MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

DEPARTMENT: MECHANICAL ENGINEERING

Scheme for Master of Technology in Production Engineering

Semester. I

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1.	21MET541	Advanced Manufacturing Technologies (AMTs)	Lecture	PC	3	3	0	0
2.	21MEP542	Advanced Manufacturing Technologies (AMTs) Laboratory	Laboratory	PC	1	0	0	2
3.	21MET543	CAD/CAM & Robotics	Lecture	PC	3	3	0	0
4.	21MET544	Theory of Machining & Forming Processes	Lecture	PC	3	3	0	0
5.		Program Elective- I	Lecture	PE	3	3	0	0
6.		Program Elective- II	Lecture	PE	3	3	0	0
7.		Program Elective- III	Lecture	PE	3	3	0	0
		Total Semester Credits			19			

Semester. II

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1.	21MET545	Industrial Tribology	Lecture	PC	3	3	0	0
2.	21MEP546	Industrial Tribology Laboratory	Laboratory	PC	1	0	0	2
3.	21MET547	Quality Management	Lecture	PC	3	3	0	0
4.	21MET548	Welding & Casting Technology	Lecture	PC	3	3	0	0
5.	21MEP549	Welding & Casting Technology Laboratory	Laboratory	PC	1	0	0	2
6.		Program Elective- IV	Lecture	PE	3	3	0	0
7.		Program Elective- V	Lecture	PE	3	3	0	0
		Total Semester Credits			17			

Semester. III

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1.	21MED641	Dissertation	Research	PC	6	0	0	6
2.	21MES642	Seminar	Seminar	PC	4	0	0	4
		Total Semester Credits			10			

Semester. IV

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1.	21MED643	Dissertation	Research	PC	12	0	0	12
		Total Semester Credits			12			

*PC= Program Core; PE= Program Elective

List of Program Elective (PE)

S.No.	Course Code	Course Title	Course Category	Type	Credit	L	T	P
1.	21MET825	Advanced Robotics and Expert Systems	Lecture	PE	3	3	0	0
2.	21MET826	Composite Materials & Processing	Lecture	PE	3	3	0	0
3.	21MET827	Experimental Stress Analysis	Lecture	PE	3	3	0	0
4.	21MET828	Maintenance Management	Lecture	PE	3	3	0	0
5.	21MET829	Mechatronics for Intelligent Manufacturing	Lecture	PE	3	3	0	0
6.	21MET830	MEMS & NEMS	Lecture	PE	3	3	0	0
7.	21MET831	Modeling & Simulation	Lecture	PE	3	3	0	0
8.	21MET832	Polymers & their Processing	Lecture	PE	3	3	0	0
9.	21MET833	Precision Manufacturing	Lecture	PE	3	3	0	0
10.	21MET834	Product Design & Development	Lecture	PE	3	3	0	0
11.	21MET835	Rapid Prototyping & Tooling	Lecture	PE	3	3	0	0
12.	21MET836	Tool Design & Engineering	Lecture	PE	3	3	0	0

*PC= Program Core; PE= Program Elective

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET541**			
Course Name	**Advanced Manufacturing Technologies (AMTs)**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	Core			
Prerequisites	Conventional manufacturing technologies, material science			

Course Contents

Advanced Machining Technologies: Review of Metal removal principles, Materials v/s manufacturing technologies, Classification of Advanced Machining Technologies, Sustainable manufacturing, Mechanical Energy Based Technologies: AJM, WJM, AWJM and USM: Process-science, Working principles, Equipment, Process parameters, Applications & Scope. Mechanical Energy Based Finishing Technologies: AFM, MAF, MRF and MRAFM- Process-science, Working Principles, Equipment, Process parameters, Applications & Scope.
Electro-Thermal Energy Based Technologies: EDM & WEDM, LBM, PAM, EBM, IBM: Process-science, Working Principles, Equipment, Process parameters, Applications & Scope, Need & Science of Beam technologies. Chemical and Electro-Chemical Energy Based **Technologies**: CHM, CMP, ECM, ECG Process-science, Working Principles, Equipment, Process parameters, Applications & Scope.
Additive Manufacturing Technologies: Transformation From RPT to AM, LOM, FDM, SLS, SLA, 3-DP etc.: Process-science, Working principles, Equipment, Process parameters, Applications & scope. **Advances in Casting Technologies:** Role of RT in pattern Making, Integration of Powder Metallurgy (PM) with AM technologies.
Advanced Welding Technologies: EBW, LBW, USW: Process-science, Working principles, Equipment, Process parameters, Applications & Scope, Green welding process.
Advanced Metal Forming Technologies: High energy rate forming (HERF), Electro-magnetic forming(EMF), explosive forming(EF), Electro-hydraulic forming(EHF), Science, Working principles, Equipment, Process parameters, Applications & Scope.
Micro/nano Manufacturing Technologies: Principles of top down manufacturing approaches, measurement of micro features, Associated technologies, Challenges with minituration, Forming Tools.

Recommended Readings

Text Books:-

1. "Nontraditional Manufacturing Processes", G.F. Benedict, Marcel Dekker, Inc. New York.

2. “Advanced Machining Processes” Vijay.K.Jain, Allied Publishers Pvt. Ltd., New Delhi.
3. “Manufacturing Engineering & Technology”, Kalpakjian.S., Pearson Education Asia, Latest Ed.
4. "Additive Manufacturing Technologies" Ian Gibson et.al, Springer, 2nd Ed.

Reference books:-

1. Materials and Processes in Manufacturing", E. P. DeGarmo, J. T Black, R. A. Kohser, Prentice Hall of India, New Delhi
2. "Manufacturing Science" A. Ghosh, and A. K. Mallik, Affiliated East-West Press Pvt. Ltd. New Delhi.
3. “Modern Machining Processes” Pandey P.C. and Shan H.S. Tata McGraw-Hill, New Delhi.
4. “Material and Processes in manufacturing” Paul De Garmo, J.T.Black, and Ronald.A.Kohser, Prentice Hall of India Pvt. Ltd., New Delhi.
5. "Introduction to micromachining" V.K Jain, Narosa Pub., 2ed Ed.
6. "Production Technology" by HMT.

Online/E resources:-

1. NPTEL :: Mechanical Engineering - Advanced Manufacturing Processes

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MEP542**			
Course Name	**Advanced Manufacturing Technologies (AMTs) Laboratory**			
Credits	**2**	**L-0**	**T-0**	**P-2**
Course Type	Core			
Prerequisites	Nil			

COURSE CONTENTS

Experiments based on:

1. CAD based part programming for
    a. CNC Lathe,
    b. Milling,
    c. VMC and
    d. FDM-AM Machines.
2. Part programming, Simulation and execution for additive manufacturing using FDM or any other AM machine.
3. Force measurement during CNC Milling and CNC Turning.
4. To make a die kind of component out of hard material on a Die Sink EDM.
5. Finish internally a die kind component on AFM.
6. Understand the need and working of Hybrid-Micro-Machine for miniaturization.
7. Understand the need and working of industrial robot.

List of facilities required

1. Master CAM® / HSM CAM® / Machining module of Hyperworks® software
2. CNC Lathe with Siemens® / Fanuc® Control
3. CNC Milling Machine with Siemens® / Fanuc® Control
4. CNC Die Sink EDM
5. CNC Abrasive Flow Machine
6. CNC Micro-Machine for Hybrid Operations
7. Computer Workstations installed with software packages

Experiments based on:

1. CAD Fundamentals.
2. Sketcher & Free Form environment
3. Solid modelling –Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc

4. Surface modelling –Extrude, Sweep, Trim..etc and Mesh of curves, Free form etc
5. Assembly-Constraints, Exploded Views, Interference check
6. Drafting- Layouts, Standard & Sectional Views, Detailing & Plotting.
7. Visualisation and Animation.

List of facilities required

1. Tools like Autodesk Fusion 360® / Inventor® / Solid Works® / HyperWorks® etc.
2. Computer Workstations installed with software packages

Recommended Readings
Online/E resources:-

1. Software and Services for Education | Autodesk Education Community

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET543**			
Course Name	**CAD/CAM & Robotics**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	Core			
Prerequisites	Nil			

Course Contents

CAD/CAM Processes, Role of CAD/CAM/CAE in the Product Cycle, CAD tools to support the design process and manufacturing, Benefits of CAD/CAM/CAE in the industry Application of CAD in Design: Application to Drafting, 3 - D Modeling, Applications, Integration of Design, Analysis and CAD.

Introduction to Robotics, Robotic System & Anatomy Classification, Future Prospects, Drives: Control Loops, Basic Control System Concepts & Models, Control System Analysis, Robot Activation & Feedback Components, Position & Velocity Sensors, Actuators, Power Transmission Systems, Robotic Application in Manufacturing: Material transfer, Machine loading & unloading, Processing operations, Assembly & Inspectors

Robot Kinematics: Coordinate Frames, Rotations, Homogeneous Coordinates, Arm Equation of Planer Robot, Four axis SCARA Robot, TCV, Inverse Kinematics of Planer Robot, Four Axis SCARA Robot.

Part Program Terminology: G and M Codes, Types of interpolation, Methods of CNC part programming, Manual part programming, Computer Assisted part programming: APT language, CNC part programming using CAD/CAM-Introduction to Computer Automated Part Programming.

Fundamental of Solid Mechanics, Finite Element Analysis, Discritization: Analysis of Spring Element: Analysis of Link element: Analysis of Beam element:

Control of Robots: Open loop control and closed loop control of robot manipulators, open loop control by computed torque method, closed loop control for disturbance rejection and trajectory execution, individual joint PID control of single link manipulators.

Recommended Readings

Text Books:-

1. CAD/CAMTheory and practices,2/e-Ibrahim Zeid (McGraw Hill).
2. JJ Craige, Introduction to Robotics, Pearson Education, New Delhi.
3. Groover, Weiss, Nagel and Odrey, "Industrial Robotics", McGraw-Hill.

Reference books:-

1. P. N. Rao "CAD/Cam principles and operations", Tata McGraw Hill

Online/E resources:- NPTEL Resources

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET544**			
Course Name	**Theory of Machining & Forming Processes**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	Core			
Prerequisites	Nil			

Course Contents

Thermodynamics of chip formation- The shear plane temperature-Interface temperature from dimensional analysis-Experimental determination of chip tool Interface temperature. Coolants-Theory of cutting fluid action at the chip tool interface, Techniques for application of cutting fluids, Tool Wear: Criteria of wear, Machinability and tool life, Flank wear-Taylor's tool life equation, crater wear, causes & mechanism of tool failure

Force system in turning, Merchant circle diagram, velocity relationship and Kronenberg relationship. Stress in conventional shear plane. Energy of cutting process, restricted cutting, Force analysis during oblique cutting. Earnest & Merchant angle relationship, Lee-shafer relationship, Forces in drilling & plane slab milling, Measurement of forces-dynamometer for measuring turning & drilling forces

Fundamentals plasticity: True stress-strain curve. Bauschinger effect. Empirical equations to stress strain curves. Three-dimensional stress and strain invariants and strain. Yield criteria of materials: Tresca and Von-Mises theory, Prandtl Reuss and Levy Mises stress strain relations, work hardening. Deformation of metals, stress-strain curves, temperature and strain rate effects, ductility and toughness, plane-strain deformation, mechanism of plastic deformation, control of material properties—alloying and heat treatment.

Analysis of Forming Processes,- Slab method, Upper & lower bound, FEM based simulation, slip line theory, Use of CAE platform for Die Design & Simulation**.**

Recommended Readings

Text Books:-

1. Modern machining process - PANDEY AND SHAH
2. Metal cutting theory and practices – A. Bhattacharya
3. Manufacturing science by Amitabh Ghosh and Mallik
4. Mechanical Metallurgy / G.E. Dieter / Tata McGraw Hill, 1998. III Edition
5. Principles of Metal Working / Sunder Kumar
6. Engineering Plasticity – W. Johnson (Von Nostrand)

Reference books:-

1. Principles of Metal Working processes / G.W. Rowe
2. ASM Metal Forming Hand book
3. Mechanical Metallurgy Si Metric Edition by George E. Dieter, McGraw Hill Book Company
4. Metal Forming: Mechanics and Metallurgy by William F. Hosford and Robert M. Caddell, PTR Prentice-Hall (USA)
5. Handbook of Metal Forming by K. Lange (Editor-inChief), Springer Verlag (Germany)
6. Metal Forming: Processes and Analysis – Avitzur (TMH)
7. The Mathematical Theory of Plasticity by R. Hill, Oxford University Press, 1950
8. Engineering Plasticity by W. Johnson and P.B. Mellor, von Nostrand Co. Ltd, 1972
9. Theory of Plasticity by J. Chakrabarty, McGraw-Hill Book Co., International Edition, 1987

Online/E resources:-

1. Mandhadi Anusha1 , Dr. Venkata Ramesh Mamilla , Dr. G.Lakshmi Narayana Rao. Optimization and Analysis of Tool Life Based on Flank Wear in a Turning Process. International Journal for Research in Applied Science & Engineering Technology (IJRASET). Volume 4 Issue VII, July 2016
2. M. Narasimha1 , K. Sridhar , R. Reji Kumar , Achamyeleh Aemro Kassie. Improving Cutting Tool Life a Review. International Journal of Engineering Research and Development e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com Volume 7, Issue 1 (May 2013), PP. 67-75
3. An experimental investigation of oblique cutting mechanics Burak Aksu,Ceren Çelebi &Erhan Budak Pages 495-521 | Published online: 19 Jul 2016. Machining Science and Technology An International Journal Volume 20, 2016
4. Metal forming progress since 2000 CIRP Journal of Manufacturing Science and Technology vol.1(1), pp 2–17.
5. Gracious Ngaile,Brad Kinsey (2011). Advances in Plastic Forming of Metals. *J. Manuf. Sci. Eng*. Dec 2011, vol. 133, issue (6): 060301 (3 pages).
6. Sanjeev Kumar and Erwin Povoden-Karadeniz. Plastic Deformation Behavior in Steels during Metal Forming Processes: A Review DOI: 10.5772/intechopen.97607
7. J.T. Gau, G. L. Kinzel, "An experimental investigation of the influence of the Bauschinger effect on spring back predictions", Journal of Materials Processing Technology Vol. 108, pp.369-375, 2001

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET545**
Course Name	**Industrial Tribology**
Credits	**3 L-3 T-0 P-0**
Course Type	Core
Prerequisites	The students should have basic knowledge of engineering mechanics, thermodynamics, fluid mechanics, design of machine elements, solid mechanics and mathematics.

Course Contents

Introduction: Tribology, Types of engineering contacts: conforming and non-conforming, Surface interactions and characterization, micro and nanotribology, surface roughness measurement techniques, surface energy and flash temperature theory.
Friction: Types, Laws of sliding friction, concept of adhesion, Models of asperity deformation, measurement of friction, friction of metals ceramics and Polymers.
Wear: Types of Wear and its Mechanisms (Adhesive Wear, Abrasive Wear, Erosive Wear, Corrosive/Oxidative Wear, Fatigue Wear), Wear of Metals, Wear of Ceramics, Wear of Polymers, Wear Test (Pin on Disc Tribometer, Reciprocating Tribometer), Wear reduction methods
Viscosity: Basic definition, conversions, dynamic viscosity, Measurement, variation with temperature, ASTM Charts, Viscosity index, Grade of oil.
Lubrication Theories: Lubrication regimes, viscous flow and viscometry, Reynold's equation, hydrodynamic lubrication, hydrostatic lubrication, elasto-hydrodynamic lubrication, boundary lubrication, squeeze films, turbulent lubrication, Lubricants and their types, Purpose of Lubrication, General Properties of Liquid Lubricants, Animal and Vegetable Oils, Mineral oils, Synthetic oils, Blended Oils, Lubricant Additives, Semi Solid Lubricant or Greases, Solid Lubricants, Testing of Lubricants.

Recommended Readings

Text Books:-

1. Friction and Wear of Engineering Materials I.M. Hutchings, Edwar Arnold, London
2. Friction and Lubrication E.P. Bowden and Tabor
3. Fundamentals of Tribology Basu, Sengupta & Ahuja
4. Engineering Tribology Stachowiak & Bachelor
5. Principles and Applications of Tribology Bhushan B.
6. Basic Lubrication Theory A Comeron

Reference books:-

1. Friction Wear & Lubrication Kenneth C.Ludema
2. Engineering Tribology J.A.Williams
3. Applied Tribology Khonsari
4. Friction and Wear of Materials Rabinowicz
5. Fundamentals of Fluid Film Lubrication Hamrock, Schmid, Jacobson

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MEP546**			
Course Name	**Industrial Tribology Laboratory**			
Credits	**2**	**L-0**	**T-0**	**P-2**
Course Type	Core			
Prerequisites	Engineering Materials and Processes			

Course Contents

1. Erosion wear behaviour of material under slurry environment using slurry jet erosion tribometer.
2. Erosion wear behaviour of material under dry environment using air jet erosion tribometer.
3. To determine the wear and co-efficient of friction of a material in dry and wet condition using pin-on-disk wear test rig.
4. Three body abrasion wear of material under dry and slurry environment using three body abrasion tribometer.
5. Estimation of wear rate of the material using linear reciprocating tribometer.
6. Determination of adhesive strength of the material using scratch test rig.
7. Torque Measurement of different lubricants at low temperature environment.

List of facilities required

1. Slurry erosion test rig
2. Abrasive wear test rig
3. Pin on disc tribometer test rig
4. Linear reciprocating tribometer
5. Air jet erosion test rig
6. Scratch test rig
7. Low temperature torque tribo-tester

Recommended Readings

Text Books:-

1. Ian Hutchings, Philip Shipway, Tribology: Friction and Wear of Engineering Materials (2nd ed.), Butterworth-Heinemann, 2017
2. Harnoy, A. “Bearing Design in Machinery, Engineering Tribology and lubrication”, published by Marcel Dekker Inc. 2003

Reference books:-

1. Ernest Rabinowicz, Friction and Wear of Materials (2nd ed.), John Willey & Sons, 1995
2. Horst Czichos, Tribology: a System Approach to the Science and Technology of
3. Friction, Lubrication and Wear, Elsevier, 1978
4. Friction and Wear Testing: Source Book of Selected References from ASTM
5. Standards and ASM Handbooks, ASM International, 1997

Online/E resources:-

1. NPTEL Resources
2. ASTM Standards

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET547**			
Course Name	**Quality Management**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	Core			
Prerequisites	Knowledge of basic statistics and working of manufacturing and service sector industries			

Course Contents

The meaning of Quality and quality control, dimensions of quality, quality of design and quality of conformance. Economics of quality. Modeling process of quality: describing variation, frequency distribution, continuous and discrete, probability distributions, and pattern of variation. Inferences about process quality: sampling distributions and estimation of process parameters. Analysis of variance.

Statistical Quality Control: Concept of SQC, Chance and assignable causes of variation, statistical basis of control chart, basic principles, and choice of control limits, sample size and sampling frequency, analysis of patterns on control charts. The magnificent seven tools. Control charts for variables,: X-bar and R charts, X-bar and S charts, control chart for individual measurement. Application of variable control charts. Control chart for attributes: control chart for fraction non-conforming P-chart, np-chart, c-chart and u-chart. Demerit systems, choice between attribute and variable control chart.

Process capability analysis using histogram and probability plot, capability ratios and concept of six sigma. Quality Assurance: Concept, advantages, Acceptance Sampling: Fundamental concepts in acceptance sampling, operating characteristics curve. Acceptance sampling plans, single, double and multiple sampling plans, LTPD, AOQL, AOQ. Introduction to Quality systems like TQM, ISO 9000 and ISO 14000. Reliability and Life Testing- Failure models of components, definition of reliability, MTBF, Failure rate, common failure rate curve, types of failure, reliability evaluation in simple cases of exponential failures in series, paralleled and series-parallel device configurations, Redundancy and improvement factors evaluations. Introduction to availability and maintainability.

Recommended Readings

Text Books:-

1. Fundamentals of Quality Control and Improvement, Amitava Mitra, 2nd Edition, Prentice Hall.
2. Statistical Quality Control, E. L. Grant and Richard S. Leavenworth, Tata McGraw-Hill.
3. Quality Control, Dale H. Besterfield, 8th Edition, Pearson/Prentice Hall

Reference books:-

1. Design and Analysis of Experiments, 5th Edition, Douglas C. Montgomery, Wiley-India
2. Quality Planning and Analysis, J.M.Juran and F.M. Gryna, McGraw Hill
3. Quality planning and analysis, McGraw Hill. Koru Ishikawa.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET548**
Course Name	**Welding & Casting Technology**
Credits	**3 L-3 T-0 P-0**
Course Type	Core
Prerequisites	Knowledge of Undergraduate level subjects of Production Technology

Contents

Gating system for casting, Elements of a gating system, Sprue, Sprue base well, Gates, Gating system design, Pouring time, Choke area, Gating ratios, Ingate design, Slag trap systems, Riser design, Caine's method, Modulus method, Naval research lab method, Chills, Feeding aids
Solidification of metals, Freezing of a pure metal, Nucleation and Growth, Shrinkage, freezing of alloys, Thermal characteristics of the mould, casting defects, gas defects, pouring metal defects, Metallurgical defects.
Basic Metallurgy of fusion welds, general theory of solidification of metals and alloys, homogeneous and heterogeneous nucleation, Effect of welding speed on grain structure, properties of weld metals, fusion boundary zone, heat affected zone, properties of heat affected zone, Welding stress and distortion, residual stress, causes of residual stress, effect of weld thermal cycle and shrinkage on residual stresses, Reaction stresses, stresses generated by phase transformation, Measurement and calculation of residual stresses in weld metals..
Pre-heat and post weld heat treatment, Methods of Pre-heating, Advantages and limitations of preheating, weld defects, classification, arc welding defects and other than arc welding defects, Weld inspection, residual inspection, NDT testing.

Recommended Readings

Text Books:-

1. Modern welding technology: - Carry H. B. (Pearson; 2004)
2. Welding and welding technology: - Richard Little (TMH;2017)
3. Welding technology: - R. S. Parmar (Khanna Publishers;2013)

Reference books: -

1. AWS- welding handbook (AWS;2019)
2. Modern Arc Welding technology: - Nadkarni S. V. (Ador Welding;2008)
3. Welding Metallurgy :- Sindo Kou (Wiley;2003)
4. Handbook of Quenchants and Quenching Technology :- George E. Totten , C. E. Bates, N. A. Clinton (ASM;1993)

Online/E resources: -

1. https://www.aws.org/
2. https://nptel.ac.in/

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MEP549**
Course Name	**Welding and Casting Technology Laboratory**
Credits	**2 L-0 T-0 P-2**
Course Type	Core
Prerequisites	Knowledge of under graduate level welding, casting and fabrication laboratories.

Course Contents

1. Effects of welding parameter on bead geometry and shape relationship with GTAW.
2. Effects of welding parameter on bead geometry and shape relationship with GMAW.
3. Effects of welding parameter on bead geometry and shape relationship with SAW.
4. Effects of welding parameter on bead geometry and shape relationship with Plasma welding.
5. Effects of welding parameter on bead geometry and shape relationship with laser welding.
6. Hands on practice on Oxy fuel welding, Oxy fuel cutting and brazing.
7. Welding, Cladding and surfacing using Robotic GMAW.
8. Study of Friction stir welding process.
9. Study and testing of corrosion and corrosion rate on various weldment.
10. Fabrication of metal matrix composite using stir casting Process, mechanical and microstructural evaluations of casted product.
11. To describe various types of casting Processes.
12. To study the various steps of investment casting process.

Recommended Readings

Text Books:-

1. Modern welding technology: - Carry H. B. (Pearson; 2004)
2. Welding and welding technology: - Richard Little (TMH;2017)
3. Welding technology: - R. S. Parmar (Khanna Publishers;2013)

Reference books: -

1. AWS- welding handbook (AWS;2019)
2. Modern Arc Welding technology: - Nadkarni S. V. (Ador Welding;2008)
3. Welding Metallurgy :- Sindo Kou (Wiley;2003)

Online/E resources: -

1. https://www.aws.org/
2. https://nptel.ac.in/

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**MECHANICAL ENGINEERING**
Course Code	**21MED641**
Course Name	**Dissertation**
Credits	**6** **L-0** **T-0** **P-6**
Course Type	Core
Prerequisites	To carryout technical and practical issues related to production engineering

Course Contents

1. Identify the problem
2. Formulate problem and select appropriate research method(s).
3. Search relevant literature and identify research gap.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**MECHANICAL ENGINEERING**			
Course Code	**21MES642**			
Course Name	**Seminar**			
Credits	**4**	**L-0**	**T-0**	**P-4**
Course Type	Core			
Prerequisites	To carryout technical and practical issues related to production engineering			

Course Contents

1. Identify and compare technical and practical issues related to production engineering
2. Outline annotated bibliography of research demonstrating scholarly skills.
3. Search the existing literature and evaluate the literature for identification of research problem
4. Prepare a well-organized report employing elements of critical thinking and technical writing.
5. Demonstrate the ability to describe, interpret and analyze technical issues and develop competence in presenting.

Semester 4 (Dissertation)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**MECHANICAL ENGINEERING**			
Course Code	**21MED643**			
Course Name	**Dissertation**			
Credits	**12**	**L-0**	**T-0**	**P-12**
Course Type	Core			
Prerequisites	The students should have studied the basic course of production engineering			

Course Contents

1. Identify a problem in area of production engineering
2. Review literature to identify gaps and develop research methodology
3. Develop a model, experimental set-up and/or computational techniques necessary to meet the objectives
4. Prepare a report as per the recommended format and defend the work.
5. Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET825**
Course Name	**Advanced Robotics and Expert Systems**
Credits	**3 L-3 T-0 P-0**
Course Type	**Program Elective**
Prerequisites	Nil

Course Contents

Introduction and Robot Kinematics: Definition need and scope of Industrial robots – Robot anatomy –Work volume – Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects.

Robot Drives and Control: Controlling the Robot motion – Position and velocity sensing devices –Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers.

Robot Sensors: Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system.

Robot Cell Design and Application: Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots.

Robot Programming, Artificial Intelligence and Expert Systems: Methods of Robot Programming –Characteristics of task level languages lead through programming methods – Motion interpolation. Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques – problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots

Recommended Readings

Text Books:-

1. K.S.Fu, R.C. Gonzalez and C.S.G. Lee, “Robotics Control, Sensing, Vision and Intelligence”,McGraw Hill, 1987.

Reference books:-

1. YoramKoren," Robotics for Engineers' McGraw-Hill, 1987
2. Kozyrey, Yu. "Industrial Robots", MIR Publishers Moscow, 1985
3. Richard. D, Klafter, Thomas, A, Chmielewski, Michael Negin, "Robotics Engineering – An Integrated Approach", Prentice-Hall of India Pvt. Ltd., 1984.

Reference books:-

1. Deb, S.R."Robotics Technology and Flexible Automation", Tata McGraw-Hill, 1994.
2. Mikell, P. Groover, Mitchell Weis, Roger, N. Nagel, Nicholas G. Odrey," Industrial Robotics Technology, Programming and Applications", McGraw-Hill, Int. 1986.
3. Timothy Jordanides et al ,"Expert Systems and Robotics ", Springer –Verlag, New York, May 1991.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET826**
Course Name	**Composite Materials & Processing**
Credits	**3 L-3 T-0 P-0**
Course Type	**Program Elective**
Prerequisites	The students must have studied basic concepts of material science and material testing at their bachelor's degree level.

Course Contents

Classifications and selecting criteria of engineering materials; concept and classification of composite materials, Difference w.r.t alloy systems, General characteristics and merits/demerits/applications; definition / role / classification of matrix phase, desired properties of matrix phases, examples of matrix phases; definition / role / classification of reinforcing phase, desired properties of reinforcing phase, examples of reinforcing phase; Role of interface, basic design criteria of composites, case studies

Classification of composites materials: Based on Matrix material: Polymer matrix composites, Ceramic matrix composites, Metal matrix composites; Based on Nature: Organic and Inorganic, Natural and Synthesis; Based on Size of reinforcements**:** Macro, Micro, Nano etc.; Based on Reinforcements**:** Fiber reinforced composites, Particulate reinforced composites;

Based on other domain: Hybrid (Multi-phase i.e. Multi-matrix phase or Multi-reinforced phase) composites, laminates composites, Homogeneous and Heterogeneous (functionally graded) composites, Friction composite materials, etc., case studies

Fabrication methods of composite materials: Polymer matrix composites: Open mold process like hand lay-up, spray lay-up, tape lay-up, bag molding (vacuum & pressure), autoclave method, etc.; Closed mold processes like compression molding, injection molding, resin transfer molding; pre-pegging; sheet molding process, etc.; Other methods like extrusion, pultrusion, filament winding

Ceramic matrix composites: Powder Metallurgy (P/M), Chemical Vapor Infiltration (CVI), Modified CVI, Slurry impregnation, Liquid Silicon infiltration (LSI) or Reactive Melt Infiltration (RMI), Direct Metal Oxidation (DIMOX), Sol-Gel infiltration; Polymer Infiltration and Pyrolysis (PIP), Non-reactive liquid melt infiltration

Metal matrix composites: Liquid state like stir casting, pressure die infiltration, squeeze casting, etc.; Solid state like diffusion bonding, power metallurgy/sintering; In-situ fabrication like particulate in-situ MMC; short-fiber reinforced in-situ MMC, long-fiber reinforced in-situ MMC; Co-deposition like electrolytic; spray; vapor, etc. Some discussions on secondary methods of composite materials, Case studie

Testing of Composites: Tensile/Compressive testing, Flexural/Intra-laminar/Inter-laminar/Shear testing, Fracture testing, Fatigue testing, Creep testing, Hardness testing, Impact testing, Corrosion

testing, Density/Void fraction determination, Ash content determination; Acetone extractable test, Swelling test etc., Case studies
Characterization techniques: SEM, TEM, XRD, DSC, DTA, TGA, DMA, etc. Case studies

Recommended Readings

Text Books:-

1. Engineering Mechanics of Composite Materials, Issac M. Daniel, Ori Ishai, Oxford University Press
2. Engineering Materials: Properties and Selection, Kenneth G., Budinski Michale, K. Budinski, PHI learning Private limited
3. Mechanical Behaviour and Testing of Materials, AK Bhargava, CP Sharma, PHI learning Private limited
4. Engineering Materials: Polymers, Ceramics and Composites, AK Bhargava, PHI learning Private limited

Reference books:-

1. Material Science and Engineering, William F Smith, Javad Hashemi, Ravi Prakash, MC Graw Hil
2. Callisters Material Science and Engineering, William D. Callister, R. Balasubramaniam, Wiley India (P) Ltd.
3. Handbook of composite fabrication, Guneri Akovali, Rapra Technolgy Ltd.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET827**			
Course Name	**Experimental Stress Analysis**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	Nil			

Course Contents

Review of basic FEM concepts, FEM Discretization and the Direct Stiffness Method: Basic concepts of structural modeling, Review of the stiffness method of structural analysis, Modeling stiffness, loads and displacement boundary conditions.
Three Dimensional Photo Elasticity: Neuman's stain optic relationship, stress freezing in models, materials for three-dimensional photo-elasticity, shear-difference method of stress separation. BIREFRINGENT COATINGS: Sensitivity reinforcing effects and thickness of bi-refringent coatings.
Electric Resistance Strain Gauges: Gauge construction and installation, temperature compensation, gauge sensitivity, gauge factor, corrections for transverse strain effects. Factors affecting gauge relation, Rosettes, Rosettes analysis, potentiometer and wheat stone bridge circuits for strain measurements.
Brittle Coatings: Introduction, coatings, stresses and failure theories, different types of crack patterns, crack detection, Composition of brittle coatings, coating cure, influence of atmospheric conditions, and effect of biaxial stress field.

Recommended Readings

Text Books:-

1. Experimental Stress Analysis Dally &Ralley
2. Introduction to Photo Mechanics Durellil&Hiley

Reference books:-

1. Photo elasticity: Principles and Methods Jesseop& Harris
2. Theory of Plasticity J. Chakrabarty

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET828**
Course Name	**Maintenance Management**
Credits	**3 L-3 T-0 P-0**
Course Type	**Program Elective**
Prerequisites	Knowledge of basics of statistics and how to perform maintenance

Course Contents

Reliability: Definition, failure data analysis, Mean failure rate, mean time to failure (MTTF), mean time between failures (MTBF), hazard rate, Bathtub curve. Use of Weibull probability chart for assessing characteristics life, guarantee period etc. System Reliability: Series, parallel and mixed configuration; Simple problems. Reliability improvement: Techniques, use of Pareto analysis-Design for reliability, redundancy unit and stand by redundancy, Optimization of reliability, Failure modes, Event Tree and Fault Tree analysis.
Introduction: Maintenance Objectives and Functions; Maintenance Organization and Administration of Maintenance Systems. Need of planned maintenance. Maintenance policies; Breakdown, time based maintenance: Block replacement, age replacement and periodic replacement policy. Corrective and Preventive maintenance. Maintenance planning, Scheduled maintenance. Cost of maintenance versus Cost of equipment and production delays. Inspection: Inspection intervals, Inspection reports, card history system.
Predictive maintenance, Equipment wears records, standards. Equipment used in predictive maintenance. Computerized maintenance, Total Productive Maintenance. Methods of condition monitoring, Non-destructive testing: Liquid Penetrate, Magnetic particles, Ultrasonic testing, and Vibration analysis. Oil analysis, Radiographic testing.

Recommended Readings

Text Books:-

1. Reliability Engineering by A.W. Von, PHI, ND.
2. Mechanical Reliability by L.S. Srinath, Published by EWP.
3. Maintenance Planning and Control by Enthory Kelly, EWP-NWP, ND.

Reference books:-

1. Smith, D.J. “Reliability Maintainability and Risk; Practical methods for engineers”, Butterworth-Heinemann, New Delhi, 2001
2. Dhillon, B.S. “Maintainability, Maintenance and Reliability for Engineers”, CRC Press 2006
3. Pha, H. “Handbook of Reliability engineering”, Springer Publication, 2003.
4. Dhillon, B.S “Engineering maintenance; a modern approach”, CRC Press, 2002
5. Mobley, R.K. “Maintenance Fundamentals”, 2nd Edition, Butterworth-Heinemann, 2004

6. Brauer, R.L. “Safety and Health for Engineers”, John Wiley Sons, 2006
7. Reliability Maintenance and Risk, Elsevier Science and Technology Books, 1997

Online / E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET829**
Course Name	**Mechatronics for Intelligent Manufacturing**
Credits	**3 L-3 T-0 P-0**
Course Type	**Program Elective**
Prerequisites	**Nil**

Course Contents

Manufacturing Automation: Components of Automation, Economics of Automation, Automation for productivity and cost reduction, Hard and soft automation, Automation in Industry 4.0 era. Definitions of mechatronics, modification in product / process design process due to Mechatronics, Mechatronic systems and components, Introduction to mechatronics based case studies i.e. CNC Machines, Robots, Automobiles etc..

Sensors and signal conditioning: Introduction, Sensor classification, Based on the Physics, Based on Application, Signal conditioning, Sensor Models, Sensor/ Transducer types, Measurement Systems**:** Data input Devices, Data output / display devices, Data presentation devices, Data Storage, Data Handling, measurement errors, Data Acquisition (DAQ), Data Logger.

Actuators and their interface**:** Classification of actuators, Mechanisms, Electric actuators, Pneumatic/Hydraulic actuators, Electro Hydraulic /Electro Pneumatic Actuators, Mechanical Actuators

Controllers and their programming: Classification of controllers, Microcontrollers, Micro Processors, Programmable Logic Controller, Embedded systems, Pseudo Codes, Low level Programming, High level Programming, Programming Strategies. Hardware and Software Interfacing, Control Schemes: Mathematical modelling, Classical and non-classical control, Design approaches, Real Time Control

Manufacturing Automation / Mechatronics Design Case Studies: CNC Machines, Robots, Automobiles etc.

Recommended Readings

Text Books:-

1. Cochin, Era and Cadwallender, “Analysis and design of Dynamic Systems”, Addison-Wesley, 1997.
2. Tomkinson, D. And Horne, J. Longman, “Mechatronics Engineering”, Mc Graw Hill, 1996.
3. Bolton, W., “ Mechatronics”, Pearson.

Reference books:-

1. Handbook of design, manufacturing &Automation : R.C. Dorf, John Wiley and Sons.
2. Automation, Production Systems and Computer Integrated Manufacturing, M.P. Groover, Pearson Education.
4. Industrial Automation : W.P. David, John Wiley and Sons.
5. Computer Based Industrial Control, Krishna Kant, EEE-PHI
6. An Introduction to Automated Process Planning Systems, Tiess Chiu Chang & Richard A. Wysk
7. Manufacturing assembly Handbook:-BrunoLotter
8. Anatomy of Automation, Amber G.H & P. S. Amber, Prentice Hall.
9. Performance Modeling of Automated Manufacturing Systems, Viswanandham, PHI
10. Automation by W. Buekinsham.

Online/E resources:-

1. Mechatronics - Course (nptel.ac.in)

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET830**			
Course Name	**MEMS & NEMS**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	Nil			

Course Contents

Introduction, History, Development and need of Micro-Electro-Mechanical Systems. Overview of MEMS technology.
Different electro-physical processes used for machining – dealing with MEMS materials; relevant non-conventional processes; IC fabrication processes used for MEMS.
MEMS sensors and actuators; Mechanical process techniques and process models for micromachining.
Fabrication processes and design of the process sequences; Agile Prototyping of design and manufacturing processes in micro-machining and computer based design.
Reliability and process control of micro manufacturing processes; Introduction and exposure to nano technology processes and systems.

Recommended Readings

Text Books:-

1. Vijay Varadan, K. J. Vinoy, K. A. Jose, "RF MEMS and Their Applications", Wiley, 2002.
2. Gabriel M. Rebeiz, "RF MEMS: Theory, Design, and Technology", Wiley, 2003.
3. Marc Madou, "Fundamentals of Microfabrication", 2nd Edition, CRC Press, 2002.
4. C. Liu, "Foundations of MEMS", 2nd Edition, Pearson, 2011.

Reference books:-

1. N. Maluf, "An Introduction to Microelectromechanical Systems Engineering", Artech House, 2000.
2. J. Pelesko & D. Bernstein, "Modeling MEMS and NEMS", CRC Press, 2002.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET831**			
Course Name	**Modeling & Simulation**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	Nil			

Course Contents

Review of basic FEM concepts, FEM Discretization and the Direct Stiffness Method: Basic concepts of structural modeling, Review of the stiffness method of structural analysis, Modeling stiffness, loads and displacement boundary conditions.
Formulation of Finite Elements: Mathematical interpretation of finite elements, variational formulation, Development of continuum elements, shape functions, consistent loads, Isoparametric elements for plane stress, Numerical integration, Convergence requirements.
Computer Implementation of the Finite Element Method: Pre-processing: model definition, Element level calculations, Equation assembly, Equation solver, Post processing: strain and stress recovery
Material nonlinearity: Rate independent elastoplasticity with return-mapping algorithm, Isotropic and kinematic hardening with Baushinger effect, Consistent tangent operator, Objective rate and finite rotation elastoplasticity.
Introduction to systems and modeling - discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation and their applications in queuing and inventory problems. Discrete Simulation, Continuous Simulation, Combined Simulation, Problem formulation, Mechanics of discrete simulation- discrete events, representation of time, generation of arrival pattern, simulation examples, simulation programming tasks, gathering statistics, measuring utilization and occupancy recording distributions and transit times, case studies
Analysis of Simulation output, Importance of the variance of the sample mean, Procedure for estimating variance, Subinterval method, Replication Method, Regenerative method; Variance reduction techniques, start up policies, Stopping rules, Statistical inferences, Design of experiments, Manufacturing Processes, Simulation case studies

Recommended Readings

Text Books:-

1. Finite element analysis by P.Seshu, PHI, 2003.
2. Geoffrey Gordon., “System Simulation”, Prentice Hall, 1978
3. An Introduction to Finite Element Method by J.N. Reddy, McGraw-hili, New York.

4. Finite Element Analysis -Theory and Programming by C.S. Krishnamurthy, Tata McGraw Hill

Reference books:-

1. The Finite Element Method in Engineering by S.S. Rao, Pergamon, New York.
2. Jerry Banks and John S, Carson II “Discrete Event system Simulation”, Prentice Hall, 1984.
3. Francis Neelamkovil, “Computer Simulation and Modelling”, John Willey and sons, 1987.

Online/E resources:-

1. NPTEL Resources

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET832**			
Course Name	**Polymers & their Processing**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	**Nil**			

Course Contents

Basics of polymers, Classifications based on occurrence, types, process, and end uses; Engineering plastics, Rubbers and fibers, Specialty polymers, Conducting polymers, Composites, Biopolymers and biodegradable polymers, Synthetic resins, Polymers for packaging application, Polymers for biomedical engineering applications, Selection criteria of polymers

Science of polymerization; Mechanical properties of polymers; Thermal properties of polymers; Electrical properties of polymers, Characterization and testing of polymers

Theoretical aspects; Visco-elastic behavior, Mathematical models for visco-elastic behavior, Deformation behavior of plastics, Reinforced plastics

Fundamental concepts, properties and analysis of polymer melt flow; Newtonian and non-Newtonian fluid flow, Flow in circular section, Flow in rectangular section etc.

Polymer Process Engineering: Introduction and classification of various polymer processing methods; Various mixing devices; Overview and analysis of extrusion moulding, Injection moulding, Special moulding techniques like Spinning, Calendaring, Methods of sheet forming – Thermoforming – Vacuum forming, Pressure forming and Matched mould forming – Rotation moulding, Compression moulding, Transfer moulding, Blow moulding, Processing of reinforced plastics, Plastic finishing techniques - powder coating - metallizing, Basic concepts of die design for simple components

Recommended Readings

Text Books:-

1. F.W. Billmayer, Text Book of Polymer Science, 3rd edition, John Wiley and sons, New York, 2002.
2. Gorge Odeon – Principles of Polymerization, 4th edition, McGraw Hill Book Company, New York. 2004.
3. Premamoy Ghosh ," Polymer Science and Technology, 2ndedition,McGraw-Hill Publishing Company Limited, New Delhi, 2003.
4. D.H. Morton-Jones, Polymer Processing, Springer verlaggmbh (2014)

Reference books:-

1. Tim A. Osswald Georg Menges “Material Science of Polymers for Engineers”, Hanser Publications, 2012.
2. Crawford R.J. Plastics Engineering, Butterworth - Heinemann, 3rd Edition, 2005.
3. Friedhelm Hansen, Plastics Extrusion Technology, 2nd Edition, Hanser Publishers, 1997.
4. Birley, Haworth, Batchelor, Physics of Plastics – Processing Properties and Materials Engineering, Hamer Publication, 1992.
5. J.J. Aklonis and J. McKnight, Introduction to Polymer Viscoelasticity, John Wiley and sons, New York, 1983.
6. S. K. Nayak, S. N. Yadav, S. Mohanty, Fundamentals of Plastic Testing, Springer, 2010.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET833**			
Course Name	**Precision Manufacturing**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	**Advanced Manufacturing Technologies**			

Course Contents

Introduction: basic definition, size scales, scaling analysis, technology change, Lithographic Processes-Optical and X-ray.

Precision Engineering and Practices: Definitions, Sources of Error, Basic Concepts of Machining, Machine Tool Variables- accuracy, stiffness, spindle vibration, flatness, straightness, and smoothness of motion, 1-2 DOF systems, Feedback Variables, Cutting Tool Variables, Workpiece Variables, Environment Effects and Thermal Errors.

Introduction to Machining Analysis: geometry of Cutting Edge, Energy Models, Comparison with Microscale Machining. Diamond Micromachining: Introduction, Diamond as a Tool Material, Compatible Materials, Diamond Performance, Diamond Machining, Micro-mechanical Applications, Diamond Machining as a Micro-mechanical Process Research Method, Ductile Regime Grinding MICRO-ECM, MICRO-EDM etc. Micromilling: Micro-milling Tools, Process Results and Micro-milling Applications-micromechanically milled X-ray masks, micro-milled mask materials, Mask Absorption Quantification, Exposure Quantification. Microdrilling: Micro-drilling and Macro-drilling Techniques. Laser Micromachining: laser Optics, Laser Ablation, Heat Affected Zone and Laser Polymerisation. LIGA, S-LIGA

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

Recommended Readings

Text Books:-

1. Jain V. K., “Introduction to micromachining”, Narosa Publishers, 2010.
2. M. Madou, “Fundamentals of microfabrication”, CRC Press, 2011.
3. M. V. Suryaprakash, “Precision Engineering”, Narosa Publishers, 2004.
4. V. C. Venkatesh and Sudin Izman, “Precision Engineering”, Mc Graw Hill, 2007.

Reference books:-

1. Kluwer, “A new direction in manufacturing”, Academic Publishers, London, 1997.
2. J. A. McGeough, “Advanced methods of machining”, Chapman and Hall, London, 1988.
3. G. Chryssolouris, “Laser machining – theory and practice”, Springer Verlag, New York, 1991.

Online/E resources:-

NPTEL course on Advanced Machining Processes by Prof. Vijay K. Jain, Department of Mechanical Engineering, IIT Kanpur.

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**
Course Code	**21MET834**
Course Name	**Product Design & Development**
Credits	**3 L-3 T-0 P-0**
Course Type	**Program Elective**
Prerequisites	The students should have basic knowledge of machine design, strength of material, material science.

Course Contents

Introduction: Need for developing products, the importance of engineering design, types of design, the design process, relevance of product lifecycle issues in design, designing to codes and standards, societal considerations in engineering design, generic product development process, various phases of product development-planning for products, establishing markets, market segments, relevance of market research.
Material selection processing and Design: Material Selection Process, Economics , Cost vs Performance, Weighted property Index, Value Analysis, Role of Processing in Design , Classification of Manufacturing Process, Design for Manufacture , Design for Assembly, Designing for castings, Forging, Metal Forming, Machining and Welding, Residual Stresses, Fatigue, Fracture and Failure.
Industrial Design concepts: Human factors design, user friendly design, design for serviceability, design for environment, prototyping and testing , cost evaluation, categories of cost, overhead costs, activity based costing, methods of developing cost estimates, manufacturing cost, value analysis in costing.
Additive manufacturing: Introduction to reverse engineering, Traditional manufacturing vs AM, Computer aided design (CAD) and manufacturing (CAM) and AM, Different AM processes and relevant process physics, Rapid Prototyping, Rapid Tooling, rapid manufacturing, 3-D printing.
Value engineering, Definition, Value Engineering Function: Approach of Function, Evaluation of Function, Determining Function, Classifying Function, Evaluation of costs, Evaluation of Worth, Determining Worth, Evaluation of Value.

Recommended Readings

Text Books:-

1. Chitle A. K and Gupta R.C, Product Design and Manufacturing, PHI
2. Product design and development, by K.T. Ulrich and S.D. Eppinger, Tata McGraw Hill
3. Product Development, by Chitale & Gupta, Tata McGraw Hill
4. The Mechanical Process Design, by David Ullman, McGrawhill Inc
5. Product design & process Engineering by Niebel & deeper, McGraw hill
6. Value Management by Heller, Addison Wasley

7. Assembly automation and product design – by Geoffrey Boothroyd, CRC Taylor & Francis

Reference books:-

1. Product Design, by Kevin Otto, Kristin wood, Pearson Education Inc.
2. Engineering Design Process, by Yousef Haik, T M MShahin, Cengage Learning
3. Value Engineering : A Systematic Approach by Arthur E. Mudge - Mc GrawHill
4. Value Engineering A how to Manual S.S.Iyer, New age International Publishers
5. Value Engineering : A Systematic Approach by Arthur E. Mudge - Mc GrawHill
6. New Product Development Timjones. Butterworth Heinmann, Oxford.

Online/E resources:-

1. https://nptel.ac.in/courses/112/107/112107217/
2. https://nptel.ac.in/courses/112/104/112104230/

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET835**			
Course Name	**Rapid Prototyping & Tooling**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	**Nil**			

Course Contents

Introduction: Need - Development of RP systems – RP process chain - Impact of Rapid Prototyping and Tooling on Product Development – Benefits- Applications – Digital prototyping - Virtual prototyping.

Liquid based and solid based rapid prototyping systems: Stereolithography Apparatus, Fused deposition Modeling, Laminated object manufacturing, Three dimensional printing: Working Principles, details of processes, products, materials, advantages, limitations and applications - Case studies.

Powder based rapid prototyping systems: Selective Laser Sintering, Direct Metal Laser Sintering, Three Dimensional Printing, Laser Engineered Net Shaping, Selective Laser Melting, Electron Beam Melting: Processes, materials, products, advantages, applications and limitations – Case Studies.

Reverse Engineering and CAD Modeling: Basic concept- Digitization techniques – Model Reconstruction – Data Processing for Rapid Prototyping: CAD model preparation, Data Requirements – geometric modeling techniques: Wire frame, surface and solid modeling – data formats - Data interfacing, Part orientation and support generation, Support structure design, Model Slicing and contour data organization, direct and adaptive slicing, Tool path generation.

Rapid Tooling: Classification: Soft tooling, Production tooling, Bridge tooling; direct and indirect – Fabrication processes, Applications. Case studies - automotive, aerospace and electronic industries.

Recommended Readings

Text Books:-

1. Rapid prototyping: Principles and applications, second edition, Chua C.K., Leong K.F., and Lim C.S., World Scientific Publishers, 2003.
2. Rapid Tooling: Technologies and Industrial Applications, Peter D.Hilton, Hilton/Jacobs, Paul F.Jacobs, CRC press, 2000.

Reference books:-

1. Rapid prototyping, Andreas Gebhardt, Hanser Gardener Publications, 2003.
2. Rapid Prototyping and Engineering applications : A tool box for prototype development, LiouW.Liou, Frank W.Liou, CRC Press, 2007.
3. Rapid Prototyping: Theory and practice, Ali K. Kamrani, Emad Abouel Nasr, Springer, 2006
4. Engineering Design and Rapid Prototyping, Ali K. Kamrani and Emad Abouel Nasr, 2010.
5. Rapid prototyping, Rafiq Noorani, 2006.
6. Rapid Prototyping, Rapid Tooling and Reverse Engineering: From Biological Models to 3D Bioprinters, Kaushik Kumar, J. Paulo Davim, Divya Zindani, 2020.

Online/E resources:-

1. New model for liquid-based rapid prototyping with a scanning Lorentz beam, ÇağlarArpali, *Optik*, https://doi.org/10.1016/j.ijleo.2021.167225
2. Adapting during the pandemic: A case study of using the rapid prototyping instructional system design model to create online instructional content, HanwenDong, The Journal of Academic Librarianship, https://doi.org/10.1016/j.acalib.2021.102356
3. In-situ monitoring of deformation in rapid prototyped injection molds, Sz.Krizsma, N.K.Kovács, Additive Manufacturing, https://doi.org/10.1016/j.addma.2021.102001
4. Rapid Prototyping of Miniaturized Powder Mixing Geometries, Rasmus Svane, Troels Pedersen, Journal of Pharmaceutical Sciences, https://doi.org/10.1016/j.xphs.2021.03.019
5. A practical guide to rapid-prototyping of PDMS-based microfluidic devices: A tutorial, Giorgio Gianini Morbioli, Nicholas Colby Speller, Amanda M.Stockton, Analytica Chimica Acta, https://doi.org/10.1016/j.aca.2020.09.013
6. A Finite-State-Machine model driven service composition architecture for internet of things rapid prototyping, RuoweiXiao, Future Generation Computer Systems, https://doi.org/10.1016/j.future.2019.04.050

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

Department/Centre	**Department of Mechanical Engineering**			
Course Code	**21MET836**			
Course Name	**Tool Design & Engineering**			
Credits	**3**	**L-3**	**T-0**	**P-0**
Course Type	**Program Elective**			
Prerequisites	**Nil**			

Course Contents

Introduction to Tool design: Introduction –Tool Engineering – Tool Classifications– Tool Design Objectives – Tool Design in manufacturing- Challenges and requirements- Standards in tool design- Tooling Materials- Ferrous and Nonferrous Tooling Materials- Carbides, Ceramics and Diamond -Nonmetallic tool materials-Designing with relation to heat treatment. Design of cutting Tools: Mechanics of Metal cutting –Oblique and orthogonal cutting- Chip formation and shear angle - Single-point cutting tools – Milling cutters – Hole making cutting tools- Broaching Tools - Design of Form relieved and profile relieved cutters-Design of gear and thread milling cutter
Design of Jigs and Fixtures: Introduction – Fixed Gages – Gage Tolerances –selection of material for Gages – Indicating Gages – Automatic gages – Principles of location – Locating methods and devices – Principles of clamping – Drill jigs – Chip formation in drilling – General considerations in the design of drill jigs – Drill bushings – Methods of construction –Thrust and Turning Moments in drilling - Drill jigs and modern manufacturing- Types of Fixtures –Vise Fixtures – Milling Fixtures – Boring Fixtures – Broaching Fixtures – Lathe Fixtures – Grinding Fixtures, Modular Fixtures, Cutting Force, Calculations.
Design of Forming Tools: Types of Sheet Metal Dies –Method of Die operation–Clearance and cutting force calculations- Blanking and Piercing die design – Pilots – Strippers and pressure pads-Presswork materials – Strip layout – Short-run tooling for Piercing – Bending dies – Forming dies – Drawing dies-Design and drafting. Design of Bulk forming dies and moulds for metals and plastic.
Tool Design for CNC machine tools: Introduction –Tooling requirements for Numerical control systems – Fixture design for CNC machine tools- Sub plate and tombstone fixtures-Universal fixtures– Cutting tools– Tool holding methods– Automatic tool changers and tool positioners – Tool presetting–

Recommended Readings

Text Books:-

1. E.G.Hoffman," Jig and Fixture Design", Thomson Asia Pvt Ltd, Singapore, 2004
2. Prakash Hiralal Joshi, "Tooling data", Wheeler Publishing, 2000
3. Venkataraman K., "Design of Jigs, Fixtures and Presstools", TMH, 2005

Reference books:-

1. Haslehurst M., “Manufacturing Technology”, The ELBS, 1978
2. Cyrll Donaldson, George H.LeCain, V.C. Goold, “Tool Design”, Tata McGraw Hill Publishing Company Ltd., 2000.

Online/E resources:-

1. NPTEL/SWAYAM Videos
2. NPTEL/SWAYAM Lectures