

GUJARAT TECHNOLOGICAL UNIVERSITY

BE-4 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK SOLUTION

Subject Name & Code:

Mechanical Measurement and Metrology- 3141901

Unit 3: Measurement of Screw Thread and Gear

Repeated Questions:

1. Explain the Three-Wire Method for measuring the effective diameter of a screw thread with a neat sketch.

Appeared in: W25 (Q3c OR, 07 marks), W23 (Q5c, 07 marks), S25 (Q3c, 07 marks), S22 (Q3c OR, 07 marks)

Answer:

- **Purpose:** Determine pitch/effective diameter accurately, independent of flank angle errors.
- **Principle:** Place three identical precision wires in thread grooves (opposite sides) and measure over wires.
- **Formula:**

$$E = M - 0.86603p + 3d_w$$
 (for 60° thread)
 E = effective diameter, M = micrometer reading over wires, p = pitch, d_w = wire diameter.
- **Best wire size:**

$$d_w = \frac{p}{2 \cos(\frac{\alpha}{2})}$$
 where α = flank angle ($60^\circ \rightarrow d_w = 0.577p$).
- **Procedure:**
 1. Select best-size wires.
 2. Wipe thread, place two wires on one side, one opposite.
 3. Gently hold wires, measure over wires with precision micrometer.
 4. Measure multiple positions and average.
 5. Compute effective diameter.
- [DG]

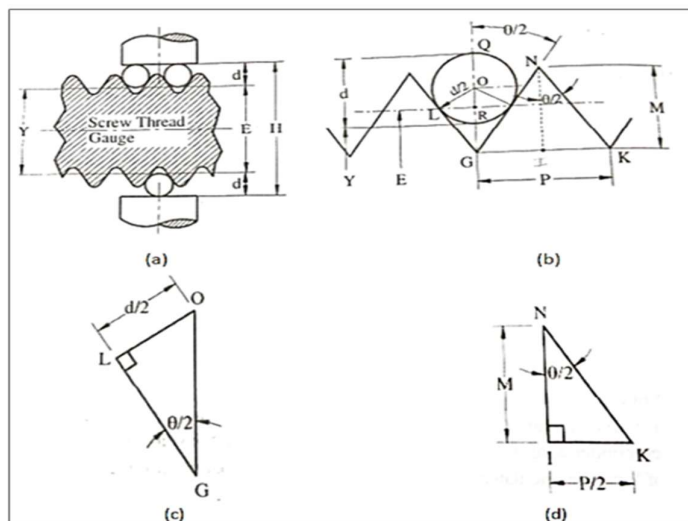


Fig.3.10 - Three-wire method

- **Advantages:** High accuracy, compensates for flank angle errors if best wire used.
- **Limitations:** Time-consuming, requires skilled operator.
(Highest weightage: 7 marks – S25 Q3c OR also appears)

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2. **Discuss the elements/terminology of a screw thread with a neat sketch. / Give the classifications of threads.**

Appeared in: W24 (Q2a, 03 marks), S25 (Q3a, 03 marks), W23 (Q2a, 03 marks)

Answer:

(key terms – also in Q.3):

- **Major diameter (D):** Largest diameter.
- **Minor diameter (d):** Smallest diameter.
- **Pitch diameter (effective diameter):** Diameter of imaginary cylinder where thread thickness equals space width.
- **Pitch (p):** Distance between two corresponding points on adjacent threads (mm).
- **Flank:** Straight side of thread profile.
- **Flank angle (α):** Included angle between flanks (e.g., 60° for metric).
- **Lead:** Distance thread advances in one revolution (for single start = pitch).
- **Crest & Root:** Top and bottom surfaces.
- [DG]

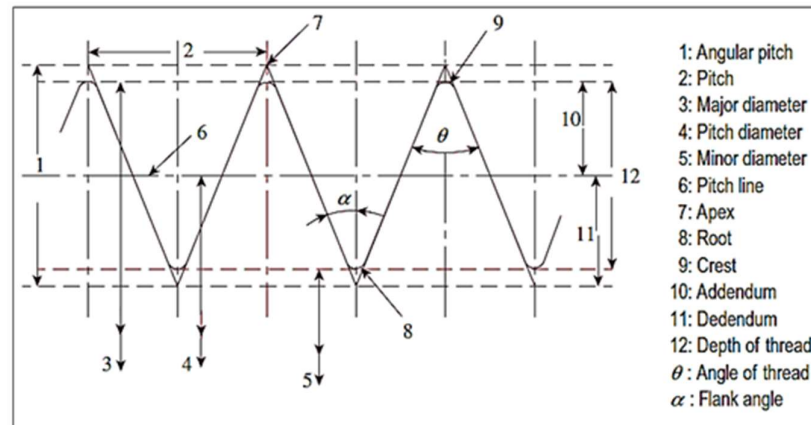


Fig.3.1 - Screw thread terminology

classifications of threads:

1. **By profile:**
 - V-thread (60° metric, 55° Whitworth)
 - Square thread
 - Acme thread (29°)
 - Buttress thread
 - Knuckle thread
2. **By direction:** Right-handed, Left-handed
3. **By number of starts:** Single-start, Multi-start
4. **By standard:** Metric, Unified (UNC/UNF), Whitworth (BSW), BSF
5. **By application:**
 - Fastening (V-thread)
 - Power transmission (square, Acme, buttress)
 - Lead screws (trapezoidal)

3. Explain the construction and working of a Tool Maker's Microscope with a neat sketch. List its applications. / Write a short note on Tool Maker's Microscope.
 Appeared in: W25 (Q2c, 07 marks), S23 (Q5b OR, 04 marks)

Answer:

• **Construction:**

- Heavy base with worktable (X-Y movement by micrometer screws).
- Vertical column with optical tube (objective, crosshair reticle, eyepiece).
- Illumination (transmitted and reflected).
- Protractor eyepiece for angular measurement.

• **Working:**

- Workpiece placed on table.
- Optical system projects magnified image onto crosshair screen.
- X-Y micrometers measure linear dimensions.
- Rotatable crosshair or protractor eyepiece measures angles.

• **Applications:**

- Thread inspection (pitch, major/minor diameter).
- Gear tooth profile and pitch.
- Tool angles (turning, milling cutters).
- Small part dimensional measurement (up to 0.001 mm).

• **[DG]**

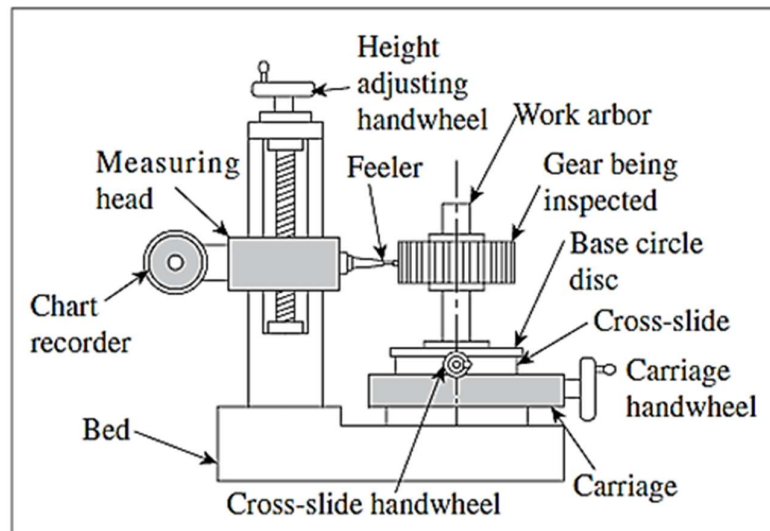


Fig.3.40 - Tool Maker's microscope – Schematic diagram

(Appears in many GTU papers – 7 marks)

4. Explain gear tooth thickness measurement using a Gear Tooth Vernier Caliper (Chordal Thickness Method).

Appeared in: W25 (Q5c, 07 marks), W24 (Q3c OR, 07 marks), S22 (Q5c OR, 07 marks)

Answer:

- **Gear tooth vernier** is a special vernier caliper with two perpendicular scales – one for chordal depth (vertical) and one for chordal thickness (horizontal).
- **Chordal thickness** = length of the chord joining two points on opposite flanks at a distance equal to the addendum from the tip.

- **Formula** (for module m , number of teeth N , pressure angle ϕ):
 - Chordal thickness $t_c = mN \sin \left(\frac{90}{N} \right)$ – approximate.
 - Exact: $t_c = mN \sin \left(\frac{180}{2N} \right) = mN \sin \left(\frac{90}{N} \right)$
 - Chordal addendum (depth) $h_c = m \left(1 + \frac{N}{2} \left(1 - \cos \frac{90}{N} \right) \right)$ – usually simplified to: $h_c = m + \frac{t_c^2}{4D}$ where D = pitch diameter.
- **Procedure:**
 1. Set gear tooth vernier to theoretical chordal depth (h_c) using vertical scale.
 2. Place the vernier jaws against the tooth flanks.
 3. Read chordal thickness on horizontal scale.
 4. Compare with standard value.
- **Advantages:** Direct reading, simple, no master gear needed.
- **Limitations:** Requires accurate tip reference, not suitable for small N (pointed teeth).
- [DG]

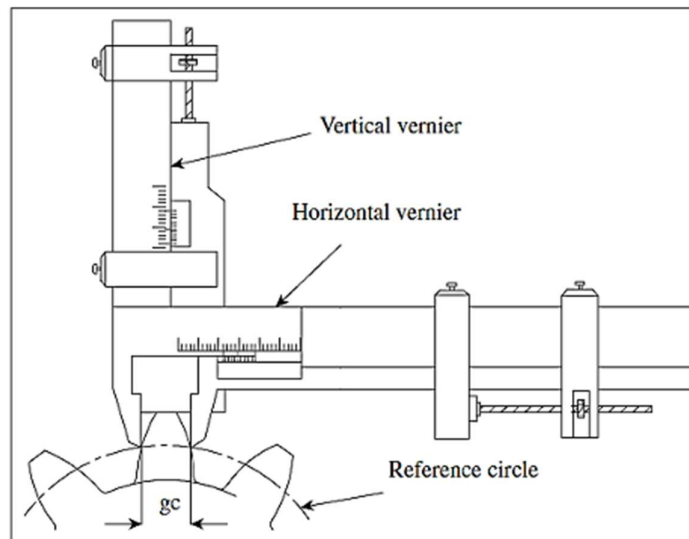


Fig.3.34 - Gear tooth caliper

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- 5. Name various methods for measurement of tooth thickness and explain any one. / Explain the Constant Chord Method for gear tooth measurement.
Appeared in: W22 (Q2c, 07 marks), S25 (Q3c OR, 07 marks)

Answer:

- **Constant chord method** measures gear tooth thickness at a constant chord length irrespective of pitch circle.
- **Definition:** Constant chord is the chord joining two points on opposite flanks at the moment they are in contact with the basic rack.
- **Formula for constant chord length (S_c) and height (h_c):**
For module m and pressure angle ϕ :

$$S_c = m \times \pi/2 \times \cos^2 \phi$$

$$h_c = m \times \left(1 - \frac{\pi}{4} \sin \phi \right)$$
- **For standard 20°:**
 $S_c = 1.387m$ (approx $1.387 \times$ module)

$$h_c = 0.747m \text{ (approx)}$$

- **Procedure using gear tooth vernier caliper:**
 1. Set depth of vernier to h_c .
 2. Place caliper jaws on tooth flanks.
 3. Measure chordal thickness.
 4. Compare with theoretical S_c .
- **Advantages:** Independent of pitch circle, one setup for all teeth.
- **Limitations:** Only for full depth involute teeth.
- [DG]

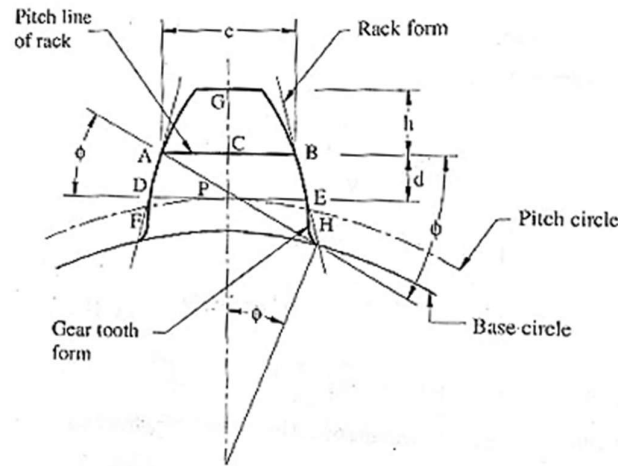


Fig.3.36 - Constant chord method

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6. **Define/Explain gear terminology: (e.g., Pressure Angle, Module, Circular Pitch, Addendum, Dedendum, Base Circle, Pitch Diameter, etc.)**

Appeared in: W25 (Q4a OR, 03 marks), W22 (Q3b, 04 marks), S25 (Q3a, 03 marks)

Answer:

- **Pressure angle (ϕ):** Angle between line of action (common normal) and common tangent at pitch point. Standard: 20° (originally 14.5°).
- **Circular pitch (p_c):** Distance along pitch circle from one tooth point to corresponding point of next tooth. $p_c = \frac{\pi D}{N}$.
- **Module (m):** Ratio of pitch circle diameter to number of teeth. $m = D/N$. Unit: mm. It is the basic sizing parameter.
- **Addendum (a):** Radial distance from pitch circle to tooth tip. $a = m$.
- **Dedendum (d):** Radial distance from pitch circle to tooth root. $d = 1.25 m$ (for full depth).
- **Base circle:** Circle from which involute curve is generated. Diameter = $D_{pitch} \times \cos \phi$.
- **Pitch diameter (D):** Diameter of pitch circle. $D = m \times N$.
- **Tooth thickness (t):** Arc length along pitch circle from one flank to the other. $t = (\pi \times m)/2$.

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7. **Explain Parkinson's Gear Tester with a neat sketch. / Write a short note on Parkinson Gear Tester.**

Appeared in: W24 (Q2c, 07 marks), W23 (Q4b, 04 marks)

Answer:

- **Purpose:** Checks composite errors (runout, pitch, tooth thickness) of spur gears.
- **Construction:**
 - Floating spring-loaded carriage holding master gear.
 - Work gear mounted on spindle with adjustable centers.
 - Dial indicator connected to the floating carriage.
 - Hand wheel and brake for contact.
- **Working:**
 - Master gear and test gear meshed under spring pressure.
 - Gears rotated slowly by hand.
 - Any eccentricity, pitch error, or tooth thickness variation causes the floating carriage to move.
 - Movement recorded by dial indicator over full rotation.
 - Maximum indicator reading gives **composite error**.
- **Composite error** = eccentricity + pitch error + tooth thickness error.
- [DG]

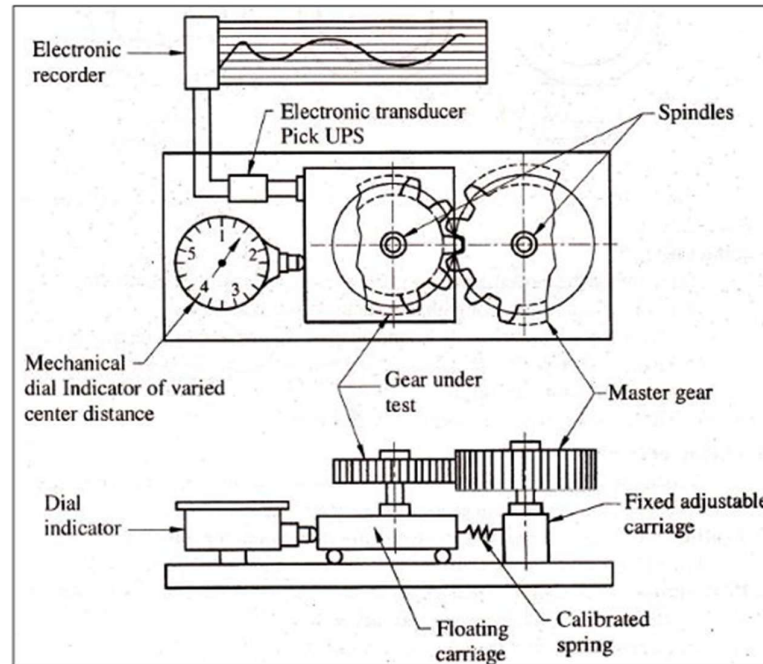


Fig.3.37 - Parkinson's gear tester – Schematic diagram

Other Important Questions:

1. Derive the expression for the best-size wire in the Two-Wire Method.

Appeared in: W23 (Q4c, 07 marks)

Answer:

(for 60° thread):

- **Best wire** is the one whose point of contact with thread flank coincides with pitch diameter cylinder.
- **Derivation:**
From geometry of 60° V-thread,

$$\text{Wire diameter } d_w = \frac{p}{2\cos(30^\circ)} = \frac{p}{2 \times 0.8660} = \frac{p}{1.732} = 0.57735p$$

- For general flank angle α :

$$d_w = \frac{p}{2\cos(\alpha/2)}$$

- **Why best?** Wire contacts at pitch diameter line; measurement is insensitive to small flank angle errors.

○

2. **Compare one-wire, two-wire, and three-wire methods of measuring effective diameter.**

Appeared in: W22 (Q5c, 07 marks)

Answer:

Method	Description	Advantages	Limitations
One-wire	One wire on one side, other side flat anvil	Simple, quick	Less accurate, needs parallel gauge block
Two-wire	Two wires on opposite sides (not same groove)	Faster than three-wire	Wire may not be vertical, error from alignment
Three-wire	Two wires on one side, one on opposite side	Most accurate, self-aligning	Slower, needs care

Conclusion: Three-wire is standard for precise measurement of effective diameter in metrology labs.

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3. **Explain the common errors in threads.**

Appeared in: S25 (Q3b, 04 marks)

Answer:

1. **Pitch error:** Cumulative or periodic discrepancy in pitch.
2. **Flank angle error:** Incorrect flank angle (e.g., 60° instead of 55°).
3. **Major diameter error:** Too large or small.
4. **Minor diameter error:** Affects clearance.
5. **Effecting diameter error:** Combined pitch + flank angle error.
6. **Thread form error:** Irregularities along flanks.
7. **Out-of-roundness:** Non-circular cross-section.
8. **Taper in thread:** Diameter varies along length.

○

4. **Explain the following gear errors: Profile error, Pitch error, Errors in pressure angle, Tooth thickness error.**

Appeared in: W24 (Q2b, 04 marks)

Answer:

- **Profile error:** Deviation from true involute curve. Caused by incorrect cutter shape or machine setting.
- **Pitch error:** Difference between actual circular pitch and nominal pitch. Can be cumulative (over many teeth) or adjacent.
- **Error in pressure angle:** Actual pressure angle differs from nominal (e.g., 20°). Affects tooth contact pattern.
- **Tooth thickness error:** Variation in chordal tooth thickness. Causes backlash problems.

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5. **Derive an expression for gear tooth thickness using the chordal thickness method.**

Appeared in: W23 (Q4b OR, 04 marks)

Answer:

- Chordal thickness $t_c = D \sin \left(\frac{90}{N} \right)$ – approximate formula used for large N.
- **Exact** (for given module m, number N):
 $t_c = mN \sin \left(\frac{90}{N} \right)$ (where $D = mN$)
 Or, $t_c = D \sin \left(\frac{360}{4N} \right)$ in degrees.
- **Chordal height** (from top): $h_c = m \left(1 - \frac{\pi}{4} \sin \phi \right)$ for constant chord method (more common in GTU).

(Derivation not asked separately, the formula is sufficient for 4 marks)

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6. **Compare involute and cycloidal gears.**

Appeared in: S25 (Q3b OR, 04 marks)

Answer:

Parameter	Involute Gear	Cycloidal Gear
Tooth profile	Involute curve	Epicycloid and hypocycloid
Pressure angle	Constant (e.g., 20°)	Varies (max at top)
Center distance sensitivity	Tolerant to small changes	Requires exact center distance
Manufacturing	Easy (hobbing, shaping)	Difficult, special cutters
Strength	Higher (robust root)	Lower (weaker root)
Interference	Occurs below certain teeth	Rare
Applications	Most industrial gears	Clocks, instruments, heavy machinery (old)

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Q. Explain the Addendum Comparator method / Base Tangent method. (4 or 7 marks)

Ans (Base Tangent Method – common):

- **Purpose:** Measure gear tooth thickness using base tangent length (over two or more teeth).
- **Principle:** When caliper jaws contact two tooth flanks on opposite sides, the distance measured is tangent to the base circle.
- **Formula for base tangent length (W_k):**

$$W_k = m \cos \phi [\pi(k - 0.5) + N \operatorname{inv} \phi]$$
 where k = number of teeth spanned, $\operatorname{inv} \phi = \tan \phi - \phi$ (involute function).
- **Procedure:**
 Choose k such that contact occurs on flanks near pitch line.
 Measure W_k using special micrometer (base tangent comparator).
 Compare with theoretical.
- **Advantages:** No need for top of tooth reference, less affected by tip errors.

○
7. Explain the measurement of major diameter, minor diameter, and pitch of screw threads.

Appeared in: (From syllabus)

Answer:

- **Major diameter:** Measured with ordinary micrometer (for external threads) or slip gauges with balls for internal.
- **Minor diameter:** Using three-wire or modified micrometer with conical anvils (for external). For internal, use small bore gauges.
- **Pitch:** Measured by thread pitch measuring machine; using pitch gauge (leaf) for rough; or tool maker's microscope.

○
8. Explain Gear Roll Tester for composite error.

Appeared in: (From syllabus)

Answer:

(similar to Parkinson tester but simpler):

- **Principle:** Two gears (master and test) meshed under spring load; any error causes center distance variation.
- **Construction:** Master gear fixed; test gear on sliding carriage with spring pressure. Dial indicator records carriage movement.
- **Output:** Composite error = total variation of center distance during one full rotation (including eccentricity, pitch error, tooth thickness variations).

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9. Draw a neat sketch of “Talsurf” and explain its working principle.

Appeared in: W24 (Q2c OR, 07 marks)

Answer:

- **Talsurf** is a surface roughness measuring instrument (profilometer) using a stylus.
- **Construction:**

- Diamond stylus (tip radius $\sim 2-10 \mu\text{m}$) mounted on a lever.
- Electromagnetic transducer (LVDT) to detect vertical motion.
- Skid (shoe) to follow contour.
- Motor drive to traverse workpiece or stylus.
- Amplifier and recorder (Picket plot).
- **Working:**
 - Stylus traverses across surface at constant speed.
 - Vertical rise and fall cause LVDT core movement \rightarrow electrical signal.
 - Signal amplified and recorded; instrument calculates R_a (average roughness) or R_z .
- **[DG PROMPT] Title:** Talsurf (Stylus profilometer). **Description:** Draw a horizontal workpiece surface. A skid contacts surface. A diamond stylus also contacts surface via a lever. The lever is attached to an LVDT core. Show LVDT coils, amplifier, and pen recorder. **Label:** Stylus, Skid, LVDT, Amplifier, Recorder, Motor drive.

○

10. **Describe briefly the most commonly used forms of gear tooth.**

Appeared in: W22 (Q3a OR, 03 marks)

Answer:

1.

Involute tooth: Most common for power transmission; constant pressure angle; easy to manufacture.

2. **Cycloidal tooth:** Used in clocks and watches; weaker but less interference.
3. **Circular arc tooth** (Novikov): High load capacity, used in heavy machinery.
- For GTU, primarily **involute** (standard 20°) is referred.

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11. **Enlist different types of threads and type of thread measuring instruments.**

Appeared in: S23 (Q4b, 04 marks)

Answer:

Thread types (by profile): Metric (60°), Whitworth (55°), Square, Acme (29°), Buttress, Knuckle.

Thread measuring instruments:

1. Thread pitch gauge (leaf type) – for pitch.
2. Thread micrometer – for major diameter.
3. Three-wire method + micrometer – for effective diameter.
4. Tool maker's microscope – for all parameters.
5. Thread plug and ring gauges – inspection.
6. Optical profile projector – for thread form.

○

12. **Explain any three elements of screw threads.**

Appeared in: S22 (Q5a OR, 03 marks)

Answer:

- **Pitch (p):** Distance between corresponding points on adjacent threads.
- **Flank angle (α):** Included angle between flanks (e.g., 60° for metric).
- **Effective (pitch) diameter:** Diameter where thread thickness equals space width. Most critical for fit.

13. List the primary reasons for surface irregularities.

Appeared in: W23 (Q4a OR, 03 marks)

Answer:

1. **Vibrations** – machine tool chatter, unbalance.
2. **Tool geometry** – nose radius, feed marks, tool wear.
3. **Material properties** – built-up edge, tearing, plastic deformation.
4. **Process conditions** – cutting speed/feed/depth, coolant.
5. **Inaccuracies in machine tool** – spindle runout, guideway errors.

14. Define surface texture with necessary sketch.

Appeared in: S22 (Q3a OR, 03 marks)

Answer:

- **Surface texture** (surface roughness) consists of the fine irregularities on a surface caused by manufacturing processes.

Components:

- **Roughness** (primary texture) – small, closely spaced irregularities.
- **Waviness** (secondary texture) – wider spacing from machine deflection.
- **Lay** – direction of dominant surface pattern.
- **Flaws** – scratches, cracks, holes.

[DG PROMPT] Title: Surface texture components. Description: Draw a wavy horizontal line representing the nominal surface. On it, add many small up-and-down spikes (roughness). Show a longer wavelength undulation (waviness). Label: Roughness height (Ra), Waviness width, Lay direction arrow.

15. Write a short note on surface roughness symbols.

Appeared in: S22 (Q3c, 07 marks)

Answer:

- Surface roughness symbols are used on engineering drawings to specify required finish.

Symbol	Meaning
✓ (Basic)	Machining allowed, no specific method
✓ with bar	Machining not allowed (as cast/forged)
✓ with circle	Machining by any method
Value (e.g., 1.6)	Ra in micrometers (μm)

- Additional symbols:
 - **Lay symbols:** = (parallel), \perp (perpendicular), X (crossed), M (multidirectional).
 - **Waviness** and **sampling length** can be added below the symbol.
- Example: ✓ 0.8 means “machine to 0.8 μm Ra”.