DEPARTMENT OF MECHANICAL ENGINEERING

SCHEME OF INSTRUCTIONS AND SYLLABUS FOR POST GRADUATE STUDIES

M. Tech. in CAD-CAM Engineering

Visvesvaraya National Institute of Technology, Nagpur

February 2016

MISSION AND VISION
OF
VISVESVARAYA NATIONAL INSTITUTE OF TECHNOLOGY, NAGPUR

MISSION

The Mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. V.N.I.T. is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

VISION

To contribute effectively to the national endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country, incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

MISSION AND VISION
OF
DEPARTMENT OF MECHANICAL ENGINEERING, V. N. I. T. Nagpur

VISION

The visiob of the department is to produce quality human resources of high standard in mechanical engineering who can contribute favorably to the technological and socio economic development of the nation.

MISSION

Mission of the Department of Mechanical Engineering is

1. **To develop state of the art facilities related to mechanical engineering**
2. **To attract highly qualified faculty to the department**
3. **To promote participation of industries in academics, research and consultancy**
4. **To undertake research at regional and national level**

Department of Mechanical Engineering offers three M. Tech program, namely, ***M. Tech. in CAD-CAM Engineering, Heat Power Engineering and Industrial Engineering***. These are four semester program, wherein student has to complete certain number of credits as indicated in Table 1. Each subject (or course) has certain number of credits. There are two types of subjects: Core and elective. Core courses are compulsory and some courses from electives are to be taken to complete the required credits.

TABLE 1. CREDIT REQUIREMENTS FOR CAD-CAM

Postgraduate Core (PC)		**Postgraduate Elective (PE)**	
Category	Credit	Category	Credit
Departmental Core (DC)	36	Departmental Electives (DE)	16
Basic Science (BS)	00	Other Courses (OC)	00
Total	36	Total	16
Grand Total PC + PE			52

The number of credits attached to a subject depends on number of classes in a week. For example a subject with 3-1-0 (L-T-P) means it has 3 Lectures, 1 Tutorial and 0 Practical in a week. This subject will have eight credits (3x1 + 1x1 + 0x1 = 4). If a student is declared pass in a subject, then he/she gets the credits associated with that subject. Depending on marks scored in a subject, student is given a Grade. Each grade has got certain grade points as follows:

Grades	AA	AB	BB	BC	CC	CD	DD	FF
Grade Points	10	09	08	07	06	05	04	Fail

The performance of a student will be evaluated in terms of two indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. SGPA & CGPA are:

$$\boldsymbol{SGPA} = \frac{\sum_{semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ except\ audit}{\sum_{semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

$$\boldsymbol{CGPA} = \frac{\sum_{All\ semester}(Course\ credits\ X\ Grade\ points) for\ all\ courses\ with\ pass\ grade\ except\ audit}{\sum_{All\ semester}(Course\ credits\ ) for\ all\ courses\ except\ audit}$$

Students can Audit a few subjects. i.e., they can attend the classes and do home work and give exam also, but they will not get any credit for that subject. Audit subjects are for self enhancement of students.

Details about Faculty members teaching to M.Tech. CAD-CAM

Name of Faculty Member	Designation	Qualifications	Areas of specialization
P.M. Padole	Professor	Ph.D.	Machine design, FEM, Mechanisms and Stress analysis
Animesh Chatterrjee	Professor	Ph.D.	Mechanical vibrations, Composites, Control Systems
A.M. Kuthe	Professor	Ph.D.	Layered Manufacturing, Bio-Medical Engineering
Y.M. Puri	Associate Professor	Ph.D.	Unconventional manufacturing, Computer aided and integrated manufacturing
A.B.Andhare	Associate Professor	Ph.D.	Machine Condition Monitoring, Manufacturing Processes
R.V. Uddanwadiker	Assistant Professor	Ph.D.	Bio-Mechanics
H.P.Jawale	Assistant Professor	Ph.D.	Measurements and Design
S.S. Chiddarwar	Assistant Professor	Ph.D.	Robotics, Artificial Intelligence, Machine Vision and Automation
A.K.Singh	Assistant Professor	Ph.D.	Contact and friction mechanics, Tribology,
A.A. Thakre	Assistant Professor	M.Tech.	Tribology, Optimization
M.S. Kotambkar	Assistant Professor	Ph.D.	Vibrations, FEM and Machine Design
T.V.K. Gupta	Assistant Professor	Ph.D.	Manufacturing Engineering
D. Ravikumar	Assistant Professor	Ph.D.	Surface Engineering
Gaurav Tiwari	Assistant Professor	Ph.D.	Fracture Mechanics

Scheme of Instructions for M. Tech. in CAD-CAM Engineering

I Semester				II Semester			
CORE				CORE			
Code	**Course**	**L-T-P**	**Cr**	**Code**	**Course**	**L-T-P**	**Cr**
MAL501	Advanced Mathematics	3-0-0	3	MEL523	Computer Integrated Manufacturing	3-0-0	3
MEL410	Computer Aided Design	3-0-0	3	MEL520	Non-linear optimization	3-0-0	3
MEP410	Computer Aided Design Lab	3-0-0	3	MEL418	Advanced Stress Analysis	3-0-0	3
MEL522	Computer Aided Manufacturing	3-0-0	3				
MEP522	Computer Aided Manufacturing Lab	0-0-2	1				
ELECTIVE (Any Two)				**ELECTIVE (Any one from the group)**			
MEL431	Advanced Mechanisms	3-0-0	3	MEL530 MEL510 MEL415	1. Machine Condition Monitoring 2. Manufacturing System Simulation and Design 3. Mechanical Vibrations	3-0-0	3
MEL450	Advanced Machining Processes	3-0-0	3	MEL532 MEL518 MEL526	1. Layered Manufacturing 2. Fracture Mechanics and Non Destructive Testing 3. Adhesion, Friction and Contact Mechanics	3-0-0	3
MEL407	Biomechanics	3-0-0	3	MEP532 MEP518 MEP526	1. Layered Manufacturing Lab 2. Fracture Mechanics and Non Destructive Testing Lab 3. Tribology and Dynamics Lab	0-0-2	1
MEL414	Tribology	3-0-0	3				
MEL515	Robotics and Machine Vision	3-0-0	3				
		17					**16**
III Semester				**IV Semester**			
	Core				Core		
MED401	Project Phase-I	-	3	MED503	Project Phase-II	-	9
MEL420	Finite Element Method	3+0+0	3				
MEP420	Finite Element Method Lab	0+0+2	1				
ELECTIVE (Any one)							
MEL433 MEL439 MEL437 MEL402	1. Design for Manufacturing & Assembly 2. Product Design and Development 3. Composite Materials 4. Surface Engineering	3-0-0	3				
			10				**9**

Programme Educational Objectives of M. Tech. in CAD-CAM Engineering

1. To impart concepts of computer aided design and computer aided manufacturing engineering through the use of analytical techniques, experiments, computer simulation methods, and other modern engineering tools in the analysis and design of variety of mechanical engineering systems and their industrial applications effectively.
2. Spreading the recent developments in CAD-CAM engineering field through educating the students using new technologies, softwares and recent trends in CAD-CAM.
3. To develop habit of individual critical thinking in analyzing a complex problem in the computer aided designing, manufacturing and optimization.
4. Student's capacity building in up-coming areas of research in design and manufacturing engineering.

Programme Outcomes of M. Tech. in CAD-CAM Engineering

a. Acquire knowledge of CAD-CAM engineering and be able to discriminate, evaluate, analyze and integrate existing and new knowledge
b. Be able to critically analyze and carry out independent research on complex problems of CAD-CAM
c. Be able to carry out systematic research, design appropriate experiments and tools, and interpret experimental and analytical data for development of technological knowledge in CAD-CAM engineering
d. Be able to function productively with others as part of collaborative and multi-disciplinary team
e. Be able to communicate effectively with written, oral and visual means, the design and research outcomes to the stakeholders
f. Be able to recognize state-of-the-art need and will be able to engage in life-long learning
g. Be able to understand professional and ethical responsibility while carryout out research and design activities
h. Be able to critically analyze, scrutinize and rectify one's decisions and actions and apply self corrective measures

COURSE SYLLABUS FOR M.TECH. (CAD-CAM)

Course Name: MAL501– Advanced Mathematics

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments (10%), End Semester exam (60%).

Course Objectives:

1. Graduates will be able to apply knowledge of mathematics, science and engineering in the solution of Mechanical Engineering problems.
2. Graduates will demonstrate an ability to identify, formulate, analyze and solve Mechanical Engineering problems.
3. Graduates will demonstrate ability to design mechanical systems, conduct experiments, analyze and interpret the resulting data.
4. Graduates will demonstrate an ability to design a system, component to meet desired needs within the context of Mechanical Engineering and considering realistic constraints.

Syllabus:

Differential Equation : Solution of Ordinary differential equation of higher order, Frobenius method, Legendre equation, Bessel equation, Legendre Polynomials, Bessel function of first and second kin

Laplace Transform : Definition & its properties, transform of derivatives and integrals, evaluation of integrals by Laplace Transform. Inverse Laplace Transform, convolution theorem, Laplace transform of periodic function and unit step function and dirac delta function, application of Laplace transform to solve ordinary differential equation and partial differential equation-One-dimensional wave and heat equation

Partial Differential Equation: Partial differential equation of first order. Linear homogeneous partial differential equation of nth order with constant coefficient, Method of separation of variables, application to simple problem of vibration of strings and beam, to simple of vibration of rectangular membrane and one dimensional heat equation

Fourier Series : Introduction, the Fourier theorem, Evaluation of Fourier coefficients, Half Range series, considerations of symmetry, Exponential form of Fourier series, Fourier integral theorem, Fourier transform, Elementary concept of double Fourier Series.

Complex Variable : Analytical function, Cauchy-Riemann conditions, conjugate functions, singularities, Couchy's integral theorem and integral formula, Taylor's and Laurent's theorem, Residue theorem, Evolution of integral by residue theorem, Conformal mapping, mapping by Linear and Inverse transformation.

REFERENCES

1. Kreyszig, E. "Advanced Engineering Mathematics", John Wiley & Sons, 7th Edition, 1993.
2. Chandrika Prasad. "Mathematics for Engineers", Prasad Mudranalaya, 12th Edition, 1981.
3. Chandrika Prasad "Advanced Mathematics for Engineers", Prasad Mudranalaya, 7th Edition, 1972
4. Speigel, M.R. "Advanced Mathematics For Engineers and Scientists", McGraw Hill., 1992.

Course Outcomes: On completion of this course, students will be

1. Able to implement fundamentals of mathematics to CAD-CAM engineering problems
2. Able to understand importance of Laplace transform and Fourier series in real life design and manufacturing problems

Course Name: MEL410-COMPUTER AIDED DESIGN

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

(i) To understand the current available CAD hardware, software and fundamentals

(ii) To be understand finite element method for design optimization

(iii) To learn new design optimization techniques and newer techniques in CAD

Syllabus:

CAD Introduction :Need of machine design, use of computer, computer fundamentals, computer aided design process, CAD configuration, CAD tools, positive and negative points of CAD, CAD and CAM integration.

CAD Hardware: Introduction to hardware specific to CAD, CRT, Random scan technique, raster scan technique, DVST, Raster display, Display systems, sequential scanning and interiaced scan.

CAD Software: Introduction to software specific to CAD, output primitives, line generation algorithm, circle generation, plane curve, transformation, windowing and clipping, line clipping technique, geometrical modeling, CSG technique & B-rep technique.

Finite element method :Introduction, principle of minimum potential energy, types of element, shape function, elemental strain displacement matrix, types of forces, elemental stiffness matrix, elemental force matrix, assembly, truss, introduction to 2 dimensional finite element method.

Optimization: Introduction, Johnson method of optimization normal specification problem, redunant specification problem, introduction to genetic algorithm.

Newer techniques of CAD :Rapid prototyping, laser and non-laser process of rapid prototyping, STL formal of CAD file, introduction to reverse engineering and related software's viz. rapid form.

Reference Books/ Material:

1. Zeid I., "CAD / CAM problem & practice", 3rd Edition, Tata McGraw Hill, 2001.
2. Newman, Sproull. "Principles of interactive computer graphics", Mc Graw Hill book Co., 1981.
3. Bathe K.K., "Finite Element Procedures",Prentice Hall of India, 1996.
4. Kuthe A.M., "Computer Graphics including CAD, AutoCAD & C", 1st Edition,S.Chand, 2005
5. Rao P.N., "CAD/CAM principles &applications", Tata Mc Graw Hill, 2002.

Course Outcomes: Upon successful completion of this course you should be able to:

• Understand the engineering design process and its role in graphic communication process.

• Generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards.

• Use CAD software to generate a computer model and technical drawing for a simple, well-defined part or assembly.

• Fluent application of engineering techniques, tools and resources

• Effective oral and written communication in professional and lay domains

Course Name: MEP410-Computer Aided Design Lab

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(0-0-2); Credits: 1]

Type of Course: Core

Course Assessment Method: Continuous Evaluation

Course Objectives:

(i) To learn graphics software

(ii) To perform various CAD operations using software

(iii) To learn programming for analysis of mechanical elements

List of Experiments:

1. Development of software for design of any mechanical element and system.
2. Development of menu driven software for graphics using output primitives.
3. Development of software for transformation using scaling, rotation, reflection.
4. Development of software for clipping of graphical entities.
5. Development of software for analysis of one dimensional element using FEM technique.
6. Software operation of customized FEM software.
7. Development of computer program for analysis of mechanical element using FEM for user input values.
8. Development of software for analysis of stress problem using FEM.
9. Development of software for design optimization of mechanical element using Johanson method. Use of commands of any computer aided drafting software package viz. AutoCAD, Pro-engineer.

Course Outcomes:

Upon successful completion students will be able to:

(i) Operate graphics software for various Cad applications

(ii) Carry out programming for optimization of design

(iii) Use customized FEM software for real application of CAD

Course Name: MEL522- Computer Aided Manufacturing

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

Students will gain a basic understanding of computer numerical control (CNC) machining processes and operations using a combination of G-codes, milling and turning machines.

Syllabus:

CAM - concept and definition : NC (Numerical Control), CNC (Computerized Numerical Control) and DNC (Direct Numerical Control) - concept, features and differences. Advantages and limitations of CNC, Selection criteria for CNC machines.

CNC machines: Types, classification, working and constructional features. Spindle drives and axes drives on CNC machines. Machine structure- Requirements and reasons. Elements of CNC machines - Types, working and importance of: Slide ways, Re-circulating ball screw, Feedback devices (transducers, encoders), Automatic tool changer (ATC), Automatic pallet changer (APC), CNC axes and motion nomenclature.

CNC tooling : i. Tool presetting-concept and importance, Qualified tools-definition need and advantages, . Tool holders- types and applications. CNC turning and Milling centers: Types, Features, Axes nomenclature, Specification, Work holding devices -types, working and applications, Tool holding and changing devices - types, working and applications.

CNC part programming: Definition and importance of various, positions like machine zero, home position, work piece zero and program zero, programming format and structure of part program. ISO G and M codes for turning and milling-meaning and applications of important codes. Simple and Complex part programming for turning and milling using ISO format having straight turning, taper turning (linear interpolation) and convex/concave turning (circular interpolation), ISO format milling. Importance, types, applications and format for: i. Canned cycles ii. Macro iii.Do loops iv. Subroutine CNC turning and milling part programming using canned cycles, Do loops and Subroutine, Need and importance of various compensations: i. Tool length compensation. ii. Pitch error compensation. iii. Tool radius compensation. iv. Tool offset. Simple and Complex part programming using various compensations.

Recent Trends in CAM :Interfacing standards for CAD/CAM - Types and applications, Adaptive control- definition, meaning, block diagram, sources of variability and applications. Flexible Manufacturing System (FMS) - concept, evaluation, main elements and their functions, layout and its importance, applications, Computer Integrated Manufacturing (CIM) - Concept, definition, areas covered, benefits. Robotics- definition, terminology, classification and types, elements and applications. Rapid prototyping - Concept and application

Reference Books/Material:

1. Pabla B.S., Adithan M.., “CNC Machines”, New Age International, New Delhi, 2014 (reprint)
2. Quesada Robert, “Computer Numerical Control Turning and Machining centers.”, Prentice Hall 2014.
3. Groover, M. P., Zimmer, W.E., “CAD/CAM: computer aided design and manufacturing”, Prentice Hall, 2011.

4. Rao, P. N., Tiwari, N. K., Kundra, T., “Computer Aided Manufacturing.”, CBS Publ. N-Delhi, 1995.

Course Outcomes: The students which finish this course in a satisfactory manner will be able

1. To demonstrate a basic understanding of machining fundamentals including speed and feed calculations, tooling systems, and work-holding systems for CNC milling and turning equipment
2. To demonstrate a basic and advanced understanding of numerical controlled (NC) programming strategies
3. To demonstrate an ability to set-up, program, and operate CNC milling and turning equipment.
4. To demonstrate an ability to generate NC code using G-codes to machine parts to specifications.

Course Name: MEP522- Computer Aided Manufacturing Lab

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(0-0-2); Credits: 1]

Type of Course: Core

Course Assessment Method: Continuous Evaluation

Course Objectives:

Course Outcomes:

List of experiments:

Course Name: MEL431- ADVANCE MECHANISMS

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. Provide theoretical background for basic and advanced kinematics and synthesis of mechanisms to achieve desired motion.

2. Introduce basic and advanced computer-based tools for analysis and synthesis of mechanisms.

3. Provide an opportunity for students to use theory and application tools through a major mechanism design project

Syllabus:

Introduction to kinematics, types of mechanism, kinematics synthesis, science of relative motion, tasks of kinematic synthesis with practical applications, Degree of freedom, class-I, class-II chain, Harding's notation, Grashof criterion, Grubler's criterion. Introduction to position generation problem, concept of pole, two & three position generation synthesis, pole triangle, Relationship between moving & fixed pivots, Four position generation, opposite pole quadrilateral, center point & circle point curve, Burmester's point. Matrix method for position generation problem, rotation matrix, displacement matrix.

Introduction to function generation problem, co-ordination of input-output link motion, relative pole technique, inversion technique, overlay technique, graphical synthesis of quick return mechanisms for optimum transmission angle. Types of errors, accuracy points cheby shev's spacing and frudenstein's equation. Introduction to path generation problem, synthesis for path generation with and without prescribed timing using graphical method. Coupler curves, cognate linkages, Robert's law of cognate linkages. Complex number method for path generation problem 3 precision point. Synthesis for infinitesimally separated position, concept of polode and centrod, Euler's savery equation, inflection circle, Bobbilier and Hartman's construction. Optimal synthesis of planer mechanisms, least square method. Introduction to spatial mechanisms, D-H notations, Introduction to kinematic analysis of robot arms.

Reference Books/Material:

1. Tad D.C, "Applied linkage synthesis", Addison Wesley publication , 1964.
2. Sandor G.N., Erdman, A. G, "Advanced mechanism design", Prentice Hall Inc, 1984
3. Suh C.H., Radcliff C.W ," Kinematics and mechanisms design", John Wiley &Sons., 1978.

Course Outcomes:

1. Students gain a solid theoretical background in kinematics and in the analysis and synthesis of mechanisms.
2. Students become familiar with basic and advanced computer-based engineering tools for the analysis and design of linkages.
3. Students have the ability to apply theory and the use of practical engineering tools in a substantial mechanism design project.

Course Name: MEL450- ADVANCED MACHINING PROCESSES

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives :

The aim of the course is to enrich the fundamentals of machining processes both conventional and unconventional processes. The course elaborates the mathematical formulations of various machining processes and analyse the influence of various process parameters in each process. This also enables the student to understand the process and further the course provides an insight to choose his research career.

Syllabus :

Advanced Metal Cutting and Grinding :Modeling of cutting process: Review of cutting mechanism; Cutting force model; Oblique Cutting; Temperature analysis (Finite Difference Method); Wear model; Evaluation of surface quality; Cutting processes for producing various shapes

Gear machining: Hobbing , Modeling of grinding process: Grinding force model; Temperature analysis; Wheel life model., Introduction of finishing process: Machining mechanism in finishing: Honing, Lapping, Super finishing, etc.

Micro-Nano Precision Machining: Introduction to nano-precision mechanical manufacturing: M4 processes

Nano-precision cutting: Machine & tool; Brittle / ductile transition; Ductile mode cutting of brittle materials

Nano-precision grinding: Machine & grinding wheel; Truing & dressing; Cutting edge evaluation; Applications to extreme optics, Nano-precision polishing: Conventional polishing; Non-conventional polishing; Plane honing; Field-assisted fine finishing

Unconventional Machining Processes :Electric Discharge Machining (EDM); Electron Beam Machining (EBM); Plasma Arc Machining (PAM); Laser Beam Machining (LBM); Ultrasonic Machining (USM); Abrasive Jet Machining (AJM); Water Jet Cutting (WJC), Abrasive Water Jet Machining (AWJM); Electro-Chemical Machining (ECM); Chemical Machining (CHM)

Reference Books / Material:

1. Boothroyd, G and Knight, W A., “Fundamentals of Machining and Machine Tools”, 3rd Third Edition, Saint Luice Pr, 2005.
2. G.F. Benedict, “Non-traditional Manu. Processes”, Marcel Dekker, Inc. New York, 1987.
3. P.C. Pandey, and H.S. Shan, “Modern Machining Processes”, Tata McGraw-Hill Publishing Co. Ltd, New Delhi, 1980.
4. J.A. McGeough, “Adv. Methods of Machining”, Chapman and Hall, London, 1988.

Course Outcomes:

At the end of course the students will be able to:

1. Illustrate advanced machining processes, cutting tools and cutting fluids for a specific material and part features.
2. Relate Generation and control of electron beam for machining, laser beam machining, comparison of thermal and non-thermal processes
3. Differentiate Thermal Metal Removal Processes, characteristics of spark eroded surface, machine tool selection and various finishing techniques.

Course Name: MEL407- BIOMECHANICS

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To understand the basic machines of human body
2. Application of Engineering tools and softwares for the betterment of society
3. To understand and analyze human body as a mechanical assembly of linkages.

Syllabus:

Definition of Biomechanics, Selected Historical highlights, The Italian Renaissance, Gait century, Mechanics, Newton's laws of motion, Equation of motion for rigid Body. Biological materials, Brief Anatomy, Bone, cartilage, ligament, tendon, Muscles, their physical properties, degree of freedom of joints. Dental Biomechanics, Function of dentin, pulp, periodontal ligament. prosthodontistry, orthodontistry. Measuring techniques for force, pressure distribution, acceleration, Optical methods, strain measurement, inertial properties of human body. General considerations for modeling, types of model, validation of model, force system analysis, assumptions, free body diagrams, Simulation, Numerical solution methods, Muscle models, modeling of external forces, optimization studies, simulation as a scientific tool. Introduction Biomedical engineering, application of advanced engineering techniques to human body, case studies.

Reference Books/Material:

1. Nigg, B.M.and Herzog, W., "BIOMECHANICS of Musculo skeleton system", John Willey & Sons, 1st Edition.
2. Saltzman, W.L., "BIOMEDICAL ENGINEERING: Bridging medicine and Technology", Cambridge Text, First Edition.
3. Winter, D., "BIOMECHANICS and Motor Control of Human Movement", WILEY Interscience Second edition

Course Outcomes:

1. Apply a broad and coherent knowledge of the underlying principles and concepts of biomechanics, particularly in the fields of kinematics and kinetics as applied to human and projectile motion.
2. Safely and effectively use biomechanics instrumentation and equipment to record and assess human and object motion.
3. Record, extract and analyse key information about teeth, muscles, bones etc.

Course Name: MEL414- TRIBOLOGY

Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives :

1. To understand basic lubrication mechanism and various lubrication systems.
2. To understand the friction and wear phenomenon
3. To understand the concept of nano tribology and green tribology and its application for various mechanical systems or processes.

Syllabus :

Component, Selection, Design and Performance Bearings : Selection criterion of journal, Antifriction bearings, thrust bearings; dry rubbing bearings, general design considerations and procedure of these bearings. Study of special types of bearings : Porous metal bearing, Hydrostatics bearings, gas bearings, crankshaft bearings. Oscillatory journal bearings, spherical bearings, universal couplings. Study of following machine elements from the point of view of friction, gear and lubrication, cams, all types of gears, power transmission chain, clutches and brakes. Design of following from the point of view of friction, gear and lubrication: wire cables / control cables, slides, valves, piston rings, cylinders & liners, seals. Gear: Analytical methods of gear analysis, zero and non-zero gear consideration, gear measuring methods, gear resistant parts, material selection, hard surface coatings: selection and applications. Lubricants: Selection of lubricant type, oils, gases, solid lubricants and coatings, other liquids. Lubrication of components: Plain bearings, antifriction bearings, gears, cams, roller chains, slides, couplings, wire ropes.

Lubrication Systems : Selection of systems, circulation systems, storage tank, pumps, filters, centrifuges warning & protection devices heaters and coolers, miscellaneous. Constructions like lubricant change periods, tests, deterioration, hazards.

Reference Books / Material:

1. Wilcock, B., "Bearing Design & Application," McGraw Hill Co, 1st Edition, 1957
2. "Bearings Reference Issue", NRB Bearing Mumbai, 1999
3. Wen Shizhu and Huang Ping, "Principles of Tribology", Wiley, Third Edition, 2011
4. Bhushan, B., "Introduction to Tribology," Wiley, 2nd Edition, March 2013

Course Outcomes:

The focus of Tribology & Lubrication is the fundamentals of interfacial contact, adhesion, friction, wear and lubrication. By the end of the course student should:

•Have a knowledge of surface topography and know how to model a rough engineering surface

•Have a clear overall picture about the basics of tribology and related sciences, theoretical background about processes in tribological system, mechanisms and forms of interaction of friction surfaces

•Understand Hertz contact and rough surface contact

•Be familiar with adhesion theories and the effect of adhesion on friction and wear

•Have a mastery of the friction/lubrication mechanisms and know how to apply them to the practical engineering problem

Course Name: MEL515- Robotics and Machine Vision
Pre-requisites: Nil

Offered in: I Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To gain fundamental skills in industrial robotics and mobile robotics
2. To obtain knowledge and understand basic concepts of industrial robotics, in terms of classification, kinematics, in terms of classification, kinematics, sensors and actuators, dynamics and motion planning for typical application.
3. To attain the principles of machine vision including image processing and its application to robot control and motion planning

Syllabus:

Industrial Robots: Frame assignment, DH parameters, forward kinematics, Inverse kinematics, Differential motion, Dynamics and Control

Mobile Robots: Mobile robot vehicles, Mobile robot kinematic and dynamic analysis, trajectory planning, mobile robot localization and navigation

Motion Planning : Configuration space approach, Disc in 2-D workspace, Polygonal robot translating in 2-D workspace, Minkowski sum, Configuration Space Obstacle, The Topology of Configuration Space, Search algorithms: breadth first, depth first, A* algorithm, Incremental A* algorithm

Machine Vision: Light and Color, Image forming, Image processing, Image feature Extraction, Using multiple images, vision based control, advanced visual servoing

Reference Books / Material:

1. K. S. Fu, R. C. Gonzalez, and C. S. G. Lee, Robotics - Control, Sensing, Vision, and Intelligence, McGraw-Hill Book Company, 1987.
2. Rafael C. Gonzalez, and Richard E. Woods: Digital Image Processing, Prentice Hall, 2nd Edition, 2001.
3. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer, 2011.".

Course Outcomes:
On completion of the course students shall be able to:
1. derive the kinematics for robot manipulators including direct and inverse kinematics
2. analyze robot dynamics for control of serial links for robot manipulators
3. give an account of the basic theories of machine vision and image processing
4. apply robotics and visual sensing technologies to engineering applications

Course Name: MEL523- COMPUTER INTEGRATED MANUFACTURING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
This course aims to acquaint the students with principles, concepts and techniques that are essential in Computer Integrated Manufacturing

Syllabus:

Manufacturing Automation: Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Strategies-The USA Principle, Ten Strategies for Automation and Process Improvement, Automation Migration Strategy. Automated Flow lines: System Configurations, Workpart Transfer Mechanisms, Storage Buffers, Control of Production Line, Analysis of Transfer Lines-Transfer Lines with No Internal Parts Storage, Transfer Lines with Internal Storage Buffers. Manual Assembly Lines: Assembly Workstations, Work Transport Systems, Line Pacing, Coping With Product Variety, Analysis of Single Model Assembly Lines-Repositioning Losses, The Line Balancing Problem, Line Balancing Algorithms-Largest Candiate Rule, Kilbridge and Wester Method, Ranked Positional Weights Method. Automated Assembly Systems: System Configurations, Parts Delivery at Workstations, Applications, Quantitative Analysis of Assembly Systems- Parts Delivery System at Workstations, Multi-station Assembly machines, Single Station Assembly Machines, Partial Automation. Automatic Material Handling and Storage systems: Design Considerations in Material Handling, Material Transport Equipment-Industrial Trucks, Automated Guided Vehicles, Monorails and Other Rail-Guided Vehicles, Conveyors, Cranes and Hoists, Analysis of Vehicle Based Systems, Conveyor Analysis. Automated Storage/Retrieval Systems, Carousel Storage Systems, Engineering Analysis of AS/RS and Carousel Systems. Automated Inspection systems: Overview of Automated Identification Methods, Bar Code Technology, Radio Frequency Identification, Other AIDC Technologies-Mangnetic Stripes, Optical Character Recognition, and Machine Vision. Cellular Manufacturing Systems: Part Families, Parts Classification and Coding, Features of Parts Classification and Coding Systems, Opitz of Parts Classification and Coding Systems, Production Flow Analysis, Composite Part Concept, Machine Cell Design, Applications Of Group Technology, Quantitative analysis of Cellular Manufacturing, Grouping of parts and Machines by Rank Order Clustering, Arranging Machines in a GT Cell. Computer Aided Process Planning: Retrieval CAPP Systems, Generative CAPP Systems, Feature Identification- Algorithms, Graph Based Approach, Attribute Adjacency Graph, Benefits of CAPP. Flexible Manufacturing Systems: Flexibility, Types Of FMS-A Dedicated FMS, A Random Order FMS, FMS Components-Workstations, Material Handling and Storage Systems, Computer Control System, Human Recourses, FMS Applications and Benefits Computer Integrated Manufacturing: The Scope of CAD/CAM and CIM, Computerized elements of a CIM System, Components of CIM, Database for CIM, Planning , Scheduling and Analysis of CIM Systems.

Reference Books / Material:

1. Mikell P Groover, " Automation, production Systems and Computer Integrated Manufacturing,"
3rd Edition, Prentice Hall Inc., New Delhi, 2007.

2. Nanua Singh, "System Approach to Computer Integrated Manufacturing," Wiley & Sons Inc.,

1996.
3. Andrew Kusiak, “Intelligent Manufacturing System,” Prentice Hall Inc., New Jersey, 1992.

Course Outcomes:

1. Understand the effect of manufacturing automation strategies and derive production metrics.
2. Analyze automated flow lines and assembly systems, and balance the line.
3. Students will have an introduction to Computer Aided Process Planning (CAPP) Systems, Robotic Systems, Group Technology and Cellular Manufacturing Systems
4. Students will cultivate understanding about Automated Material Handling Systems, Automated Inspection Systems, Flexible Manufacturing Systems(FMS)

Course Name: MEL520- NON-LINEAR OPTIMIZATION

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives :

1. To present the basic theory of non linear constrained and unconstrained problems that arose in engineering.
2. To give a thorough understanding of getting solution to these problems and some experience in solving them.
3. To develop the skills for the formulation and solution of mathematical models in their own research.

Syllabus:

Introduction to Optimization Techniques, Historical Development, Engineering application of Optimization, Formulation of design problems as mathematical programming problems, Classification of optimization problems, Statement of an Optimization problem, design vector, design constraints, constraint surface, objective function, objective function surfaces, classification of Optimization problems, Graphical Method. Necessary and Sufficient conditions for minimum/maximum, Lagrange multipliers. Unconstrained optimization Techniques, Direct search method, Univariate and pattern search method, Indirect search methods: Steepest Descent (Cauchy) method, Conjugate gradient method, Newton's method, Application to engineering problems.

Constrained Optimization Introduction, Linear Programming (Simplex), Duality and Sensitivity analysis, Sequential Linear Programming, Generalized reduced gradient method, Methods of feasible direction Indirect method, Interior and exterior penalty function. Karush-Kuhn-Tucker conditions. Application to engineering problems. Dynamic Programming, Sequential optimization; Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality, Recursive equations – Forward and backward recursions; Computational procedure in dynamic programming (DP),Discrete versus continuous dynamic programming; Multiple state variables; curse of dimensionality in DP, Applications,

Integer Programming Integer linear programming; Concept of cutting plane method, Mixed integer programming; Solution algorithms, Applications. Advanced Topics: Multi objective optimization-Weighted and constrained methods, Multi level Optimization, Evolutionary algorithm for optimization and search, Applications.

Reference Books / Material:

1. Rao, S. S., " Engineering Optimization (Theory and Practice)", John Wiley & Sons
2. Jasbir S. Arora, "Introduction to Optimum Design", Elsevier Academic Press
3. K. Deb, " Optimization for Engineering Design-Algorithms and Examples", PHI Learning Private Limited, New Delhi
4. K. Srinivasa Raju and D. Nagesh Kumar, " Multicriterion Analysis in Engineering and Management", PHI Learning Pvt. Ltd., New Delhi, India

Course Outcome: After completion of this course, the student will have

1. Understanding the construction and main solution ideas for nonlinear optimization problems.
2. Ability to assess the quality of available methods and solutions for such problems, as well as to potentially develop such optimization techniques and implementations.

Course Name: MEL418- ADVANCED STRESS ANALYSIS

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

The objective of this course is to provide students the tools required for design and analysis of complex problems in mechanics of materials.

Syllabus:

Fundamentals of stress and strain, stress strain relationship, Elastic constant, plane stress, plane strain.

Stress analysis for two-dimensional problems in Cartesian coordinate system, differential equations of equilibrium. Boundary conditions, compatibility equation, Airy's stress function.

Two dimensional problems in polar coordinate systems, general equations in polar coordinate systems, general equations in polar coordinates, stress distribution about systematic axis. Pure bending of curved beams, effect of hole on stress distribution in plates.

Thermal stress, circular disc, thin plate, long cylinder.

Photo elasticity Introduction, polarized light, wave plates, plane and circular poloriscope, Isochromatic & isoclinic fringes, compensation techniques, separation techniques, analysis of fringe patterns. Introduction to 3-D photo elasticity.

Strain Gauge techniques, strain gauge circuit, recording instruments, analysis of data, strain rosette. Brittle coating technique, coating stress, failure theories, crack patterns, crack detection, Moire fringe techniques.

Reference Books / Material:

1. Timoshnko, Goodiar, "Theory of Elasticity", McGraw Hill Book Co., 3rd Edition, 1970
2. Dalley, Rille, "Experimental Stress Analysis", McGraw Hill Book Co., 3rd Edition, 1991
3. Dove, Adams, "Experimental Stress Analysis," Prentice Hall of India, 1965

Course Outcomes: After completion of this course, student will be able to

i. Explain the concept of elasticity, and the difference between stress and strain
ii. Explain the terms: isotropic, orthotropic and anisotropic, as applied to materials
iii. Explain the terms: plane stress and plane strain
iv. Use the concepts of principal stress and principal strains
v. Use the basic tensor notations, the stress, strain and inertia tensors, and their reduction to principal axes
vi. Apply the analytical procedures involved in strain gauge measurements, in particular the transformation equations
vii. Solve basic problems in two-dimensional elasticity using Airy's stress function

Course Name: MEL530 - MACHINE CONDITION MONITORING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To know various methods of condition monitoring
2. To know and use various instruments used for condition monitoring
3. To process and analyze machine signal for diagnosis
4. To apply modern methods for machine condition monitoring

Syllabus:

Introduction: Definition, Need and relevance to maintenance, Different techniques and their practical applications. Vibration and AE based condition monitoring, Measurement of vibration and acoustic emission – Measuring parameters, Transducers, selection of appropriate parameters and transducers Data acquisition and signal processing: A/D converters, Filters, Time & Frequency domain analysis, Analysis of stationary and non stationary signals- FFT and Wavelet Transform in machine condition monitoring. Analysis and interpretation of vibration and AE data, trending, indices for condition monitoring, their significance, normal and fault indicating values, ISO and other standards, Oil & wear debris analysis and ferrography: Principles, methods and instruments for wear debris analysis and ferrography. Condition monitoring of various machine components and machines like bearings, gears, pumps, compressors, turbines, machine tools, cutting tools, etc. to diagnose various defects. Machinery prognostics, prediction of failures, concept of integrated analysis

Reference Books/Material:

1. Randall R. B., " Vibration Based Condition Monitoring," Ch.1, Ch. 2, Ch 3, Wiley, New Delhi, 2010.
2. Cempel C., "Ellis Horwood Series in Mechanical Engineering, Vibroacoustic Condition Monitoring," pp. 1 – 43, Michigan
3. Piersol A. and Paez T , "Harris' Shock and Vibration Handbook," Mc-Graw Hill, 2010
4. Alan Davies, "Handbook of Condition Monitoring: Techniques & Methodology," Chapman & Hall, London , 1998.

Course Outcomes:

At the conclusion of this course, it is expected that student will be able to:

1. Know basic machine problems and their monitoring methods.
2. Use of appropriate parameter for monitoring
3. Use of modern tools for monitoring
4. Draw charts, graphs, etc. to indicate machine status

Course Name: MEL510- MANUFACTURING SYSTEM SIMULATION AND DESIGN

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

(i)Understand the concepts in system simulation and underlying statistical theories.

(ii)Develop the appropriate model of manufacturing systems in system specific context and simulate it to understand system behaviour and further to aid in system design.

(iii)Differentiate and understand various system simulation strategies.

(iv)Develop the skills of modelling and simulation using various software / programming languages.

Syllabus:

Systems concepts in manufacturing, Types of systems, Basic concepts in simulation, Probability and statistical distributions, Random numbers and random variates, Monte Carlo simulation, Discrete event simulation, Input and output data analysis, Variance reduction techniques, Model verification and validation, Markov chain model, Introduction to systems dynamics and agent based simulation, Application of simulation in manufacturing system design such as machining, assembling, material handling, queueing systems, warehousing, inventory control, scheduling, line balancing, supply chains, project management, maintenance management, traffic-flow management, etc., Simulation of service systems.

System modelling and simulation using appropriate software / programming language. Case studies and mini projects in system simulation.

Reference Books/Material:

1. Banks, Jerry; Carson II, John; Nelson, Barry and Nicol, David, "Discrete Event System Simulation,", 2013, Prentice-Hall
2. Law, Averill, "Simulation Modelling and Analysis," 2007, Tata McGraw Hill
3. Sterman, John, "Business Dynamics: Systems Thinking and Modeling for a Complex World", 2000, McGraw-Hill
4. Gilbert, Nigel, "Agent-based models," SAGE Publication, 2008

Course Outcomes:

Upon successful completion of this course, the students will

(i) appreciate concepts in system simulation and underlying statistical theories.

(ii) be able to design and simulate the appropriate model of manufacturing systems in system specific context (iii)Differentiate and understand various system simulation strategies.

(iv) have knowledge of modelling and simulation using various software / programming languages.

Course Name: MEL415-MECHANICAL VIBRATIONS

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1)To learn importance of vibration in machine design and dynamic stress analysis.
2)To learn how to present dynamic stress analysis
3)To learn how to present dynamic stress related failure in machines and structure
4)To learn vibration measurement in industrial machines.

Syllabus:

Introduction to vibration in mechanical and structural systems. Discrete system modeling. Hamilton's principle and Lagrange's equation. Free and forced vibration response of single degree of freedom system with and without damping under harmonic excitation. Discussion on various types of damping; viscous, coulomb, hysteretic etc. Forced response under periodic excitation and transient response through Du-hamel's integral. Concept of response spectrum.
Rotor whirling and critical speed. Vibration isolation and transmissibility ratio. Vibration isolation in automobiles. Dynamic vibration absorber. Torsional vibration in rotors. Numerical simulation in Cosmo-Kgp using Bond graph modeling and in Simulink of Matlab. Modeling of multi degree of freedom systems. Determination of natural frequencies using matrix iteration and deflation technique. Concept of mode shapes and orthogonality principle. Rayleigh's quotient. Free and forced response through modal analysis. Vibration of continuous systems. Longitudinal vibration of rods, transverse vibration of beams and torsional vibration of shafts. Determination of natural frequencies and mode shapes under various boundary conditions. Introduction to FEM modeling of continuous systems. Free and forced response through modal analysis. Introduction and distinguishing characteristics of nonlinear vibration. Phase plane, equilibrium points and limit cycles. Random vibration, correlation and spectral density functions. Vibration measurement parameters and procedures. Vibration transducers and instruments. Source of vibration in Machineries. Role of vibration measurement and analysis in machine design and machine condition monitoring.

Course Outcomes: Upon completion of this course, student will have

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

Reference Books/Material:

1. Rao, Gupta, "Theory & practice of Mechanical vibration," 3rd Edition, NewAge Publication.
2. Thomson, "Theory of Vibration," 3rd Ed , CBS publication
3. Meirovitch, " Elements of Vibration analysis", 2nd Ed, McGraw Hill
4. Timoshenko, "Vibration Problems in Engineering," 5th Ed, John Willey & Sons
5. S. S. Rao , "Mechanical Vibration", Fourth Edition, Pearson Education

Course Name: MEL532- LAYERED MANUFACTURING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To Learn the fundamentals of layered manufacturing of polymers, metals, and ceramics, along with those for emerging materials and complex architectures.
2. To Understand the operating principles, capabilities, and limitations of state-of-the-art AM methods, including laser melting, fused deposition modeling, stereolithography, and jetting.
3. To Understand the principles of "Design for layered Manufacturing" and compare and contrast additive processes with conventional manufacturing methods such as machining and molding in terms of rate, quality, cost, and flexibility.

Syllabus:

Importance and overview of Rapid Prototyping, Tooling and Manufacturing ; Typical Process Chain; Introduction to CAD and Data Exchange Formats; Data format details, conversion, checking, repairing and transmission ;Part slicing and orientation. Classification of Rapid Prototyping (RP), Tooling (RT) and Manufacturing (RM) processes; Materials for RP/RT/RM; Operating principles, characteristics and analysis of current and developing R P / R T / R M processes; Selection of RP/RT/RM processes based on the product requirements; Case studies

Course Outcomes: Upon completion of this course, student will have

1. To identify the need for reduction of product development time.
2. Model any complex part for rapid manufacture.
3. Illustrate the working principles of rapid manufacturing technologies.
4. Select the rapid manufacturing process to fabricate a given product.
5. Identify and minimize errors that occur during conversion of CAD models.
6. Optimize the responses in rapid manufacturing process to improve the quality of parts.

Reference Books/Material:

1. Gibson, I, Rosen, D W., and Stucker,B., “Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing,” Springer, 2010.
2. Hopkinson, N, Haque, R., and Dickens, P., “Rapid Manufacturing: An Industrial Revolution for a Digital Age”, Wiley, 2005.
3. Bartolo, P J (editor), “Virtual and Rapid Manufacturing: Advanced Research in Virtual and Rapid Prototyping,” Taylor and Francis, 2007.
4. Chua, C K, Leong, KF., Lim CS, “Rapid Prototyping,” World Scientific, 2003.
5. Pique,A., Chrisey, DB., “Direct Write Technologies for R P Applications: Sensors, Electronics and Integrated Power Sourses”, Academic Press, 2002.
6. Venuvinod,P.K., Ma, W., “Rapid Prototyping – Laser Based and Other Technologies,” Kluwer, 2004.

Course Name: MEP532- LAYERED MANUFACTURING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit: [(0-0-2); Credits: 1]

Type of Course: Elective

Course Assessment Method: Continuous Assessment

Course Objectives:

List of Experiments:

Course Name: MEL518 - FRACTURE MECHANICS AND NON DESTRUCTIVE TESTING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To know characteristics of basic mechanics of crack propagation and fracture phenomenon
2. Design the parts from fracture mechanics point of view by selecting proper materials and geometric features.
3. To Damage tolerance design of the components

Syllabus:

Introduction to fatigue and fracture mechanics, ductile and brittle fractures. Linear elastic fracture mechanics (LEFM) and Elasto plastic fracture mechanics (EPFM) approach. Crack propagation energy release rate, Fracture behaviour, stress intensity factor, Fracture mechanism, Failure modes Mechanism of fatigue crack initiation and propagation. Fatigue data representation, life prediction, prevention of fatigue failures, corrosion fatigue., The pattern of stress and deformation near the tip of the crack. Determination of fracture toughness, condition for the fracture, Paris equation. Fatigue and fracture safe designs. Investigation and analysis of failures. Principles of various NDT techniques, Equipment, methodology, applications and benefits of various NDT techniques such as Visual inspection and eddy current testing, Liquid penetrant testing, Magnetic particle testing, Radiographic testing and Ultrasonic testing

Reference Books/Material:

1. P.Kumar, "Elements of Fracture Mechanics", McGraw Hill, 2012.
2. M. Jansen, J. Zuidema, R. Wanhill, " Fracture Mechanics" Spon Press, 2004.
3. T.L. Anderson, "Fracture Mechanics:- Fundamentals and Application", Taylor and Francis, 2005.
4. R.W. Hetzberg, " Deformation and fracture mechanics of engineering material", John wiley and son, 1996.

Course Outcomes:

Upon completing this course,

1. Student will have knowledge of basic crack growth mechanism.
2. Student will select proper design based on fracture mechanics.
3. Student will be able to estimate the safe life design product.
4. Students will be able to get the knowledge of different NDT testing.

Course Name: MEP518 - FRACTURE MECHANICS AND NON DESTRUCTIVE TESTING

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Continuous Assessment

List of Experiments:

1. Evaluation of fracture toughness by using crack tip opening displacement method.
2. Study of Radiography testing (X- Ray method) method for testing of materials.
3. Study of Ultrasonic testing machine and its calibration using straight beam probe.
4. Calibration of Ultrasonic testing machine using angle beam probe.
5. Detection of internal cracks using Ultrasonic testing machine and straight beam probe.
6. Detection of internal cracks using Ultrasonic testing machine and angle beam probe.
7. Study of Magnetic particle testing method for testing of surface cracks in material.
8. Study of Eddy current testing method for testing of surface cracks in material.
9. Dye penetration testing method for crack analysis of materials.
10. Analysis of stresses by using photo elasticity.

Course Name: MEL526 - ADHESION, FRICTION AND CONTACT MECHANICS

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:

1. To explain the students about the basics and practical significance of AFCM
2. To enable students to apply mathematical approaches to solve AFCM problems
3. To train students for using software such as excel/matlab for solving AFCM problems
4. To enable students for research and jobs

Syllabus:

Introduction: basic concepts of adhesion, friction and contact mechanics and their practical examples, relationship between friction and fracture, surface energy, thermodynamics of surfaces, soft and hard solids friction, surface roughness, static, dynamic and stick-slip process, tribology and its significance.

Stress analysis of contact problems: hertzian, jkr, and dmt contact mechanics, fracture mechanics of adhesion, adhesion of particles.

Surface characterization techiniques: linear velocity tribometer, hardness testers, use of spm/afm.

Dynamics of frictional sliding: static and dynamic stability analysis of sliding surfaces, linear and non-linear analysis of stability, friction induced self excited vibrations etc.

Numerical modelling of contact problems: modelling of contact problems with finite element software ansys.

Recent advances in adhesion and friction: nano and biotribology, application of chaos and fractals, geophysical applications

Reference Books/Material:

1. Maugis D., "Contact, Adhesion and Rupture of Elastic Solids", Springer,Berlin, Heidelberg, First edition,1999
2. Popov V.L., "Contact Mechanics and Friction", Springer, Berlin, Heidelberg, First edition, 2010
3. Persson Bo.N.J., ",Sliding friction: Physical principles and applications", Springer, Berlin, Heidelberg, 2000
4. Johnson K.L., "Contact Mechanics", Cambridge University Press, Cambridge,USA, First edition 1987

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

1. understand traditional and advanced metrology and characterization techniques to visualize/image, describe, and analyze rough surfaces.

2. understand and apply classic tribology and contact mechanics theory to solve engineering problems that involve contacting rough surfaces on the nanoscale.

3. understand and apply techniques such as digital signal processing, and finite differences method to solve contact and lubrication (viscous flow) problems

Course Name: MEP526 - TRIBOLOGY AND DYNAMICS LAB

Pre-requisites: Nil

Offered in: II Semester (Even Semester)

Scheme and Credit:[(0-0-2); Credits: 1]

Type of Course: Elective

Course Assessment Method: Continuous Evaluation

Course Objectives:

a.The students will be able to understand adhesion, friction, and contact mechanics though experiments.

b.The students will demonstrate an ability to conduct experiments and analyze the results under realistic constraints .

c.Graduates will be trained with computer programming language such as MATLAB and ANSYsoftwares.

d.Graduates will be trained for higher studies and research.

List of Experiments:

1.Finite element modeling of Hertzian contact.

2.Experimental and numerical simulations of wedge adhesion experiment.

3.Stick-slip experiments on soft and hard surfaces.

4.Stick-slip experiments on hard-hard surfaces.

5.Experimental analysis of interfacial fracture of soft rubbers.

6.Linear and non-linear dynamics of simple pendulum(SP) with Rayleigh damping.

7.Linear and non-linear dynamics of multiple pendulum(MP) with Rayleigh damping.

8.Experiment and simulations of elastic pendulum.

9.Dynamics of sliding/rolling of a block in presence of corilios force.

10.Experiments on road roughness device.

Course Name: MEL420 – FINITE ELEMENT METHOD

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
1. Equip the students with the Finite Element Analysis fundamentals,
2. Enable the students to formulate the design problems into FEA,
3. Enable the students to perform engineering simulations using Finite Element Analysis software (ANSYS & LSDYNA).
4. Enable the students to understand the ethical issues related to the utilization of FEA in the industry

Syllabus:

Introduction to variational methods in boundary value problems. Rayleigh-Ritz method. Concept of finite elements. Brief introduction to finite analysis. Discretisation, approximation and assembly of finite elements, Strain-displacement and stress-strain relations for plain-stress, plain-strain and axismmetric problems. Temperature effect. Finite element modeling of 1-D problems. Langranian and Hermitian shape functions, element stiffness matrix and load vector. Assembly of global stiffness matrix and global load vector. Boundary constraints and solution for nodal displacements. Convergence criteria and compatibility requirement. Higher order elements. Weak formulation, Gelerkin FEM and non-linear problems. Eigen value problems of 1-D models, vibration of bars. 2-D problems with constant strain triangles. Co-ordinate transformation and Jacobian. Straight sided and curved sided elements. Gauss-quadrature integration formula. Beam flexure modeling with finite elements. Vibration of beams. Plate bending problem with triangular, rectangular, and curve sided elements. Types of curve sided elements. Triangular and rectangular isoperimetric elements. Sub parametric and super parametric elements. Finite element modeling of incompressible inviscid fluid flows and steady state heat conduction problem.

Reference Books/Material:

1. Cook, R.D, "Concepts and application in Finite Element Analysis", 3rd Ed, The Wiley & Sons
2. Chandragupta, Bellegundu, "Introduction to Finite Element Engineering", 2nd Ed , Prentice Hall
3. Krishnamurthy , "Finite Element Analysis", 2nd Ed, Tata Mc Graw Hill

Course Outcomes: Upon completing this course, the students will be able to:
1. Identify mathematical model for solution of common engineering problems.
2. Formulate simple problems into finite elements.
3. Solve structural, thermal, fluid flow problems.
4. Use professional-level finite element software to solve engineering problems in Solid mechanics, fluid mechanics and heat transfer.
4. Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts

Course Name: MEP420 – FINITE ELEMENT METHOD

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(0-0-2); Credits: 1]

Type of Course: Core

Course Assessment Method: Continuous Assessment

Course Objectives:
1. Equip the students with the Finite Element Analysis fundamentals,
2. Enable the students to formulate the design problems into FEA,
3. Enable the students to perform engineering simulations using Finite Element Analysis software (ANSYS & LSDYNA).
4. Enable the students to understand the ethical issues related to the utilization of FEA in the industry

List of Experiments:

Course Name: MEL433– Design for Manufacturing & Assembly

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
1. To know characteristics of basic manufacturing processes and their capabilities
2. Select appropriate materials, processes and features for various design requirements
3. Design products which are suitable for manufacturing
4. Evaluate the design for available manufacturing alternatives

Syllabus:
Introduction – Definition, History, Advantages and Impact . Selection of materials and processes – General requirements, process capabilities, Systematic selection of processes and materials, design examples
Product design for manual assembly – General guidelines, systematic design for assembly, effect of various design features on manufacturing, design examples
Design for high speed automatic and robotic assembly – Design for high speed feeding and orientating, High speed inspection, Analysis of assembly, design examples
Design for machining – Design for single point / multi point / abrasive machining, assembly of components, accuracy and surface finish, cost estimating, design examples
Design for injection moulding – Injection moulding materials, moulding cycles, estmation of optimum number of cavities, design examples
Design for sheet metal working – Dies and Press working, Press selection, Design rules
Design for sand casting, die casting, investment casting – Materials, Basic characteristics of process and mould features, cost estimating, design rules for different castings.
Design for forging – characteristics, cost estimation and design rules.

Reference Books/Material:
1. Boothroyd, G., Dewhurst, P., Knight, W. A. “Product Design for Manufacturing and Assembly”, Third Edition, CRC Press, 2011.
2. Allen, C. W., “Simultaneous Engineering -Integrating Manufacturing and Design”, Society of Manufacturing Engineers, Nov. 1990.
3. James Bralla, “Design for Manufacturability Handbook” McGraw Hill, 2004.
4. Anderson, D.M., "Design for manufacturability & concurrent engineering: how to design for low cost, design in high quality, design for lean manufacture, and design quickly for fast production," CIM press, 2nd Edition, 2010.

Course Outcomes: Upon completing this course,:
1. Student will have knowledge of basic manufacturing processes and their capabilities
2. Student will select appropriate material, process and features for a design
3. Student will design products which are easy for assembly & manufacturing
4. Student will evaluate the design for alternatives of manufacturing

Course Name: MEL433– Design for Manufacturing & Assembly

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
1. To know characteristics of basic manufacturing processes and their capabilities
2. Select appropriate materials, processes and features for various design requirements
3. Design products which are suitable for manufacturing
4. Evaluate the design for available manufacturing alternatives

Syllabus:
Introduction – Definition, History, Advantages and Impact . Selection of materials and processes – General requirements, process capabilities, Systematic selection of processes and materials, design examples

Product design for manual assembly – General guidelines, systematic design for assembly, effect of various design features on manufacturing, design examples

Design for high speed automatic and robotic assembly – Design for high speed feeding and orientating, High speed inspection, Analysis of assembly, design examples

Design for machining – Design for single point / multi point / abrasive machining, assembly of components, accuracy and surface finish, cost estimating, design examples

Design for injection moulding – Injection moulding materials, moulding cycles, estmation of optimum number of cavities, design examples

Design for sheet metal working – Dies and Press working, Press selection, Design rules

Design for sand casting, die casting, investment casting – Materials, Basic characteristics of process and mould features, cost estimating, design rules for different castings.

Design for forging – characteristics, cost estimation and design rules.

Reference Books/Material:

1. Boothroyd, G., Dewhurst, P., Knight, W. A. “Product Design for Manufacturing and Assembly”, Third Edition, CRC Press, 2011.
2. Allen, C. W., “Simultaneous Engineering -Integrating Manufacturing and Design”, Society of Manufacturing Engineers, Nov. 1990.
3. James Bralla, “Design for Manufacturability Handbook” McGraw Hill, 2004.
4. Anderson, D.M., "Design for manufacturability & concurrent engineering: how to design for low cost, design in high quality, design for lean manufacture, and design quickly for fast production," CIM press, 2nd Edition, 2010.

Course Outcomes: Upon completing this course,:
1. Student will have knowledge of basic manufacturing processes and their capabilities
2. Student will select appropriate material, process and features for a design
3. Student will design products which are easy for assembly & manufacturing
4. Student will evaluate the design for alternatives of manufacturing

Course Name: MEL439– Product Design & Development

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
1. To understand the relationship of art and science to design
2. To develop proficiency in design skills and methodologies
3. To gain first-hand experience of the design process in the context of a 'real', open-ended multidisciplinary design project
4. To work effectively and professionally in a team while executing a design project
5. To apply engineering analysis tools in the design process
6. To understand the holistic context of design, including global, societal, ethical, economic and environmental concerns
7. To improve proficiency in professional communication skills

Syllabus:
Definition of Product Design
Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle.
Product Design Practice and Industry: Introduction, Product Strategies, Time to Market, Analysis of the Product, The Three S's Standardization, Renard Series (Preferred Numbers) Simplification, The Designer and His Role, The Designer: Myth and Reality, The Industrial Design Organization, Basic Design Considerations, Problems faced by Industrial Designer, Procedure adopted by Industrial Designers, Types of Models designed by Industrial Designers What the Designer contributes, Role of Aesthetics in' Product Design, Functional Design Practice.
Economic Factors Influencing Design :Product Value, Design for Safety, Reliability and Environmental Considerations Manufacturing Operations in relation to Design, Economic Analysis, Profit and Competitiveness, Break-even Analysis, Economics of a New Product Design (Samuel Eilon Model).
Human Engineering Considerations in Product Design: Introduction, Human Being as Applicator of. Forces, Anthropometrics: Man as Occupant of Space The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Reference Books/Material:
1. Chitale, Gupta, " Product Design & Manufacturing", 2nd Ed 2002, Prentice Hall of India

Course Outcomes: Upon completing this course,:
1. Students should be able to design a product using computer aided design.
2. Students should be able to carry out product development and planning process.
3. Students should be able to understand the concept of prototyping.

Course Name: MEL437- Composite Materials

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives: To familiarise the students with recent advances in engineering materials and selection particularly for composites. This will help for design in advanced applications, cost reduction and material optimisation. This is to give a sound understanding of properties and characteristics of orthotropic materials in comparison to conventional isotropic matreials

Syllabus:
Introduction to composite materials, evolution and applications in engineering. Characteristics and classification of composite materials; Fibrous, laminated and particulate composites. Basic terminology=ies; volume fraction and weight fraction. Laminae and laminates. Different fibres, matrices and their properties. Advantages and disadvantages of polymer matrix composites, metal matrix composites and ceramic matrix composites.
Mechanical properties of unidirectional composite lamina. Longitudinal and transverse Young modulus, shear modulus, poisson ratio. Empirical relationship of Halpin-Tsai. Longitudinal and transverse Strength. Composites under compressive loading.
Properties of angle ply lamina. Transformation of Young modulii, shear modulus. Concept of coupling coefficients. General and special orthotrpic materials. Psai Pagano invariants
Strength of orthotropic lamina. Biaxial strength theories. Maximum strength, maximum strain theory. Tsia-Hill maximum work theory. Tsai Wu tensor theory. Applications to pressure vessels, composite shafts etc.
Codes and engineering representation of Laminates. Macro mechanical behaviour of a laminate. Laminate stiffness for different types; symmetric, anti-symmetric, cross ply laminates. Stresses in different laminae in a laminate. Configurations and design of laminates for special properties
Strength and mechanism of failure in a composite laminate. Concept of FPF(First Ply Failure and total failure). Hygroscopic and thermal stresses.

Text Book:
P K Mallick, Fibre-Reinforced Composites, CRC press, New York, 2007
R.M.Jones, Mechanics of Composite Materials, Mc Graw Hill, New Delhi
Reference Book:
Broutman and Agarwal, Analysis and Performance of Composite materials, John Willey and Sons, New York

Course Outcomes: Upon completing this course,

1. Predict elastic properties of long fiber and short fiber composites.
2. Design of a laminate for a given load condition.
3. Describe fundamental fabrication processes for polymer matrix, metal matrix, and ceramic matrix composites.
4. Demonstrate the ability to independently analyze and extend a given course subject, compose a report paper and effectively communicate the essentials through an oral presentation.

   Student would be able to understand behaviour and specialities of orthotropic materials.

They will be able to find appropriate applications where a particular composite can be used.
Students will also have sound understanding of theory of elasticity and mechanics of orthotropic materials and behaviour under bi-axial stress conditions.
Students will learn the concept of design optimisation with proper material selection.

Course Name: MEL402- Surface Engineering

Pre-requisites: Nil

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Elective

Course Assessment Method: Sessional I (15%), Sessional II (15%), Internal assessment through assignments/seminar/quizzes (10%), End Semester exam (60%).

Course Objectives:
1.To educate students on the technologies of surface engineering for wear resistance by introducing different methods for coatings and surface treatments.
2.To introduce the concepts of surface heat treatment, thermo chemical diffusion treatment, and mechanical treatment techniques.
3.To introduce the concepts of surface alloying and surface composites by laser melting and solid state processing techniques.
4.To give various concepts of thermal spraying techniques, PVD/CVD techniques and thermal barrier coatings (TBC).

Syllabus:
Need for surface engineering, Classification of surface engineering methods and Surface Preparation. Surface Hardening without modification of surface chemistry - Induction hardening, Flame hardening, Laser beam hardening and Electron beam hardening.
Thermo Chemical Diffusion Treatments - Carburizing, nitriding and boriding techniques. Mechanical treatments - Cold working, Shot peening and SMAT processes. Laser peening, laser surface alloying, laser cladding, friction surfacing and friction stir processing techniques.
Thermal spraying techniques – Flame spraying, Oxy-fuel powder spraying, D-gun spraying, HVOF coating, Plasma spraying and Cold/kinetic spraying. Electro plating and electroless plating of pure metals and composite materials.
Physical vapour deposition – PVD system, Thermal evaporation, Sputtering, Pulsed laser deposition, Electron beam deposition. Chemical Vapour Deposition (CVD) – CVD system, Hot wall and Cold wall reactors, Thermally activated and Plasma assisted CVD techniques. CVD diamond – A case study. Protective coatings for high temperature applications – Diffusion coatings, Overlay coatings, Pack cementation. Thermal Barrier Coatings (TBC) – Coating architecture, deposition methods and applications.

Reference Books/Material:

1. Budinski ,K.G., “Surface Engineering for Wear Resistances”, Prentice Hall, Englewood Cliffs, 1988
2. Ohring, M., “ The Materials Science of Thin Films”, Academic Press Inc, 2005
3. Morton,P.H., “Surface Engineering & Heat Treatment”, Brooke field, 1991

Course Outcomes: Upon completing this course,:
1. By the end of the course, the students should be able to:
2. Demonstrate an understanding and critical awareness of the concepts of surface engineering
3. Demonstrate a sound knowledge for the systematic application of alternative technologies used to fabricate coating systems.

4. Recommend techniques used to characterise the surface and explain the principles behind their operation.
5. Demonstrate knowledge of why the surface treatment affects the bulk properties of the material.
6. Select the most suitable surface engineering techniques that would give the required properties

Course Name: MED401- Project Phase I

Pre-requisites: Semester I and Semester II credits must be complete

Offered in: III Semester (Odd Semester)

Scheme and Credit:[(3-0-0); Credits: 3]

Type of Course: Core

Course Assessment Method: Sessional I (25%), Sessional II (25%), End Semester exam (50%).

Course Objectives:

1. To define the aim, objective, scope of the project topic from the thorough literature review
2. To design the methodology to be followed for the project
3. To finalize the design of experiments or fabrication of required setup or questionnaire

Course Name: MED503- Project Phase II

Pre-requisites: MED401

Offered in: IV Semester (Even Semester)

Scheme and Credit:[(9-0-0); Credits: 9]

Type of Course: Core

Course Assessment Method: Sessional I (25%), Sessional II (25%), External Examination (50%).

Course Objectives:

1. To perform simulations or experiments or study as designed in MED401
2. To obtain results and analysis of the results
3. To draw conclusions and decide future scope of the work
4. To write and submit thesis based on project work

Course Outcome:

1. On successful completion of this course, student will be eligible for award of master's degree