B.E. Mechanical (Production) 2016 Course Scheme (ALL YEARS) after Modifications as suggested in DAAC on October 3, 2016 and SUGC on October 18, 2016, Senate meeting 07/11/2016

SEMESTER – I (Group-A)

S. No.	Course No.	Title	L	T	P	Cr
1	UMA003	MATHEMATICS-I	3	1	0	3.5
2	UTA007	COMPUTER PROGRAMMING - I	3	0	2	4.0
3	UPH004	APPLIED PHYSICS	3	1	2	4.5
4	UEE001	ELECTRICAL ENGINEERING	3	1	2	4.5
5	UHU003	INTRODUCTION TO PROFESSIONAL ENGINEERING#	2	0	2	3.0
6	UTA008	ENGINEERING DESIGN-I	2	4	0	4.0
		Total	**16**	**7**	**8**	**23.5**

For the students of Thapar University title of this course will be written as 'Professional Communication'

SEMESTER – II (Group-A)

S. No.	Course No.	Title	L	T	P	Cr
1	UMA004	MATHEMATICS-II	3	1	0	3.5
2	UTA009	COMPUTER PROGRAMMING-II	3	0	2	4.0
3	UES009	MECHANICS*	2	1	2*	2.5
4	UEC001	ELECTRONIC ENGINEERING	3	1	2	4.5
5	UCB008	APPLIED CHEMISTRY	3	1	2	4.5
6	UTA010	ENGINEERING DESIGN-II (Catapult project) (6 Self Effort Hours)	1	0	2	5.0
		Total	**15**	**4**	**8**	**24.0**

*Each student will attend one lab session of 2 hours in a semester for a bridge project in this course (mechanics).

SEMESTER – III (Group-A)

S. No.	Course No.	Title	L	T	P	Cr
1	UMA031	OPTIMIZATION TECHNIQUES	3	1	0	3.5
2	UTA002	MANUFACTURING PROCESSES	2	0	3	3.5
3	UES010	SOLIDS AND STRUCTURES	3	1	2	4.5
4	UES011	THERMO-FLUID	3	1	2	4.5
5	UTA011	ENGINEERING DESIGN-III (Buggy projects) (6 Self Effort Hours)	1	0	4	6.0
6	UME306	MECHANICS OF MACHINES	3	1	2	4.5
		Total	**15**	**4**	**13**	**26.5**

SEMESTER – IV (Group-A)

S. No.	Course No.	Title	L	T	P	Cr
1	UMA007	NUMERICAL ANALYSIS	3	1	2	4.5
2	UES012	ENGINEERING MATERIALS	3	1	2	4.5
3	UMT802	INDUSTRIAL AUTOMATION	3	0	2	4.0
4	UEN002	ENERGY AND ENVIRONMENT	3	0	0	3.0
5	UME409	COMPUTER AIDED DESIGN & ANALYSIS (Includes 7 Self-Effort Hours)	3	0	3	8.0
6	UME504	MACHINE DESIGN	3	2	0	4.0
		Total	**18**	**4**	**9**	**28**

SEMESTER – V

S. No.	Course No.	Course Name	L	T	P	Cr
1.	UPE501	Work study and Ergonomics Engineering	3	1	0	3.5
2.	UME733	Industrial Metallurgy	3	1	0	3.5
3.	UME705	Machining Science	3	1	2	4.5
4.	UME844	Machine Tool Design	3	1	0	3.5
5.	UME407	Inspection and Quality Control	3	1	2	4.5
6.	UTA012	Innovation & Entrepreneurship (5 Self effort Hours)	1	0	2	4.5
		Total	**16**	**5**	**6**	**24**

SEMESTER – VI

S. No.	Course No.	Course Name	L	T	P	Cr
1.	UPE691	Project Semester*	--	--	--	20
					Total	**20.0**

OR (Alternate Scheme)

S. No.	Course No.	Course Name	L	T	P	Cr
1.	UPE697	Group Project	--	--	--	13
2.	UPE601	Facility Planning	3	1	0	3.5
3	UPE602	Supply Chain Management	3	1	0	3.5
		Total	**6**	**2**	**0**	**20.0**

** To be carried out in Industry/Research Institution.*

OR

UPE695: Start-up Semester
This module shall be offered as an alternative to Internship for interested students. This semester will comprise of Hands-on Workshops on innovation & entrepreneurship and a project course. Students will be encouraged to extensively use Design Lab and Venture Lab.

SEMESTER – VII

S. No.	Course No.	Course Name	L	T	P	Cr
1.	UME502	Automobile Engineering	3	0	2	4.0
2.	UPE704	Computer Aided Manufacturing	3	1	2	4.5
3.	UPE702	Metal Casting and Joining	3	1	2	4.5
4.		Elective I	3	1	0	3.5
5.	UPE893	Capstone Project (Starts) 4 self-effort hours	0	0	2	--
6.	UPE703	Metal Forming	3	1	0	3.5
7.		Elective II	3	1	2	4.5
		Total	**18**	**5**	**10**	**24.5**

SEMESTER – VIII

S. No.	Course No.	Course Name	L	T	P	Cr
1	UPE801	Micro Machining Processes	3	1	2	4.5
2.	UME836	Operations Management	3	1	0	3.5
3	UHU005	Humanities For Engineers	2	0	2	3.0
4.		Elective -III	3	1	0	3.5
5.	UME847	Rapid Prototyping	2	1	2	3.5
6	UPE893	Capstone Project (Completion) 8 self-effort hours	0	0	2	8
		Total	**13**	**4**	**8**	**26**

Elective-I

S. No.	Course No.	Course Name	L	T	P	Cr
1	UME722	System Modelling and Simulation	3	1	0	3.5
2.	UME805	Robotics Engineering	3	1	0	3.5
3	UME832	Finite Element Method	3	1	0	3.5
4	UME721	Tribology	3	1	0	3.5

Elective-II

S. No.	Course No.	Course Name	L	T	P	Cr
1	UME501	Applied Thermodynamics	3	1	2	4.5
2.	UME513	Dynamics & Vibrations	3	1	2	4.5
3	UME712	Heat Transfer	3	1	2	4.5
4	UME713	Fluid Mechanics & Machinery	3	1	2	4.5

Elective-III

S. No.	Course No.	Course Name	L	T	P	Cr
1	UPE831	Processing of Polymers and Composites	3	1	0	3.5
2.	UEC742	MEMS	3	1	0	3.5
3	UPE832	Management Information System	3	1	0	3.5
4	UPE833	Design of Experimentation and Analysis	3	1	0	3.5

Semester wise Credits

Semester	Credits
1st	23.5
2nd	24.0
3rd	26.5
4th	28.0
5th	24.0
6th	20.0
7th	24.5
8th	26.0
Total	**196.5**

UME705: MACHINING SCIENCE

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course inculcates specialized knowledge and skill in machining processes using the principles and methods of engineering analysis and design. This course also cultivates the ability to develop and optimize the conventional machining processes resulting in creation and distribution of value in engineering applications. This course also imparts knowledge about the significance of optimal process parameters used for the optimal performance of various machining processes used in manufacturing industries.

Machining with Single Point Cutting Tool: Machining parameters, geometry of chip formation, determination of velocity relationships, cutting force and power requirement in single point turning process, Merchant's circle theory, Lee and Shaffer theory, Palmer and Oxley theory, Power and energy relationships, shear angle relationships, specific cutting pressure, friction and thermal aspects of machining.

Machining with Multi-Point Cutting Tools: Determination of chip cross section in plain milling and face milling operations, specific cutting pressure, Power requirement in milling, mechanics of grinding operation, Testing of grinding wheels: Peklenik and Opitz method, Colwell method, Micheletti and Russo method, cutting action of grit, determination of maximum grit chip thickness,

Tool Wear: Tool life, factors affecting tool life, Taylor's tool life equation, Universal machinability index, factors affecting machinability, factors influencing surface quality, dimensional accuracy and material removal rate in machining, calculation of economic cutting speed, Gilberts model for economic tool life, Determination of optimal cutting speed for maximum production, Maximum profit cutting speed, Economics of multistage cutting, high efficiency zone.

Jigs and Fixtures: Elements and importance of jigs and fixtures in production, Materials used for jigs and fixtures, Steps for design, foolproofing, locating methods, redundant locators, Clamping, Cam clamping, quick action clamps, Toggle clamps, Mechanical, pneumatic , hydraulic and vacuum clamping.

Laboratory Work: Cutting angles of a single point turning tool, Machining of metallic materials; Chip reduction coefficient, Shear angle; Cutting force measurements in turning and milling operations; Effects of friction and Wear; Effects of Speed, feed and depth of cut on power consumption; Tool-Tip Temperature; Alignment Tests; Use of dynamometer, Abrasive blaster Set up, Surface finish measurement tests.

Micro Project/ Research assignments: Students will be divided in groups comprising of 4–5 students. Each group may be assigned with a separate research topic related to parametric analysis and optimization of process parameters involved in various conventional machining processes. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, gaps in the existing literature, key findings etc.

Course Learning Outcomes (CLOs):

The students will be able to:

1. analyse the machining processes using Lee and Shaffer, Palmer and Oxley, Merchant's theories of machining
2. design the conditions for the maximum tool life and factors influencing surface quality, dimensional accuracy and material removal rate in machining.
3. identify the locating and clamping devices to be used for different machining processes
4. analyse the thermal and frictional aspects of machining parameters used in manufacturing industries

Text Books

1 *Pandey, P. C. and Singh, C. K., Production Engineering Sciences, Standard Publishers, New Delhi (2004).*

2 *Ghosh, A. and Mallik, A., Manufacturing Science, East –West Press ltd, New Delhi (2010).*

3 *Bhattacharyya , A. Metal Cutting Theory and Practice, New Central Book Agency Ltd, Calcutta (2000).*

4 *Joshi, P.H., Jigs and Fixtures, Second Edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi (2004).*

Reference Books

1 *Shaw, M.C., Metal Cutting, Tata McGraw Hill, New Delhi (1997).*

2 *Venkatesh, V.C., Techniques in Metal Cutting, Prentice Hall of India, New Delhi (1997).*

3 *Juneja, B. L. and Sekhon, G. S., Metal Cutting, New Age International, New Delhi (2003).*

4 *Mehta, N. K., Machine Tools, Tata McGraw Hill, New Delhi (2002).*

5 Grant, H.E., Jigs and Fixture, Tata McGraw Hill Publishing Co. Ltd., New Delhi(2003)

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	35
3.	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UME407: INSPECTION AND QUALITY CONTROL

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course enables the students to understand the organization and procedures for industrial inspection. It helps in developing an understanding with regards to the basic concepts/ tools of quality engineering. The course helps to study the development, operational procedure, and applications of control charts to signify their role in quality control. The course enables the students to study, design and use acceptance sampling plans. The course introduces the concept of process capability analysis to gage process performance.

Industrial Inspection: The basic concepts, objectives and functions of inspection in industry, meaning and significance of quality, essential components of quality, phases or elements for building quality, evolution of the concepts of quality, spiral of progress of quality, changing scope of quality activities, quality circles, quality system economics, hidden quality costs, economic models of quality costs, quality loss function.

Statistical Process Control: Understanding the process, process data collection and presentation, process variability, process control, control chart for variables ($\overline{X}-R$, $\overline{X}-S$ charts etc.), control charts for attributes, (p, c charts etc.), acceptance sampling.

Process Capability Analysis: Need and significance, process capability for variable data, process capability indices(c_p, c_{pk}, $c_{pm\ etc.}$), interpreting the indices, use of process capability data.

Process Improvement: Quality improvement process, quality tools for process improvement viz. Pareto charts, C & E analysis, scatter diagrams etc.

Six Sigma Process Quality: Introduction, DMAIC process, role of design of experimentation, ANOVA analysis.

Engineering Metrology: Scope of engineering metrology, types of measurement methods, characteristics of a measurement system (range/span, precision/accuracy, hysteresis, dead zone, drift, sensitivity), calibration process, importance of surface texture, gauge R & R.

Research Assignments: Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic in the field of inspection and quality control. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, major findings and gaps in the existing literature. The topics may include review of latest trends in procedures for industrial inspection, special control charts for variables and attributes, designing for six sigma processes, latest research in field of acceptance sampling, engineering metrology etc.

Laboratory Work: To determine error in circularity using concentricity tester, measurement of angles, arc etc. using profile projector, use of sine table for angle measurements, use of surface roughness tester, use of mechanical, electrical, and opto-mechanical comparators, use of tool maker's microscope, use of various types of callipers and gauges.

Course Learning Outcomes (CLOs):

The students will be able to:

1. identify and analyze the functions and organization of industrial inspection.
2. apply and analyze the seven Ishikawa's tools and conduct quality cost analysis.
3. analyze various control charts for quality control of the different production processes
4. evaluate through process capability studies if a given process is proficient in meeting customer's specifications
5. apply the basic concepts involved in the working of instruments for line and angle measurements.

Text Books

1 Juran, J.M. and Gryna, F.M, Quality Planning & Analysis, McGraw Hill (2001).

2 Gupta, I. C., Engineering Metrology, Dhanpat Rai and Sons, New Delhi (2007).

Reference Books

1 Grant, E.L., Statistical Quality Control, McGraw Hill (2008).

2 Feignbaum, A.V., Total Quality Control, McGraw Hill (1991).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May include Assignments/Tutorials/Quizzes)	25

UPE501: WORK STUDY AND ERGONOMICS ENGINEERING

L	T	P	Cr
3	1	0	3.5

Course objective: This course introduces the role of Work Study in the industry and how productivity issues in the industry can be addressed by the application of Work Study, while stimulating critical thinking on the techniques of Method Study and Work Measurement. The course also introduces the concept of conducting time studies and production studies to assess time standards and production standards for fulfilling production goals in an organization. The course further introduces the scope of ergonomics and the application of ergonomic principles to workplace design and work organisation and culminates with the concept of evaluating the impact of various human factors to design of safe workplace environment.

Introduction: Definition, Scope, Historical review and areas of application of work study in industries, Inter-relation between method study and work measurement, Reaction of management and labor, Role in improving plant productivity.

Method Study: Objectives and step-wise procedure for method analysis, Recording & evaluation techniques, Micro-motion and macro motion study, Therbligs and simo-charts, Principle of motion economy, Normal work areas and design of work places, Principles of work design, Multiple activity chart, Flow process chart, String diagram, Travel charts.

Work Measurement: Work measurement objectives, Techniques & criteria for selection of technique, Stop watch time study, Systems of performance ratings, Calculation of standard time, Introduction to allowances, Production study, Work sampling, Standard data usage, Engineered time standard, Predetermined motion time system (PMTS).

Ergonomics Engineering

Anthropometry: Significance of human body measurement in design of equipment, Facilities, Work place and operation, Static and dynamic anthropometry, Anthropometric data.

Task Analysis: Task description, Posture measurement, RULA & REBA analysis and evaluation, Lifting & lowering tasks, Lifting index, Lifting & carrying tasks, NIOSH lifting equation.

Biomechanics: Introduction to levers of Human Body, Ligaments & Tendons, Joints. Kinetics to include forces producing motion

Research Assignment:

- Conduct an ergonomic study of jobs with varying degrees of risk and difficulty
- Use tools of method study to critically examine existing methods of working in job and suggest improvements

Course Learning Outcomes (CLOs):

The students will be able to:

1. develop a case for productivity improvement in any manufacturing or service industry scenario
2. independently conduct a method study in any organization with the objective of improving a process, material movement system or design of a work place
3. develop time standards for operations, identify production bottlenecks and improvise operations

4. apply principles of good ergonomic design of work areas and equipment
5. identify, explain and evaluate the impact of various personal attributes (anatomical, physiological and anthropometric) on proper safe working practice

Text Books:

1. *Niebel, B.W., Motion & Time Study, 9th Edition McGraw Hill Higher education (1992).*
2. *Kanawaty, G., Work Study, ILO, Geneva,4th revised edition (1992).*
3. *Barnes, R. M., Motion & Time Study, 7th edition, John Wiley & Sons (1980).*
4. *Bridger, R.S., Introduction to Ergonomics, McGraw Hill (2008).*
5. *Halender, M., A guide to Human Factors and Ergonomics. Taylor & Francis, Second Edition, 2006*

Reference Books:

1. *Mundel, M., and Danner, D. L., Motion & Time Study, 7th Edition, Englewood Cliffs, NJ, Prentice Hall, (1994)*
2. *Curie, R., Introduction to Work Study, McGraw Hill (1992).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UPE697: GROUP PROJECT

L	T	P	Cr
-	-	-	13

Course Objectives: To develop design skills according to a Conceive-Design-Implement-Operate (CDIO) compliant methodology. To implement engineering skill and knowledge to complete the identified project work while encouraging creativity and innovation. To develop spirit of team work, communication skills through group-based activity and foster self-directing learning and critical evaluation.

Scope of work:

For this course groups of the students shall be formulated with one student acting as group leader and students shall be encouraged for self-learning. During this project work students are expected to identify the problem of their choice through interactions with industry, R&D labs and other reputed institutions. Subsequently, each group shall make presentation of their effort of problem formulation in fourth-fifth week of the semester followed by completion of project work. Apart from this each group shall be making periodic presentation during semester for continuous evaluation and monitoring.

At the end of this project each group shall be required to submit a detailed technical report, daily diary and presentations related to the project undertaken.

Course Learning Outcomes (CLOs):

The students will be able to:

1. identify a problem based on the need analysis of community /industry/ research.
2. create a flowchart of methodology for solving the identified problem
3. demonstrate team work with work division, team meetings and communications among team members.
4. write technical report for the project work and present the same through power point presentations or posters.

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	Regular Evaluations	30
2.	Final Evaluation- Presentation and Report, Daily diary	70

UPE601: FACILITIES PLANNING

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course introduces the concept of facility planning, its need and importance in the industry, factors affecting facility location decision, plant design, concept of line balancing, and material handling systems.

Facilities Planning: Need for facilities planning, Importance of plant layout in plant design, classifications of production process structures, types of layout, Characteristic features, suitability and applications of different types of layout.

Plant Location: Factors affecting plant location, optimum decision on choice of plant location, quantitative techniques for making plant location decision

Planning Design And Presentation: Principles of plant layout design, Procedure for plant layout design, evaluate alternative layouts, installation of layout, Quantitative techniques for developing alternative layouts, Design of process and product layouts, line balancing techniques.

Material Handling: Principles of material handling, classification of material handling systems, characteristic features of key material handling equipment, concept of unit load, introduction, guidance methods, applications.

Research Assignments: Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic in the field of facility planning. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, major findings and gaps in the existing literature. The topics may include finding out suitable location for a facility, designing/ re-designing of an existing layout.

Course Learning Outcomes (CLOs):

The students will be able to:

1. upon completion of this module, students will be able to:
2. analyse an existing facility in context to its location and design.
3. develop a new plant layout or to improve an existing layout.
4. design/ re-design proposed a new material handling system.

Text Books

1. *Tompkins, J. A., White, J. A., Bozer, Y.A. and Tanchoco, J.M.A., Facilities Planning, John Wiley (2003) 3rd ed.*

2. *Facilities Planning and materials Handling, Sheth, V., Marcel Decker, 1995*

Reference Books

1. Muther, R., Practical Plant Layout, McGraw Hill Book Company (1995).

2. *Agrawal G. K., Plant layout and Material Handling, Khanna Publishers (2003).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessional (May include Assignments/Tutorials/Quizzes)	25

UPE602: SUPPLY CHAIN MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course objectives: This course educates students about the concepts of and the role supply chain management by developing an understanding about markets, logistics, drivers of supply chain and matching supply and demand through planning, forecasting and replenishment.. The course further develops basic knowledge about competitive performance, network design, planning for inventories in supply chain and opportunities for growth. The course culminates with the introduction of concepts regarding synchronization and risk management in the supply chain.

Introduction: Understanding the Supply Chain, Process view, Decision phases and importance of supply chain, Supply chain management and logistics, Supply chain and the value chain, Competitive advantage, Supply chain and competitive performance, Changing competitive environment, Supply Chain drivers and obstacle

Matching supply and demand The lead-time gap, Improving the visibility of demand, supply chain fulcrum, Forecast for capacity, execute against demand, Demand management and aggregate planning, Collaborative planning, Forecasting and replenishment.

Creating the responsive supply chain Product 'push' versus demand 'pull' The Japanese philosophy, Foundations of agility, Route map to responsiveness.

Strategic lead-time management: Time-based competition, Lead-time concepts, Logistics pipeline management.

Planning and managing inventories in a supply chain: Managing economies of scale in supply chain cycle inventory, Managing uncertainty in supply chain, Determining optimal level of product availability.

Transportation, Network Design and Information Technology in a supply chain: Transportation, Facility design network design in a supply chain, Extended enterprise and the virtual supply chain,Role of information and information technology in the supply chain, Laying the foundations for synchronization, 'Quick response' logistics, Production strategies for quick response, Logistics systems dynamics.

Managing risk in the supply chain: Vulnerability in supply chains, Understanding the supply chain risk profile, Managing supply chain risk.

Research Assignment:

- Use a case study related to assessing cost imperatives of reverse logistics in a battery manufacturing unit
- An assessment of supply chain drivers

Course Learning Outcomes (CLOs):

The student will be able to:

1. explore opportunities for cost reduction through Supply Chain efficiency,
2. assess demand versus supply and use it for aggregate planning
3. optimize product availability to improve revenue streams

4. assess performance of a supply chain – up stream as well as down stream
5. assess vulnerability in supply chains

Text Books:

1. *Chopra, S. and Meindl, PSupply Chain Management, , Prentice Hall, .(2010) 4th Edition*
2. *Christopher, M. Logistics & Supply Chain Management, , FT Prentice Hall, (2011) 4th Edition,*

Reference Books:

1. Michael H. Hugos, M. H, Essentials of Supply Chain Management, John Wiley.(2011) 3rd Edition

2. Simchi-Levi, D.,Kaminsky, P., Simchi-Levi, E Designing and Managing the Supply Chain McGraw Hill Higher Education.(2011)

3. John T. Mentzer, J. T. Supply Chain Management, illustrated edition, SAGE Publications. (2001),

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UPE704: COMPUTER AIDED MANUFACTURING

L	T	P	Cr
3	1	2	4.5

Course Objectives: To introduce the students to the standard terminologies, conventions, processes, design and operational characteristics of key hardware components, programming techniques and applications of modern multi-axis computer numerical control (CNC) machining centers. To expose the students to automatic computer assisted CNC tool path programming and virtual simulation of toolpath data for CNC milling and turning centres using modern professional software.

Introduction: fundamental concepts in computer numeric control (CNC):types, definition and designation of control axes, special constructional and design characteristics of CNC machine tools, standard tooling for CNC turning and milling centres, types and functions of CNC systems, advantages of CNC technology compared to conventional manufacturing, types and functions DNC (direct numeric control), advantages of combined CNC/DNC systems.
CNC part programming: Work holding and tool setting procedures for CNC turning and milling centres, tool zero pre-setting, tool length and radius compensation, manual part programming including use of standard canned cycles for CNC turning and milling centres, introduction to automatic part programming using standard CAM software.
Computer numerical control elements: introduction to sensors, drives and feedback devices used in CNC systems, control loop circuit elements in point to point (PTP) and contouring system, interpolation schemes for linear and circular interpolations, types and functions adaptive control systems.
Introduction to advanced CNC machining systems: Advantages of3-1/2-1/2 axis, 4-axis and 5-axis CNC machining systems, types of 5-axis machining centres, advanced CNC controllers and their special features for multi-axis machining, fundamentals of automatic tool path planning for multi-axis CNC machining systems, introduction to group technology, introduction to automated quality control in manufacturing, automated material transfer, handling, storage and identification systems: AGVs, ASRS, carousel, and RFID technologies.

Micro Project:

Students in a group of 5/6 will carry out micro project/ a research assignment on the following topics:

- Automatic/ manual generation of tool path data for machining of a part shape in milling or turning centre using standard canned cycles. Each student group will submit a report on the procedure followed for executing the given assignment along with the part machined on specified CNC machining centre.
- A short report on design criteria to be used for selection of a critical CNC machine component or development of a computer program for CNC interpolation algorithms, need and design of special control features in CNC controller, or design of CNC tool path algorithms in consultation with the course instructor. The evaluation of this assignment will be on the basis of understanding of students group about the state of the art in the area of CAM particularly related to areas like CNC machining processes, CNC control systems or the advancement in the design of CNC machine tools, literature survey, and design

methodology used, if any.

(10% weightage of total marks shall be given to this assignment).

Laboratory Work

Exercises in tool pre-setting, workpiece referencing and manual part programming for machining of simple parts on CNC turning and milling centres, use of CAM software for simulation of turning and millingtoolpath data for simple parts, automatic cutter location data generation from CAD models and post-processing for machining on CNC machines using standard CAD-CAM software, and use of CMM for automatic quality control.

Course Learning Outcomes (CLOs):

The students will be able to:

1. create plan for automatic machining of a given part on a multi-axis CNC machining centerincluding selection of machining parameters, cutting tools, process sequence and controller settings for tool presets.
2. create and validate a CNC part program data using manual data input (MDI) for automatic machining of a given parts/ surface using a2-axis turning center or 3-axis vertical milling center.
3. create and validate a CNC part program data using a commercial CAM package for automatic machining of precision parts or part surface for a multi-axis CNC machining centre.
4. produce an industrial component from given 3D part model/ 2D part drawings using CNC machining centers through programming, setup, and ensuring safe operation of automatic machine tools.

Recommended Books:

1. *Koren, Y., Computer Control of Manufacturing systems, McGraw Hill (2009).*
2. *Suh Suk-Hwan, Kang Seong-Kyoon, Chung Dae-Hyuk, Stroud Ian., Theory and Design of CNC Systems, 2008, Springer-Verlag London Limited*
3. *Smith Peter, CNC programming handbook, 2nd edition, 2003, Industrial Press Inc.*
4. *Groover, M. P. and Zimmers, E. W., CAD/CAM:Computer Aided Design & Manufacturing, 2006, Pearson Education India*
5. *Hood-Daniel P., and Kelly J.F., Build Your Own CNC Machine, 2009, Springer-Verlag New York*
6. *Manuals of CAD/CAM Software Package on CAM Module and CNC Machines.*

Evaluation Scheme:

S. No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessional (Including assignments/ Minor Projects/ Quizes etc.)	35

UPE703: METAL FORMING

L	T	P	Cr
3	1	0	3.5

Course Objectives: This course imparts knowledge and principles for deciding yielding criteria during forming of metals, analysis of different bulk metal forming processes using different analysis approach. The course also helps to analyze and understand the process mechanics during different metal forming processes and reflects the importance of various controlling process parameters in determining force, power requirements etc.

Fundamentals of Metal Forming: Description of stress-strain behavior, Principal quantities, Mohrs Circle, Elastic vs. Plastic deformation, Strain hardening, Hot, Cold and Warm working of metals, strain rate characteristics of materials, Concept of yield surface/function, Different theories of yielding: von-Mises and Tresca yield criteria, Concept of formability, forming limit diagram, metal forming analysis through ideal work, Slip line field, Upper bound and Slab Method

Metal Forming Processes: Bulk forming Vs. Sheet metal forming, Classification of metal forming processes: Rolling, Forging, Extrusion, Drawing and Sheet metal operation.

Sheet Metal Working Processes: Bendability, determination of work load and spring back, Shearing of sheet metals, die and punch design for different shearing operations

Rolling: Rolling principle, Rolling Mills, process parameters, pressure distribution and roll separating force, rolling pressure, driving torque and power requirements, Rolling defects

Forging: Forging operation, Forging types, Determination of forces in disc forging considering sticking and slipping, Forging defects.

Extrusion: Principle of extrusion, Hot extrusion and Cold extrusion, Analysis of direct cold extrusion process through conical dies

Drawing: Principle of drawing, Drawing stresses, Limiting draw ratio, Factors affecting drawability, Determination of force and power in wire drawing, Determination of maximum allowable reduction

Research Assignment:
Assignment containing the analysis for any bulk or sheet metal forming process to obtain the variations of force, torque, power etc. with process parameters. Student should submit individual report with derivations of equations and results of parametric analysis.

Course Learning Outcomes (CLOs):

The student will be able to:

1. decide yielding of a material according to different yield theory for a given state of stress.

2. analyze the different bulk metal forming process mechanics using different analysis approach and calculate the force, power requirements etc.
3. calculate the die and punch sizes for different sheet metal operations and to calculate the required load for the process.
4. evaluate the effect of process parameters on the process mechanics during bulk metal forming.

Text Books

1 Reddy, N.V. and Lal, G.K., Theory of Plasticity, Narosa Publication, New Delhi (2009).

2 Avitzur, B., Metal Forming Analysis, McGraw Hill, New York (1968).

Reference Books

1. R.H. Wagoner and J. L. Chenot, Metal Forming Analysis, Cambridge University Press, 2001.

2 Dixit, P.M. and Dixit, U.S., Modeling of Metal Forming and Machining Processes, Springer-Verlag, London (2008).

3. Ghosh, A. and Malik, A. K., Manufacturing Science, Affiliated East-West Press, New Delhi (1985).

4. Bruno, E. L., High Velocity Forming of Metals, ASTME, New York (1970).

5. Johnson, W and Millore, P.B., Plasticity for Mechanical Engineers, Van Nostrand, London (1962).

6. Narayansamy, R., Metal Forming Technology, Ahuja Book Publishers, New Delhi (1995).

7. Rowe, J. W., An Introduction to the Principles of Industrial Metal Working, Edward Arnold, London (1968).

Evaluation Scheme:

Sr. No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UPE702: METAL CASTING AND JOINING

L	T	P	Cr
3	1	2	4.5

Course Objectives: To inculcate the principle, thermal and metallurgical aspects during solidification of metal and alloys. To impart knowledge about principles/methods of casting with detail design of gating/riser system needed for casting, defects in cast objects and requirements for achieving sound casting. To impart knowledge about welding behavior of machine and process during welding, analysis of common and newer welding techniques and metallurgical and weldability aspects of different common engineering materials.

Introduction: Casting technology& problems, Survey and scope, Interfacial Heat Transfer, Thermodynamics & metallurgical aspects in solidification of pure metals and alloys, Solidification of actual castings, Homogeneous and heterogeneous nucleation, Fluidity of metals

Moulds Design: Risering curves, Caine method, Feeding distance, Gating systems and their characteristics. Type of gates, Aspiration of gases,Chills, Pattern design consideration, Sand testing, Advanced metal casting processes, Casting defects, Their causes &redressal,

Metal Joining: Classification of welding processes – Welding power source, Arc and arc characteristics, Behavior of arc with variation in current and voltage, Welding electrodes, Electrode coating,Arc efficiency, temperature distribution in the arc; Arc forces, Modes of metal transfer, Newer welding process- such as plasma arc, Laser beam,

Welding Metallurgy: Heat flow is welding metallurgical transformation, Implication of cooling rate, HAZ, Weldability of plain carbon steels, SS, CI, Al, Residual stresses and distorting, Welding defects, Testing-destructive and NDT.

Laboratory Work: Joint preparation through various welding processes like Gas Metal Arc Welding, Gas Tungsten Arc Welding, Submerged Arc welding, Shielded Metal Arc Welding, Defect analysis through various non destructive testing, Resistance Spot Welding, Green Sand Casting, Core Making, Sand Casting, Defects Analysis.

Micro Project and Research Assignment: Students will be divided in groups comprising of 4–5 students. Each group will be assigned with a separate research topic related to parametric analysis and optimization of process parameters involved in various non-conventional casting and joining processes. Students will be required to go through the topics from sources like reference books, journals etc. in the relevant field. Each group will be required to submit a report (and presentation) containing review of literature, summary, gaps in the existing literature, key findings etc.

Course Learning Outcomes (CLOs):

The student will be able to:

1. analyze the thermal aspects during solidification in casting and their role on quality of cast
2. design the gating and riser system needed for casting and requirements to achieve

defect free casting.

3. analyze the welding process behavior of common and newer welding techniques
4. analyze the requirements to achieve a sound welded joint of engineering materials.

Text Books

1. *Ramana Rao, T. V., Metal Casting – Principles and Practice, New Age International Pvt. Ltd. (2003).*
2. *Rao, P. N., Manufacturing Technology, McGraw Hill (2008).*

Reference Books

1. *Campbell, J., Castings, Butter Worth – Heinemann Publishers (2003).*
2. *Nadkari, S. V., Modern Arc Welding Technology, Oxford & India Book House Pvt. Ltd. (2005) 2nd ed.*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	25
2.	EST	40
3.	Sessionals (May include Assignments/Projects/Quizes/Lab Evaluations)	35

UPE893: CAPSTONE PROJECT

	L	T	P	Cr
UPE893: Semester VII Part-I (Starts)	**0**	**0**	**2**	**----**
UPE893: Semester VIII Part-II (Completion)	**0**	**0**	**2**	**8.0**

Course Objectives: A design project based course to implement integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters. Design a mechanical system from component level to assembly using CAD and CAE tools individually or in a team and generate a design project report with production drawings using drawing standards, symbols, conventions and rules. Plan the production of a mechanical system given the detailed drawings. Schedule and execute a production plan for the components and assemble the working prototype of the mechanical system. Analyse the prototype manufactured for improvement in design, manufacturing and function.

Scope of work:

Capstone project shall be comprising of two parts. Part-I is focused on an integrated approach to the design of mechanical systems using concepts of mechanical design, thermal and manufacturing courses studied in the previous semesters wherein mechanical systems are to be designed satisfying requirements like reliability, fatigue loading, optimized design, manufacturability, assembly, installation, maintenance, transportation-to-site, economic, environmental, social, political, ethical, health and safety and sustainability considerations. Part-I builds around use of a system design approach by incorporating learnings from various courses already studied by the students and the use of relevant design codes and standards (ASTM or equivalent) and software tools specific to the selected project.

Each student group led by a team leader will develop a system design project involving need analysis, problem definition, analysis, synthesis, optimization. assembly and detailed production drawings will be prepared for the presentation of the design along with a printed report, powerpoint/ poster presentation and soft copy submission of CAD and CAE work for final evaluation by a committee. CAE software like Pro Engineer, Pro Mechanica, Solidworks, ANSYS along with a spread sheet may be used for the design modeling, synthesis, optimization, analysis and preparing production drawings.

Part-I shall be evaluated for 30% of the marks in the VII semester and marks shall be carried forward to the next semester.

Design details evolved in Capstone Project Part-I will be used for the manufacture of prototype in Part-II of Capstone project work. Use of conventional / unconventional manufacturing processes along with CAM and RP technologies may be made for the fabrication of the physical prototype. The final manufacturing and working of the system will be required to be analysed.

Capstone project-II shall be evaluated for 70% of the marks which shall essentially consist of powerpoint / poster presentation and submission of a group project report. The report must contain the project planning, work distribution and contribution of group members, detailed design procedures and use of standards like IS, ASTM or other industry equivalent standards in design, production planning, scheduling, details of manufacturing / fabrication work and analysis of the working of the final product, reflection on the design experience, learning in different stages of work as a team and references. The course concludes with a final showcase using poster/ presentation along with comprehensive viva.

Course Learning Outcomes (CLOs):

The students will be able to:

1. design a mechanical system implementing an integrated system design approach applying knowledge accrued in various professional courses.
2. work in a design team lead by a team leader and demonstrate team work.
3. design, analyze and optimize the design of a mechanical system considering various requirements like reliability, fatigue loading, optimized design, manufacturing, assembly, installation, maintenance, cost and transportation-to-site aspects, use of design standards, industry standards.
4. create production drawings for mechanical components and systems using manual drafting and CAD tools following relevant standards and conventions.
5. read production drawings for mechanical components and systems and plan a production based on it.
6. use suitable manufacturing and fabrication processes for manufacturing a prototype.
7. assemble a mechanical system after manufacturing its components and analyze its working.

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	Semester VII Problem definition, Regular evaluation.	15
2.	Semester VII Final Design Detailing.	15
3.	Semester VIII Regular evaluation	10
4.	Semester VIII Final Evaluation showcase, project website and Report	60

UPE801: MICRO MACHINING PROCESSES

L	T	P	Cr
3	1	2	4.5

Course Objectives: This course imparts the knowledge in terms of principle/ methodology used for various micromachining processes used in manufacturing industries. This course also cultivates the ability to develop and optimize the micro machining processes resulting in creation and distribution of value in engineering applications. This course also imparts the knowledge in terms of significance and selection of controlling process parameters used for the optimal performance of various engineering materials.

Introduction to Micromachining: Historical background, classification, Need and applications of Micromachining in engineering industries.

Traditional Micromachining Processes: Diamond Turning, Micro- milling, Micro-grinding.

Mechanical Advanced Micromachining And Nano-finishing Processes: Abrasive Jet Micromachining, Ultrasonic Micromachining, Abrasive Water Jet Machining, Abrasive Flow nanofinishing.

Thermoelectric Advanced Micromachining Processes: Electric Discharge Micromachining, Electric Discharge Grinding, Wire Electric Discharge Micromachining, Laser Beam Micromachining, Electron Beam Micromachining, Microwave processing of materials

Electrochemical and Chemical Micromachining Processes: Electrochemical Micromachining, Electrochemical Micro Grinding, Electrostream Microdrilling, Electrochemical Microdeburring, Chemical Micromachining (ChMM).

Integrated-circuits based microfabrication technology: Surface micromachining, Bulk micromachining

Laboratory Work:

Experimental determination of material removal rate, tool wear rate, Surface finish of the machined surfaces for the Ultrasonic, Electric discharge, Laser beam machining processes, Determination of impact strength of shot blasted surfaces, Use of dynamometer

Micro Project:

Students in a group of 4/5 will carry out micro project on any one of the following topic: improvement in material removal rate and achieving better surface finish in non-conventional machining processes; fabrication of micro components or features such as micro holes, microchannels etc. The topics may include review of traditional micromachining techniques, Micro USM, Micro EDM, and Micro ECM.

Course Learning Outcomes (CLOs):

The students will be able to:

1. model the material removal and tool wear rate in various micro machining processes

2. analyze the processes and evaluate the role of each process parameter during micro machining of various advanced materials.
3. design the requirements to achieve best quality of machined surface while micro machining of various industrial engineering materials.

Text Books:

1. *Jain V. K. , Introduction to Micromachining, Narosa Publishers, New Delhi (2014)*
2. *Jackson M. J., Micro and Nanomanufacturing, CRC Press, Taylor and Francis (2006).*
3. *Ghosh, A. and Mullick, S., Manufacturing Science, New Age International (2001).*
4. *Pandey, P.C. and Shan H.S., Modern Machining Processes, McGraw Hill (2004).*

Reference Books:

1. *Mishra, P.K., Non Conventional Machining, Narosa (2006).*
2. *Hofy, H.E., Advanced Manufacturing Process, B and H Publication (1998).*
3. *Micromachining of Engineering Materials J.A. McGeough. CRC Press.*
4. *Bhattacharya, A., New Technology, Institution of Engineers (I) (1995).*
5. *Jain, S.K. andSchmid, S.R., Manufacturing Engg. & Technology, Addison Wesley(2000).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	25
2	EST	35
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	40

UME836: OPERATIONS MANAGEMENT

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective of this course is to develop understanding of the strategic role of operations management in creating and enhancing a firm's competitive advantages. This will help to apply key concepts and issues of operations management in both manufacturing and service organizations by enabling the students to apply analytical skills and problem-solving tools for the analysis of the operations problems like forecast demand, material requirement planning, inventory etc.

General: Operations Management: meaning and scope; significance of operations management in increasing productivity of firms; soft variety and hard variety; categories of production systems and layouts.

Forecasting Analysis: Need and benefits, various qualitative and quantitative models, error analysis in quantitative forecasting.

Production Planning: Aggregate production planning, pure and mixed aggregate planning strategies; Master production scheduling; material requirements planning and manufacturing resource planning (MRP I and MRP II); Supply Chain Management.

Inventory Management and Control:Need and types inventory, methods of handling inventory uncertainties, methods of inventory control systems, perpetual (fixed order-quantity) system, periodic (fixed order-interval) system, economic run length

Course Learning Outcomes (CLOs):

The student will be able to:

1. analyze the fundamental theory of operations and production management
2. analyze forecasting problems or issues faced by service and manufacturing industries
3. solve problems on materials requirement planning, aggregate production planning
4. analyze inventory management problems

Text Books

1 Monks, J. G., Operations Management: Theory and Problems, McGraw Hill, New York (1987).

2 Krajewski, L. J., Ritzman, L. P. and Malhotra, M. K., Operations Management, Prentice Hall, New Delhi (2009).

Reference Books

1 Ebert and Adams, Production/Operations Management, Prentice Hall of India, New Delhi (2007).

2 Chase, R. B., Aquilano, N. J. and Jacob, F. R., Production and Operations Management: manufacturing and services, Tata McGraw Hill, New Delhi (1999).

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
4.	MST	30
5.	EST	45
6.	Sessionals (may include Assignments/Projects/Quizes/Seminar presentation)	25

UPE832: MANAGEMENT INFORMATION SYSTEMS

L	T	P	Cr
3	1	0	3.5

Course objectives: This course introduces the basic concepts of data, information, systems and management, facilitating students to understand the working of theinformation systems used in industry and in service sector. The course enables the students to identify inadequacies in the work systems, analyze problems, and design information systems related to business processes both in the manufacturing and service industry. The course culminates with inculcating the concepts regarding the implementation of information systems and post implementation management of information systems.

Introduction: Introduction to computer-based information systems, philosophies governing information systems, role of computer-based information systems in organizations, work centered analysis of information systems, computer-based information system taxonomies, characteristics of information systems, process of Information System Planning, Strategic Alignment of Business and IT, Information System Architecture

System Analysis & Design: Principle-based Systems Analysis Method, Measuring Work System Performance, Process Modelling, tools for process modelling Process Characteristics, Evaluating Business Process Performance, Communication and Decision-Making Concepts, Data Modelling and database management**,** Phases of an Information System, Alternative Approaches for Building Information Systems, Information system implementation and post implementation issues

Research Assignment:

- Analysis of existing information systems using process modeling tools
- Design modules of information systems

Course Learning Outcomes (CLOs):

The student will be able to:

1. explore opportunities to critically analyse existing information systems to assess scope of improvement
2. use process modeling tools for the analysis and design of business processes with regards to information systems
3. develop plans for information system development
4. design information systems structure to improve business process effectiveness and efficiency.
5. integrate business processes through the use of data information systems and improve functional integration in organizations

Text Books:

1. *.Alter, S., Information Systems: Foundation of E-Business,4th edition, Pearson Education, New Delhi (2002).*
2 *.Laudon, K. and Laudon, J., Management Information Systems, 12th edition, Pearson*

Education, New Delhi (2013).

Reference Books:

1. *.Brien,O., Management Information Systems, Galgotia Publishers, New Delhi (2010).*
2. *Yourdon, E., Structured Analysis, Yourdon Press, New York (1988).*
3. *Gupta, U. G., Management Information Systems: A Managerial Perspective, Galgotia Publishers, New Delhi (1996).*
4. *Davis, G and Olson, M.H., Management Information Systems, McGraw Hill, International, New York (1984).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UPE833: DESIGN OF EXPERIMENTS AND ANALYSIS

L	T	P	Cr
3	1	0	3.5

Course Objectives: The objective of this course is to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. The course also offers the knowledge and concepts for experimental design, design for experimentation and statistical based analysis of the experimental data for different industrial and manufacturing processes, process development, and manufacturing process improvement.

Design of Experiments: Overview and basic concepts of Design of Experiments, blocking, randomization, replication, and interaction; Full factorial design, 2-level full and fractional factorial design, 3-level fractional factorial design, mixed level designs, central composite method, Box-Behnken and other designs, complete and incomplete block designs; Special designs: dummy treatment, nested designs, repeated measures. Practical aspects of planning experiments.

Statistical Analysis: Introduction to statistics, sampling distributions, confidence intervals, introduction to the analysis of variance (ANOVA) for individual factor, study of interaction effect, one way, two way, three way and multiple ANOVA, residuals and model adequacy checking, ANOVA for data obtained from special design, ANOVA of attribute data, Signal-to-Noise ratio analysis, Optimal design.Simple linear regression, non-linear regression analysis, response surface methodology of analysis.

Research Assignment:
Students will require to design a proper experimental plan for different kinds of situations related to different manufacturing processes, collect experimental data and follow statistical approach of analysis, draw conclusions and suggest optimum parametric settings. Students may refer recent journal publications for this purpose. Student should submit report individually.

Course Learning Outcomes (CLOs):

The student will be able to:

1. plan experimental design leading to reduced development lead time for new processes and products, improved manufacturing process performance and products,
2. design special experimental design based on suitability and need,
3. analyze the experimental data to obtain the influence of factors and their interactions through statistical analysis,
4. decide the parametric combinations that leads to optimized solution for better process control.

Text Books

1 *Montgomery, D. C., Design and Analysis of Experiments, Wiley, NY (2012).*
2 *Ross, P. J., Taguchi Techniques for Quality Engineering, Tata McGraw Hill, New Delhi (1995).*

Reference Books

1 *Antony,J., Design of Experiments for Engineers and Scientists, Butterworth-Heinemann, UK (2003).*
2 *Panneerselvam, R., Design and Analysis of Experiments, PHI, New Delhi (2010).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1.	MST	30
2	EST	45
3	Sessionals (May include Assignments/Projects/Tutorials/Quizes/Lab Evaluations)	25

UPE831: PROCESSING OF POLYMERS AND COMPOSITES

L	T	P	Cr
3	1	0	3.5

Course objective: To impart knowledge of the basic nature of different polymers and manufacturing processes associated thereof. Tailoring properties in composites as required for specific applications.To introduce attendants to the principles of the processing and concept of the deformation behaviour of plastics. To provide an outline account for all major processing routes, thermoplastics, as well as thermoset and rubbers.

Properties and processing of polymers: Structure and mechanical properties of plastics: thermoplastics and thermosets, their properties and applications, processing the polymers considering crosslinking and curing, influence of time, temperature, and mass, shelf life and pot life, stoichiometric considerations. additives in polymers: dispersion aids, UV stabilizers, antioxidants and antiozonents, processing/flow modifiers, different fillers.
Extrusion using single and twin screw extruders, injection moulding, thermoforming, compression moulding, transfer moulding, general behavior of polymer melts, machining of polymers, processing of rubbers, testing of polymers, Recycling of plastics.

Properties and processing of composites: Classification of composite materials, properties of composites, processing methods of polymeric matrix composites: Hand lay-up, autoclaving, filament winding, pultrusion, compression molding, pre-pegging, sheet molding compounds etc.,
Secondary processing of composite materials, need of secondary operations, different type of secondary operations, machining, drilling, joining of composites. welding of polymers using thermal, ultrasonic and laser bonding, destructive and non-destructive inspection and evaluation, characterization of composites using microscopy : Scanning electron microscopy and transmission electron microscopy, review of simulation technologies for composite design, manufacturing and performance, applications of polymer composites in automotive, marine and aerospace

Research Assignment: Students in a group of 4/5 will do term projects with help of critically reviewing some technical research papers on the recent technology developments and industrial applications as well as challenges for processing of polymers and composites.

Course Learning Outcomes (CLOs):

The student will be able to:

1. analyze the behavior of polymers, their properties to select suitability for engineering applications.
2. know the behavior during processing of polymers.
3. gain knowledge on the properties and industrial applications of the polymers.
4. gain practical knowledge of the structure-property relationships to improve properties of polymers and the manufacturing the products with alternative technology.
5. derive and calculate stress, strain and modulus for a given problem of unidirectional composite.

Text Books:

1. *Strong, A.B., Plastic Materials and Processing, Prentice Hall, New Delhi (1999)*
2. *Middleman, S., Fundamentals of Polymer Processing, Houghton Mifflin Company, UK(1997)*

Reference Books:

1. *Chawala, K.K., Composite materials, Springer-Verlag, New York (1987)*
2. *Tadmor, Z. and Gogos, C.G., Principles of Polymer Processing, John Wiley, US (2006).*

Evaluation Scheme:

S.No.	Evaluation Elements	Weightage (%)
1	MST	30
2.	EST	45
3.	Sessionals (May include Research Assignments/Projects/Tutorials/Quizes)	25