. A. P. Arya, "Elementary Modern Physics" Addison –Wesley, Singapore, (1974).
3. H. S. Mani and G. K. Mehta, "Introduction to Modem Physics", Affiliated East West Press, New Delhi, (1991).
4. P. W. Milonni and J. H. Joseph Eberly, "Lasers" John Wiley and Sons, Singapore.

			L	T	P	Credit
ICX-101	**Electrical Science**	**Core Course**	**2**	**0**	**0**	**2**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	After completing this course the student is expected to solve and analyze various simple electrical networks (both ac and dc) using network laws and theorems.
CO 2	The student will be learning basic concepts of ac circuits and is expected to solve simple single phase and three phase ac circuits.
CO 3	He will also learn the principle and working of basic electrical measuring instruments and devices so that he can understand the behavior and performance of them.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
CSX-101	**Computer Programming**	**Core Course**	**2**	**0**	**0**	**2**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Identify and understand the working of key components of a computer system (hardware, software, firmware etc.).
CO 2	Understand, analyse and implement software development tools like algorithm, pseudo codes and flow charts.
CO 3	Analyse and understand logical structure of a computer program, and different construct to develop a program in 'C' language.
CO 4	Write, compile and debug programs in C language.
CO 5	Analyse and understand simple data structures, use of pointers, memory allocation and data handling through files in 'C'.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
BTX-101	**Introduction to Bio Sciences**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand basic knowledge of biosciences, biological materials.
CO 2	Develop awareness about contemporary environmental problems.
CO 3	Develop skills they will need when collaborating with biological scientists.
CO 4	Understand human physiology and capable for applications in future in Medical Engg, biosensors, artificial organs, biomaterials etc.

Detailed Syllabus:

Unit I:

Structure and function of Carbohydrates, Proteins, Amino Acids and Peptides, Nucleic Acids and Nucleotides, Lipids and Enzymes. Cell, Prokaryotic and Eukaryotic cell with short description of Bacterial cell, plant cell and animal cell. Microscopes, Cell count method: Membrane filter count method. Ecosystem: Biodiversity, Microorganisms, Biogeochemical Cycle.

Unit II:

Microbiology of Domestic water: Water Purification, Bacteriological evidence of pollution: Coliform and *E. coli*, Bacteriological Technique: Examination using standard plate count method along with membrane filter technique Microorganisms other that Coliform bacteria: Fecal Streptococci, Slime-Forming Bacteria, Iron bacteria, Sulfur bacteria, Algae, Viruses, Deterioration of water quality and its effect in Swimming pool. Eco-friendly Bio-products: Biofuels, Bio Hydrogen Generation, Bio pesticides, Bio fertilizers, Microbial Fuel Cell, Biodegradable Plastics. Microbiology of Foods: Microbial spoilage of food, Microbial Examination of foods, Preservation of foods and fermented foods. Industrial Microbiology: Lactic acid production, Vinegar production, Insulin, Alcohol fermentations, Penicillin Production, Enzyme production Deterioration of materials: paper, textiles, painted surface, Prevention of microbial deterioration.

Unit III:

Cardiovascular System, Respiratory System, Nervous System.

Recommended Books:

1. Pelczar M J, Chan E C S and Krieg N R "*Microbiology, 5th Edition*," Mc Graw Hill, New York (1995).
2. Stanley A S "*Cell Biology for Biotechnologists*" Narosa Book Distributors Pvt Ltd (2010).
3. Chatterji A K "*Introduction to Environmental Biotechnology*" Phi Learning Private Limited (2011).
4. Lehninger, A L "*Principles of Biochemistry*", 4th Edition Butterworth Publishers, New York (2003).
5. Marieb E N "*Essentials of Human Anatomy & Physiology, Eighth Edition*," Pearson Education Inc. USA (2007).

			L	T	P	Credit
HMX-101	**Introduction to Management and Human Values**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will be able to understand the basic concept of the management, its nature and its relevance in the practical world.
CO 2	Students will also be able to understand the basic role of the management in the success of an organization. A student will also be able to understand the history of the evolution of the management which is nowadays established a so profession.
CO 3	Students will also be able to have a sense of the management process which starts with planning and ends with a success and strong control.
CO 4	Develop awareness about the social environment its impact on the common human beings and the psychological factors which influences a strong motivational in an individual.
CO 5	Develop a strategy for transition into a universal human order at the individual level as well as at the level of the responsible society.
CO 6	Develop group behaviour and team building skills, handle out stress and conflict resolution.
CO 7	Imbibe a positive learning attitude with cognition, emotional intelligence and a learned attitude.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
MEX-101	**Engineering Graphics**	**Core Course**	**1**	**0**	**4**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will be able to acquire knowledge of different conventions and methods of engineering drawing.
CO 2	Student's capability to generate and draw various geometric constructions & engineering objects (2D & 3D) with different drawing tools will upgrade.
CO 3	Students will enhance their imagination and conceptualization skills so as to impart this knowledge in designing and development of various objects.
CO 4	Knowledge gained will further help students for future project works.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
PHX-102	**Physics Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	After completing the course PHX-102, students should be familiar with practical training of basic electrical circuits.
CO 2	Students would have the practical knowledge about the basics phenomenon's related to physical optics i.e. interference, diffraction and polarisation. They should know about how interference patterns are formed in thin films and how the diffraction patterns are formed in diffraction grating.
CO 3	Students would know about the basic properties of Laser beams. They would know the basic physical principle behind the working of laser, different types of lasers and their applications.
CO 4	After completing the course students would know about the application and working of basic semiconductor devices.

Detailed Syllabus:

List of Experiments

1. To verify the laws of vibrating strings by Melde's experiments.
2. To determine the frequency of AC Mains by using a sonometer and an electromagnet.
3. To determine the impedance of A.C. Circuits.
4. To study the characteristic of PN diode and Zener diode.
5. To find out the intensity response of a solar cell/Photo diode.
6. To analyze the suitability of a given Zener diode as a power regulator.
7. To determine the band gap of a semiconductor.
8. To determine the Refractive index of the Prism material using spectrometer.
9. To determine the wavelength using Fresnel's Biprism /Diffraction grating.
10. To determine the wavelength of sodium light using Newton's ring method.
11. To determine the specific rotation of sugar using Laurent's half-shade polari meter.
12. To determine the velocity of ultrasonic waves in liquids.
13. To study the effect of voltmeter resistance on voltage measurement.
14. To study the variation of magnetic field with distance along the axis of a circular coil carrying current and its estimate the radius of the coil.
15. To determine the Laser Parameters like divergence, Wavelength etc. for a given laser source.

Recommended Books:

1. Dr. R.S. Sirohi, Practical Physics, Wiley Eastern, New Delhi.

			L	T	P	Credit
ICX-102	**Electrical Science Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	After completing this course the student is expected to solve and analyze experimentally various simple electrical networks (both ac and dc) using network laws and theorems.
CO 2	The student is expected to solve and analyze experimentally the behavior of simple single phase and three phase ac circuits and analyze them.
CO 3	He is expected to verify the behavior and performance characteristics of basic electrical measuring instruments and devices experimentally.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
CSX-102	**Computer Programming Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand key components of computer and work with internal and external DOS commands.
CO 2	Understand C programming development environment, compiling, debugging, linking and executing a program using the development environment.
CO 3	Analysing the complexity of problems, Modularize the problems into small modules and then convert them into programs.
CO 4	Understand and apply the in-built functions and user defined functions for solving the problems.
CO 5	Understand and apply various data structures such as arrays, structures, union, enum etc.
CO 6	Understand and apply the pointers, memory allocation techniques and use of files for dealing with variety of problems.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
MAX-101	**Mathematics-I**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To develop skill of higher derivative, expansion of functions in ascending power of variable & value of the function in neighboured of some points.
CO 2	To determine limits of indeterminate function applicable to already word problems & engineering problems.
CO 3	To gain the knowledge to solve differential equation arising in different Engineering branch and able to form mathematical & physical interpretation of its solution which place important role in all branches of engineering.
CO 4	To demonstrate the basic concepts in Fourier series, properties, parseval's identity.
CO 5	To apply the concepts of Fourier and integral transform.
CO 6	To develop the concepts of Laplace transformation & inverse Laplace transform with its property to solve partial differential equation and ordinary differential equation with given boundary conditions which is helpful in all engineering & research work.
CO 7	To develop the concepts of Z-Transform and its application.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
CHX-101	**Chemistry**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To understand the solid state chemistry of the materials along with the distribution of solvents and their application in solvent extraction.
CO 2	To understand the phase transitions of different compositions of the elements, alloys and interpret the phase diagram of phases present.
CO 3	To study the spectra of compounds and propose the structures of the compounds along with applications of the spectroscopy in various fields.
CO 4	To study the reaction mechanisms of the various reactions and use of various reagents. To understand the shape and structure, stability, magnetic properties, and applications of coordination complexes.
CO 5	To examine the role of metals in biology, the study biological processes such as respiration, oxygen transport, role of Myoglobin and Hemoglobin and metal properties in biological chemistry.
CO 6	To understand the basic concept of Nanochemistry alongwith fabrication, characterization and application of nanomaterials.
CO 7	To identify and formulate the conducting polymers and their applications in different fields.

Detailed Syllabus:

1. **Solid State and Distribution Law:** Introduction to Solid State Chemistry, Law of rational indices, Miller indices, Interplaner spacing, X-ray diffraction, Nernst distribution law, Applications of distribution law: solvent extraction.
2. **Chemical and Phase Equlibria:** Phase diagram for single component system, carbon dioxide system, sulphur system, carbon system, helium system, Two component systems: Pb-Ag system, Bi-Cd system, Kl-H_2O system, Freezing mixtures, Azeotropic mixtures, solubility of partially miscible liquids.
3. **Spectroscopic Studies of Materials:** Lambert-Beer's Law**,** Principles and applications of U. V. Visible, Molecular Absorption Spectroscopy, Chromophores, Effect of conjugation on chromophores, Absorption by aromatic systems, Rotational and Vibrational spectroscopy: Principles and application to simple molecules, Magnetic Resonance Spectroscopy: Principles and application to simple molecules and Introduction to Photoelectron Spectroscopy.
4. **Organic Reactions and Reagents:** Oxidation of hydrocarbons, Oxidation of alcohols (chromic acid), oxidation of carbon-carbon double bonds (sharpless epoxidation) including Palladium-catalyzed oxidation, oxidation of ketones (Baeyer-Villiger oxidation). Catalytic hydrogenation, homogeneous hydrogenation (Wilkinson's catalyst), Reduction by dissolving metals (Birch reduction), Reduction by hydride-transfer reagents ($NaBH_4$), Reduction with boranes(BF_3).
5. **Coordination Complexes:** Crystal field theory of octahedral and tetrahedral complexes, Spectrochemical series, High spin and low spin complexes. Charge transfer spectra, John-Teller effect, colour & magnetic properties.
6. **Biological Inorganic Chemistry:** Oxygen transport and storage-Myoglobin, Hemoglobin, The chemistry of elements in medicine – chelation therapy, Cancer treatment, Anti-arthritis drugs, contributions of individual elements to biological systems.
7. **Nano-science and Technology:** Introduction to Nano-science and technology, Self

Assembly, Lithography, Soft Lithography, Dip pen nanolithography, CNTs, bio-nanoinformation, Applications in microelectronics.

8. **Conducting Polymers:** Introduction, types, n-doping, p-doping, some specific examples of conducting polymers, conducting polymers – a comparison between metals and CPs, applications in diversified fields.

REFERENCES:

1. *Advanced Inorganic Chemistry* (6th edition), F. A. Cotton and G. Wilkinson, John Wiley and Sons, **2003.**
2. *Inorganic Chemistry* (4th edition), D. F. Shrives and P. W. Atkins, Oxford University, Oxford, **2006.**
3. *Modern methods of organic synthesis* (3rd edition), W. Carruthers, Cambridge University Press (Cambridge Low Price editions) 1986, Reprinted **2004.**
4. *Reactions, Rearrangements and Reagents* (4th edition), S. N. Sanyal, Bharti Bhawan (P & D), **2003.**
5. *Polymer Science and technology* (2nd Edition), P. Ghosh, Tata McGRAW Hill, 2008.
6. *Applications of Absorption Spectroscopy of Organic Compounds* (4th edition), John R. Dyer, Prentice Hall of India Pvt. Ltd., **1978.**
7. *Introduction to Nanotechnology* , C. P. Poole Jr. , F. J. Owens, Wiley Interscience, **2003.**
8. *Nanotechnology Science, Innovation and Opportunity*, L. E. Foster, Pearson Education, **2007.**
9. *Spectroscopic methods in organic chemistry* (4th Edition), Williams & Fleming, Tata McGRAW Hill, **2003.**

			L	T	P	Credit
MEX-102	**Elements of Mechanical Engineering**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Emphasis laid upon the principles and fundamentals involved in the inter-conversion of thermal energy into mechanical energy and vice versa.
CO 2	The subject also offers a birds eye-view to all students about the common engineering materials finding vide application in Mech. Engg. Industry and about their strength and other related vital aspects.
CO 3	Understand the basic concepts of fundamental of fluid mechanics and thermodynamics.
CO 4	To understand basic principle of engineering mechanics to design and analyze various types of structural elements.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
HMX-102	**English Communication**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students are equipped with effective speaking and listening skills.
CO 2	Helps to develop their soft skills, which will make the transition from college, to workplace smoother and help them to excel in their jobs.
CO 3	Enhances students' performance at Placement interviews, Group Discussions and other recruitment exercises.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
IDX-101	**Environmental Science and Technology**	**Core Course**	**2**	**0**	**0**	**2**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students could understand the mechanism of various environmental issues and due to this a new idea for remedy of environmental problems may be solved. The students could also understand responsibility towards environmental and spread this to others for perform our duties to environment.
CO 2	Students ethical values could be enhance.
CO 3	Students are updated about various energy resources (renewable and non-renewable) from this they could understand the importance of energy conservation and consumption.

Detailed Syllabus:

Ecology and Ecosystem
Ecology and environment, functions of an ecosystem, habitats of biological species, ecological succession, food-chains and food-webs, the bio-geo-chemical cycles of elements and minerals.
Biodiversity and its Conservation
Introduction, components, importance and threats to biodiversity, factors causing loss of biodiversity, in situ and ex situ techniques for conservation of biodiversity.
Environment and Human Population
Population growth, population explosion, human health, human rights, value based environmental education, environmental ethics, environmental movements.
Sustainable Development and Utilization of Resources
Introduction types of natural resources, present status, utilization of renewable and non-renewable resources, role of individual in conservation of resources.
Global environment issues
Global warming, ozone depletion, green house effect, acid rain, carbon trading, remote sensing, natural disaster, environmental toxicology and degradation environmental biotechnology.

Section – B

Environment Pollution
Introduction, definition, sources, characteristics and perspective of air pollution, water pollution, soil pollution, noise pollution, marine pollution and thermal pollution.
Legislation for Biodiversity Protection
Environmental Laws, Acts, Rules and Regulations, National Conservation Strategy and policy statement on environment and development, Policy statement for abatement of pollution.
Environmental Management Systems
International Standards Organization (ISO), Introduction, Terminology and Certification, ISO 14000 family of standards, guides and technical reports.
Environmental Impact Assessment

Concept, Origin, Procedure and Evaluation methodology for environmental impact assessment, scope studies, preparation and review of environmental impact statement.

International Efforts for Environmental Protection

United Nation's conference on human environment, Earth Summits, Basel Convention, Kyoto Protocol, Montreal Protocol.

Recommended Books:

1. S. C. Santra, Environmental Science, New Central Book Agency (P) Ltd., Kolkatta, Second Edition, 2011.
2. N. K. Uberoi, environmental Management, Excel Books, New Delhi, Second Edition, 2006.

			L	T	P	Credit
INX-101	**Manufacturing Process**	**Core Course**	**1**	**0**	**4**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Ability to clear basic fundamental concepts of machining, welding, casting, forming and list of major metal, non metal, alloy and their physical characteristics.
CO 2	Selecting or suggesting suitable manufacturing processes to achieve the required products with the aim of avoiding material and time wastage.
CO 3	Recommend appropriate part manufacturing processes when provided a set of functional requirements and product development constraints.
CO 4	Developing manufacturing processes and tools for typical applications in the industries.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
ECX-101	**Basic Electronics**	**Core Course**	**2**	**0**	**0**	**2**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will be able to acquire knowledge of different measuring instruments for study of various electrical parameters.
CO 2	Students could understand basic fundamental concepts of basic semiconductor diodes, its application.
CO 3	Gain knowledge of transistors and its applications for amplifiers and oscillators.
CO 4	Gain knowledge about digital logic families and basic circuits design.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
HMX-104	**English Communication Lab**	**Core Course**	**0**	**0**	**3**	**2**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students are equipped with effective speaking and listening skills.
CO 2	Helps to develop their soft skills, which will make the transition from college, to workplace smoother and help them to excel in their jobs.
CO 3	Enhances students' performance at Placement interviews, Group Discussions and other recruitment exercises.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
ECX-102	**Basic Electronics Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To understand measuring process of different measuring instruments for study of various electrical parameters.
CO 2	To study practical behaviour of semiconductor diodes and its applications for rectifiers deign.
CO 3	To study transistor and its applications for amplifiers.
CO 4	Able to deign digital circuits and analyse it behaviour.

Detailed Syllabus: Available on institute website.

			L	T	P	Credit
CHX-102	**Chemistry Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To understand the mechanism of synthesis of polymers and their applications.
CO 2	To understand the concept of water purification through ion exchange, COD etc techniques.
CO 3	To study the partition coefficient and distribution of solute in different solvents.
CO 4	To study the synthesis of drugs like aspirin.
CO 5	To understand the concept of acid-base titrations using pH and conductance measurements.
CO 6	To analyze the solutions and extraction of metals using spectrophotometric techniques.
CO 7	To learn other techniques like thin layer chromatography, determination of molecular weight, and adsorption phenomenon.
CO 8	To find viscosity of different solvents and their applications.

Detailed Syllabus:

1. To draw the phase diagram of lead-in binary system.
2. To study the adsorption of acetic acid on activated charcoal.
3. To verify Bear's law for a coloured solution and to determine the concentration of a given unknown solution.
4. Determine the partition coefficient of iodine between carbon tetrachloride and water.
5. Determine the viscosity of a given liquid by Oswald's viscometer.
6. To determine the molecular weight of a given compound by cryoscopy.
7. Isolation of caffeine from tea leaves.
8. To synthesize paracitamol and determine percentage yield of the product.
9. To synthesize Phenol and Urea formaldehyde resin.
10. Thin layer-chromatographic separations of amino acids / organic molecules.
11. Determination of ion-exchange capacity of a given ion-exchange (cationic / Anionic).
12. Determination of COD of water sample.
13. To draw the pH-titration curve of strong acid vs strong base.
14. To determine concentration of trace metals by atomic absorption spectrophotometer.
15. An investigatory project (compulsory for all students).

			L	T	P	Credit
MEX-201	**Strength of Materials**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Elements of Mechanical Engineering (MEX-102).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To establish an understanding of the fundamental concepts of mechanics of deformable solids.
CO 2	To provide students with exposure to the systematic methods for solving engineering problems in solid mechanics.
CO 3	To understand 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.
CO 4	To build necessary theoretical background for further structural analysis and design course.

Detailed Syllabus:

Simple stresses and strains: Concept of stress and strain: St. Venants principle of stress and strain diagram, Hooke's law, Young's modulus, Poisson ratio, stress at a point, stresses and strains in bars subjected to axial loading, Modulus of elasticity, stress produced in compound bars subjected to axial loading, Temperature stress and strain calculations due to applications of axial loads and variation of temperature in single and compound walls.
Compound stresses and strains: Two dimensional system, stress at a point on a plane, principal stresses and principal planes, Mohr's circle of stress, ellipse of stress and their applications, Two dimensional stress-strain system, principal strains and principal axis of strain, circle of strain and ellipse of strain, Relationship between elastic constants.
Bending moment and shear force diagrams: Bending moment and shear force diagrams, SF and BM definitions. BM and SF diagrams for cantilevers, simply supported and fixed beams with or without overhangs and calculation of maximum BM and SF and the point of contraflexure under Concentrated loads, Uniformity distributed loads over the whole span or part of span,combination of concentrated loads (two or three) and uniformly distributed loads, uniformly varying loads, application of moments.
Theory of bending stresses: Assumptions in the simple bending theory, derivation of formula: its application to beams of rectangular, circular and channel sections, composite/fletched beams, bending and shear stresses in composite beams. Unsymmetrical Bending, Combined bending and torsion, bending and axial loads etc.
Slope and deflection: Relationship between moment, slope and deflection, Moment area method, Macualay's method, Use of all these methods to calculate slope and deflection for the determinant beams.
Torsion: Derivation of torsion equation and its assumptions. Applications of the equation of the hollow and solid circular shafts, torsional rigidity, combined torsion and bending of circular shafts, principal stress and maximum shear stresses under combined loading of bending and torsion, analysis of close-coiled-helical springs.
Thin cylinders and spheres: Derivation of formulae and calculations of hoop stress longitudinal stress in a cylinder, and sphere subjected to internal pressures increase in Diameter and volume.
Columns and struts: Columns under uni-axial load, Buckling of Columns, Slenderness ratio and conditions. Derivations of Euler's formula for elastic buckling load, equivalent length, Rankine Gordon's empirical formula.

Books Recommended

1. Pytel A H and Singer F L, *"Strength of Materials",* 4th Edition, Harper Collins, New Delhi
(1987).
2. Beer P F and Johnston (Jr) E R, *"Mechanics of Materials",* SI Version, Tata McGraw Hill, India (2001).
3. Popov E P, *"Engineering Mechanics of Solids",* SI Version 2nd Edition, Prentice Hall of India, New Delhi (2003).
4. Timoshenko S P and Young D H, *"Elements of Strength of Materials",* 5th Edition, East West Press, New Delhi (1984).
5. Jindal U C, *"Introduction to Strength of Materials",* 3rd Edition, Galgotia Publishing Private
Limited New Delhi (2001).

			L	T	P	Credit
MEX-203	**Theory of Machines**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None.
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand the concepts of machines, mechanisms and related terminologies.
CO 2	Analyze planar mechanism for displacement, velocity and acceleration graphically.
CO 3	Analyze various motion transmission elements like gears, gear trains, cams, belt drives and rope drives.
CO 4	Utilize analytical, mathematical and graphical aspects of kinematics of machines for effective design.
CO 5	Perform the kinematic analysis of a given mechanism.

Detailed Syllabus:

Basic Concepts: Kinematics of machine, Kinematic link and their different types, types of kinematic pair, kinematic chain, mechanism and inversions of four bar chain and slider crank mechanism. Degree of freedom, synthesis of linkages – number synthesis, Grashof's riterion and introduction to dimensional synthesis.
Velocity Analysis: Motion of a link, velocity of a point on a link by relative velocity method, velocities of slider crank mechanisms, rubbing velocity at a pin joint, velocity of a point on a link by instantaneous center method, properties and types of I-Center, Kennedy theorem and methods of locating I-centers in a mechanism.
Acceleration Analysis: Acceleration of a point on a link, acceleration in slider crank mechanism, Coriolis component of acceleration, Quick-return mechanism.
Cams and Follower: Types of cams and followers, cam terminology, types of motion of the follower, analysis of motion of the follower, analysis of motion of the follower for cams with specified contours.
Gears: Classification of gears, terminology used in gears, law of gearing, velocity of sliding, forms of teeth, construction and properties of an involute, construction and properties of cycloidal teeth, effect of variation of center distance on the velocity ratio of involute profile tooth gears, length of path of contact, arc of contact, number of pairs of teeth in contact, interference, minimum number of teeth, interference between rack and pinion, undercutting, terminology of helical and worm gears.
Gear Trains: Definition of simple, compound, reverted and epicyclic gear trains, velocity ratio of epicyclic gear trains.
Belt, Rope and Chain Drive: Types of belt drives, velocity ratio, law of belting, length of belt, ratio of friction tensions, power transmitted, effect of centrifugal tension on power transmission, condition for maximum power transmission, concept of slip and creep. Chain drive, chain length and angular speed ratio.
Governors: Different types of centrifugal and inertia governors: hunting, isochronism, stability, effort and power of governor, controlling force.
Note: In addition to the tutorials several studies related to mechanism, mechanism trains (Lathe, Milling Machines, Shaper), automobiles mechanisms, automobile gearbox, differential mechanisms will be performed by the students. Characteristics of governors, cam and cam profile experiments will be demonstrated during the tutorial classes.

Books Recommended

1. Bevan T, "*The Theory of Machines",* 3rd Edition CBS Publishers and Distributors (2002).
2. Shigley J E and Vickar J J, *"Theory of Machines and Mechanism"*, 2nd Edition, McGraw Hill, New Delhi (1995).
3. Wilson C and Sadler J, *"Kinematics and Dynamics of Machine"*, 3rd Edition, Prentice Hall (2002).
4. Ratan S S, *"Theory of Machines",* 1st Edition, Tata McGraw Hill, New Delhi (1993).
5. Rao J S and Dukkipati R V, *"Mechanism and Machine Theory",* 2nd Edition, New Age International (P) Limited, Delhi (1992).

			L	T	P	Credit
MEX-205	**Machine Drawing**	**Core Course**	**1**	**0**	**6**	**4**

Pre-requisites: Engineering Graphics (MEX-101)
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Recognize to use modern engineering tools, software and equipment to analyse different drawings for Design & manufacturing.
CO 2	Identify the elements of a detail drawing and prepare Engineering Drawing using orthographic projections and sectional views.
CO 3	Recognition of the need and an ability to engage in self education and life-long learning.
CO 4	An Ability to understand and apply the knowledge of machine drawing as a system of Communication in which ideas are expressed clearly and all information fully conveyed.

Detailed Syllabus:

Review of Principle of Orthographic Projections, fits and tolerances, machining symbols, sectioning and conventional representation, dimensioning, welding symbols, various types of screw threads, screw fasteners.
Assembly and Disassembly:
Coupling, Pin type, flexible coupling, and cone friction clutch.
Pipe and Pipe fittings.
Boiler Mountings: steam stop valve, feed check valve safety valve, blow off cock valve.
Bearings: Swivel bearing, thrust bearing, Plummer block.
Machine Tool Parts: Lathe tail stock, tool post.
Miscellaneous: Screw jack, drill press vice, connecting rod, eccentric.
Introduction to Computer Aided Drafting: Students may be given some drawing problems involving the application of available CAD softwares.
NOTE: First angle projection to be used. BIS codes for various applications in Machine Drawing. Drawings should contain bill of materials and illustrate the use of its tolerances and surface finish requirements. The syllabus given above indicates the broad outlines and the scope of the subject to be covered.
Based on the syllabus a number of sheets will be prepared by the students in practical classes as listed below:
Sheet No.1 : Types of lines, Conventional Representation for materials.

Assignment No.1 : Sectioning Practice on sketch book.

Sheet No. 2 : Various types of machine components for sectioning.

Assignment No.2 : Tolerances, Limits and Fits, Practice on Sketchbook.

Assignment No.3 : Machining Symbols – Surface Texture and its importance.

Assignment No.4 : Screw threads practice on sketchbook.

Sheet No. 3 : Various Types of Nuts, Bolts, Studs and Setscrews & Foundation Bolts

Assignment No. 5 : Coupling, its types and applications.

Sheet No. 4 : Pin type flexible coupling and cone friction clutch.

Sheet No. 5 : Assembly of various pipe joints and fittings.

Sheet No. 6 : Assembly and part drawing of Screw Jack.

Sheet No. 7 : Assembly of Drill press vice.

Sheet No. 8 : Assembly and part drawing of Steam stop valve.

Sheet No. 9 : Assembly of safety valve.

Sheet No. 10 : Assembly of Blow of cock.

Sheet No. 11 : Assembly and part drawing of Tail Stock.

Sheet No. 12 : Assembly of Thrust bearing and Plummer block.

Assignment No. 6 : Sketch of Swivel bearing on the sketch book.

Sheet No. 13 : Assembly and part drawing of connecting Rod and eccentric.

Books Recommended

1. Gill P S, *"Machine Drawing",* 17th Edition, S K Kataria and Sons, New Delhi (2002).
2. Bhatt N D, *"Machine Drawing",* 26th Edition, Charotar Publishing House, Anand (1991).
3. Sidheshwar N, Kannaiah P and Sastry V V S, *"Machine Drawing",* 27th Reprint, Tata McGraw Hill, New Delhi (2003).
4. Luzadder W J, *"Fundamentals of Engineering Drawing",* PHI, New Delhi, 9th Edition (1988).
5. Bertoline G R, Wiebe E N., Miller C L, and Mohler J L, *"Technical Graphics Communication",* 2nd Edition, IRWIN McGraw Hill, New York (1997).

			L	T	P	Credit
MEX-207	**Applied Thermodynamics-I**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Understanding of properties of the steam, Rankine cycle, reheating, regeneration, Binary vapour cycle.
CO 2	Working of different types of boilers, Mountings and accessories boiler draught and its calculations, Boiler performance.
CO 3	Flow the steam through the different types of nozzles, Nozzle efficiency, steam injector.
CO 4	Working of different types of steam turbines, Analysis of performance of turbines, governing of turbines.
CO 5	Working of different types of steam condensers, calculation of cooling loads.
CO 6	Study of reciprocating compressors, Analysis of the work done, isothermal efficiency, etc.

Detailed Syllabus:

Fundamentals: Pure substances, Thermodynamic property relations, Properties of mixtures, Fuel and Combustion.

Steam Generators: Review of steam generation process. Classification, Fire and water tube boilers, Description of Cochran, Locomotive, Lancashire Babcock and Wilcox boilers and Sterling Boiler, mountings and accessories: Economizer, super heater etc. Modern high pressure boilers, Characteristics of high pressure boilers, Advantages of forced circulation, steam accumulators, boiler performance, equivalent evaporation, boiler efficiency, Boiler Trial.

Working Cycles: Simple Rankine cycle, methods of improving efficiency: Feed water heating (Bleeding), reheat cycle, combined reheat and regenerative cycle, Ideal working fluid – Binary vapour cycle, combined power and heating cycles. Introduction to Steam Engine with brief discussion.

Nozzle: Types of nozzles and their utility, Flow of steam through nozzles, Critical pressure and discharge, Area of throat and exit for maximum discharge, Effect of friction on Nozzle efficiency, Supersaturated flow.

Steam Turbines : Classification; Impulse & Reaction Steam turbines, description of components , Pressure and velocity compounding, Velocity diagram and work done, Effect of blade friction on velocity diagram, Stage efficiency and overall efficiency, Reheat factor and condition curve. Degree of reaction, blade efficiency and its derivation; calculation of blade height, backpressure and extraction turbines and cogeneration; Economic assessment. Method of attachment of blades to turbine rotor, losses in steam turbines, Governing of steam turbines, Labyrinth packing.

Condensers: Function, Elements of condensing plant, types of condensers, Dalton's law of partial pressure applied to condenser problems, condenser and vacuum efficiencies. Cooling water calculations. Effect of air leakage, Methods to check and prevent air infiltration. Description of air pump and calculation of its capacity.

Reciprocating Air Compressors: Use of compressed air in industry. Classification of air compressors, Operation of single stage reciprocating compressors, Work input and the best value of index of compression. Isothermal and polytropic efficiency. Effect of clearance and

volumetric efficiency, Multistage compression and its advantages. Optimal multistaging, work input in multistage compression, Reciprocating air motors.

Books Recommended

1. Yunus Cengel& John Cimbala,"Fluid Mechanics: Fundamentals and Applications", 2nd reprint 2007, Tata McGraw Hill, New Delhi.
2. F M White, "Fluid Mechanics", 6th ed., McGraw Hill, New York.

			L	T	P	Credit
MEX-209	**Material Science and Metallurgy**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To apply knowledge of mathematics, science & engineering.
CO 2	To apply and integrate knowledge of structure and properties processing and performance to solve materials selection problems.
CO 3	To analyse and learn the behaviour of different material under the testing of Hardness, Impact, Creep, Fatigue, Torsion and fracture test.
CO 4	Ability to learn the various defects and imperfections in crystals of material, diffusion among metals, various phase transformations of Fe w.r.t change in carbon composition and fundamental mechanism of chemical and heat treatment like normalizing, tempering, hardening, carburizing, nitriding and cyaniding etc.

Detailed Syllabus:

Structure of Crystalline Solids: Crystal structure and crystal systems, closed packing, some prominent crystal structures, Miller indices, determination of crystal structure, reciprocal lattice.

Imperfections In Solid: Points imperfections and their equilibrium concentration, edge and screw dislocations, Burgers vector and the dislocation loop, stress field and energy of dislocation, Dislocation multiplication.

Strengthening Mechanisms: Grain Boundaries and deformation, strengthening from grain boundaries, Yield Point Phenomenon, Strain Ageing, Solid Solution strengthening, Strengthening from fine particles, fiber strengthening, strengthening due to point defects, Martensite strengthening etc.

Fracture: Types of Fracture, Griffith Theory, Metallographic aspects of fracture, Fractography, Ductile Fracture, Notch Effects, Ductile to Brittle Transition.

Mechanical Testing: Tension test, Hardness tests, Torsion test, Impact Test, Creep & Fatigue Testing.

Iron Carbon Diagram: Allotropic forms of carbon, solid and liquid state reactions, types of steels, types of cast irons, microstructures at various carbon percentages, properties as a function of microstructures, significance of IC diagram. Cooling curves and equilibrium diagrams for brass and aluminum alloys.

TTT Diagrams: Time temperature transformations diagram, transformations as a function of cooling rate, mechanism of various transformations, and significance of TTT diagram.

Heat Treatment Methods: Mechanism of annealing and advantages, mechanism of normalizing and advantages, mechanisms of tempering and advantages, mechanism of hardening and advantages, mechanism of case hardening and advantages, mechanism of induction hardening and advantages.

Chemical Heat Treatment Methods: Introduction to chemical heat treatment, mechanism and methods of carburizing, nitriding, cyaniding, introduction to flame hardening.

Hardenability: Meaning of hardenability, tests of hardenability, factors affecting hardenability

Effect Of Alloying Elements: Effect on strength and hardness, effect on hardenability, effect on transformation temperature.

Books Recommended

1. Lakhtin Yu, "*Engineering Physical Metallurgy & Heat Treatment*", Mir Publishers (1990).
2. Dieter E G, *"Mechanical Metallurgy*", McGraw Hill Book Company (1988).
3. Shackelford F J, Murlidhara K M, "*Introduction to Materials Science for Engineers*", Pearson Education (2007).
4. Askerland RD, Phule P, " *The Science & Engineering of Materials*", Thomson Education (2006).
5. Van Vlack L.H, *"Elements of Material Science and Engineering",* Addison Wasley Publishers (1989).
6. Smith W F, *"Principles of Material Science and Engineering",* McGraw Hill, New York (1993).

			L	T	P	Credit
MAX-201	**Mathematics-II**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Mathematics-I (MAX-101)
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To understand the theory of matrices for solving linear system of algebraic equations, eigen value problems and its application to system of ordinary differential equations.
CO 2	To attain knowledge of the concepts of partial differentiation, maxima and minima, power series expansion of function of several variables.
CO 3	To understand and apply the knowledge of double and triple integrals for evaluation of area, surface area and volume.
CO 4	To analyse the physical interpretation of gradient, divergence and curl of various scalar and vector fields.
CO 5	To understand the basics of vector integration and theorems related to line, surface and volume integrals.
CO 6	To solve linear, non-linear, homogeneous, non-homogeneous partial differential equations which arise in many branches of science and engineering.

Detailed Syllabus:

Linear dependence of vectors and rank of matrices, linear transformations and inverse of matrices, reduction to normal form, bilinear form and quadratic form, consistency and solution of linear algebraic system of equations, Eigen values, Eigen vectors and their applications to system of ordinary differential equations, Cayley Hamilton theorem, orthogonal, unitary, hermitian and similar matrices.

Differential calculus of functions of several variables, partial differentiations, homogeneous functions and Euler's theorem, Taylor's and Maclaurin's Taylor's theorem for functions of two variables, maxima and minima of functions of several variables, Lagrange's method of multipliers.

Double and triple integrals, change of order of integration, change of variables, applications to evaluation of area, surface area and volume.

Scalar and vector fields; differentiation of vectors, velocity and acceleration, vector differential operators, Del, Gradient, Divergence and Curl and their physical interpretations, formulae involving these operators, line, surface and volume integrals, solenoidal and in irritation vectors, Greens theorem, Gauss divergence theorem, stoke's theorem and their applications.

Formulation and classification of partial differential equations, solution of first order linear equations, standard forms of non-linear equations, Charpit's method, and linear equations with constant coefficient, non-homogeneous linear equations, Monge's method for non-homogenous equations of second order separation of variables method for solution of heat, wave and Laplace equations.

Book Recommended:

1. E Kreyszig, “Advanced Engineering Mathematics”, 8th Ed., John Vilwy, Singapore (2001).
2. R K Jain and S R K lyengar, “Advanced Engineering Mathematics” 2nd Ed, Narosa Publishing House, Ndew Delhi.
3. I A N Sneddon, “Elements of Partial Differential Equations” Tata McGraw Hil, Delhi (1974).
4. B S Grewal, “Higher Engineering Mathematics”. Thirty-fifth edition, Khanna Publishers, Delhi.

			L	T	P	Credit
MEX-211	**Material Characterization Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Performing basic characterization of mechanical and morphological properties of materials.
CO 2	Tests for the investigation of the nature, microstructure of materials, grain structure by using metallurgical microscope of different material under different heat treatment conditions.
CO 3	An integrated understanding of the scientific and engineering principles of Metallurgical and Materials Engineering.
CO 4	To analyse the experimental data and interpretation of the results with relation to the properties of the investigated materials under different testing conditions like tensile, compression, bending, Impact etc.

Detailed Syllabus:

1. Determination of Young's modulus, tensile, strength and percentage elongation for steel, aluminum, brass and cast iron specimens on universal testing machine. Also plot the stress strain diagram.
2. To perform the compression test for cast iron specimen on universal testing machine.
3. To determine the deflection for mild steel specimen and verify the beam formula for specimen in bending.
4. To determine the stiffness of the following:
(i) Cantilever beam (ii) Spring under compressive and tensile loading.
5. To measure the total energy absorbed in fracturing of the ductile specimen on Charpy and Izod setup, Cryogenic temperature testing and demonstration of Ductile to Brittle Transition temperature.
6. To plot and study the S-N curve for steel, aluminum and fibre reinforced composite material at 25%, 50%, 60% and 75% of ultimate tensile strength of the specimen.
7. Preparation of specimen for hardness test & testing of prepared specimens for Brinell hardness, Rockwell hardness & Vickers Hardness.
8. To study the behaviour of steel and aluminum specimen under torsion.
9. Analyzing the microstructure of steel and cast iron using Metallurgical Microscope.
10. Determining the grain size of the given specimen using Metallurgical Microscope.
11. Hardening of ferrous specimen by quenching in oil bath & Analyzing the microstructure using Metallurgical Microscope.
12. Annealing of ferrous specimen by slow cooling in the furnace & Analyzing the microstructure using Metallurgical Microscope.

			L	T	P	Credit
MAX-202	**Mathematics-III**	**Core Course**	**3**	**0**	**0**	**4**

Pre-requisites: Mathematics-II (MAX-102).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	In analysing of real to complex numbers and apply them whenever the problem arises in real analysis and calculus.
CO 2	To understand path and contour integrals.
CO 3	To apply different theorems of integral formulae.
CO 4	To evaluate some standard integrals using contour integrals.
CO 5	To evaluate the real integrals using special functions.
CO 6	To know the complex variable techniques and knowledge of mapping and transforms play a major role in several areas of engineering.

Detailed Syllabus:

Limit and derivation of a complex function, analytic, functions and Cauchy Riemann equations, line integral of elementary functions, Cauchy's integral theorem, Cauchy's Integral formula and derivatives of analytic functions, Taylor and Laurent series, zeros and singularities, residues and residue theorem, evaluation of real improper integrals, conformal mapping, linear fractional transformations and mapping by elementary functions.

Series solution of differential equations, Bessel's differential equation and Bessel functions and their properties, differential equations reducible to Bessel's differential equations, Legendre's differential equation, Legendre's polynomials and their properties, Fourier-Legendre expansion of a functions.

Fundamental concepts of calculus of variations, functional involving several independent functions, one end fixed and other end free problems, both end free problems, constrained extreme.

Book Recommended:

1. B S Grewal, "Higher Engineering Mathematics". Thirty-fifth editions, Khanna Publsihers, Delhi.
2. L E Elsgole, "Calculus of Variations", Addison-Wisley Publishing Company.
3. J B Conway, "Functions of One Complex Variables", Narosa Pblishing House, 1980.

			L	T	P	Credit
MEX-202	**Applied Thermodynamics-II**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Applied Thermodynamics-I (MEX-207)

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Apply mass, momentum, energy and entropy balances to compressible flow and use compressible flow tables and relations to solve problems involving compressible flow in a nozzle and diffuser.
CO 2	Apply the principles of thermodynamics to evaluate the performance of Rotary, Centrifugal and Axial Air compressors,
CO 3	Design the blading, study the velocity triangles and estimate the performance of centrifugal and axial flow compressors.
CO 4	Understand the ideal and real thermodynamic cycles of air-breathing engines and Industrial gas turbines Gas Turbines incorporating intercooling, reheat, regeneration, afterburning, etc.

Detailed Syllabus:

Introduction: Stagnation properties, sonic velocity and Mach number, Mach waves, Flow through Nozzles and diffusers ,Metastable state and super saturated flow, thrust function. Flow through variable area, isentropic flow, adiabatic flow with friction; Flow through constant area with friction (Fanno Flow), Frictionless Flow through a constant area duct with heat transfer (Rayleigh Flow), Isothermal flow through a constant area duct, normal shock waves, Rankine Hugoniot equation, Strength of shock waves, application of gamma function to specific flow process.

Rotary Compressors: Classification of rotary compressors, comparison with reciprocating compressors, working of rotary compressors like Roots blower, Lysholm Compressor and Vanetype Blower. Determination of total work done for compressors, energy loss in internal friction. Isentropic, polytropic and isothermal efficiencies of compressor.

Centrifugal Compressors: Thermodynamic analysis of centrifugal compressor: Stage, polytropic, isentropic and isothermal efficiencies, velocity vector diagrams for centrifugal compressors, power calculation, , pre-guided vanes,pre-whirl, Slip factor, power input factor. Modes of energy transfer in impeller and diffuser. Degree of reaction and its derivation, energy transfer in backward, forward and radial vanes, Derivation of Non-dimensional parameters for plotting compressor characteristics, surging and choking in centrifugal compressors. Various losses occurring in centrifugal compressors and application of centrifugal compressors.

Axial Flow Compressor: Components of axial flow compressor, aerofoil blading, angle of attack, coefficients of lift and drag, turbine versus compressor blades, velocity vector diagrams, thermodynamic analysis and power calculations. Modes of energy transfer in rotor and stator blade flow passages. Work done factor, Degree of reaction and Blade efficiency, Isentropic polytropic and Isothermal Efficiencies. Surging, choking and stalling in axial flow compressors, characteristic curves for axial flow compressor, flow parameters of axial flow compressor pressure coefficient, flow coefficient, work coefficient and temperature rise coefficient ,specific speed etc. Comparison of axial flow compressor with centrifugal compressor and reaction turbine. Application of axial flow compressors.

Gas Turbines: Classification, Open and closed cycle and their comparison. Application of gas turbine. Position of gas turbine in power industry. Thermodynamic analysis-Brayton cycle, calculation of net output, work ratio, and thermal efficiency , Operating variables and

their effects on thermal efficiency and work ratio. Gas turbine cycle with regeneration, intercooling, multistage compression and expansion. Closed and semi closed gas turbine cycle, requirements of a gas turbine combustion chamber, types of combustion chambers, Pressure losses in heat exchangers and combustion chambers. Gas turbine fuels.

Jet Propulsion : Principle of jet propulsion, Performance characteristics of different propulsion systems, Application of various propulsion systems.

Books Recommended

1. Shepherd D G, *"An Introduction to Gas Turbine",* Von Nastrand, New York (1949).
2. Stodola A, *"Steam and Gas Turbines"*, McGraw Hill Book Company, (1970).
3. Shapiro A M, *"Dynamics and Thermodynamics of Compressible Fluids"*, Ronald's Press, New York (1953).
4. Benson R W, *"Advanced Engineering Thermodynamics"*, Pergamon Press, London (1975).
5. Cohen H, Rogers G F C and Saravanamuttoo H I H, *"Gas Turbine Theory",* Orient Longman Limited, New Delhi (1996).

			L	T	P	Credit
MEX-204	**Dynamics of Machines**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Theory of Machines (MEX-203).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Able to do static and dynamic force analysis on different mechanism.
CO 2	Able to demonstrate the torque analysis on any kind of fly wheel i.e., either on engine fly wheel or machine fly wheel.
CO 3	Understand and avoid/suppress certain common dynamical problems a machinery may undergo.
CO 4	Understand the fundamentals of machine design for desired kinematic or dynamic performance.
CO 5	Understand the fundamentals of mechanical vibrations.

Detailed Syllabus:

Brakes and Dynamometers: Types of brakes, principle and function of various types of brakes, problems to determine braking capacity, different types of dynamometers.
Static Force Analysis: Static equilibrium, equilibrium of two-force and three-force members, members with two forces and a torque, free body diagram, principle of virtual work, friction in mechanisms.
Dynamic Force Analysis: D' Alembert Principle, dynamic analysis of four-link mechanisms and slider-crank mechanisms, analytical and graphical method, velocity and acceleration of piston, angular velocity and angular acceleration of connecting rod, piston and crank effort, inertia of connecting rod, inertia force in reciprocating parts.
Balancing: Static and dynamic balancing, balancing of several masses in different planes, Balancing of reciprocating masses, balancing of locomotive, partial balancing, direct and reverse crank method, balancing of inline engines and V-Engines, balancing machines.
Lower Pairs: Pantograph, straight line mechanisms, engine indicators, automobile steering gears, Hooke's joint and Double Hooke's joint.
Gyroscope: Effect of gyroscopic couple on supporting and holding structures of machines. Gyroscopic effect on naval and air ships and automobiles.
Flywheels: Turning moment diagram for steam engine and four-stroke internal combustion engine and for multicylinder engines, fluctuation of energy and speed in flywheels, size of flywheel and flywheel for punching press.

Books Recommended

1. Bevan T, *"The Theory of Machines",* 3rd Edition CBS Publishers and Distributors (2002).
2. Shigley J E and Vickar J J, *"Theory of Machines and Mechanism",* 2nd Edition, McGraw Hill, New Delhi (1995).
3. Wilson C and Sadler J, *"Kinematics and Dynamics of Machine",* 3rd Edition, Prentice Hall (2002).
4. Ratan S S, *"Theory of Machines",* 1st Edition, Tata McGraw Hill, New Delhi (1993).
5. Rao J S and Dukkipati R V, *"Mechanism and Machine Theory",* 2nd Edition, New Age International (P) Limited, Delhi (1992).

			L	T	P	Credit
MEX-206	**Mechanics of Deformable Bodies**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Strength of Materials (MEX-201).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	3-D stress analysis: Analytical and graphical methods (Mohr's circle) understanding and problem solving.
CO 2	Basic concept of strain energy for 2-D and 3-D state of stress.
CO 3	Theories of Failure: Ability solve problem related to maximum stress, maximum strain, and strain energy theory of failure.
CO 4	Thick Cylinders and Bending of curved beams: Basic concept of design of thick cylinders and bending of curved beams and problem solving.
CO 5	Springs: Analysis of closed and open coiled helical, flat spiral, and leaf springs. Problem solving related to mentioned topics.
CO 6	Indeterminate systems: Basic concept of indeterminate structures and problem solving.
CO 7	Distribution of shear stress in beams: Derivation of general formula and its application to rectangular, triangular, I, C, T, L, circular and hollow sections and problem solving.

Detailed Syllabus:

Strain energy: Energy of dilation and distortion, resilience stress due to suddenly applied loads, Castigliano's theorem, Maxwell's theorem of reciprocal deflection.
Theories of Failure: Maximum principal stress theory, maximum shear stress theory, maximum strain energy theory, maximum shear strain energy theory, graphical representation and derivation of equation for each and their application to problems relating to two dimensional stress systems only.
Distribution of Shear Stress in Beams: Derivation of general formula and its application to rectangular, triangular, I, C, T, L, circular and hollow sections.
Springs: Closed and open coiled helical springs: Derivation of formula and application for deflection and rotation of free end under the action of axial load and or axial couple; flat spiral springs – derivation of formula for strain energy, maximum stress and rotation. Leaf spring, deflection and bending stresses
Thick Cylinders: Derivation of Lame's equations, calculation of radial longitudinal and hoop stresses and strains due to internal pressure in thick cylinders, compound cylinders, hub shrunk on solid shafts.
Bending of curved beams: Calculation of stresses in crane or chain hooks, rings of circular section and trapezoidal section and chain links with straight sides, Deflection of curved bars and rings.
Statically Indeterminant Systems: Force Method, Displacement method, Method of superposition and Analysis by differential equation of the deflection curve.
Unsymmetrical bending: Shear center for angle, channel and Z sections.
Rotational stresses: Discs and rims, discs of uniform strength.
3 D stress analysis: Analytical and graphical methods (Mohr's circle).

Books Recommended
1. Timoshenko, S P, James M and Gere, *"Mechanics of Materials",* 2nd Edition, CBS

Publishers, New Delhi (1998).
2. Boresi A P, Schmidt R J and Sidebottom O M, *"Advanced Mechanics of Materials",* John Wiley and sons Inc, New York (1993).
3. Ryder GH, *"Strength of Materials",* 3rd Edition English Language Book Society / Macmillan Hongkong (2002).
4. Hibbeler, Russel C, *"Mechanics of Materials",* 4th Edition, Prentice Hall (2000).
5. Dieter G.E. *"Mechanical Metallurgy",* McGraw Hill, New York (1996).

			L	T	P	Credit
MEX-208	**Production Processes**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Manufacturing Process (INX-101).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Analyze and calculate forging loads using slab model plane rolling, extrusion and wire drawing and sheet metal forming processes.
CO 2	Suggesting the simplified manufacturing processes with the aim of cost reduction and material wastage.
CO 3	Selecting the appropriate methods and tooling for typical applications in the industries to produce critical design components.
CO 4	Ability to clear the fundamental concepts of powder metallurgy, casting, welding, forming and the advance manufacturing processes.

Detailed Syllabus:

Attributes of Manufactured Products: Mechanical properties, physical properties, chemical properties, geometric attributes, material selection.
Machining and Machine Tools: Elements of machining, classification of machine tools, concept of orthogonal metal cutting.
Metal Casting: Casting alloys, solidification of metals, melting and pouring, casting processes, finishing processes, designs for casting.
Welding Processes: Survey of welding processes. Weldability of Steels, Cast irons, aluminium and Copper alloys, Joint Design and specifications, Inspection of welds.
Forming Processes: Rolling, Drawing, Extrusion, Forging, Press working and die design and High Velocity Rate Forming.
Powder metallurgy: Process details, component and die design considerations.
Processing of Plastics: Introduction and types of plastics, Properties of plastics, Materials required for processing plastics, Forming and Shaping of plastics, Comparison of plastic forming processes.
Jigs and Fixtures: Introduction, Production Devices, Advantages of Jigs and Fixtures, Elements of Jigs and Fixtures, Principles of Location and Clamping.
Process Planning: Definitions of process planning, contents of process planning, process operations, steps of process planning.

Books Recommended

1. Schey A J, *"Introduction to Manufacturing Processes",* McGraw Hill Book Company, New York (1987).
2. Sharma P C, " *Production Technology*", S Chand & Co, (2003).
3. DeGarmo E Paul, "*Materials & Processes in Manufacturing*" , Wiley, 9th Edition.
4. Parmar R S, "*Welding Processes & Technology*", Dhanpat Rai Publishers.
5. Juneja B L, "*Fundamentals of Metal Cutting & Machine Tools*", New Age International (1998).

			L	T	P	Credit
MEX-210	**Production Processes Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will be conversant with the software's like Auto Cad, Solid Works etc.
CO 2	To be able to understand the application of the different joining techniques, and be able to select an appropriate technique according to a specific requirement.
CO 3	Students should be able to analyze the effect of various welding process parameters on the bead geometry.
CO 4	Students should be able to design gating and risering system for a given casting.
CO 5	Students should be able to understand AFM, EDM machining process.
CO 6	To understand the different wear mechanisms, how they occur, and how to analyse &interpret wear-related problems of tools.

Detailed Syllabus:

A small project covering the various aspects of Engineering from Design to Fabrication comprising of the following:

(i) Preparation of Engineering Drawing on any CAD software – Weightage 20%.

(ii) Preparation of Bill of materials along with cost estimate (from market)- Weightage 10%.

(iii) Process Planning with details of Machines and tools required - Weightage 20%.

(iv) Completion of Project- Weightage 50%.

NOTE: Group size of minimum 2 students and maximum 3 students shall be used.

			L	T	P	Credit
MEX-212	**Fluid Mechanics-I**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To make the student understand the utility of studying the course of Fluid Mechanics in understanding the physical phenomenon involving fluids either at rest or in motion.
CO 2	To enable the students understand the theoretical aspect of solving different physical problems involving fluids at rest or in motion.
CO 3	To discuss with the students different modeling techniques for writing the mathematics (e.g., differential and integral formulations) for fluid mechanics problems.
CO 4	To make students understand about the different techniques used for analyzing the theoretical, flow visualization and experimental solutions of problems pertaining to fluid mechanics.
CO 5	To make students understand key contributions by various scientists for development of theoretical understanding of major issues related to fluid mechanics physics.
CO 6	To discuss with the students some bench mark analytical solutions available for fluid mechanics and problems and general procedure for solving theoretical models equations and limitations of analytical solution techniques.

Detailed Syllabus:

Introduction

The Concept of a Fluid, The Fluid as a Continuum, Dimensions and Units, Properties of the Velocity Field Thermodynamic Properties of a Fluid, Viscosity and other Secondary Properties, Basic Flow-Analysis Techniques

Fluid Statics

Hydrostatic Pressure Distributions, Application to Manometry, Hydrostatic Forces on Plane Surfaces, Hydrostatic Forces on Curved Surfaces, Hydrostatic Forces in Layered Fluids, Buoyancy and Stability, Pressure Distribution in Rigid-Body Motion

Fluid Kinematics

The Acceleration Field of a Fluid, The Differential Equation of Mass Conservation, The Differential Equation of Linear Momentum, The Differential Equation of Angular Momentum, The Differential Equation of Energy, Boundary Conditions for the Basic Equations, The Stream Function, Vorticity and Irrotationality, Frictionless Irrotational Flows. **Flow Patterns**: Streamlines, Streaklines, and Pathlines, the Engineering Equation Solver, Uncertainty of Experimental Data, the Fundamentals of Engineering (FE) Examination, Problem-Solving Techniques, History and Scope of Fluid Mechanics Basic Physical Laws of Fluid Mechanics, the Reynolds Transport Theorem, Conservation of Mass, the Linear Momentum Equation, the Angular-Momentum Theorem, the Energy Equation, Frictionless Flow: The Bernoulli Equation,

Dimensional Analysis and Similarity: Dimension, Units, dimension reasoning, dimensional quantities, construction of relationship by dimensional analysis using the indicial methods, dimensional analysis by group methods, significant of dimensionless numbers, Geometric similarity, Dynamic similarity, similarity applied to rotodynamic machines.

Viscous Flow: Navier-Stokes equation of motion, relationship between shear stress and pressure gradient, two-dimensional laminar flow between two fixed parallel planes and pipe flow, plain Couette flow and its application to hydro-dynamic theory of lubrication, Flow in Noncircular Ducts, Minor Losses in Pipe Systems, Multiple-Pipe Systems, Experimental Duct Flows: Diffuser Performance , Fluid Meters.

Turbulence and Turbulent through pipes: Growth of instability and transition from laminar to turbulent flow, turbulent velocity profile for flow through pipes, Flow losses in pipes, Darcy equation for head loss due to friction.

Flow Around Immersed Bodies: Concept of friction, pressure, wave and induced drag- lift and drag coefficients; variation of drag coefficient with Reynolds number for two dimensional bodies (flat plate, circular cylinder); Vortex shedding from cylindrical bodies, effect of streamlining; drag coefficient versus Reynolds number for flow past axisymmetric bodies (sphere); Terminal velocity, lift of an airfoil, airfoil of finite length-effect on drag and lift, downwash and induced drag.

Books Recommended

1. Douglas J F, Gasionckw, and Swaffield J P, *"Fluid Mechanics",* 3rd Edition Addision Wesley Longman, Inc Pitman (1999).
2. Pao H F Richard, *"Fluid Mechanics",* John Wiley and Sons (1995).
3. Kumar D S, *"Fluid Mechanics and Fluid Power Engineering",* 6th Edition SK Kataria and Sons, Delhi (1998).
4. Fay J A, *"Introduction to Fluid Mechanics",* Prentice Hall of India Private Limited, New Delhi (1996).
5. Bansal R K, *"A text book of Fluid mechanics and Hydraulic Machines",* 8th Edition, Laxmi Publications (P) Ltd. New Delhi (2002).
6. Yunus Cengel& John Cimbala,"Fluid Mechanics: Fundamentals and Applications", 2nd reprint 2007, Tata McGraw Hill, New Delhi.
7. F M White, "Fluid Mechanics", 6th ed., McGraw Hill, New York.
8. Som & Biswas, Fluid Mechanics, Tata-McGraw Hill, New York.

			L	T	P	Credit
MEX-301	**Design of Machine Elements**	**Core Course**	**3**	**0**	**2**	**4**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Analysis of Selection of materials for different mechanical component.
CO 2	Use the knowledge of other subject like mathematics, science and material science for designing purpose.
CO 3	Design the individual component for the mechanical system.
CO 4	Practical approach for designing and analysis of component of machine.

Detailed Syllabus:

Scope and meaning of Design with special reference to machine Design, Design process.

Various considerations required for design of a component: Concept of tearing, bearing, shearing, crushing, bending etc. Selection of materials, mechanical behavior of materials, Stress concentration, factor of safety under different loading conditions, design stresses for variable and repeated loads, endurance limit, fatigue strength, Basic Principles of fatigue fracture, mechanism of fatigue, stress cycles, S-N curve, effect of mean stress on fatigue, cyclic stress-strain curve, Introduction to fracture and fracture mechanisms, Fits, tolerances and surface finish.

Fasteners and joints: Screws and screw jack, bolts, preloaded bolts subjected to shear, and torsion. Bolted, Welded and Riveted joints, eccentrically loaded welded and riveted joints, Cotter and cotter joints, pin fasteners, Knuckle joints.

Transmission shafts: Design of shaft subjected to static loading: pure torsion, simple bending, combined bending and torsion, combined bending torsion and axial loads. Design of shaft for fluctuating loads.

Keys: Different types of keys and splines, representations and use in Couplings.

Rigid couplings: Sleeve couplings, Flange couplings, Flexible couplings: Bush pin type, Universal type.

Levers: Hand and foot levers, cranked lever.

Gaskets, seals, Pipe joints: Oval, circular and square pipe joints.

Brakes and Clutches: Brakes: Design consideration of brakes, Flat plate, and conical plate clutches.

Books Recommended

1. Norton L R, *"Machine Design an Integrated Approach",* Pearson Education Asia, Ist Indian Reprint (2001).

2. Sharma P C and Aggrawal D K, *"A text book on Machine Design",* S K Kataria & sons, 9th Edition (2000).

3. Bhonsle R S and Weinmann J K, *"Mathematical modeling for Design of Machine Components",* TK Integrated, Prentice Hall (1999).

4. Spotts M F and Shoup T E, *"Design of Machine Elements",* Prentice Hall Seventh Edition (1998).

5. Shigley J E and Mischke C R, *"Mechanical Engineering Design",* Tata Mcgraw Hill, New Delhi (2003).

6. Bhandari V. B., "Design of Machine Elements", Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2nd edition (2007)

			L	T	P	Credit
MEX-303	**Heat Transfer**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To enable the students to understand the physics of different modes of heat transfer and importance of the subject of heat transfer in day to day life and in engineering applications.
CO 2	To enable the students to take up different problems related to heat transfer and write the corresponding mathematical models for them.
CO 3	To make students appreciate that the theoretical solutions are convenient ways to solve physical problems and also aware the students about the limitations of the theoretical solutions.
CO 4	To develop a competence in the students to solve heat transfer problems analytically by incorporating appropriate approximations in the complex models.
CO 5	To make the students understand the importance information of fluid mechanics in solving the coupled problems involving fluid flow and heat transfer.
CO 6	To make the students understand the importance of studying the course of mathematics in solving complex engineering problems theoretically with special reference to the problems on heat transfer in various modes.

Detailed Syllabus:

Introduction: Concept of heat transfer, Difference between the subject of "Heat Transfer" and its parent subject "Thermodynamics". Different modes of heat transfer: conduction, convection and radiation.

Conduction: Fourier's law of heat conduction, coefficient of thermal conductivity, effect of temperature and pressure on thermal conductivity of solids, liquids and gases and its measurement. Three- dimensional general heat conduction equation in rectangular, cylindrical and spherical coordinates. Derivation of equations for simple one dimensional steady state heat conduction from three dimensional equations for heat conduction though walls, cylinders and spherical shells (simple and composite), electrical analogy of the heat transfer Equivalent areas, shape factor, conduction through edges and corners of walls and critical thickness of insulation layers on electric wires and pipes carrying hot fluids. Internal generation cases along with some practical cases of heat conduction like heat transfer through underground electrical cables, simple model of heat conduction through piston crown and case of nuclear fuel rod with cladding. Influence of variable thermal conductivity on conduction. Introduction to unsteady heat transfer, Newtonian heating and cooling of solids; thermal diffusivity.

Theory of Fins: Straight rod type fins of uniform cross-section;. Straight fins with varying crosssectional area and having triangular or trapezoidal profile area, circumferential fin of rectangular cross-section provided on the circumference of a cylinder. Optimum design of straight fin of rectangular and triangular cross-sections; fin effectiveness and fin efficiency. Application of fins in temperature measurement of flow through pipes and determination of error in its measurement.

Convection: Free and forced convection, derivation of three dimensional mass, momentum and energy conservation equations (with introduction to Tensor notations). Boundary layer formation, laminar and turbulent boundary layers (simple explanation only and no derivation). Theory of dimensional analysis as applied to free and forced convective heat transfer. Analytical formula for heat transfer in laminar and turbulent flow, flow over vertical and horizontal tubes and plates. Newton's law of cooling. Overall coefficient of heat transfer. Different design criterion for heat exchangers. Log mean temperature difference for evaporator and condenser tubes, parallel and counter flow heat exchangers. Calculation of number and length of tubes in a heat exchanger.

Convection with Phase Change: (Boiling and Condensation) Pool boiling, forced convection boiling, heat transfer during pool boiling of a liquid. Nucleation and different theories of nucleation, different theories accounting for the increased values of heat transfer coefficient during nucleate phase of boiling of liquids; different phases of flow boling (theory only).

Radiation: Process of heat flow, definition of emissivity, absorptivity, reflectivity and transmissivity. Concept of black and grey bodies, Planck's law of monochromatic radiation. Kirchoff's law and Stefan Boltzman's law. Interchange factor. Lambert's Cosine law and the geometric factor. Intensity of Radiation, radiation density, irradiation, radiosity and radiation shields. Derivation of formula for radiation exchange between two bodies using the definition of radiosity and irradiation and its application to cases of radiation exchange between three or four bodies (e.g. boiler or other furnaces). Error in Temperature measurement by a thermocouple probe due to radiation losses.

Books Recommended

1. Holman J P, *"Heat Transfer",* McGraw Hill Book Company (1997).
2. McAdam W H, *"Heat Transmission"*, McGraw Hill Book Company, New York (1954).
3. Drake R M and Eckert E R G, *"Heat and Mass Transfer"*, McGraw Hill, Kogakusha (1972).
4. Kreith F, *"Principles of Heat Transfer"*, PWS Publishing Company, Boston (1997).
5. Rao Y V C, *"Heat Transfer"*, University Press, Hyderabad (2001).

			L	T	P	Credit
MEX-305	**I.C. Engines and Control**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Learn to classify different types of internal combustion engines and their applications, Demonstrate a basic understanding of engine function, performance, fuels for IC engines and design methodology.
CO 2	Analyze thermodynamic cycles for Otto, Diesel cycles, striling, Carnot and duel cycle, Given an engine design specification, predict performance and fuel economy trends with good accuracy.
CO 3	Determine and understand the effects of spark timing, valve timing, A/F ratio, engine geometry, fuel type, and manifold tuning on engine performance and emissions, Understanding of the performance and emission analysis of internal combustion engine and after treatment devices.

Detailed Syllabus:

Introduction to IC Engines: Heat Engine versus Internal combustion Engine, Historical development of IC Engines, Classification and Nomenclature, Applications of IC Engines. Review of Air standard cycles: Carnot, Sterling, Ericsson, Otto, Diesel and Dual Cycle etc.
Working of IC Engines: Working of 4 stroke SI and CI Engines and their valve timing diagram, working of 2-stroke SI and CI engines and their valve timing diagrams, Comparison of two stroke and four stroke Engines, Fuel Air Cycles and their analysis: Composition of cylinder gases, variable specific heats, Dissociation, Effect of number of moles, Air standard versus fuel air cycles, Effect of operating variables like compression ratio, fuel air ratio. Actual engine cycles and losses: Comparison between Actual, Fuel- Air cycle, Air standard cycles for S.I. and C.I engines.
IC Engine Fuels: Requirements of fuel in I C engines, Type of Fuels- Solid, Liquid and Gaseous fuels, Chemical structure of petroleum, petroleum refining process, Important qualities of SI and CI engine fuels and their ratings. Combustion of Fuels: Heating values of Fuels, Theoretical determination of heat of reactions of fuel, Combustion equation for Hydrocarbon fuels, Determination of minimum air required for combustion, conversion of volumetric analysis to mass analysis, Determination of air supplied from volumetric analysis of Dry flue gases, Determination of excess air supplied, Determination of percentage of carbon from exhaust gas composition.
Mixture Preparation Systems: Fuel supply system and fuel pumps, Simple carburetor and its working, approximate analysis of single jet carburetor, Actual Air fuel calculation of single jet
carburetor, Ideal requirements from an ideal carburetor, limitations of single jet carburetor, Different devices used to meet the requirements of an ideal carburetor, Different modern carburetors, Petrol injection. Fuel Injection systems for CI Engines: Classification of Injection Systems, Injection Pump, Fuel Injector, Nozzle, and Injection in SI Engines.
Combustion in SI Engine: Stages of Combustion in S I Engine, flame front propagation, factors influencing the flame speed, ignition lag and factors affecting the ignition lag, Abnormal combustion and knocking, control and measurement of knock, Anti knock agents, combustion chambers of S I engines.

Combustion in CI Engines: Stages of combustion, Delay period, factors affecting delay period; detonation and factors affecting detonation; comparison of abnormal combustion in SI & CI engine, rating of IC engine fuels, combustion chambers for IC engines.

Supercharging: Purpose of supercharging, types of superchargers. Analysis of superchargers. Arrangement of supercharger and its installation, turbo charged engines, supercharging of SI & CI engines, limitations of supercharging.

Measurement and Testing: Measurement of Friction Power, Brake Power, indicated Power, Measurement of Speed, Air consumption, fuel consumption, heat Balance Sheet for engine, governing of IC Engines. Performance Characteristics of IC Engines: Performance parameters, performance of SI engines, performance of C.I. engines, Engine performance maps.

Emission and Control.Emission of various pollutants from the engine, kinetics of NOx formation,NO formation in S.I.engines, NOx formation in C.I.engines, Emission of carbon monoxide, HC emission in S.I.engine and hydrocarbon emission in C.I engine, particulate emissions in S I engine ,characteristics of diesel particulates, Soot formation fundamentals, Exhaust gas treatment: Catalytic convertors, Thermal reactors, Particulate traps.

Books Recommended

1. Heywood J B, *"Internal Combustion Engine Fundamentals"*, McGraw Hill, Publication, New Delhi (1988).
2. Taylor C F, *"The Internal Combustion in Theory land Practice"*, Volume I and II, MIT Press, Cambridge, Mass (1968).
3. PulkRabek W W, *"Engineering Fundamentals of Internal Combustion Engine",* Pearson Education, New Delhi (2003).
4. Stone R, *"Introduction to Internal Combustion Engines"*, 2nd Edition, Macmillan (1993).
5. Milton B E*, "Thermodynamics, Combustion and Engines"*, Champman and Hall (1995).

			L	T	P	Credit
MEX-307	**Mechanical Measurement & Metrology**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None.
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will be able to understand the operating principles of a range of widely used instrumentation techniques and will know how to use them in the design of measurement systems.
CO 2	To familiar with various standards and calibration methods used in industry.
CO 3	To be familiar with different sensors and transducers and to conceptualize the suitable measurement technique.
CO 4	Use basic statistical methods to aid data evaluation and decision making.
CO 5	Understand the formal metrology concepts in designing and using measurement systems.

Detailed Syllabus:

General Concept: Need and classification of measurements and instruments, Standards, Calibration, basic and auxiliary functional, elements of a measurement system, mechanical versus electrical/electronic instruments, primary, secondary and working standards.
Static and Dynamic Characteristics of Instruments: Range and span, accuracy and precision, Calibration, hysterics and dead zone, sensitivity and linearity, threshold and resolution, speed of response, lag, fidelity, and dynamic errors, dead time and dead zone. Sources of errors in measurements, Basic concepts of measurement methods, Processing of experimental data, curve fitting. regression analysis and Uncertainty analysis.
Functional Elements: Review of electro-mechanical sensors and transducers-variables resistance, inductance and capacitive pick-ups, resistance strain-gauges, gauge-factor, boned and unbounded strain gauges, surface preparation and Bonding Techniques, application of strain-gauges for direct, bending and torsional loads, hydraulic and pneumatic load cells.
Temperature Measurement: Bimetallic thermometers, liquid-in-glass thermometers and filledin-system Thermometers, thermocouples, metal resistance thermometers and thermistors.
Pressure and Flow Measurement: Bourdan Tube, Vacuum Measurement-Mcleod Guage, Thermal Conductivity gauge and Ionization gauge. Electromagnetic flux-meters, Ultrasonic Flow meters and Hot Wire anemometers.
Force, Torque and Power Measurement: Vibration Reed tachometer, Stroboscope, Proving Ring, Mechanical and Hydraulic Load cell, Torque on rotating shafts, Absorption, transmission and driving dynamometers.
Data Sampling and Data Acquisition: Sampling concepts, Data Acquisition systems and its components
Metrology: linear Measurements-Vernier caliper and vernier height gauge. Angular Measurements: Sine bar, clinometers, angle gauges, vernier bevel protector, Comparators: Their types, relative merits and limitations, use of comparators, construction of Mechanical, electrical & optical comparators, Measurement of tooth thickness, pitch and checking of profile for spur gears, Measurement of major diameter, minor diameter, effective diameter pitch, angle of screw thread.

Books Recommended

1. Holman J P, *"Experimental Methods for Engineers"*, 6th Edition, McGraw Hill Inc (1994).
2. Doeblin E O, *"Measurement System Application and Design"*, 5th Edition, Mcgraw Hill, Singapore (2004).
3. Beckwith T G, Marangoni R D and Lienhard J H, *"Mechanical Measurements"*, 5th Edition, Pearson Education India, (1993).
4. Jain R K, *"Engineering Metrology"*, 3rd Edition Khanna Publishers, Delhi (1998).
5. Figloila RS and Beasley D E, *"Theory and Design for Mechanical Measurements"*, 2nd Edition, John Wiley and Sons Inc, New York (1995).

			L	T	P	Credit
MEX-309	**Mechatronics**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None..

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Understanding of the Mechatronics approach; Binary arithmetic and Boolean Logic; Formulate automation problems based on Boolean Logic; Design, simplify and optimize circuits for automation problems.
CO 2	Ability to develop Mechatronic products for automation in industry conceptually.
CO 3	Understand and apply concepts of Digital and Analog domains; Design mechatronic devices based on Digital input, Digital output, Digital to Analog and Analog to Digital.
CO 4	Mini project work based on 8-bit microcontrollers with a view to develop ability of self learning, working in a team.
CO 5	Understand and apply detailed concepts relating to actuators, sensors, and their integration with drives and signal conditioning.
CO 6	Develop ability and competence in modeling, simulation and control of Mechatronic systems in multi-energy domains.

Detailed Syllabus:

Introduction: Mechatronics: What and Why?

Essential electronics and Boolean algebra:

Digital representation: Binary, Decimal, Hexadecimal, Conversion from Binary to Decimal and vice-versa,

Binary arithmetic: Addition, Subtraction: 2's complement, Multiplication and Division, Boolean algebra: AND, OR, NOT, NAND, NOR, XOR logic, Truth table, Realization of logic in physical systems: switches-LEDs, cylinders. Fundamental identities, De Morgan's theorems and relationship with sets, Simplification.

Electronics fundamentals: Review of some semiconductor devices, Concepts of Digital and Analog systems, Digital output (DO) and input (DI), Using switches, transistors, pneumatic devices, etc. to realize DI & DO.

Operational Amplifier: Principles, Configurations: Inverting; Summing; Integrating and Differentiating configurations, Digital to Analog conversion (DAC), The R-2R and summing Op-Amp circuit, Analog to Digital conversion (ADC), Successive approximation method, Flash method, etc., Programs for DI, DO, DA and AD for PC based plug in cards.

Microprocessor, Computers and Embedded systems: Introduction to the 8085 (8-bit microprocessor) and microcontroller: Architecture, programming, I/O, Computer interfacing, Programmable logic controller basics.

Sensors and actuators: Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezo electric accelerometer, Hall effect sensor, Optical Encoder, Resolver, Inductosyn, Pneumatic and Hydraulic actuators, stepper motor, DC motor, AC motor.

Control Systems: Mathematical modeling of Physical systems, System equations, Controllability and Observability, Pole placement, PID controller, Control of Hydraulic, Pneumatic, Mechanical and Electrical Systems.

Integration and case studies: Integration of Mechatronics component subsystems into a complete Mechatronics system Applications to CNC machines and Robotics.

Recommended Books

1. David G. Alciatore, and Michael B. Histand, *"Introduction to Mechatronics and Measurement Systems",* 3rd Edition, Tata McGraw Hill Publishing Company Ltd., New Delhi (2007).
2. W.Bolton, *"Mechatronics",* 2nd Edition, Pearson Education Asia, New Delhi (2001).
3. Dan Necsulescu, *"Mechatronics",* Pearson Education Asia, New Delhi (2002).
4. N. P. Mahalik, *"Mechatronics",* Tata McGraw Hill Publishing Company Ltd., New Delhi (2003).
5. Wolfram Stadler, *"Analytical Robotics and Mechatronics",* McGraw-Hill Book Co., Singapore (1995).
6. Eronini Umez-Eronini, *"System Dynamics & Control",* Thomson Asia Pvt. Ltd., Singapore
(1999).
7. Shetty Devdas and Richard A Kolk, *"Mechatronics System Design",* Thomson Learning, Vikas Publishing House, New Delhi (2001).
8. IEEE Robotics & Automation Magazine, Special Issue on Mechatronics, June 2001.

			L	T	P	Credit
MEX-311	**Fluid Mechanics-II**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Fluid Mechanics-I (MEX-212)

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To enable the students to appreciate the happening in the nature due to fluid flow motions and their causes and effects.
CO 2	To enable the students to learn about the mathematical modeling techniques for fluid mechanics problems.
CO 3	To understand the phenomenon of flow turbulence and its mathematical modeling.
CO 4	To enable the students to understand the importance of analytical approximate solutions.
CO 5	To enable the students to learn about various other solution techniques of mathematical modeled equations using computational methods.

Detailed Syllabus:

Potential 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: Salient features of flow pattern in a boundary layer, Velocity and shear stress distribution along the boundary, similarity solutions, Von-Karman momentum integral equation, Approximate Methods, quantitative correlations for boundary layer thickness, local skin friction coefficient and drag coefficient in laminar, turbulent and laminar turbulent combined boundary layer flows on a flat plate without pressure gradient, flow over a curved surface boundary layer separation and its control.

Elements of Stability Theory: Concept of small-disturbance stability, Orr-Sommerfeld equation, Inviscid stability theory, Boundary layer stability, Thermal instability, Transition to turbulence.

Turbulent Flow: Introduction, Fluctuations and time-averaging, General equations of turbulent flow, Reynolds averaging, Turbulent boundary layer equation, Flat plate turbulent boundary layer, Turbulent pipe flow, Prandtl mixing hypothesis, Turbulence modeling, Free turbulent flows.

Compressible Flows: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

Introduction to Computational Fluid Dynamics (CFD): Boundary conditions, Basic discretization – Finite difference method, Finite volume method and Finite element method.

Books Recommended

1. Çengel, Y.A. and J.M. Cimbala, Fluid Mechanics, McGraw-Hill, Boston, MA. Web link.
2. Munson, B.R., D.F. Young, and T.H. Okiishi, Fundamentals of FLUID MECHANICS, 4th Ed., Wiley, New York, NY, 2002._(TOC)
3. White, F. M., Fluid Mechanics, Fifth Edition, McGraw Hill 2003.

4. Kundu, P. K., and Ira M. Cohen, Fluid Mechanics, 4th ed., Academic Press 2007/Elsevier, 2008. ISBN-10: 0123737354, ISBN-13: 978-0123737359.
5. White, F. M., , Viscous Fluid Flow, 2nd Edition, McGraw Hill 1991.
6. Currie, I.G., Fundamental Mechanics of Fluids, 2nd Edition, McGraw Hill 1993.
7. Panton, R.L., Incompressible Flow, 2nd Ed., John Wiley & Sons, 1996.
8. Fay, J. A., Introduction to Fluid Mechanics Cambridge, MA: MIT Press, 1994. ISBN: 0262061651
9. Chevray, R. and J. Mathieu, Topics in Fluid Mechanics, Cambridge University Press, 1993.
10. Schlichting, H., Boundary Layer Theory, McGraw-Hill, 1968.
11. Batchelor, G.K., An Introduction to Fluid Dynamics, Cambridge University Press, 1967.
12. Aris, R., Vectors, Tensors, and the Basic Equations of Fluid Mechanics, Prentice-Hall, 1962.
13. Bird, R.B., W.E. Stewart, and E.N. Lightfoot (1960), Transport Phenomena, Wiley, New York.
14. Stefan Popes, Turbulent Flows, McGraw-Hill, Boston, MA.
15. Fundamentals of Compressible flow by S.M. Yahya
16. Gas Dynamics by Z. Hussain
17. Computational Fluid Dynamics by Anderson

			L	T	P	Credit
MEX-313	**Heat Transfer Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To make students understand of experimental procedure to solve heat transfer problems by selecting some physical situations pertaining to different modes of heat transfer.
CO 2	To make students understand the measurement procedure for monitoring the physical parameters like temperature, flow velocity and energy.
CO 3	To make students understand the experimental data analysis and the errors involved in experimental measurements and discuss the correct measurement techniques to acquire most reliable information.
CO 4	To teach students the correct way to write the report based on experimental observations.

Detailed Syllabus:

1. To study and compare temperature distribution, heat transfer rate, overall heat transfer in parallel flow and counter flow heat exchanger.
2. To study the heat transfer and counter flow heat exchanger.
3. To find the thermal conductivity using two slab guarded ho plate method.
4. To determine heat transfer coefficient in natural convection.
5. To determine heat transfer coefficient in forced convection for air flowing in a tube.
6. To determine heat transfer coefficient in drop wise and film wise condensation.
7. To determine the emissivity of a given plate at different temperatures.

			L	T	P	Credit
MEX-315	**Thermal Engineering Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Perform the load test on petrol/ diesel engine and draw the performance characteristics.
CO 2	Determine the volumetric and isothermal efficiency of two stage air compressor.
CO 3	Determination of IP, BP and FP by Morse test in a Multicylinder Petrol engine.

Detailed Syllabus:

1. To conduct a load test on a single cylinder, 4 stroke petrol engine and study its performance under various loads.
2. To conduct a load test on a single cylinder high speed diesel engine to study its performance under various loads.
3. To conduct a performance test of a single cylinder high speed diesel engine and to study its performance under different loads.
4. To conduct the experiment on two stroke air compressor and to find out its volumetric efficiency and isothermal efficiency.
5. To study the effect of forward curved, backward, curved and radial vanes in a centrifugal compressor and to find out the overall efficiency of the compressor.
6. To determine the volumetric and isothermal efficiency of two stage air compressor.
7. To study the performance of axial flow fan.

			L	T	P	Credit
MEX-317	**Mechanical Measurement & Metrology Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Introduction to various mechanical Instruments.
CO 2	Students will Enable to understand the working Principles of various mechanical instruments.
CO 3	Enable to understand the application of various mechanical Instruments.

Detailed Syllabus:

1. Measurement with the help of vernier caliper and micrometer.
2. Measurement of an angle with the help of sine bar.
3. Measurement of surface roughness.
4. Measurement of gear elements using profile projector.
5. Three wire method to determine effective diameter of external threads.
6. Measurement of thread element by Tool makers microscope.
7. Calibration of a pressure gauge with the help of a dead weight guage tester.
8. Use of stroboscope for measurement of speed of shaft.
9. Use of pilot type to plot velocity profile of a fluid through a circular duct.
10. Preparation of a thermocouple, its calibration and application for temperature measurement.
11. Measurement of flow using (i) Rotameter (ii) Venturimeter (iii) Orifice meter
12. Measurement of power using dynamometer.
13. Measurement of Load using Load cell.
14. Measurement of strain using strain meter.

			L	T	P	Credit
MEX-302	**Fluid Machinery**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Impulse momentum theorem, Analysis of Impact of jets on different types of vanes, Jet propulsion.
CO 2	Study of hydraulic turbines like Pelton, Francis and Kaplan turbines including their performance analysis, cavitations in turbines, similarity analysis.
CO 3	Study of different types of pumps like centrifugal pumps and reciprocating pumps, including its performance analysis.
CO 4	Study of hydraulic devices like hydraulic intensifier, hydraulic press, torque convertor, hydraulic accumulator, etc.

Detailed Syllabus:

General Concepts: Impulse momentum principle, jet impingement on stationary and moving flat plates, and on stationary or moving vanes with jet striking at the center and tangentially at one end of the vane, calculations for force exerted, work done and efficiency of jet. Basic components of a turbomachine and its classification on the basis of purpose, fluid dynamic action, operating principle, geometrical features, path followed by the fluid , Euler's equation for energy transfer in a turbomachine and specifying the energy transfer in terms of fluid and rotor kinetic energy changes.

Pelton Turbine: Components and its operation, velocity triangles for different runners, work output, Effective head, available power and efficiency; design aspects such as mean diameter of wheel, jet ratio, number of jets, number of buckets with working proportions. Francis and Kaplan Turbines: Components and operation, velocity triangles and work output; working proportions and design parameters for the runner; Degree of reaction, draft tubes – its function and types. Function and brief description of commonly used surge tanks.

Centrifugal Pumps: Layout and installation; Main elements and their functions, Various types and classification, Pressure changes in a pump - suction, delivery and manometric heads, vane shape and its effect on head-capacity relationships, Departure from Euler's theory and losses, pump output and efficiency, Minimum starting speed and impeller diameters at the inner and outer periphery, Priming and priming devices, Multistage pumps - series and parallel arrangement; submersible pumps. Construction and operation, Axial and mixed flow pumps, Trouble shooting - field problems, causes and remedies. Similarity Relations and Performance Characteristics: Unit quantities, specific speed and model relationships, scale effect, cavitation and Thoma's cavitation number; Concept of Net Positive Suction Head (NPSH) and its application in determining turbine / pump setting.

Reciprocating Pumps: Components parts and working, pressure variations due to piston acceleration, acceleration effects in suction and delivery pipes, work done against friction, maximum permissible vacuum during suction stroke, Air vessels.

Hydraulic Devices and Systems: Construction, operation and utility of simple and differential accumulator, intensifier, fluid coupling and torque converter, Air lift and jet pumps; introduction to gear, vane and piston pumps.

Books Recommended

1. Daughaty R L, *"Hydraulic Turbines",* McGraw Hill Book Company (1965).

2. Jagdish Lal, *"Hydraulic Machines",* Metropolitan Book Company Private Limited, New Delhi, (2000).
3. Stepanoff A J, *"Centrifugal and Axial Flow Pumps",* John Wiley and Sons (1970).
4. Binder R C, *"Advanced Fluid Mechanics and Fluid Machinery",* Prentice Hall (1966).
5. Nechleba M, *"Hydraulic Turbine",* Constable and Company (1957).

			L	T	P	Credit
MEX-304	**Industrial Automation**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Characterize the architecture of Hydraulic Systems, Pneumatic Systems, Mechanization, Industrial Robots.
CO 2	Apply the knowledge gained to design and simulate hydraulic and pneumatic circuits.
CO 3	Analyze the application of Mechanization systems and Industrail Robots for various applications.
CO 4	Propose a suitable automation solutions meeting the requirements.

Detailed Syllabus:

Introduction: Basic concept of Automation, Types of Automation, Feasibility etc.
Industrial Hydraulics: Introduction, basic concepts, Hydraulic fluids, Classification and properties of hydraulic fluids, Contaminates in hydraulic system, control and cleanliness standards, Fluid power generators, i.e. Gear, Vane, Piston pumps, linear and Rotary Actuators, Direction Control Valves, types, actuation methods, pressure control valves; pressure reducing valves, pressure relief valve, Unloading valve, Sequence valve, Counterbalance valve, Flow control valves simple and pressure compensated type. Standard ISO Symbols for Hydraulic Components. Sealings in hydraulic system, Accumulators, hydraulic hoses and tubing, Design and analysis and hydraulic circuits, conventional as well as computer aided design.
Pneumatics: Introduction, Basic components, Source, storage and distribution, treatment of compressed air, linear and Rotary actuators, Direction control valves – types, actuation methods, pressure control valves, logic devices – twin pressure valve, shutter valve, time delay valve, Pneumatic circuit design and analysis, conventional as well as computer aided design.
Automatic Assembly System: Development of Automatic Assembly process, Transfer devices – continuous, Intermittent, synchronous and asynchronous, Vibratory feeders – Mechanics, effect of frequency, acceleration, track angle, friction, load sensitivity, orientation of parts – active and passive devices, Mechanical feeders – computation and operational details, feed tracks, Escapement devices. Product design for high-speed automatic assembly, examples of design modifications.
Mechatronics: Introduction mechatronic system design, sensors and transducers for displacement, proximity, velocity, force, pressure temperature measurement. Microprocessors – Introduction, structure micro-controllers, application programmable logic controllers – basic structure, specifications programming of PLC's, importance of Timers, Counters, marker relays, analog comparators in PLC programming, Introduction to Data Acquisition and virtual instrumentation using LABVIEW.
Robotics: Basic concepts, classification based on Geometry, programming, drives, work volume of robots world and joint coordinates various joints, DOF, end effectors – Types and uses, Sensors in Robots, programming – Teach pendant and Computer programming, Introduction to forward and inverse kinematics, Applications of Robots.

Books Recommended

1. Anthony Esposito, *"Fluid Power with Application",* 5th Edition, Pearson Education (2003).
2. Majumdar S R, *"Oil Hydraulic System"*, Tata McGraw Hill (2001).
3. Bolton W, *"Mechatronics"*, 2nd Edition, Pearson Education, New Delhi (1999).
4. Necsulelscu Dan*, "Mechatronics"*, Pearson Education, New Delhi (2002).
5. Geoffrey Boothroyd, "Assembly Automation and Product Design", Marcel Dekker In

			L	T	P	Credit
MEX-306	**Production Management**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand the core features of the operations and production management function at the operational and strategic levels specifically the relationships between people, process, technology, productivity and quality improve an organizations performance.
CO 2	Develop an integrated framework for strategic thinking and decision making to analyze the enterprise as a whole with a specific focus on the wealth creation processes.
CO 3	Able to communicate effectively through discussion in seminars, teamwork and writing in discussion board, and a project report by gather evidence, data and information to make decisions.
CO 4	Utilize Tools viz. Value analysis, TPM and their contribution towards current production and operations management.

Detailed Syllabus:

Introduction: Definition and scope of industrial engineering, Role of industrial engineer in industry. Qualities of an Industrial Engineer.

Work Study: Productivity and the standard of living, reducing work content and ineffective time, the human factor in the application of work-study, Working conditions and the working environment.

Method Study: Introduction of method study and the selection of jobs, Methods and movements at the workplace.

Work Measurement: Introduction, Work sampling, Time Study, equipment, timing the job, rating, Calculation of standard time, Setting time standard for works and machines, Predetermined time standards, Standard data and its use. Specific case studies.

Value Engineering: Types and concept of value engineering, phases of value engineering studies, application of value engineering.

Job Design: Traditional engineering dimensions of job design, Concepts of job enlargement, Job enrichment, Job rotation, effective job design in relation to technological and behaviour factors.

Ergonomics: Introduction, Considerations in designing man machine systems with special reference to the design of displays and control.

Maintenance Management: Introduction, types, total productive maintenance, condition monitoring.

Books Recommended

1. Barnes M R, "*Motion and Time Study*", John Wiley and Sons (2002).
2. Oborne D J, *"Ergonomics at Work",* John Wiley and Sons (1985).
3. Miles, *"Techniques of Value Analysis and Engineering",* 2nd Edition, McGraw Hill (1997).
4. Ulrich Cart T and Eppinger Steven D, *"Product Design and Development",* Tata McGraw Hill, New Delhi (1995).
5. Hicks, *"Industrial Engineering and Management",* 2nd Edition, Tata McGraw Hill, New Delhi (1994).

			L	T	P	Credit
MEX-308	**Fluid Machinery Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To study the performance of the Pelton turbine in terms of parameters like hydraulic efficiency, mechanical efficiency and its variation with head and discharge.
CO 2	To study the performance of the Francis turbine in terms of parameters like hydraulic efficiency, mechanical efficiency and its variation with head and discharge.
CO 3	To study the performance of the Kaplan turbine in terms of parameters like hydraulic efficiency, mechanical efficiency and its variation with head and discharge.
CO 4	Performance of centrifugal pump in terms of terms of hydraulic efficiency, mechanical efficiency and its variation with head and discharge.

Detailed Syllabus:

1. Determination of various efficiencies of Hydraulic Ram.
2. To draw characteristics of Francis turbine.
3. To study the constructional features of reciprocating pump and to perform test on it for determination of pump performance.
4. To draw the characteristics of Pelton Turbine.
5. To draw the various characteristics of Centrifugal pump.
6. Determine the effect of vane shape and vane angle on the performance of centrifugal fan.

			L	T	P	Credit
MEX-310	**Industrial Automation & Mechatronics Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To attain knowledge about the architecture and programming of Industrial Robotic systems.
CO 2	To study the working of various Hydraulic and pneumatic components.
CO 3	To carry out the designing and simulation of Hydraulic and Pneumatic Circuits using Trainer Board and Software.
CO 4	To study the use of various types of sensors in automation systems with examples.

Detailed Syllabus:

1. Study of various pneumatic components and Assembly and operation of some basic pneumatic circuits using pneumatics transfer package.
2. Study of various electro-pneumatic Components and Assembly and operations of some basic and advanced electro-pneumatic, PLC controlled pneumatic circuits using pneumatics trainee package.
3. Study of various components in hydraulic circuits. Assembly and operation of some basic hydraulic and electro-hydraulic circuits.
4. Study the basic geometry motions of Jointed Arm Robot. Teach Pendant programming of the robot using various basic and advanced programming techniques i.e. WAIT commands etc.
5. Study the operation of Hydraulic circuit simulation software and using the same for drawing and simulating some hydraulic circuits.
6. Study the operation of pneumatic circuit simulation software and using the same for drawing and simulating some pneumatic circuits.
7. Study the basic features of a PLC. Programming of the ABB, PLC for various logic and regulated decisions.
8. Study the basic features of a programmable motion controller programming of the DC servo motion controller and its accessories for simple programs.
9. Study the operation of a Robotics simulation software and simulation of some basic robot configuration using Industry specific language.

			L	T	P	Credit
MAX-206	**Numerical Methods**	**Core Course**	**3**	**1**	**0**	**4**

Pre-requisites: Mathematics-I (MAX-101), Mathematics-II (MAX-201), Mathematics-III (MAX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To attain knowledge of finding the roots of algebraic and transcendental equations this is a problem of great importance in applied mathematics by various numerical methods.
CO 2	To understand direct and iterative methods for solving linear system of equations.
CO 3	To attain knowledge of eigen value problems and several methods of finding the inverse of matrix which require less of computational labour and can be easily extended to matrices of higher order.
CO 4	To understand interpolation, numerical differentiation and integration using basic concepts of finite differences.
CO 5	To apply various numerical methods for solving ordinary differential equations where solutions cannot be obtained using available analytical methods and even to solve ordinary differential equations which have analytical solutions with greater ease.
CO 6	To understand finite difference methods for boundary value problems and for elliptic, parabolic and hyperbolic partial differential equations which arise in description of physical processes in applied sciences and engineering.

Detailed Syllabus:

Roots of algebraic and transcendental equations, Bisection method, Regula-Falsi method, Newton Raphson method, Bairstow's method and Graeffe's root squaring method.

Solution of simultaneous algebraic equations, matrix inversion and Eigen-value problems, triangularisation method, Jacobi's and Gauss-Siedel iteration method, partition method for matrix inversion, power method for largest eigen-value and Jacobi's method for finding all Eigen-values.

Finite differences, interpolation and numerical differentiation, forward, backward and central differences, Newton's forward, backward and divide difference interpolation formulas, Lagrange's Interpolation formula, Stirling's and Bessel's central difference interpolation formulas numerical differentiation using Newton's forwarded and backward difference formulas and numerical differentiation using Stirling's and Bessel's central difference interpolation formulas.

Numerical integration, Trapezoidal rule, Simpson's one-third rule and numerical double integration using Trapezoidal rule and Simpson's one-third rule.

Taylor's series method, Euler's and modified Euler's methods, Runge-Kutta fourth order methods for ordinary differential equations, simultaneous first order differential equations and second order differential equations.

Boundary value problems, finite difference methods for boundary value problems.

Partial differential equations, finite difference methods for elliptic, parabolic and hyperbolic equations.

Books Recommended:

1. S S Sastry, Introductionary Methods of Numerical Analysis, 3rd Edition, Prentice Hall of India Pvt. Lrd., New India-1999.
2. S C Chopra and R P Canale, Numerical Methods for Engineers, 2nd Edition, McGraw Hill Book Company, Singapore 1990.
3. B S Grewal, " Numerical Methods", Khanna Publishers. Delhi.

			L	T	P	Credit
MEX-401	**Refrigeration and Air Conditioning**	**Core Course**	**4**	**0**	**0**	**4**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To review thermodynamics and thermal systems engineering and develop understanding of vapor compression and heat-driven refrigeration systems.
CO 2	To understand the components of vapour compression refrigeration system.
CO 3	To develop familiarity with refrigerants from the performance and environment point of view.
CO 4	To develop understanding of the principles and practice of thermal comfort.
CO 5	To apply the basic principles of Psychrometry and applied Psychrometry.
CO 6	To develop an ability for design the whole system consisting of several components and subsystems

Detailed Syllabus:

Basic Concept: Natural and Mechanical Refrigeration, Application of refrigeration, Units of refrigeration and Coefficient of performance, Refrigeration effect, cooling capacity and COP of a refrigerator, heating effect, heating capacity and COP as heat pump.

Bell Coleman Cycle and Aircraft Refrigeration: Bell Coleman Cycle and its analysis; optimum COP and pressure ratio, necessity of air craft refrigeration – air cycle refrigeration systems and their comparison.

Vapour Compression Refrigeration Cycle: Vapour compression cycle on P-V, P-H and T-S diagrams, deviation of actual cycle from theoretical cycle, compressor capacity and volumetric efficiency, analysis of theoretical and actual vapour compression cycles, effect of suction pressure, discharge pressure, sub-cooling, super heating and pressure drop in valves on performance and cooling capacity.

Vapour Compression Refrigeration with Multiple Evaporators and Compressors: Compound compression with single and multiple expansion valves, water inter-cooling and flash inter-cooling, multiple load systems with single and multiple expansion valves.

Vapour Absorption Refrigeration Cycle: (No Mathematical Analysis) Principle of absorption system; components of the system, Desirable properties of absorption system refrigerant and absorbent, Aqua– ammonia absorption refrigeration system, Lithium Bromide–water absorption refrigeration system; Lithium Bromide–water absorption system, Comparison between absorption and compression system.

Refrigerants: Classification and nomenclature of refrigerants, Desirable thermodynamic, chemical and physical properties of refrigerants, comparative study of commonly used refrigerants and their fields of application; Azeotropes, Effect of moisture and oil miscibility, Refrigerant drying agents and antifreeze solution, leak detection and charging of refrigerants, environmental, aspects of conventional refrigerants, friendly refrigerants.

Non-Conventional Refrigeration Systems (No Mathematical Analysis): Cascade Refrigeration System, Linde and Claude cycles for liquefaction of gases.

Air Conditioning: Concept and Applications, Psychometric properties of air, Dry bulb, wet bulb and dew point temperatures; Relatives and specific humidity; degree of saturation, adiabatic saturation temperature, enthalpy of air and water vapours, psychometric chart. Human requirements of comforts, effective temperature and comfort charts, Industrial and comfort air conditioning.

Psychrometric Process: Sensible heating and cooling, cooling with dehumidification, Heating with dehumidification, by-pass factor, chemical dehumidification, adiabatic mixing, air washer. Cooling and heating load estimation

Refrigeration and Air Conditioning Equipment: Brief description of compressors, condensers and evaporators and expansion devices, Cooling towers.

Books Recommended

1. Arora C P, *"Refrigeration and Air Conditioning"*, 19th Edition, Tata McGraw Hill, Delhi (1985).

2. Pradad M, *"Refrigeration and Air Conditioning"*, 2nd Edition, New Age International Private Limited, Delhi (2002).

Dossat, R J, *"Principles of Refrigeration"*, 4th Edition, Pearson Education (Singapore), India, (2002).

4. Mcquiston F G, Parker J D and Spilter J D, *"Heating, Ventilating, and Air Conditioning"*, 5th Edition, John Wiley and Sons Inc, New York (2001).

5. Jordan and Priester, *"Refrigeration and Air Conditioning",* Prentice Hall of India (1998).

6. Ananthanarayan, "Basic Refrigeration and Air Conditioning",3rd Edition, Tata McGraw Hill

			L	T	P	Credit
MEX-403	**CAD/CAM**	**Core Course**	**2**	**0**	**0**	**2**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To be familiar with CAD/CAM Hardware and software.
CO 2	To be familiar with types of geometric modelling and parametric representation of curves, surfaces and solids.
CO 3	Enables to select, design and use of numerical controlled technology for the manufacturing applications.

curves, parametric representation of analytical and synthetic curves, curve manipulation, mathematical representation of surfaces, plane surface, ruled surface, Bezier surfaces, B-spline surfaces, coons surfaces, blending surfaces. Fundamental of solid modeling, half spaces, boundary representation. Solid modeling based applications Data exchange, IGES, PDES, geometrical transformations and visual realism.

Finite Element Analysis: Introduction, Procedures, Element types, Nodal approximation, Element matrices, vectors and equations, Global connectivity, Assembly, Boundary conditions, Solution techniques, Interfaces to CAD, Introduction packages, Software development for design of mechanical components.

Computer Aided Manufacturing: Evolution of Computer Numerical Control, Components, Coordinate system, Working principle of CNC Lathe, Turning Centers, Milling Machine, Machining Center, Drilling Machine, Boring Machine.

Part Program Terminology: G and M Codes, Types of interpolation, Methods of CNC part programming, Manual part programming, Computer Assisted part programming: APT language , CNC part programming using CAD/CAM-Introduction to Computer Automated Part Programming.

Books Recommended

1. Groover and Zimmers, *"CAD / CAM: Computer Aided Design and Manufacturing",* Prentice Hall of India, New Delhi (1994).

2. Ramamurthi V, *"Computer Aided Mechanical Design and Analysis",* Tata McGraw Hill Publishing Co Ltd (1998).

3. Ibrahim Zeid, *"CAD - CAM Theory and Practice"*, Tata McGraw Hill Publishing Co. Ltd (1991).

4. Steave Krar and Arthur Gill, *"CNC Technology and Programming"*, McGraw-Hill Publishing Company (1990).

5. Radhakrishnan P, Subramanyam S, Raju V , *"CAD/ CAM/CIM"*, New Age International Publishers (2000).

			L	T	P	Credit
MEX-405	**System Design**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: Design of Machine Elements (MEX-301).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Apply Statics, Dynamics and Strength of materials to machine component design.
CO 2	Ability to perform selection of size, design and analysis of mechanical components/ systems.
CO 3	Ability to select the material, thermo-mechanical condition and configuration of a variety of machine elements and drives under a variety of environmental and service conditions.
CO 4	To enable students to learn how to identify and quantify the specifications for selection and application of components those are used in the design of mechanical systems.

Detailed Syllabus:

System Design involves preparing of complete design of system, production drawings for selected projects in power drive, engines, machine tools, mechanical handling equipment etc.

Books Recommended

1. Norton L R, *"Machine Design an Integrated Approach"*, Ist Indian Reprint, Pearson Education Asia (2001).
2. Sharma P C and Aggrawal D K, *"A text book on Machine Design"*, 9th Edition, S K Kataria and sons (2000).
3. Shigley J E and Mischke C R, *"Mechanical Engineering Design"* Tata Mcgraw Hill, New Delhi, (2003).
4. Acherkan N, *"Machine Tool Design",* Volume 1 to 4, MIR Publishers, Moscow (1969).
5. Burr H and John B Cheatham, *"Mechanical Analysis and Design"*, PHI Private Limited, New Delhi (2001).

			L	T	P	Credit
MEX-407	**Metal Cutting and Machine Tools**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: Mechanical Measurement & Metrology (MEX-307).
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Apply cutting mechanics to metal machining based on cutting force and power consumption.
CO 2	Operate lathe, milling machines, drill press, grinding machines, etc.
CO 3	Students will be able to analyze cutting forces in turning, drilling and milling.
CO 4	Select appropriate machining processes and conditions for different metals.
CO 5	Students will be able to adjust varies parameters and reduce temperature developed during machining.
CO 6	Learn machine tool structures and machining economics. Students will be able to reduce the cost of machinery.
CO 7	Students will be able to prevent failures of cutting tool.
CO 8	Write simple CNC programs and conduct CNC machining.

Detailed Syllabus:

Machining of Metals: Mechanics of metal cutting, Cutting Tool Nomenclature, Orthogonal and Oblique Cutting, Tool Angle Specification Systems, Effect of Cutting Parameters on Tool Geometry, Temperature at the Shear Plane in orthogonal Cutting, Experimental Determination of Tool Temperature.
Tool Wear and Cutting Fluids: Cutting Fluids, Types of Cutting Fluids, Selection of Cutting Fluids, Methods of Applying Cutting Fluids, Kinds of Tool Damage, Tool Wear Equation, Tool Life Equations, Tool Life Tests.
General Purpose Machine Tools and Operations: Lathe and turning operations, Lathe and its accessories, Lathe specifications, lathe cutting tools, Classification of milling machines, specifications of milling machine, milling machine operations, indexing methods: simple and compound indexing. Shaper and Planes, Grinding Machines, Drilling Machines.
Introduction to new Machining Processes.
Mechanisms for rectilinear motion: Methods for producing rectilinear motion in machine tools, Rack and pinion drives, rotary and materials uses for pinions and racks, worm and rack drives, materials used, lead screw and nut drives, materials used for bad screws and nuts.
Structural Features of Machine Tools: Beds, Bases columns, material for beds, bases and columns typical constructions of beds, bases and columns, machine tool columns, Housings, Tables cross rails and carriages.
Frames and Guides: Sideways, Antifriction ways, circular ways.
Speed and Feed Gear Boxes: Speed gearboxes in machine tools, types of speed gearboxes, feed gearboxes, types of feed gearboxes.
Introduction to Numerical Control of Machine Tools.
Installation and maintenance of machine tools: Machine Tool installation and maintenance safety in machine tools, reconditioning of machine tools, trouble shooting.

Books Recommended
1. Devris W R, *"Analysis of Material Removal Processes"*, Springer – Verlag (1992).

2. Panday P C and Shan H S, *"Modern Machining Processes"*, Tata McGraw Hill Publishing Company Limited, New Delhi (1980).
3. Schey A John, *"Introduction to Manufacturing Processes"*, McGraw Hill Book Company, New York (1987).
4. HMT Bangalore, *"Production Technology"*, Tata McGraw Hill, New Delhi (1980).
5. Acherkan N, *"Machine Tool Design"*, Volume 1 to 4, MIR Publishers, Moscow (1969).

			L	T	P	Credit
MEX-409	**Refrigeration and Air Conditioning Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: Applied Thermodynamics-I (MEX-207), Applied Thermodynamics-II (MEX-202).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Demonstrate knowledge and application of basic concepts and terminology.
CO 2	Demonstrate by performing experiments, the working of basic refrigeration machines such as window air conditioner, Ice Plant, Mechanical Heat Pump.
CO 3	Demonstrate knowledge and application of various controls in HVACR systems.
CO 4	Demonstrate knowledge of refrigeration and its application in troubleshooting and servicing HVACR systems.
CO 5	Demonstrate an understanding of the mathematics and science involved in the operation of HVACR systems.

Detailed Syllabus:

1. To find out the coefficient of performance of vapour compression refrigeration test rig Using (a) Capillary tube as an expansion valve. (b) Thermostatic expansion valve.
2. To find out the EPR (Energy Performance Ratio) of a Mechanical Heat Pump based on vapour compression refrigeration cycle.
3. To study the working of Electrolux vapor absorption refrigeration systems using three fluids.
4. To study the window type air conditioning test rig and performing the experiments related to basic air conditioning processes.
5. To study the ice plant test rig.
6. To study the effect of variation of brine concentration on the formation of ice.
7. To study the cut sections of reciprocating compressor of window type air conditioner.
8. To study the working of window air conditioner.

			L	T	P	Credit
MEX-411	**Project Phase-I & Seminar**	**Core Course**	**0**	**0**	**4**	**2**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Students will demonstrate the ability to discern the assignment's intended audience and objectives and respond appropriately.
CO 2	Students will demonstrate the ability to identify the disciplinary context for different kinds of writing, including both formal and informal writing.
CO 3	Students will demonstrate the ability to construct a paper consistent with expectation of the discipline, including an appropriate organization, style, voice and tone.

			L	T	P	Credit
MEX-413	**CAD/CAM Lab**	**Core Course**	**0**	**0**	**4**	**2**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Design a part or assembly of parts using Computer-Aided Design software.
CO 2	Use motion and interference checking to ensure that parts will not interfere throughout their complete range of motion.
CO 3	Use CAD software collaboratively when designing on a team.
CO 4	Communicate effectively the geometry and intent of design features.

Detailed Syllabus:

1 Introduction of various commands used for working with layers and layer groups in AutoCAD Mechanical: Changing a layer by selecting objects, Creating layer groups ,Using a layer group to copy object.

2 Design of lever: Lever inserted from the parts library, and then you refines the design using many of the design options, Inserting a library part, Preliminary setting: snap configuration, Creating construction lines, Creating a contour and applying a fillet, Creating a contour and applying a fillet, Creating a contour and trimming projecting edges, Cross- hatching the lever, Dimensioning the lever, Creating a detail and additional dimensions.

3 Calculate a chain length, and insert sprockets and chain links into a drawing: Performing a length calculation Optimizing the chain length, Inserting sprockets, Inserting a chain.

4 Calculate a spring for existing boundary conditions and insert the spring into a drawing: Starting the spring calculation, Specifying the spring restrictions, Calculating the selecting the spring, Inserting the spring, Copying the spring with Power Copy, Editing the spring with Power Edit.

5 Design of shaft: Create a shaft with cylindrical and conical sections, Add threads and a profile to the shaft, Edit the shaft, Add Standard part of the shaft, Shade and display 3 D views of the shaft.

6 Analysis with FEM: Start a finite element analysis, Define stress loads, Generate a mesh, Calculate and display the result.

7 Design a cam, perform calculations and generate data for NC Production: Starting the cam design and calculation, Defining the motion sections, Calculating the strength, Exporting cam data and viewing the result.

8 Part-programming on CNC machines

9 Execution of part programme for machining given profile.

10 Programming of robots for various applications

			L	T	P	Credit
MEX-415	**System Design Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: Design of Machine Elements (MEX-301).

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	To be familiar with layouts of transmission systems and concepts to improve their design conceptually.
CO 2	To be able to comprehend the design calculations to justify belt and pulley mechanisms.
CO 3	To be familiar with various gear boxes assembly and have ability to calculate velocity ratios of gear constituting the gear boxes.
CO 4	To be able to suggest design parameters for flywheel for a press of machine shop.

Detailed Syllabus:

1. Study the layout of some existing transmission system design and suggest a new conceptual design by removing the shortcomings of the existing design.
2. Find an assembly containing the belt and pulley mechanism and to do the complete design calculations and then justify the existing design.
3. Calculation of the velocity ratios required in a gear box and then design the gear box in practical application (gear box application must involve different type of gears like bevel, spur and helical).
4. Find a transmission system involving the worm and worm wheel and then find out the inputs required for its design and justify the design.
5. The gearbox design in exp. No. 5, design the shaft required to support the assembly and design it for manufacturing and assembly (with actual calculations of the loads and the end condition).
6. For a press of your machine shop, study the process and suggest the design parameters of the flywheel required. Justify the design if flywheel is already there.
7. Select a mechanical component or system, convert its design procedure into an algorithm and write a code for its design or with the help of application software.

			L	T	P	Credit
MEX-417	**Metal Cutting and Machine Tools Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Hands on experience on operating various machine tools like lathe, milling machines, drill press, grinding machines, etc.
CO 2	Better understanding on selecting appropriate machining processes and conditions for different metals.
CO 3	Students will be able to adjust various parameters and reduce temperature developed during machining.
CO 4	Learn machine tool structures and machining economics. Students will be able to economic use of machine tools.
CO 5	Students will be able to know the probable reasons and timings of cutting tool failure.
CO 6	Write simple CNC programs and conduct CNC machining operations by hand.

Detailed Syllabus:

- In this course, the students apply the fundamentals and principles of metal cutting to practical applications through multiple labs using lathes, milling machines, grinding machines, and drill presses, Computer Numerical Control etc.
- To demonstrate the fundamentals of machining processes and machine tools.
- To develop knowledge and importance of metal cutting parameters.
- To develop fundamental knowledge on tool materials, cutting fluids and tool wear mechanisms.

			L	T	P	Credit
MEX-400	**Project Phase-II**	**Core Course**	**0**	**0**	**8**	**4**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Ability to demonstrate understanding of a broad range of subjects.
CO 2	Ability to analyze problems and model appropriate solutions.
CO 3	Ability to organize and manage information and knowledge.
CO 4	Ability to interact effectively with peers and superiors.
CO 5	Ability to understand the financial aspect of a solution.
CO 6	Ability to demonstrate behaviors that are consistent with the code of professional ethics and responsibilities.

			L	T	P	Credit
MEX-402	**Vibrations and Control**	**Core Course**	**3**	**0**	**0**	**3**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Ability to mathematical model and analyze 1- DOF: (i) undamped free and forced, damped forced, and free vibratory system,(ii) for vibration isolation (vibration control) and transmissibility.
CO 2	Ability to mathematical model and analyze 2-DOF damped and undamped free vibratory system, Understand the static, dynamic and dissipative coupling.
CO 3	Basic understanding of methods of prediction of natural frequency and mode shapes for multi degree freedom vibratory system.
CO 4	Ability to model and analyze whirling of shafts.
CO 5	Continuous System: Ability to analyze longitudinal, tortional free vibrations of circular bar, and transverse free vibration of beam.

Detailed Syllabus:

Introduction: Basics of vibration, its effects, Harmonic and non-harmonic motions, kinetic and potential energy, Conservative non-conservative system in reference to vibrations.

Single Degree Freedom System: Free vibrations of systems without damping, equilibrium and energy methods, Rayleigh's method, equivalent system, systems with compound springs, shafts of different diameters, free vibrations with viscous damping, logarithmic damping, coulomb and structural damping etc., Forced vibration with viscous damping, equivalent viscous damping, impressed force due to unbalanced masses and excitation of supports, jump phenomenon, vibration isolation, Transmissibility, commercial isolators.

Two Degree Freedom Systems: Free undamped vibrations, static and dynamic coupling, principal modes of vibration dynamic vibration absorber, centrifugal absorber, and friction damper, vehicle suspension system response.

Multi degrees Freedom System: Holzer's analysis for multimass and multi inertia systems, simple geared systems; Dunkerlay's methods, Stodla method.

Whirling of shafts: Whirling and its implications, whirling of light flexible shaft with a unbalance disc at the center, uniform shaft with and without unbalance - Rayleigh's method.

Continuous System: Free longitudinal vibrations, tortional vibrations of circular shaft, and transverse vibration of beam.

Books Recommended

1. Rao S S, *"Mechanical Vibrations",* Pearson Education, Delhi (2004).
2. Roger A A, *"Fundamentals of Vibrations",* Amerind Publisher Company Private Limited, New Delhi (1999).
3. Srinivas P, *"Mechanical Vibration Analysis",* Tata McGraw Hill Company Limited, New Delhi (1990).
4. Mallik A K, *"Principles of Vibrations Control",* Affiliated East West Press Private Limited, New Delhi (2000).
5. Daniel J Inman, *"Engineering Vibration",* Prentice Hall, New Jersey (2001).

			L	T	P	Credit
MEX-404	**Vibrations and Control Lab**	**Core Course**	**0**	**0**	**2**	**1**

Pre-requisites: None.

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	An ability to design and conduct experiments, as well as to analyze and interpret data.
CO 2	Assess the validity of the experimental results and compare with theoretical results when possible.
CO 3	An ability to communicate effectively by writing and submitting report.

Detailed Syllabus:

1. Determination of radius of gyration of a pendulum.
2. Determination of radius of gyration of a bar using Bi-Filar suspension.
3. Study of undamped free vibration of a equivalent spring mass system.
4. Study of forced vibrations of equivalent spring mass system.
5. Study of torsional vibrations (undamped) of single rotor shaft system.
6. Study of free vibrations of two rotor system and to determine the natural frequency of vibration theoretically and experimentally.
7. Study of damped torsional oscillations and determine the damping co-efficient.
8. Verification of Dunkerley's rule.
9. Study of forced lateral vibrations of the beam for different damping.

Syllabi of Department Electives

			L	T	P	Credit
MEX-330	**Unconventional Methods of Machining**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Student will learn the technology and history for the development of newer/ non-traditional machining process.
CO 2	The students will demonstrate the comparison between non-traditional with the traditional machining processes with respect to the different parameters- Energy sources; Economics of the processes; Shape and size of material etc.
CO 3	The students analyse the concept, mechanism of material removal with respect to different processes.
CO 4	Different parameters associated with the process, their influence on the machining, will be analysed.
CO 5	Advantages, applications and limitations of the various non-traditional machining processes will be evaluated.

Detailed Syllabus:

Introduction: Mechanical Processes, Material removal theories, Fundamental principles, Process parameter characteristics, Metal removal rate analysis, Principles and Mechanism of Water jet machining, Abrasive jet machining, Ultrasonic machining.
Chemical and Electro-Chemical Machining: Introduction, Principles, Process parameters, Applications, limitations, Kinematics, Dynamics and Hydro-dynamics, Analysis of Material removal, Introduction to lithography.
Electric Discharge Machining: Basic Principles and Scheme Circuitrary controls, Metal removal rate, Machining Accuracy Optimization, Selection of Tool Material, Dielectric, Analysis of the Process.
Laser Beam Machining & Electron Beam Machining: Introduction, Production of Laser, Machining by Laser and its other applications: Electrons Beam action, Process controls, and applications.
Special Methods: Plasma Arc machining and Ion Implantation. High Velocity Forming of Metals, Explosive forming principles and various applications**.**

Books Recommended
1. Mishra P K, *"Non Conventional Machining"* Narosa Publishing House, New Delhi (1997).
2. Panday P C and Shan H S, *"Modern Machining Processes"* 5th reprint, Tata Mc Graw Hill, New Delhi (1998).
3. Ghosh Amitabha and Malik A K "*Manufacturing Science"* East West Publication, New Delhi (1985).
4. Code No. 244 *"Non Traditional Machining Processes"* All India Council for Technical Education (CEP) Bangalore (October 1992).
5. Code No. 308 *"Advance Machining Process"* All India Council for Technical Education (CEP) Bangalore.

MEX-331	Design for Production	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Sight and define problems to decide project.
CO 2	Solve project problem in conceptual range multi-options.
CO 3	Perform student estimate and analyses of solutions under corner realization capability, financial, utilitarian, information and other, make a decision and substantiate choice.

Detailed Syllabus:

Product Design: Definition of product design, design by evolution, innovation and imitation, product life cycle, consumption cycle, types of products. Design process steps, morphology of design, relationship of innovation to design, management of research and development in the organization, role of technology transfer in innovation, problem solving and decision making techniques used in design, models used in design- physical and analytical, prototypes. Standardization, simplification and specialization in design, factors affecting product specifications and range, design for manufacturability, consideration of safety and reliability in design, economic analysis, time value of money, cost comparison, break-even analysis and cost benefit analysis. Role of value engineering, ergonomics and computers in design.
Ergonomics: Introduction, history of development, man-machine system and its components. Introduction to structure of the body- features of the human body, stress and strain, metabolism, measure of physiological functions- workload and energy consumption, biomechanics, types of movements of body members, strength and endurance, speed of movements. Applied anthropometry-types, use, principles in application, design of work surfaces and seat design. Visual displays for static information, visual displays of dynamic information, auditory, tactual and olfactory displays and controls. Effect of vibration, noise, temperature and illumination on performance.

Books Recommended

1. Karl T Ulrich and Steven D Eppinger, *"Product design and Development"*, McGraw-Hill Inc (2000).
2. George E Dieter, *"Engineering Design"*, McGraw-Hill Inc (2000).
3. R S Bridger, *"Introduction to Ergonomics",* McGraw-Hill Inc (1995).
4. Mark S Sandeer and Ernert J Mc Cormick, *"Human Factors in Engineering andDesign",* McGraw-Hill Inc (1993).
5. Kelvin Otto and Kristen Wood, *"Product Design",* Pearson Education, Delhi (2001).

MEX-332	Solar Thermal Process	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Study of the Solar radiation on the earth surface and its characteristics, instruments used to measure solar radiation, solar radiation data, solar radiation geometry.
CO 2	Analysis of Flat plate collectors, principles of energy conversion into heat, energy balance equation, collector efficiency.
CO 3	Study of Solar energy storage like scribble heat storage, latent heat storage, thermo chemical heat storage.
CO 4	Understanding and designing Solar water heating system, pressurized and non pressurized, space heating and cooling.

Detailed Syllabus:

Solar Radiation: Solar radiation outside the earth's atmosphere, solar radiation at the earth's surface, instruments for measuring solar radiation and sunshine, solar radiation data, solar radiation geometry, solar radiation on tilted surfaces.
Solar Energy Collection: Flat – Plate collectors: Transmissivity of cover system, physical principles of conversion of solar radiation into heat, energy balance equation and collector efficiency, concentrating collectors: Focusing type, selective absorber coating.
Thermal Energy Storage: Scribble heat storage, latest heat storage, thermo-chemical heat storage.
Solar Water Heating Systems: Natural circulation water heater; (pressurized and nonpressurized) Forced circulation solar water heater, space heating and cooling.
Solar Crop Drying: Working principle: Open sun drying, direct solar drying, and indirect solar drying.
Solar Distillation and Solar Pond and other Applications: Worming Principle, principle and description of solar pond and operational problem, collection – cum storage water heater, Green house, solar cooker, heating of biogas plant by solar energy.

Books Recommended
1. Sukhatme S P, "*Solar Energy: Principles of Thermal Collection and Storage"*, 2nd edition, Tata McGraw Hill, Delhi (1997).
2. Tiwari G N, *"Solar Energy: Fundamentals, Design, Modeling and Applications"*, 1st Edition, Narosa Publishing House, New Delhi (2003).
3. Rai G D, *"Non-Conventional Sources of Energy"*, 4th Edition, Khanna Publisher, Delhi (1999).
4. Agarwal M P, *"Solar Energy"* S Chand, New Delhi (1989).
5. Garg H P and Parkash J, *"Solar Energy: Fundamentals and Applications"*, Tata McGraw Hill, Delhi (2003).

MEX-333	Advances in Metal Forming	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	The students should learn and understand the necessity of forming process compared with other manufacturing techniques.
CO 2	The learning of various forming methods gives an idea for the selection of process for different materials.
CO 3	Students will be able to analyse the stresses and yield criteria used for the deformation analysis of the different metal forming process.
CO 4	Students should be able to select the process, load required and possible reason the formation defects for the forged, rolled, extruded components.
CO 5	The students should have the knowledge to identify production of wire, rod , tubes using different process and problems occurred in the process.

Detailed Syllabus:

Stress and strain analysis, yield conditions, stress strain relation in elastic and plastic deformations, hardening, formulations of elastic and plastic problems, methods of solution, slab method, slip line and extra-mium principles, applications of theory of plasticity to metal working operations like wire drawing, extrusion, rolling, forging, deep drawing, spinning etc. Friction in metal working, recent developments in technology and theory.

Books Recommended:

1. Harris J N, *"Mechanical Working of Metals: Theory and Practice",* 1st Edition, Pergamon, New York (1983).
2. Mielnik E M, *"Metal Working Science and Engineering"*, McGraw Hill (1991).
3. Wagoner H Robernt, Chenot Iean-Loup, *"Fundamentals of Metal Forming"*, Wiley Text Books (1996).
4. Proceedings of the Conference, *"Mechanical Working and Steel Processing 20th"*, Iron and Steel Society (1983).
5. Kumar S, *"Principles of Metal Working",* Oxford and IBH Publishing Company, New Delhi
(1985).

			L	T	P	Credit
MEX-334	**Numerical Control for Machine Tool**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Student will enable to understand the functioning of NC, CNC and DNC Machine tools.
CO 2	Enable to understand and use Adaptive Control System to increase productivity, increase tool life and reduce rejections.
CO 3	Generate manual/computer assisted programs for a given part to be machined on NC/CNC system.

Detailed Syllabus:

Introduction: Basic concepts of manufacturing system and CAD/CAM. NC/CNC machine tools, NC machine tools-basic components, coordinate systems, features of NC machine tools. Computerized numerical control (CNC), tooling for NC machines-tool, presetting equipment, flexible tooling, tool length compensation, tool path graphics, NC motion control system, manual part programming, fixed/floating zero. block format and codes, computer assisted part programming. DNC and adaptive control, direct numerical control, adaptive control in machining system, combined DNC/CNC system.

Books Recommended

1. Zeid Ibraham, *"CAD/CAM Theory and Practice",* Tata McGraw Hill Publishing Company (1999).
2. Chris McMohan, *"CAD/CAM:Principles: Practice and Manufacturing Management"*, Pearson Education India (1998).
3. Groover M, *"Computer Aided Design and Manufacturing"*, Pearson Education India (2003).
4. Rao P N, *"CAD/CAM"*, Tata McGraw Hill Publishing Company (1999).
5. Bedworth D and Henderson M R, *"Computer Integrated Design and Manufacturing"*, Tata McGraw Hill Publishing Company (1998).

			L	T	P	Credit
MEX-335	**Tool Design**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand the fundamental principles of conventional machine tools and CNC machine tools for the desired machining purpose.
CO 2	Develop the ability to identify, formulate and solve engineering problems by applying knowledge of machine tool design.
CO 3	An ability to use techniques, skills and modern engineering tools necessary for engineering practice.

Detailed Syllabus:

Tool Design Methods: Introduction, The Design Procedure, Drafting Practice, Drawing Layout.
Tool Making Practice: Introduction, tools of the toolmaker, hand finishing and polishing, screws and dowels, jig boring practice, punch and die manufacture, electrodischarge machining for cavity applications.
Tooling Materials and Heat Treatment: Introduction, properties of materials, ferrous tooling materials, nonmetallic tooling materials, factors affecting heat treatment, heat treatment and tool design.
Design of Cutting Tools: The basic requirements of a cutting tool, general considerations for metal cutting, design of single point cutting tools, milling cutters, drills and drilling, reamers taps, carbide tools.
Sheet Metal Dies: Blanking and piercing die construction, press work materials, strip layout, bending dies, forming dies, drawing operations, single and double action draw dies.
Principles of Tool Design for Forging, Extrusion and Dies Casting: Introduction, general principles.
Tool Design for Numerically Controlled machine Tools: Need for numerical control, fixture design for numerically controlled machine tools, cutting tools for numerical control, tool-holding methods for numerical control, automatic tool changers and tool positioners, tools presetting.

Books Recommended

1. Donaldson Cyril, Lecain George H, Goold V C, *"Tool Design",* Tata McGraw Hill Publishing Company Limited, New Delhi (1993).
2. Battacharayya A and Ham L, *"Design of Cutting Tools",* SME, Dearborn, Mich (1969).
3. Paquin J R, *"Die Design Fundamentals",* The Industrial Press, New York (1962).
4. Wilson F W, *"Fundamentals of Tool Design"*, Prentice Hall, Englewood Cliffs, N J (1962).
5. Wilson F W, *"Numerical Control in Manufacturing"*, McGraw Hill, New York (1963).

			L	T	P	Credit
MEX-336	**Flexible Manufacturing System**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To make students aware of new trends in manufacturing such as job shop, mass production systems and most importantly flexible manufacturing systems (FMS).
CO 2	To describe material handling systems and processing systems utilized in FMS.
CO 3	To provide fundamental knowledge of computer assisted programming language and programming languages.
CO 4	To stipulate a proper software and database for the FMS.

Detailed Syllabus:

Review of Computer Aided Design and Drafting (CADD): The design processes, advantages and applications of CAD, computer hardware system, computer programming languages, model storage and data structure, CADD software packages – AutoCAD, orthographic projections.
CAD/CAM Interface and Product Design: Rationale for CAD/CAM, Computer-Aided Manufacturing, Elements of CAM Systems, NC in CAM, Product Design and Development.
Machine Tool Control: Elements of the NC Systems, Types of Control Systems, NC Part Programming, Computer Aided Part Programming, Machining Centers.
Manufacturing Systems and Automation: Trends in Manufacturing Systems, system Defined, Classification of Manufacturing Systems, Leveling and balancing the manufacturing Systems.
Robotics and Automated Guided Vehicles: Definition Robotics, Terminology, Types of Robots, basic robot motion and their control, robot programming, Automated Guided Vehicles. Typical applications in manufacturing like in welding, assembly, material handling, spray painting etc.
Group Technology (G T): Part families, parts classification, machine group/cell, cad/cam and GT, applications.
Flexible Manufacturing Systems and Computer Integrated Manufacturing Systems: (FMS) (CIMS): Components of FMS, components of CIMS, applications. Hardware and software pertaining to FMS installations.\

Books Recommended
1. Rao P N, Tewari N K and Kundra T K, *"Computer Aided Manufacturing"*, Tata McGraw Hill Publishing Company Limited, New Delhi (1993).
2. Rehg J A, *"Introduction to Robotics – A System Approach"*, Prentice Hall International, Englewood Cliffs, New Jerrey (1985).
3. Tercholz E, *"CAD/CAM Handbook"*, McGraw Hill, New York (1984).
4. Malcolm D R Jr, *"Robotics: An Introduction"*, Delmar Publishers Inc (1988).
5. McMahon C and Browne J, *"CAD CAM: From Principles to Practice",* Addison –Wesley Publishing Company, New York (1993).

MEX-430	Total Quality Management	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Select and apply appropriate techniques in identifying customer needs, as well as the quality impact that will be used as inputs in TQM methodologies.
CO 2	Measure the cost of poor quality and process effectiveness and efficiency to track performance quality and to identify areas for improvement.
CO 3	Understand proven methodologies to enhance management processes, such as benchmarking and business process reengineering.
CO 4	Choose a framework to evaluate the performance excellence of an organization, and determine the set of performance indicators that will align people with the objectives of the organization.

Detailed Syllabus:

Quality and Total Quality Management: Excellence in manufacturing/services, factors of excellence, and relevance of TQM.
Concept and definition of quality: Total quality control (TQC) and Total quality Management (TQM), salient features of TQC and TQM. Total Quality Management Models, benefits of TQM.
Just-in-Time (JIT): Definition: Elements, benefits, equipment layout for JIT system, Kanban system, MRP (Material Requirement Planning) vs JIT system, Waste elimination, workers involvement through JIT: JIT, cause and effect chain, JIT implementation.
Customer: Satisfaction, data collection and complain, redressal mechanisms.
Process Management: Factors affecting process management, Quality function deployment (QFD), Quality Assurance System.
Total Employees Involvement: Empowering employees: Team building; quality circles, Reward and Recognition; Education and Training, Suggestion schemes.
Problem solving: Defining problem, problem identification and solving process, QC tools.
Benchmarking: Definition, concept, process and types of benchmarking.
Quality Systems: Concept of quality system standards, Relevance and origin of ISO 9000, Benefits, Elements of ISO 9001, ISO 9002, ISO 9003.

Books Recommended

1. Besterfield and Besterfield, *"Total Quality Management",* 2nd Edition, Pearson Education (Singapore) P Ltd, India (2001).
2. Sunder Raju, *"Total Quality Management A Primer",* 3rd Edition, Tata McGraw Hill, Delhi (2001).
3. Zairi M, *"Total Quality Management for Engineers",* 2nd Edition, Aditya Books, Delhi, (1995).
4. Hradesky J L, *"Total Quality Management Handbook",* McGraw Hill (1994).
5. Dalela S and Saurabh, *"A manual of ISO 9000 Quality System",* 2nd Edition, S Chand & Company Ltd, Delhi (1999).

MEX-431	Operation Management	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Analysis of System concepts: Classification of systems Organizations as systems.
CO 2	Definition, objectives, functions and scope of operations management.
CO 3	Industrial management – relationship of operations management with the areas of industrial management.
CO 4	Types of productive systems and their characteristic features – Continuous and intermittent systems.
CO 5	Decision making in production systems: Scientific process Characteristics of decisions Framework for decision making.

Detailed Syllabus:

Operations Management: Introduction, Historical Evolution of Production and Operations Management, Trends in Operation Management, Production and Operations management as a Career, Operation strategies for competitive advantages, Productivity and Quality, Technology and Mechanization.
Production Planning and Control: Forecasting, Capacity Planning, Layout Planning, Location Analysis, Plant Layout and Materials Handling.
Product Design and Development: Steps involved in Product design and development, Factors affecting Project Design and Development like ergonomics, aesthetic, economic, technical. Case studies.
Materials Management and Inventory Control: Inventory concepts, Scope, function and objectives of Inventory, Inventory costs, Determination of E.O.Q., ERP, MRP-I, MRP-II, Just in time, Concept of Zero Inventory.
Quality Control: Meaning of Quality Control and its Impact, Functions of Quality Control, Introduction to SQC, Japanese Contribution to Quality Control, Managing Quality, Introductory Concept of Six Sigma, Introduction to ISO 9000 and 14000, Specific Case Studies.
MIS: Introduction to Management Information system, Steps involved in designing an MIS, Role and Application of Computers in MIS, Case studies.
Project Management: Project planning, Project scheduling models, Managing the project, Work breakdown structure, Progress reporting, Role of Human Behavior in project environment.

Books Recommended

1. Buffa and Sarin, *"Modern Production / Operation Management",* 8th Edition, John Wiley and Sons (1987).
2. Adam and Ebert, *"Production and Operations Management",* 5th Edition, Prentice Hall of India, New Delhi (2000).
3. Krajenski and Ritzman, *"Operations Management Strategy and Analysis'',* 6th Edition, Pearson Education, New Delhi (2002).
4. Mazda Fraidoon, *"Engineering Management",* 3rd Reprint, Pearson Education (2000).
5. Besterfiled, *"Total Quality Management",* Pearson Education (2003).

MEX-432	Non Conventional Energy	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To make the students aware about the present energy scenario and importance of non conventional energy resources.
CO 2	To know about the various prevalent, non conventional energy resources and their respective worldwide with specific to India.
CO 3	To acquire the knowledge related to various energy conversion technologies, Direct and Indirect.
CO 4	To develop an ability for design and analysis of various energy conversion systems and devices.
CO 5	Introduce students to societal catalysts and challenges regarding renewable energy implementation.
CO 6	To enhance a student's ability to communicate in written form.

Detailed Syllabus:

Wind Energy: Basic principle of wind energy conversion, wind data and energy estimation, site selection considerations, basic components of a WECS, classification of WECS system, application of wind energy.
Biomass Energy: Biomass conversion technologies, photosynthetic, biogas generation, factors affecting bio-digestion, classification of biogas plants with their advantages and disadvantages, types of biogas plants, constructional details of digesters, site selection for biogas plants, methods of obtaining energy from biomass.
Geothermal Energy: Nature of geothermal fields, types of geothermal sources. Advantages and disadvantages of geothermal energy over other energy forms, application of geothermal energy, geothermal energy prospects in India.
Energy from Ocean: Ocean thermal electric conversion, methods of ocean thermal elective power generation, energy from tides, basic principal of tidal power, components of tidal power plant, methods of utilization of tidal energy ocean waves and introduction and wave energy conversion devices.
Fuel Cell: Design and principle of operation of fuel cell, classification of fuel cells.
Magneto Hydrodynamic Power Generation: Principle of MHD power generation, types of MHD systems.
Thermo Electric Power: Basic principle of thermoelectric power generation, thermoelectric materials, selection of materials.
Thermionic Generation: Thermionic emission and work function, basic thermionic generator.
Hydrogen Energy: Hydrogen production, hydrogen storage and transportation, hydrogen as a alternative fuel for motor vehicles.

Books Recommended
1. Rai G D, *"Non-Conventional Energy Sources",* 4th Edition, Khanna Publishers, Delhi (1999).

2. Rao S and Paruleka B B, *"Energy Technology",* 1st Edition Khanna Publishers, Delhi (1999).
3. Abbasi S A and Abbasi Narsema, *"Renewable Energy Sources and their Environmental Impact",* Prentice Hall of India Private Limited, New Delhi (2001).
4. Kothari,D.P,Singal,K.C. & Ranjan, Rakesh, " Renewable Energy sources and Emerging Technologies", Ist Edition Prentice Hall of India(2008).

MEX-433	Automobile Engineering	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Develop chassis and identify suitable engine for different applications and formulate steering, braking and suspension systems.
CO 2	Select a suitable conventional and automatic transmission system.
CO 3	Identify the usage of electrical and hybrid vehicles.
CO 4	Use of ANSYS software.

Detailed Syllabus:

Introduction to Automobile: Importance, applications, job opportunities, classification, types of vehicles, Basic structure, general layout, hybrid vehicles.
Automotive Electric and Electronic Systems: Electric and electronics principles, systems, and circuits, automotive batteries, construction, and operation, starting system, charging system, operation and service, ignition system, electronic ignition and fuel control, engine management, electric vehicles.
Automotive Drive Trains: Clutches, manual and automotive transmission and transaxles, drive shafts, universal joints, drive axles.
Automotive Chassis: Suspension system, steering system, wheel alignment, brakes, wheels and tyres.
Maintenance and Trouble Shooting: Automobile performance, drivability, emissions and emission norms, noise and vibration, engine tuning, equipment for measuring various vehicle parameters such as bhp, a/f ratio, noise, vibration and emission, comfort and safety.
Recent advances in automobiles and automotive components.

Books Recommended
1. Crouse W H and Anglin D N, *"Automotive Mechanics",* McGraw Hill, 10th Edition, Singapore (1993).
2. Bosch, *"Automotive Handbook",* SAE Publication (2000).
3. Tom Denton, *"Automobile Electrical and Electronics Systems",* Butterworth-Heinemann (2003).
4. Layne Ken, *"Automotive Engine Performance: Tune up, Testing and Service",* Englewood Prentice Hall of India (1986).
5. Tom Denton, *"Advanced Automobile Fault Diagnosis",* Butterworth-Heinemann (2002).

			L	T	P	Credit
MEX-530/MEX-675	**Mechanics of Composite Material**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Ability to analyze: anisotropic material for stress-strain i.e., to determine stiffness and compliance matrix, Macro mechanics of continuous fiber-reinforced lamina, and Multi axial theory of failure for fiber reinforced composite materials, understand the classical lamination theory, A-B-D matrix and design laminated composite structure economically thereafter.
CO 2	An ability to analyze FRP using micromechanical methods such as mechanics of material, semi empirical, and elasticity approach.
CO 3	Basic understanding of: Modeling of Discontinuous fiber reinforced composites, Hygrothermal analysis of composite lamina and laminates, and Viscoelastic behavior of fiber reinforced composites.
CO 4	Study of mechanical testing of the constituent and the elastic moduli, viscoelastic and dynamic properties of composites.
CO 5	Enable the students to independently analyze and extend a given course subject, compose a report paper and effectively communicate the essentials through an oral presentation.

Detailed Syllabus:

Introduction: Basic concepts and definitions, constituent materials, applications and fabrication process related to composite materials.
Macromechanics: Lamina stress-strain relation, anistropic behaviour, engineering contents, stiffness and compliance matrices, transformed matrices and invariants. Analysis of laminates, classification of laminates, laminated beams. Laminated plates, theory of laminated plates with coupling, stiffness characteristics of related laminates, laminate compliances, lamina and laminate stresses and strains, and laminate engineering constants. Introduction to interlaminar stresses, laminate strength and failure analysis.
Micromechanics: Continuous fiber-reinforced lamina, prediction of elastic moduli by mechanics of material, elasticity and semi-empirical models and model for prediction of lamina strength. Discontinuous fiber-reinforced lamina, elastic moduli and stress-strain relationship.
Mechanical Testing: Measurement of constituents i.e., fiber and matrix, measurement of elastic moduli, viscoelastic and dynamic properties of composites.
Books Recommended
1. Jones R M, *"Mechanics of Composite Materials",* Scripta Book Company (1975).
2. Herkovic C T, *"Mechanics of Fibres Composites",* University of Virginia, John Wiley and Sons, Inc (1998).
3. Tsai Stephen W, *"Introduction to Composite Materials"*, Technomic Publishing Company Inc (1980).
4. Gibson R F, *"Principles of Composites Materials Mechanics"*, McGraw Hill International Edition, New York (1994).
5. Hyer M W, *"Stress analysis of Fiber-Reinforced Composites Materials",* WCB McGraw Hill, Boston (1997).

MEX-531	Lubrication and Wear	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: Fluid Mechanics-I and II (MEX-212; MEX-302)
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Be familiar with the adhesion theories and effect of adhesion on friction and wear.
CO 2	Have a knowledge of surface topography and know how to model a rough engineering surface.
CO 3	Have a knowledge of friction/lubrication mechanisms and know how to apply them to the practical engineering problem.

Detailed Syllabus:

Introduction: Tribological consideration, Nature of Surfaces and their contact; physicomechanical properties of surface layer, Geometrical properties of surfaces, method of studying surface, contact of smooth surface, contact of rough surfaces.
Friction and Wear: Role of friction laws of static friction, Causes of friction, Adhesion theory, Laws of rolling friction, friction of metals and non-metals, friction measurement. Definition of wear, mechanism of wear, factors effecting wear, wear measurement, wear of metals andnonmetals.
Lubrication and Lubricants: Introduction, dry friction, Boundary lubrication, hydrostatic and elasto hydrodynamic lubrication.
Functions of lubricants: Types of lubricants and their industrial uses, Properties of liquid and grease lubrications. Lubricant additives, general properties and selection.
Special Topics: Bearing design, selection of bearings and lubrications, Bearing maintenance, diagnostic maintenance of tribological components.

Books Recommended
1. O'Conner and Boyel, *"Standard Handbook of Lubrication Engineering",* McGraw Hill Company, New York (1968).
2. Bharat Bhushan, *"Principles and Applications of Tribology",* 1st edition, Wiley-Interscience (1999).
3. Raymond O Gunther, *"Lubrication",* Bailey Bros and Swinten Limited (1971).
4. Rowe William Brian, *"Hydrostatic and Hybrid Bearing Design",* Butter worth-Heinemann (1983).
5. Barwell P T, *"Bearing Systems, Principles and Practice",* 1st Edition, Oxford University Press, New York (1980).

			L	T	P	Credit
MEX-532	**Industrial Safety and Environment**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Develop a broad base knowledge in science. Apply knowledge to anticipate, recognize, and quantify agents, factors, and stressors generated by and/or associated with defined sources, unit operations, environmental processes, & work tasks.
CO 2	Develop an ability to analyse, evaluate, management systems and programs to prevent hazardous acts and conditions that lead to loss events. The programs will include cost/benefit analysis, training programs, etc.; Develop and evaluate appropriate strategies designed to mitigate risk.
CO 3	Evaluate and recommend engineering, administrative, and personal protective equipment controls or other interventions to reduce or eliminate hazards; Recognize important professional, ethical, social, cultural, global, and current issues impacting worker health and the environment.
CO 4	Interpret and apply current applicable occupational and environmental regulations; Participate as a team player in the development of scientific reports, and technical summaries; Effectively communicate verbally and in writing using computers and state of the art media; and Recognize the importance of continuous and ongoing learning.

Detailed Syllabus:

Safety: Meaning & need for safety. Relationship of safety with plant design, equipment design and work environment. Industrial accidents, their nature, types and causes. ssessment of accident costs; prevention of accidents. Industrial hazards, Hazard identification techniques, Accident investigation, reporting and analysis. Safety and economics, safety and productivity. Employees participation in safety. Safety legislation .
Environment: Environmental factors in industry. Effect of temperature, Illumination, humidity noise and vibrations on human body and mind. Physiology of heat regulation. Thermal environment and its measurement. Thermal comfort. Indices of heat stress. Thermal limits for comfort, efficiency and freedom from health risk. Natural ventilation. Mechanical ventilation. Air conditioning Process ventilation. Control of heat exposures, control at source, insulation, and local exhaust ventilation. Control of radiant heat, dilution ventilation. Local relief.
Industrial Lighting: Purpose of lighting, benefits of good illumination. Phenomenon of lighting and safety. Lighting and the work. Sources and types of artificial lighting. Principles of good illumination. Recommended optimum standards of illumination. Design of lighting installation.
Noise and Vibrations: Continuous and impulse noise. The effect of noise on man. Noise measurement and evaluation of noise. Noise isolation. Noise absorption techniques. Silencers vibrations: Effect, measurement and control measures. Measurement and mitigation of physical and mental "fatigue" Basics of environment design for improved efficiency and accuracy at work.

Books Recommended

1. Krishnan N V, *"Safety management in Industry",* Jaico Publishing House, Delhi (1993).
2. Kocurek Dianna and Woodside Gayle, *"Environment, Safety, and Health Engineering"*, John Wiley and Sons, New York (1997).
3. McCormick J, *"Human Factors in Engineering and Design"*, Tata McGraw Hill Publishing Company Limited, New Delhi (1979).
4. Willie Hammer, Dennis Price, "Occupational Safety Management and Engineering", 5th Ed., Pearson Education (2000).
5. David Goetsch, "The Safety and Health Handbook", Pearson Education (1999).

			L	T	P	Credit
MEX-533	**Cryogenics**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: Refrigeration and Air Conditioning (MEX-401)
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Describe various methods to produce low temperature and phenomena's at cryogenic temperature.
CO 2	Understand the working principle of different cryogenic refrigeration and liquification system.
CO 3	Understand the functions and working principles and various low temperature measuring and storing device.

Detailed Syllabus:

Introduction: Historical review, application areas, properties of cryogenic fluids.
Cryogenic Liquefaction System: Refrigeration and liquefaction cycles, ideal cycle, actual liquefaction cycles.
Cryogenic Refrigeration Systems: Joule Thompson, striling, Gifford – McMahon, magnetic refrigeration system.
Air Separation System: Linde and Claude system for air liquefaction.
Components of cryogenic systems: Heat exchanges, expanders, compressors, storage dewars and transfer lines.

Books Recommended
1. Barron R F, *"Cryogenic Systems",* Oxford (1983).
2. Jacobsen T R, *"Thermodynamics Properties of Cryogenic Fluids"*, Plenum, London (1997).
3. Thomas M, *"Cryogenic Engineering",* (1997).
4. HeselDen G G, *"Cryogenic Fundamentals"*, Academic Press, London (1971).
5. Flynn T M, *"Cryogenic Process Engineering",* Plenum (1989).

			L	T	P	Credit
MEX-534	**Power Plant Engineering**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To be familiar with basics of power plant and functioning of thermal, gas turbine and hydro power plant along with various components and their functions.
CO 2	To be able to analyze different types of steam cycles and operating procedure of thermal power plant as well as estimate efficiencies in a steam power plant.
CO 3	To be familiar with basic working principles of gas turbine and hydro power plant and define the performance characteristics and components of such power plants.
CO 4	To be familiar with types, principles of operations and applications of steam turbines, steam generators, condensers, feed water and circulating water systems.
CO 5	To be able to define terms and factors associated with power plant economics. Estimate the cost of producing power per kW.

Detailed Syllabus:

Introduction: Power plant, classification, steam power plant, gas turbine, based, I C Engine based, nuclear power based, hydropower.
Steam Power Plant: Components of steam power plant, carnot cycle, Rankine cycle, Different methods to improve the efficiency of steam power plant, regeneration, reheating of steam, regenerative feed water heating. Supercritical pressure cycle, cogeneration of power and process heat.
Combined cycle power generation: Binary vapour cycles, coupled cycles, gas turbine – steam turbine power plant, MHD – Steam power plant, thermionic steam power plant. Fuels and Combustion: Various types of fuels, coal, fuel oil, natural and petroleum gas, synthetic fuels, biomass, combustion process, combustion equipments like cyclone furnace, fluidized bed combustion.
Steam Generators: Classification, fire tube boiler, water-tube boilers, economizers, super heaters,air prehater, deaeraton, boiler blowdown, air handling system, electrostatic precipitators.
Steam Turbines: Types of turbines, Impulse and Reaction, compounding in turbine, pressure, velocity compounding.
Condensers: Direct contact condensers, surface condensers, cooling towers, cooling tower calculations.
Gas Turbine Power Plant: Components of gas turbine based power plant, open cycle and closed cycle, methods to increase the efficiency of gas turbine plant like intercooling, reheating and regeneration.
Hydro Power Plant: Classification of water turbines, construction and working of Pelton Francis and Kaplan turbines.
Economics of Power Generation: Load duration curves, power plant economics, location, Indian energy scenario.

Books Recommended

1. Wiesman J and Eckart R, *"Modern Power Plant Engineering"*, Prentice Hall,New Delhi (1985).
2. Nag P K, *"Power Plant Engineering",* Tata McGraw Hill,New Delhi (1998).
3. Kostyuk.A and Frolov V, *"Steam and Gas Turbines",* Mir Publishers, Moscow (1988).
4. Aschner F S, *"Planning Fundamentals of Thermal Power Plants",* John Wiley (1978).
5. Eastop T D and McConkey, *"Applied Thermodynamics",* Longman Scientific and Technical (1986).

			L	T	P	Credit
MEX-535/MEX-677	**Finite Element Methods**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Review the mathematical knowledge studied in previous semester.
CO 2	To understand the advantage of discreatization of the object.
CO 3	To develop familiarities with FEM software.
CO 4	To develop program for solving the problems.

Detailed Syllabus:

Fundamentals of the Finite Element Method, discritization of the domain, one-two and three dimensional elements and interpolation functions, local and global coordinates, properties of interpolation functions, compatibility and completeness requirements, Assembly and boundary conditions; Formulation for FEM solutions.Application to solid mechanics, vibrations, plates and shell problems.

Books Recommended

1. Desai and Abel, *"Introduction to Finite Element Method",* East West, CBS Delhi (1987).
2. Zienkiewicz O C, *"Finite Element Method",* McGraw Hill (1989).
3. Krishnamurthy C J, *"Finite Element Method – Analysis Theory and Programming",* Tata McGraw Hill (1994).
4. Bathe k J, *"Finite Element Procedures",* Prentice Hall of India Private Limited, New Delhi, (1996).
5. Belegundu Ashok D and Chandrupatla T, *"Introduction to Finite Element Method",* PHI Private Limited, New Delhi (2003).

			L	T	P	Credit
MEX-536	**Experimental Stress Analysis**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: Mechanics of Deformable Bodies (MEX-206), Design of Machine Elements (MEX-301)

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	The course is designed to provide practical knowledge and applications in experimental stress analysis. Students utilize current techniques to measure and analyze stress magnitudes and distributions.

Detailed Syllabus:

Basic Elasticity: Laws of stress transformation, principal stresses and principal planes. Cauchy's stress quadric strain analysis, strain equations of transformation, stress-strain relationship.

Photo elasticity Method:

Two dimensional photoelasticity: Behaviour of light, Stress optics law, plane and circular polariscope, dark and light field arrangement, fringe multiplication, compensation techniques, commonly employed photo elastic materials.

Three dimensional photoelasticity: Newman's strain optic relationship, stress freezing in model materials for three dimensional photoelasticity, shear difference method for stress separation.

Coating:

Birefringence coatings: sensitivity, reinforcing effects, thickness of birefringence coatings.

Brittle coatings: Introduction, coating stresses and failure theories, different types of crack patterns, crack detection, composition of brittle coatings, coating cure, influence of atmospheric conditions, effects of biaxial stress field.

Electric resistance strain gauge: Gauge construction and installation, temperature compensation, gauge sensitivities, gauge factor, corrections for transverse strain effects, factors effecting gauge relation, rosetters, Rosetre analysis, potentiometer and whetstone's bridge circuits for strain measurement.

Books Recommended

1. Dally J E and Rilley W P, *"Experimental Stress Analysis",* 3rd Edition, McGraw Hill, New Delhi (1991).

2. Dove R C and Adams P H, *"Experimental Stress Analysis and Motion Measurement",* McGraw Hill, New York (1978).

3. Holister C S, *"Experimental Stress Analysis",* 5th Edition, Cambridge University Press (1987).

4. Dally J E and Rilley W P, *"Introduction to Photomechanics",* Prentice Hall Inc, NJ (1981).

5. Mubeen A, *"Experimental Stress Analysis",* 1st Edition Dhanpat Rai and Sons, New Delhi (1997).

			L	T	P	Credit
MEX-630/MEX-687	**System Dynamics & Control**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Understanding the concept of physical systems in multi-energy domains and modeling their dynamics through the unified approach of Bond graph.
CO 2	Understanding the concept of causality and its implications for deriving system equations from bond graph models.
CO 3	Understanding and applying principles of classical and modern control theory to the control of multi-energy physical systems.
CO 4	Ability to simulate models of multi-energy physical systems and analyse their response through case studies.

Detailed Syllabus:

Introduction to Physical System Dynamics
Modeling of Physical System Dynamics: A Unified Approach: Physical systems, Introduction to Bond graphs, Ports, Bonds and Power; Elements of Bond graphs, 1-port elements – resistor R, Stiffness C, and Inertia I, Source of Effort Se and Flow Sf; 2-port elements – Transformer TF and Gyrator GY, with modulation, Junction elements 1 and 0; Causality: Causality for basic 1-port and multi-ports. Derivation of System equations from Bond graphs in first order state space form.
Bond graph modeling of multi-energy systems:
Mechanical Systems, Translation and rotation (about a fixed axis), Electrical Systems, Electromechanical Systems, Fluid systems, Transducer models – cylinder, rack and pinion, electromechanical transducers - motors, pumps – positive displacement and centrifugal pump, gear trains, etc.
Analysis of linear systems:
Free and forced response for first and second order systems, Undamped and damped oscillator, Derivation of Signal flow graphs from Bond graphs, Derivation of Transfer functions, Bode plots
State variable analysis:
State transition matrix, Characteristic equation, Eigen values and Eigen vectors, Their impact on system response, Similarity transformations and their properties, Controllability and Observability, Canonical forms: Controllable, Observable, Diagonal.
Stability Criteria:
Routh-Hurwitz criterion, Liapunov stability criteria.
Controllers:
Pole-placement method, Proportional Integral and Derivative feedback.
Simulation and case studies:
Computer simulation of Dynamic Systems using Bond graphs.

Recommended Books
1. Karnopp, Margolis, Rosenberg, System Dynamics: Modeling and Simulation of Mechatronic Systems, Fourth Edition, Wiley (Higher education), 2005.

2. Karnopp, Margolis & Rosenberg, System Dynamics: A Unified Approach, Wiley , 1990.
3. Amalendu Mukherjee & R. Karmakar, Modeling & Simulation of Engineering Systems through Bond Graphs, Narosa, 2000.
4. Amalendu Mukherjee, Ranjit Karmakar and Arun Kumar Samantaray, Bond Graph in Modeling, Simulation and Fault Identification, I. K. International Publishing House Pvt. Ltd, 2006.
5. Eronini Umez-Eronini, System Dynamics & Control, Brooks/ Cole Publishing Company, 1999.
6. B. C. Kuo, Feedback Control Systems, Prentice Hall.
7. K. Ogata, Modern Control Engineering, Prentice Hall.
8. Bernard Friedland, Control Systems Design, McGraw-Hill.

			L	T	P	Credit
MEX-631	**Robotics: Mechanics and Control**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None

Course Assessment Method: Both continuous and semester end examination.

Topics to be covered: All.

Course Outcomes: At the end of the course the student will be able to:

CO 1	Understand the importance of robotics and its impact on human safety, quality of life, economy, environment.; basics of open ended type robotic manipulators.
CO 2	Understand the kinematics and dynamics of open ended robotic mechanism; Fixing frames using the Denavit-Hartenberg convention, Jacobian, singularity, Newton-Euler formulations for dynamics of rigid body systems.
CO 3	Ability to formulate, derive, analyse and synthesize kinematics and dynamics of open ended robotic mechanisms.
CO 4	Understand and apply detailed concepts relating to various actuators, sensors, and their integration with drives and signal conditioning for robotics.
CO 5	Understanding concepts of feedback control of robotic manipulators based on modern control theory;PID Control; and applying them to Joint control and trajectory control.

Detailed Syllabus:

Introduction to Robotics:

Kinematics and Dynamics of Robotic linkages (open ended type manipulators):

Frames, Transformations: Translation and rotation, Denavit-Hartenberg parameters, Forward and Inverse Kinematics, Jacobian, Dynamics: Equations of motion, Newton-Euler formulation.

Sensors and actuators:

Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezo electric accelerometer, Hall effect sensors, Optical Encoders, Pneumatic and Hydraulic actuators, servo valves, DC motor, stepper motor, drives.

Control of Manipulators:

Feedback control of II order Linear systems, Joint control, Trajectory control, Controllers, PID control.

Recommended Books

1. John J. Craig, *Introduction to Robotics: Mechanics and Control*, Addison-Wesley, 2005.
2. Tsuneo Yoshikawa, *Foundations of Robotics*, MIT Press, 1990.
3. Saeed B. Niku, *Introduction to Robotics: Analysis, Systems, Applications*, Pearson Education Inc., 2001
4. Spong M. W., and Vidyasagar M., *Robot Dynamics and Control*, John Wiley & Sons, 1989.
5. Murray R. M., et al, *A Mathematical Introduction to Robotic Manipulation*, CRC Press, 1994.
6. Waldron K. J., and Kinzel G. L., *Kinematics, Dynamics and Design of Machinery*, John Wiley & Sons, 2004.
7. Eronini Umez-Eronini, *System Dynamics & Control*, Brooks/ Cole Publishing Company, 1999.

8. Amalendu Mukherjee, Ranjit Karmakar and Arun Kumar Samantaray, *Bond Graph in Modeling, Simulation and Fault Identification*, I. K. International Publishing House Pvt. Ltd, 2006.

			L	T	P	Credit
MEX-632	**Computational Fluid Dynamics**	**Department Elective**	**3**	**0**	**0**	**3**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	To enable the students to understand different problem solving techniques theoretically and appreciate the importance of mathematics in engineering problem solutions.
CO 2	To illustrate different techniques to solve continuous formulations in differential form and transform them to discrete formulations using different discretization techniques like, FDM, FEM and FVM.
CO 3	To make students understand that FVM is most appropriate technique for developing discrete formulations and discuss the same technique in detail.
CO 4	To make students aware of different algorithms to solve numerically the fluid dynamics problems.
CO 5	To make students understand the utility of using commercial codes like, FLUENT and CFX and compare the competence of these codes with the dedicated codes written for engineering problems.

Detailed Syllabus:

Review of basic fluid mechanics and the governing Navier-Stokes equations, Techniques for solution of PDEs – finite difference method, finite element method and finite volume method, Finite volume (FV) method in one-dimension, Differencing schemes, Steady and unsteady calculations, Boundary conditions, FV discretizationin two and three dimensions, Simple algorithm and flow field calculations, variants of SIMPLE, Turbulence and turbulence modeling, illustrative flow computations, Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

Recommended Books:

1. S V Patankar, *Numerical Heat Transfer and Fluid Flow*, McGraw Hill, NY, (2005).
2. John Anderson, "*Computational Fluid Dynamics*", McGraw-Hill Publication, First edition (February 1, 1995).
3. W M Kays and M E Crawford, *Convective Heat and Mass Transfer*, Mc-Graw Hill, New York (1993).
4. F M White, *Viscous Fluid Flow* by, Mc-Graw Hill, New York, 2nd Ed. (1991).
5. Robert Siegel and John Howell, *Thermal radiation Heat Transfer*, 4th Edition, Taylor and Francis NY, (2002).

MEX-633	Operations Research	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Illustrate the need to optimally utilize the resources in various types of industries.
CO 2	Apply and analyze mathematical optimization functions to various applications.
CO 3	Demonstrate cost effective strategies in various applications in industry.

Detailed Syllabus:

Overview: Introduction**,** Definition, characteristics and scope of O.R., Objectives of O.R., Phases and models in O.R.
Linear Programming: Introduction, Concept of linear programming, Graphical method, Simplex method, Big M method, Dual simplex method, Two-phase method, Duality in linear programming.
Transportation Problem: Introduction, Mathematical models for T.P., Formulation and solution of balanced and unbalanced T.P., Transshipment models.
Assignment Models: Definition, Comparison with transportation model, Mathematical representation of assignment models, Formulation and solution of assignment models, Variations of the assignment problem and alternate optimal solutions.
Sequencing Models: Processing n jobs through two machines, processing n jobs through three machines, processing two jobs through m machines, processing n jobs through m machines, Travelling salesman problem.
Inventory Control: Purchase model with instantaneous replenishment and with and without shortages, Manufacturing model with and without shortages, Quantity discount.
Queueing Theory: Introduction, Terminologies of queueing system, Emperical queueing models.
Replacement Models: Replacement of items that deteriorate with time, Replacement of items that fail suddenly, Individual and group replacement.
Game Theory: Introduction and terminologies of game theory, games with pure and mixed strategies.
CPM and PERT: Basics steps in PERT and CPM, PERT and CPM computations, Cost analysis, Contracting and Updating, Resource Scheduling.

Books Recommended :
1. Panneerselvam R, “Operations Research”, PHI, 2002.
2. Tulsian P.C., Pandey Vishal, “Quantitative Techniques”, Pearson Education, 2002.
3. Wagner, “Principles of Operations Research”, Prentice-Hall India, 2000.

MEX-634	Fundamentals of Combustion	Department Elective	L	T	P	Credit
			3	0	0	3

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: At the end of the course the student will be able to:

CO 1	Understanding of basic dimensional units applied in the analysis of combustion systems.
CO 2	Understanding of the basics of equilibrium processes that impact on combustion.
CO 3	Understanding of the basics of combustion kinetics and mechanisms.
CO 4	Understanding of how fuel/waste characteristics affect important system behaviour and operational parameters
CO 5	Application of combustion engineering analysis principles to waste, boilers, burners, etc.
CO 6	Application of kinetic principles in the analysis of combustion systems.

Detailed Syllabus:

Introduction. Chemical thermodynamics and chemical kinetics. Conservation equations for multi-component systems. Premixed systems - detonation and deflagration, laminar flames, effects of different variables on burning velocity, methods for measuring burning velocity, flammability limits, ignition and quenching turbulent pre-mixed flames. Non-premixed systems: laminar diffusion flame jet, droplet burning. Combustion of solids: drying, devolatilization and char combustion. Practical aspects of coal combustion. Review of combustion fundamentals. Gas-fired furnace combustion. Oil-fired furnace combustion. Gas turbine spray combustion. Combustion of solids. Industrial applications involving combustion. Burner design, testing and control. Emissions. Combustion safety.

Books Recommended:

1. Stephen R. Turns, *An Introduction to Combustion: Concepts and Applications*, 2nd Edition, Mc-Graw Hill, (2005).
2. Kenneth Kuan-yun Kuo, *Principals of Combustion*, John Wiley and Sons, NY (2005).
3. Charles E Baukal Jr., *Industrial Burners Hand Book*, CRC Press, Boca Raton, New York (2004).
4. Charles E Baukal Jr., *Heat Transfer in Industrial Combustion*, CRC Press, Boca Raton, New York Ed. (2005)
5. N H Afgan and J M Beer, *Heat Transfer in Flames*, Scripta Book Co., Washington D C (1974)