Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NMED 541	Micro and Precision Manufacturing	3	0	0	3

Course Objective

Objectives of this course are to:

- Impart knowledge on various machining and abrasive-cutting processes suitable for micro-fabrication with a high degree of precision.
- familiarize the students on the fundamental mechanics during manufacturing in micro scales, Size Effect phenomenon, and material behaviour at micro level deformation, domination of ploughing, integral roles of microstructures, and interfacial friction.

Learning Outcomes

Upon successful completion of this course, students will:

- Have knowledge and visualization of various machining processes capable of generating features in micro-scale and/or with high degree of precision
- Understand the mechanics of material removal at micro-scales
- Understand the surface integrity and feature accuracy at sub-micron level
- Understand the cooling and lubrication scenarios for energy-efficient high-speed machining.

Module	Topics	Lecture Hours	Learning Outcome
1	**Introduction to micro-manufacturing**: Need for tight tolerance and miniaturized products, Fundamental challenges in miniaturization, Various micro-precision manufacturing processes and their classification, Surface quality quantification.	3	Knowledge of the need of micro-features and devices.
2	**Micro-grinding:** Process and variants, Size Effect, tools and wheels, machines, capability, surface quality, tolerance level, applications, subsurface deformation, specific cutting energy, ductile regime machining, sources of error and potential remedies.	6	Detailed knowledge on abrasive cutting process for micro-feature generation.
3	**Lapping, honing, & superfinishing**: Process and mechanisms, tools, machines, capability, surface quality, dimensional tolerance, applications, specific cutting energy, sources of error and potential remedies.	3	Detailed knowledge on lapping, honing, and superfinishing for surface finishing.
4	**Micro-milling**: Process, machine, high-speed spindle, micro-tool material, coating, geometry, and fabrication, Size Effect and MUCT, ploughing-shearing, roles of interfacial friction, chip formation mechanism, burr formation, surface generation, step-formation, machining time, and tool wear.	6	Detailed knowledge on micro-milling process for micro-feature generation.
5	**Micro-drilling**: Process, machine, micro-tool material, coating, geometry, and fabrication, variation of speed and angles, chip formation mechanism, burr formation,	3	Detailed knowledge on micro-drilling process for micro-feature generation.

	surface generation, machining time, tool wear, micro-drilling of composites.		
6	**Diamond turning**: Process, machine, diamond tool geometry, chip formation mechanism, burr formation, surface generation, machining time, tool wear, mirror finishing of lenses.	6	Detailed knowledge on diamond turning process for micro-feature generation.
7	**Cooling-lubrication**: Cutting fluids, coolants vs lubricants, fluid delivery strategy, spray delivery, nozzles, cryogenic cooling, reachability of cutting fluid, penetration capability, cooling-lubrication action, friction changes, cleaning and circulation system, sustainability issues.	6	Detailed knowledge on cooling and lubrication scenario and relevant sustainability aspects.
8	**Miro-deburring:** Need for burr removal, various deburring processes based on mechanical, electrical, magnetic, thermal, chemical, and hybrid energy.	3	Detailed knowledge on deburring processes for micro-burr removal.
9	**Machine tool development**: Development of high-speed vibration-free structures, drives and controls, stability issues.	3	Detailed knowledge on high precision machine development.
10	**Energy-efficient machining**: Reduction in frictional energy wastage by tool texturing, cutting fluid, vibration, and material hardening.	3	Detailed knowledge on the various ways for reducing energy consumption in machining.

Text book:

1. Introduction to micromachining, VK Jain, Narosa Publisher, 2nd edition.
2. Nano and Micromachining, JP Devim and MJ Jackson, Wiley Publisher, 1st edition.

Reference books:

1. Micromachining of Engineering Materials by JA McGeough, Taylor & Francis, 1st edition.
2. Micro manufacturing processes by VK Jain, CRC Press, 1st edition.