



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

## COURSE CONTENT

MACHINING PROCESSES AND METROLOGY LABORATORY								
IV Semester: ME								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AMED18	Core	L	T	P	C	CIA	SEE	Total
		0	0	2	1	40	60	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45			Total Classes: 45			
Prerequisite: Manufacturing Processes Laboratory								

### 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:

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.
2. Estimate machining times for machining operations at specified levels of cutting parameters of machine tools.
3. Analyze the chip formation mechanism by measuring the cutting forces during the chip formation process.
4. Apply surface grinding operations to improve the quality of the surface with desired dimensions by removing uneven spots on the surface.
5. Apply the principles of limits, fits and tolerance while designing and manufacturing the components of their requirement to get form and position.
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

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**Note:** All dimensions are in mm in experiments.

## Getting started experiments

### Introduction

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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:

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- 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 loose 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.

## Getting Started Exercises

### Introduction to Machining Processes and Metrology Laboratory

The **Machining Processes and Metrology Laboratory** provide hands-on experience in machining operations and precision measurement techniques, bridging theoretical knowledge with practical applications. Machining processes such as turning, milling, drilling, and grinding using conventional and CNC machines, while learning to optimize cutting parameters for improved efficiency and accuracy. The laboratory also focuses on metrology, equipping students to use tools like vernier calipers, micrometer for precision measurements.

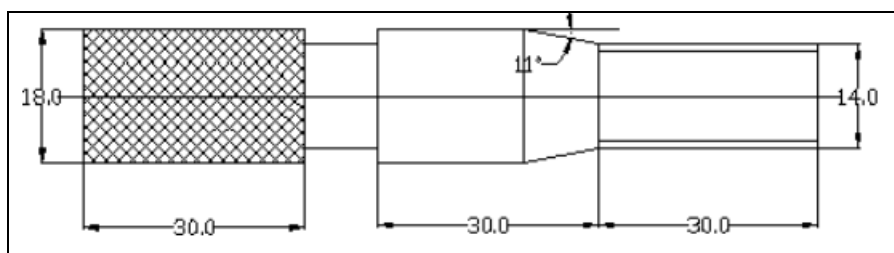
#### 1. LATHE MACHINE

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.

**1.1 Perform Various Lathe Operations Such As Plain Turning, Step Turning, Taper Turning Knurling And Chamfering 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**

**Hint:**

- The work piece and HSS single point cutting tool are securely held in the chuck and tool post respectively.
- Operations such as facing, rough turning and finish turning are performed on a given mild steel bar one after the other in sequence up to the dimensions shown. Then the step turning is performed using parting tool.
- Then the compound rest is swiveled by calculated half taper angle and taper is generated on the work piece. Rotation of the compound slide screw will cause the tool to be fed at the half-taper angle.
- HSS single point cutting tool is replaced by the knurling tool and knurling operation is performed at the slowest speed of the spindle.
- The knurling tool is replaced by the HSS single point tool again; the work piece is removed from the chuck and re fixed with the unfinished part outside the chuck. This part is also rough turned, finish turned and facing is done for correct length.
- Finally, the chamfering is done at the end of the work piece.



**Figure 1.1 Finished Work piece**

Try:

**Perform Various Lathe Operations Such As Plain Turning, Step Turning, Taper Turning Knurling and Chamfering on Aluminum bar of 150 mm long and 30 mm diameter, tools required Vernier calipers, steel rule, spanner, chuck spanner, and H.S.S. single point cutting tool.**

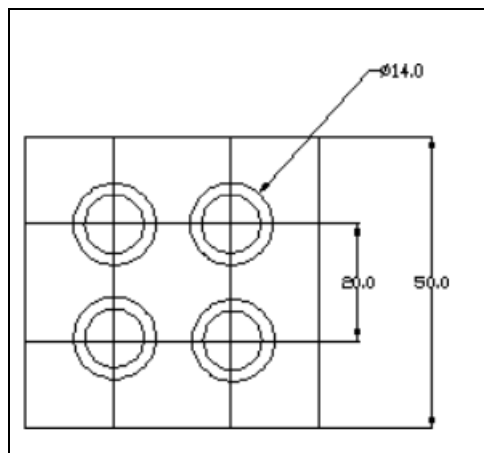
## 2. DRILLING AND TAPPING

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. Perform Drilling, tapping and step boring using drilling machine on Mild Steel Flat of 50 X 50 mm.

Hint:

- To drill the given work piece as required and then to perform to make, counter boring, Countersinking and tapping operations.
- Always clamp the workpiece firmly to prevent movement during drilling, tapping, or boring operations.
- Choose the correct drill bit, tap, or boring tool based on material and required dimensions.
- Adjust spindle speed, feed rate, and use cutting fluids for smooth operations and reduced tool wear.
- Mark hole centers accurately and use measuring tools to verify dimensions and depths at each step.



**Figure 2.1 Drilled Work piece**

Try:

**Perform Drilling, tapping and step boring using drilling machine on Aluminum Flat of 50 X 50 mm.**

### 3. PLANNING AND SHAPING

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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. Perform V and Dovetail machining & U-cut on the given work piece of Mild steel flat

Hint:

- The job is fixed on a vice. The tool is fixed on tool post.
  - The stroke of ram is adjusted to required length and machine is switched-on. Always during machining the job should be properly fixed with the half of try Square and vice to get a right angle surface after machining
  - After completion of work, the job should be filled help of file before fixing the job, V block dimensions are marked on the job with the help of dot punch.
  - The tool head should be rotated at  $45^\circ$  to make the V-groove. 8. The feed is given such that the tool moves gradually on either side of the middle line. The tool is moved to get the required groove.
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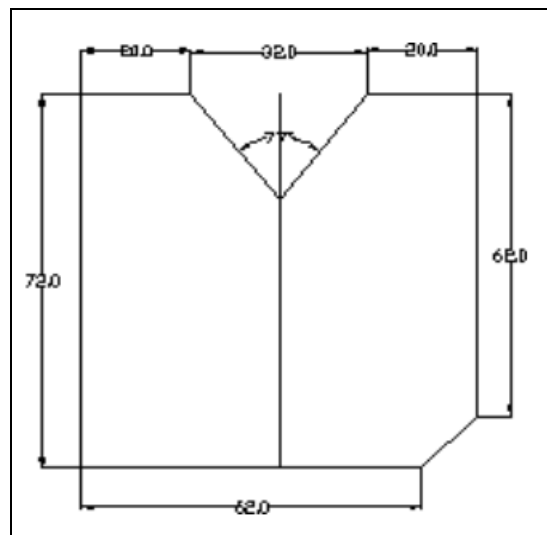


Figure 3.1 Machined Work piece

Try:

**Perform V and Dovetail machining & U-cut on the given work piece of Aluminum flat**

## 4. 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 slots 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. Perform a keyway using slotter machine.

**Hint:**

- Ensure the workpiece is firmly clamped on the slotter machine table, aligned with the cutting tool.
- Use a suitable keyway cutter that matches the required width and depth of the keyway.
- Set the stroke length and depth of cut based on the required keyway dimensions.
- Apply cutting oil or coolant to reduce heat, improve surface finish, and extend tool life during the keyway machining process.

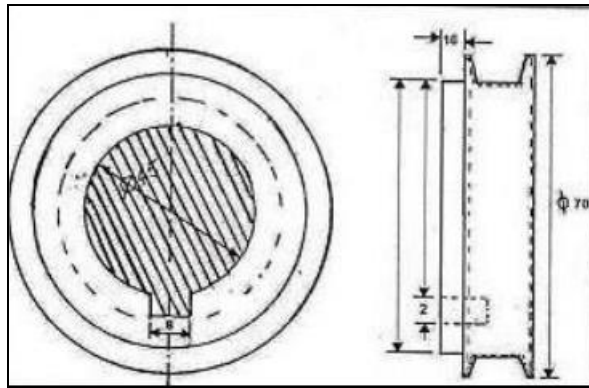


Figure 4.1 Slotted Work piece

Try:

### Perform Keyways on Aluminum flat

## 5. Milling

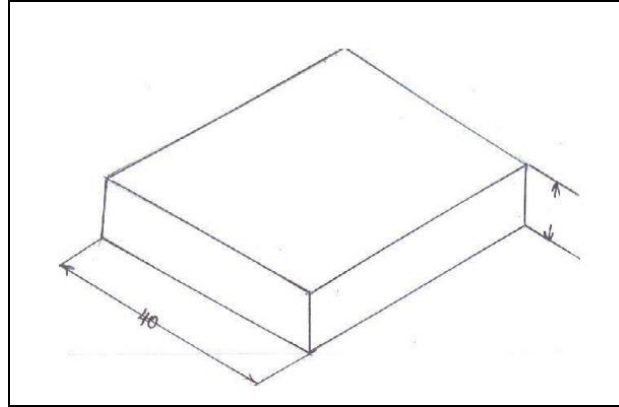
A milling machine removes material from a work piece by rotating a cutting tool (cutter) and moving it into the work piece. Milling machines, either vertical or horizontal, are usually used to machine flat and irregularly shaped surfaces and can be used to drill, bore, and cut gears, threads, and slots.

### 5.1 Perform plane milling operation on the given specimen (mild steel) & get to its correct dimensions.

**Hint:**

- Keep the work piece on the working table in required position with the help of magnetic chuck.

- Down the cutting grinder to just touch the surface of work piece.
- Then give the power supply.
- Move the work table forward and backward with the help of lever.
- Repeat the same procedure by changing the positions of work piece to get the correct dimensions of work piece completely.



**Figure 5.1 Slotted Work piece**

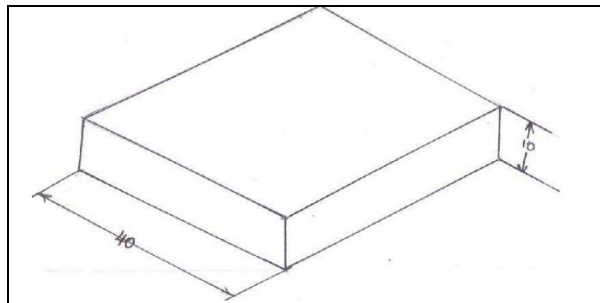
## 6. SURFACE GRINDING

Surface grinding is a precision machining process used to produce flat, smooth surfaces on work pieces. The primary goal of surface grinding is to remove material from a work piece to achieve a desired surface finish, flatness, and dimensional accuracy. It is typically performed using a machine called a **surface grinder**, which utilizes a rotating abrasive wheel to grind the surface of the material.

### 6.1 make surface finish of given work piece of mild Steel 40\*40\*20

#### Hint:

- Keep the work piece on the working table in required position with the help of magnetic chuck.
- Down the cutting grinder to just touch the surface of work piece.
- Then give the power supply.
- Move the work table forward and backward with the help of lever.
- Repeat the same procedure by changing the positions of work piece to get the surface finish of work piece completely.



**Figure 6.1 Slotted Work piece**

Try:

## Perform on Aluminum flat

### 7. Cylindrical GRINDING

Cylindrical grinding is a precision machining process used to produce a smooth surface finish and achieve tight tolerances on cylindrical or round parts. It is one of the most widely used grinding operations and is typically performed on a cylindrical grinding machine. Cylindrical grinding involves the rotation of a cylindrical workpiece while a grinding wheel removes material from its surface. The process can be applied to the external or internal surfaces of a part and is essential for creating components with high precision and excellent surface finish.

#### 7.1 Achieve a precise diameter, excellent surface finish, and roundness on a mild steel work piece.

Hint:

- Mount the work piece between the centers of the grinding machine.
- Align the work piece axis parallel to the grinding wheel axis.
- Select the appropriate grinding wheel based on the material and required finish.
- Measure the final diameter using a micrometer.

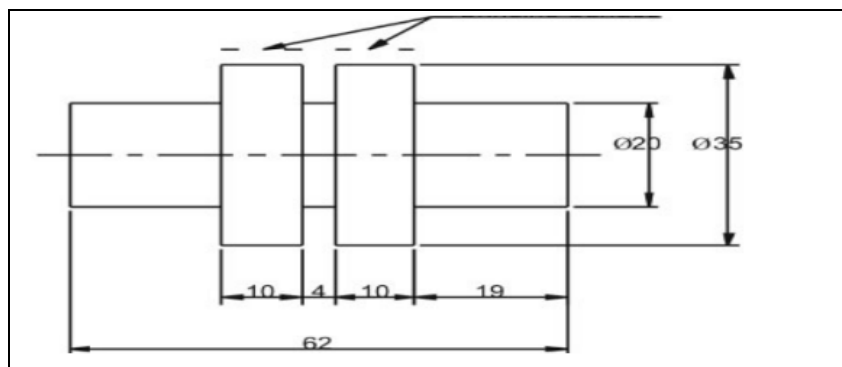


Figure 7.1 Grinded Work piece

Try:

## Perform on Aluminum round bar

### 8. VERNIER CALIPERS

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.

#### 8.1 Measure the Length, depth, diameter of given specimen using vernier calipers

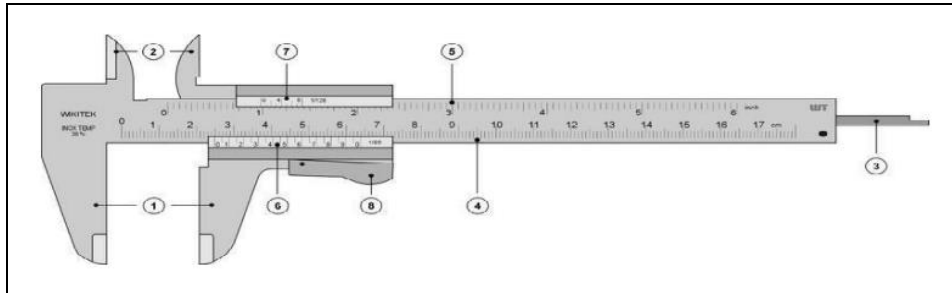
Hint:

- These are used for both – internal and external measurement.
- Its generate used for measuring by closing the jaws on work surface and taking



readings from main scale is examined to ascertain which of its division coincide and added to the main scale reading.

- Line of measurements and scale must coincide.
- Measurement tips of caliber should parallel to the work piece centre line



**Figure 8.1 Vernier Caliper**

**Try:**

**Perform on Aluminum Flat**

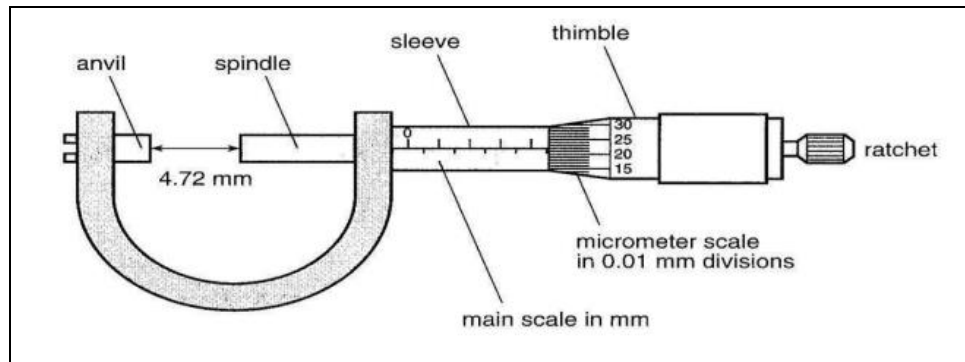
## 9. MICROMETER

A micrometer consists of a movable spindle (jaw) that advances toward another parallel-faced jaw, called an anvil, by rotating the thimble. The thimble rotates over an engraved sleeve or barrel that is mounted on a solid frame. Most micrometers are equipped with a ratchet, at the far right in figure 2, which allows slippage of the screw mechanism when a small constant force is exerted on the jaw. This permits the jaw to be tightened on an object with the same amount of force each time. The axial main scale on the sleeve is calibrated in mm and the thimble scale is the vernier scale and is usually divided into increments of 0.01mm.

### 9.1 Measure the Length, depth, diameter of given specimen using micrometer.

**Hint:**

- Select the micrometer with a desired range depending upon the size of the work piece to be measured.
- The next step is to check it for zero error. In case of 0.25mm micrometer, the zero error is checked by contracting the faces of the fixed anvil and the spindle.
- The barrel has graduation, in intervals of 1mm above the reference line
- For measuring the dimension, hold work b/w faces of the anvil the spindle by rotating then touches the work piece



**Figure 9.1 Micrometer**

**Try:**

**Perform on Aluminum round bar**

## 10. BORE GAUGE

This is used for measuring and checking linear measurement. These require less skills in their use than other instruments such as micrometer, gauges etc, when dial indicator is used as essential part in mechanism of any set up for measure purpose. It is referred as dial gauge. This gauge measures the displacement of its plunger, on a circular dial by means of rotating point. A dial gauge consists of graduated circular dial, pointer, contact point. Pointer gear train arrangement vessel clamp, revolution counter.

### 10.1 Measure the bore diameter of engine block using bore gauge.

**Hint:**

- Select the suitable anvil and washer to measure the dimension of given specimen.
- Insert anvil and washer at the bottom of vertical column of bore gauge
- Then insert the bore gauge and take the reading from dial indicator.
- Subtract the dial indicator value from the sum of anvil and washer value, which gives the bore diameter of given specimen.
- Repeat same procedure to get the bore diameter at different positions of specimen.



**Figure 10.1 Micrometer**

**Try:**

**Measure the bore diameter of single cylinder diesel engine using bore gauge.**

## 11. ANGLE MEASUREMENT – I (Bevel Protractor)

A universal bevel protractor is used to measure angles between two planes. This consists of stem, which is rigidly attached to main scale and a blade, which is attached to the Vernier scale and can be rotated to read angles. To improve the accessibility, the blade can also slide.

### 11.1 Measure different angles using bevel protractor

**Hint:**

- Place the adjustable blade on one side of the component.
- Tight the blade using lock nut
- Take the main scale reading
- Take the vernier scale reading from vernier scale which is fixed on the main scale through lens

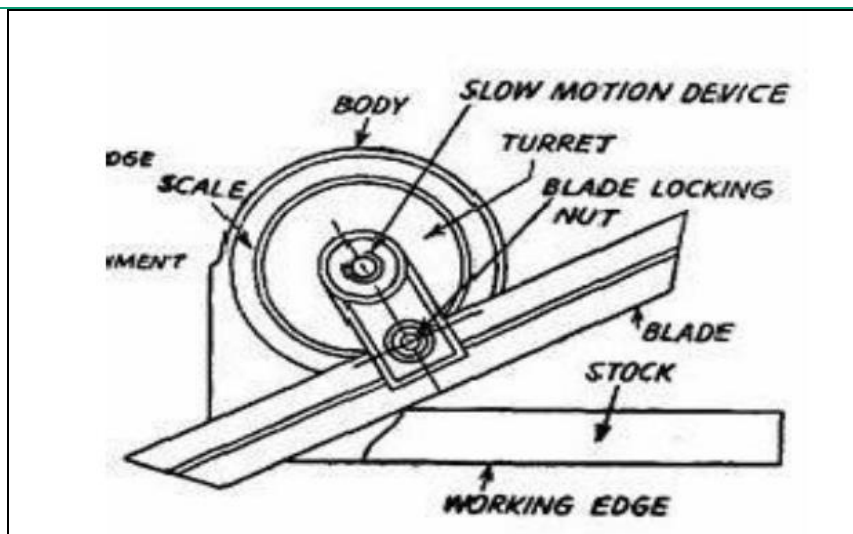


Figure 11.1 Micrometer

**Try:**

**Measure the lathe and milling guide ways.**

## 12. ANGLE MEASUREMENT – II (Sine Bar)

Sine bars are used either to measure angles very accurately or for locating any work to a given angle within very close limits. Sine bars are made from high carbon, high chromium, corrosion resistant steel, hardened, ground and stabilized. Two cylinders of equal diameter are attached at the ends. The axes of these two cylinders are mutually parallel to each other and also parallel to and at equal distance from the upper surface of the sine bar.

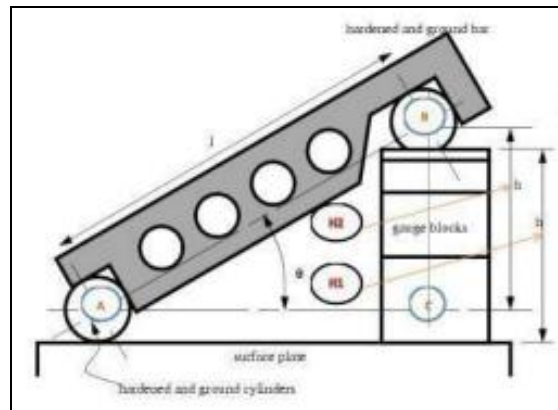
### 12.1 Determine the Morse taper angle through the utilization of a sine bar setup.

**Hint:**

- Place the work piece/wedge above the sine bar and make it horizontal with the base.
- The dial gauge is then set at one end of the work moved along the upper surface of the

component.

- If there is any variation in parallelism of the upper surface of the component and the surface plate, it is indicated by the dial gauge.
  - The combination of the slip gauges is so adjusted that the upper surface is truly parallel with the surface plate.
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**Figure 12.1 Sine Bar**

**Try:**

**Measure the lathe dead center Morse taper.**

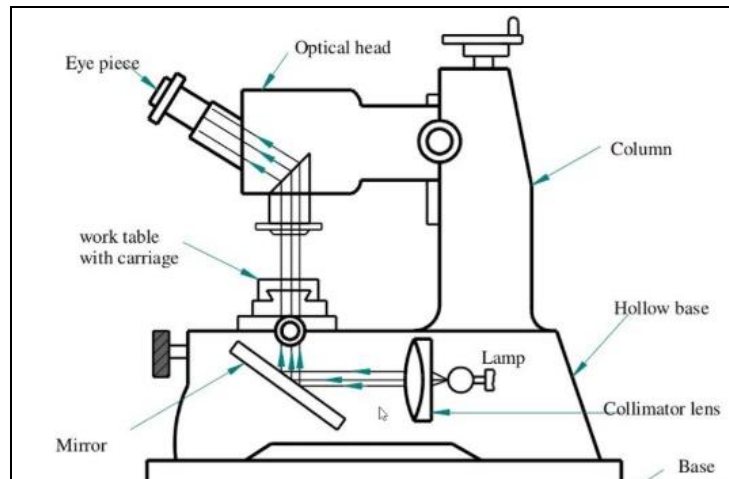
### 13. TOOL MAKERS MICROSCOPE

Tool makers microscope is based on the Principle of optics. The microscope consists of a heavy-duty hollow-duty hollow base, which accommodates the illuminating unit underneath, and above this on the top surface of the base, the work table carriage is supported on ball and controlled by micrometer screws. Projecting up from the rear of the base is a column, which carries the microscope unit and various interchangeable eyepieces.

#### 13.1 Determine the tool signature using tool makers microscope

**HINT:**

- The image of the thread profile is set so that some of the profile coincides with the cross hair as seen on the ground-glass screen.
  - The reading on thimble of the longitudinal micrometer screw is noted down.
  - Then the part is traversed by the micrometer screw until a corresponding point on the profile of the next thread coincides with the crosshairs.
  - The reading on thimble is again noted and the difference in two readings gives the actual pitch of the screw.
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**Figure 13.1 Tool Makers Microscope**

**Try:**

**Measure the Screw Pitch of lead screw of lathe.**

## **14. SURFACE ROUGHNESS MEASUREMENT**

The surface irregularities of small wavelength are called primary texture or roughness these are caused by direct action of the cutting elements on the material i.e., cutting tool shape, feed rate or by some other disturbances such as friction, wear or corrosion. The surface considerable wavelength of a periodic character are called secondary texture or waviness. These irregularities result due to inaccuracies of slides, wear of guides, misalignment of centers, non-linear feed motion, vibrations of any kind etc.

### **14.1 To measure the surface roughness of a given specimen using SJ210**

**HINT:**

- The work to be tested is placed on the table of the instrument. It is traversed by means of a lead screw.
- The stylus, which is pivoted to a mirror, moves over a tested surface. A light source sends a beam of light through lens and a precision slit to the oscillating mirror.
- The reflected beam of light is directed to a revolving drum, upon which a sensitized film is arranged. The drum is rotated through 2-bevel gears from the same lead screw.
- A profilograph will be obtained from the sensitized film, that may be subsequently analyzed to determine the value of the surface roughness.



**Figure 14.1 Surface Roughness Tester**

**Try:**

**Measure the Surface generated by milling machined parts.**

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**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. Geoffrey," Fundamentals of metal machining and machine tools", Tata McGraw Hill Education, 3<sup>rd</sup> 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](https://akanksha.iare.ac.in/index?route=course/details&course_id=337)

**VIII. MATERIALS ONLINE:**

1. Course Template.
2. Laboratory manual.