INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

MACHINE TOOLS AND METROLOGY LABORATORY								
V Semester: ME								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMEC25	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: There is no prerequisite for this course.								

I. COURSE OVERVIEW:

This course introduces the mechanism of metal cutting of different geometrical shapes using wide variety of cutting tools. This emphasizes on the development/ demand of the newer materials with cutting edge technology tools. It is designed to impart the practical knowledge about the various machining processes like turning, shaping, planning, drilling, milling and grinding to produce desired shape of a product. This course introduces the metrological equipment to measure form and positional accuracy of manufactured/machined components and to interpret the results.

II. COURSES OBJECTIVES:

The students will try to learn

I. The empirical knowledge on machine tools so that they can identify, manipulate and control various process parameters during machining processes in the manufacturing industry.
II. The details related to thermal aspects during machining for defect free manufacturing components.
III. The mechanics of machining process and significance of various process parameters in order to yield the optimum machining.
IV. The principles of linear and angular measuring instruments for accurate measurement of a given component.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO 1 Apply the appropriate cutting parameters for prismatic operations and their critical tool development / selection of Lathe, Milling, drilling, slotting shaping and surface grinding machines for manufacturing the components of their requirement.
CO 2 Estimate machining times for machining operations at specified levels of cutting parameters of machine tools.
CO 3 Analyze the chip formation mechanism by measuring the cutting forces during the chip formation process.
CO 4 Apply surface grinding operations to improve the quality of the surface with desired dimensions by removing uneven spots on the surface.
CO 5 Apply the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement to get form and position.
CO 6 Apply equipment's like Surface Roughness tester, and Tool makers Microscope to find out parameters of gear, thread, tool and surface roughness.

IV. COURSE CONTENT:

EXERCISES IN MACHINE TOOLS AND METROLOGY LABORATORY

Note: All dimensions are in mm in experiments.

Getting started experiments

Introduction

A machine tool is a machine for handling or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformations. Machine tools employ some sort of tool that does the cutting or shaping. All machine tools have some means of constraining the workpiece and provide a guided movement of the parts of the machine. Thus, the relative movement between the workpiece and the cutting tool (which is called the toolpath) is controlled or constrained by the machine to at least some extent, rather than being entirely "offhand" or "freehand". It is a power-driven metal cutting machine which assists in managing the needed relative motion between cutting tool and the job that changes the size and shape of the job material.

Safety

Safety is a vital issue in all workplaces. Before using any equipment and machines or attempt practical work in a workshop everyone must understand basic safety rules. These rules will help keep all safe in the workshop.

Safety Rules:

- Always listen carefully to the teacher and follow instructions.
- When learning how to use a machine, listen very carefully to all the instructions given by the faculty / instructor. Ask questions, especially if you do not fully understand.
- Always wear an apron as it will protect your clothes and holds lose clothing such as ties in place.
- Bags should not be brought into a workshop as people can trip over them.
- Do not use a machine if you have not been shown how to operate it safely by the faculty / instructors
- Know where the emergency stop buttons are positioned in the workshop. If you see an accident at the other side of the workshop you can use the emergency stop button to turn off all electrical power to machines.
- Wherever required, wear protective equipment, such as goggles, safety glasses, masks, gloves, hair nets, etc.
- Always be patient, never rush in the workshop.
- Always use a guard when working on a machine.
- Keep hands away from moving/rotating machinery.
- Use hand tools carefully, keeping both hands behind the cutting edge.
- Report any UNSAFE condition or acts to instructor.
- Report any damage to machines/equipment as this could cause an accident.
- Keep your work area clean.

DO's

- Students must always wear uniform and shoes before entering the lab.
- Proper code of conduct and ethics must be followed in the lab.
- Note down the specifications/drawings before working on the preparation of models.
- Receive the tools and materials required for preparation of models with signing in register.
- Properly fix hacksaw blade in frame with help of instructor.
- Use of safety goggles / face shield during welding.
- Do the models under the supervision/guidance of a faculty/ lab instructor only.
- Keep the sufficient distance from other students while preparing models.
- In case of fire use fire extinguisher/throw the sand provided in the lab.
- In case of any physical injuries or emergencies use first aid box provided.

DONT's

- Do not touch electrical circuits of welding machine.
- Be cautious while fixing hacksaw blade in frame, that may cause injuries to hand.
- Don't touch /operate power tools without aid from instructors.
- Don't gather while preparing models, that may hurt other with tools.
- Don't unlock snip/sheet metal cutter lock, without use.

1. LATHE MACHINE

1.1. Experiments on Lathe: Step turning, taper turning, Thread cutting and knurling using lathe machine

Lathe removes undesired material from a rotating work piece in the form of chips with the help of a tool which is traversed across the work and can be fed deep in work. The tool material should be harder than the work piece and the later help securely and rigidly on the machine. The tool may be given linear motion in any direction. A lathe is used principally to produce cylindrical surfaces and plane surfaces, at right angles to the axis of rotation. It can also produce tapers and bellows etc.

Perform Operations on mild steel bar of 100mm long and 25 mm diameter, tools required Vernier calipers, steel rule, spanner, chuck spanner, and H.S.S. single point cutting tool

2. Introduction to DRILLING AND STEP BORING

Drilling is an operation of making a circular hole by removing a volume of metal from the job by cutting tool called drill. A drill is a rotary end-cutting tool with one or more cutting lips and usually one or more flutes for the passage of chips and the admission of cutting fluid. A drilling machine is a machine tool designed for drilling holes in metals. It is one of the most important and versatile machine tools in a workshop. Besides drilling round holes, many other operations can also be performed on the drilling machine such as counter- boring, countersinking, honing, reaming, lapping, sanding etc.

2.1. Experiments on Drilling, tapping and step boring using drilling machine

To drill the given work piece as required and then to perform to make, counter boring, countersinking and tapping operations

3. Introduction to PLANNING AND SHAPING

Planning is a manufacturing process of material removal in which the workpiece reciprocates against a stationary cutting tool producing a plane or sculpted surface. Planning is analogous to shaping. The main difference between these two processes is that in shaping the tool reciprocates across the stationary workpiece. Planning motion is the opposite of shaping. Both planning and shaping are rapidly being replaced by milling.

3.1. Experiments on Shaping of V-groove using shaper

To perform V and Dovetail machining & U-cut on the given work piece

4. Introduction to SLOTTING

The slotting machine is a reciprocating machine tool in which, the ram holding the tool reciprocates in a vertical axis and the cutting action of the tool is only during the downward stroke. The slotting machine is used for cutting grooves, keys and slotes of various shapes making regular and irregular surfaces both internal and external cutting internal and external gears and profiles The slotter machine can be used on any type of work where vertical tool movement is considered essential and advantageous.

4.1. Experiments on Slotting of a keyway using slotter machine.

To perform V and Dovetail machining & U-cut on the given work piece

5. Introduction to MILLING AND SURFACE GRINDING

A milling machine removes material from a work piece by rotating a cutting tool (cutter) and moving it into the work piece. Milling machines, either vertical or horizontal, are usually used to machine flat and irregularly shaped surfaces and can be used to drill, bore, and cut gears, threads, and slots. The three main components of a surface grinding machine are the rotating abrasive wheel, the workholding device, and the reciprocating or rotary table. The abrasive wheel smooths and refines the surface of a material by removing excess material from it. The work holding device (i.e., a chuck) holds the workpiece in place as it is processed. The table moves the workpiece around and across the face of the wheel as needed to achieve the desired specifications.

5.1. Experiments on Milling of gear and surface grinding

To perform plane milling operation on the given specimen (mild steel) & get to its correct dimensions.
To perform surface grinding operation on the given (50*50*20) work piece

6. Introduction to VERNIER CALIPERS AND MICROMETER

A vernier calliper is defined as a measuring device that is used for the measurement of linear dimensions. It is also used for the measurement of diameters of round objects with the help of the measuring jaws. A micrometer is an instrument used for making precise linear measurements of dimensions such as diameter, thickness, and lengths of solid bodies. It is made of a C-shaped frame with a movable jaw operated by an integral screw. The fineness of the measurement depends on the lead of the screw while the accuracy of the measurement depends on the accuracy of the screw-nut combination.

6.1. Experiments Length, depth, diameter measuring using vernier calipers and micrometer

To measure the height of the object using vernier height gauge. To measure the depth of the object using Depth gauge. To measure the diameter of the object using Vernier calipers.

7. Introduction to SCREW THREAD MEASUREMENT

Threads are of prime importance; they are used as fasteners. It is a helical groove, used to transmit force and motion. In plain shaft, the hole assembly, the object of dimensional control is to ensure a certain consistency of fit. The performance of screw threads during their assembly with nut depends upon a number of parameters such as the condition of the machine tool used for screw cutting, work material and tool.

7.1. Experiments on Screw thread measurement by three wire method.

To measure the screw thread parameters using two wire method by Floating carriage micrometer.

8. Introduction to SURFACE ROUGHNESS MEASUREMENT

Surface roughness measurement can be characterized using either quantitative or qualitative methods. Qualitative techniques include optical appearance such as the reflectivity of a surface or the strength of the machining lay as well as dragging a thumbnail across the surface as a crude tactile sensor. Quantitative analysis has evolved from simple two-dimensional profilometry to more advanced three-dimensional area analysis where information regarding surface structure can be easily obtained. In order to quantify a surface profile, it is essential to remove the unnecessary wavelength components and establish a datum from which the parameters can be calculated. Stylus-based surface roughness measurement system

8.1. Experiment on Surface roughness by talysurf

To measure the surface roughness of a given specimen

9. Introduction to BORE GAUGE

Bore Gauge is the comparative measuring instrument which measures internal diameter of a hole by comparing with master gauge (micrometer, ring gauge etc.). Center of prove and anvil are guided to diameter part of a hole by guide assembly and displacement of contact point is transferred to dial indicator (Automatic centripetal mechanism) by right angle change in the ratio of1:1 with cam mechanism. Measurement accuracy is changed according to graduation (resolution) of used dial indicator. Measuring range are available from minimum φ6mm to maximum φ450mm according to size of diameter. It is used for measuring internal diameter of a hole, which is machined. The bore dial gauge consists of one fixed measuring head and one movable measuring head. The movement of the movable measuring rod is transmitted to dial indicator by push rod through a spring actuated hinged member. Thus, the horizontal movement of the rod is

transmitted into vertical direction gives indication of variation of size. The calibrated rods are made in different sizes and sometimes numbers of short rods threaded at the ends are used in combination to get different desired lengths

9.1. Experiments on Bore measurement using bore gauge

To measure the bore of a give specimen

10. Demonstration on GEAR TEETH CALIPER/MICROMETER

Gear tooth Vernier is used to measure the pitch line thickness of the tooth. The origin of calipers occurred 9th A.D. in the dynasty. The second point to reduce the margin of error of a vernier was done by Pierre Vernier a French mathematician in 1631. The use of Vernier calipers is to find the external and internal dimensions or distance extremely accurate. Vernier calipers are used over other flat devices like rulers as they contain an extremely small reading error of 0.05mm, which is around 0.0019 inches. Tooth Thickness (Chordal thickness): It is the arc distance measured along the pitch circle from its intercept with one flank to its intercept with the flank of same tooth. The teeth thickness measurement is the most important measurement. Most of the gear manufacturers may not undergo checking of all other parameters but thickness measurement is must.

10.1 Experiments on Use of gear teeth caliper for checking the chordal addendum and chordal height of spur gear

To measure gear tooth thickness (Chordal thickness) and depth (Chordal depth)..

11. Introduction to ANGLE MEASUREMENTS

Sine bar is used in conjunction with slip gauges for precise angular measurement. Sine bar is used either to measure angle very accurately or face locating any work to a given angle. Sine bars are made from high chromium, corrosion resistant steel, hardened, ground and stabilized. It is an angular measuring instrument capable of measuring angles to within 5 min. The name universal refers to the capacity of the instrument to be adaptable to a great variety of work configurations and angular interrelations. It consists of a base to which a vernier scale is attached. A protractor dial is mounted on the circular section of the base. The protractor dial is graduated in degrees with every tenth degree numbered. The sliding blade is fitted into this dial; it may be extended to either direction and set at any angle to the base. The blade and the dial are rotated as a unit. Fine adjustment are obtained with a small knurled headed pinion that, when turned, engages with a gear attached to the blade mount. The protractor dial may be locked in any position by means of the dial clamp nut. Measurement in a universal bevel protractor is made either by embracing the two bounding elements of the angle or by extraneous referencing, for example, the part and the instrument resting on a surface plate

11.1 Experiments on Tool angle measurements using bevel protractor, sine bar, slip gauges

To measure the angle of the given wedge using Sine bar & Bevel Protractor

12. Introduction to TAPER MEASUREMENTS

Taper turning is a fundamental machining process that allows for the precise and gradual reduction or increase in the diameter of a cylindrical workpiece. **Taper turning methods** involve the controlled removal of material from the workpiece, resulting in a gradual change in its diameter, often in a conical or tapered form. Whether in the production of machine parts, construction materials, or artistic creations, the art of taper turning plays a critical role in shaping the physical world around us.

12.1 Taper measurements using Tool Maker ‘s microscope

To measure the pitch & angle of the screw thread.

V. TEXT BOOKS:

1. R. K. Jain, “Production Technology”, Khanna Publishers, 18th Edition, 2021.
2. B. S. Raghu Vamshi, —Workshop Technology Vol – II, 9th Edition, Dhanpat Rai Publishers, New Delhi, India. 2020.

VI. REFERENCE BOOKS:

1. B.L. Juneja, G.S. Sekhon, Nitin Seth” Fundamentals of Metal Cutting and Machine Tools”, New Age Publishers, 2nd Edition,2019.
2. Geofrey,” Fundamentals of metal machining and machine tools”, Tata McGraw Hill Education, 3rd Edition, 2019.
3. 3. M Mahajan”, A Textbook of Metrology”, Dhanpatrai and Co, 2nd Edition, 2021

VII. ELECTRONICS RESOURCES:

1. https://elearn.nptel.ac.in/shop/iit-workshops/ongoing/additive-manufacturing-technologies-for-practicing-engineers/.
2. https://akanksha.iare.ac.in/index?route=course/details&course_id=337

VIII. MATERIALS ONLINE:

1. Course Template.
2. Laboratory manual.