UNIT-V					
10	a)	Why the slip gauges are termed as "End standard"? Explain.	L2	CO5	5M
	b)	State the principle of micrometer. Sketch an outside micrometer and name its various parts.	L3	CO5	5M
OR					
11	a)	Explain the use of sine bar for measuring angle of a taper plug gauge with the help of a neat sketch.	L3	CO5	5M
	b)	Describe the working principle of an optical projector.	L3	CO5	5M

Code: 23ME3501

III B.Tech - I Semester - Regular Examinations - NOVEMBER 2025

MACHINE TOOLS AND METROLOGY
(MECHANICAL ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.
4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

		BL	CO
1.a)	What is metal cutting?	L2	CO1
1.b)	List the properties of coolants.	L2	CO1
1.c)	Define 'taper'.	L2	CO2
1.d)	What are the operations that can be performed on a shaper?	L2	CO2
1.e)	Name different types of drilling machines.	L2	CO3
1.f)	What are the various methods of indexing?	L2	CO3
1.g)	Name any two instruments used to measure surface roughness.	L2	CO4
1.h)	Define 'tolerance'.	L2	CO4
1.i)	What is wringing of slip gauges?	L2	CO5
1.j)	Name the various instruments used for measuring angles.	L2	CO5

PART – B

			BL	CO	Max. Marks
		UNIT-I			
2	a)	Explain with the help of neat sketch the complete geometry of a single point cutting tool.	L3	CO1	5M
	b)	Distinguish between orthogonal cutting and oblique cutting.	L2	CO1	5M
		OR			
3	a)	State the general form of Taylor's equation for tool life, and discuss the parameters involved in it.	L2	CO1	5M
	b)	Sketch Merchant's force diagram and explain the different quantities involved.	L3	CO1	5M
		UNIT-II			
4	a)	Discuss in brief an engine lathe.	L3	CO2	5M
	b)	Distinguish between capstan and turret lathe.	L2	CO2	5M
		OR			
5	a)	Name different parts of a shaper. Describe them in brief pinpointing their functions.	L3	CO2	5M
	b)	Describe various slotting tools and slotting operations.	L3	CO2	5M

		UNIT-III			
6	a)	Sketch and describe in brief of a radial drilling machine.	L3	CO3	5M
	b)	What are the different horizontal boring machines? List them and specify their suitability.	L2	CO3	5M
		OR			
7	a)	Classify milling machines and list them accordingly. How milling differs from lathe?	L2	CO3	5M
	b)	Determine the cutting time in cutting 125 mm long keyway using HSS end mill of 20 mm diameter, having four cutting teeth. The depth of keyway is to be 4.5 mm. Feed per tooth is 0.1 mm and cutting speed is 90 m/min.	L3	CO3	5M
		UNIT-IV			
8	a)	Describe the various types and kind of abrasives.	L2	CO4	5M
	b)	Briefly explain the process of lapping.	L2	CO4	5M
		OR			
9	a)	Define "Interchangeability" and discuss its importance.	L2	CO4	5M
	b)	A 75 mm shaft rotates in a bearing. The tolerance for both shaft and bearing is 0.075 mm and the required allowance is 0.10 mm. Determine the dimensions of the shaft, and the bearing bore with the basic hole standard.	L3	CO4	5M

PVP 23

Code: 23ME3501

III B.Tech - I Semester - Regular Examinations - NOVEMBER 2025

MACHINE TOOLS AND METROLOGY
(MECHANICAL ENGINEERING)

Duration: 3 hours Max. Marks: 70

Note: 1. This question paper contains two Parts A and B.
2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.
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4. All parts of Question paper must be answered in one place.

BL – Blooms Level CO – Course Outcome

PART – A

1.a)	**What is metal cutting?** Definition; removal of metal by shear with cutting tool.	2M
1.b)	**List the properties of coolants.** Cooling, lubrication, chip removal, corrosion prevention	2M
1.c)	**Define 'taper'.** Gradual reduction of diameter along length.	2M
1.d)	**What are the operations that can be performed on a shaper?** Shaping flat surfaces, grooves, dovetails, keyways, etc	2M
1.e)	**Name different types of drilling machines.** Sensitive, upright, radial, gang, multi-spindle	2M
1.f)	**What are the various methods of indexing?** Simple, compound, angular, differential indexing methods	2M
1.g)	**Name any two instruments used to measure surface roughness.** Profilometer, Talysurf,	2M
1.h)	**Define 'tolerance'.** Permissible limit of variation in dimension.	2M
1.i)	**What is wringing of slip gauges?** Sliding and twisting blocks to adhere by molecular attraction	2M
1.j)	**Name the various instruments used for measuring angles.** Protractor, sine bar, bevel protractor, angle gauge	2M

PART – B

2 a) **Explain with the help of neat sketch the complete geometry of a single point cutting tool.** 5M

- Clear sketch ------------2 Marks
- rake angle ------------1 Mark
- clearance angle, ------------1 Mark
- cutting edge, ------------1 Marks

	b)	**Distinguish between orthogonal cutting and oblique cutting.** Differences in: ➢ tool orientation ------------2 Marks ➢ shear plane, ------------1 Mark ➢ force direction, ------------1 Mark ➢ chip flow, ------------1 Mark	5M
3	a)	**State the general form of Taylor's equation for tool life, and discuss the parameters involved in it.** ➢ Equation form, ------------1 Mark ➢ definitions of V, T, n, C, feed ------------3 Marks ➢ effect explained ------------1 Mark	5M
	b)	**Sketch Merchant's force diagram and explain the different quantities involved.** ➢ Diagram with forces ------------3 Marks ➢ explanations. ------------2 Marks	5M
4	a)	**Discuss in brief an engine lathe.** ➢ Diagram ------------3 Marks ➢ explanations. ------------2 Marks	5M
	b)	**Distinguish between capstan and turret lathe.** Differences in: ➢ Construction, ------------2 Marks ➢ operation, ------------1 Mark ➢ applications, ------------1 Mark ➢ tool holding. ------------1 Mark	5M
5	a)	**Name different parts of a shaper. Describe them in brief pinpointing their functions.** ➢ Diagram ------------3 Marks ➢ List major parts and brief functions. ------------2 Marks	5M
	b)	**Describe various slotting tools and slotting operations.** ➢ Listing any 4 Types of slotting tools ------------ 4 Marks ➢ Brief discussion ------------ 1 Mark	5M
6	a)	**Sketch and describe in brief of a radial drilling machine.** ➢ Diagram ------------3 Marks ➢ List major parts and brief functions. ------------2 Marks	5M
	b)	**What are the different horizontal boring machines? List them and specify their suitability.** ➢ Listing any 4 Types of slotting tools ------------ 4 Marks ➢ Brief discussion ------------ 1 Mark	5M
7	a)	**Classify milling machines and list them accordingly. How milling differs from lathe?** ➢ Classification ------------3 Marks ➢ comparison table with lathe ------------2 Marks	5M
	b)	**Determine the cutting time in cutting 125 mm long keyway using HSS end mill of 20 mm diameter, having four cutting teeth. The depth of keyway is to be 4.5 mm. Feed per tooth is 0.1 mm and cutting speed is 90 m/min.**	5M

- ➢ Correct formula, ------------1 Mark
- ➢ calculations for spindle speed, feed, ------------2 Marks
- ➢ Machining time. ------------2 Marks

8 a) **Describe the various types and kind of abrasives.** 5M

Discussion on

- ➢ Natural abrasives ------------2 Marks
- ➢ synthetic abrasives ------------3 Marks

b) **Briefly explain the process of lapping.** 5M

- ➢ Diagram ------------3 Marks
- ➢ Brief explanation of lapping process ------------2 Marks

9 a) **Define "Interchangeability" and discuss its importance.** 5M

- ➢ Concept of "Interchangeability" ------------2 Marks
- ➢ discussing its importance ------------3 Marks

b) **A 75 mm shaft rotates in a bearing. The tolerance for both shaft and bearing is 0.075 mm and the required allowance is 0.10 mm. Determine the dimensions of the shaft, and the bearing bore with the basic hole standard.** 5M

- ➢ Determine Hole dimensions ------------3 Marks
- ➢ Determine Shaft dimensions ------------2 Marks

10 a) **Why the slip gauges are termed as "End standard"? Explain.** 5M

- ➢ Reason ------------2 Marks
- ➢ Explanation ------------3 Marks

b) **State the principle of micrometer. Sketch an outside micrometer and name its various parts.** 5M

- ➢ Diagram ------------3 Marks
- ➢ Brief explanation ------------2 Marks

11 a) **Explain the use of sine bar for measuring angle of a taper plug gauge with the help of a neat sketch.** 5M

- ➢ Diagram ------------3 Marks
- ➢ Brief explanation ------------2 Marks

b) **Describe the working principle of an optical projector.** 5M

- ➢ Diagram ------------3 Marks
- ➢ Brief explanation of principle ------------2 Marks

III B.Tech - I Semester - Regular Examinations - NOVEMBER 2025

MACHINE TOOLS AND METROLOGY
(MECHANICAL ENGINEERING)

PART – A

1.a) **What is metal cutting?** **2M**

Metal cutting is a subtractive manufacturing process that involves removing unwanted material from a metal workpiece using mechanical force or erosion techniques, typically with cutting tools. The main purpose is to shape the metal into desired parts with specific size, finish, and tolerance for creating finished components.

1.b) **List the properties of coolants.** **2M**

- High thermal conductivity
- Good lubricating qualities
- High flash point
- Non-corrosiveness
- Chemical stability against oxidation
- Resistance to gum or precipitate formation
- Odorless and operator-friendly
- Effective at chip/swarf removal
- Environmentally safe

1.c) **Define 'taper'.** **2M**

A 'taper' in machining refers to a gradual and uniform reduction in the diameter or width of a workpiece or tool over a specific length, resulting in a shape that transitions smoothly from a larger cross-section to a smaller one, often resembling a cone.

1.d) **What are the operations that can be performed on a shaper?** **2M**

Common Operations on a Shaper

- Horizontal surface machining
- Vertical surface machining
- Angular surface machining
- Slotting and grooving
- Cutting internal surfaces

Cutting dovetails and V-grooves

1.e) **Name different types of drilling machines.** **2M**

- Portable Drilling Machine
- Sensitive or Bench Drilling Machine
- Upright or Pillar Drilling Machine
- Radial Drilling Machine
- Gang Drilling Machine
- Multi-Spindle Drilling Machine
- CNC Drilling Machine
- Deep Hole Drilling Machine

- Turret Drilling Machine

1.f) **What are the various methods of indexing?** **2M**

- Direct Indexing
- Simple or Plain Indexing
- Compound Indexing
- Differential Indexing
- Angular Indexing

1.g) **Name any two instruments used to measure surface roughness.** **2M**

- Profilometer
- Taylor Hobson Talysurf

1.h) **Define 'tolerance'.** **2M**

- Tolerance in manufacturing and engineering is the permissible limit or range of variation in a physical dimension, measured value, or property of a manufactured component.
- It defines the maximum acceptable deviation from the specified nominal value, ensuring that parts fit, function, and perform as intended despite minor variations during production.
- Essentially, tolerance is the allowable error or variation that does not adversely affect the part's usability or assembly.

1.i) **What is wringing of slip gauges?** **2M**

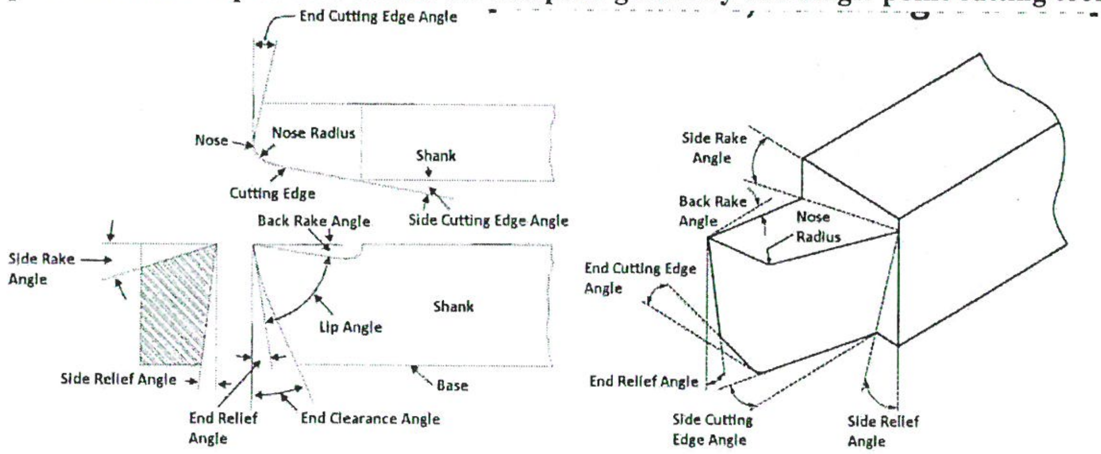
Wringing of slip gauges is a process in precision engineering where two extremely flat and smooth surfaces of slip gauges (gauge blocks) are joined together without using any adhesive or external force. The blocks adhere tightly due to molecular attraction and the exclusion of air between the surfaces. This adhesion allows multiple slip gauges to be combined into a stack with a precise total length, which can be handled as a single unit. The process requires the surfaces to be clean, and the wringing is done by sliding and rotating one gauge on another until they stick firmly together.

1.j) **Name the various instruments used for measuring angles.** **2M**

- Bevel Protractor
- Sine Bar
- Autocollimator

PART – B

2 a) **Explain with the help of neat sketch the complete geometry of a single point cutting tool.** 5M



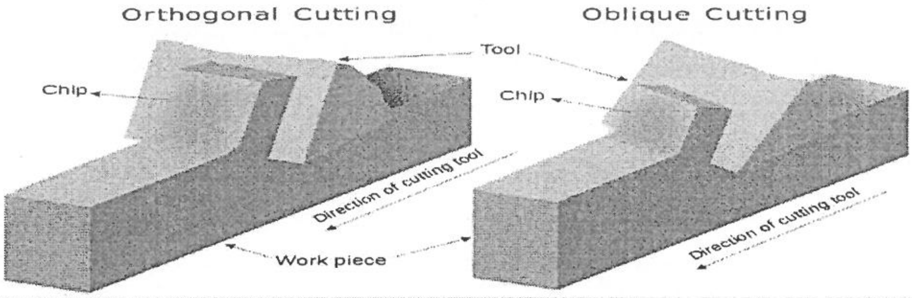
A single point cutting tool is used in machining processes like turning, shaping, and facing to remove material from the workpiece. The complete geometry of a single point cutting tool is defined by several important angles and surfaces, which affect its cutting performance and the quality of the machined surface.

Geometry of a Single Point Cutting Tool

Here is the explanation of the key terms and angles in the geometry of a single point cutting tool:

- Cutting Edge: The edge where the tool first contacts the workpiece and initiates cutting.
- Face: The surface over which the chips flow after being cut.
  - Rake Face: The top surface of the tool where chips flow.
- Flank: The surface below the cutting edge that contacts the finished surface of the workpiece.
  - Primary Flank: The major surface adjacent to the cutting edge.
  - Secondary Flank (or Clearance Surface): Provides clearance to prevent rubbing against the workpiece.
- Rake Angle (α): The angle between the rake face and a plane perpendicular to the cutting surface; it influences chip formation and cutting forces.
- Clearance Angle (β): The angle between the flank surface and the machined surface, providing the tool clearance and avoiding friction.
- Side Cutting Edge Angle: The angle between the cutting edge and the axis of the tool.
- End Cutting Edge Angle: The angle between the end cutting edge and the axis of the tool.
- Nose Radius: The rounded tip of the cutting edge that improves surface finish and strength.
- Back Rake Angle: Angle of the face behind the cutting edge that helps control chip flow.
- Side Relief Angle: Angle on the side flank to avoid rubbing.

b) Distinguish between orthogonal cutting and oblique cutting. 5M



S. No.	Orthogonal cutting	Oblique cutting
1.	The cutting edge of the tool is perpendicular to the direction of cutting.	The cutting edge is inclined at an acute angle with the normal to the direction of cutting.
2.	The chip flows over the tool face and the direction of chip flow velocity is normal to the cutting edge.	The chip flows on the tool face making an angle with the normal on the cutting edge.
3.	The cutting edge is longer than the width of the cut.	The cutting edge may or may not be longer than the width of the cut.
4.	The maximum chip thickness occurs at its middle.	The maximum chip thickness may not occur at the middle.
5.	The tool is perfectly sharp and it contacts the chip on rake face only.	Frequently, more than one cutting edge is in action.
6.	Only two components of cutting forces act on the tool. They are mutually perpendicular to each other.	Three components of the cutting forces act on the cutting edge of the tool.
7.	Tool life is less.	Tool life is more.

3 **a) State the general form of Taylor's equation for tool life, and discuss the parameters involved in it.** 5M

The general form of Taylor's equation for tool life is expressed as:

$$VT^n = C$$

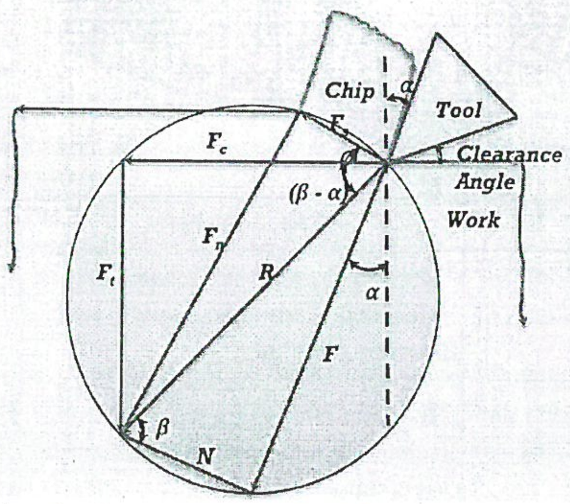
Explanation of the parameters involved:

- V is the cutting speed, usually measured in meters per minute (m/min).
- T is the tool life, typically measured in minutes (min), which is the time the tool can be used before it needs replacement or resharpening.
- n is an exponent that depends on the tool material and the workpiece material; it characterizes the sensitivity of tool life to the cutting speed.
- C is a constant for a given tool-work material pair under specific cutting conditions; it represents the product of cutting speed and tool life raised to the power n.

The equation represents an inverse relationship between cutting speed and tool life: as the cutting speed increases, the tool life decreases according to the power law defined by n. This formula is empirical and derived from experimental data and is fundamental for optimizing machining processes to balance productivity and tool usage cost. n and C are determined experimentally for each combination of cutting tool, workpiece material, and cutting conditions.

b) Sketch Merchant's force diagram and explain the different quantities involved. 5M

Merchant's force diagram (Merchant's circle diagram) is used in orthogonal cutting to analyze the forces acting between the cutting tool and the workpiece during machining.



$$F = F_C \sin\alpha + F_t \cos\alpha$$
$$N = F_C \cos\alpha - F_t \sin\alpha$$
$$F_S = F_C \cos\phi - F_t \sin\phi$$
$$F_N = F_C \sin\phi + F_t \cos\phi$$
$$F_N = F_S \tan(\phi + \beta - \alpha)$$

Merchant's diagram is a circle with diameter equal to the resultant force F, which is the vector sum of the cutting force F_c and thrust force F_t. The circle is drawn such that the forces F_c (cutting force) and F_t (thrust force) act as perpendicular components forming a right triangle within the circle.

Quantities and Explanation:

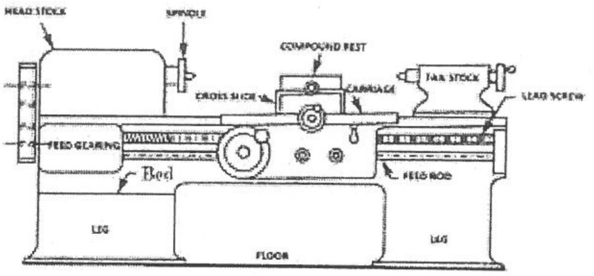
- F: Resultant force (diameter of the circle), resultant of cutting force F_c and thrust force F_t
- F_c: Cutting force, acts horizontally in the direction of the cutting velocity
- F_t: Thrust force, acts perpendicular to F_z, thrust direction
- P: Frictional force between the chip and tool rake face, tangential to the tool surface
- N: Normal force at the tool-chip interface, perpendicular to friction force P
- F_s: Shear force acting along the shear plane where chip separates
- F_n: Normal force acting on the shear plane
- α: Rake angle of the tool
- β: Shear angle of the chip formation plane
- γ: Friction angle, related to friction coefficient $\mu = \tan\gamma$

Relationships:

- The friction coefficient μ between the tool and chip is $\mu = P/N = \tan\gamma$
- F is composed of F_x and F_z: $F = \sqrt{F_c^2 + F_t^2}$
- Force decomposition on the shear plane:
  - Shear force $F_s = F_c\cos\beta - F_t\sin\beta$
  - Normal force on shear plane $F_n = F_c\sin\beta + F_t\cos\beta$
- Forces on the tool rake face:
  - Friction force $P = F_t\cos\alpha + F_c\sin\alpha$
  - Normal force $N = F_c\cos\alpha - F_t\sin\alpha$

This diagram and these relations enable calculation of unknown force components based on measurable forces F_c and F_t, helping in analysis and optimization of machining operations such as cutting force, shear force, friction, and stresses involved.

4 a) **Discuss in brief an engine lathe.**



An engine lathe is a general-purpose, horizontally mounted lathe machine widely used for metal cutting and shaping cylindrical components. It operates by rotating the workpiece against a cutting tool that moves longitudinally and crosswise to create the desired shape. Originally developed in the 19th century and powered by steam engines, modern engine lathes are powered by electric motors and can be bench- or floor-mounted, with increased precision and versatility. 5M

Key features of an engine lathe include:

- A headstock containing the spindle and gear mechanisms for variable speeds.
- A carriage assembly that controls the cutting tool's movement in longitudinal and lateral directions.
- A tailstock used to support long workpieces or hold drilling tools.
- A lead screw and feed rod used for threading and automatic feeding.
- Adjustable speed and feed controls along with manual and automatic feeds.
- Ability to perform various operations such as turning, facing, threading, drilling, boring, grooving, knurling, and taper turning.

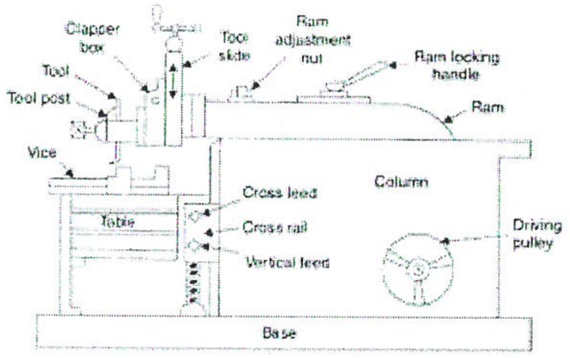
Engine lathes are highly valued for their flexibility in handling a wide range of workpieces from simple single-piece jobs to small batch production. They are used extensively in industries like aerospace, automotive, and general engineering for producing shafts, bushings, and other precision parts. Modern engine lathes often have CNC options for automation, improving accuracy and reducing manual effort

b) **Distinguish between capstan and turret lathe.**

S.No	Capstan lathe	Turret lathe
1	It is a light duty machine	It is a heavy duty machine
2	The turret head is mounted on the ram and the ram is mounted on the saddle.	The turret head is directly mounted on the saddle and the saddle slides over the bed ways
3	The saddle will not be moved during machining	The saddle is moved along with the turret head during machining
4	The lengthwise movement of turret is less	The lengthwise movement of turret is more
5	Short work pieces only can be machined.	Long work pieces can be machined
6	It is easy to move the turret head as it slides over the ram	It is difficult to move the turret head along with saddle
7	The turret head cannot be moved crosswise	The turret head can be moved crosswise in some turret lathes
8	As the construction of lathe is not rigid, heavy cut cannot be given	As the construction of lathe is rigid, heavy cut can be given
9	It is used for machining work pieces up to 60mm diameter	It is used for machining work pieces up to 200mm diameter
10	Collet is used to hold the work piece	Jaw chuck is used to hold the work piece

5M

5 a) **Name different parts of a shaper. Describe them in brief pinpointing their functions.** 5M



Principal parts of a shaper

A shaper machine consists of several main parts, each with a specific function to facilitate shaping operations:

- Base: The base is the foundation of the shaper machine, made of cast iron to hold the entire machine and absorb vibrations and shocks during operation. It supports all other parts and ensures stability.
- Column: Mounted on the base, the column is a box-like casting that houses the ram driving mechanism and provides guideways for the ram's reciprocating motion. It supports the ram and work table.
- Cross-rail: Attached to the front vertical face of the column, the cross-rail moves vertically and carries the table. Its elevation can be adjusted using an elevating screw to position the workpiece as needed.
- Table: The table is mounted on the cross-rail and supports the workpiece. It can be moved laterally by the operator to position the workpiece under the cutting tool.
- Ram: The ram is the reciprocating component that moves back and forth carrying the tool head. It holds the cutting tool, and its forward stroke performs the cutting, while the return stroke is idle.
- Tool head and Clapper box: The tool head secures the cutting tool and is attached to the ram. The clapper box allows the tool to lift or "snap" back on the return stroke to avoid dragging, reducing tool wear and improving cut quality.
- Feed Mechanism: Through a down-feed screw mechanism, the tool head can be fed vertically to adjust the depth of the cut with each stroke.

b) **Describe various slotting tools and slotting operations.** 5M

A slotting tool is a single-point cutting tool used in slotting machines to cut slots, grooves, keyways, and internal shapes in workpieces. The slotting machine operates by a reciprocating vertical cutting motion.

Various Slotting Tools

- Single Point Tool: Usually made of high-speed steel (HSS) or carbide-tipped, it has a specific shape for cutting slots, keyways, and grooves.
- Key seater Tool: Specially designed for cutting keyways, it has a particular shape to enter the workpiece from the bottom and cut in the downward stroke.
- T-slot Cutter: A rotating milling cutter used to produce T-shaped slots, with side-cutting flutes and enlarged lower diameter for undercutting.
- Woodruff Key Cutter: Used to cut semicircular slots or keyways.
- Gang Cutters: A set of cutters used together for parallel slots.

6 a) Sketch and describe in brief of a radial drilling machine. 5M

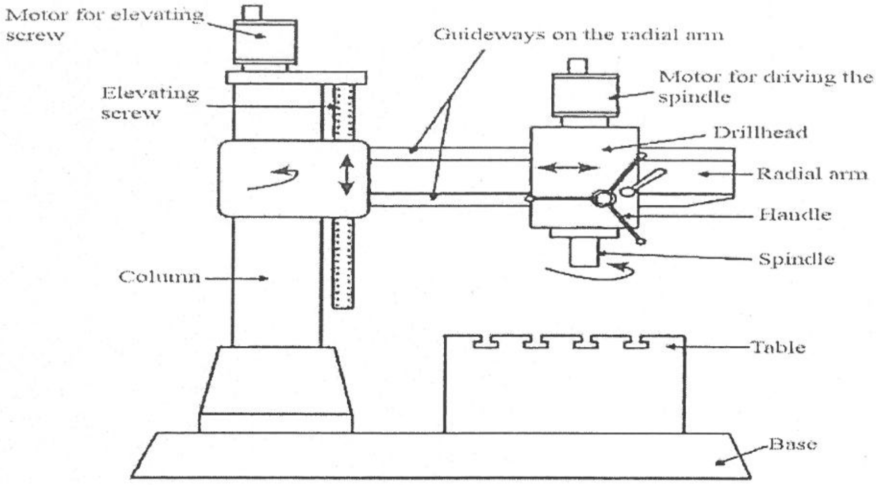


Figure: Radial Drilling Machine

A radial drilling machine is a versatile machine used primarily for drilling holes in large and heavy workpieces that cannot be easily placed in a regular drilling machine vice.

Main Parts and Their Functions

- Base: Provides a sturdy, vibration-damping foundation made of cast iron or steel. Supports all other components.
- Column: A vertical pillar fixed to the base, supporting the radial arm, allowing it to rotate around it.
- Radial Arm: A horizontal arm mounted on the column that can rotate around it and slide vertically up and down. The drill head slides along this arm.
- Drill Head: Mounted on the radial arm, it houses the spindle and motor. Controls the rotation and feed of the drill bit.
- Spindle: Rotates the drill bit, powered by the motor.
- Table: Positioned below the arm to hold the workpiece. It can be adjusted vertically or swiveled as needed.
- Motor: Drives the spindle for drilling operation.
- Feed Mechanism: Controls the advancement of the drill bit into the workpiece.

b) **What are the different horizontal boring machines? List them and specify their suitability.** 5M

Table Type Horizontal Boring	Features a movable table that supports the workpiece and can move in multiple directions. Suitable for general purposes including boring, milling, and facing of medium-sized workpieces. Most commonly used type.
Floor Type Horizontal Boring	Has a fixed floor plate with T-slots to hold very large and heavy workpieces. The spindle and tool move while the workpiece remains stationary. Ideal for machining large, heavy components difficult to mount on tables.
Planer Type Horizontal Boring	Resembles the table type but with a table sliding directly on the bed and adjustable columns. Suitable for long workpieces and irregular sizes requiring flexibility in workpiece positioning.
Multiple Heads Type	Equipped with several boring heads. Used for complex and simultaneous machining operations on large workpieces requiring multiple boring centers.

7 a) **Classify milling machines and list them accordingly. How milling differs from lathe?** 5M

Milling machines are broadly classified based on their construction, spindle orientation, and purpose. The main classes and types are:

Classification of Milling Machines

- Column and Knee Type Milling Machines
  - Hand Milling Machine
  - Plain or Horizontal Milling Machine
  - Vertical Milling Machine
  - Universal Milling Machine
  - Omniversal Milling Machine
- Fixed Bed Type Milling Machines
  - Simplex Milling Machine
  - Duplex Milling Machine
  - Triplex Milling Machine
- Planer Type Milling Machines
- Special Purpose Milling Machines
  - Rotary Table Milling Machine
  - Drum Milling Machine
  - Profile Milling Machine
  - Planetary Milling Machine
  - Tracer Control Milling Machine
  - Pantograph Milling Machine
  - NC/CNC Milling Machine

Feature	Milling Machine	Lathe Machine
Workpiece Motion	Workpiece may be stationary or moved in different directions; cutter rotates	Workpiece rotates; cutter is stationary or moves parallel to axis
Cutting Tool	Multi-point cutting tools like end mills and face mills	Single-point cutting tool
Operation	Produces flat, curved, or irregular surfaces by moving tool relative to workpiece	Produces cylindrical shapes via turning operations
Applications	Slotting, cutting gears, flat surface machining, drilling	Turning, facing, threading cylindrical parts
Material Removal Direction	Tool removes material by moving across workpiece surfaces	Tool removes material by moving along rotating workpiece surface

b) **Determine the cutting time in cutting 125 mm long keyway using HSS end mill of 20 mm diameter, having four cutting teeth. The depth of keyway is to be 4.5 mm. Feed per tooth is 0.1 mm and cutting speed is 90 m/min.** 5M

To determine the cutting time, we need to find the machining parameters.

Given Data

- Length of keyway, $L = 125$ mm

- Diameter of end mill, $D = 20$ mm
- Number of cutting teeth, $z = 4$
- Depth of keyway, $d = 4.5$ mm (Usually affects pass count, but here not needed directly for t_c)
- Feed per tooth, $f_t = 0.1$ mm/tooth
- Cutting speed, $V = 90$ m/min $= 90000$ mm/min

Step 1: Calculate Spindle Speed *N*

$$N = \frac{V \times 1000}{\pi D}$$

$$N = \frac{90 \times 1000}{\pi \times 20} = \frac{90000}{62.83} \approx 1433 \text{ rpm}$$

Step 2: Calculate Feed Rate *F*

$$F = f_t \times z \times N = 0.1 \times 4 \times 1433 = 573.2 \text{ mm/min}$$

Step 3: Calculate Cutting Time t_c

Cutting time is the time taken to cut length L at feed rate F.

$$t_c = \frac{L}{F} = \frac{125}{573.2} \approx 0.218 \text{ minutes} = 13.08 \text{ seconds}$$

8 a) **Describe the various types and kind of abrasives.** 5M

Abrasives are hard materials used to cut, grind, polish, and finish workpieces by removing material through friction. They are classified mainly into natural and synthetic abrasives, each suited for specific applications based on hardness, toughness, and usage form.

Types of Abrasives

1. Natural Abrasives

- Extracted naturally with minimal processing.
- Examples:
    - Diamond: The hardest natural abrasive used for precision cutting and grinding.
    - Corundum (Aluminum Oxide): Used for grinding and polishing metals.
    - Garnet, Emery, Flint, Quartz: Used in sandpaper and grinding applications.
    - Pumice and Talc: Softer abrasives used for polishing and finishing.

2. Synthetic Abrasives

- Manufactured abrasives designed for high performance.
- Examples:
    - Aluminum Oxide: Durable, widely used in grinding wheels and sandpapers.
    - Silicon Carbide: Sharper but more brittle, ideal for cutting hard materials like glass and ceramics.
    - Boron Carbide: Extremely hard, used in aerospace and bulletproof materials.
    - Ceramic Abrasives: Very hard and long-lasting, used in heavy-duty grinding.
    - Synthetic Diamond and Cubic Boron Nitride: Super abrasives for ultra-hard materials and precision machining.

Forms of Abrasives

- Bonded Abrasives: Abrasive grains bonded together to form grinding wheels or blocks.
- Coated Abrasives: Abrasive grains adhered to flexible backings like paper or cloth (e.g., sandpaper, abrasive belts).
- Loose Abrasives: Free grains or powders used in polishing, sandblasting, or buffing.

b) **Briefly explain the process of lapping.** 5M

Lapping is a precision machining process in which two surfaces are rubbed together with an abrasive compound (often called slurry) between them. It can be done manually or with machines. The abrasive particles, suspended in a liquid vehicle like oil or water, roll and slide between the workpiece surface and a softer lapping plate or lap, removing tiny amounts of material to produce extremely smooth and flat surfaces.

Key Points of Lapping Process:

- It involves loose abrasive grains applied to a lap plate.
- The workpiece is pressed and moved against the rotating lap plate.
- Material removal is very small and uniform, targeting a high surface finish and dimensional accuracy.
- It is typically used for finishing after other machining processes.
- It produces flat, smooth, and burr-free surfaces.
- Common in finishing hard materials like steel, carbide, or ceramics.
- The process is a low-pressure, low-speed abrasive operation.

Lapping achieves superior flatness and surface quality by averaging out surface irregularities through the gentle rolling and sliding action of abrasive particles.

9 a) **Define "Interchangeability" and discuss its importance.** 5M

Interchangeability refers to the ability to replace a component or part with another identical part made to the same specifications, without the need for custom fitting or adjustment. In manufacturing, this means any randomly selected part can fit and function properly with any other mating part of the same type, ensuring consistent assembly and operation.

Importance of Interchangeability:

- Enables mass production by allowing parts to be made in large quantities without manual fitting.
- Facilitates easy assembly and reduces assembly time since parts fit together without adjustment.
- Simplifies repair and maintenance by allowing worn-out parts to be replaced quickly with standard parts.
- Reduces production costs by minimizing the need for skilled labor during assembly.
- Allows parts to be manufactured in different locations but assembled correctly anywhere.
- Enhances quality control by adhering to standardized dimensions and tolerances.
- Improves product reliability through consistent fit and function.

Interchangeability is fundamental to modern manufacturing, standardization, and the concept of spare parts, leading to efficient production and service systems.

b) **A 75 mm shaft rotates in a bearing. The tolerance for both shaft and bearing is 0.075 mm and the required allowance is 0.10 mm. Determine the dimensions of the shaft, and the bearing bore with the basic hole standard.** 5M

To solve this problem using the basic hole system, where the hole size is taken as the basic size (nominal dimension), and tolerances and allowances are applied to shaft and hole accordingly:

Given:

- Nominal diameter $D = 75$ mm
- Tolerance on shaft and bearing $= 0.075$ mm
- Allowance $A = 0.10$ mm
- Basic hole system means hole lower limit = basic size = 75 mm

Step 1: Determine Hole dimensions

- Since the hole tolerance is 0.075 mm and basic hole system fixes the hole lower limit as basic size:
- Hole Lower Limit $= 75.00$ mm (Basic size)
- Hole Upper Limit $= 75.00 + 0.075 = 75.075$ mm

Hole size = 75.000 to 75.075 mm

Step 2: Determine Shaft dimensions

- Allowance $A =$ min clearance $=$ lower limit of hole $-$ upper limit of shaft

Rearranged,

$$\text{Upper limit of shaft} = \text{Hole Lower Limit} - A = 75.00 - 0.10 = 74.90 \text{ mm}$$

- Tolerance on shaft = 0.075 mm (shaft size variation)

Shaft Lower Limit = Upper limit - Tolerance = 74.90 - 0.075 = 74.825 mm

Shaft size = 74.825 mm to 74.90 mm

Final Answer:

- Bearing bore (hole) dimension = 75.000 mm to 75.075 mm
- Shaft dimension = 74.825 mm to 74.900 mm

10 a) **Why the slip gauges are termed as "End standard"? Explain.** 5M

Slip gauges are termed as "End standards" because they are used to measure length as the distance between two parallel flat surfaces or ends. In other words, the length being measured or calibrated is expressed as the distance between the two faces (ends) of the slip gauge blocks.

Explanation:

- End standards define length by the distance between two flat, parallel end faces, unlike line standards which measure length by the distance between two engraved lines.
- Slip gauges consist of precision ground, rectangular blocks with flat ends, so the measurement is always between these ends.
- This property allows slip gauges to be "wrung" or slid together to build up a precise desired length by stacking the end surfaces.
- Since these gauges rely on end face measurements, they serve as physical length standards for calibration and precision measurement in workshops.

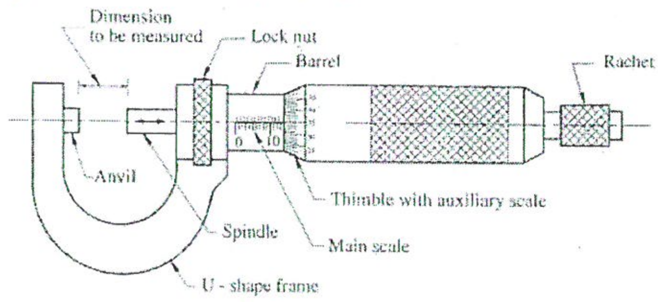
Hence, slip gauges are universally accepted as end standards in precision length metrology because they define length based on the separation of their two end faces, providing accurate and reliable measurement references

b) **State the principle of micrometer. Sketch an outside micrometer and name its various parts.** 5M

The principle of a micro meter is based on the mechanical advantage of a screw. The micro meter uses the distance moved axially by the screw for each rotation to precisely measure small lengths or thicknesses. One complete turn of the micrometer thimble moves the spindle axially by the pitch of the screw, enabling measurement with high accuracy.

Principle:

- The micro meter screw has a known pitch.
- Rotation of the thimble causes the spindle to move forward or backward.
- The axial displacement of the spindle corresponds to the thickness or diameter being measured.
- The scale on the sleeve and thimble allows reading the displacement accurately, usually to 0.01 mm or less.



- Outside micrometer

Parts:

- Frame: Holds the instrument rigidly.
- Anvil: Fixed measuring face.
- Spindle: Moves towards or away from anvil to measure object.
- Sleeve (Barrel): Scale graduated usually in millimetres; linear scale.
- Thimble: Rotates around sleeve; circular scale for fractional readings on screw pitch.
- Ratchet stop: Provides uniform force to ensure consistent measuring pressure.
- Lock nut: To lock the spindle in place after measurement (sometimes present).

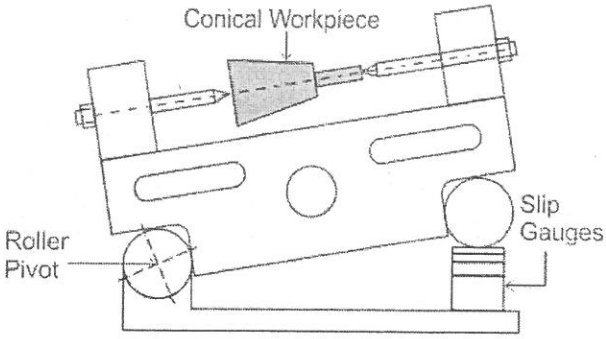
An outside micro meter measures the external dimensions such as thickness or diameter of small objects with precision following the micro meter screw principle.

11 a) **Explain the use of sine bar for measuring angle of a taper plug gauge with the help of a neat sketch.** 5M

The sine bar is a precision measuring instrument used to measure angles accurately by leveraging the trigonometric principle of sine. It is commonly used to measure angles on taper plug gauges, which have a precise taper.

Use of Sine Bar for Measuring Angle of a Taper Plug Gauge

Principle:



The sine bar works on the relationship:

$$\sin\theta = \frac{h}{L}$$

where:

- θ = angle to be measured,
- h = height of gauge blocks used to raise one end of the sine bar,
- L = length between the two precision rolls on the sine bar (base length).

Procedure to Measure Angle of Taper Plug Gauge:

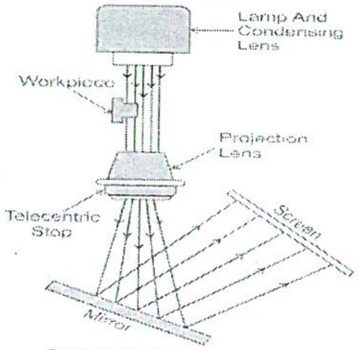
1. Place the sine bar on a surface plate.
2. Place the taper plug gauge on the sine bar such that the taper surface contacts the sine bar.
3. Adjust the height h under one end of the sine bar using gauge blocks until the taper surface of the plug gauge is perfectly aligned horizontally (no tilt).
4. Measure the height h of the gauge blocks used.
5. Using the sine formula, calculate the taper angle θ:

$$\theta = \sin^{-1}(\frac{h}{L})$$

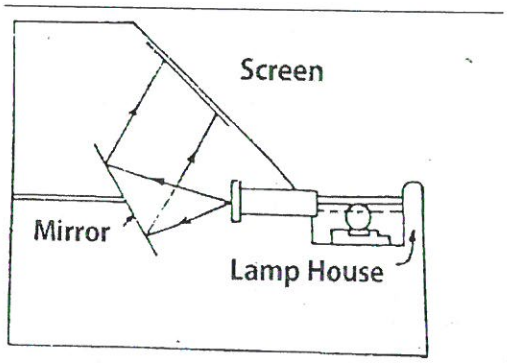
- The sine bar is elevated on one side by a stack of gauge blocks of height h.
- The distance L is fixed between the two rollers of the sine bar.
- The angle of taper θ is calculated from the height and length.
- This method provides a highly accurate way to measure taper angles, essential for quality checking of taper plug gauges.

b) **Describe the working principle of an optical projector.** 5M

The working principle of an optical projector (also known as a profile projector or optical comparator) is based on optical magnification and shadow projection.



Optical Projector



Working Principle:

- A light source illuminates the workpiece placed on a glass stage.
- Light passes through or around the workpiece, creating a shadow or profile image of the workpiece.
- This profile is magnified through an optical lens system (projection lenses).
- The magnified image is projected onto a large frosted glass screen.
- The image on the screen shows the profile or silhouette of the workpiece enlarged for easy inspection.
- By comparing the projected image with a reference template or using graduated scales on the screen, precise measurement of linear, angular, and geometric dimensions can be performed.
- The work stage usually has fine X-Y movement controlled by micrometer screws or digital readouts to measure distances and dimensions accurately.

Thus, the optical projector converts the physical dimensions of small or intricate parts into a large, clear projected image, aiding in visual inspection, measurement, and quality control.