Academic Document for the Programme M Tech in Manufacturing Technologies and Engineering Management

Program Code – 121

Batch – 2022 - 2024

RAMAIAH UNIVERSITY OF APPLIED SCIENCES

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M.S. Ramaiah University of Applied Sciences
Bangalore - 560 054

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Faculty of Engineering and Technology
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Faculty	Engineering and Technology
Department	Mechanical and Manufacturing Engineering
Name of the Programme	M Tech in Manufacturing Technologies and Engineering Management
Programme Code	121
Mode of Study	Full Time
Date of Commencement of the Programme	August 2022
Date of Programme Approval by the Academic Council of MSRUAS	June 2019

1. Programme Objective

The programme integrates the salient features of two disciplines namely, manufacturing technologies and engineering management. The programme aims to prepare the students to solve operational problems in manufacturing and service industries. The students are exposed to various simulation tools to further strengthen their knowledge and skills in the respective domains of chosen specialization.

2. Programme Outcomes (POs) / Graduate Attributes

PO 1. Resolve manufacturing issues after considering strategic and financial implications
PO 2. Select the appropriate materials and manufacturing processes for efficient and effective manufacturing
PO 3. Optimize the manufacturing operations by applying advanced concepts of manufacturing technologies and engineering management in a shop-floor
PO 4. Analyze and suggest suitable manufacturing technologies for the relevant functional applications
PO 5. Develop manufacturing and automation strategies for efficient operations
PO 6. Design robust manufacturing systems for achieving excellence
PO 7. Practice team work, effective communication of ideas and lifelong learning

3. Programme Specific Outcomes (PSOs)

The programme specific outcomes are listed under four headings:

1. Knowledge and Understanding
2. Cognitive skills
3. Practical skills and
4. Capability/Transferable skills

Knowledge and Understanding: After undergoing this programme, a student will be able to:

PSO1: Explain principles of project management, manufacturing management, materials and process selections
PSO2: Explain the impact of operational strategies and process specifications on the overall goals of the organization
PSO3: Discuss the significance of modelling and simulation for manufacturing processes
PSO4: Discuss manufacturing technologies and competitive manufacturing management concepts

Cognitive Skills: After undergoing this programme, a student will be able to:

PSO5: Analyse and improve the operational performance of an organization through analytical modelling and simulations
PSO6: Analyze the suitability of the appropriate manufacturing technologies for enhancing organizational competitiveness
PSO7: Analyse process parameters and their effect on resultant component features and production

rate

PSO8: Examine the projects and manufacturing operations with a systems approach and analyze the scope for continuous improvement

Practical Skills: After undergoing this programme, a student will be able to:

PSO9: Select appropriate materials and the corresponding processes for producing a component/product

PSO10: Work with simulation tools to model and simulate casting, forging, sheet metal forming and welding

PSO11: Optimize the operations, control the quality of products and services in an organization and evaluate the performance of a system

PSO12: Formulate manufacturing strategies to meet business objectives

Capability Skills / Transferrable Skills: After undergoing the programme, a student will be able to:

PSO13: Manage information, develop technical reports and make presentations

PSO14: Work under various constraints to meet business objectives

PSO15: Work in sync with a team for achieving the organizational objectives

PSO16: Effectively communicate and facilitate smooth transfer of technical know-how between individuals and groups for addressing knowledge gaps

4. Eligibility for Admission:

4.1. Eligibility for students seeking admission under Government of Karnataka quota (for 40% seats):

i. A candidate seeking admission to postgraduate programme must have passed graduate level in Engineering and Technology in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

ii. A candidate belonging to SC/ST category will be entitled to a relaxation in the qualifying marks in accordance with the related government notification in this regard.

4.2. Eligibility for Indian students seeking admission under the university quota:

Students seeking admission under University quota must have passed graduate level degree in Engineering in a related discipline with at least 50% marks in aggregate or equivalent CGPA.

4.3. Eligibility for foreign students seeking admission under University quota:

i. Foreign students should have Association of Indian Universities recognized first degree qualification in the Engineering related discipline of equivalent

ii. Should have proof of proficiency in English.

4.4: Selection of Students

Selection of students for admission under Government of Karnataka will be based on Karnataka

Government notified admission tests.

Selection of students for admission to University quota of seats is based on admission policy of the University notified from time to time.

Selection of foreign students for admission to University quota of seats is based on the admission policy of the University notified from time to time.

4.4.1: Admission to Programme

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Selected candidates shall complete the admission procedure within the prescribed date by paying the prescribed fees and completing all other admission formalities notified by the University. Failure to do so may lead to cancellation of the selection.

4.4.2: Annual Programme Fee
Details of the fees payable for each Programme will be notified well in advance to the commencement of the programme.

The fees, once paid, will not be refunded under any circumstances.
The continuation of a student's registration in subsequent academic years is subject to payment of the prescribed programme and registration fees for each of those years.

4.4.3: Free-ship and scholarships
The Board of Management, in consultation with the Board of Governors, may consider offering free ships / scholarships to deserving students who maintain a minimum level of academic performance on a yearly basis.

5. Programme Duration

5.1. Normal Duration: The normal duration of the M.Tech. postgraduate programme is:

a. Two years in the Full-Time Route
b. Three years in the Part-Time Route

5.2. Maximum Duration: The maximum period a student is allowed to complete the M.Tech Programme shall be double the normal duration of the programme, i.e., Four Years for Full-Time students and Six years for Part-Time students.

5.3. Duration for Lateral Entry Scheme: N/A

6. Medium of Instruction

English is the medium of instruction for the programme.

7. Programme Structure

The programme structure is presented in **Appendix A**.

8. Programme Curriculum

The programme curriculum is presented in **Appendix B**.

9. Attendance Requirement

A student is required to have a minimum attendance of 80% to be eligible to appear for the examination and for assignment submission. Students who fail to achieve the minimum attendance will be declared as "FAIL". A failed student is required to re-register, attend the course and take up all the components of assessment at the next offering.

10. Assessment

10.1. Achievement Testing: During each semester, students' performance is assessed through two components, Continuous Evaluation (CE) and a Semester-End Examination (SEE). Both CE and SEE carry equal weight.

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10.1.1. Continuous Evaluation (CE): This includes term tests, assignments, viva-voce, quiz, seminars, mini projects and other such evaluation methods designed for specific courses and conducted as per the norms of the University for Assessment.

10.1.2. Semester End Examination (SEE): This includes a written/laboratory examination conducted as per the norms of the University for Assessment.

The attainment of student in all COs are evaluated. A typical evaluation template in a theory course is presented in Table 1. A student is required to score a minimum of 40% marks in each course, scoring a minimum of 40% in each of CE and SEE.

Table 1: Typical evaluation template for a theory course

Course Outcome	CE (Weightage: 50 %)				SEE (Weightage: 50 %) Semester End Exam
	Component	Component	Component	Component	
	XX Marks	XX Marks	XX Marks	XX Marks	50 Marks
CO-1					
CO-2					
CO-3					
CO-4					
CO-5					
CO-6					

In the case of a laboratory course, there are two components: Component-1 and Component-2. Component-1 (CE) carries a weight of 50% and Component -2 (SEE) carries a weight of 50%.

The template for weightage of CE and SEE in percentages for each course is indicated in Table 2.

Table 2: Typical evaluation template for a laboratory course

Course Outcome		CE (Weightage: 50 %) 25 Marks				SEE (Weightage: 50 %): 25 Marks
	Assessment Type	Conduction of Lab Exercises	Viva-Voce	Lab Record Submission	Lab Test	SEE
	Component Weightage	10 Marks	05 Marks	05 Marks	05 Marks	25 Marks
CO-1						
CO-2						
CO-3						
CO-4						
CO-5						
CO-6						

10.1.2: Second Assessment and External Review

Each student's work is first assessed by the Course teaching team. All the answer scripts of a given course are to be assessed by a second examiner. 10% of the evaluated scripts will be further reviewed by an examiner who is external to the University. An External examiner will have tenure of 2 years

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which can be renewed for a further period of 2 years. The first assessor or assessing team is required to fill in the evaluation data and write the Post Module Assessment Report (PMAR).

10.1.2.2: Feedback on Assessed work

The awarded marks and distribution pattern will be reviewed by the Dean of the Faculty before scheduling a face-to-face feedback session with the student. After completing assessment of the course, the course teaching team along with the concerned Head of the Department should provide face-to-face feedback to the student regarding his/her performance after handing over the assessed documents on a prescheduled day. After the feedback, the assessed documents are collected and deposited with the Examination and Assessment Unit of the Faculty.

10.3. Credits not earned in a Course and Opportunities for Make-up:

A minimum of 40 % marks in the assignment and a minimum of 40% marks in the written examination are required for successful completion of a course. A student failing in any one of the components will be declared 'FAILED' in the course. A failed student who has fulfilled the attendance criterion is eligible to re-sit under the fast track scheme.

There is no provision for a re-examination or re-submission of any of the assessment components for a failed course.

A maximum of 3 attempts, including the first attempt, are permitted for successful completion of a course.

11. Academic Awards

Award of Grades: Students will be awarded grades based on the marks scored. The basis for awarding grades is shown in Table 3.

Table 3: Grade Definition and Grade Points

Sl. No.	Marks Scored	Grading	GPA Grade Points
1.	91-100	O (Outstanding)	10
2.	75-90	A+ (Excellent)	9
3.	61-74	A (Very Good)	8
4.	55-60	B+ (Good)	7
5.	50-54	B (Above Average)	6
6.	45-49	C (Average)	5
7.	40-44	P (Pass)	4
8.	Below 40	F (Fail/Absent) RS – Re-sit RR – Re-registration	0
'RS' and 'RR' to be considered as 'F' for SGPA and CGPA calculations.			

The SGPA is indicated in the transcript only if all credits prescribed for the semester are earned by the student.

Computation of CGPA:

$$\text{CGPA} = \frac{\sum_1^N \text{Grade points scored in a given course} \times \text{Number of credits for that course}}{\text{Total number of registered credits}}$$

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Table 4: SGPA and CGPA calculations for two semesters					
SGPA and CGPA: Sem-1 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C1	A	8	4	32	**SGPA** = 129/18 = 7.166 = 7.17
C2	B+	7	4	28	
C3	C	5	3	15	
C4	B	6	4	24	
C5	O	10	3	30	
		Total	**18**	**129**	
Cumulative Credits and Grade Point * Credits			**18**	**129**	**CGPA** = 129/18 = 7.17
SGPA and CGPA: Sem-2 (All courses excluding 'Consideration Courses')					
Course	**Grade**	**Grade Point (GP)**	**Credit**	**GP * Credit**	
C10	O	10	3	30	**SGPA = 97/14 = 6.93**
C11	A+	9	3	27	
C12	C	5	4	20	
C13	C	5	4	20	
		Total	**14**	**97**	
Cumulative Credits and Grade Point * Credits			**18 + 14 = 32**	**129 + 97 = 226**	**CGPA** = 226/32 = 7.0625 = 7.10

Here, N is the total number of courses registered for in a semester.

Example: Typical SGPA and CGPA calculations for two semesters are shown in Table 4.

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Appendix A

Programme Structure

The Programme consists of four semesters as shown below. A student is required to successfully complete the following courses and earn credits for the award of the degree.
Complete details of each of the courses such as ILO's, content, resources, teaching-learning processes and other related information are outlined in Course Specification of the respective programme.

SEMESTER 1

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19MME501A	Computer Aided Design and Engineering	3	1	2	5	100
2	19MME502A	Engineering Materials and Processes	3	1		4	100
3	19MEC501A	Project Management	3	1	2	5	100
4	19MEC502A	Quality Management and Six Sigma	3	1		4	100
5	19MEC503A	Manufacturing Systems and Automation	3	1		4	100
6	19FET508A	Research Methodology & IPR	2	--	--	2	50
7	19FET509A	Professional Communication	1	--	--	0	
		Total	**18**	**3**	**4**	**24**	**550**
	25 hours						
	Minimum			**19**		**Maximum**	**24**

SEMESTER 2

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
1	19MEC504A	Quality By Design	3	1		4	100
2	19MEE5X1A	*Refer Elective Course Table*	3	1		4	100
3	19MEE5X2A	*Refer Elective Course Table*	3	1		4	100
4	19MEE5X3A	*Refer Elective Course Table/ MOOC*	3	1		4	100
5	19MEE5X4A	*Refer Elective Course Table/ MOOC*	3	1		4	100
6	19FET510A	Value Education	1			0	
			16	**5**	**X**	**20**	**500**
		21 hours					
		Minimum	**16**			**Maximum**	**20**

SEMESTER 3

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
X	19MEP521A	*Internship*			10	4	100
	19MEP522A	Group project			15	8	200
	19MEP523A	Dissertation – Phase -1					
Total					25	12	300
Total number of contact hours per week			XX hours				
Number of credits can be registered			Minimum	XX		Maximum	XX

SEMESTER 4

Sl.No.	Code	Course Title	Theory (h/W/S)	Tutorials (h/W/S)	Practical (h/W/S)	Total Credits	Max. Marks
	19MEP523A	Dissertation and Publication – Phase - II			24	24	400
Total					24	24	400
Total number of contact hours per week			24 hours				
Number of credits can be registered			Minimum	24		Maximum	24

Elective Course List			
Stream / Specialization	**S. No.**	**Course Code**	**Course Title**
Stream-1: Manufacturing Technologies	E11	**19MEE511A**	Metal Casting Technologies
	E12	**19MEE512A**	Metal Forming Technologies
	E13	**19MEE513A**	Machining Technologies
	E14	**19MEE514A**	Polymers and Composites
Stream-2: Engineering Management	E21	**19MEE521A**	Kaizen and Lean Operations
	E22	**19MEE522A**	Supply Chain Management
	E23	**19MEE523A**	Manufacturing System Simulation
	E24	**19MEE524A**	Manufacturing Strategy and Business Economics
Stream-3: Materials Engineering	E31	**19MEE531A**	Additive Manufacturing
	E32	**19MEE532A**	Material Testing and Characterization
	E33	**19MEE533A**	Surface Engineering Techniques
	E34	**19MEE514A**	Polymers and Composites

Note:
The Vacations and other activities shall be as per the Timetable for the corresponding batch.

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Course Title	Computer Aided Design and Engineering
Course Code	19MME501A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with creation of geometric models and performing finite element analysis of engineering components/assemblies as part of product development cycle. Students are taught the principles of geometric modeling and engineering analysis and are trained to use commercial 3D modeling, discretisation and finite element analysis tools. They will also be trained to carry out reverse engineering and rapid prototyping processes to create engineering components.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Specify and evaluate tools and techniques of CAE and their role in product development cycle
- **CO 2.** Create geometric models and generate manufacturing drawings of engineering components
- **CO 3.** Create rapid prototype model of a reverse engineered engineering component
- **CO 4.** Develop finite element model for different types of analysis using Hyper-Mesh software
- **CO 5.** Perform discretisation and engineering analysis using geometric modelling tools like CATIA and ANSYS software

Course Contents

Unit 1: CAE Systems:
Need and role of CAE systems in product realisation process, Emerging trends in CAE systems, Fundamental geometric modelling and computer graphics techniques, algorithms connected with geometric modelling. Considerations for selection of Computer Aided Design/CAM hardware and software

Unit 2: Geometric Modelling:
CAD techniques for generating three-dimensional, wire frame, surface, and solid models, Preparation of design documents according to current ISO and ANSI standards, GD and T, Preparation of production drawing

Unit 3: Reverse Engineering and Rapid Prototyping:
Reverse Engineering, Rapid Prototyping, Rapid tooling, Virtual Reality applications in product development

Unit 4: Finite Element Modelling:
Modelling consideration: Types of elements, element selection (kind, type size and order), meshing techniques, representation of geometry, material models, application of loads, representation of and application of boundary condition, Grid independence study, Post processing of results and discussions

Unit 5:
Demonstration of different types of Finite Element Analysis examples / case studies

Unit 6:
Laboratory Practice:

Geometric Modelling exercises using CATIA Finite Element Modelling using ANSYS
Reverse Engineering practice using 3D laser scanner and RP practice using FDM

Course Resources

a. Essential Reading

1. Class Notes
2. Chris McMahon and Jimmie Browne, (2005), CAD-CAM Principles, Practice and Manufacturing Management, 2nd Edition, Pearson Education.
3. Ibrahim Zeid, (2008), Mastering CAD/CAM, Tata McGraw-Hill.
4. O.C. Zienkiewicz, (2005), The Finite Element Method, Tata McGraw-Hill.

b. Recommended Reading

1. K.J. Bathe, (1997), Finite Element Procedures, 1st Edition, PHI, New Delhi.
2. Robert D. Cook, David S. Malkus, Michael E. Plesha and Robert J. Witt, (1998), Concepts and Applications of Finite Element Analysis, 4th Edition, Wiley Publications
3. Ibrahim Zeid and R. Sivasubramanian, (2008), CAD/CAM Theory and Practice, Tata McGraw-Hill.
4. Cornelius Leondes, (2000), Computer-Aided Design, Engineering, and Manufacturing: Systems Techniques and Applications, (Volume 1-7), CRC Press.
5. Kunwoo Lee, (1999), Principles of CAD/CAM/CAE Systems, Addison Wesley.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Engineering Materials and Processes
Course Code	19MME502A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course will enable the students to critically evaluate and make appropriate selection of materials and manufacturing processes for automotive, aircraft and general engineering components. The course will elucidate structure-property-processing correlation, typically used in metallic and non-metallic materials, manufacturing processes, interrelation between manufacturing processes and materials. The students will get hands on experience on software package Cambridge Engineering Selector (CES), for selection of materials and manufacturing techniques for a given component based on specific attributes.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Identify different metallic and non-metallic materials and their application areas
- **CO 2.** Arrive at material properties and requirements for achieving intended functionality in an engineering product
- **CO 3.** Critically evaluate and select suitable materials / alternate materials based on the performance of the component
- **CO 4.** Analyse the correlation between materials and processes and recommend suitable manufacturing process to produce a component
- **CO 5.** Construct a process flow for manufacturing the component
- **CO 6.** Select appropriate combination of materials and manufacturing process for a specified application using CES Software

Course Contents

Unit 1 :
Overview of materials and manufacturing: classification of materials, functional classification of materials, classification based on structure, importance of microstructure, properties, processing and performance, processing characteristics of materials

Unit 2 :
Strengthening Mechanisms in Metals: Strengthening mechanisms and types of strengthening mechanisms

Unit 3 :
Ferrous Alloys in general engineering applications: Ferrous alloys and its classification, AISI/SAE and UNS designation systems, steels, stainless steels. Cast iron: classification, structure, properties and engineering applications, Heat treatment of steels - bulk and surface heat treatments

Nonferrous Alloys general engineering and applications: Aluminum alloys, Copper alloys, Magnesium alloys, Zinc alloys, Titanium alloys - classification, structure, properties and engineering applications

Unit 4
Polymers: structure, classification and properties and engineering applications of polymers, Processing techniques for polymer components

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Ceramics: classification, properties and engineering applications of ceramics, different forming techniques for ceramics, powder metallurgy process

Unit 5 :
Composites: classification, properties, engineering applications of composites, manufacturing processes for composite materials

Unit 6 :
Metal Casting Processes: Overview of sand casting, investment casting and die casting processes, casting process capabilities, casting process selection, application examples

Metal Forming Processes: Overview of rolling, forging, extrusion, drawing, sheet metal operations, process capabilities of forming processes, process selection, application examples

Unit 7 :
Material Removal Processes: Overview of machining processes, cutting tool materials and cutting fluids, Advanced machining processes- USM, EDM, ECM and LBM, process selection and application examples

Joining Processes: Overview of joining processes, classification, solid state and fusion welding techniques – resistance, arc, friction, laser welding processes and mechanical sheet metal joining processes

Unit 8:
Selection of Engineering Materials and Manufacturing Processes: Basics of material selection, strategy for optimum selection of a material for a particular application based on the case studies

Exercises on identification of service conditions in which a particular material is used, category of materials and their properties. Identification of manufacturing processes adopted
Materials characterisation- testing of commonly used engineering materials- strength tests, chemical and metallurgical tests
Use of Cambridge Engineering Selector for selection of material and manufacturing processes

Course Resources

a. Essential Reading

5. Class Notes
6. Serope Kalpaljian, Steven R. Schmid, (2004), Manufacturing Processes for Engineering Materials, Pearson Education
7. W. D. Callister, (2005), Materials Science and Engineering- An Introduction, 6th Edition, John Wiley & Sons

b. Recommended Reading

6. M. P. Groover, (2005), Fundamentals of Modern Manufacturing: Materials, Processes and Systems, 2nd Edition, John Wiley & Sons
7. M. F. Ashby and H. Shercliff, D. Cibon, (2007), Materials Engineering Science, Processing and Design, Butterworth Publications
8. Manas Chanda, Salil K. Roy, (2006), Plastics Technology Handbook, CRC Press.
9. Robert M. Jones, (1999), Mechanics of Composite Materials, McGraw-Hill.
10. C. Barry Carter, M. Norton Grant, (2007), Ceramic Materials - Science and Engineering, Springer.

c. Other Electronic Resources

2. http://nptel.ac.in/

Course Title	Project Management
Course Code	19MEC501A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with project management (PM) techniques used in industries. The students will be exposed to various concepts and practices of PM. All the phases and steps required for successful project execution will be explained and discussed with case studies. Critical decision making skills, trade off analysis, project audit and project proposals drafting will be explored in the course.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the principles of project management
- **CO 2.** Prepare project plan, perform feasibility study and analyze the tradeoffs for project acceptance
- **CO 3.** Apply the concepts of project management to monitor, determine most economical route/s to execute projects and carryout post completion audits
- **CO 4.** Estimate the accurate cost of the overall project and evaluate the worthiness of the project using capital budgeting techniques
- **CO 5.** Formulate a comprehensive project management plan for real life projects using MS Project tool

Course Contents

Unit 1 :
Understanding Project Management, PM Triangle and Relevance, Members of PM team

Unit 2 :
Different views of Project Management, Development of Business system, modeling a business system, Product vs. Project Management, Project life cycles

Unit 3 :
Feasibility Study, Planning and Scheduling
Identification of Strategic Project Variables: Statement of Work, Project Specifications and Milestone Schedules; Project Feasibility Studies: Technical, Operational, Financial, Economic, Social and Environmental; Work Breakdown Structure and Planning Cycle, Master Project Scheduling, PERT/ CPM; Crashing of Projects; Resource Levelling.

Unit 4 :
Trade off Analysis, Project Proposals and Project Audit Methodology for Trade off Analysis; Risk Analysis – Range, Probability, Standard Deviation, covariance etc.; Costing and its components; Calculating Interest During Construction (IDC)

Unit 5 :
Capital Budgeting and most economical project – Concept and need, Methods: NPV, IRR, ARR, PBP etc. Performing Sensitivity Analysis for a given problem

Unit 6 :
The low Bidder Dilemma; Contacts – their influence on Projects, Industry Trade off Preference, Developing Marketing Strategy: The Bid – No Bid Decision, The Kickoff Memo, Proposal Types: The

single Volume, The Technical Volume, The Management Volume, The Cost Volume proposals; Project Audit: Methods of Audit, Metrics like ACWS, ACWP, BCWS, BCWP

Course Resources

a. Essential Reading

8. Class Notes
9. Harold Kerzner, (2003), Project Management: A Systems Approach to Planning, Scheduling, 8th Edition, Wiley Publications.

b. Recommended Reading

11. Parameshwar P. Iyer, (2004), Engineering Project Management with Case Studies, Vikas Publishing House Pvt. Limited

c. Other Electronic Resources

3. http://nptel.ac.in/

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Course Title	Quality Management and Six Sigma
Course Code	19MEC501A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with evolution of quality paradigm and enables students to adopt quality as a strategy for continuous improvement in business performance. The students will be taught strategies of competitive quality, quality in design and manufacture and supplier quality. The student will be able to apply the methodology of Six sigma –DMAIC approach to address industry relevant quality issues. Six Sigma Suite and MINITAB software tools will be extensively used for data analysis and root cause identification. In addition, the course emphasises the role of Quality Management Systems like ISO 9000, ISO 14000 etc., which are essential part of the present manufacturing organizations.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss various aspects of inspection, Quality Control, Quality Assurance and TQM
- **CO 2.** Evaluate maturity level of an organization's quality program including cultural and leadership aspects
- **CO 3.** Assess customer focus and market forces as basis for all quality related activities
- **CO 4.** Develop a roadmap for implementation of TQM in an organization
- **CO 5.** Apply Six sigma -DMAIC methodology for analyzing and solving industry problems
- **CO 6.** Analyse data and identify root causes for a given problem using Minitab and Six sigma suite software

Course Contents

Unit 1 :

The Philosophies and Principles of TQM, incorporating Customer Focus: Definition of quality, Principles of TQM and its powerful ability to identify trends in market forces and customer focus philosophy, Benefits of TQM

Evolution of TQM through Phases of Inspection: Stages of Inspection, QC, QA and TQM progress and their critical review, Evolution of quality concepts through different stages and times; Difference in approach to quality management between modern and traditional thinkers

Unit 2 :

The Tools, Techniques, Systems and Management and Leadership styles Applicable to a TQM Environment: Definition of process management; Tools and Techniques used in the main processes of a company; (QFD, FMEA and MP tools) Leadership styles most suitable for TQM; Building a quality culture in an organization

Cultural and Leadership Aspects and the Influence of Quality Gurus and their Contribution to TQM: Study of various persons and institutions who made an impact on the journey to TQM; Study and understanding of awards of excellence in quality. Quality grid that capture present status of quality in the organization

Unit 3 :

Concept of Variation and its Analysis: As an aid to Continuous Improvement, SPC and Process capability, Causes of variation in processes, Basic statistics; Concept of process capability; Understanding and practice in usage of quality control tools and Management Planning Tools

ISO 9000, ISO 14000 and related Quality Management Systems: Introduction to ISO family of standards; Understanding the elements of the standard and the basis for these elements; Modern process view of ISO standards, Methodology of getting accredited
Benefits of getting certified

Unit 4 :
Understanding and Implementation of Six Sigma programs: DMAIC philosophy of Six Sigma; Tools and techniques in each phase of six sigma like SIPOC, CTQ, MSA, Hypothesis Testing , Regression, ANOVA , Design of Experiments and Process Optimization

Quality Costing as an Aid to Managing Quality and Motivating Continuous Improvement:
Definition and importance of cost of Quality; Constituents and behavior of the costs of quality, ABC method of costing, implementing cost of quality

Unit 5 :
Benchmarking: Review of BPR and Business excellence awards as an aid to develop both strategic and tactical competitive advantage, Definition of Benchmarking and best practices; Different approaches to benchmarking, Steps in benchmarking, Details of BPR

Quality Engineering: Study of Taguchi methods; Loss function, Loss estimation for batch, S/N ratio, design and execution of experiments for improvement in process

Unit 6 :
Advances in Quality Management and Six Sigma: Need of new skills for future quality professionals and Building Six Sigma capability into the product development process. Adding concepts associated with eco-effective design

Course Resources

a. Essential Reading

10. Class Notes
11. John. S. Oakland, (2003), Total Quality Management, Butterworth-Heinmann Publishers.
12. James R. Evans and William M. Lindsay, (2010), An Introduction to Six Sigma and Process Improvement, Cengage Learning.

b. Recommended Reading

12. Sundara Raju S.M, (2001), Total Quality Management, Primer, McGraw Hill.
13. Kume and Hitoshi, (2004), Quality Management in New Product Development, Productivity Press.
14. Gopalan M. R. and Bicheno John, (2005), Management Guide to Quality and Productivity, Biztantra.
15. Besterfield and Dale H, (2006), Total Quality Management, Pearson Education Publication.
16. Basem El-Haik, (2005), Axiomatic Quality Integrating Axiomatic Design with Six Sigma, Reliability and Quality Engineering, Wiley.
17. Bergma, Boklefjo and Bengt, (2006), Quality; From Customer needs to Customer satisfaction,Overseas Press.
18. K. Sridhar Bhat, (2007), Total Quality Management, Himalaya Publishing House.
19. Bhote and Kekir, (2007), The Ultimate Six Sigma; Beyond Quality Excellence to Total Business Excellence, Prentice Hall India.

c. Other Electronic Resources

4. http://nptel.ac.in/

Course Title	Manufacturing Systems and Automation
Course Code	19MEC503A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with concepts and configuration of a manufacturing system and the need for automation in a manufacturing system. The students are taught about the state of the art manufacturing concepts like horizontal and vertical integration, green manufacturing and Industry 4.0. Apart from these, students will also be exposed to automation system components and cost-benefit analysis to evaluate capital investment decisions on automation. Motors, drives and motion controls used in machines will be discussed. The students will be able to develop PLC programs. In addition, robot technology, robot cell design and programming for manufacturing automation will be taught.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the significance of manufacturing systems and automation for a successful business
- **CO 2.** Develop plant, department, line and machine level KPIs for improving manufacturing systems
- **CO 3.** Recommend the degree of automation required for the application and perform cost-benefit analysis
- **CO 4.** Evaluate the smart and green solutions for manufacturing excellence
- **CO 5.** Design an automation solution for the given manufacturing operation using PLC and SCADA systems

Course Contents

Unit 1 : Manufacturing Systems
Need for Manufacturing Systems, types, planning, operations and improvement methods and methodologies. Role of automation in manufacturing systems. Interrelationship between manufacturing systems and business success. Current and future challenges and opportunities in Manufacturing Systems. Road map for building a Manufacturing systems for given requirements.

Unit 2 : Manufacturing Systems Management
Process approach for improving manufacturing systems. Functions and deliverables of Process technologies, Maintenance, Material Handling, People development, Facilities, Purchase, Suppliers and customer relationship, Quality standards & systems and regulatory and Safety requirements. Development of Plant, Department, Line and Machine level KPIs for monitoring and improving manufacturing systems

Unit 3 : Automation hierarchy in industrial automation
Principles of automation, need for automation, overview of control and automation system components, system specification and cost benefit analysis for making decisions, Role of automation in manufacturing systems, selection of automation degree based on manufacturing systems requirements.

Unit 4 : Automation technology and sub-systems
Sensors – generic and sensors for motion control (force, torque, acceleration, encoders), Actuators, CNC, Motors, Drives, Motion controllers, Vision systems and inspection, Flexible Manufacturing systems. Relay based, PLC, HMI, PC and SCADA based control approaches.

Unit 5 : Automation of manufacturing process using robots
Robot technology for Manufacturing, Robot anatomy, Control systems, Accuracy and repeatability, end effectors, Sensors and actuators in robots. Robotic cell design, Robot building and programming for manufacturing applications.

Unit 6 : Smart Manufacturing with IOT (Internet of Things)
Need for Industry 4.0, Building blocks of Industry 4.0: Additive Manufacturing, Industrial Internet of things, Predictive Maintenance, Horizontal and Vertical Integration, cyber security, operational analytics, and simulation, Industrial Robotics, cloud, Augmented reality, Digital manufacturing. Implementation requirements and challenges of Industry 4.0. Green Manufacturing Frame work. Implications of GM on existing manufacturing systems and design of new manufacturing systems. Green Manufacturing cases and guidelines for practicing green manufacturing systems.

Course Resources

a. Essential Reading

13. Class Notes
14. John M. Nicholas, (2008), Competitive Manufacturing Management: Continuous Improvement, Lean Production , Customer –Focused Quality, McGraw-Hill
15. Mikell P. Groover, (2008), Automation, Production Systems and Computer-Integrated Manufacturing, 3rd Edition, PHI Learning Private Ltd.

b. Recommended Reading

20. Yingfeng Zhang, (2017), Optimization of Manufacturing systems Using Internet of things, Elsevier.
21. Trevathan, Vernon L, (2006), A Guide to the Automation body of knowledge, 2nd Edition, ISA Publications.
22. Jeffrey Liker, (2004), The Toyota Way , McGraw-Hill.
23. Eliyahu M Goldratt, (2013), The Goal , Productivity and Quality Publishing Pvt Ltd.

c. Other Electronic Resources

5. http://nptel.ac.in/

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M.S. Ramaiah University of Applied Sciences

Course Title	Research methodology and IPR
Course Code	19FET508A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the principles of research, research methodology, significant phases of research, Intellectual property and its rights. Students are taught the realistic guidelines to be followed in the choice of field of research, topic of research and formulation of research problem. Key and careful considerations in the choice of tools for the solution of research problem are covered in this course. The course emphasizes the desirable close knit relation between innovation and concept of out of the box thinking. The principles of effective research and the need for a Proactive approach in a successful research programme are also explained. The course discusses the significant role of Literature Review in a research cycle and the expectations from good literature review as well as procedure for systematic literature review. Students will get an insight into the privilege, honour and the associated responsibilities of a researcher. This course gives insight of the intellectual property rights and over view of the benefits.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the value, scope, relevance and mandatory steps of research as well as principles of effective research, Nature of Intellectual Property
- **CO 2.** Discuss the guidelines to progress from the choice of broad field of research to specific topic of research, patent rights, process of patenting at National and International level, New Developments in IPR
- **CO 3.** Demonstrate the application and utility of the Systematic approach and out of box thinking concepts for research to be effective
- **CO 4.** Adapt ,Analyze and prepare well-structured research proposal and research paper invoking clearly outlined principles

Course Contents

Unit 1 :
Foundations of Research – Definitions of Research, Mandatory Steps in Research, Types of Research, Relevance of Research for Innovation and Technology Development, Effective Research and Self Discipline.

Unit 2 :
Formulation of Research Problem: Identification of problems, Narrowing down the problem, Factors to be considered for problem selection. History and Evolution of Science & Technology

Unit 3 :
Out Of the Box Thinking and Systematic approach in Research – Transformation to Impossible Thinking, Convergent and Divergent Thinking, Generation, Evaluation and Selection of Ideas, Critical Thinking
Literature Review – Importance of Literature Review, Constituents of Good Literature Review, Strategies for Literature Search, Referencing, Paraphrasing, and Summarizing Academic Standards and Ethics
Research Proposal – Structure of a Good Research Proposal, Getting Started, Tips for Compilation of Good Research Proposal.

Unit 4 :

Nature of Intellectual Property: Patents, Designs, Trade and Copyright.
Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Unit 5 :

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology.
Patent information and databases, Geographical Indicators

Unit 6 :

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Copy rights for Software's Traditional knowledge Case Studies.

Course Resources

a. Essential Reading

16. Class Notes
17. Dr. Chakroborty, S.K. ValuStuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students"
18. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
19. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
20. Halbert, (2007) "Resisting Intellectual Property", Taylor & Francis Ltd.

b. Recommended Reading

24. Mayall, (1192),"Industrial Design", McGraw Hill.
25. Niebel, (1972), "Product Design", McGraw Hill.
26. Asimov, (1962), "Introduction to Design", Prentice Hall.
27. Robert P. Merges, Peter S. Menell, Mark A. Lemley, (2016)," Intellectual Property in New Technological Age".
28. T. Ramappa, (2008)"Intellectual Property Rights Under WTO", S. Chand.

c. Other Electronic Resources

6. http://nptel.ac.in/

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M.S. Ramaiah University of Applied Sciences

Course Title	Professional Communication
Course Code	19FET509A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to the essentials of professional communication. Professional Communication is essential to achieve the objectives of an organisation.

Course Outcomes

After undergoing this course students will be able to:

CO 1. Compose effective written business communication
CO 2. Practice the techniques of presentation

Course Contents

Unit 1 :
Introduction to Professional Communication, Conversation and Listening

Unit 2 :
Reading Skills for Effective Professional Communication: Introduction, SQ3R (Survey, Question, Read, Retrieve, and Review) Technique of Reading

Unit 3 :
Written Business Communication: Writing Memos, Letters, Circulars and Notices, Communicating through Email

Unit 4 :
Presentation Skills: Message development, content, projection, inflection, and delivery

Course Resources

a. Essential Reading

21. Class Notes
22. Dr. C.S.G. Krishnamacharyulu (2016) Business Communication, Himalaya Publishing House

b. Recommended Reading

29. V. Lesikar, John D. Pettit, Jr., Marie E. Flatley. (1999), Basic Business Communication, 8th Edition, Tata McGraw Hill

c. Other Electronic Resources

7. http://nptel.ac.in/

Course Title	Quality By Design
Course Code	19MEC504A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims to introduce students to the approach of quality by design for building robust product/process. Design of experiments and its importance to deduce vital input parameters will be taught. Single factor, multi factor, factorial experimentation techniques and interpretation of results will be taught. Students will be equipped to conduct experiments using Taguchi techniques, multi-level factor designs and other multi-response optimization techniques. Students will be able to compare results obtained through various techniques. Students will be exposed to various cases adopting above techniques. Appropriate software will be used to solve cases.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss various principles and concepts of statistically designed experiment and their applications for building robustness in product/process
- **CO 2.** Interpret given situation and select appropriate design - single and multi-factor, factorial, Taguchi or special techniques for experimentation
- **CO 3.** Formulate problems to conduct experiments for arriving at optimal solutions
- **CO 4.** Apply experimental designs to determine optimal process parameters for a given problem/criteria and interpret results
- **CO 5.** Model the given situation using appropriate software tool and compare results

Course Contents

Unit 1 : Need for Experiments:
Need, Strategy of Experimentation, Basic Principles and process of design of experiments, Guidelines for Designing Experiments, Basic Statistical Concepts, Sampling and Sampling Distributions, Inferences about differences in means and variance, Linear regression-simple and multiple linear regression

Unit 2 : Analysis of Variance:
ANOVA, Chi-Square distribution, T distribution, F distribution, confidence intervals, one-way ANOVA, two-way ANOVA, Multivariant ANOVA, Model Adequacy Checking, Regression Approach to ANOVA

Unit 3 : Deriving the Critical Input Parameters Using Simple Experiments:
Single Factor Experiments - Completely randomized design, Randomized block design, effect of coding the observations, Latin Square design, orthogonal contrasts, comparison of treatment means

Unit 4 : Orthogonal Array Selection and Utilization:
Types of Orthogonal Arrays, selection of standard orthogonal arrays, Linear graphs and Interaction assignment, Dummy level Technique, Compound factor method, Modification of linear graphs, numerical

Unit 5 : Factorial Experimentation:
Basic definitions and principles, advantages of factorials, the two-factor factorial design, the general factorial design, fitting response curves and surfaces 2k designs with two and three factors, Yate's algorithm, practical applications

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Unit 6 : Special Experimental Designs:
Blocking and confounding in 2k and 3k factorial design, Two and three level fractional factorial designs, mixed levels, numerical

Unit 7 : Taguchi Methodology for Quality improvement :
Taguchi's quality philosophy, Loss function, Smaller-the- better type, Nominal-the –better-type, Larger-the- better type. Illustration through Numerical examples. Robust design-Parameter and tolerance design concepts, Steps in experimentation, Orthogonal Taguchi's inner and outer arrays-selection and utilisation, Data Analysis using ANOVA and Response Graph methods, Signal to Noise ratios, parameter design strategy, numerical

Unit 8 : Advanced Concepts:
Multi-response optimization – steps, working principle, types; Response Surface Methodology, Shainin DOE, Case studies on DOE applications using appropriate software, comparison of results

Course Resources

a. Essential Reading

1. Class Notes
2. Douglas C. Montgomery, 2013, Design and Analysis of Experiments, John Wiley & Sons.
3. Philip J. Ross, 1989, Taguchi Techniques for Quality Engineering, Prentice Hall.

b. Recommended Reading

1. Ajit C. Tamhane, 2009, Statistical Analysis of Designed Experiments: Theory and Applications, John Wiley & Sons.
2. K. Krishnaiah and P. Shahabudeen, 2013, Applied Design of Experiments and Taguchi Methods, PHI Learning Pvt. Ltd.
3. Angela M.Dean and Daniel Voss, 2000, Design and Analysis of Experiments, Springer.
4. Nicolo Belavendram, 1999, Quality by Design - Taguchi Techniques for Industrial Experimentation, Prentice Hall.
5. Jiju Antony, 2003, Design of Experiments for Engineers and Scientists, Butterworth-Heinemann.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Metal Casting Technologies
Course Code	19MEE511A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with metal casting and additive manufacturing processes and technologies. Students are taught principles and exposed to application areas of advanced casting/molding processes. Students are trained on casting design, riser and gating system design and mould filling simulation through process modeling. Emphasis is given to Additive Manufacturing (AM) processes, their significance and application areas. Fused Deposition Modelling (FDM) as an example of AM process will be demonstrated.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the technologies pertaining to metal casting processes and additive manufacturing
- **CO 2.** Select and discuss suitable casting/ additive manufacturing process based on material, component features and application
- **CO 3.** Propose appropriate heat treatment process and non -destructive testing technique for a component
- **CO 4.** Design riser and gating system for a casting development
- **CO 5.** Analyse and identify the reasons for defects and suggest suitable remedies for reducing the casting defects
- **CO 6.** Create model and simulate casting process using process simulation software

Course Contents

Unit 1 :

Metal Casting

Overview to Metal casting and Advanced Casting Processes: Need for various casting processes – process outcome, Principle, Operation and applications of advanced casting processes, casting alloys, New casting development, Review of casting processes for special alloys used in aeronautical and automotive applications

Solidification of Castings: Solidification of alloys, Nucleation and Grain growth, Solidification characteristics of alloys, Mechanism of dendrite formation, Solidification time, Chvorinov's rule, solidification microstructures of ingots, Progressive and Directional solidification, Methods of achieving directional solidification

Unit 2 :

Pattern, mould and core design: Types of pattern, orientation and parting, pattern design, mould parting analysis, cored features, core print design and analysis

Riser and Gating design and analysis:

Gating design and analysis: Gating system, Functions of gating system, Design of gating system, Pressurised and un-pressurised gating system, gating element design, mould filling analysis, numerical simulation, optimization and validation

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Unit 3 :

Riser design and analysis: Risers, function, types, riser and directional solidification, Riser design methods – Caine's method, modulus method, NRL method, feeding distances. Feeding aids like chills, Insulators and Exothermic, Filters to achieve directional solidification, feeder neck design, optimization and validation using numerical simulation

Casting process planning and costing: Casting process selection, capability and limitations of various casting processes, Tooling, material and conversion cost estimation

Unit 4 :

Castings process design: input material design, melt and melt control, Ladle treatments- refining, degasification, grain refinement, desulphurization, liquid metal cleanliness, pouring temperature, pouring time, cooling time etc.

Design for castability: Product design for castability, process friendly design, castability analysis, collaborative engineering

Unit 5 :

Non-destructive test for casting: Non-destructive examination - Dye penetrant test, Magnetic particle testing, Ultrasonic inspections, X- Radiography, Eddy current inspection. Defect analysis and remedies

Additive Manufacturing:

Rapid Product Development, additive manufacturing, Advantages, disadvantages and application, generalized additive manufacturing process chain

Additive manufacturing processes: Photo polymerization processes, Powder bed fusion processes, Extrusion based processes, 3D Printing processes, Sheet lamination processes, Beam deposition processes

Course Resources

a. Essential Reading

1. Class Notes
2. B. Ravi, (2010), Metal Casting Computer Aided Design and Analysis, PHI Learning Private Limited
3. Ian Gibson, David W. Stucker, (2010), Additive Manufacturing Technologies, Springer

b. Recommended Reading

1. Heine, Loper and Rosenthal, (2008), Principles of Metal Casting, McGraw-Hill
2. ASM Metal Hand Book, (1998), Volume 15, Casting
3. Paul Degarmo E. and Black Jt, (2004), Materials and Processes in Manufacturing, 9th Edition, JWS
4. P N Rao, (2003), Manufacturing Technology, 2nd Edition, TMH
5. Peter Beeley, (2001), Foundry Technology, 2nd Edition, Butterworth-Heinemann
6. Serope Kalpakjian and Steven R. Schmid, (2004), Manufacturing Engineering and Technology, 4th Edition, Pearson Education
7. Peter J Shull (Ed), (2001), Non-destructive Evaluation – Theory Practice and Application, Marcel-Decker Inc.

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Kaizen and Lean Operations
Course Code	19MEE521A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is aimed at enabling students to perform effectively as middle and senior managers and equip them to initiate actions that will lead to continuous improvement through team working. The student will be able to identify improvement opportunities at all levels of the organization and use Kaizen tools and techniques. Team working in various forms to promote better working practices across the business leading to the creation of higher levels of commitment and motivation will be taught. Further, it will enable the students to identify and eliminate waste / non-value adding activities at all levels to improve business competitiveness. Students will be taught lean tools and techniques and value stream mapping. Assessment of transformation to lean and management of lean organisation will be discussed.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the salient qualities of world class manufacturing companies
- **CO 2.** Discuss significance of change management and the need for Kaizen culture along with interrelationship between Gemba and Management for an organization
- **CO 3.** Apply the techniques of lean manufacturing to reduce wastes and improve flow of value (Point Kaizens)
- **CO 4.** Develop current and future value stream maps for products and deduce action plans
- **CO 5.** Build roadmap for Kaizen and lean journey

Course Contents

Unit 1 :
World Class Manufacturing: World class manufacturing practices, Trends in Global competitiveness, Important characteristics of world class companies
Concepts and Systems of Kaizen and Team Building: Definition of Kaizen; Important pillars of kaizen; Quality circles, Teams and techniques to build them; Concept of Empowerment and creating an ownership culture

Unit 2 :
Gemba Kaizen Management: Understanding the meaning and power of Gemba, understanding seven basic quality improvement tools

TPM: Understanding of the significance of TPM pillars
Types of Teams and Building and Sustaining Performance: Work needs of Individuals, Theories of people at workplace, Personal Profiling Personality typing; Psychometric testing; McGregor's and Mintberg theories of Employee behavior and Managerial roles and team games

Unit 3 :
Change Programs and their Management: Importance of participative and supportive culture for success of Kaizen; Kaizen and lean as Change management exercise; How to manage CHANGE (cultural and structural issues), using team building games and role play

History of Lean manufacturing and the Need for Change: Evolution of lean, Contributions of Taylor, Gilbert, Ford, Solan and Toyoda family and relationship with five principles of lean thinking

Unit 4 :

Current Industrial Requirements, Practitioner Thinking, People Issues: New economics of lean, House of lean, Different kind of wastes

Visual Management: 5S, Poka yoke, Jidoka, Andon, Yamazumi board, Kanban, Performance measures, TPM and OEE

Waste Identification and Elimination Techniques: Wastes, Product flow analysis, String diagrams, Cluster analysis, Non value added analysis, Single Minute Exchange of Die (SMED)

Pull Production: JIT production system, Kanban, Rules of Kanban system, Standard operations, Capacity charts, Walk diagrams

Unit 5 :

Manufacturing Cell Design: Flow lines, Standard cells, Work allocation, Cell layout

Value Stream Mapping: Current state mapping, Lean Metrics, Line balancing, Load leveling

Lean implementation roadmap and management of lean organization through building a waste free manufacturing model, Relevance of lean accounting for manufacturing companies

Course Resources

a. Essential Reading

1. Class Notes
2. Masaaki Imai, (2012), Gemba Kaizen: A Commonsense Approach to a Continuous Improvement Strategy, 2nd Edition, Tata McGraw - Hill Education
3. Pascal Dennis, (2007), Lean Production Simplified: A Plain Language Guide to the World's Most Powerful Production System, 2nd Edition, Productivity Press

b. Recommended Reading

1. Harrison A, (1992), Just in Time Manufacturing in Perspective, Prentice Hall
2. Hirano H, (1995), 5 Pillars of visual workplace, Productivity Press
3. Monden Y, (1998), Toyota Production System: An integrated approach to Just in Time, Chapman & Hall
4. Nicholas J.M, (1998), Competitive Manufacturing Management, McGraw-Hill
5. Rother and Shock, (1999), Learning to See, Lean Enterprise List
6. Tapping D, (2002), Value Stream Management, Productivity Inc.
7. Javier Santos, Richard A. Wysk and Jose M. Torres, (2006), Improving production with lean thinking, John Wiley
8. Bill Carreira, (2007), Lean manufacturing that works: powerful tools for dramatically reducing waste, Prentice Hall
9. James Huntzinger, (2007), Lean cost management for lean by establishing flows
10. Chis Harris and Rick Harris, (2007), Developing a lean work force, Productivity Press
11. Greg Lane, (2007), Made to order lean: Excelling in a high mix-low volume environment, Productivity Press

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Polymers and Composites
Course Code	19MEE514A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with polymers and composites processing to meet the design intent. Process principles, parameters and applications of polymer processing techniques like injection moulding, blow moulding, etc. will be discussed. Students will be trained to design the mould for polymer components. The students are exposed to polymer composites and nanocomposites. Lay-up processes of composites and characterisation of composites will be demonstrated. Students will be trained in modeling and simulation of plastic moulding processes using process modeling software.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Identify and explicate polymers and composite materials used in engineering applications
- **CO 2.** Discuss the effects of matrix and reinforcements on the properties of composites
- **CO 3.** Recommend suitable processing methods for polymers and composites to achieve required properties
- **CO 4.** Perform process simulation to select process parameters in polymer/composite moulding
- **CO 5.** Prepare polymer and composite specimens and characterise them

Course Contents

Unit 1 :
Overview of Polymers
Classification of polymers; Structure of polymers; Application of polymers
Properties of Polymers
Amorphous state; Glass transition temperature; Crystalline state; Crystalline melting temperature; Introduction to viscoelasticity; Mechanical properties

Unit 2 :
Rubber
Types of Rubber; Rubber Processing; Rubber compounding; Introduction to Rubber elasticity
Polymer Processing and Machinery
Injection moulding; Extrusion; Blow moulding; Thermoforming; Calendaring; Rotational moulding; Compression moulding and transfer moulding
Mould Construction and Simple Exercises in Mould Design: Injection mould elements, cores, cavities and inserts, fitting core and cavity inserts, pillars and bushes; Feed System, Gates, Runners, Impression layout, sprues, mould shrinkage and ejectors
Moulds: Plate mould, hot runner moulds and runner less moulds, Defects in moulding and its remedies

Unit 3 :
Overview of Composites
Classification and characteristics of composite materials; Contribution of matrix and reinforcement on performance of composites; Types of matrix materials; Types of reinforcement materials; Laminated Composites, Hybrid Composites, Applications
Fabrication of Composites
Polymer matrix composites – Open mould manufacturing process and closed mould manufacturing process
Fabrication processes and resultant properties mapped to specific applications

Nanocomposites
Introduction to nanocomposites; Types of reinforcements; Advantages of nanocomposites; Preparation of nanocomposites; Properties of nanocomposites; Applications of nanocomposites
Machining and Joining of Polymers and Composites: Machining, Drilling, Mechanical fasteners and Adhesive bonding, Fabrication equipment

Unit 4 :
Laboratory practice
Exercises in mould design for polymers
Modeling and simulation of plastic moulding processes using process-modeling software
Demonstration of hand lay-up composite manufacturing process
Characterization of polymers and composites

Course Resources

a. Essential Reading

1. Class Notes
2. J. A. Brydson, (1999), Plastic Materials, 7th Edition, Butterworth-Heinemann
3. P.K. Mallick, Ed., (1997), Composites Engineering Handbook, Marcel Dekker

b. Recommended Reading

1. Manas Chanda, Salil K. Roy, (2008), Plastics Fundamentals, Properties and Testing, CRC Press
2. Manas Chanda, Salil K. Roy, (2006), Plastics Technology Handbook, CRC Press
3. John S. Dick, (Ed.), (2001), Rubber Technology–Compounding and Testing for Performance, Hanser-Verlag
4. Robert M. Jones, (1999), Mechanics of Composite Materials, McGraw-Hill
5. ASM handbook on Composites, (2001), Volume 21
6. A. Kelly, (Ed.), (1994), Concise Encyclopedia of Composite Materials, Pergamon, Oxford
7. P. M. Ajayan, L. S. Schadler, P. V. Braun, (2003), Nanocomposite Science and Technology, Wiley-VCH Verlag GmbH

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Metal Forming Technologies
Course Code	19MEE512A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at equipping students to select forming and joining methods and process parameters based on the component features and application. Emphasis is on modelling and simulation of forming and joining processes using advanced simulation tools to optimise process parameters. The students will be taught to identify the forming and welding defects and suggest suitable remedies.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate metal forming and welding processes and process parameters based on the materials, components features and production volume
- **CO 2.** Select and discuss suitable forming process based on material, component feature, production volume and application
- **CO 3.** Perform simulation studies to optimize the forming and welding process parameters iteratively
- **CO 4.** Asses the importance, principles, and applications of high energy rate forming
- **CO 5.** Analyse and identify the reasons for forming and welding defects and suggest suitable remedies for reducing the defects

Course Contents

Unit 1 :
Metal Forming Processes
Deformation Processing: Classification of forming processes based on type of stress, strain rate, temperature, the flow curve, true stress, true strain, mechanics of metal working, temperature in metal working, strain rate effects, metallurgical structures. Friction and lubrication, lubricants for hot and cold working

Forging Design: Forging process parameters, parting plane, die design parameters, design guidelines, defects and remedies, case studies on simulation and modelling

Unit 2 :
Rolling Design: deformation and microstructure during rolling, roll passes scheduling, forces and geometric relationship, torque and power defects in rolled products, case studies on simulation and modelling

Extrusion Design: deformation zone geometry, hydrostatic extrusion, extrusion die design, lubrication, defects and remedies, case studies on simulation and modelling

Unit 3 :
Sheet Metal forming Design: effect of clearance, calculation of punching force, bending, spring back in bending, limiting draw ratio, forming limit criteria, sheet metal forming dies, formability and formability limit diagram, defects in formed parts, case studies on simulation and modelling

Modelling and Simulation of Forming Processes: Modelling and simulation of forging and sheet metal forming processes and optimisation of process parameters

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Unit 4 :

High Energy Rate Forming: Need, principles, equipment, operation parameters - Explosive forming, electro forming, super plastic forming and magnetic pulse forming

Unit 5 :

Welding Processes

Overview of welding processes: Fusion and non-fusion welding processes- cold, resistance, friction welding, arc based welding processes, beam based welding processes

Welding Physics, Instrumentation and Automation – Effect of polarity, arc physics, power sources (self-controlled arc and self-adjusted arc), metal transfer modes and heat transfer aspects of fusion welding. Arc welding equipment, automation in welding- arc sensing and vision, seam tracking, welding robots

Welding Design and Process Selection – Weld solidification, effect of heat (HAZ), weldability and weldability testing, welding characteristics of alloys, process selection, design consideration for welding, characterization and testing of welds (strength – tension, bending, fatigue and corrosion, composition and microstructure), residual stresses and stress relieving, weld defects, failure of weldments - analysis and remedies, safety considerations in welding

Modelling and Simulation of Welding Processes: Modelling and simulation of welding processes

Course Resources

a. Essential Reading

1. Class Notes
2. George E. Deiter, (1988), Mechanical Metallurgy, McGraw-Hill Book Company, UK
3. N Rao, (2003), Manufacturing Technology- Foundry Forming and Welding, 2nd Edition, TMH

b. Recommended Reading

1. Vukota Boljanovic, (2004), Sheet Metal Forming Processes and Die Design, Industrial Press, Inc
2. Prakash M. Dixit and Uday S. Dixit, (2008), Modeling of Metal Forming and Machining Processes, Springer
3. John G Lenard (Ed), (2002), Metal Forming Science and Practice, Elsevier
4. Ivana Suchy, (2006), Handbook of Die Design, 2nd Edition, McGraw-Hill
5. Larry Jeffus, (2007), Welding Principles and Applications, 6th Edition, Thomson Publishers
6. Howard B Cary and Scott, (2004), Modern Welding Technology, Prentice Hall
7. John Geoffrey Hicks, (1999), Industrial Joining Processes, 3rd Edition, Industrial Press

c. Other Electronic Resources

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Course Title	Supply Chain Management
Course Code	19MEE522A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course is intended to prepare the students to establish supply chain in a business enterprise. The format of this subject follow the case based approach and students will be able to learn the strategic importance of supply chain design, planning and operation for a firm. Also students should able to improve key areas of drivers of supply chain performance, analytical methodologies for supply chain analysis and their interrelationships. Also students will be familiarized to the advanced concept of supply chain logistics like 4PL, 5PL, sustainable and green supply chains.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the concepts of logistics, Value Chain and supply chain management
- **CO 2.** Explicate the role of supply chain drivers in achieving competitive advantage at various decision phases
- **CO 3.** Determine capacity and inventory requirements for optimality and interpret results
- **CO 4.** Select factors and analyse their impact on supply chain design, planning and operations for managing supply and demand
- **CO 5.** Apply principles and concepts of logistics and supply chain in manufacturing and service based organizations for performance improvement
- **CO 6.** Demonstrate given supply chain process using ERP software

Course Contents

Unit 1 :

Introduction to Logistics and Supply Chain Management:

Introduction to core supply chain processes, customer management processes, demand management processes. Supply chain structure and complexity from a predominantly manufacturing scenario to one of a value chain from supplier to customer process. Links to strategy and contribution to business performance and competitive advantage. Push/Pull views of supply chain. Decision phases in supply chain.

Unit 2 :

Supply Chain Sourcing Decisions:

Vertical integration and Outsourcing: Related issues and impact on supply chain, core competency. Primary Drivers of Make or Buy: Cost, Technology, Obsolescence, Environmental factors, Laws of the land. Short time comfort and long- time benefits. Historical reasons and Inertia. Shedding of Jobs and problems of downsizing. Numerical problems on Make or Buy. Related cases

Unit 3 :

Achieving Supply Chain Strategic Fit, Drivers and Metrics:

Achieving strategic fit and expanding scope of the supply chain, Challenges to achieving and maintaining strategic fit. Drivers of supply chain for competitive performance: Framework, Role, components of decision making and related metrics, Pursuit of responsiveness and efficiency, Porter's model of value chain. Related cases

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Unit 4 :

Designing the Supply Chain Network:

Distribution Networking – Role, Influencing factors, Design options. Supply Chain Network (SCN) Design – Role, Factors, Framework for Network Design Decisions. Impact of uncertainty on SCN – discounted cash flow analysis, evaluating network design decisions using decision trees. Aggregate planning in a supply chain. Related cases

Unit 5 :

Planning and coordinating Demand and Supply:

Role and Evolution of Purchasing, Enablers of Purchasing, Purchasing objectives and process. Role of sourcing, Strategic sourcing, Types of supply management strategies, supplier – scoring and assessment, selection and contracts. Managing Supply Chain Inventory: Cycle Inventory- Role, Related Costs, Estimation, Lot sizing, and Quantity Discounts. Safety Inventory- Role, Factors affecting the level of inventory, Impact of supply and lead time uncertainty on safety inventory, Aggregation, Demand forecasting methods and its metrics. Role of IT in inventory Management Inbound and Outbound Logistics. Third party logistics Factors affecting transportation and warehousing. Role of transportation and trade-offs. Related cases

Unit 6 :

Supply Chain Coordination:

Co-ordination in a supply chain: Bullwhip effect. Obstacles to coordination. Managerial levers to achieve co-ordination, Building strategic partnerships, Supply Chain Performance Measurement-need, categories and development of measurement and evaluation system. The role of IT supply Chain, The Supply Chain IT framework, ERP. The role of E-business in a supply chain, The E-business framework, E-business in practice. Related cases

Unit 7 :

Logistics and Sustainability:

4PL and 5PL Logistics, Global Logistics, Reverse Logistics, Activities. Risks and Resilience development in supply chains, Lean supply Chains, Sustainable and Green supply Chains. Related cases.

Course Resources

a. Essential Reading

1. Class Notes
2. Sunil Chopra, Peter Meindl and Dharam Vir Kalra, 2016, Supply Chain Management: Strategy, Planning, and Operation, Pearson
3. Robert B. Handfield, Robert M. Monczka, Larry C. Giunipero and James L. Patterson 2011, Sourcing and Supply Chain Management, Cengage

b. Recommended Reading

1. Shapiro and Jeremy F., 2002, Modelling Supply Chain, Thomson
2. Poirer C. C. and Bauer M. J., 2002, E- Supply Chain, Using the Internet to Revolutionize your Business, Viva Books
3. Martin Christopher, 2006, Logistics and Supply Chain Management, Strategies for Reducing Cost and Improving Service, Pearson
4. Stanley Fawcett E., Lisa Ellram M., 2007, Supply Chain Management, From Vision to Implementation, Prentice Hall

c. Other Electronic Resources

1. http://nptel.ac.in/

Course Title	Material Testing and Characterization
Course Code	19MEE532A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with the concepts and principles of testing of materials. Students are taught stress, strain, deformation and solving engineering problems. Students are taught the principles of nondestructive testing techniques . The course will elucidate important techniques used to characterise and study the properties of materials. Students are taught different methods of characterisation techniques such as optical , X-ray diffraction and electron microscopy methods. Students will be able to apply principles of characterization methods to materials engineering.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the properties, deformation mechanisms and testing of various engineering materials
- **CO 2.** Discuss usage of appropriate material and testing methods for a given application
- **CO 3.** Evaluate ductile to brittle transition behaviour related to fracture of metals
- **CO 4.** Arrive at different non -destructive testing methods and their importance for engineering applications
- **CO 5.** Perform micro examination of specimens and characterise for functionality

Course Contents

Unit 1 :
Fundamentals of elastic and plastic deformation of metals, deformation by slip and twin dislocations and their properties. Concept of recrystallization and grain growth during cold and hot working on metals.
Evaluate important engineering properties like physical, mechanical, and thermal properties of metals through tests.

Tension test and ductility measurement, effect of strain rate, temperature and flow properties of metals.
Hardness test, Brinnel, Rockwell and Vickers hardness, flow of metal under the indenter, relationship between hardness and flow curve. Hardness at elevated temperatures.

Unit 2 :
Ductile to brittle transition behavior, factors affecting transition temperature and stress systems related to fracture of metals.

Time dependent deformation due to creep, different stages of creep, mechanisms and microstructural aspects of creep and study of creep resistant alloys.

Fatigue testing of metals, study of crack propagation due to fatigue, effect of stress concentration, size, surface and temperature.

Unit 3 :
NDE Methods
Visual examination; liquid penetrant testing – procedure; penetrant testing materials, penetrant testing method – sensitivity; application and limitations

Radiography – basic principle, electromagnetic radiation in film, radiographic imaging, inspection techniques, applications, limitations
Principle of pulse echo method, resonance method, contact testing, coolants– Data presentation A, B and C scan displays, Pulse Echo instrumentation controls and circuits, signal detection, detectability of defects. Comparison and selection of NDT methods VE, LPT, MPT, ECT, RT, UT, AET and thermography

Unit 4 :
Macro and micro examination of metals – specimen preparation -- qualitative and quantitative examination of Optical microscopy techniques

X-ray Diffraction techniques: X-ray Diffraction and Bragg's law, Laue techniques, Debye-Scherrer techniques. Determination of crystal structure, particle size, Phase identification.

Unit 5 :
Electron microscopy (SEM and TEM): Electron diffraction, Principles and operation of scanning electron microscope. Geometry of electron microscopes, Electron Sources, Specimen Handling and preparation, Secondary electron image, Backscattered electron image, example of scanning electron micro-graphs and fractography studies.

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes: Scanning Tunnelling Microscope, Atomic Force Microscope

Course Resources

a. Essential Reading

1. Class Notes
2. George E. Dieter, Mechanical Metallurgy, McGraw Hill, 2nd Edition, 2005
3. Cullity B. D., 'Elements of X-ray Diffraction', 4th Edition, Addison Wiley, 1978

b. Recommended Reading

1. J.E.Dorn, Mechanical Behavior of Materials at Elevated Temperatures, McGraw Hill, 2000
2. Electron Microscopy and Analysis - P.J. Goodhew, F.J. Humphreys, Taylor & francis, 2nd edition, 1997
3. Modern Metallographic Techniques and their Applications - Philips V. A., Wiley Interscience, 1971
4. D. Brandon & W.D. Kaplan, Microstructural Characterization of Materials; John Wiley & Sons Publ., 1999
5. Material Characterization, Metals Handbook, Vol 10, Ruth E. Whan, ASM, 1986
6. Scanning electron microscopy and X-ray microanalysis, J. I. Goldsetin, , C E. Lyman, D. E. newbury, E. Lifshin, P. Echlin, L. Sawyer, D. C. Joy, j. R. Michael, springer, 2003.
7. Testing of Metallic Materials – A V K Suryanarayana (Prentice Hall India, 1990)

c. Other Electronic Resources

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Course Title	Machining Technologies
Course Code	19MEE513A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

In this course, the students will be taught various advanced machining technologies. Emphasis will be given for selection of suitable advanced material removal processes depending on part features and volume. More focus will be on aspects of CNC machining techniques. Students will be exposed to the principles of advanced machining processes, hybrid machining processes, micro-fabrication and nano-fabrication techniques. Students will be trained to manufacture component/part using CNC machine.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the need for advanced material removal and micro/nano fabrication technologies
- **CO 2.** Select suitable CNC machine tools and develop appropriate programming based on material to achieve the desirable component quality
- **CO 3.** Recommend suitable non-traditional machining process based on the process capability and economy
- **CO 4.** Analyse and select suitable micro/nano fabrication process for a specified device/application
- **CO 5.** Generate CNC codes of CAD models/drawings and automate manufacturing of component using multi-axes CNC machines

Course Contents

Unit 1 :

Material Removal Processes

Classification, Tool geometry and role of tool angles in material removal, Mechanism of chip formation, Tool materials and cutting fluids, Machining economics

CNC Machining

Developments in manufacturing technology in automation, Systems requirements and automatic control technology, Classification of NC systems

Unit 2 :

Features of numerically controlled machines – Fundamentals of machining; Design considerations of NC machine tools; Tooling Systems for Computer Numerical Control Machines - turning tool geometry, milling tooling systems, tool presetting, automatic tool changer, work holding, tool holding; CNC controls, CRT displays, drive motors, stepping motors and open-loop systems, servo motors and closed loop systems

Fundamentals of NC part programming – Preparatory functions, Axis motion commands, Feed and speed commands, Miscellaneous command, Conventional numerical control, Direct numerical control, Computer numerical control, Computer aided part programming, Automatically Programmed Tool (APT) language basics, CAD/CAM based part programming

Unit 3 :

Types of CNC machines – CNC plasma machines, CNC spring forming machines, CNC laser cutting machines, vertical machining centres, horizontal machining centres, variable axes machining control, CNC press brakes, CNC punch press

Non-Traditional Material Removal Processes
Need for NTM, Classification, Equipment, Working Principle, Process Mechanism, Process Parameter and Applications of – Mechanical Process – USM, WJM, AJM, Ice Jet Machining; Chemical Process – CM, Photochemical Milling, Electropolishing; Electrochemical Process – ECM, ECD, Shaped tube electrochemical milling; Thermal Process – EDM, LBM, EBM, PBM, IBM

Unit 4 :
Hybrid Machining Processes
Hybrid ECM Process – Electrochemical grinding, Electrochemical honing, Electrochemical superfinishing, Electrochemical buffing, Ultrasonic assisted ECM, Laser assisted ECM
Hybrid Thermal Process – Electroerosion Dissolution Machining, Electrodischarge Grinding, Abrasive Electrodischarge Machining, EDM with Ultrasonic Assistance, Electrochemical Discharge Grinding, Brush Erosion-Dissolution Mechanical Machining

Unit 5 :
Material Addition Process - MEMS and NEMS Fabrication Techniques
Basic Micro-fabrication Techniques, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques
Importance of Nano-technology, Bottom-up and Top-down approaches, challenges in Nano Technology, Fundamentals of film growth
Chemical based material addition process – Lithography, Sol-Gel Films, Molecular Beam Epitaxy (MBE), Chemical Vapour Deposition (CVD)
Thermal based material addition process - Atomic layer deposition (ALD), Electrochemical deposition (ECD)

Unit 6 :
Laboratory
Part programming concepts and exercises in CNC lathe and CNC milling machine using appropriate software tools
Demonstration – CNC Machine operation and work and tool setting

Course Resources

a. Essential Reading

1. Class Notes
2. Hassan Abdel-Gawad El-Hofy, (2005), Advanced Machining Processes: Non-traditional and hybrid Machining Processes, McGraw Hill
3. Hans B. Kief, Helmut A. Roschiwal, (2013), CNC Handbook, Hanser

b. Recommended Reading

1. Serope Kalpakjian, Steven R. Schmid, (2004), Manufacturing Processes for Engineering Materials, Pearson Education
2. V K Jain, (2002), Advanced Manufacturing Processes, Allied Publishers Pvt. Ltd.
3. HMT Production Technology, (1986), McGraw Hill Education
4. J.A. McGeough, (2001), Micromachining of Engineering Materials, CRC Press
5. Robert W. Johnstone, M Parameswaran, (2004), An Introduction to Surface-Micromachining, Springer

c. Other Electronic Resources

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Course Title	Manufacturing System Simulation
Course Code	19MEE523A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with optimization of resources to achieve better performance on factory floor through simulation. Students will be equipped with knowledge and skills on Discrete Event Simulation (DES) for system design and optimization. In addition, the complete enterprise simulation including aspects of supply chain, value stream and lean six sigma will be discussed.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the concepts of probability, statistics, mathematics and simulation with reference to manufacturing system simulation
- **CO 2.** Model and simulate a factory floor and evaluate performance and identify areas for improvement
- **CO 3.** Plan resources for specified level of performance using simulation
- **CO 4.** Conduct enterprise level simulation based on lean six sigma frame work
- **CO 5.** Simulate the events of a given manufacturing line and shop-floor using ARENA tool

Course Contents

Unit 1 :
Probability and Statistics : Probability theory, Random variables, Distribution functions, Expectations, Moments, correlations, Common discrete distributions, Common continuous distributions, Stochastic processes, Estimation, Hypothesis testing, Random number and Variate generation

Unit 2 :
Discrete event simulation :Systems and models, Analytical versus simulation modelling, Simulation modelling and analysis, Model building, simulation costs and risks, Elements of discrete event simulation, Examples of DES models, Monte Carlo sampling and histories, DES languages, Arena basics, model testing and debugging facilities

Unit 3 :
Simulation studies: Input Analysis, Model goodness via Inspection of test runs, performance analysis, model verification and validation, output analysis – terminating and steady-state models, point estimation, etc., ARENA output and processor analyser, Correlation Analysis and , Modelling production lines

Unit 4 :
Enterprise simulation: Modelling supply chain systems, Simulation for Six sigma systems and for manufacturing strategy

Unit 5 :
Advanced concepts in simulation: Steady state simulations – warm-up, run length, truncated replications, Variance reduction, Sequential sampling, Simulation study project handling Experimentation techniques in simulation: Design of experiments for experimentation and analysis of the results Output analysis and resource optimization

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Unit 6 :

Simulation of Manufacturing lines and factory floor: Modelling transportation systems, Analysis of AGV's from network minimization and statistics generation perspective (MPG, 3rd edition, chapter 10), AS/RS system throughput analysis and statistics generation using simulation, Mixed model manual assembly lines, Transfer lines and multi-stage automated lines, Quantitative analysis of assembly systems, FMS layout and quantitative analysis

Course Resources

a. Essential Reading

1. Class Notes
2. Basem El-Haik and Raid Al-Aomar, (2006) Simulation-based lean six-sigma and design for six-sigma, Wiley & Sons, Inc.
3. Kelton W.D., Sadowski R.P., Sadowski D.A., (1998) Simulation with ARENA, McGraw Hill.
4. Jerry Banks, Carson John S., Nelson Barry L. and Nicol Dovi, (2002) Discrete Event System Simulation, Prentice Hall

b. Recommended Reading

1. Tayfur Altiok and Benjamin Melamed, (2011) 'Simulation modelling and analysis with Arena', Academic Press, Elsevier Inc.
2. Papadopoulos H. T., Heavey C. and Browne J., (1993) Queuing Theory in Manufacturing System Analysis and Design, Chapman

c. Other Electronic Resources

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Course Title	Surface Engineering Techniques
Course Code	19MEE533A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The course deals with surface engineering techniques to enhance the performance of engineering components. The students are taught with significance of surface layer, development and importance of surfaces and surface layers; surface preparation and coating techniques. The student will be able to analyse the interaction of surface with service conditions such as corrosion, wear, fatigue, etc. and suggest suitable surface treatment techniques to meet the requirements. Students will carry out coating on specimens and characterise for service functionality.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Explicate the importance of concepts of surface properties for solid surface
- **CO 2.** Discuss different type of corrosions occurring in components
- **CO 3.** Analyse different types of surface engineering methods and their importance for engineering applications
- **CO 4.** Evaluate and recommend appropriate coating methods based on the applications
- **CO 5.** Arrive at appropriate range for coating process variables
- **CO 6.** Perform coating on specimens and characterise for functionality

Course Contents

Unit 1 :
Significance of surface engineering, General applications, Mapping of applications with respect to various types of coatings

Unit 2 :
Solid Surface: Geometrical, mechanical and physico-chemical concept; Surface energy, Surface phenomena; Surface Layers: Superficial layer - Concepts of superficial layer, surface roughness, stereometric-physico-chemical parameters of superficial layer

Unit 3 :
Types of Corrosion: Improtance of corrosion, Wet or Dry corrosion, galvanic, pitting, environemntal corrosion etc.

Unit 4 :
Surface Preparation Techniques: Process principles, capabilities, parameters, properties and applications of - Lapping and Super finishing, shot blasting, Peening, Burnishing processes
Surface hardening techniques: Principles and processing of surface hardening process like induction hardening, flame hardening, carbusrizing, nirtriding, carbonitriding, etc

Unit 5 :
Coatings: Concept of coatings, Types of coatings by material - Metallic & Non-metallic coating, Classification of coatings by manufacturing methods, Potential properties of coatings - Residual stresses, Adhesion, Hardness, Ductility, Strength properties, Fatigue strength, Tribological properties, Anti-corrosion properties, Electrical properties, Magnetic properties, Decorative properties, Applications

Unit 6 :

Conventional Coating techniques: Process principles, capabilities, properties and applications of - Thermal spraying, Diffusion coating, Dip coating, Electroplating, Electroless plating, Hard facing, Galvanization, Conversion coating, Anodizing, Porcelain enameling, Ceramic coating and Organic coatings, Diamond coating, Thermal Barrier Coating, Painting, Surface texturing, Cladding, etc.

Unit 7 :

Advanced Coating Techniques: Classification of advanced coating techniques, Process principles, capabilities, properties and applications of - Vacuum deposition by Physical techniques (PVD), Electron Beam Techniques, Laser Beam Techniques, Ion Implantation Techniques, CVD techniques, etc.

Unit 8 :

Characterization and Testing: Different types of testing for thickness, roughness, charcateristics using profilometer, hardness, Microscopy, Scanning Electron Microscopy (SEM), etc.
Demonstrations on coatings on specimens
Characterisation of coated samples based on service functionality

Course Resources

a. Essential Reading

1. Class Notes
2. Taudeusz Burakowski, (1999), Surface Engineering of Metals, Principles, Equipment, Technologies, CRC Press

b. Recommended Reading

1. ASM Handbook, Volume 5, Surface Engineering
2. Surface Engineering for Corrosion and Wear Resistance, (2001), ASM International
3. Peter Martin, (2011), Introduction to Surface Engineering and Functionally Engineered Materials, John Wiley & Sons Publications
4. Anderson John D, (2001), Surface Engineering Process: Fundamentals, Applications, McGraw Hill
5. Paul Swaraj, (1996), Surface Coating: Science & Technology, John Wiley
6. Gissler W. and Jehn H. A, (1992), Advanced Techniques for Surface Engineering, Kluwer Publications

c. Other Electronic Resources

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Course Title	Polymers and Composites
Course Code	19MEE514A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course deals with polymers and composites processing to meet the design intent. Process principles, parameters and applications of polymer processing techniques like injection moulding, blow moulding, etc. will be discussed. Students will be trained to design the mould for polymer components. The students are exposed to polymer composites and nanocomposites. Lay-up processes of composites and characterisation of composites will be demonstrated. Students will be trained in modeling and simulation of plastic moulding processes using process modeling software.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Identify and explicate polymers and composite materials used in engineering applications
- **CO 2.** Discuss the effects of matrix and reinforcements on the properties of composites
- **CO 3.** Recommend suitable processing methods for polymers and composites to achieve required properties
- **CO 4.** Perform process simulation to select process parameters in polymer/composite moulding
- **CO 5.** Prepare polymer and composite specimens and characterise them

Course Contents

Unit 1 :
Overview of Polymers
Classification of polymers; Structure of polymers; Application of polymers
Properties of Polymers
Amorphous state; Glass transition temperature; Crystalline state; Crystalline melting temperature; Introduction to viscoelasticity; Mechanical properties

Unit 2 :
Rubber
Types of Rubber; Rubber Processing; Rubber compounding; Introduction to Rubber elasticity
Polymer Processing and Machinery
Injection moulding; Extrusion; Blow moulding; Thermoforming; Calendaring; Rotational moulding; Compression moulding and transfer moulding
Mould Construction and Simple Exercises in Mould Design: Injection mould elements, cores, cavities and inserts, fitting core and cavity inserts, pillars and bushes; Feed System, Gates, Runners, Impression layout, sprues, mould shrinkage and ejectors
Moulds: Plate mould, hot runner moulds and runner less moulds, Defects in moulding and its remedies

Unit 3 :
Overview of Composites
Classification and characteristics of composite materials; Contribution of matrix and reinforcement on performance of composites; Types of matrix materials; Types of reinforcement materials; Laminated Composites, Hybrid Composites, Applications
Fabrication of Composites
Polymer matrix composites – Open mould manufacturing process and closed mould manufacturing process
Fabrication processes and resultant properties mapped to specific applications

Nanocomposites
Introduction to nanocomposites; Types of reinforcements; Advantages of nanocomposites; Preparation of nanocomposites; Properties of nanocomposites; Applications of nanocomposites
Machining and Joining of Polymers and Composites: Machining, Drilling, Mechanical fasteners and Adhesive bonding, Fabrication equipment

Unit 4 :
Laboratory practice
Exercises in mould design for polymers
Modeling and simulation of plastic moulding processes using process-modeling software
Demonstration of hand lay-up composite manufacturing process
Characterization of polymers and composites

Course Resources

a. Essential Reading

1. Class Notes
2. J. A. Brydson, (1999), Plastic Materials, 7th Edition, Butterworth-Heinemann
3. P.K. Mallick, Ed., (1997), Composites Engineering Handbook, Marcel Dekker

b. Recommended Reading

1. Manas Chanda, Salil K. Roy, (2008), Plastics Fundamentals, Properties and Testing, CRC Press
2. Manas Chanda, Salil K. Roy, (2006), Plastics Technology Handbook, CRC Press
3. John S. Dick, (Ed.), (2001), Rubber Technology–Compounding and Testing for Performance, Hanser-Verlag
4. Robert M. Jones, (1999), Mechanics of Composite Materials, McGraw-Hill
5. ASM handbook on Composites, (2001), Volume 21
6. A. Kelly, (Ed.), (1994), Concise Encyclopedia of Composite Materials, Pergamon, Oxford
7. P. M. Ajayan, L. S. Schadler, P. V. Braun, (2003), Nanocomposite Science and Technology, Wiley-VCH Verlag GmbH

c. Other Electronic Resources

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Ramaiah University of Applied Sciences

Course Title	Manufacturing Strategy and Business Economics
Course Code	19MEE524A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of the course is to equip students to adopt appropriate strategy for realizing business objectives. Principles of corporate and manufacturing strategy and link between the two will be discussed. Students will be taught assessment techniques for evaluating business performance and develop manufacturing strategies for competitive advantage. Students will be exposed to business economics relevant to contemporary business.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss relationship between Business, manufacturing and corporate strategy
- **CO 2.** Evaluate a business scenario using appropriate business economics models
- **CO 3.** Develop SWOT analysis of a company for competitive advantage
- **CO 4.** Assess business performance and develop manufacturing strategies for competitive advantage
- **CO 5.** Develop strategy to turn around the companies, carryout product portfolio analysis and performance assessment to solve problems in a business

Course Contents

Unit 1 :
Overview of Manufacturing Strategy: Reason for business failure, Environmental issues influencing business, Contribution of manufacturing strategy, Classification of Industries, Manufacturing technology types, what is strategy? Why strategy? Intended and emergent strategy, Elements of strategy and its formulation

External and internal analysis: Macro P.E.S.T analysis, Micro Porter's 5 force model, Organization structure and system, Organization culture, style and value, Organization skill and resources

Unit 2 :
Corporate and business strategy: Combining internal and external analysis- SWOT analysis, Growth strategies, Stability strategies, Retrenchment strategies, Global strategy

Market Qualifying and Order Winning Criteria: Quality, Delivery, Lead time, Flexibility, Innovativeness, Performance as order winners, Case studies

Unit 3 :
Product Life Cycles and product portfolio: Product life cycle and its analysis, BCG Matrix, product Portfolio analysis, Case studies

Manufacturing Strategy: Links between manufacturing strategy and company strategy, Contribution of manufacturing strategy to business performance and competitive advantage, manufacturing strategy theories. Make or buy polices, Manufacturing strategy framework

Unit 4 :
Framework for Developing and Analysing Manufacturing Strategy: Study of product/ volume, Layout/ flow (PV/LF), Manufacturing levers, Levels of Manufacturing Capability, Competitive Analysis,

Selection of appropriate Manufacturing systems Supporting methodology for the design of a manufacturing strategy

Process choice, Study of Manufacturing Systems & their Characteristics: Fit between manufacturing systems and PLC, Manufacturing focus, Manufacturing infrastructure, Case studies
Strategy Performance Measurement: Key performance metrics, Strategy evaluation, Bench marking, Value chain, ERP as a tool for evaluation

Unit 5 :
Business Economics: Costing system, elements of product cost, Evaluation cost using traditional and ABC Costing, Life cycle cost analysis, Break even analysis, Working capital cycle, Quality cost, profit and loss accounting, Evaluating capital expenditure

Course Resources

a. Essential Reading

1. Class Notes
2. Charles W. Hill & Gareth Jones, (1998), Strategic Management Theory, All India Publishers & Distributors, Chennai
3. John Miltenburg, (1995), Manufacturing Strategy, Productivity Press, U.S.A

b. Recommended Reading

1. Hill T, (2000), Manufacturing Strategy Text and Cases, Macmillan
2. Johnson G and Scholes K, (2001), Exploring Corporate Strategy Text and Cases, 6th Edition, Prentice Hall
3. Slack, (2001), Operations Management, 3rd Edition, Pitman Publishing
4. John L. Thompson, (2001), Strategic Management, 12th Edition, Chapman and Hall
5. Slack N and Lewis M, (2002), Operations Strategy, Prentice Hall
6. Huczynski and Buchanan, (2001), Organisational Behaviour, 4th Edition, Prentice Hall
7. Hill T, (2000), Operations Management Strategic Context and Managerial Analysis, MacMillan
8. Grinblatt, Mark, Titman and Sheridan, (2006), Financial Markets and Corporate Strategies, Tata McGraw Hill
9. Thompson and Arthur A, (2006), Crafting and Executing Strategy, The Quest for Competitive Advantage Concepts, Tata McGraw Hill
10. Johnson and Gerry, (2007), Exploring Corporate Strategy, Pearson
11. Hanna Barger and Chuck, (2007), Balanced Score Card Strategy for Dummies, Wiley India
12. Ghemawat and Pankaj, (2007), Redefining Global Strategy, Crossing borders in a world where differences Still Matter, Harvard Business School
13. Ghosal, Piramal, Bartlett, (2000), Radical Change: What Indian Companies must do to become world class, Penguin Books of India
14. Arindam Choudhuri, (2001), Count Your Chickens Before They Hatch, Vikas Publishing

c. Other Electronic Resources

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Course Title	Value Education
Course Code	19FET510A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course aims at sensitising students to learn the importance of value education. It gives an insight about the Universal Brotherhood.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Discuss the role of Values and Ethics in Self-Development
- **CO 2.** Appreciate the importance of Universal Brotherhood

Course Contents

Unit 1 :
Values, Ethics and Self-Development; Awareness of self-destructive habits, Power of faith, Positive Thinking

Unit 2 :
Value judgements – Stereotypes, prejudices and biases

Unit 3 :
Sense of duty, Self-reliance, Confidence, Concentration, Discipline, Honesty, Truthfulness

Unit 4 :
National Unity, Patriotism, Love for nature

Unit 5 :
Universal brotherhood and religious tolerance

Course Resources

a. Essential Reading

1. Class Notes

b. Recommended Reading

1.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Internship
Course Code	19MEP521A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

The aim of this course is to make a student experience an industrial or business environment. The student will visit various departments of an industry/business and observe the activities in each department for a certain duration of time and try to relate his/her experience with the theory practiced back at the faculty. The student should develop a report and make a presentation on his/her experience at the industry/business.

Course Outcomes

After undergoing this course students will be able to:

CO 1.
CO 2.

Course Contents

Industry Internship in the relevant organization

Course Resources

a. Essential Reading

1. Organization Website
2. Discussions with Managers/Mentor/Supervisor of different departments of the organization

b. Recommended Reading

1.

c. Other Electronic Resources

1. http://nptel.ac.in/

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Course Title	Group Project
Course Code	19MEP522A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to provide student an opportunity to synergise their learning from the earlier courses through working in a team, sharing responsibilities, to conceiving, designing and fabricating a working prototype of a system related to an automotive application. The students will learn skills related to project identification, planning, management and execution, working in teams and verbal and written communication. During design, analysis and synthesis stage, they will get an opportunity to apply theoretical knowledge to develop real life product and prototyping stage will provide them experience of converting a design into a working system through use of various fabrication techniques available.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Work in a team and undertake a project in their area of specialization
- **CO 2.** Apply their knowledge of general and automotive engineering and application, develop a system for automotive application
- **CO 3.** Apply appropriate research methodology while formulating a project
- **CO 4.** Prepare specifications, design, analyse, synthesize, prototype and assess the system
- **CO 5.** Prepare and present appropriate forms of audio-visual and verbal presentations, and written document, to describe the project, its execution and outcome

Course Contents

Unit 1 :
Team building, Team work and Leadership skills

Unit 2 :
Preparing design specifications, design, analysis and synthesis, design evaluation

Unit 3 :
Costing, Finance Management, Project management

Unit 4 :
Procurement, prototype building and related manufacturing methods

Unit 5 :
Preparing and presenting audio-visual and verbal presentations and preparing written documents

Course Resources

a. Essential Reading

3. Assigned reading relevant to the group project

b. Recommended Reading

2.

c. Other Electronic Resources

2. http://nptel.ac.in/

Course Title	Dissertation and Publication
Course Code	19MEP523A
Department	Mechanical and Manufacturing Engineering
Faculty	Faculty of Engineering and Technology

Course Summary

This course is intended to give an insight to the students on application of principles of research methodology, preparation of research project proposal, research project management, execution of research project and effective technical communication and presentation. It also emphasizes the need and the relevance of a structured approach to identify a research topic and undertake research. This course provides an opportunity for students to apply theories and techniques learnt during programme work. It involves in-depth work in the chosen area of study.

Course Outcomes

After undergoing this course students will be able to:

- **CO 1.** Critically review scholarly literature collected from various sources for the project purpose and formulate a research
- **CO 2.** Prepare and present a research proposal
- **CO 3.** Conduct research to achieve research objectives
- **CO 4.** Propose new ideas/methodologies or procedures for further improvement of the research undertaken
- **CO 5.** Create research document and write research papers for publications
- **CO 6.** Defend the research findings in front of scholarly audience

Course Contents

Unit 1 :
Research Methodology

Information search, retrieval and review

Unit 2 :
Project definition and project planning

Use of conceptual models and frameworks

Unit 3 :
Problem solving and Evaluation

Interpretations and drawing conclusions

Unit 4 :
Proposing ideas or methods for further work

Thesis writing

Unit 5 :
Oral presentation

Authoring Research paper

Course Resources

a. Essential Reading

4. Lecture Sessions on individual project, Thesis Preparation delivered by the concerned Head of Dept.

b. Recommended Reading

3.

c. Other Electronic Resources

3. http://nptel.ac.in/

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