College of Engineering, Pune
(An Autonomous Institute of Govt. of Maharashtra, Permanently Affiliated to S.P. Pune University)

Department of Manufacturing Engineering and Industrial Management

Curriculum Structure & Detailed Syllabus (UG Program)

Third Year B. Tech. (Production Engineering S/w)
(Revision: A.Y. 2020-21, Effective from: A.Y. 2021-22)

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Program Education Objectives (PEOs):

The Undergraduate students will demonstrate:

I. **PEO1**: Advance professionally as a result of his/her ability to solve complex technical problems using the knowledge of mathematics, science, engineering and humanities and to work in multidisciplinary areas whose solutions lead to significant societal benefits.

II. **PEO2**: Demonstrate professional engineering competence to real life problems and compete successfully using principles of manufacturing and time and quality management in the design and manufacture of products and services.

III. **PEO3**: Exhibit professionalism, ethical attitude, communication skills, teamwork in their profession and adapt to current trends by engaging in lifelong learning.

Program Outcomes (POs):

The Undergraduate Students will demonstrate:

a. Graduates will apply the basic knowledge of mathematics, science, engineering and humanities to Production Engineering field
b. Graduates will have the ability to define the problems and provide solutions by designing and conducting experiments, interpreting and analyzing data for manufacturing.
c. Graduates will design manufacturing systems that would encompass machining science and technology, production processes, metal forming, tool and die design with the fully acquaintance with engineering thermodynamics and heat transfer, theory of machines, strength of material and would meet specifications and requirements as demanded by the customers.
d. Graduates will apply design and tooling for manufacturing, Kinematics of Machine Elements, Quality Control, modeling of manufacturing systems to solve production engineering problems.
e. Graduates understand manufacturing technologies like computer-controlled processes and Industrial Engineering, production management, SCLM, and Total Quality Management concepts.
f. Graduates will have the confidence to apply engineering solutions in global and societal contexts.
g. Graduates will understand quantitative modeling and analysis of a broad array of systems-level decision problems concerned with economic efficiency, work design, productivity and quality with environmental focus.
h. Graduates should be capable of self-education and clearly understand the value of achieving perfection in their professional endeavors.
i. Graduates will participate as members of engineering and science laboratory teams, as well as members of multidisciplinary design teams.
j. Graduates will be proficient in English language in both verbal and written forms which will enable them to compete with graduates of international engineering institutions.
k. Graduates will have the ability to choose and apply appropriate resource management technique/s so as to optimally utilize resources in manufacturing systems.
l. Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.

Correlation between the PEOs and PO's/PSO's

Program Objectives		Program Outcome												Program Specific Outcomes		
		a	b	c	d	e	f	g	h	i	j	k	l	PSO1	PSO2	PSO3
PEO's	I	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓
	II	✓	✓	✓	✓	✓	✓					✓	✓	✓		
	III	✓	✓				✓		✓	✓	✓		✓			✓

Program Specific Outcomes:

After completion of the program, the graduates should be able to:

PSO1: Apply knowledge of manufacturing systems, Industrial Engineering and analytical techniques to solve real world problems.

PSO2: Apply knowledge of machine tool design,

measurement systems, quality control and management systems to identify, formulate and solve complex engineering problems.

PSO3: Design, develop and manufacture innovative products using emerging manufacturing and computing technologies like CAD/CAM/CIM, Rapid prototyping, machine learning, artificial intelligence etc.

List of Abbreviations

Abbreviation	Title	No of courses	Credits	% of Credits
BSC	**Basic Science Course**	**9**	**27**	16.27
ESC	**Engineering Science Course**	**5**	**18**	10.84
MLC	**Mandatory Learning Course**	**3**	**0**	0.00
SLC	**Self-Learning Course**	**2**	**4**	2.41
HSMC	**Humanities/Social Sciences/Management Course**	**6**	**7**	4.22
LLC	**Liberal Learning Course**	**1**	**1**	0.60
SBC	**Skill Based Course**	**7**	**26**	15.66
IFC	**Interdisciplinary Foundation Course**	**2**	**4**	2.41
IOC	**Interdisciplinary Open Course**	**2**	**4**	2.41
DEC	**Department Elective Course**	**2**	**6**	3.61
PCC	**Program Core Course**	**17**	**49**	29.52
LC	**Laboratory Course**	**19**	**20**	12.05
		75	**166**	

Third Year B. Tech (Production S/w)
Curriculum Structure
(w.e.f. 2021-22)

Semester V [Odd Term]

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	SBC	PE-21009	Industrial In-plant Training	0	0	0	10
2	LC	PE-21010	Seminar-I	0	0	0	1
3	SLC	PE-21011	Basics of Kinematics and Dynamics of Machines/ Equivalent MOOC course	0	0	0	3
				0	**0**	**0**	**14**
			Total Academic Engagement and Credits	**Max. 0**			**14**

For Other departments

			Interdisciplinary Fundamental Course-III	**L**	**T**	**P**	**Credits**
1	IFC	PE(IF)-21003	Robotics	2	0	0	2

Semester VI [Even Term]

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	BSC	MA-21001	Probability and Statistics for Engineers	3	0	0	3
2	HSMC	HS-21004	Industrial Engineering and Engineering Economics	3	0	0	3
3	HSMC	HS-21001	Entrepreneurship Principles and Process	1	0	0	1
3	MLC	ML-21001	Constitution of India	1	0	0	0
4	SBC	PE-21012	Mini project ["D-S-P-T: Design-Simulate-Prototype-Test"]	0	0	4	2
5	IOC	IOC-210XX	Interdisciplinary Open Course	2	0	0	2
6	DEC	PE(DE)-210XX	Department Elective -I/Industry floated Course/Co-Taught Course	3	0	0	3
7	PCC	PE-21013	Tool and Die Design	3	0	0	3
8	PCC	PE-21014	Material Forming	2	1	0	3
9	PCC	PE-21015	Kinematics and Dynamics of Machines	3	0	0	3
10	LC	PE-21016	Tool and Die Design Laboratory	0	0	2	1
11	LC	PE-21017	Kinematics and Dynamics of Machines Laboratory	0	0	2	1
12	LC	PE-21018	Software Laboratory	0	0	2	1
				21	**1**	**10**	**26**

For other departments

			Interdisciplinary Open Course-I	**L**	**T**	**P**	**Credits**
1	IOC	IOC-21007	Reliability Engineering	2	0	0	2

Department Elective-I

Sr. No.	Course Type	Course Code	Course Name	Teaching Scheme			Credits
				L	T	P	
1	DEC	PE(DE)-21001	Supply chain and Logistics Management	3	0	0	3
2	DEC	PE(DE)-21002	Reliability and Terotechnology	3	0	0	3
3	DEC	PE(DE)-21003	Facility Planning and Design	3	0	0	3
4	DEC	PE(DE)-21004	Nano Manufacturing	3	0	0	3

Minors- Manufacturing Technology (Mechanical)

Semester	Course Code	Course offered	Teaching Scheme			Credits
			L	T	P	
V	PE(MI)-21001	Metrology and Quality Control	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Minors- Manufacturing Technology (Civil/ENTC/Electrical/Instru/Comp/IT/Meta)

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(MI)-21003	Production Processes	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Honors- Manufacturing Systems Engineering

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21001	Precision Engineering	3	-	-	3
VI	PE(HO)-21002	Reliability and Maintenance Engineering	3	-	-	3
VII		Performance Modeling of Production Systems	3	-	-	3
VIII		Machine Tool Systems	3	-	-	3

Honors- Mechatronics

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21003	Principles of Electronics	3	-	-	3
VI	PE(HO)-21004	Industrial Instrumentation and Control	3	-	-	3
VII		Mechatronics System Design	3	-	-	3
VIII		Fluid Power Systems and Factory Automation	3	-	-	3

Semester V (ODD TERM)

(SBC) (PE-21009) Industrial In-plant Training

Teaching Scheme
Contact Hours: 2 hrs/week/student.
Duration of Training in Industry: 6 months

Examination Scheme
Term Work: 50 Marks
Oral Exam: 50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

1. Figure out the organizational structure, scale and type of production.
2. Understand basic manufacturing technology in terms of scale of production.
3. Understand the functioning of the various departments in the manufacturing environment.
4. Understand the advanced manufacturing and finishing process.
5. Able to handle manufacturing and inspection machines.
6. Understand International Standards on Quality and Reliability
7. Understand various Production Planning and Control functions. Process and Operation Planning
8. Understand material handling methods and equipment.
9. Design manufacturing jigs and fixtures and other accessories
10. Understand different types of tooling system and their role in precision manufacturing.

Syllabus Contents:

General guidelines to the institutions running production - Sandwich degree course and to the students opting for sandwich course. Students are expected to learn following things during the Industrial In plant Training of 6 months:

He shall be given training in large or medium size manufacturing unit in various departments.

1. **Orientation / Rotational Training:**
   Organizational Structure of the Company, scale and type of production, types of products, functional departments like Manufacturing, Process Planning & Control, Quality Assurance, Assembly, Testing, Maintenance, Stores, Purchase, Marketing, Human Resources Department, Design and Drawing Department, General Administration, Packing and Dispatching. Tool Engineering, Materials & Material Handling etc.
2. **Industrial Design and Drawing Practice:**
   Design and Drawing standards, study of Mechanical components and mechanical components and introduction to machine element design such as gears, gear boxes, chain and belt drives, electric motor selection, couplings, shafts, keys, bearings, brackets, bolted and welded connections. Sub - assembly and assembly design and drawings. Various ISO and BIS standards for design. Simple assignments based on the above items, selection of materials, material specification, beat treatment, and properties of materials.
3. **Study of Manufacturing Processes:**

Study of Processes such as casting, forging, sheet metal working, plastic moulding, extrusion, rolling and machining operations on various machines. Study of finishing processes like grinding, lapping, honing, burnishing, buffing, etc. chip less manufacturing processes.

4. Study of Various Manufacturing Machine Tools such as lathes, capstan and turret lathes, planer, shaper and milling. Mechanical and Hydraulic Presses, Gear hobbing, shaping and grinding machines.
5. Study of special purpose machines, jig boring machines, NCICNC machines, work centers and transfer lines and automatic machines.
6. Study of single point cutting tools and multipoint tools, form tools, jig and fixtures, special purpose machine tools and Press tools, Tool material and tool selection, study of cutting parameters.
7. Study of material handling methods and equipment.
8. Introduction to Quality and Quality Policy, need for Quality Control, National and
9. International Standards on Quality and Reliability. Study of various inspection gauges, selection of gauges, comparators, calibration of gauges, Standards Room, etc. Product Performance Test Procedures.
10. Study of various Production Planning and Control functions. Process and Operation Planning, Yearly and Monthly Planning, Forecasting, Scheduling, Planning.
11. Study of various Industrial Engineering functions, Work Study, (Motion Study and Time analysis), Ergonomic considerations, Plant Layout, Safety aspects of working, Safety gadgets used on machines and Personal Safety Equipment.

The students shall be asked to do simple assignments in various departments where he is undergoing training. Industries shall be requested to prepare training program before hand, covering as much as possible from above mentioned topics depending upon the type of industry.

Term Work:

Term Work will consist of a comprehensive report based on his observation, training received and assignments completed during 6 months of training. The report shall also include good drawing figure, process sheets and machine and product specifications. Students should maintain training project diary and report to internal guide every week. For writing project report, students must follow the format given in the project diary.

Oral Examination

Oral examination will be based on In-plant Training Report (Term Work), which will be conducted jointly by internal examiner from within the institute and external examiner from the industry.

(LC) (PE-21010) Seminar - I

Teaching Scheme
Practical: 2 hrs/week

Examination Scheme
Oral: -- 50 Marks
Term Work: - 50 Marks

Course Outcomes:

- Understanding of seminar topic and its importance
- Excellent presentation & communication skill
- Interest towards research-oriented fields with ability to search the literature and brief report preparation.
- Technical writing skill.

Syllabus Contents:

Seminar shall be based on deep study of any topic related to production engineering; format of the report shall be as follows:

- Title Page (Refer format given)
- Certificate (Refer format given)
- Acknowledgements: - There should not be any mistake in name and initials.
- Abstract: - A page explaining the Seminar topic in maximum 150 words.
- Content / Index (Refer format given in the Project Diary)
- List of Tables/Figures or Nomenclature and Symbols: - List of Tables, Figures, Graphs etc. with respective page numbers.
- Introduction: - 2-3 pages.
- Seminar Report: - Description of topic about 12-15 pages.
- Conclusion
- References (Refer format given in the Project Diary)

Instructions regarding Seminar Report Printing:-

Page size	:-	A4.
Page Format	:-	Left-1.25", Right-1", Top & Bottom 1" – No Border / Frame.
Font	:-	Arial Regular.
Font Size and Colour	:-	12, Black.
Line Spacing	:-	1.5
Printing / Typing	:-	On one side of the paper only. (No blank sheet be left anywhere in the report.)
Paragraph	:-	Justified.
Paragraph Indent	:-	Nil.
Page numbers	:-	Right bottom, starting from 'Contents' page.
Printing	:-	Laser.
Binding	:-	Spiral with front and back cover of card paper neatly cut to size.

Number of Copies of the Seminar Report: - **Two.**

Instructions for figures and tables: -

i. Figures should be drawn on separate sheets or inserted on the page on which the text is typed. The figures are drawn in either permanent black ink or printed on paper. The figures should be numbered.

ii. Tables shall be typed in text. A separate sheet may be used, if necessary. The table shall be numbered.

iii. Mathematical portion of the text shall be preferably typed. If this is not possible, it should be written in permanent black ink. Lengthy Mathematical derivations shall not be included. Only the important steps and expressions shall be given.

iv. Discussions and conclusions shall form the last paragraph of the text.

Front page (on Binding and Title Page):-

COLLEGE OF ENGINEERING, PUNE

Title Line (Font size to extend across 5'' width)

Title should be in one line, if required use two lines.

_____

_____

Submitted by:-

Class:- _____ Roll No.:- _____

DEPARTMENT OF PRODUCTION ENGINEERING AND INDUSTRIAL MANAGEMENT

COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute of Government of Maharashtra)

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Certificate Page: -

DEPARTMENT OF PRODUCTION ENGINEERING AND INDUSTRIAL MANAGEMENT
COLLEGE OF ENGINEERING, PUNE

(An Autonomous Institute of Government of Maharashtra)

CERTIFICATE

This is to certify that Mr./Miss_____ has completed the Seminar entitled _____in partial fulfilment of the requirement of the V/VIII semester Production Engineering (Sandwich) Course at the Department of Production Engineering of COLLEGE OF ENGINEERING, PUNE – 411005, during the academic term 200 - 200 .

(Name of Guide)
Date:- dd/mm/yyyy Guide

(Name of HOD)
Place:- Pune-411005. Prof. & Head
Department of Production Engg. & Industrial Management,
College of Engineering, Pune:- 411005.

(Examiner)

Term Work

Term Work shall comprise of Seminar report. Topic of seminar should be pre-approved by guide.

Oral Examination

Seminar Presentation / Oral examination will be assessed by guide and one internal examiner from within the institute.

(SLC) (PE-21011) Basics of Kinematics and Dynamics of Machines

Teaching Scheme
Lectures: Self Study

Examination Scheme
T1, T2 – 20 marks each,
End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Describe the at least five types of cams and followers with their specific use.
- Recognize the factor that affects the magnitude of endurance strength.
- Recognize and describe the main features of Spur gear, helical gear, Bevel gear and Worm gear sets.
- Describe the significance of turning moment diagram, basic function and application of fly wheel.
- Describe at least five types of clutched, brakes and dynamometers.
- Identify the types of bearings that are commercially available and select the appropriate type of given application.

Syllabus Contents:

Unit 1 **(6 hrs)**

Cams and Follower:

Function of cams, classification of cams, Classification of follower, Terms used in radial cams, Motion of follower, Displacement, Velocity, Acceleration and Jerk diagram when follower moves with Uniform velocity, Simple Harmonic Motion, Uniform acceleration and Retardation and Cycloidal motion.

Fatigue Consideration In Design:

Fatigue, Fatigue Loading, Fatigue Failure, Fatigue Failure Mechanism, Fatigue Failure Stages. Stress Life Relations, Standard Testing, The S-N Diagram, Endurance Limit, Endurance Strength, S-N Diagram-Operational Regions and Design Concepts. Effect of Fatigue on different Material, Relationship Between UTS And Fatigue Strength, Surface finish of part and Fatigue, Fatigue Stress Concentration, Fatigue Stress Concentration Factor, Reduction of Stress concentration factor, Numerical on stress concentration Notch sensitivity, Low cycle and High cycle fatigue, Endurance Strength Modification Factors, Load Factor-Torsional Loading, Miscellaneous Effects Factor, Endurance limit approximate estimate by considering various factors., , Fluctuating stresses, Fatigue Failure, Endurance limit, Types Of Cyclic Loading, Factors influencing Cyclic Loading, Design Approach For Fatigue Loadings, Cumulative Fatigue Damage.

Unit 2 **(6 hrs)**

Fundamental of Spur Gears Design:

Mechanical drives, Gear drives, History Of Gears, Definition Of Gears, Types Of Gears And Their Applications, Selection of type of gears, Law of Gearing, Nomenclature Of Involute Spur Gears, Gear Profiles, Meshing Of Gears, Standard system of gear tooth Interference and Undercutting In Gears, Methods Of Eliminating Interference , Minimum Number Of Teeth To Avoid Interference, Backlash, Length Of Line Of Action, Effect of pressure angle and centre distance, Path of contact, Arc of contact, Contact Ration, Profile Shifted Gears, Volutomitrid, Design of Gear Blanks.

Scoring, Wear, Pitting, Plastic Flow, Tooth Breakage, Gear Noise.
Selection of gear material, Scoring, Wear, Pitting, Plastic Flow, Tooth Breakage, Gear Noise. Gear lubrication.
Spur Gear Tooth Force Analysis, Spur Gear Bending Stress – Lewis Equation, Spur Gear Bending Stress AGMA Procedure, Permissible Bending Stress, Buckingham Equation for Dynamic Load On Gears.
Surface Durability, Surface Failures, Buckingham Contact Stress Equation Contact Stress AGMA Procedure, Surface Fatigue Strength AGMA Procedure.

Unit 3 **(6 hrs)**

Helical Gears:

Terminologies of Helical gears, Advantages of Helical gears, Application of Helical gear virtual or formative helical gear, Virtual Number of Teeth, relationship between actual and
virtual number of teeth and the helix angle, Advantages , disadvantage and applications of a single helical gear, double helical gear and herringbone helical gear.
Tooth properties of Helical Gear, Force Analysis with numerical examples.

Bevel Gears:

Terminologies of Bevel gears, Classification of Bevel Gears , Miter Gears, Crown Gear, Internal Bevel Gears, Skew Bevel Gears, Hypoid Gears, Zerol Gears, Face Gears, Application, advantages and limitations of Bevel gears Bevel Gear Force Analysis

Worm Gears:

Terminologies of Worm gears, application of worm gear, material for worm and Worm wheel Friction in Worm gears and thermal consideration of worm Gears.

Unit 4 **(10 hrs)**

Fundamentals of Brakes, Dynamometer, and Clutches:

Brakes and Dynamometer:

Brakes, Types of Brakes, Mechanical Brakes, Heat Generated In Braking, Temperature Rise, Time-Temperature Relation, Energy To Be Absorbed, Frictional Material, Linings, Basic Mechanism Of Braking, Design And Analysis, Preliminary Analysis, Short Shoe Analysis, Self-Energizing, Self Locking, Dynamometer, Classification of Absorption and Transmission dynameters, Bevis Gibson Flash light dynamometer.

Clutch:

Clutch Introduction, Mechanical Model, Friction Clutches, Frictional Contact Axial Or Disc Clutches, Method Of Analysis, Uniform Pressure And Wear, Elementary Analysis, Uniform Wear Condition , Single Plate Dry Clutch – Automotive Application, Single Clutch And Multiple Disk Clutch, Operation Of Clutch, Clutch Construction, Clutch Or Driven Plate, Plate To Hub Connection, Friction Facings Or Pads, Multiple Plate Clutches.

Unit 5 **(6 hrs)**

Turning Moment Diagram and Flywheel:

Turning Moment Diagram for Single cylinder double acting steam engine, Four stroke Internal combustion engine, Multi cylinder engine, Fluctuation of Energy, Determination of Maximum fluctuation of energy, Coefficient of Fluctuation of Energy, Fly wheels, Flywheels-Function Need

and Operation, Speed Fluctuation, Coefficient of fluctuation of speed, flywheel and governors, Design Equation, Torque Variation And Energy, Torque Time Relation Without Flywheel, Geometry Of Flywheel, Stresses In Flywheel, Material for Flywheel, Flywheel in Punching Press with Numerical examples.

Unit 6 **(6 hrs)**

Rolling Contact Bearings:

Basic Modes of lubrication, Viscosity, Measurement of Viscosity, Viscosity Index, Hydrodynamic Lubrication, Lubricants and Their Properties, Design parameters for journal bearings, Bearing construction, bearing material, Sintered material bearing, lubricating oils, additives for mineral oil, Selection of lubricants, Greases, Journal bearing failure cause and remedies, comparison of Rolling Contact Bearings and Sliding Contact Bearings. Bearing Materials,

Rolling Contact Bearings:

Types of Rolling Contact bearing, Deep groove ball bearing, cylindrical roller bearing, Angular contact bearing, Self aligning bearing, Taper roller bearing, thrust ball bearing, Principal of self aligning bearing, Needle bearing, Bearing failure Cause and Remedies, Lubrication of Rolling contact bearing, Mounting of bearing.

Text Books:

- B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007
- S. S. Rattan, “Theory of Machines”, Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007

References:

- R.S. Khurmi J. K. Gupta, “Theory of Machines”ǁ, Eurasia Publishing House (Pvt.) Ltd, 2nd Edition
- Joseph E. Shigley, John J. Uicker, “Theory of Machines and Mechanisms”ǁ, Oxford University Press, 3rd Edition
- Robert L. Mott, P.E, “Machine elements in mechanical design”, Pearson Prentice Hall Publication 4th Edition
- M. F. Spotts, “Design of Machine Elements”ǁ, Dorling Kindersley (India) Pvt. Ltd., 8th Edition

E(IF) -21003) Robotics

Teaching Scheme	Examination Scheme
Lectures: 2 hrs/week	T1, T2 – 20 marks each, End-Sem Exam – 60

Course Outcomes:

- To enable students to understand the basic concepts and principles in robotics.
- To enable students to classify the robot structures, grippers, drives and their design and selection.
- To enable students about kinematics of robot manipulator and transformation analysis.

- To enable students to understand robot programming and write the programs.
- To enable students to analyze the trajectory planning of robot joints.
- To select robots for various applications and perform economic analysis

Syllabus Contents:

Unit 1 **(5 hrs)**

Basic Concepts in Robotics:

Automation and robotics, robot anatomy, basic structure of robots. Classification and Structure of Robotics System: Point to point and continuous path systems. Control loops of robotic system, manipulators, wrist motions andgrippers.

Robot End Effectors:

Grippers and tools, Types of end effectors-mechanical, magnetic and vacuum, gripper force analysis and gripper design considerations.

Unit 2 **(6 Hrs)**

Drives and Sensors: Basic control systems, concepts and models, types of drive system-Hydraulic systems, pneumatic and electrical, DC servo motors, analysis, robot activation and feedback components,

Sensors, internal-external sensors, contact and non-contact sensors, position and velocity sensors, Touch and slip sensors, Force and torque sensors, tactile sensors, Proximity and range sensors.

Unit 3 **(5 Hrs)**

Robot Arm Kinematics: Homogenous coordinates and homogenous transformations, Forward and Inverse kinematics in robot, Denavit Hartenberg convention and its applications Lagrange-Euler formation.

Unit 4 **(4 Hrs)**

Robot Programming:

Robot Programming: Methods of robot programming, lead through, motion interpolation, WAIT, SIGNAL and DELAY commands, branching capabilities and limitations of lead through methods. Robot Language: The textual robot languages, generations of robot programming languages, variables, motion commands, end effectors and sensor commands, computations and operations.

Unit 5 **(4 Hrs)**

Trajectory Planning

Introduction, Joint Space Scheme, Cubic Polynomials with via points, Blending scheme

Unit 6 **(4 Hrs)**

Robot Applications in Manufacturing:

Material transfer and machine loading/unloading, processing operations assembly and inspection. Concepts of safety in robotics, social factors in use of robots, economics of robots, Telecheric machines and its application.

Text Books:

- S. R. Deb.: Robotics Technology and Flexible Automation, Tata McGraw Hill Publishing Co. Ltd.
- P.A. Janakiraman, Robotics and Image Processing, Tata Mcgraw Hill, 1995

References Books:

- Yoren Koren: Robotics for Engineers, McGraw Hill Book Co., ISBN 0-07-035341-7.
- M. P. Grover, M. Weiss, R. N. Nagel, N. G. Odrey, Industrial Robotics Technology, ISBN 0-07-100442-4.
- K. S. Fu, C. G. S. Lee, R. C. Gonzaler, Robotics Control, Sensing, Vision and Intelligence, TataMcGraw Hill. 2008, ISBN 13: 9780070226258.

MA-21001 Probability and Statistics for Engineers

Teaching Scheme	Examination Scheme
Lectures : 2 hrs / week	T1, T2 – 20 marks each,
Tutorial : 1 hr / week	End-Sem Exam – 60

Course Outcomes:

Students will be able to

- Learn a number of methods of summarizing and visualizing data sets, compute probabilities of events.
- Use the concepts of random variables and associated probability distributions, understand the meaning of central limit theorem.
- Do basic statistical inference (t-test, z-test, F-test, χ^2 –test, confidence interval).
- Do basic regression analysis.
- Demonstrate use of R software for all the above.
- Identify and apply the basic knowledge of statistics for solving real world problems.

Syllabus Contents:

Unit I **[5 Hrs]**

Descriptive statistics: Measures of location and variation. Visualization of data: Frequency tables, bar diagrams, histograms, heat maps, other visualization tools. Review on introduction to combinatorics and probability theory

Unit II **[5 Hrs]**

Some of the basic probability distributions: Binomial, Poisson, Exponential, and Normal. Central limit theorem.

Unit III **[4 Hrs]**

Introduction to 'R': Introductory R language fundamentals and basic syntax, major Rdata structures, Using R to perform data analysis, creating visualizations using R.

Unit IV **[6 Hrs]**

Basic statistical inference and hypothesis testing: Estimation, basic tests such as t-test, z-test, F-test, χ^2 -test.

Unit V **[4 Hrs]**

Regression methods: Simple linear regression and multiple regression.

Unit VI **[4 Hrs]**

Engineering applications of statistics: Discussion on reliability and quality control. Introduction to random processes, stochastic processes, Markov chains.

Text Books:

- Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists (8th Edition), Pearson Prentice Hall, 2007.
- Ross S.M., Introduction to probability and statistics for Engineers and Scientists (8th Edition), Elsevier Academic press, 2014.

References Books:

- S. P. Gupta, Statistical Methods, S. Chand & Sons, 37th revised edition, 2008.
- Morrison S.J., Statistics for Engineers - An introduction, Latest edition, 2009.
- William W. Hines, Douglas C. Montgomery, David M. Goldsman, Probability and Statistics for Engineering, (4th Edition), Wiley Student edition, 2006.
- Kishor S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications (2nd Edition), Wiley Student edition, 2008.
- Stephens L.J., Schaum's outline of statistics for Engineers, Latest edition, 2019.
- The practice of Business Statistics by Manish Sharma and Amit Gupta, Khanna Publishing Company Private Limited, New Delhi, 2014

(HS-21004) Industrial Engineering and Engineering Economics

Teaching Scheme
Lectures : 3 hrs / week

Examination Scheme: 100 marks:
Assignments /Quiz/T1/T2 - 40 Marks,
End Sem Exam- 60 marks

Course Outcomes:

Student will be able to:

- Understand different organization structures.
- Understand the concepts of productivity.
- To understand the Concept of Productivity and apply the knowledge gained to improve the productivity
- To identify the nature of problem and accordingly suggest the appropriate Work study method for its solution
- To understand economics related to Industrial problems.

- To be able to draw the cash flow diagram

Syllabus Contents:

Unit 1 **(7hrs)**

Introduction

Definition and Role of Industrial Engineering, Contribution of Taylor and Gilbreth, Organization : Concept of organization, characteristics of organization, elements of organization, organizational structure, organization charts; Introduction to types of organization- formal line, military organization, functional organization, line & staff organization; authority and responsibility, span of control, delegation of authority. Productivity: Definition of productivity, Productivity of materials, land, building, machine and power. Measurement of productivity: factors affecting the productivity.

Unit 2 **(7 hrs)**

Method Study and scope of work-study

Method Study Definition, objective and scope of work-study. Human factors in work-study. Method Study : Definition, objective and scope of method study, activity recording and exam aids, Charts to record moments in shop - operation process charts, flow process charts, travel chart, two handed chart and multiple activity charts. Charts to record movement at work place - principles of motion economy, classification of moments, SIMO chart, and micro motion study. Definition and installation of the improved method, brief concept about synthetic motion studies Numerical), Introduction to Value Engineering and Value Analysis.

Unit 3 **(7 hrs)**

Work Measurements

Work Measurements: Definition, objectives and uses; Work measurement techniques. Work sampling - need, confidence levels, sample size determinations, random observation, conducting study with the simple problems. Time study: Definition, time study equipment, selection of job, steps in time study. Breaking jobs into elements, recording information. Rating and standard rating, standard performance, scales of rating, factors affecting rate of working, allowances and standard time determination; Introduction to PMTS and MTM. (Numerical), Introduction to MOST.

Unit 4 **(7 hrs)**

Introduction to Engineering Economics, Definition and scope of Engineering Economics, Time value of money: Simple and compound interest, Time value equivalence, Compound interest factors, Cash flow diagrams Calculation, Calculation of time –value equivalences. Present worth comparisons, Comparisons of assets with equal, unequal and infinite lives, comparison of deferred investments, Future worth comparison, payback period comparison.

Unit 5 **(7 hrs)**

Ratio analysis: Classification of ratios, structural group, standards for comparison limitations of Ratio analysis, returns on investment and integral ratio.

Cost volume profit analysis: mechanics of break even chart, profit planning and break-even analysis, margin of safety.

Unit 6 **(7 hrs)**

Standard Costing:- Concept, Development and use of Standard Costing, Budget and Budgetary Control, Variance Analysis. Marginal Costing: - Use of Marginal Costing in Decision Making.

Allocation of Resources: Capital Budgeting: Control of Capital Expenditure, Evaluation Process – Payback approach, Accounting of Rate of Return, Present Value Method Vs Internal Rate of Return.

Cost of Capital: Relevant Cost, Measurement of Cost of Capital, Cost of Debt, Preference Shares, Equity Shares, Internal Financing, Dividends, Cost of Retained Earnings Concept.

Text Books:

- Basu S.K., Sahu K.C and Rajiv B, Industrial Organization and Management –. PHI New Delhi, 2012, ISBN No. 9788120344211.
- Prasad N. K., Cost Accounting Book, Syndicate Pvt. Ltd. Kolkata

References:

- Work Study, ILO
- Henry M. Steiner, Engineering economics Principles, Mc Grow hill Publication.
- P. A. Samuelson, Economics, Mc Grow hill International.
- Colin Drury, management and Cost Accounting, English Language Book Society, Chapman & Hall London

[HS-21001] Entrepreneurship Principles and Process

Teaching scheme	Evaluation scheme
Lectures: 1 hrs / week	Field Work/Assignments 40 Marks End Semester 60 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Discover, develop, and assess different types of Entrepreneurial ventures and opportunities.
- Learn about opportunity and risk analysis
- Use the strategies for valuing your own company, and how venture capitalist and angel investors use valuations in negotiating milestones, influence and control
- Pick correct marketing mix and how to position the company in the market by using analytical tools
- Learn how to sale themselves and the product/service and to handle objections
- Know how organizations operates, their process matrices, start new ventures, write winning business plans

Unit 1 **[2 Hrs]**

Market Research

Introduction to Entrepreneurship, Profile of the Entrepreneur, Market Gap /Opportunity Analysis,

Market Research Methods, Defining the Focal Market: Market Segmentation, Industry analyzing– Research /Competitive Analysis

Unit 2 **[1 Hr]**

Types of Companies and Organizations

Company/ Organization Types, Legal Aspects, Taxation, Government Liaison, Building the Team, Mergers and Acquisitions

Unit 3 **[2 Hrs]**

Business Finance

Shares and Stakes, Valuation, Finance Creation (Investors/Financers), Revenue Plans and Projections, Financial Ratios, Business Lifecycle, Break Even

Unit 4 **[2 Hrs]**

Marketing &Digital Marketing

Marketing Basics, Marketing Strategy and Brand Positioning, Plans and Execution Techniques, Marketing Analytics, Online Marketing

Unit 5 **[2 Hrs]**

Sales

Understanding Sales, Pitching Techniques, Sales strategies, Inside Sales v/s Outside Sales, RFP

Unit 6 **[1 Hr]**

Operations Management

Operational Basics, Process Analysis, Productivity, Quality

Unit 7 **[2 Hrs]**

Start-ups

Start-up Basics, Terms, Start-up Financing, Start-up Incubation, Start-up Incubation, Getting Listed

Text Books

- TheStartupPlaybook:SecretsoftheFastest-GrowingStartupsFromTheirFoundingEntrepreneursbyDavidKidder
- Creativity, Inc.: Overcoming the Unseen Forces That Stand in the Way of True Inspiration by Ed Catmull
- True North by Bill George and Peter Sims
- Bhargava , S.(2003).Transformational leadership: Value based management for Indian Organizations(Ed.). New Delhi: Response-Sage.
- Cardullo,M.W.P.E.(1999).Technological entrepreneurism: Enterprise formation, financing, and growyh. England: Research Studies Press Ltd.
- Hisrich,R.D.&Peters,M.P.(2001).Entrepreneurship:Starting,developing,andmanagingane wenterprise(5thEd.).NewYork: McGraw-Hill.

Reference Books

- Kanungo,R.N.(1998).Entrepreneurshipandinnovation:Modelsfordevelopment(Ed.,Vol.2). New Delhi: Sage.
- Mc Cleland, D.C.(1961).Achieving society. Princeton
- Van Nostrand. Verma , J.C.,& Singh ,G.(2002).Small business and industry: A hand

book for entrepreneurs. New Delhi: Response-Sage.
- RichardABrealy&StewardCMyres.PrinciplesofCorporateFinance,McGrawHills, 7thEdn,2004
- PrasannaChandra,FinancialManagement:TheoryandPractice,TataMcGrawHills, 6thEdn, 2004IMPandey,FinancialManagement,VikasPublishing

[ML-21001] Constitution of India

Teaching scheme
Lectures: 1hr / week

Evaluation scheme
T1: 20 marks
T2: 20 marks
End Semester 60 Marks

Course Outcome (CO)

At the end of the course, student will demonstrate the ability to:

- Comprehend how India has come up with a Constitution which is the combination of the positive aspects of other Constitutions.
- Interpret the Preamble and know the basics of governance of our nation.
- Identify the different aspects covered under the different important Articles.
- Apprehend the basic law, its interpretation and the important amendments.
- Understand our Union and State Executive better.
- Recognize the basic that along with enjoying the rights one needs to fulfill one's duties.
- Summarize and Gain confidence on our Constitution by knowing it better.

Unit 1 **[2 Hrs]**
Understanding the concept 'Rule of Law '
Meaning and history of Constitution.
Understanding the concept of Human Rights and Fundamental Rights.

Unit 2 **[3 Hrs]**
Introduction to The Constitution of India, understanding its objects.
Preamble to the constitution of India.

Unit 3 **[2 Hrs]**
Fundamental rights under Part – III, exercise of the Rights, limitations and important cases.

Unit 4 **[2 Hrs]**
Fundamental duties & their significance.
Relevance of Directive principles of State Policy.

Unit 5 **[2 Hrs]**
Legislative, Executive & Judiciary (Union and State)
Prerogative Writs.

Unit 6 **[2 Hrs]**
Constitutional Provisions for Scheduled Castes, Scheduled Tribes, & Backward classes.
Constitutional Provisions for Women & Children

Unit 7 **[2 Hrs]**

Emergency Provisions.
Electoral procedure in India
Amendment procedure and few important Constitutional Amendments

Text Books :

- Introduction to the Constitution of India by Durga Das Basu (Students Edn.) Prentice – Hall EEE, 19th/20th Edn..
- Engineering Ethics by Charles E.Haries, Michael. S.Pritchard and Michael J. Robins Thompson Asia,.

Reference Books:

- An Introduction to Constitution of India by M.V. Pylee, Vikas Publishing

PE-21012 Mini Project

Teaching Scheme
Lectures: -
Practical- 4 Hrs/Week

Examination Scheme
End-Sem Exam- 100

Course Objectives:
At the end of the course, students will be able to:

- Identify needs and develop a problem statement for a particular problem.
- Initiate systematic approach to develop solution for a given problem.
- Apply basic engineering fundamentals along with modern tools and techniques to attempt solutions to the problems.
- Infuse the process of self-learning and research.

Guidelines for Mini Project

The mini project will consist of design, simulation and prototype fabrication of any device which can attempt to address technological solution to the existing problems based on the societal and/or research needs, identified in consultation with faculty mentor/supervisor. The expected prototype must consist of design of the system using any one of CAD tools, simulation/analysis of predicted behaviour/ expected outcome and fabrication of functional prototype utilizing various prototype fabrication techniques, such as 3D printing, digital fabrication processes and conventional metal fabrication. It is desirable that the prototype should consists of three systems, mechanical structure, embedded electronics (control system for motors, sensors etc. or as per application) and programming of control systems.

- Students shall form a group of 3 to 5 students, while forming a group shall not be allowed less than three or more than five students.

- Students should do survey and identify needs, which shall be converted into problem statement in consultation with faculty supervisor.
- Students shall submit implementation plan in the form of Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A log book to be prepared by each group, wherein group can record weekly work progress, guide/supervisor can verify and record notes/comments.
- Faculty may give inputs during mini project activity; however, focus shall be on self-learning.
- Students in a group shall understand problem effectively, propose multiple solution and select best possible solution in consultation with guide/ supervisor.
- Students shall convert best solution into functional prototype which includes design, simulation and prototype fabrication using 3D printing, digital fabrication processes and conventional metal fabrication.
- The solution to be validated with proper justification and report to be compiled in standard format decided by the department.

- The progress of Mini-Project to be evaluated on continuous basis, minimum two reviews in each semester. Final viva-voce examination based on project should carried out by external examiner along with faculty supervisor/guide.

(PCC) (PE-21013) Tool and Die Design

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Objectives:

Students will be able

- To understand the basic concepts, importance and functions of Jigs, Fixtures, press tools and moulding dies.
- To understand the design aspects of Jigs, Fixtures, press tools and moulding dies.
- To gain proficiency in the development of required tooling.
- To understand the analytical/theoretical analysis of Jigs, Fixtures.
- To understand the analytical/theoretical analysis of press tools and moulding dies.
- To understand the theory of Plastic Moulding process.

Syllabus Contents:

Unit 1 **(6 hrs)**

Jigs and Fixtures

Significance and purpose of jigs and fixtures and their functions in the manufacturing processes.
Classification of jigs and fixtures such as machining, assembly and inspection fixtures; universal jigs and fixtures; modular jigs and fixtures.
Design features of main elements of jigs and fixtures such as locating, clamping and guiding elements and their integration.

Indexing, locking and auxiliary elements. Bodies, bases or frames of jigs and fixtures.

Unit 2 **(8 hrs)**

Basic Types of Press Working Operations and Equipment:

General classification and components of Press Tools.

Dies and Punches:

Elements of Dies and Punch set. Types of dies – simple, compound, combination and progressive dies and punches of various press working operations such as punching, blanking, drawing, bending, forming, coining, Fine Blanking Burr free blanking etc.

Design of Blanking die, Progressive die, Calculations of clearances, center of pressure, different forces, press tonnage, strip layout, sheet utilization ratio, methods of reducing forces.

Unit 3 **(6 hrs)**

Drawing and Bending dies:

Design of Shallow & Deep drawing die, Calculation of blank size, number of draws, drawing force, press capacity, ironing & ironing force, Types of Bending dies, various methods used to overcome spring back, Calculation of total bend length and calculation of various forces.

Unit 4 **(8 hrs)**

Design of simple dies for forging

Types of Forging, Guidelines for selection of various design factors, parting line , draft, rib-web, Corner & fillet radius, shrinkage & die wear etc., Detailed calculations of stock size, Design of Fullering, edging, types of die inserts.

Unit 5 **(6 hrs)**

Design of Die casting dies.

Die Casting processes Hot & Cold Chamber, Metals for die casting, Design considerations in die casting. Types of cores, feeders, inserts, die lubrications & rules, heat transfer consideration, directional solidification, cooling system, feed and flow system and ejection system, interlocks & safety devices, die casting defects and remedies.

Unit 6 **(8 hrs)**

Plastic and Plastic Moulding :

Introduction of compression and transfer moulding process, Study of Injection and blow moulding process; - machine specifications, moulding cycle.

Mould Design – Design of simple two plate injection moulds. Design of simple blow moulds for articles like bottles, cans, etc. Study of types of ejectors, gates, runner's, Study of cooling systems and heat transfer consideration. Calculation of no. of cavities, Mould opening force, ejection force etc.

Text Books:

- Cyril Donaldson, George H.LeCain, V.C. Goold, "Tool Design", Tata McGraw Hill Publishing Company Ltd., 2000, 3rd Edition.
- Vukota Boljanovic, "Sheet Metal Forming Processes And Die Design", Industrial Press,

New York, 2004.

Reference Books:

- Wilson, Fundamentals of Tool Design, A.S.T.M.E., Prentice Hall of India.
- S. K. Basu, S.N. Mukherjee, R. Mishra, Fundamental of Tool Engineering Design, Oxford & IBH Publishing Co. Pvt. Ltd., 1979.
- J. R. Paquin, R. E. Crowley, Die Design Fundamentals, Industrial Press Inc., 2nd Edition,1987.
- Handbook of Die design Handbook, McGraw Hill, 2006.
- P.C. Sharma; A Text Book of Production Engineering, S. Chand and Company Ltd., New Delhi.
- P.N. Rao, Manufacturing Technology, Tata Mcgraw Hill Publishing Co Ltd, 2000.
- M.H.A. Kempster, Introduction to Jigs and Fixture Design, ELBS Edition, 1990.
- R.G.W. Pye, Injection Mould Design, Longmans Publications, 4th Edition,1989.
- A.S. Athalye, Injection Moulding, Multitech Publishers Co. Mumbai
- Metal Hand Book, Vol-II and III.ASME.
- Forging Handbook, ASM, Vol. 5, 9th edition.
- P.H. Joshi, Press Tools Design & Construction, S. Chand & Company Ltd. Delhi, 2nd Edition (Revised), 2008.

(PCC) (PE-21014) Material Forming

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2 - 40 Marks, End Sem Exam- 60 marks

Course Objectives:

students will demonstrate the ability to:

- Learn basic concept of different metal forming process and the application of concept to analyze the processes.
- Learn application of theoretical approach to solve practical problems associated with different material forming processes such as rolling, drawing, forging, and extrusion.
- Gain an understanding and appreciation of the breadth and depth of the field of material forming.
- Understand the various basics of formability, working on metals.
- Learn how to apply different theory criterions to metal forming.

Syllabus Contents:

Unit 1 **(10 hrs)**

Introduction of forming processes.

Strain hardening Concept of flow stress determination,

Theory of plasticity, Yield criteria for ductile materials- Von-mises criteria, Tresca Criteria,

flow stress concept. Effect of temperature, strain rate, metallurgical microstructure, chemical composition and mechanical properties, for Classification of material forming process. Concept of Formability, formability limits and formability diagram.

Unit 2 **(10 hrs)**

Forging

Introduction, classification of forging processes. Forging equipment- Hammers, presses, furnaces etc. construction working capacities and selection of equipment. Basic forging operations such as drawing, fullering edging, blocking etc. wing Forgability tests, design of forging as a product, Slab Method of Analysis friction in forging. Forging defects and the remedies. New technologies: Liquid metal forging, isothermal forging, No draft forging, P/M forging, Rotary swaging, roll forging, Lubrications in forging.

Unit 3 **(6 hrs)**

Wire and Tube Drawing

Introduction rod and wire drawing machines - construction and working. Preparation of stock for wire drawing. Wire drawing dies, material and design. Patenting heat treatment. Variables in wire drawing, Maximum reduction in wire in one pass, forces required in drawing. Multiple drawing, work hardening, lubrication in wire drawing. Tube drawing: Methods, force calculation, stock penetration. lubrication in tube drawing

Unit 4 **(8 hrs)**

Rolling of Metals

Scope and importance of rolling. Types of Rolling Mills- Construction and working. Roll bite, reduction, elongation and spread. Deformation in rolling and determination forces required. Process variables, redundant deformation. Roll flattening, Roll camber - its effect on rolling process, mill spring. Defects in rolling. Automatic gauge control- Rollpass classification & design. Lubrication in rolling. Sheet Metal Forming, blanking, bending, drawing and deep drawing.

Unit 5 **(6 hrs)**

Extrusion

Types: Direct, reverse, impact, hydrostatic extrusion. Dies for extrusion, stock penetration. Extrusion ratio Force equipment (with and without friction), metal flow in extrusion, defects. Role of friction and lubricants. Manufacture of seam-less tubes.

Unit 6 **(6 hrs)**

Advanced metal forming processes.

High velocity forming- principles, comparison of high velocity and conventional Forming processes. Explosive forming, Magnetic pulse forming, Electro hydraulic Forming, Microforming, Microcoining, microextrusion, Microbending Stretch forming, coining embossing, curling spinning, flow forming advantages, limitations and application of the process.

Text Books:

- Dieter, Mechanical Metallurgy, ISBN0071004068
- P.N. Rao, “Manufacturing Technology”, Tata Mc-Graw Hill ISBN0070087695

Reference Books:

- G.W. Rowe, “Principles of industrial metal working process”, Edward Arnold ISBN8123904282.
- Dr. R. Narayanswamy, Metal Forming Technology, Ahuja Book Co.ISBN8176190020
- ASM Metal hand book Vol: 14 Forming and Forging.

(PCC) (PE-21015) Kinematics and Dynamics of Machines

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	T1, T2 – 20 marks each,
Tutorial: 1 hr/week	End-Sem Exam – 60

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Analyse the load-carrying members to be safe under their particular expected loading patterns commonly encountered by machine parts.
- To select the type of follower motion for particular application.
- Analyse the stresses on the on different types of gear teeth considering various factors and design the gear pair to be safe under bending and pitting conditions.
- Select the appropriate type of bearing for a given application, considering static and dynamic loading conditions.
- Describe journal bearing system and complete the basic design of such bearings.
- Perform the design and analysis of at least five types of clutches and brakes to specify the required capacity to drive the given system reliably.

Syllabus Contents:

Unit 1 **(6 hrs)**

Cams and Follower:

Analysis of motion, determination of cam profile for given follower motion (stress should be for cams and follower used in automats).

Design for fluctuating loads:

S-N Diagram, Endurance limit, Factors affecting Endurance Strength, Design for Finite and Infinite life under reverse stresses, Cumulative damage, Soderberg‘s and Goodman‘s Diagram, Design of components like shaft, bolted joints, springs etc. subjected to variable loading.

Unit 2 **(6 hrs)**

Spur Gears:

Law of Gearing, Minimum number of teeth to avoid interference, Design of Spur Gears, Selection of Type of Gears, Force Analysis, Gear tooth Failures, Selection of Materials, Beam Strength, Wear Strength, Effective Load Calculation, Dynamic Load, Gear Design for Maximum Power Transmitting Capacity.

Helical Gears:
Virtual Number of Teeth, Force Analysis, Beam Strength, Wear Strength, Effective Load, Helical Gear Design.

Unit 3 **(6 hrs)**

Bevel Gears:
Force Analysis, Design Calculations of Bevel Gears, Beam Strength, Wear Strength, Effective Load.

Worm Gears:
Force Analysis, Friction in Worm Gears, Strength Rating of Worm Gears, Wear Rating of Worm Gears, Heat Dissipation.

Flywheel:
Introduction, Design Parameters, Energy Storage Capacity of the Flywheel, Weight of the Flywheel, Engine Flywheels, Flywheels for Punches, Stresses in Flywheel Rims, Design of Rimed Flywheel, Stresses in Arms, Design of Arms, Construction of Flywheel.

Unit 4 **(10 hrs)**

Balancing:
Balancing of rotating masses, balancing of reciprocating masses in multicylinder engines & machines (primary and secondary) direct & reverse crank concept. Crankshaft balancing machines.

Mechanical Vibrations
Introduction to Mechanical Vibrations, Importance of the Study of Vibrations, Elements of a Vibratory System, Examples of Vibratory Motion, Terms used in Vibratory Motion, Degrees of freedom and Examples of Degrees of freedom, Discrete and Continuous system, Types of Vibrations, Types of Free Vibrations

Free Undamped Vibrations:
Methods to determine the Equation of Motion, Vibration Analysis Procedure, Determination of Natural Frequency of Free Transverse Vibrations:- Derivation and Examples, Determination of Natural Frequency of Free Torsional Vibrations:- Derivation and Examples, Effect of Inertia of the Constraint (Mass of the Constraint) in Longitudinal Vibrations, Equivalent Stiffness of Spring Combinations:- Derivations and Examples, Examples on Determination of Natural Frequency (Equation of motion) of given system by any of the four methods.
Frequency of Free Damped Vibrations:
Types of Dampers, Free Damped Vibrations: - Damping coefficient, Damping Factor or Damping Ratio and Logarithmic Decrement, Under damped, Over damped and Critically Damped systems and Examples on Free Damped Systems.
Frequency of Under damped Forced Vibrations:

Magnification Factor or Dynamic Magnifier: - Theory and Examples.
Forced Damped Vibrations:
Theory and Examples, Vibration Isolation and Transmissibility: - Theory and Examples.

Unit 5 **(6 hrs)**

Friction Clutches, Brakes and Dynamometer:

Pivot collar friction, design consideration for plate, cone & centrifugal clutches. Design of various brakes, like band brake, shoe brake, band & block brake, Disc Brakes, thermal considerations.

Unit 6 **(6 hrs)**

Rolling Contact Bearings: Selection of bearing from Manufacturer‘s Catalogue, Design for variable loads and Speeds, Bearings with Probability of Survival other than 90%.

Sliding Contact Bearings:

Hydrostatic Step Bearing, Energy Losses in Hydrostatic Step Bearing, Reynold‘s Equation, Raimondi and Boyd Method, Bearing Design – Selection of Parameters, Sommerfeld Number, Constructional Details of Bearings, Temperature Rise

Text Books:

- B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007
- S. S. Rattan, “Theory of Machines”, Tata McGraw Hill Publishing Company Ltd., 2nd Edition, 2007

References:

- R.S. Khurmi J. K. Gupta, “Theory of Machines”ǁ, Eurasia Publishing House (Pvt.) Ltd, 2nd Edition
- Joseph E. Shigley, John J. Uicker, “Theory of Machines and Mechanisms”ǁ, Oxford University Press, 3rd Edition
- Thomas Bevan, “Theory of Machines”ǁ, CBS Publishers and Distributors, 3rd Edition
- Robert L. Norton, “Design of Machinery”ǁ, McGraw Hill Higher Education, 3rd Edition
- Robert L. Mott, P.E, “Machine elements in mechanical design”, Pearson Prentice Hall Publication 4th Edition
- M. F. Spotts, “Design of Machine Elements”ǁ, Dorling Kindersley (India) Pvt. Ltd., 8th Edition
- S. S. Rao, “Mechanical Vibrations”ǁ, Dorling Kindersley (India) Pvt. Ltd., 4th Edition

(LC) (PE-210016) Tool and Die Design Laboratory

Teaching Scheme	Examination Scheme
Practical: 2 hrs/week	Term-work: 50 Marks
	Oral: 50 Marks

Course Outcomes:

- To understand the design methodology of various press tools, Jigs, Fixtures, press tools and dies.
- To acquire proficiency in the design and development of required tooling's and dies.
- To understand use of simulation tool for analysis of press tools and dies.
- To enable the students to Design & drawing of dies for shearing, forming operation.
- To enable the students to effectively use CAD/Simulation software for die design.

Syllabus Contents:

Assignments:

1. Detail design and drawing of die for Blanking/Punching operation. (use of CAD desirable)
2. Detail design and drawing of Progressive die. (use of CAD desirable)
3. Detail design and drawing of shallow drawing die. (use of CAD desirable)
4. Detail design and drawing of deep drawing die. (use of CAD desirable)
5. Detail design and drawing of forging die. (use of CAD desirable)

Note: For the above assignments analysis of design can be carried out by using simulation software.

The oral will be based on above term work.

(LC) (PE-21017) Kinematics and Dynamics of Machines Laboratory

Teaching Scheme	Examination Scheme
Practical: 2 hrs/week	Term-work: 50 Marks
	Oral: 50 Marks

Course Outcomes:

- To develop the design skills in the students to carry out the design of simple mechanical system using standard design procedures.
- Students will be able to do cam mechanism classification, construct cam profile, and generation of gear teeth profile.
- Student will be able to find resonance frequency and effect of damping in a single degree of freedom vibratory system.
- The students will be able to carry out design project design of simple mechanical system by using standard material, procedures and design standards.
- Student will be able to design cam and draw cam profile.
- The student will be able find the degree of freedom, resonance frequency and effect of damping in a single degree of freedom vibratory system.

List of Experiments:

One design project like gearbox using spur gears, clutch, brake etc. Two imperial size drawing sheets one involving assembly drawing with part list and overall dimensions and other sheet involving drawing of individual components giving manufacturing tolerances, geometric tolerances and finish symbols for critical components. A design report with all necessary calculations in a separate file.

A journal consisting of following experiments and exercises.
To draw a cam profile for a given automat motion.
Experiments on free undamped vibration for single degree of freedom system.
Experiment on free damped vibration for single degree of freedom system.
Experiment on forced damped vibration for single degree of freedom system.
To draw a gear profile on gear generating apparatus for various rack shifts.

The oral will be based on above term work.

PE-21018 SOFTWARE LABORATORY

Teaching Scheme	Examination Scheme
Practical: 2hrs/week	Term Work: -- 50 Marks
Tutorial: 1 hr/wk	Oral/Practical Exam: --50 Marks

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Develop a basic understanding of the Java platform.
- Able to develop classes for mathematical operators.
- Assign Work Resources to Tasks, Assign Material Resources to Tasks and Assign Cost Resources to Tasks, track progress on tasks usage and resource utilization and monitor project execution compared with the planned schedule.
- Simulate Processes and Networks regarding production facility to reduce the work in process inventory and optimize resource optimization.
- To select the layout having optimum productivity and resources.

Syllabus Contents:

1 . Introduction to scheduling of a project in MS Project 2010, Fine-Tuning Task Details, Fine-Tuning the Project Plan, Creating Summary tasks and Milestones, defining Task Dependencies, Constraint types and Task types, Studying Gantt Chart view.

2. Introduction to CPM/PERT using MS Project 2010, Assigning resources, Resource Levelling, cash flow and Project overview analysis by generating reports.

3. Introduction to production facility planning and scheduling using WITNESS software, Defining Location, Entities, Arrivals, Processing and Attributes related to the facility, introduction to What-If scenarios, Assigning Machine downtimes and setup times.

4. Introduction to WITNESS software. Simulating multiple iterations of a layout and

comparative analysis of different layouts using WITNESS Manufacturing Edition software.

5. Overview to Java Platform: Compiler Vs Interpreter, JVM and Byte code concept, JNI concept, Security in Java.

6. Basic Language components of Java: Variable, operators, Expressions, Statements and Block, Control structures, Arrays, Functions.

7. Object Oriented Concepts in Java: Creating Classes, Managing Inheritance, Polymorphism and other COP concepts, Interfaces and Packages, Enumerated Types, Annotations, Nested Classes, Inner classes and Anonymous classes

8. Essential Java Classes: String class, Other classes in java.lang, Classes for mathematical operations, Exception Handling, Collections

9. File and other I/O Handling: Overview of I/O streams, java.io package classes overview, Reading/Writing standard I/O, Reading/Writing in File

10. GUI programming: AWT Classes, Event Handling, Introduction to SWING, Introduction to Advanced Core Java: Threads, Socket Programming, 2D-3D programming, Image Handling API, RMI, Reflection, JNI programming, Applets

List of Assignments

1. Write programs for
   a. Fibonacci Series up to given number of terms.
   b. Prime Number within a given range.
   c. That reads a String from the command line and writes it backward.

2. Write a program that continues to read a line from user and print all the characters back in reverse. The program terminates when the user writes "End'

3. Write a program to count the number of tokens, given a string and a separator.

4. Number Generator is class that generates random numbers continuously while Running Average class calculates the average of a set of numbers generated. Write These Classes. Write a program that uses tile piped stream to pipe the number generator with the average calculator.

5. Create a Circle class that contains a radius field. Give it a constructor where you pass in the radius. Have your test routine create a few circles, assign a value to the radius, then print out some information about the circles. Give your Circle a get Area method that calculates its area, and a print Info method that prints out the radius and area. Make a program that creates an array of 100 circles, each with a random radius. Print out the sum of the areas of the 100 circles. Also print the biggest and smallest areas.

6. Write a program for rectangle as in Assignment 5. Have your Circle and Rectangle inherit from a common Shape class. Change all your existing classes so that the fields are private, and you have getXxx and setXxx methods to lookup and change the values of the fields. If you haven't already made a Square class, do so. Make your Square inherit from Rectangle, but still enforce the restriction that the width and the height are the same. Hint: override some method(s). Make a method that will take an array of Shape objects and sum their areas. Where is the best place to put this method? Make a test case consisting of an array of mixed shapes.

7. Write a program to count the numbers of characters entered through stdin. The program exits upon entering Ctrl+Z. Also write all these characters in to given file.

8. Write a program to append a set of files to a given file.

9. Design a calculator in AVVT and SWING.

Note: Oral shall be based on above assignments.

(IOC) (IOC21007) Reliability Engineering

Teaching Scheme	Examination Scheme
Lectures : 2 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Student will be able to understand and familiarize with concept of reliability and maintainability.
- Student will be able to understand the that how to analyze a system for reliability assessment and life cycle costing.
- To familiarize with condition monitoring in maintainability.
- Student will be able to understand the importance and application of reliability.
- Student will be able to use the concepts of reliability in designing and maintenance of products.
- Student will be able to simulate techno economic life which is very important for industry application

Syllabus Contents:

Unit 1 **(6 hrs)**

Reliability

Definition -methods of improving reliability, derivation of Reliability function, configurations of reliability, series parallel & mixed configuration, simple problems

Unit 2 **(6 hrs)**

Reliability Calculations

methods of improving reliability, redundancy element, unit stand-by redundancy, reliability

models, constant hazard, simple problems, hazard models.

Unit 3

Maintenance Systems **(6 hrs)**

Objective, of maintenance, maintainability and availability concepts, types of availability - mean time to failure-mean time between failures-mean time to repair-mean down time- Reliability allocation

Unit 4 **(6 hrs)**

Life Cycle Costing

Techno economic Life; Reliability effort function, simple cost models for Life cycle.

Unit 5 **(4 hrs)**

Maintenance Management

Principles types of maintenance breakdown, periodic, preventive and total productive maintenance etc

Text Books:

- L. S. Srinath Reliability Engineering, -Affiliated East -West press, 2002.
- S.K. Basu & B.Bhadury, Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1stEdition, 2003.

Reference Books:

- K. K. Ahuja, Industrial management and Organizational Behaviour, Khanna Publications. 1999
- H. P. Garg, Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar, Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997
- S.K. Basu & B.Bhadury, Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1stEdition, 2003.
- A.K. Gupta, Reliability Engineering & Terotechnology

Department Elective-I
DEC) (PE(DE)-21001) Supply Chain and Logistics Management

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Understand, analyze the designing, planning and operational decisions of SCM.
- Identify, clarify managerial action to improve supply chain performance for the desired goals.
- Understanding of techniques used in the management of critical components of logistics and supply chains e.g., transportation, warehousing, inventory.
- Explain the likely future development of logistics and supply chain management

Syllabus Contents:

Unit 1 **(6hrs)**

Introduction to Supply chain management

Definition of Supply chain and supply chain management, Supply chain stages and decision phases, process view of a supply chain. Supply chain flows. Internal supply chains and External supply chains. Information systems and SCM, Inventory management across the SC.

Drivers of supply chain performance. Competitive and supply chain strategies. Achieving strategic fit. Expanding strategic scope, Challenges facing SC managers

Unit 2 **(8hrs)**

Supply Chain Network

Supply Chain Network (SCN) - Role, Factors, design options for distribution network. Models for Facility Location and Capacity Allocation and problem solving, Impact of uncertainty on SCN - Discounted Cash Flow Analysis

Unit 3 **(8hrs)**

Planning & Managing Inventories in a Supply Chain

Role of forecasting in the SC, Time series forecasting methods, Review of inventory concepts. Trade promotions, Managing Cycle Inventory, Cycle time overview, Causes of long cycle times, Methods of reducing cycle time, Safety inventory determination.

Unit 4 **(8hrs)**

Sourcing and Transportation in the supply chain

Role of Sourcing, Supplier - Scoring & Assessment, Selection & Contracts. Design Collaboration. Role of transportation, Factors affecting transportation decisions. Modes of transportation and their performance characteristics. Designing transportation network, Tailored transportation, Routing and scheduling in transportation. International transportation.

Unit 5 **(6hrs)**

Coordination and Technology in the Supply Chain

Coordination in a supply chain: Bullwhip effect. Obstacles to coordination. Managerial levers to achieve co-ordination, Building strategic partnerships. The role of IT in Supply Chain, The Supply Chain IT Framework, CRM, SRM. The role of E-business in a supply chain, The E-business framework, E-business in Practice. Case discussions.

Unit 6 **(4hrs)**

Performance measurement and Cases in SCM

Performance metrics in SCM, Balanced scorecard approach.

Text Books:

- Sunil Chopra & Peter Meindl; Supply Chain Management -Strategy, Planning & Operation; 11 Edition - 2003. Pearson Education Inc.
- Douglas Lanibert& James Stock: Strategic Logistics Management: Irwin McGraw Hill
- Robert B. Handfield, Ernest L. Nichols, Jr, Introduction to Supply chain management, Prentice Hall

Reference Books:

- Robert B. Handfield, Ernest L. Nichols, Jr.; Supply Chain Redesign-Transforming Supply Chains into Integrated Value Systems 2002, Pearson Education Inc.,ISBN:8129701138.
- Jeremy F. Shapiro, Duxbury ; Modelling the Supply chain: 2002, Thomson Learning, ISBN: 0-534-37363-
- David Simchi Levi, Philip Kaniinsky& Edith Simchi Levi: Designing and Managing the Supply Chain: McGraw Hill
- B.S. Sahay, Supply Chain Management: Mc. Millen.

(DEC) (PE(DE)-21002) Reliability & Terotechnology

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- To make students acquainted with concept of reliability and maintainability.
- Student will be able to analyze a system for reliability assessment and life cycle costing.
- Student will be able to understand and get familiarized with condition monitoring in maintainability.
- Student will be able to understand the importance and application of reliability.
- Student will be able to use the concepts of reliability in designing and maintenance of

products.

- Student will be able to simulate techno economic life which is very important for industry application.

Syllabus Contents:

Unit 1 **(5 hrs)**

Reliability

Definition -methods of improving reliability, derivation of Reliability function, configurations of reliability, series parallel & mixed configuration, simple problems

Unit 2 **(8 hrs)**

Reliability Calculations

methods of improving reliability, redundancy element, unit stand-by redundancy, reliability models, constant hazard, simple problems, hazard models.

Unit 3 **(8 hrs)**

Maintenance Systems

Objective, of maintenance, maintainability and availability concepts, types of availability - mean time to failure-mean time between failures-mean time to repair-mean down time- Reliability allocation

Unit 4 **(8 hrs)**

Life Cycle Costing

Techno economic Life; Reliability effort function, simple cost models for Life cycle.

Unit 5 **(8 hrs)**

Maintenance Management

Principles types of maintenance breakdown, periodic, preventive and total productive maintenance, maintenance planning and control strategies, maintenance planning, maintenance policies, maintenance organization, maintenance standards-quality service standards-maintenance Strategy, influence of Terotechnology on maintenance management maintenance performance indices, maintenance system documentation.

Failure Analysis: using causes & effects using Ishikawa diagram FMEA, FMECA.

Unit 6 **(8 hrs)**

Condition Monitoring

Definitions, advantages, limitations, through ferrography and particle analyser, spectroscopic oil analysis programme (SOAP), contaminant analysis, vibration monitoring, use of monitoring, instruments and applications-magnetic chip detector. Role of computers in condition monitoring. Monitoring, systems- layers & monitors.

Text Books:

- L. S. Srinath Reliability Engineering, -Affiliated East -West press, 2002.

- S.K. Basu & B.Bhadury, Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1st Edition, 2003.

Reference Books:

- K. K. Ahuja, Industrial management and Organizational Behaviour, Khanna Publications. 1999
- H. P. Garg, Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar, Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997
- A.K. Gupta, Reliability Engineering & Terotechnology

(DEC) (PE(DE)-21003) Facility Planning and Design

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Learn formulations, models, and analytical procedures for the study of facilities layout planning.
- Learn fundamental principles of material handling.
- Be able to design a factory layout incorporating product, process, and personnel requirements.
- Determine the space and area location tools and techniques.

Syllabus Contents:

Unit 1 **(8 hrs)**

Plant Location And Layout

Factors influencing plant location, Theories of plant location and location economies.

Plant Layout

Objectives of plant layout, Principles of plant layout, type: of plant layout, their merits and demerits.

Unit 2 **(8 hrs)**

Material Handling

Definition, principles, system design and selection of equipment, unit load concepts, basic layout types Immer, Nadler, Muther, Apple James and Reed's approaches to plant layout, Modular design concept, Production Line balancing.

Unit 3 **(8 hrs)**

Computer Aided Layout

CRAFT, COFAD, PLANET, CORELAP, ALDEP, Muther’s Classification, formation of cells of machines.

Unit 4 **(8 hrs)**

Space Determination And Area Allocation

Factors for consideration in space planning, receiving, storage, production, shipping, other auxiliary) service actions, Establishing total space requirement, area allocation factor to be considered, expansion, flexibility, aisles column and area allocation procedure. Design of layout using Travel chart, plot plan, block plan, Sequence demand straight-line method and non - directional method.

Construction of the Layout

Methods of constructing the layout, evaluation of layout, efficiency indices, presenting layout to management, implementing layout.

Unit 5 **(8 hrs)**

Quantitative Approaches to Facilities Planning

Deterministic models - single and multi facility location models, Location allocation problems - quadratic assignment problems, Warehouse layout models, plant location problems. Conveyor models. Storage models.

Unit 6 **(8 hrs)**

Probabilistic Models

Conveyor models, waiting line models and simulation models. Evaluation, selection, implementation and maintenance of the facilities plan.

Text Books:

- Tompkins, J A and White, J. A. Facilities Planning, John Wiley & Sons.
- Francis, R.L. and White, J. A. Facility Layout and Location, John Wiley & Sons.

Reference Books:

- James M. Apple, Plant Layout and Material handling 2ndEdition., The Ronald Press Company John, Wiely and Sail
- Muther Richard, Practical Plant Layout, McGraw hill.
- Sunderesh Heragu, Facilities Design, PWS Publishing Company, ISBN- 0-534- 95183.
- James M Moore, Plant Layout Design, MacMillon Co. 1962 LCCCN: 61 - 5204.

(DEC) (PE(DE)-21004) Nano Manufacturing

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- The course will enable the students to know the basic concepts of and principles of Micro and nano systems.
- The course will impart fundamental knowledge of micro and nano fabrication processes to the students.

- This course will help students to know about working principles and applications of micro sensors/micro actuators.
- This course will help students to know the advance applications of micro-nano systems to various critical applications such as biomedical, microfluidics etc.

Syllabus Contents:

Unit 1 **(6 hrs)**

Fundamental of micro and nano technology, Micro and Nanofabrication, concepts of micro and Nano-systems and Microsystems Products, Microsystems and Microelectronics, Application of Microsystems, Standardisation and Commercialization Issues of Micro-Nano Systems

Unit 2 **(8 hrs)**

Micro machining – Ultra Sonic Micro Machining, Abrasive Water Jet Micro Machining – Tool based Micro-machining, Chemical and Electro Chemical Micro Machining – Electric Discharge Micro machining. Electron and Laser Beam Micro Machining, Hybrid Micro machining, Electro Chemical Discharge micro machining, Machining of Micro gear, micro nozzle, micro pins and its applications. Tool based micromachining (TBMM)

Unit 3 **(8 hrs)**

Nano machining and Finishing: Focused Ion Beam Machining –Plasma Beam Machining – electrochemical nanomachining, Abrasive Flow finishing –- Magnetic Float polishing – Elastic Emission Machining – Chemo-Mechanical Polishing, Magnetic Abrasive Finishing – Magneto rheological finishing – Magneto Rheological abrasive flow finishing

Unit 4 **(7 hrs)**

Concepts of micro forming and welding, Micro extrusion – Micro and Nano structured surface development by Nano plastic forming, Roller Imprinting, Electrochemical and Electro-discharge machining etc, Micro bending and micro welding with LASER, Electron beam for micro welding, Metrology for micro machined components.

Unit 5 **(6 hrs)**

Micro sensors, Micro actuation, MEMS with Micro actuators, Micro actuators with mechanical Inertia – Micro fluidics, micro/nano biosensors: Classification of physical sensors, Integrated, Intelligent or Smart sensors, Bio sensing Principles and sensing methods, Biosensors arrays and Implantable devices, Innovative Applications on Present Devices: Nano chips, Nanotubes and Nanowires, Integration of chips and microprocessors.

Unit 6 **(7 hrs)**

Introduction to different Biomedical Applications of Microsystems:

Delivery of Diagnostic and Therapeutic Agents to Vascular Targets, Real-Time Biological Imaging and Detection,

Diagnostic and Therapeutic Applications of Metal Nano shells, Micro devices for Oral Drug Delivery etc. Technology Support, Meeting Social Needs , future scope of micro-nano system

Text Books:

- Foundations of MEMS, Chang Liu 2006, Prentice Hall
- Jain V.K., _Introduction to Micro machining Narosa Publishing House, 2011

Reference Books:

- Bhattacharyya B., "Electrochemical Micromachining for Nanofabrication, MEMS and Nanotechnology", William Andrew publications (Imprint of Elsevier) 2015
- Bandyopadhyay. A.K., Nano Materials, New age international publishers, New Delhi, 2008, ISBN: 8122422578.
- Tai-Ran Hsu, "MEMS and MICROSYSTEMS", John Wiley & Sons, New Jersey, 2008.
- Micro fabrication & Nano manufacturing by Mark J. Jackson
- Bharat Bhushan, Handbook of nanotechnology, springer, Germany, 2010.
- Nanotechnology and Nano electronics – WR Fahrner, Springer International Z. Cui, Nanofabrication, Springer, 2008
- Stephen.D. Senturia, "Microsystems design", Springer, 2000.
- Nanotechnology and Nano electronics – WR Fahrner, Springer International Z. Cui, Nanofabrication, Springer, 2008
- Janocha H., Actuators – Basics and applications, Springer publishers – 2012
- Company Ltd., 2000, 3rd Edition.

Minors- Manufacturing Technology (Mechanical)

Semester	Course Code	Course offered	Teaching Scheme			Credits
			L	T	P	
V	PE(MI)-21001	Metrology and Quality Control	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Minors- Manufacturing Technology (Civil/ENTC/Electrical/Instru/Comp/IT/Meta)

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(MI)-21003	Production Processes	3	-	-	3
VI	PE(MI)-21002	Engineering Economics and Operations Research	3	-	-	3
VII		Manufacturing Automation	3	-	-	3
VIII		Industrial Design of Products	3	-	-	3

Honors- Manufacturing Systems Engineering

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21001	Precision Engineering	3	-	-	3
VI	PE(HO)-21002	Reliability and Maintenance Engineering	3	-	-	3
VII		Performance Modeling of Production Systems	3	-	-	3
VIII		Machine Tool Systems	3	-	-	3

Honors- Mechatronics

Semester	Course Code	Course offered	Teaching scheme			Credits
			L	T	P	
V	PE(HO)-21003	Principles of Electronics	3	-	-	3
VI	PE(HO)-21004	Industrial Instrumentation and Control	3	-	-	3
VII		Mechatronics System Design	3	-	-	3
VIII		Fluid Power Systems and Factory Automation	3	-	-	3

Minors- Manufacturing Technology (Mechanical)
SEMESTER-V
PE(MI)-21001 Metrology and Quality Control

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Interpret the manufacturing drawings and perform inspection.
- Able to use different types of measuring instruments.
- Select appropriate measurement techniques for geometric features.
- Carryout data collection and use statistical tools for analysis.
- Identify and analyze the cause for variation and recommend suitable corrective actions.
- Design an acceptance sampling plan for inspection and carry out process capability studies.

Syllabus Contents:

Unit 1 **(8 hrs)**

Introduction: Meaning of Metrology, Precision, Accuracy, Methods and Errors in Measurement, Calibration.

Linear Measurement: Standards, Line Standards, End Standard, Wavelength Standard, Classification of Standards, Precision and Non-Precision Measuring instruments and their characteristics, Slip Gauges.

Interferometry: Introduction, Flatness testing by interferometry, NPL Flatness Interferometer. Study of Measuring Machines, Recent Trends in Engineering Metrology, use of interferometery for length angle and surface roughness measurement.

Angle Measurement: Sine bars, Sine Centers, Uses of sine bars, angle gauges, Auto Collimator Angle Dekkor, Constant deviation prism.

Measurement System Analysis: -Introduction, Influence of temperature, operator skills and the instrument errors etc. on the MSA, Gauge R and R study.

Unit 2 **(8 hrs)**

Limits, Fits and Tolerances: Meaning of Limit, Fits and Tolerance, Cost – Tolerance relationship, concept of Interchangeability, Indian Standard System.

Design of limits Gauges: Types, Uses, Taylor's Principle, Design of Limit Gauges, Three surface Generation.

Inspection of Geometric parameters: Straightness, Flatness, Parallelism, Concentricity, Squareness, and Circularity.

Comparators: Uses, Types, Advantages and Disadvantages of various types of Comparators.

Measuring Machines: -Theory of Co-ordinate Metrology, Universal Measuring Machines, Co-ordinate Measuring Machines (CMM), different configurations of CMM, Principle, Error involved, calibration, Probing system, automated inspection system**.**

Unit 3 **(6 hrs)**

Surface Finish Measurement: Surface Texture, Meaning of RMS and CLA values, Roughness Measuring Instruments, Tactile and Non-tactile measuring instruments, difference between waviness and roughness, Grades of Roughness, Specifications, Assessment of surface roughness as per IS, Relationship between surface roughness and Manufacturing Processes.

Screw Thread Metrology: External Screw Thread terminology, Floating Carriage Instruments, Pitch and flank Measurement of External Screw Thread, Application of Tool Maker's Microscope, Use of Profile Projector.

Gear Metrology: Spur Gear Parameters, Gear tooth thickness measurement: Gear tooth vernier calliper, Constant chord method, Span Micrometer.

Unit 4 **(8 hrs)**

Introduction: Meaning of Quality, Approaches- Deming's Approach, Juran's Approach, Quality of Product, Quality of Service, Cost of Quality, Value of Quality, and Difference between Inspection, Quality Control and Quality Assurance, Role of Quality in Present day environment.

Introduction to Quality Control:1) Meaning of quality Control 2) 100% Inspection and Selective Inspection 3) Statistics in Selective inspection.

Introduction to Statistical Quality Control: Interpretation of SPC Charts, benefits for use on shop floor, Control charts- Attribute (P, nP, C, U) and Variable (X bar, R chart and X&R chart), Sampling inspection, OC Curves and Sampling Plan, Process Capability Index (Cp, Cpk), Concept, Methods of determining Cp and Cpk.

Unit 5 **(5 hrs)**

Quality Assurance Systems:

Total quality management (T.Q.M):-7 tools of Problem Solving, Like Cause and Effect Diagram, Pareto Analysis etc., Q.F.D., Quality Circles, Kaizen, six sigma, 5S System.

ISO 9001-2000 Series of Standards:- History and Evolution of ISO 9000 Series , importance and overview of ISO 9000- 1998 Series standards, structure of ISO 9000-2000 Series standards, clauses of ISO 9000 series standards and their interpretation and implementation, quality system documentation and audit.

ISO 14000:-environmental management concepts, and requirement of ISO 14001, benefits of environmental management Systems.

Unit 6 **(5 hrs)**

Statistics: - Role of statistics in industries, Role of statistics as industrial engineering tool correlation & regression (Linear Up to 2 independent variables).

Probability: -Addition & multiplication theorem (review), probability distributions (Binomial, Poisson, Exponential, Normal),sampling distribution of 't', 'χ2', 'F' Distribution, elementary sampling theory, test of hypothesis & it's significance.

Design of experiment: -Meaning, objective, and types of research, approaches, two factorial experiments, Taguchi Method.

Reliability Engineering: - Concept, Definitions of MTTF, MTBF, FEMA.

Text Books:

- R. K. Jain, A Text book of Engineering Metrology, Khanna Publications Pvt. Ltd.18th Edition, 2002
- S.P.Gupta, Statistical Methods, Danpat Rai and Sons, New Delhi, 2007.

Reference Books:

- John S. Oahland, Total Quality Management, Elsevier Publications, 3rd Edition 2006.
- P. N. Mukerjee Total Quality Management, Prenice Hall of India Publications, 2nd Edition 2005.
- Amitava Mitra, Fundamental of Quality Control and improvement, Prenice Hall of India Publications, 2nd Edition 2006.
- G.M.S. De Silva, Basic Metrology for ISO 9000 Certification Elsevier Publications, 3rd Edition 2002.
- I.C.Gupta, A Text book of Engineering Metrology, Dhanpat Rai PblicationsPvt. Ltd.6th Edition, 2004

Minors- Manufacturing Technology (Mechanical)

SEMESTER –VI
PE(MI)-21002 Engineering Economics and Operations Research

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Be able to apply concepts of economic analysis to a manufacturing industry.
- Be able to understand Break Even Analysis, Standard Costing, Marginal Costing.
- Be able to apply probabilistic risk analysis methods.
- To apply mathematical approach to take managerial decision.
- To understand budgeting, risk estimation, business strategy etc.

Syllabus Contents:

Unit 1 **(6 hrs)**

Engineering Economy

Introduction, Importance, Time value of money, Net present value, Payback period, Return on investment, Internal rate of return, Equity, Shares, Dividends.

Unit 2 **(6 hrs)**

Accounting tools

Income statement, Project cash flow statement, Cost estimation, LCC estimation, capital cost estimation, Turnover ratio, Lang's factor, operating cost, marginal cost estimation, evaluation of economic alternatives, profit planning and break-even analysis.

Unit 3 **(8 hrs)**

Decision making under deterministic model

Simplex method, linear programming, deterministic inventory model, Assignment technique, Replacement etc.

Unit 4 **(8 hrs)**

Decision making under probabilistic model

Theory of games, Queuing theory and simulation, Stock control under uncertainty.

Unit 5 **(6 hrs)**

Sequencing Models (6 hrs)

Scheduling and sequencing. Assumptions in sequencing models. Processing "n" jobs on machines. Processing of two jobs on machines with each having different processing order

Unit 6 **(6 hrs)**

Network Models:

Introduction to PERT / CPM and its importance in project management. (Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time, Resource allocation and load smoothening.

Text Books:

- C. B.Gupta -*Fundamentals of Business*, Sultan Chand & Co
- Gupta P. K. and Hira D. S. -*Operations Research,* S Chand & Company Ltd.

Reference Books:

- K R Sharma - Fundamentals of Engineering economy, Cognella, , the United States of America,2011
- Henry M. Stenier - Engineering economics Principles, Mc Grow hill Publication.
- P. A. Samualson -Economics, Mc Grow hill International.
- Colin Drury - Management and Cost Accounting, English Language Book Society, Chapman & Hall Landon.
- Sharma J. K. -Mathematical Models in Operations Research, Tata McGraw – Hill
- Publishing Company Limited.
- Engineering economy- web based course- Georgia university, USA

Minors- Manufacturing Technology (Mechanical)
SEMESTER-VII
Manufacturing Automation

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1-20,
Tutorial: -	T2 – 40,

ESE- 60 marks

Course Outcomes:

- To have an overview of manufacturing, manufacturing operations and automation technologies
- To study the definition and elements of Mechatronics and automation system
- To learn how to apply the principles of Mechatronics and automation for the development of productive and efficient manufacturing systems.
- To study the hydraulic and pneumatic systems employed in manufacturing industry.
- To study material handling technologies for their identification in automated material control purposes.
- To learn the integration of automation technologies and material handling technologies into manufacturing systems.

Syllabus Contents:

Unit 1 **(8 hrs)**

Overview of Manufacturing: Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics.

Automation, Mechatronics and Control Technologies: Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Microsensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

Unit 2 **(8hrs)**

Material Handling and Identification Technologies: Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle System (AGVS), Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture

Manufacturing Systems: Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

Unit 3 **(6 hrs)**

Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis: Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

Unit 4 **(6 hrs)**

Programmable Automation (Processor) Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly

language programming of microcontroller

Unit 5 **(8 hrs)**

Control System and Controllers: Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions

Discrete Control: Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

Unit 6 **(6 hrs)**

Mechatronic Systems: Control Architectures, Design Strategy and Case Studies Introduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Text Books:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Reference Books:

- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw Hill
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw Hill
- HMT Ltd. Mechatronics, Tata McGraw-Hill
- Joji P. Pneumatic Controls, Wiley India

Minors- Manufacturing Technology (Mechanical)
SEMESTER-VIII
Industrial Design of Products

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1/T2/Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Students learn basics of product design process and morphology of design.
- Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product.
- Students learn about process of design for production of metal components.
- To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
- To understand all phases of product. Concept to final manufacturing

Syllabus Contents:

Unit 1 **(5 hrs)**

Introduction To Product Design: Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly

Unit 2 **(8 hrs)**

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 their 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. Review of Strength, Stiffness and Rigidity Considerations in Product Design Principal Stress Trajectories (Force - Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience, Designing for Uniform Strength, Tension vis-à-vis Compression.

Unit 3 **(8 hrs)**

Design for Production -Metal Parts: Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood: Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic, Rubber Parts, Design Recommendations for Rubber Parts, Distortion in Rubber, Dimensional Effects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts, Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood. Design for assembly and disassembly.

Unit 4 **(8 hrs)**

Rapid Prototyping: Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain for RP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application and case studies.

Unit 5 **(8 hrs)**

Economic Factors Influencing Design: Product Value, value analysis, 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, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(6 hrs)**

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods

Text Books:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rd Edition, 2003

Reference Books:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland Engene Y.,Inetoviez, New Product Development: Design &nalysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & DewburstP.,Design for Assembly, a Designer's Hand book, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prortotyping –Laser Based and Other Technologies, Kluwer,2004.

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER-V
PE(MI)-21003 Production Processes

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Gain an understanding and appreciation of the breadth and depth of the field of Manufacturing Engineering.
- Understand the various basic Production Processes and Machine Tools.
- Learn how to select a particular production process for the given component from the available conventional as well as non-conventional manufacturing processes.
- Learn development and application of advanced technologies and components & processes for Manufacturing.
- to select a particular manufacturing process for the given component from the available conventional as well as non conventional manufacturing processes.

Syllabus Contents:

Unit 1 **(7 hrs)**

Casting Processes, Expendable Mould Casting Processes: Sand Casting, types of pattern materials, pattern making allowances, core prints, moulding sand properties and testing, hand and machine moulding, core, core boxes, melting and pouring, study of furnaces – cupola, fuel fired, electric arc, induction furnaces. Investment casting, shell moulding. Casting techniques of cast iron, steels and nonferrous metals of alloys; solidification; design of casting, gating and riser in Cleaning, finishing and heat treatment of castings, defects in casting, Permanent Mould Casting Processes, Die casting, low-pressure permanent mould casting – hot and cold chamber processes, centrifugal casting, semi-centrifugal casting, centrifuging, continuous casting.

Unit 2 **(6 hrs)**

Turning, Boring, Related Processes: Fundamentals of turning and boring, lathe – construction, accessories, operations. Thread Cutting – single and multistart threading, Different tools, tool materials, tool geometry. Concept of speed, feed, depth of cut. Capstan and Turret Lathe-Construction, Working and Applications. Introduction to boring machines – general arrangement and nature of work done.

Unit 3 **(7 hrs)**

Drilling and Milling Machines

Drilling: Fundamentals of drilling process, twist drill geometry, tool holders. Types of drilling machines, operations performed on drilling machines. Types of drills. Reaming process, reamers types, geometry.

Milling Machines: Fundamentals of milling process, cutters - types and geometry. Operations performed on milling machines. Dividing head, methods of indexing. Gear train calculations for

helical and cam milling.
Shaper, Planer and Slotting Machines: Construction, working of quick return mechanism, operations performed.

Unit 4 **(7 hrs)**

Abrasive Machining Processes: Abrasive machining, abrasives - types, size and geometry. Grinding wheels, wheel marking, wheel selection, wheel mountings. Types of grinding machines. Honing, Lapping, Super Finishing, Buffing.
Surface treatment processes
Honing, lapping, buffing, polishing, honing tools, lapping materials. Abrasive, buffing, polishing wheels and burnishing processes. Electroplating, Electroless plating, plasma coating, phosphating, galvanizing, metal spraying, anodizing, rubbling and tumbling.

Unit 5 **(7 hrs)**

Hot and cold working of metals: Principles of rolling, forging, drop, press, upset, roll forging, extrusion, drawing, spinning, effects of hot working. Cold working processes, Cold rolling, swaging, forging, extrusion- forward, backward and impact roll forming, tube drawing, wire drawing, spinning, shot penning, high energy rate forming.

Unit 6 **(7 hrs)**

Joining Processes: Welding Processes: Theory, control and applications, Arc Welding – SMAW, GTAW, GMAW, FCAW, Submerged arc welding, etc.
Resistance welding – theory, Spot, Seam, Projection welding processes etc., Gas welding. Friction welding, Ultrasonic welding, Thermit welding, Electron beam and Laser welding. Defects in welding, their cause and remedy, weldability, welding of dissimilar metals. NDT and other methods of testing welded joints. Soldering and Brazing applications. Use of adhesives for joining. Classification of adhesives, types of adhesives and their applications, surface preparation and various joints.

Text Books:

- S.K. HajraChoudhary and S.K. Bose, Elements of workshop Technology, Volume I, II, Asia Publishing House, 10th Edition 2000.
- P.N. Rao, Manufacturing Technology, Tata McGraw-Hill Publishing Limited, II Edition, 2002.

Reference Books:

- Chapman W.A.J, Workshop Technology, Volume I, II, III, CBS Publishers and distributors. 5th Edition 2002
- Degarmo, Black and Kohser, Materials and processes in Manufacturing, Prentice Hall of India.2nd Edition 1998
- Milton Shaw, Metal Cutting Principles, Oxford University Press, 4th Edition 2001
- O.P. Khanna and M. Lal, Production Technology, Vol. I,II, Dhanpatrai Publication, 5th Edition,1999.
- B.S. Raghuwanshi, Workshop Technology, Dhanpat Rai Publication, 9th Edition, 1999

Minors- Manufacturing Technology (Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER-VI
PE(MI)-21002 Engineering Economics & Operations Research

Teaching Scheme	Examination Scheme
Lectures: 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Gain an understanding and appreciation of the breadth and depth of the field of Manufacturing Engineering.
- Understand the various basic Production Processes and Machine Tools.
- Learn how to select a particular production process for the given component from the available conventional as well as non-conventional manufacturing processes.
- Learn development and application of advanced technologies and components & processes for Manufacturing.
- To be able to select a particular manufacturing process for the given component from the available conventional as well as non-conventional manufacturing processes.

Syllabus Contents:

Unit 1 **(6 hrs)**

Engineering Economy

Introduction, Importance, Time value of money, Net present value, Payback period, Return on investment, Internal rate of return, Equity, Shares, Dividends.

Unit 2 **(6 hrs)**

Accounting tools

Income statement, Project cash flow statement, Cost estimation, LCC estimation, capital cost estimation, Turnover ratio, Lang's factor, operating cost, marginal cost estimation, evaluation of economic alternatives, profit planning and break-even analysis.

Unit 3 **(8 hrs)**

Decision making under deterministic model.

Simplex method, linear programming, deterministic inventory model, Assignment technique, Replacement etc.

Unit 4 **(8 hrs)**

Decision making under probabilistic model.

Theory of games, Queuing theory and simulation, Stock control under uncertainty.

Unit 5 **(6 hrs)**

Sequencing Models

Scheduling and sequencing. Assumptions in sequencing models. Processing "n" jobs on machines. Processing of two jobs on machines with each having different processing order

Unit 6 **(6hrs)**

Network Models:

Introduction to PERT / CPM and its importance in project management. (Concepts and construction of network diagrams. Critical path and project duration, floats, network crashing, optimum project duration and cost, PERT activity, time estimate, probability of completion of a project on before specified time, Resource allocation and load smoothening.

Text Books:

- C. B.Gupta -*Fundamentals of Business*, Sultan Chand & Co
- Gupta P. K. and Hira D. S. -*Operations Research,* S Chand & Company Ltd.

Reference Books:

- KR Sharma - Fundamentals of Engineering economy, Cognella, , the United States of America,2011
- Henry M. Stenier - Engineering economics Principles, Mc Grow hill Publication.
- P. A. Samualson -Economics, Mc Grow hill International.
- Colin Drury - Management and Cost Accounting, English Language Book Society, Chapman & Hall Landon.
- Sharma J. K. -Mathematical Models in Operations Research, Tata McGraw – Hill
- Publishing Company Limited.
- Engineering economy- web based course- Georgia university, USA

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
SEMESTER VII
Manufacturing Automation

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1-20, T2 – 40, ESE- 60 marks
Tutorial: -	

Course Outcomes:

- To have an overview of manufacturing, manufacturing operations and automation technologies
- To study the definition and elements of Mechatronics and automation system
- To learn how to apply the principles of Mechatronics and automation for the development of productive and efficient manufacturing systems.
- To study the hydraulic and pneumatic systems employed in manufacturing industry.
- To study material handling technologies for their identification in automated material control purposes.
- To learn the integration of automation technologies and material handling

technologies into manufacturing systems.

Syllabus Contents:

Unit 1 **(8 hrs)**

Overview of Manufacturing: Introduction to Production Systems, Automation in Production Systems, Overview of Manufacturing, Manufacturing Operations, Manufacturing Models and Metrics

Automation, Mechatronics and Control Technologies: Introduction to Automation, Definition of Mechatronics, Mechatronics in Manufacturing, Industrial Control Systems, Hardware Components for Automation, Mechatronics and Process Control (Data Conversion Devices, Sensors, Microsensors, Transducers, Signal Processing Devices, Relays, Contactors and Timers), Data Acquisition, Actuators and Mechanisms

Unit 2 **(8hrs)**

Material Handling and Identification Technologies: Introduction to Material Handling, Principles of Material Handling, Material Transport Systems, Automated Guided Vehicle System (AGVS), Conventional and Automated Storage Systems, Engineering Analysis of Storage Systems, Automatic Identification and Data Capture

Manufacturing Systems: Introduction to Manufacturing Systems, Single Station Manufacturing Cells, Manual Assembly Lines: Single Model and Mixed Assembly Line Balancing, Automated Production Lines, Automated Assembly Systems

Unit 3 **(6 hrs)**

Automation and Principle of Hydraulic and Pneumatic Circuit Design and Analysis: Hydraulic and Pneumatic Controls, Application in Machine Tools and other Mechanical Fields, Hydraulic and Pneumatic Circuit Design Considerations, Functional Diagram in Circuit Design, Pneumatic Circuit Analysis, Electrical Controls for Fluid Power Circuits, Fluid Logic Control Systems, Fluid Power Maintenance and Safety, Synthesis of circuits, circuit optimization techniques.

Unit 4 **(6 hrs)**

Programmable Automation (Processor): Overview of Microcomputer systems, Microcontroller, 8051 Microcontroller Architecture, 8051 Instruction set and interfacing, applications and assembly language programming of microcontroller.

Unit 5 **(8 hrs)**

Control System and Controllers: Transfer function and block diagram, Block Diagram Reduction, Controller Principles, Process Characteristics, Control System Parameters, Controller Modes, Control Actions

Discrete Control: Programmable Logic Controllers, Basic Structure, Ladder Logic Programming, Types and Selection of PLC

Unit 6 **(6 hrs)**

Mechatronic Systems: Control Architectures, Design Strategy and Case Studies
Introduction, Control Architecture, Traditional and Mechatronics Designs, Possible Mechatronic Design Solutions, Case Studies of Mechatronic Systems

Text Books:

- Mikell P. Groover, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Prentice-Hall of India Private Limited.
- W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson Education Limited
- S. R. Majumdar, Pneumatic Systems: Principles and Maintenance, Tata McGrawHill

Reference Books:

- N. P. Mahalik, Mechatronics: Principles, Concepts and Applications, Tata McGraw Hill
- S. R. Majumdar, Oil Hydraulic Systems: Principles and Maintenance, Tata McGraw Hill
- HMT Ltd. Mechatronics, Tata McGraw-Hill
- Joji P. Pneumatic Controls, Wiley India

Minors- Manufacturing Technology
(Civil/ENTC/Electrical/Instru/Comp/IT/Meta)
Semester VIII
Industrial Design of products

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Students learn basics of product design process and morphology of design.
- Students are exposed to Concept design, detail design, manufacturing, marketing, Introduction strategy of new product. Students learn about process of design for production of metal components.
- To understand optimization tools and ergonomic principles applied on typical product design as well as concept of value engineering in new product design.
- To understand all phases of product. Concept to final manufacturing.

Syllabus Contents:

Unit 1 **(5 hrs)**

Introduction to Product Design: Asimow's Model: Definition of Product Design, Design by Evolution, Design by Innovation, Essential Factors of Product Design, Production-Consumption Cycle, Flow and Value Addition in the Production-consumption Cycle, The Morphology of Design (The sever phases), Primary Design Phases and flowcharting, Role of Allowance Process Capability, and. Tolerance in Detailed Design and Assembly

Unit 2 **(8 hrs)**

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 their 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. Review of Strength, Stiffness and Rigidity Considerations in Product Design Principal Stress Trajectories (Force - Flow Lines), Balanced Design, Criteria and Objectives of Design, Material Toughness: Resilience, Designing for Uniform Strength, Tension vis-à-vis Compression.

Unit 3 **(8 hrs)**

Design for Production -Metal Parts: Producibility Requirements in the Design of Machine Components, Forging Design, Pressed Components Design, Casting Design, Design for Machining Ease, The Role of Process Engineer, Ease of Location and Clamping, Some Additional Aspects of Production Design, Die Casting and Special Castings, Design for Powder Metallurgical Parts, Expanded Metals and Wire Forms.

Designing with Plastics, Rubber, Ceramics and Wood: Approach to Design with Plastics, Plastic Bush Bearings, Gears in Plastic, Fasteners in Plastic, Rubber Parts, Design Recommendations for Rubber Parts, Distortion in Rubber, Dimensional Effects, Tolerances, Ceramics and Glass Parts, Production Design Factors for Ceramic Parts, Special Considerations for Design of Glass Parts, Dimensional Factors and Tolerances, Wood. Design for assembly and disassembly.

Unit 4 **(8 hrs)**

Rapid Prototyping: Importance and overview of Rapid Prototyping, Classification of Rapid Prototyping (RP) Process (FDM, LOM, SLA, SLS, Stereo lithography etc.), Typical Process Chain for RP, Introduction to CAD and Data exchange format, data format details, conversion, validation, repairing, Part Slicing and Orientation and its importance, application, and case studies.

Unit 5 **(8 hrs)**

Economic Factors Influencing Design: Product Value, value analysis, 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, Anthropometry: Man as Occupant of Space, The Design of Controls, The Design of Displays, Man/Machine Information Exchange.

Unit 6 **(6 hrs)**

Modern Approaches to Product Design: Concurrent Design, Quality Function Deployment (QFD) for design, product design optimization methods

Text Books:

- A.C. Chitale and R.C. Gupta, Product Design and Manufacturing by PHI.
- Karl T. Ulrich & Steven D., Product Design & Development Eppinger Tata McGraw Hill, 3rd Edition, 2003

Reference Books:

- Tim Jones, Butterworth Heinmann, New Product Development by Oxford, TAC-1997.
- Roland Engene Y., Inetoviez, New Product Development: Design & Analysis, John Wiley and Sons Inc., N.Y. 1990.
- Geofferry Boothroyd, Peter Dewhurst and Winston Knight. Product Design for Manufacture and Assembly, Amherst, 1983.
- Bill Hollins, Stwout Pugh, Butterworth, Successful Product Design by London 1990.
- Boothroyod & DewburstP., Design for Assembly, a Designer's Handbook, University of Massachusets, Amherst, 1983.
- Keyinotto and Kristini Wood, Product Design Pearson Education 2004.
- Venuvinod, PK., MA. W., Rapid Prototyping –Laser Based and Other Technologies, Kluwer,2004.

HONORS - Manufacturing Systems Engineering

SEMESTER-V
PE(HO)-21001 Precision Engineering

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

After studying this course, the students would be able to understand

- The meaning precision machining and the importance of it.
- The requirements of machine network elements to achieve precision in the components.
- The principles of various precision engineering processes and apply them in actual field.
- Various method of micromachining using LASER and other processes.
- To posses basic knowledge related to new trends in manufacturing and its precise control.

Syllabus Contents:

Unit 1 **(7 hrs)**

Precision engineering: Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility.

Unit 2 **(7 hrs)**

Precision machine element: Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers – Rolling elements – hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings.

Unit 3 **(7 hrs)**

Error Control: Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods – Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping & setting errors – Control errors due to locations – principle of constant location surfaces.

Unit 4 **(7 hrs)**

Precision Manufacturing: Micro machining processes-diamond machining - micro engraving - Micro replication techniques forming-casting-injection moulding - micro embossing - Energy assisted processes LBM, EBM, FIB, Micro electro discharge machining-photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition.

Unit 5 **(7 hrs)**

MEMS: Introduction – MEMS –characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.,

Unit 6 **(7 hrs)**

Micromachining: Laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. LIGA, S-LIGA Micro welding: Micro welding in similar and dissimilar materials; welding processes like ultrasonic, EB, LB; applications. Micro casting: Casting processes like vacuum, semi-solid state; applications Processing of Integrated Circuits, Clean rooms, crystal growing and shaping of wafers, Etching, Photo and other lithography techniques, Impurity introduction, Thermal oxidation, CVD, Metallisation etc. IC packaging

Text Books:

- Venkatesh V.C. and Izman S., —Precision Engineering‖, Tata McGraw Hill, 2007.
- Murthy R.L., —Precision Engineering‖, New Age International, 2009

Reference Books:

- Nakazawa H., —Principles of Precision Engineering‖, Oxford University Press, 1994.
- Institute of Physics Publishing, Bristol and Philadelphia, Bristol, BSI 6BE U.K

HONORS - Manufacturing Systems Engineering
SEMESTER-VI
PE(HO)-21002 Reliability and Maintenance Engineering

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments /Quiz/T1/T2- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Student will be able to understand the importance and assessment of reliability and maintainability.
- Student will be able in a position to analyze reliability in designing and maintenance of product.
- Student will be aware of several maintenance strategies for wide range of application.
- Students will able to use and apply analytical methods of maintenance.

Syllabus Contents:

Unit 1 **(6 hrs)**

Fundamental concepts of reliability, maintainability: Definition, Failure pattern, Distribution, Life characterization phases, MTBF, MTTF etc.

Unit 2 **(8 hrs)**

Component and system reliability: Probability distribution of failure, Component reliability estimation, Conditioning probability, Parallel and series combination, Redundancy etc.

Unit 3 **(8 hrs)**

Maintainability and availability: Objectives, factors affecting them, Markov chain analysis, fault tree analysis, FMECA etc, RPN, evaluation of availability.

Unit 4 **(6 hrs)**

Maintenance models and strategy: Preventive and corrective maintenance TPM, CBM, RCM et

Unit 5 **(6 hrs)**

Analytical methods in maintenance: Optimal inspection frequency, Corrective maintenance planning under CBM- mathematical model, Repair limit model, opportunistic maintenance policy.

Unit 6 **(6 hrs)**

5n: Software maintenance cost, medical equipment maintenance and repair, spare parts inventory models, Optimal overhaul internal model, human related maintenance activity, robot maintenance under maximum profit.

Text Books:

- L. S. Srinath - Reliability Engineering, -Affiliated East -West press, 2002.
- S.K. Basu & B.Bhadury- Terotechnology: Reliability Engg& maintenance Management, Asian book Private Ltd., Delhi, 1stEdition, 2003.

Reference Books:

- L Lamberson, KC Kapur - Reliability in engineering design- John Wiley & Sons, 1977.
- K. K. Ahuja - Industrial management and Organizational Behaviour, Khanna Publications.
- 1999
- H. P. Garg - Industrial Maintenance, S. Chand & company. Ltd, Third Edition 1990.
- Dr. Shankar - Industrial engineering Management Golgotia Publications Pvt. Ltd. 1997
- B.S. Dhillon- Maintainability, Maintenance, and Reliability for Engineers, CRC press, taylor and francis group, 2006
- Charles Ebeling- An introduction to reliability and maintainability engineering, Tata macgraw-Hill, 1997.
- Plant engineering handbook
- LC Morrow - Maintenance engineering handbook, McGraw-Hill, 2nd ed, 1966,

Honors - Manufacturing Systems Engineering
Semester VII
PE(HO)- Performance Modeling of Production Systems

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1/T2/Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- Identify the type of Production system and its modeling.
- Perform line balancing and buffer stock simulation.
- Analyze the production system using Markov chain & Petri Net..
- To understand how AGV are used in the production systems.

- Use of Petri Nets in the production systems.

Syllabus Contents:

Unit 1 **(5 hrs)**

Dedicated manufacture versus Flexible manufacture, mechanization versus automation, semi-automatic versus automatic systems using 'in-line' transfer, rotary transfer, Balancing of assembly line using available algorithms. Transfer line-monitoring system (TLMS) using Line Status, Line efficiency. Buffer stock Simulation.

Unit 2 **(8 hrs)**

Hard automation using relays, solenoid operated valves, magnetic selectors, hydraulic and pneumatic systems in automation. 'In travel' control, 'centralized travel' control and 'time sequence' control.

Unit 3 **(8 hrs)**

Automatic inspection of parts and loading unloading using Robots and Vision systems with CCD cameras, LED's for three-dimensional On-line inspection.

Unit 4 **(8 hrs)**

AGV and its various guiding technologies.

Unit 5 **(8 hrs)**

Markov chain analysis for production systems with discrete time and continuous time analysis. Markov chain analysis with zero or with one or more repair facility, Reversible markov chains in manufacturing. Use of analytical hierarchy process in Cellular Manufacturing Systems.

Unit 6 **(6 hrs)**

Uses of Petri Nets. Generalized timed Petri Nets, Extended stochastic Petri Nets and their applications in Production systems.

Reference Books:

- N. Viswanadhan& Y. Narahari, "Performance Modelling of Automated Manufacturing Systems", Prentice Hall of India (Eastern Economy Edition) 1992.
- Mikell P. Groover, "Automation, Production Systems & Computer Integrated Manufacturing" Prentice Hall India Learning Pvt. Ltd.3rdEdition. 2008
- Benjamin S. Blanchand, "Logistics Engineering and Management (5th Edn.) - Pearson Education Asia - Indian Reprint 2001

Honors - Manufacturing Systems Engineering
Semester VIII
Machine Tool System

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1/T2/Quiz- 40 Marks, End Sem Exam- 60 marks

Course Objectives:

- To get up to-date knowledge in machine tool development field
- To understand basic design principles of macro/micro elements of system.
- To understand machine tool utilization to increase effective productivity.
- To learn machine tool structure and their elements
- To understand basic design features of machine elements

Syllabus Contents:

Unit 1 **(6 hrs)**

Machine tool configuration: Recent development in machine tool field, Basic concepts and requirements, types of machine tool, structure of machine tool system, Design approach by matrix method, Introduction to CNC and machining centre configuration.

Unit 2 **(6 hrs)**

Drive system review: Elements of machine tool system, their requirements and design criteria-drive system viz speed/ feed drive, power transmission screw etc

Unit 3 **(8 hrs)**

Supporting elements and design analysis: Supporting elements in machine tool-like bed, guides and lubrication, and stick slip, spindle, Machine column etc.

Unit 4 **(6 hrs)**

Rigidity & reliability of machine tool: Rigidity of machine tool-static and dynamic, dynamic characterization analysis of cutting process, vibration and chatter, Machine compliance estimation, Tobius curve etc. Reliability of machine tool, Availability etc.

Unit 5 **(6 hrs)**

Automation and feedback: Open loop and closed loop control, pre-selective and selective control, micro movements of elements, micro sensors, electrical/electronic control of motor, hydraulic controls, in-process gauging etc.

Unit 6 **(8 hrs)**

Introduction to modern machine tool: Principle of automation, multi-axis machining centres, additive manufacturing machines, super finishing machines etc., machine tool power utilization with full tool life, Machine tool performance (Coefficient of merit).

Text Books:

- S K Basu, D. K. Pal - *Design of Machine Tools*, Oxford & IBH Pub., 1995
- Gopal Chandra Sen, Amitabha Bhattacharyya - *Principles of Machine Tools*, New Central Book Agency, 1967

Reference Books:

- N. Ignatyev, N. Acherkan et al - *Machine Tool Design*, Volume 4, University Press of the Pacific, 2000.
- N K Mehta - *Machine tool design and Numerical control*, third edition, Tata McGraw hill publications limited, 2012
- Stanley John Martin-*Numerical Control of Machine Tools*, Hodder and Stoughton, 1970
- T.K. Kundra- *Numerical Control and Computer-Aided Manufacturing*, McGraw-Hill Education, 1987
- JW Gardner, F Udrea- *Microsensors: principles and applications*,2nd John Wiley & Sons, 2009.
- A Gebhardt, A Gebhardt- *Understanding additive manufacturing*,CarlHanser Verlag GmbH & Co.,2012.
- RS Schmid, S Kalpakjian- *Manufacturing engineering and technology*, Pearson Prentice Hall, 2006.
- B Lu, D Li, X Tian- *Development Trends in Additive Manufacturing and 3D Printing*,Engineering, vol-1,issue-1,2015
- Menz et al - *Microsystem technology* - wileyvch verlag,2000

Honors- Mechatronics
Bridge Course (Mechanical/Electronics)
Semester V
PE(HO)-21003 Principles of Electronics

Teaching Scheme	Examination Scheme
Lectures : 2 hrs/week	T1/T2/ Assignments/ Quiz - 40
Tutorial: 1 hr/.week	End-Sem Exam- 60 marks

Course Outcomes:

- To develop and employ circuit models for elementary electronic components, e.g., resistors, sources, inductors, capacitors, diodes and transistors;
- Become adept at using various methods of circuit analysis.
- Be able to use basic techniques for analyzing analogue and digital electronic circuits
- Be able to understand basic methods of control systems

Syllabus Contents:

Role of various Engineering disciplines in Mechatronics, Mechatronics Design elements, Scope and Applications of Mechatronics, Analog electronic components and devices, Oscillators as signal generators, Power supplies and voltage regulators, Power Electronics- Devices, Industrial electronic circuits, Digital Electronics- Arithmetic circuits, Multiplexers/ Demultiplexers, Registers, Counters, Memories, Few examples of transducers, Signal conditioning Circuits using Operational amplifiers, Noise Problems, Grounding and shielding, Data acquisition systems,-Single channel and multichannel, Data loggers, Control Systems Components, Classification of Control Systems, Transfer functions, Time and Frequency response Analysis tools.

Reference Books:

- Allen Mottershed, “Electronic Devices and Circuits”, Prentice Hall International, Third Edition
- M. D. Singh and J. G. Joshi, “Mechatronics – Principles and Applications”, Prentice Hall India publication-EEE.

Honors – Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VI
PE(HO)-21004 Industrial Instrumentation and Control

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1/T2/Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

- An ability to identify, formulate and solve a problem of Instrumentation and Control Engineering

- An ability to design and conduct experiments for measurement and ability to analyze and interprets data.
- Demonstrate an understanding of sensors / transducers.
- Able to understand and use various types fuses, breakers etc.

Syllabus Contents:

General concepts and terminology of measurement systems, static and dynamic characteristics, errors, standards and calibration. Introduction, principle, construction and design of various active and passive transducers. Introduction to semiconductor sensors and its applications. Design of signal conditioning circuits for various Resistive, Capacitive and Inductive transducers and piezoelectric transducer. Introduction to transmitters, two wire and four wire transmitters, Smart and intelligent Transmitters. Design of transmitters. Introduction to EMC, interference coupling mechanism, basics of circuit layout and grounding, concept of interfaces, filtering and shielding. Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures – NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety.

Reference Books:

- M. Sze, “Semiconductor sensors”, John Wiley & Sons Inc., Singapore, 1994.
- Noltingk B.E., “Instrumentation Reference Book”, 2nd Edition, Butterworth Heinemann, 1995.
- L.D.Goettsche, “Maintenance of Instruments and Systems – Practical guides for measurements and control”, ISA, 1995.
- John P. Bentley, Principles of Measurement Systems, Third edition, Addison
- Wesley Longman Ltd., UK, 2000.
- Doebelin E.O, Measurement Systems - Application and Design, Fourth edition, McGraw-Hill International Edition, New York, 1992.

Honors – Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VII
Fluid Power Systems and Factory Automation

Teaching Scheme	Examination Scheme
Lectures : 3 hrs/week	100 marks: Continuous evaluation- Assignments T1/T2/Quiz- 40 Marks, End Sem Exam- 60 marks

Course Outcomes:

At the end of the course, students will be :

- Aware of the importance and the scope of hydraulics and pneumatics in the modern industry.
- Able to select and size the different components required to design a fluid power system.

- Able to select a control system to control the operation of designed fluid power system.
- Able to design and implement low-cost automation system.

Syllabus Contents:

Hydraulic Power Generators - Selection and specification of pumps, pump characteristics.
Linear and Rotary Actuators - selection, specification and characteristics.
Pressure - direction and flow control valves - relief valves, non return and safety valves - actuation systems.
Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits – press circuits - hydraulic milling machine - grinding, planning, copying, forklift, earth mover circuits - design and selection of components - safety and emergency mandrels.
Pneumatic fundamentals - control elements, position and pressure sensing
Pneumatic logic circuits - switching circuits -fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods – step counter method - compound circuit design - combination circuit design.
Pneumatic equipments - selection of components - design calculations -application - fault finding – hydro pneumatic circuits –
Use of microprocessors/microcontrollers for sequencing - PLC, Low cost automation - Robotic circuits.

Reference Books:

- Antony Esposito, "Fluid power with Applications", Prentice Hall India, 7th Edition, 2014.
- Dudleyt, A.Pease and John J.Pippenger, "Basic Fluid Power", Prentice Hall, 1987.
- Andrew Parr, "Hydraulic and Pneumatic", Jaico Publishing House, 1999.
- Bolton. W. “Pneumatic and Hydraulic Systems", Butterworth - Heinemann, 1997.
- Anthon H. Hehn, “Fluid Power Troubleshooting”, 2nd Edition, Marcel Dekker.
- S. R. Majumdar, “Pneumatic Systems: Principles and Maintenance”, Tata McGraw Hill Publishing Company Limited, 1995.

Honors- Mechatronics
Bridge Course (Mechanical/Electronics)
Semester VIII
(PCC) Mechatronics System Design

Teaching Scheme	**Examination Scheme**
Lectures : 3 hrs/week	T1/T2/ Assignments/ Quiz - 40
	End-Sem Exam- 60 marks

Course Outcomes:

- Demonstrate how Mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products that are useful in everyday life.
- Application of theoretical knowledge: understanding selection of suitable sensors

and actuators; designing electro-mechanical systems.

- Technical work: working with mechanical systems that include digital and analogue electronics as a data acquisition model.
- Students should possess theoretical knowledge and make students familiar to select suitable sensors and actuators while designing electro-mechanical systems.
- To demonstrate technical requirement while working with Mechatronics Systems.

Syllabus Contents:

- **Rotational drives** - Pneumatic Motors: continuous and limited rotation - Hydraulic Motors: continuous and limited rotation - Brushless DC Motors - Motion convertors, Fixed ratio, invariant motion profile, variators, remotely controlled couplings Hydraulic Circuits and Pneumatic Circuits.
- **Mechanical Systems and Design** - Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.
- **Real time interfacing** - Introduction Elements of data acquisition and control Overview of I/O process-Installation of I/O card and software - Installation of application software- Over framing.
- **Case studies on Data Acquisition** - Transducer calibration system for Automotive applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers.
- **Case studies on Data Acquisition and Control** - Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.
- **Case studies on design of Mechatronics products** - Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

References

- W. Bolton, Mechatronics - Electronic Control systems in Mechanical and Electrical Engineering-, 2nd Edition, Addison Wesley Longman Ltd., 1999.
- Devdas Shetty, Richard A. Kolk, Mechatronics System Design, PWS Publishing company, 1997
- Bradley, D.Dawson, N.C. Burd and A.J. Loader, Mechatronics: Electronics in Products
- and Processes, Chapman and Hall, London, 1991.
- Brian Morris, Automated Manufacturing Systems - Actuators, Controls, Sensors and Robotics, Mc Graw Hill International Edition, 1995.
- Gopal, Sensors- A comprehensive Survey Vol I & Vol VIII, BCH Publisher.