DEPARTMENT OF MECHANICAL ENGINEERING

Course Book for

M. Tech. in

Computer Aided Design & Manufacturing

For

Academic Year: 2020 - 2021

Visvesvaraya National Institute of Technology,

Nagpur-440 010 (MH)

Institute Vision Statement

To contribute effectively to the National and International endeavor 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 and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT 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.

Department Vision Statement

To produce quality human resource of high standard in mechanical engineering who can contribute favorably to the technological and socio-economic development of the nation.

Department Mission Statement

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

Brief about Mechanical Engineering Department

Department of Mechanical Engineering is one of the oldest department started in 1960, currently department is offering 1 UG and 3 PG programs. Faculty members of the department are highly experienced and motivated for teaching and conducting research in the diversified fields of mechanical engineering.

List of faculty Members

Sr No	Faculty Name	Areas of specialization
1	Dr. P. M. Padole	Design Engineering
2	Dr. H. T. Thorat	Design and Industrial Engineering
3	Dr. S. B. Thombre	Thermal Engineering
4	Dr. A. M. Kuthe	Manufacturing
5	Dr. V. R. Kalamkar	Thermal Engineering
6	Dr. A. Chatterjee	Design Engineering
7	Dr. Y. M. Puri	Manufacturing and Industrial Engineering
8	Dr. D. B. Zodpe	Thermal Engineering
9	Dr. A. B. Andhare	Manufacturing
10	Dr. J. G. Suryawanshi	Thermal Engineering
11	Dr. S. S. Chiddarwar	Manufacturing and Design Engineering
12	Dr. R. V. Uddanwadiker	Design Engineering
13	Dr. A. S. Dhoble	Thermal Engineering
14	Dr. H. P. Jawale	Design Engineering
15	Dr. M. S. Kotambkar	Design Engineering
16	Dr. A. K. Singh	Design and Thermal Engineering
17	Dr. Trushar B. Gohil	Thermal Engineering
18	Dr. T. V. K. Gupta	Manufacturing
19	Dr. Ravikumar Dumpala	Manufacturing
20	Dr. R. K. Peetala	Thermal Engineering
21	Dr. P. V. Kane	Industrial Engineering
22	Dr. D. A. Jolhe	Industrial Engineering
23	Dr. V. M. Nistane	Design Engineering
24	Dr. G. Tiwari	Design Engineering
25	Dr. S. Roga	Thermal Engineering
26	Dr. A. A. Thakre	Design and Industrial Engineering
27	Dr. K. M. Asthankar	Industrial Engineering
28	Dr. P. D. Sawarkar	Thermal Engineering
29	Dr. N. K. Lautre	Industrial Engineering

UG/ PG Programmes Offered by Mechanical Department:

The department offers following undergraduate and postgraduate programmes

	Program	Description
UG	B. Tech inMechanical Engineering	Intake: 115
PG	M. Tech. in 1. Computer Aided Design & Manufacturing 2. Industrial Engineering 3. Heat Power Engineering	Intake : 25 each

Credit System at VNIT:

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are, it's a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.

For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and

For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.

Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. 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, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is 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. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained.

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ (Course credits) for courses passed in all completed semesters in which AA-DD grades are awarded.

Overall Credits Requirement for Award of Degree

SN	**Category of Course**	**Symbol**	**Credit Requirement**			
			B. Tech. (4-Year)	B. Arch. (5 Year)	M. Tech. (2 Year)	M. Sc. (2 Year)
	Program Core					
1	Basic Sciences (BS)	BS	18	04	-	-
2	Engineering Arts & Sciences (ES)	ES	20	18	-	-
3	Humanities	HU/ HM*	05	06	-	-
4	Departmental core	DC	79-82	168	33-39	54-57
Program Elective						
3	Departmental Elective	DE	33-48	17-23	13-19	06-09
4	Humanities & Management	HM	0-6	0-3	-	-
5	Open Course	OC	0-6	0-3	-	-
Total requirement :BS + ES + DC+ DE + HM + OC =			**170**	**219**	**52**	**63**
Minimum Cumulative Grade Point Average required for the award of degree			**4.00**	**4.00**	**6.00**	**4.00**

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Program Outcomes for M. Tech (Common to all PG programmes):

a. An ability to independently carry out research /investigation and development work to solve practical problems.
b. An ability to write and present a substantial technical report/document.
c. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

Scheme for M. Tech. in Computer Aided Design & Computer Aided Manufacturing

I. Courses to be offered in Odd semester

S. No	Code	Title	DC/DE	Structure L-T-P	Credit	Pre-requites
1	MEL410	Computer Aided Design	DC	3-0-0	3	
2	MEP410	Computer Aided Design	DC	0-0-2	1	
3	MEL420	Finite Element Method	DC	3-0-0	3	
4	MEP420	Finite Element Method	DC	0-0-2	1	
5	MEL522	Computer Aided Manufacturing	DC	3-0-0	3	
6	MEP522	Computer Aided Manufacturing	DC	0-0-2	1	
7	MAL505	Mathematical Elements For Engineers	DC	3-0-0	3	
8	MED501	Project Phase I	DC		3	**25 Credits**
9	MEL402	Surface Engineering	DE	3-0-0	3	
10	MEL407	Bio Mechanics	DE	3-0-0	3	
11	MEL414	Tribology	DE	3-0-0	3	
12	MEL431	Advanced Mechanism	DE	3-0-0	3	
13	MEL433	Design for Manufacturing and Assembly	DE	3-0-0	3	
14	MEL437	Composite Materials	DE	3-0-0	3	
15	MEL439	Product Design and Development	DE	3-0-0	3	
16	MEL452	Advanced Machining Processes	DE	3-0-0	3	
17	MEL515	Robotics and Machine Vision	DE	3-0-0	3	
18	MEL533	Failure Analysis	DE	3-0-0	3	
19	MEL537	Product Ideation and Design	DE	3-0-0	3	
20	MEL527	Hydraulics and Pneumatics	DE	3-0-0	3	
21	MEP527	Hydraulics and Pneumatics	DE	0-0-2	1	

II. Courses to be offered in Even semester

S. No	Code	Title	DC/DE	Structure L-T-P	Credit	Pre requites/ Remark
1	MEL418	Advanced Stress Analysis	DC	3-0-0	3	
2	MEL520	Non - Linear Optimization	DC	3-1-0	4	
3	MEL523	Computer Integrated Manufacturing	DC	3-0-0	3	
4	MED502	Project Phase-II	DC		9	**35 Credits+ Project Phase I**
5	MEL415	Mechanical Vibration	DE	3-0-0	3	
6	MEL510	Manufacturing System Simulation and Design	DE	3-0-0	3	
7	MEL529	Industrial Product Development	DE	3-0-0	3	
8	MEL530	Machine Condition Monitoring	DE	3-0-0	3	
9	MEL518	Fracture Mechanics and Non Destructive Testing	DE	3-0-0	3	
10	MEP518	Fracture Mechanics and Non Destructive Testing	DE	0-0-2	1	
11	MEL526	Adhesion, Friction and Contact Mechanics	DE	3-0-0	3	
12	MEP526	Adhesion, Friction And Contact Mechanics	DE	0-0-2	1	
13	MEL532	Layered Manufacturing	DE	3-0-0	3	
14	MEP532	Layered Manufacturing	DE	0-0-2	1	
15	MEL***	Design of Fixtures in Manufacturing	DE	3-0-0	3	

III. Total credits to be earned for completion of the degree program:

a) Through DC category courses = 37 credits
b) Through DE category courses = 15 credits

Total = 52 Credits

IV. This DC/DE categorization of the courses for the M.Tech Program in **Computer Aided Design & Manufacturing** applicable for the students admitted to the first semester of the programme during the academic year 2020-2021.

ODD SEMESTER

MEL410COMPUTER AIDED DESIGN

3 credits (3-0-0)

Pre-requisite: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

1. Understand the engineering design process and its role in graphic communication process.
2. Generate and interpret engineering technical drawings of parts and assemblies according to engineering design standards.
3. Use CAD software to generate a computer model and technical drawing for a simple, well-defined part or assembly.
4. Fluent application of engineering techniques, tools and resources
5. Effective oral and written communication in professional and lay domains

Mapping with POs:

POs→ / COs↓	PO1	PO2	PO3
CO1	M	M	M
CO2	H	H	H
CO3	H	H	H
CO4	H	M	H
CO5	M	H	M
Overall	H	H	H

Content:

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 interlaced 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, redundant 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.

Text Books/ Reference Books:

1. Zeid I., "CAD / CAM problem & practice", 3rd Edition, Tata McGraw Hill, 2001.
2. Newman, Sproull. "Principles of interactive computer graphics", McGraw 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

Rao P.N., "CAD/CAM principles &applications", Tata McGraw Hill, 2002.

MEP410COMPUTER AIDED DESIGN (Lab)

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon successful completion students will be able to:

1. Operate graphics software for various Cad applications
2. Carry out programming for optimization of design
3. Use customized FEM software for real application of CAD

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	M	H
CO2	H	M	H
CO3	M	M	M
Overall	H	M	H

Content:

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.

Text Books/ Reference Books:

MEL420 FINITE ELEMENT METHOD

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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.
5. Derive element matrix equation by different methods by applying basic laws in mechanics and integration by parts

Mapping with POs*:

POs → COs ↓	PO1	PO2	PO3
CO1	H	L	H
CO2	H	H	M
CO3	H	M	H
CO4	H	H	H
CO5	M	M	H
Overall	H	M	H

Content

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.

Text Books/ Reference Books:

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 McGraw Hill

MEP420 FINITE ELEMENT METHOD LAB

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ 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

Mapping with POs*:

POs → / **COs ↓**	**PO1**	**PO2**	**PO3**
CO1	H	M	H
CO2	H	M	H
CO3	H	H	H
CO4	M	M	M
Overall	H	M	H

Content

Text Books/ Reference Books:

MEL522COMPUTER AIDED MANUFACTURING
3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:
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 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.

Mapping with POs:

POs → / COs ↓	**a**	**b**	**c**
CO1	H	H	L
CO2	H	H	L
CO3	M	H	M
CO4	H	M	H
Overall	H	H	M

Content:

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.(CO1)

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. (CO1)

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. (CO2)

Important, 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. (CO3)

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. (CO4)

Text Books/ Reference Books:

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.

MEP522COMPUTER AIDED MANUFACTURING

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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 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.

Mapping with POs:

POs → / COs ↓	**a**	**b**	**c**
CO1	H	H	L
CO2	H	H	L
CO3	M	H	M
CO4	H	M	H
Overall	H	H	M

Content:

1. Study of CNC VMC part programming fundamentals and writing part program. (CO1)

2. Study and demonstration of CNC VMC (CO3, CO4)

3. Study and demonstration of WEDM (CO1 , CO3)

4. Study and demonstration of CNC CMM (CO1, CO2)

5. Study and demonstration of RP machine. (CO2, CO4)
6. Study and demonstration of Die sinking EDM. (CO2)
7. Study and demonstration of various Sensors. (CO1)
8. Study and demonstration of Various Actuators. (CO1)

Text Books/ Reference Books:

MAL505 MATHEMATICAL ELEMENTS FOR ENGINEERS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

On completion of this course, students will be

- CO 1: able to understand the basic importance of Linear Algebra and numerical techniques to solve scientific problems and improve ability to think logically, analytically, and abstractly.
- CO2: able to implement fundamentals of Linear Algebra and numerical techniques to CAD-CAM engineering problems.
- CO3: able to formulate and solve physical problems mathematically.

Mapping with POs:

POs → COs ↓	**PO1**	**PO2**	**PO3**
CO1	M	L	L
CO2	H	M	H
CO3	H	H	M
OVERALL	H	M	M

Content:

Linear algebra and Matrices: Linear vector spaces,, Linear dependence, basis and dimensions,. Four fundamental subspaces, Linear transformations. Transformation from one linear space to another. Inner product space and applications. Eigen values and Eigen vectors, diagonalization, complex matrices, similarity transformations, matrix norms & condition number, iterative methods for solving AX = b.

Numerical techniques: Review of topics in elementary numerical analysis. Basic principles, Construction. Approximate integration formulae using method of undermined weights and nodes, Gauss Legendre formula, Gauss- Chebyshev formula, Gauss- Hermite formula. Errors in numerical integration.

Finite Difference method: Approximation of derivatives (ordinary and partial) in terms of pivotal value. Applications to solve:

Boundary value problems in ordinary differential equations

Boundary value problems in partial differential equations, Laplace equation, one dimensional heat equation and one dimensional wave equation.

Introduction to mathematical modeling: Study of cases of modeling through linear equations and different equations.

Text Books/ Reference Books:

1. G. D. Smith, "Numerical solution of partial differential equations, Finite difference methods", Oxford University Press, 1985.
2. R. K. Jain and S. R. Iyengar, "Advanced Engineering Mathematics", Narosa Publishing, 2008
3. Kreyszig, E. "Advanced Engineering Mathematics", John Wiley & Sons, 8th Edition, 2008.
4. M. K. Jain, S. R. Iyengar and R. K. Jain,", "Numerical methods for Scientific and Engineering Computation", New Age International, 2008.
5. G. Strang, "Linear Algebra and Its Applications", Thompson Publications, 2006

MED501 PROJECT PHASE I

3 credits

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students will be able to

1. To identify research problem
2. To review literature
3. To present research report
4. To carry out scientific investigation

Mapping with POs*:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	M	M
CO2	H	M	M
CO3	M	H	H
CO4	H	H	H
Overall	H	H	H

Content

Text Books/ Reference Books:

MEL402 SURFACE ENGINEERING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon completing this course: Students will be able to

1. Demonstrate an understanding and critical awareness of the concepts of surface

engineering

2. Demonstrate a sound knowledge for the systematic application of alternative technologies used to fabricate coating systems.
3. Recommend techniques used to characterize the surface and explain the principles behind their operation.
4. Select the most suitable surface engineering techniques that would give the required properties

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1		-	H
CO2	-	-	H
CO3	L	-	M
CO4	L	L	H
Overall	L	L	H

Content

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 and Laser peening. Friction based - friction surfacing and friction stir processing techniques.

Hard facing - selection of hard facing materials and techniques. Laser cladding and laser surface alloying.

Thermal spraying techniques – Flame spraying, Oxy-fuel powder spraying, D-gun spraying, HVOF coating, Plasma spraying and Cold/kinetic spraying. 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.

Structural, microstructural and mechanical characterization techniques with focus on surface engineering.

Text Books/ Reference Books:

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

MEL407 BIOMECHANICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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.

Mapping with POs:

POs → COs ↓	**PO1**	**PO2**	**PO3**
CO1	M	H	M
CO2	H	M	-
CO3	L	H	--
Overall	M	H	L

Content

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.

Text Books/ Reference Books:

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 InterscienceSecond edition

MEL414 TRIBOLOGY

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

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

surface.

2. Have a clear overall picture about the basics of tribology and related sciences, theoretical background about processes in tribological system, mechanisms and interaction of friction surfaces.
3. Understand Hertz contact and rough surface contact.
4. Be familiar with adhesion theories and the effect of adhesion on friction and wear.
5. Have a mastery of the friction/lubrication mechanisms and know how to apply them to the practical engineering problem.

Mapping with POs:

POs→ / COs ↓	a	b	c
CO1	H	H	M
CO2	H	H	H
CO3	H	H	H
CO4	H	M	M
CO5	H	H	H
Overall	H	H	H

Content: (CO wise, mention applicable COs at the end of each unit or paragraph):

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. (CO1,CO2,CO5)

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. (CO2, CO3,CO4,CO5)

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. (CO2, CO3,CO4,CO5)

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. (CO2, CO3,CO4,CO5)

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. (CO2, CO3,CO4,CO5)

Text Books/ Reference Books:

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

MEL431ADVANCE MECHANISMS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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.

Mapping with POs:

POs→ COs↓	**PO1**	**PO2**	**PO3**
CO1	H	M	H
CO2	H	M	H

CO3	H	H	H
Overall	H	M	H

Content

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 chebyshev'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.

Text Books/ Reference Books:

1. Tao 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.

MEL433 DESIGN FOR MANUFACTURING & ASSEMBLY

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

Mapping with POs*:

POs → COs ↓	PO1	PO2	PO3
CO1	L	L	H
CO2	H	M	H
CO3	H	M	H
CO4	H	M	H
Overall	H	M	H

Content

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.

Text Books/ Reference Books:

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.

MEL437 COMPOSITE MATERIALS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon completing this course,

1. Student would be able to understand behavior and specialties of orthotropic materials.
2. They will be able to find appropriate applications where a particular composite can be used.
3. Students will also have sound understanding of theory of elasticity and mechanics of orthotropic materials and behavior under bi-axial stress conditions.
4. Students will learn the concept of design optimization with proper material selection.

Mapping with POs:

POs→ COs ↓	**PO1**	**PO2**	**PO3**
CO1	H	H	H
CO2	M	M	H
CO3	H	H	M

CO4	M	M	L
Overall	H	H	M

Content

Introduction to composite materials, evolution and applications in engineering. Characteristics and classification of composite materials; Fibrous, laminated and particulate composites. Basic terminologies; 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 moduli, shear modulus. Concept of coupling coefficients. General and special orthotropic 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 behavior 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 Books/ Reference Books:

1. Mallick, P. K. , “Fibre-Reinforced Composites, CRC press,” New York, 2007
2. Jones, R.M., “Mechanics of Composite Materials,” McGraw Hill, New Delhi
3. Broutman and Agarwal, “Analysis and Performance of Composite materials”, John Willey and Sons, New York

MEL439 PRODUCT DESIGN & DEVELOPMENT

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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.

Mapping with POs*:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	M	H
CO2	M	L	H
CO3	M	M	H
Overall	M	M	H

Content

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.

Text Books/ Reference Books:

1. Chitale, Gupta, " Product Design & Manufacturing", 2nd Ed 2002, Prentice Hall of India

MEL452ADVANCED MACHINING PROCESSES

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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.
4. To provide an insight to choose his research career.

Mapping with POs:

POs → **COs ↓**	**PO1**	**PO2**	**PO3**
CO1	H	H	M
CO2	L	M	H
CO3	H	M	L
CO4	H	M	M
Overall	H	M	M

Content

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)

Text Books/ Reference Books:

1. Boothroyd, G and Knight, W A., “Fundamentals of Machining and Machine Tools”, 3rd Third Edition, Saint LuicePr, 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.

MEL515ROBOTICS AND MACHINE VISION

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	L	H
CO2	H	L	M
CO3	H	L	M
CO4	H	L	H
Overall	H	L	H

Content

Industrial Robots: Frame assignment, DH parameters, forward kinematics, Inverse kinematics, Differential motion, Dynamics and Control (CO1, CO2)

Mobile Robots: Mobile robot vehicles, Mobile robot kinematic and dynamic analysis, trajectory planning, mobile robot localization and navigation (CO1)

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 (CO4)

Machine Vision: Light and Color, Image forming, Image processing, Image feature Extraction, Using multiple images, vision based control, advanced visual servoing.(CO3)

Text Books/ Reference Books:

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.".

MEL533 FAILURE ANALYSIS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The objective of the course is to provide the students with fundamental knowledge to conduct a failure analysis due to different loading conditions.
2. Describe the diverse factors that cause mechanical failures.
3. Identify the different facture modes and their characteristics.
4. Identify failure mechanisms.
5. Apply the procedures to conduct a failure analysis investigation

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	H	L
CO2	H	H	L
CO3	H	M	M
CO4	H	M	H
CO5	M	H	M
Overall	H	H	M

Content

General principle and procedure of failure analysis, Causes of failure: material selection, defective process, environment condition, load variables, temperatures, defective design and assembly, surface micro and macro cracks Failure of brittle and ductile material. CO1,CO2, CO3

Details of fractographic, Crack initiation and propagation in ductile and brittle material, Griffith theory, Irwin's modification, surface and embedded cracks, Surface treatments to minimize the surface cracks, Crack growth mechanism for plane stress and plain strain, Notch sensitivity, stress tri-axiality, Failure due to tension and torsion, Modulus of rupture, stress intensity factor, Fatigue crack growth, striations, identifications and remedies. CO1,CO2, CO3, CO4

Material and process defects: Significance and corrective actions against material and process defects, Inclusions, Casting defects, forging defects, welding defects, Heat affected zone, Defects in coatings.CO3, CO4

Non-destructive testing: Principle and methodology of different NDT methods, Liquid Penetration Testing, Ultrasonic Testing, Radiographic Testing, Magnetic Particle Testing. CO5

Case Studies and mini project: Failure investigations of crack shaft, boiler tube, turbine rotor, blades, aircraft fuselage.CO1, CO2,CO,CO4 and CO5

Students will work in groups to provide a preliminary investigation of a failure, including macroscopic inspection and photographic documentation. A report detailing the initial findings and development of a proposal for a more detailed analysis will be required.

Text Books/ Reference Books:

4. Title Failure Analysis of Engineering Materials
   Author Charlie R. Brooks, Ashok Choudhury
   Publisher McGraw Hill
   Edition Second Edition
5. Title Deformation and Fracture Mechanics of Engineering Materials
   Author Richard W. Hertzberg, Richard P. Vinci, Jason L. Hertzberg
   Publisher John Wiley & Sons
   Edition Fifth Edition
6. Title Failure Analysis of Engineering Structures: Methodology and Case Histories
   Author V. Ramachandran

Publisher ASM International, 2005 - TECHNOLOGY & ENGINEERING

MEL537 PRODUCT IDEATION AND DESIGN

3 credits (3-0-0)

Pre-requisites: NIL

Overlaps with: NIL

Course Outcomes/ Objectives :

1. To explain students essentials of product design process for engineering product,
2. To make student understand various definitions and theoretical concepts related to engineering product development to PG level students.
3. To explain student the product design strategies and subsequent generalisedsteps to convert conceptualised idea into a product.
4. To make the students comprehendintegration of engineering knowledge, technology tools and other resources to deliver successful product.
5. To analysesuccessful product with above objectives through case studies

Content:

1. Ideation in Engineering Product

Understanding users, defining their needs and defining the problem to solve. Methods for creating creative concepts - exploration of alternative solutions. Mapping the functional requirements to possibilities of form. Considerations of user requirement like function, materials and processes, sketching and modelling for product ideation

2. Industrial Product Design

Product functions relationship. Situation/ Context of use, users, market research, and product research with a focus on materials and processes. Opportunity Identification, Product development charter, Strategies for handling industrial product, Analysis of research information and identification of problem areas leading to a problem statement and articulation of constraints.

Methods/ Techniques for evolution of creative alternative concepts. Gate clearances, Validation of concepts through Exploratory Mock ups from the point of view of product functions by the users and other stakeholders. Finalisation of the concept, preparation of final model, technical drawings and other supporting documentation

Text Books/ Reference Books:

1. 1 Engineering Design methods strategies for product design, Nigel Cross, Willey Publication
2. Kevin Otto and Kristen Wood, Product design: Techniques in Reverse Engineering and New Product development, Prentice Hall, USA, 2001
3. Product planning and Management by William l Moore and E. A. Pressemier McGraw-

Hill International edition 2nd Edition, 2009

4. Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, McGraw-Hill, 5th Edition, 2015 reprint.

MEL527HYDRAULICS AND PNEUMATICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The students will able to understand various definitions, theoretical concepts and derive equations related to fluid properties and relationship between them, and apply the equations to various hydraulic and pneumatic components. (CO1)
2. The students will able to understand principles of working of various measuring devices used in hydraulic and pneumatic circuits like pumps, valves, hydraulic motors etc., from undergraduate perspective. (CO2)
3. The students will able to apply mathematical treatment to various problems related to fluid systems and calculate the values of various parameters and design simple hydraulic and pneumatic circuits. (CO3)

Mapping with POs*:

POs→ COs↓	PO1	PO2	PO3
CO1	M	L	H
CO2	H	L	L
CO3	M	L	H
Overall	M	L	H

Content

1. Basic Concepts of Hydraulics : Introduction & definitions of important terms like hydraulics, pressure, force, vacuum etc., Pascal’s law and its application to hydraulics, Bernoulli's principle , Hydraulic jack, Hydraulic symbols, Advantages and disadvantages of hydraulic system, Hydraulic oil, purpose, ideal characteristics of hydraulic oil, maintenance of hydraulic oil, Relief valve & safety valve. (CO1)

2. Accessories of Hydraulic System: Connectors - steel pipe, tubing, hose, Gauges, Packing & seals, Filters & strainers, Hydraulic tank, Plumbing, pipes & tubes, installation. (CO1)

3. Hydraulic Valves And Auxiliaries : Directional control valves, Pressure control valves, Flow control valves, Relief valve & safety valve, Pressure intensifiers, Actuators – rotary, oscillatory & linear, force speed / torque speed diagram, selection of actuator, speed control, Accumulators, Cartridge valves, Proportional valves – types, Introduction to servo-hydraulic systems.(CO2)

4.Hydraulic Pumps and Motors: The power pack, elements of power pack, Positive displacement pump, fixed delivery/variable delivery, Pump characteristics and specifications, Construction & working of gear pump, vane pump, radial piston pump, Pump maintenance & trouble shooting, Hydraulic motor specifications, Construction & working of gear motor, vane motor, radial piston motor, Storage, commissioning, trouble shooting, maintenance and safety (CO2)

5. Hydraulic Circuits: Clamp control circuit, Injection control circuit, Reciprocating screw circuit, Oil filtration circuit, Deceleration circuit, Prefill circuit, Hydraulic motor circuit, Hi-low pump circuit, Meter–in, meter–out & bypass circuits, Designing, simulation and testing of hydraulic control circuits for simple as well as complex machine systems (CO3)

6. Pneumatics: Pneumatics, symbols, Comparison with hydraulic system, Air Compressors, Compressed air, generation, control & distribution, Components of pneumatic system, Actuators, single and double acting cylinders, Air receiver, size determination and pressure control, Pressure loss calculation and air line design, Stages of air treatment – intercooler, lubricator, filter, air dryer, Design, operation and testing of pneumatic circuits for typical processing machines and heavy equipment (CO3)

7. Introduction to fluidics and safety aspects of hydraulic and pneumatic systems (CO1)

Text Books/ Reference Books:

1. Oil Hydraulic Systems: Principle and Maintenance by S. Majumdar, Publisher McGrawHill Publication,
2. Pneumatic System: Principles and Maintenance by S. Majumdar, Publisher McGrawHill Publication
3. Hydraulic and Pneumatic by Andrew Parr, Publisher: Elsevier Science & Technology Books

4. Fluid Mechanics and its applications by V. Gupta and S.K. Gupta, New Age International Publisher,2007

MEP527HYDRAULICS AND PNEUMATICS (Lab)

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students will be able to

1. Know basic elements of hydraulic and pneumatic circuits
2. Use different valves and actuators
3. Make different hydraulic and pneumatic circuits

Mapping with POs:

POs→ COs↓	PO1	PO2	PO3
CO1	M	M	H
CO2	H	M	H
CO3	H	M	H
Overall	H	M	H

Content

1. Operation of double acting cylinder using4/3 hand lever valve (CO3)
2. Operation of double acting cylinder using4/2 hand lever valve (CO3)
3. Experimentation on actuator speed control circuit setup (CO1)
4. Experimentation on hydraulic accumulator (CO1)
5. Study of transverse and feedback circuit (CO2)
6. Experimentation on the operation of telescopic cylinder(CO2)
7. Study of pressure sequence valve in hydraulic circuit (CO2)
8. Demonstration of operation of limited rotary actuator (CO2)
9. Experimentation for verification of operation of regenerative circuit (CO2)
10. Design and operation of hydraulic brake circuit (CO3)

Text Books/ Reference Books:

EVEN SEMESTER COURSES

MEL418ADVANCED STRESS ANALYSIS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. Explain the concept of elasticity, and the difference between stress and strain
2. Explain the terms: isotropic, orthotropic and anisotropic, as applied to materials
3. Explain the terms: plane stress and plane strain
4. Use the concepts of principal stress and principal strains
5. Use the basic tensor notations, the stress, strain and inertia tensors, and their reduction to principal axes

Mapping with POs:

POs→ / COs ↓	**PO1**	**PO2**	**PO3**
CO1	H	H	H
CO2	H	L	M
CO3	H	M	M
CO4	M	H	M
CO5	H	M	M
Overall	H	M	M

Content

Fundamentals of stress and strain, stress strain relationship, Elastic constant, plane stress, plane strain: CO1, CO2 and CO3

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

CO1,CO5

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: CO1, CO5

Thermal stress, circular disc, thin plate, long cylinder: CO3, CO4 and CO5

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: CO1,CO5

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: CO4, CO5

Text Books/ Reference Books:

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

MEL520NON-LINEAR OPTIMIZATION

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: After completion of this course, the student will have

1. Understanding the formulation and deriving solution for complex nonlinear optimization problems.
2. Ability to assess the quality of available methods and solutions for such problems.
3. Ability to generate own algorithms for various optimization techniques and implement.

Mapping with Pos:

Pos → / **Cos ↓**	**a**	**b**	**c**

CO1	H	M	H
CO2	M	M	M
CO3	H	H	H
Overall	H	M	H

Content: (CO wise, mention applicable COs at the end of each unit or paragraph):

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. (CO1, CO2)

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. (CO2, CO3)

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. (CO2, CO3)

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. (CO2, CO3)

Advanced Topics: Multi objective optimization- Weighted and constrained methods, Multi level Optimization, Evolutionary algorithm for optimization and search, Applications. (CO2)

Text Books/ Reference Books:

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. SrinivasaRaju and D. Nagesh Kumar, "Multicriterion Analysis in Engineering and Management", PHI Learning Pvt. Ltd., New Delhi, India

MEL523 COMPUTER INTEGRATED MANUFACTURING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. Develop an understanding of computer-integrated manufacturing (CIM) and its impact on productivity, product cost, and quality
2. Develop an understanding of classical and state-of-the-art production systems, control systems, management technology, cost systems, and evaluation techniques
3. Obtain an overview of computer technologies including computers, database and data collection, networks, machine control, etc, as they apply to factory management and factory floor operations.
4. Describe the integration of Design & manufacturing activities into a complete system through standards, interfaces etc

Mapping with POs:

POs→ / COs ↓	PO1	PO2	PO3
CO1	L	H	M
CO2	L	H	M
CO3	L	H	H
CO4	L	M	H
Overall	L	H	M

Content

Introduction to CIM, Types of Manufacturing, CIM hardware and software, Elements of CIM, Product development through CIM, CIM Management, Emerging Technologies and

Ramifications

Introduction, Database requirements of CIM, Database, Database management, Database Models, Product Data Management (PDM), Advantage of PDM. Introduction to PLM.

Product Design: Design and Engineering, CAD,CAE, Transportability, Need of CIM and Reverse Engineering,

Production: Manufacturing cell**,** Group Technology, Cellular Manufacturing.

Introduction to EMS. Manufacturing integration model, flexible manufacturing strategy, Components of Flexible Manufacturing-Pallets and fixtures, machining centers, inspection equipment, material handling stations, storage system, In-process storage, manually operated stations, allied operation centers.

Principles of networking, Network Techniques, Local area network (LAN), networking standards, hardware elements of networking, Networking topologies, MAP, Collaboration Engineering.

Text Books/ Reference Books:

1. S. Kant Vajpayee, "Principles of Computer-Integrated Manufacturing", Prentice Hall Career & Technology, 2007.
2. Mikell P. Groover, "Automation, Production Systems, and Computer-integrated Manufacturing" Wiley & Sons Inc., Prentice Hall, 2008
3. Roger Hannam, "Computer-Integrated Manufacturing, From concepts to realization., Addison-Wiley4th Edition 2005

MED502 Project Phase II

9 credits

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students will be able

1. To identify research problem
2. To review literature
3. To present research report
4. To carry out scientific investigation

Mapping with POs*:

POs→ / COs ↓	PO1	PO2	PO3
CO1	L	M	M
CO2	M	M	M
CO3	H	H	H
CO4	H	H	H
Overall	H	H	H

Content

Text Books/ Reference Books:

MEL415MECHANICAL VIBRATION

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

Mapping with POs:

POs → / COs ↓	1	2	3
CO1	H	L	H
CO2	H	L	H
CO3	H	H	H
CO4	M	L	H
CO5	H	M	H
CO6	M	M	M
Overall	H	M	H

Content

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. Numericalsimulation 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.

Text Books/ Reference Books:

1. Rao, Gupta, "Theory & practice of Mechanical vibration," 3rd Edition, New Age 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

MEL510 MANUFACTURING SYSTEM SIMULATION AND DESIGN

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon successful completion of this course, the students will

1. Understand the concepts in system simulation and underlying statistical theories.
2. 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.

3. Differentiate and understand various system simulation strategies.
4. Develop the skills of modelling and simulation using various software / programming languages.

Mapping with POs:

(**Relationship of Course Objectives to Program outcomes: (A Sample is given below)**

The correlation of the COs with the POs are given in the following table. Letters 'H', 'M', or 'L' in a cell indicates 'high', 'medium' or 'low' correlation of the CO with the corresponding PO. A blank cell indicates no correlation.)

POs→ COs ↓	**a**	**b**	**c**
CO1	L	M	H
CO2	H	H	M
CO3	L	-	H
CO4	H	M	-
Overall	M	M	H

Content: (CO wise, mention applicable COs at the end of each unit or paragraph):

Systems concepts in manufacturing, Types of systems, Basic concepts in simulation, Probability and statistical distributions. [CO1]

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. [CO3]

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. [CO2]

System modelling and simulation using appropriate software / programming language. Case studies and mini projects in system simulation. [CO4]

Text Books/ Reference Books:

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

MEL529 Industrial Product Development

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with: NIL

Course Outcomes/ Objectives :

1) To explain students what is an engineering product,

2) To make student understand various definitions and theoretical concepts related to Industrial product development at PG level.

3) To explain student the product development strategies and subsequent steps to manifest conceptualized product idea into an engineering product form Industry perspective.

4) To make the students comprehend the need of organization, integration of engineering knowledge technology tools and other resources to deliver commercial engineering product.

5) To analyse commercial engineering product with above objectives through the case studies.

Content:

1. New Product Development

Basic Concepts in Design, Concept Level, Cost v/s Time evaluation, Necessity of new products, Organizational Strategies to handle new product Development, Management Approaches towards Engineering Design, Emergence of Engineering Product Development, Market Research, Formation of cross functional Teams, Quality Function Development, Product Brief, Business Case preparation and clearance , Budget Planning, Product Costing, Roles of respective CFT members, Stakeholders’ meeting, concept gate review.

2. Generation -1

Building first generation aggregate and prototypes, Tooled up exclusive components few, in quantity and percentage wise, 3D Modelling of the components, Validation through CAE rout, Testing and Validations of aggregates, Field testing of prototypes for identified application, Generation 1 gate review.

3. Generation -2

Corrections form generation -1, Tooled up exclusive and prototypes and aggregate build, Capital budget outflow, pre-production approval process, manufacturing location total involvement, role of CFT members from plant, Jury panel evaluation, Progress on validation, issue on capturing and resolution process, Virtual 3D modelling of the product through virtual assembly line, Generation 2 gate review

4. Seeding

Seeding of the product, batch size, Implementation of Quality Function Deployment, Monitoring the performance at customer end, Monitor and ensure Budget utilization, Enhanced role of customer care, Marketing, Component development, quality assurance and product development teams, Monitoring the cost v/s target, capturing the issues and resolution process, Seeding Gate review.

5. Pilot Production

Gradual ramp up in production, ramp up planning, CFT team dynamics, CFT accountability, Product strengthening in the market, Spares availability, certification of the pre-production approval process, Capturing the issues and resolution process, Stakeholders' clearances for production batches, Pilot production gate review.

6. Start of the volume production(SoVP)

Planning for SoVP, enhancement in the accountability of different functions, Spare parts management, Team strengthening for production success, Quality and customer care initiative, Handing over the issue resolution process, Material development function handover, Quality Assurance function handover to plant QA team, Engineering release for production, SoVP gate review. Formal Project Closure

Customer satisfaction Index, Commercial brand Marketing , Stakeholders review meeting

Text Books/ Reference Books:

1. New product Management, Crawford and Bendetto, Irwin MCGraw Hill, 6th Edition, ISBN 978, 2010 editionRao, S. S., "Engineering Optimization (Theory and Practice)",

John Wiley & Sons,

2. Product planning and Management by William l Moore and E. A. Pressemier McGraw-Hill International edition 2nd Edition, 2009
3. Engineering design methods strategies for product design, Nigel Cross, Willey Publication
4. Product Design and Development by Karl T. Ulrich and Steven D. Eppinger, McGraw-Hill, 5th Edition, 2015 reprint

MEL530 MACHINE CONDITION MONITORING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

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

Mapping with POs:

POs → / **COs ↓**	**PO1**	**PO2**	**PO3**
CO1	M	L	H
CO2	H	L	H
CO3	H	M	H
CO4	M	M	H
Overall	H	M	H

Content

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

Text Books/ Reference Books:

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 PaezT , "Harris' Shock and Vibration Handbook," Mc-Graw Hill, 2010
4. Alan Davies, "Handbook of Condition Monitoring: Techniques & Methodology," Chapman & Hall, London , 1998.

MEL518 FRACTURE MECHANICS AND NON DESTRUCTIVE TESTING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives :

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.

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	H	M
CO2	M	H	H
CO3	M	H	H
CO4	H	H	M
Overall	H	H	H

Content

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: CO1 and CO2

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: CO1, CO2 and CO3

Paris equation. Fatigue and fracture safe designs. Investigation and analysis of failures: CO1, CO2 and CO3

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: CO3 and CO4

Text Books/ Reference Books:

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.

MEP518FRACTURE MECHANICS AND NON DESTRUCTIVE TESTING (Lab)

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students will be able to use:

1. Basic NDT methods
2. Handle NDT equipment with confidence
3. Calibrate equipment

Mapping with POs*:

POs→ / COs ↓	**PO1**	**PO2**	**PO3**
CO1	H	H	M
CO2	H	M	H
CO3	M	M	H
Overall	H	M	H

Content

1. Evaluation of fracture toughness by using crack tip opening displacement method. CO1
2. Study of Radiography testing (X- Ray method) method for testing of materials. CO1
3. Study of Ultrasonic testing machine and its calibration using straight beam probe. CO1, CO2 and CO3
4. Calibration of Ultrasonic testing machine using angle beam probe. CO1, CO2 and CO3
5. Detection of internal cracks using Ultrasonic testing machine and straight beam probe. CO1, CO2 and CO3
6. Detection of internal cracks using Ultrasonic testing machine and angle beam probe. CO1, CO2 and CO3
7. Study of Magnetic particle testing method for testing of surface cracks in material. CO1,

CO2 and CO3

8. Study of Eddy current testing method for testing of surface cracks in material. CO1, CO2
9. Dye penetration testing method for crack analysis of materials. CO1
10. Analysis of stresses by using photo elasticity. CO1, CO2 and CO3

Text Books/ Reference Books:

MEL526 ADHESION, FRICTION AND CONTACTMECHANICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students 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

Mapping with POs*:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	M	H
CO2	M	M	H
CO3	H	M	H
Overall	H	M	H

Content

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 chaosandfractals, geophysical applications

Text Books/ Reference Books:

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. PerssonBo.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

MEP526ADHESION, FRICTION AND CONTACT MECHANICS (Lab)

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The students will be able to understand adhesion, friction, and contact mechanics though experiments.
2. The students will demonstrate an ability to conduct experiments and analyze the results under realistic constraints .
3. Graduates will be trained with computer programming language such as MATLAB and ANSYS softwares.
4. Graduates will be trained for higher studies and research.

Mapping with POs*:

POs→ / COs ↓	PO1	PO2	PO3
CO1	H	M	H
CO2	H	M	H
CO3	H	M	H
CO4	H	M	H
Overall	H	M	H

Content

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

Text Books/ Reference Books:

MEL532LAYERED MANUFACTURING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon successful completion students will be able to:

1. Understand the current available layered manufacturing systems, their operating principles and their characteristics
2. Be able to describe complementary, secondary fabrication processes
3. Be able to select the appropriate fabrication technology or technologies for a given task

Mapping with POs:

POs→ / COs↓	PO1	PO2	PO3
CO1	H	H	M
CO2	M	H	H
CO3	H	H	H
Overall	H	H	H

Content

Overview of Rapid prototyping and automated fabrication technologies

Need of prototype in typical design cycle, Ideal design cycle and manufacturing, Free from fabrication for product design and manufacturing

Rapid prototyping technologies, History of layered manufacturing, Steriolithography, Solid ground curing, Selective laser sintering, Fused deposition modeling, Laminated object manufacturing

Other systems

The underlying material science, Photopolymers, Thermoplastics, Powders

Generating CAD models suitable for automated fabrication, The .STL file format, Repairing CAD models, Adding support structures, Model slicing

Rapid prototyping assisted casting, Casting simulation, Pattern making using Rapid prototyping, Die making using Rapid prototyping, Application, Remote manufacturing on demand

Ongoing research activities, Medical implant manufacturing

Text Books/ Reference Books:

1. Nasr, E.A., Kamrani, A.K., "Engineering design and Rapid prototyping", Springer
2. Cooper, K.G., "Rapid prototyping Technology: Selection and application", CRC press

MEP532LAYERED MANUFACTURING (Lab)

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Students will be able to use:

1. 3 D modelling software
2. To fabricate model of given component
3. To use simulation software

Mapping with POs*:

POs→ / COs ↓	PO1	PO2	PO3
CO1	H	H	M
CO2	H	M	H
CO3	H	M	H
Overall	H	M	H

Content

1. Study and use of 3-D modeling software to generate .STL file

2. Generation and repairing of .STL file for Rapid prototyping
3. Fabrication of physical model on Rapid prototyping machine using Break-away support system
4. Fabrication of physical model on Rapid prototyping machine using Soluble support system
5. Use of simulation software for rapid prototyping assisted casting

Text Books/ Reference Books:

MEL* Design of Fixtures in Manufacturing**

3 credits (3-0-0)

Pre-requisites: Nil
Overlaps with:MEL310

Course Outcomes/Objectives:On completion of this course, students will be able to

- To understand the importance of precision manufacturing and tool design.
- To understand the principles and design techniques of jigs and fixtures.
- To design and develop jigs and fixtures for a particular part.
- To select the suitable materials for the jigs and fixture elements.

CO/ PO	a	b	c	d	e	f	g	h	i	j	k
CO1	L	L	M	-	-	-	M	-	L	M	L
CO2	M	M	H	-	-	-	M	-	-	M	H
CO3	H	H	H	M	M	H	M	-	M	H	M
CO4	H	L	M	L	-	-	L	-	M	M	M
Overall	H	M	H	L	L	M	M	-	M	H	M

Content:

Precision Manufacturing: Part Accuracy, Geometric Dimensioning and Tolerancing (GD&T), Static Stiffness & Accuracy, Supporting Elements for Work Setting, Concept of Tool Design, Overview of Tool Design. CO1

Introduction to Jigs & Fixtures: Elements and their Function, Classification and Types of Jigs & Fixtures, Fundamental Principles of Jigs & Fixtures, Features: Locating/Datum Surface, Loading/Unloading and Clamping, Tolerancing on Fixtures. CO2

Supporting, Locating and Clamping Principles: Referencing, Basic Rules for Locating, Fool Proofing, Planes of Movement and Restriction, Stability of Work, Locating Principles and Types, Locating from an External Profile,Rules of Clamping, Cutting and Clamping Forces, Types of Clamps, Non-mechanical Clamping, Clamping Accessories. CO1, CO2

Design of Jigs & Fixtures: Design Economics, Tool Design Parameters, Developing the Initial Design, Initial Drawing and Dimensioning, Limits and Critical Dimensions, Design of Milling Fixtures, Turning and Welding Fixtures, Sheet Metal Forming Fixtures, Case Studies. CO2, CO3

Materials for Jigs &Fixture Elements: Basic Properties Required for Jigs & Fixtures, Ferrous, Non-ferrous and Non-metallic Tool Materials, Designing with Relation to Heat Treatment, Dimensional Stability. Safety and Maintenance. CO3, CO4

Text Books/ Reference Books:

1. Jig & Fixture Design, by Edward Hoffman
2. Metal Cutting and Design of Cutting Tools and Jigs & Fixtures, by N.K. Mehta
3. Jigs and Fixtures, by P. H. Joshi
4. Jigs and Fixtures: Non-standard Clamping Devices, by Hiram E Grant
5. Tool Design, by Cyril Donaldson

EL*DYNAMICS OF MECHANICAL SYSTEM**

3 credits (3-0-0)

Pre-requisites: MEL301 Theory of Machine-II

Overlaps with: Nil

Course Outcomes/ Objectives:

1. To explain the students about the basics and practical significance of Dynamics of Machine
2. To expose the students to basic principle of governing the motion of mechanical systems
3. To enable students to apply mathematical approaches to solve engineering problems related to the dynamics of machine
4. To develop their skill in analysis and control of their motion and enable students for higher studies and research

Mapping with POs:

POs → / COs ↓	PO1	PO2	PO3
CO1	H	H	M
CO2	H	H	M
CO3	H	H	H
CO4	L	M	H
Overall	H	H	M

Content

Basic Concepts: Functional Laws of Motion, Mechanics of Particles and System of Particles, Inertia Coordinate System, Principles of Linear and Angular Momenta, Work-energy principles.

Lagrangian Dynamics: Degrees of Freedom, Generalized Coordinates and Generalized Forces, Holonomic and Non-holonomic Constraints, Lagrange's Equation from D' Alembert's Principles, Application of Lagrange's equation for Conservative and Non-conservative with holonomic and Non-holonomic Constraints, Applications to systems with very Small Displacements and Impulsive Motion.

Hamilton Dynamics: Hamilton Principle from D' Alembert's Principle, Lagrange Equation from Hamilton's Principle

Multi-body Dynamics: Space and Fixed body Coordinate Systems, Coordinate Transformation Matrix , Direction Cosines, Euler Angles, Euler Parameters, Finite and Infinitesimal Rotations, Time Derivatives of Transformations Matrices, Angular Velocity and Acceleration Vectors, Equations of Motion of Multi-Body System, Newton-Euler Equations, Planer Kinematic and Dynamic Analysis, Kinematic Revolute Joints, Coordinate Partitioning, Equations of Motion, Joint Reaction Forces, Simple Applications of Planer Systems.

Stability of Motion: Fundamental Concept in Stability, Routh's Criteria for Stability, Lyapunov Method,

Text/Reference Books:

1. Lyapunov's Stability Theorems, Lyapunov's Function to Determine Stability of the System.
2. J. H. Ginsberg, "Advanced Engineering Dynamics", Harper and Row, 1988
3. L. Meirovitch, "Methods of Analytical Dynamics", McGraw Hill Inc, 1970
4. Greenwood "Principles of Dynamics", Prentice Hall Inc, 1987
5. Goldstein, "Classical Mechanics", Addison Wesley, 1983
6. R .H. Canon, "Dynamics of Physical System", McGraw Hill Inc, 1967

MEL 4xx: ADVANCED MECHANICS OF SOLIDS

3 credits (3-0-0)

Pre-requisites: MEL206 Solid Mechanics

Overlaps with: MEL418 Advanced Stress Analysis (10%)

Course Outcomes/ Objectives :

1. To provide students with the fundamental understanding of advanced area and applications of solid mechanics and theory of elasticity.
2. To develop analytical and mathematical modeling skill among students in the area of Solid mechanics.
3. To develop computational skill in the area of two/three dimensional stress and deflection analysis.
4. To make the students confident with actual engineering problems :

Mapping with POs:

CO/ PO	a	b	c	d	e	f	g	h	i	j	k
CO1	H	H	H	H	H	M	M	H	H	H	H
CO2	H	H	M	M	H	M	M	H	M	H	H
CO3	M	L	M	H	H	M	M	L	L	H	H
CO4	H	M	H	M	H	M	M	L	L	M	H
Overall	H	H	M	M	H	M	M	H	M	H	H

Course Content:

Unit 1: Bending of straight beams

Deflections in statically determinate and indeterminate beams. Energy method and application of Castiglianos theorem. Maxwell-Betti reciprocal theorem. Influence functions (Green's functions) for beams. Beams on elastic foundations.

Unit 2: Bending of curved beam (Winkler-Bach formula).

In-plane and out of plane loaded curved beams. Applications in helical springs, crane hooks etc.

Unit 3: Stresses in cylindrical discs.

Rotating discs and discs with pressure and shrink fits.Thick walled cylinder subjected to internal and external pressure.

Unit 4: Bending of Plates

Differential equation of plate bending under small defelection. Rectangular and circular plates with various boundary conditions. Navier solution for simply supported and uniformly loaded rectangular plates. Plates under hydrostatic pressure and under concentrated loading. Equation of bending of plates in polar co ordinate. Axisymmetric bending of circular plate under various loading conditions. Solutions using Greens functions.

Unit 6: Two-dimensional problems in elasticity.

Equilibrium equations. Strain-displacement and compatibility relations. Biharmonic equation. Plane stress and plane strain problems. Stress functions approach. Airy's stress function. Polynomial function approach.

Text Books/ Reference Books

1. Theory of Elasticity by Timoshenko and Goodier. McGraw Hill publications 3rd Edition
2. Advanced Mechanics of Solids by L S Srinath Tata McGraw Hill 1st Ediiton
3. Advanced Mechanics of Materials by Solecki and Conant Oxford University Press
4. Theory of Plates and Shells by Timoshenko and Woinowsky-Krieger McGraw Hill 3rd Edition