Curriculum of Master of Laser Technology

FIRST SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Departmental / Specialization Basket	Subject Code	**Specialization Subject Name**	Lecture	Sessional	Examination	Sessional	
Paper-I		Laser Fundamentals and Fabrication	3		100		3
Paper-II		Laser and Its Applications	3		100		3
Paper-III		Laser Machining Processes Thermodynamics in Materials Processing	3		100		3

Note: The students have to select 3 subjects from the departmental/ specialization basket, i.e. one subject each from the list given in the baskets of Paper-I, Paper-II and Paper-III

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Inter-Disciplinary Basket	Subject Code	Subject Name	Lecture	Sessional	Examination	Sessional	
Paper-IV		Laser Joining Processes	3		100		3
	PG / ME / T/ 114E	Optimization Techniques For Engineering Design					
	PG / ME / T/ 114F	Advanced Thermodynamics					
Paper-V		Laser Additive Manuf acturing	3		100		3
	PG / ME / T/ 115B	Basics of Finite Element Method					
Paper-VI		Laser Based Measurement - Process Diagnostics & Control	3		100		3
	PG / ME / T/ 116H	Heat and Mass Transfer					

Note: The students have to select 3 subjects from the inter-departmental basket, i.e. one subject each from the list given in the baskets of Pap er-IV, Paper-V and Paper-VI

Sessional Courses							
Inter-Disciplinary Basket	Subject Code	Subject Name	Lecture	Sessional	Examination	Sessional	
Sessional 1		Laboratory		4		100	3
Sessional 2		Seminar		3		200 marks to be included in 2nd semester	
			18	**7**	**600**	**100**	**21**

Total Periods/Week = 25 Total Marks = 700

SECOND SEMESTER

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Departmental / Specialization Basket	Subject Code	**Specialization Subject Name**	Lecture	Sessional	Examination	Sessional	
Paper-VII		Laser Surface Modification & Forming	3		100		3
Paper-VIII		Laser Damage of Materials	3		100		3
Paper-IX		Laser Automation and In-process Sensing & Laser Safety	3		100		3
	PG / ME / T/ 129 I	Advanced Manufacturing Processes					
	PG / ME / T/ 129B	Computational Fluid Dynamics					

Note: The students have to select 3 subjects from the departmental/ specialization basket, i.e. one subject each from the list given in the baskets of Pap er-VII, Paper-VIII and Paper-IX

Theoretical Courses	Subjects		Periods/Weeks		Marks		Credit Points
Inter-Disciplinary Basket	Subject Code	Subject Name	Lecture	Sessional	Examination	Sessional	
Paper-X		Laser Electronics	3		100		3
		Introduction to Concurrent Engineering					
		Micro-scale Heat Transfer					

Note: The students have the freedom to choose one subject from the list under Paper-X.

Sessional Course

	Subject Code	**Subject Name**	Lecture	Sessional	Examination	Sessional	Credit Points
Sessional 1		Term Paper Leading to Thesis		3		100	3
Sessional 2		Seminar		3		200	6
			12	**6**	**400**	**300**	**21**

Total Periods/Week = 18 **Total Marks = 700**

THIRD and FOURTH SEMESTER

Sessional Courses							
	Subject Code	**Subject Name**	Lecture	Sessional	Examination	Sessional	Credit Points
1		Thesis Work		16		300	12
2		Viva-Voce on Thesis				100	
				16		**400**	**12**

Total Periods/Week = 16 **Total Marks = 400**

Syllabus

FIRST SEMESTER SUBJECTS

Deptt. Basket

Paper 1: Laser Fundamentals and Fabrication

The Nature of Electromagnetic Radiation, Interaction of Electromagnetic Radiation with Matter, Absorption and Emission of Radiation by atoms, ions and molecules. Laser medium (solid state medium: srystals, glass, semiconductor, gaseous medium: CO2, N2, Ar, He-Ne, liquid: die solution, other organic materials). Phenomenon of population inversion. Laser cavity (fiber laser, and other cavities), generation of coherent beam, Q-switching, short pulse generation, power amplification.

Effect of wavelength, Effect of temperature, Effect of surface films, Effect of angle of incidence, Effect of Materials and Surface Roughness, Refraction, Scattering, Interference, Diffraction, Laser Beam Characteristics, Wavelength, Coherence, Mode and Beam Diameter, Polarisation, Focusing with a Single Lens, Final Spot Size, Depth of Focus, Optical Components, Lens Doublets, Depolarisers, Collimators, Metal Optics, Diffractive Optical Elements - Holographic Lenses, Laser Scanning Systems, Fibre Delivery Systems.

Paper 2: Laser and Its Applications

Basic Laser Principles:

Theory of Laser, Properties of Laser, Fundamental Optical properties, Modified Optical properties, Laser output – its characteristics

Laser Material Interaction:

Heating by Laser, temperature distribution, Thermo liaison and heat flow, impact of absorption on temperature.

Melting & solidification: Regimes of laser remelting, interference characteristics

Evaporation & Plasma formation – its fundamentals, Hydrodynamics, ionization of vapour, gas breakdown evaporation at moderate irradiance levels, beam heating and evaporation, vapour expansion and recoil.

Laser supported combustion waves, plasma enhance coupling, effects of laser supported detonation waves on beam material interaction.

Phenomena at very high irradiance – self regulating plasma, inertial confinement.

Types of lasers: He-Ne laser, CO_2 laser, Argon laser, Nd:YAG, Excimer laser, Diode laser, Fiber laser etc.

Application of high power lasers.

Paper 3: Laser Machining Processes

Laser Cutting
Forms of Laser Cutting: Fusion Cutting, Sublimation Cutting, Photochemical Ablation; Components of a Laser Cutting System, Processing Conditions: Beam Power, Beam Characteristics, Traverse Speed, Assist Gas Functions, Effect of Focal Position; Laser Cutting Principles: Beam Absorption, Process Modeling; Quality of Cut Part; Material Considerations; Advantages and Disadvantages; Comparison with Conventional Processes; Special Techniques

Laser Marking
Introduction, Basic principles, Materials, Dot matrix marking, Engraving, Image micromachining, Comparison with other techniques, Lasers for Marking and application areas

Laser Drilling
Forms of Laser Drilling, Process Parameters: Beam Characteristics, Drilling Characteristics, Process Defects, Analysis of Material Removal During Drilling, Advantages and Disadvantages of Laser Drilling, Applications

Micromachining and Laser-Assisted Machining

Paper 3: Thermodynamics in Materials Processing
Activity, change in enthalpy, entropy and free energy on mixing, ideal and non-ideal solutions, equilibrium of a multi-phase multi-component system, phase equilibrium, non-equilibrium thermodynamics and its applications in rapid solidification of materials, an introduction to statistical thermodynamics of phase change processes, thermodynamics and interfacial kinetics in melting and solidification due to laser processing of materials. The thermodynamics and kinetics of evaporation. Thermo capillary effects in liquid phase.

Interdisciplinary Basket

Paper 4: Laser Joining Processes
Laser Welding Parameters: Beam Power, Spot diameter and Traverse Speed;, Effect of Beam Characteristics: Beam Mode, Beam Stability, Beam Polarization, Pulsed Beams, Plasma Formation, Gas Shielding, and Effect of Ambient Pressure, Beam Size and Focal Point Location, Joint Configuration; Welding Efficiency; Mechanism of Laser Welding: Conduction Mode Welding, Keyhole Welding; Material Considerations; ferrous, Nonferrous alloys, Ceramics, Polymers, Dissimilar Materials; Weldment Discontinuities: Porosoty, Humping, Spiking; Advantages and Disadvantages of Laser Welding; Special Techniques; Heat Treatment; Specific Applications.

Laser Brazing, Laser Soldering

Paper 5: Laser Additive Manufacturing
Rapid Prototyping- Computer-Aided Design: Geometric Transformation, Translation, Scaling, Rotation; Curve and Surface Design: Splines, Bezier Curves, Surface Representation; Solid Modeling: Constructive Solid Geometry, Boundary Representation; Rapid Prototyping Software Formats: STL, IGES; Supports for Part Building; Slicing; Part Building: Liquid-Based Systems-Beam Scanning, Parallel Processing; Powder-Based Systems: Selective Laser Sintering (SLS), 3D Printing, Ballistic Particle Manufacturing; Solid-Based Systems: Fused Deposition Modeling, Laminated Object Manufacturing; Comparison of Major Systems; Post-Processing; Applications.

Paper 6: Laser Based Measurement - Process Diagnostics & Control
Beam Optics : Gaussian beam, Gaussian beam propagation in free space, transmission, through optical components, Hermit – Gaussian beam, Lagurre – Gaussian and Bessel beam
Optical Modulation: Phase and polarization modulation, E – O modulator, Acoustic optic modulator.
Electronics: Rectification, Amplification, Oscillation, Pulse generation, Elements of analog and digital circuitry, power and control system.

Photo-detectors: Basic of photodetectors, different types of photodetectors, their inherent characteristics, response curve, noise
Measurement: Alignment, targeting, tracking, dimension, gauging, velocity measurement, surface quality measurement, control measurement, profile detection, measurement of distance (interferometric, pulse echo, beam modulation), laser gyroscope, environmental measurement.

Holography: Holography interferometry, double exposure and real time holography, sandwich holography, holographic interferomatic measurement, NDT

SECOND SEMESTER SUBJECTS

Departmental Baskets

Papers 7: Laser Surface Modification & Forming

Laser Surface Heat Treatment: Process parameters; Temperature Field; Microstructural Changes in Steels; Nonferrous Alloys; Hardness Variation; Residual Stresses; Advantages and Disadvantages of Laser Surface Treatment; Laser Surface Melting; Laser Direct Metal Deposition: Processing Parameters, Methods for Applying the Coating Material, Dilution; Advantages and Disadvantages of Laser Cladding; Laser Physical Vapor Deposition (LPVD); Laser Shock Peening: Analysis, Advantages and Disadvantages of Laser Shock Peening.
Laser Forming: Principle of Laser Forming, Process Parameters; Laser Forming Mechanisms: Temperature Gradient Mechanism, Buckling Mechanism, Upsetting Mechanism; Process Analysis; Advantages and Disadvantages; Applications.

Paper 8: Laser Damage of Materials

Causes of failure in materials – fracture mechanics. Degradation of materials – chemical, physical and structural; causes of degradation of materials – both thermal and mechanical.

Energy transfer due to laser irradiation – effect of laser beam characteristics, temperature field modes. Melting and solidification due to laser irradiation. Evaporation and plasma formation laser induced stresses and strains in materials, distribution of residual stress and strains.

Hot crack formation, cold crack formation, resistance to cold cracking. Description of damage threshold in respect of mechanical, chemical and structural characteristics.

Chemical degradation due to melting and evaporation. Structural degradation due to thermal effects in laser processed materials. Mechanical damage due to induced stresses. Techniques for assessment of laser induced damage in materials. Laser induced damage in optical materials with special reference to optical coating materials.

Paper 9:Laser Automation and In-process Sensing & Laser Safety

Laser Automation and In-process Sensing

Automation principles
In-process monitoring – monitoring beam characteristics, monitoring work table characteristics, monitoring process characteristics
In-process control – In-process power control, In-process temperature control
"Intelligent" In-process control

Laser Safety

1. Laser fundamentals – Laser technology, why laser safety? The properties of laser.
2. Laser hazards – a) Eye hazards; b) laser radiation effects on skin; c) biological effects of laser radiation.
3. Associated hazards – Electrical hazards, safety guidelines, chemical hazards, collateral radiation, fire hazards, explosion hazards.
4. Laser classification – Criteria for laser classification, different classes of laser, signs & warning labels.
5. Hazard evolution – Standard operating procedures, Max. Possible Explosive (MPE), Nominal Hazard Zone (NHZ).
6. Personal Protective equipments – Eye protection : Laser protective eyewear requirement.
7. Laser Accidents – Laser accident information

8. Control measure – Engineering control, Engineering control protective housing, laser safety control, service access panels, laser controlled area, administrative control, hazard distance
9. Laser Worker Training – Laser Safety manual, Laser Worker registration form
10. Effective Laser Safety

Interdisciplinary Baskets

Paper 10: Laser Electronics

Power Supplies for Laser Equipment

(i) Review of Power Diode, SCR, Bipolar Transistors, MOSFET's, IGBT's.
(ii) Principles of Diode rectifiers & SCR phase controlled rectifiers. Use of L-C fitters on DC output to reduce ripple. Voltage & current feedback control in SCR rectifiers.
(iii) Principles of DC Chopper. Duty cycle control. Voltage & current feedback control. Current profile generation by pulse width modulation.
(iv) Principles of high frequency power conversion.
(v) Issues relating to effect on utility system for power supplies.