| Course Type | Course Code | Name of Course | L | T | P | Credit |
|---|---|---|---|---|---|---|
| DC | NMEC 501 | Machining Science | 3 | 1 | 0 | 4 |

**Course Objective**

Objectives of this course are to train the students on selection of suitable machining process, machines, cutting tools, and process parameters for different material removal operations; to address the issues related to high cutting temperature, low tool life, cutting fluid usage; to understand the mechanics of chip formation during metal cutting under different operations, and to evaluate the socio-economic factors associated with the machining process.

**Learning Outcomes**

Upon successful completion of this course, students will:

- have understanding on the geometrical specifications of the single-point and multi-point cutting tools,
- have understanding on the fundamental mechanism of chip formation and different types of chips,
- be able to understand the force measurement principles and analyze the cutting forces using MCD,
- have understanding on the pattern of tool wear and fundamental theorems of tool life,
- be able to estimate the machining time and corresponding economics,
- have knowledge on heat generation, cutting zone temperature, and cooling-lubrication approaches,
- have knowledge on abrasive cutting processes such as grinding, lapping, honing, superfinishing, etc.

| Module | Topics | L+T | Learning Outcome |
|---|---|---|---|
| 1 | **Introduction to machining science**: Introduction to manufacturing, Types of manufacturing processes, Subtractive manufacturing, Need, MFTW system. Machine tool, cutting tool, generatrix&directrix, process parameters, fixtures, and general working principle of various machining processes such as straight turning, taper turning, step turning, threading, grooving, parting, face turning, tapping, knurling, shaping, planning, face milling, plain milling, end milling, drilling, boring, reaming, tapping, etc. | 4L+0T | Knowledge on the working principle, tool-workpiece interaction, and motion directions in various machining processes. |
| 2 | **Tool geometry:** Concepts of tool angles and radii of SPTT, different planes of measurement, positive and negative values and their effects on machinability, Tool nomenclature in ASA, ORS, and NRS systems. Geometry of drill and different milling cutters. | 6L+0T | Knowledge on systematic measurement and presentation of various tool angles. |
| 3 | **Tool angle conversion**: Concepts of ML, Rake and clearance angle conversion from one system to another using ML, Maximum rake system, Angle measurement in any arbitrary direction, tool angle conversion using vector method. | 8L+2T | Knowledge on tool angle conversion in any required direction using some known angles. |
| 4 | **Mechanism of chip formation**: Deformation zones, Lamella formation, Piispannen card model, Shear zone and plane, Chip thickness ratio, Roles of interfacial friction, Shear angle, Cutting strain, Chip-tool contact lengths, Types of chips and BUE, Restricted cutting and chip flow deviation, Effective rake angle. | 6L+2T | Knowledge on the shear deformation and lamellar chip formation, and relevant chip-tool interfacial characteristics both on orthogonal and oblique planes. |
| 5 | **Forces during machining**: Force evolution and its influences, Force measurement using dynamometer, Working principles of strain gauge and piezoelectric based dynamometers, Different directions of measurement and MCD based analysis for ductile, semi-ductile, and brittle materials. | 5L+3T | Knowledge on cutting force evolution and MCD-based analysis to estimate machining power consumption. |

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| 6 | **Cooling and lubrication**: Heat generation and thermal damage, Analytical estimation of temperature, Various temperature measurement methods, Need for cutting fluid, Basic properties of MWF, Various delivery strategies of cutting fluid, Benefits in terms of reduced forces, temperature, surface deformation, etc. Brief introduction on sustainability regarding cutting fluids. | 3L+1T | Knowledge on cutting temperature increase and potential reduction methods. |
| 7 | **Tool material and tool life**: Tool failure – catastrophic breakage, thermal dulling, and gradual wear, Different tool wear patterns, Measurement of tool wear, Tool life curve and life estimation, Effects of process parameters on tool life, Taylor's equation and modified equation. Brief account on consequence of tool wears on force, temperature, and surface subsurface quality. Tool materials and coatings with compatible work material and speed range. | 4L+2T | Knowledge on cutting tool failure/wear methods, control of wear rate, tool/coating materials to enhance tool life. |
| 8 | **Machining time&Machining economics:** Actual cutting time estimation for turning, taper turning, face turning in conventional as well as CNC lathe. Cutting time estimation in drilling and different milling processes. Estimation of overall machining time per piece considering tool changing time, Optimum velocity for minimum machining time, Optimum velocity for minimum machining cost. | 2L+3T | Knowledge on actual cutting time required for various machining processes and evaluation of optimum process parameters to maximize profit and productivity. |
| 9 | **Abrasive multi-grit cutting process:** Introduction, working principle, and surface quality of grinding, honing, lapping, and superfinishing process. | 2L+1T | Knowledge on the working principles of secondary surface finishing methods. |
| 10 | **Smart machining factory:** Sensors for real time process monitoring through image processing and machine learning techniques. Deployment of robots to facilitate machining processes. | 2L+0T | Knowledge on the digital manufacturing. |
| | **Total** | **42L+14T** | |

**Text books:**


1. Machining and Machine Tools by A. B. Chattopadhyay,Wiley.
2. Metal Cutting: Theory and Practice by A. Bhattacharya, New Central Book Agency.


**References:**


1. Manufacturing Engineering and Technology by S. Kalpakjian and Schmid, Pearson Education.
2. Metal Cutting Theory and Practice by D. A. Stephenson and J. S. Agapiou, CRC Press.