Engineering Drawing

Short notes for all 1st-year B.Tech branches · GATE ME

Uncodemy Handwritten Notes · free for students

1. Basics of Engineering Drawing

- **Engineering drawing** = the universal graphic language of engineers. It shows shape, size, material and finish of an object exactly.
- In India, drawing practice follows the BIS code **SP 46 : 2003** (based on ISO standards).
- Instruments: drawing board, mini-drafter / T-square, set squares (45° and 30°–60°), compass, divider, protractor, French curves, pencils (H, 2H for thin lines, HB for thick lines and lettering).

➤ Drawing sheet sizes (ISO A series)

Sheet	Size (mm)
A0	841 x 1189 (area 1 m^2)
A1	594 x 841
A2	420 x 594
A3	297 x 420
A4	210 x 297

- Each size is half of the previous one. Ratio of sides = 1 : sqrt(2).
- **Title block** at the bottom right corner: name, title, scale, projection symbol, sheet number, date.

Types of lines

Line	Use
Continuous thick	Visible outlines and edges
Continuous thin	Dimension, extension, leader and hatching lines
Dashed	Hidden outlines and edges
Chain thin (long dash–dot)	Centre lines, lines of symmetry, pitch circles
Chain thin, thick at ends and turns	Cutting plane lines
Continuous thin freehand / zigzag	Short breaks / long breaks

Lettering and dimensioning

- Lettering: single-stroke capital letters, type A (h/14) or type B (h/10), vertical or inclined at 75°.
- **Dimensioning systems**: aligned (read from bottom or right side) and unidirectional (all read from the bottom).
- Arrangement: chain (in series), parallel (from a common base line), combined, progressive.
- Rules: each feature dimensioned once, avoid dimensioning hidden lines, keep dimensions outside the view where possible, diameter symbol Ø, radius R.

2. Scales

FORMULA Representative fraction RF = length on drawing / actual length (same units). Length of scale = RF x max length to be measured.

- Reducing scale RF < 1 (buildings, maps). Full size RF = 1. Enlarging scale RF > 1 (watch parts).
- **Plain scale**: reads two units (e.g. m and dm). **Diagonal scale**: reads three units (e.g. m, dm, cm). **Vernier scale**: also reads small fractions, using a vernier.

Worked construction: diagonal scale

EXAMPLE Draw a diagonal scale of RF = 1/50 to read metres, decimetres and centimetres, up to 6 m.

1. Length of scale = 6 m x 1/50 = 0.12 m = 12 cm.

2. Draw a 12 cm line and divide it into 6 equal parts (each 2 cm = 1 m).
3. Divide the first part (left) into 10 equal parts; each = 1 dm.
4. At the left end, draw a vertical line of any length (say 5 cm) and divide it into 10 equal parts; draw horizontal lines through them.
5. Join the 10th division at the top to the 9th at the bottom, and so on, with parallel diagonals. Each step up a diagonal adds 1 cm.
6. Mark 0 at the end of the first main part, label metres to the right and decimetres to the left. Write "RF = 1/50" below the scale.

3. Engineering Curves

➤ Conic sections

- A **conic** is the curve cut from a cone by a plane. Also: locus of a point that moves so that (distance from a fixed point / distance from a fixed line) is constant.

FORMULA Eccentricity e = distance from focus / distance from directrix. Ellipse e < 1, parabola e = 1, hyperbola e > 1.

Cutting plane of a cone	Section
Perpendicular to axis	Circle
Inclined, cuts all generators	Ellipse
Parallel to one generator	Parabola
Parallel to the axis (or steeper than generator)	Hyperbola
Through the apex	Triangle

- Ellipse methods: concentric circles, rectangle (oblong), arcs of circles, eccentricity method.
- Ellipse property: sum of distances from the two foci to any point = major axis.

➤ Worked construction: ellipse by concentric circles

EXAMPLE Draw an ellipse with major axis 120 mm and minor axis 80 mm.

1. Draw the major axis AB = 120 mm and the minor axis CD = 80 mm crossing at right angles at centre O.
2. With O as centre, draw two circles of diameter 120 mm and 80 mm.

3. Divide both circles into 12 equal parts by radial lines.
4. From each point on the big circle draw a vertical line; from the matching point on the small circle draw a horizontal line.
5. The meeting points lie on the ellipse. Join them with a smooth freehand / French curve.
6. Foci: with C as centre and radius 60 mm (half major axis), cut AB at F1 and F2.

➤ Cycloidal curves and involute

Curve	Definition	Use
Cycloid	Point on a circle rolling on a straight line	Cycloidal gear teeth
Epicycloid	Circle rolls outside another circle	Gear tooth face
Hypocycloid	Circle rolls inside another circle	Gear tooth flank
Involute	End of a string unwound from a circle	Involute gear teeth
Archimedean spiral	Point moves out at uniform rate while rotating uniformly	Cams, scroll chucks

- Cycloid base length = circumference of rolling circle = πD. For $D = 50$ mm, base = 157.1 mm.

4. Orthographic Projection

- **Projection**: view of an object on a plane by parallel projectors normal to it.
- Principal planes: **HP** (horizontal plane, top view / plan), **VP** (vertical plane, front view / elevation), **PP** (profile plane, side view).
- **XY line** = reference line where HP and VP meet.

Point	First-angle projection	Third-angle projection
Object position	Between observer and plane	Plane between observer and object
Top view	Below the front view	Above the front view
Left side view	On the right of front view	On the left of front view
Used in	India (BIS), Europe	USA

- Second and fourth angles are not used because the views overlap.

- Projection symbol: a truncated cone shown in two views. Always draw the correct symbol in the title block.

➤ Projection of points

Point position	Front view	Top view
1st quadrant (above HP, in front of VP)	Above XY	Below XY
2nd quadrant (above HP, behind VP)	Above XY	Above XY
3rd quadrant (below HP, behind VP)	Below XY	Above XY
4th quadrant (below HP, in front of VP)	Below XY	Below XY

5. Projection of Lines and Planes

- **True length (TL)** appears only in the view on the plane to which the line is parallel.
- θ = true inclination with HP, ϕ = true inclination with VP. α and β = apparent angles in FV and TV.
- A line parallel to both planes shows TL in both views. A line perpendicular to HP shows a point in the top view.
- $\theta + \phi <= 90°$. If $\theta + \phi = 90°$, the line lies in a profile plane (both views are normal to XY).
- **Traces**: HT = point where the line (or its extension) meets HP; VT = where it meets VP.
- Methods to find TL from given views: rotating line method, auxiliary plane method, trapezoid method.

➤ Worked construction: line inclined to HP, parallel to VP

EXAMPLE Line AB, 80 mm long, is parallel to VP and inclined at 30° to HP. A is 20 mm above HP and 30 mm in front of VP. Draw its projections.

1. Draw XY. Mark a' 20 mm above XY and a 30 mm below XY on the same vertical projector.
2. Since AB is parallel to VP, the front view a'b' shows true length and true angle. Draw a'b' = 80 mm at 30° to XY.
3. b' is 20 + 80 sin30 = 60 mm above XY.

4. Top view ab is parallel to XY (30 mm below it). Its length = 80 cos30 = 69.3 mm.
5. Project b down from b' to the top view line. Darken the views and add dimensions.

➤ Projection of planes

- Plane shapes: triangle, square, rectangle, pentagon, hexagon, circle.
- If the plane is parallel to a reference plane, its view on that plane shows the true shape. If perpendicular to a plane, it shows as a line on it.
- Inclined planes are drawn in **two stages**: first draw it in a simple position (true shape), then tilt it and project the new views.

6. Projection of Solids

Group	Solids
Polyhedra	Prisms, pyramids, cube, tetrahedron
Solids of revolution	Cylinder, cone, sphere

- **Right solid**: axis is perpendicular to the base. **Oblique solid**: axis is inclined to the base. **Frustum**: part of a cone or pyramid between the base and a cutting plane parallel to it.
- Positions of the axis: perpendicular to HP or VP, parallel to both, inclined to one plane, inclined to both.
- Axis inclined: use the two- or three-stage method (start with the axis perpendicular to a plane, then tilt).
- Hidden edges are shown as dashed lines.

7. Sections and Development of Surfaces

➤ Sections of solids

- The solid is cut by a **section plane**; the cut surface is hatched (thin lines at 45°).
- **True shape of section**: draw an auxiliary view on a plane parallel to the section plane.

- Section planes: parallel to HP (true shape in top view), parallel to VP (true shape in front view), inclined (auxiliary view needed).

➤ Development of surfaces

Solid	Method	Development of lateral surface
Prism, cylinder	Parallel line	Rectangle
Pyramid, cone	Radial line	Sector (cone), triangles (pyramid)
Transition pieces	Triangulation	Series of triangles
Sphere	Approximate (zone / lune)	Not exact

FORMULA Cone development: sector angle $\theta = 360° \times r / L$ (r = base radius, L = slant height).

➤ Worked construction: development of a cone

EXAMPLE Develop the lateral surface of a cone, base diameter 60 mm, height 40 mm.

1. Slant height $L = \sqrt{30^2 + 40^2} = \sqrt{2500} =$ **50 mm**.
2. Sector angle $\theta = 360 \times 30 / 50 =$ **216°**.
3. With radius 50 mm, draw an arc of 216° from the apex point O.
4. Divide the arc into 12 equal parts (matching 12 points on the base circle) and join them to O.
5. These are the generator lines; use them to transfer points if the cone is cut.

- Cylinder development: rectangle of length πD and width = height. For $D = 50$ mm, $h = 60$ mm: 157.1 mm x 60 mm.
- Uses: sheet metal ducts, funnels, hoppers, chimneys.

8. Isometric Projection and CAD

- **Isometric projection**: a single 3D-looking view; the three axes are at **120°** to each other (two at 30° to the horizontal).
- **Isometric scale**: lengths are shortened to $\sqrt{2/3} \approx$ **0.816** of true length (about 82%).
- **Isometric drawing (view)**: uses true lengths (no scale), so it looks about 22.5% bigger than isometric projection. Mostly used in exams unless the question says

"projection".

- Circles in isometric appear as ellipses; draw them by the **four-centre method**.
- Non-isometric lines (not parallel to the axes) are drawn by locating their end points with the box (offset) method.

Pictorial type	Feature
Isometric	All three axes equally inclined (120°)
Oblique	Front face true shape; receding lines at 30°/45°
Perspective	Lines converge to vanishing points; like a photograph

➤ CAD basics

- **CAD** (computer aided drafting / design): AutoCAD, SolidWorks, CATIA, Creo, Fusion 360.
- Common 2D commands: LINE, CIRCLE, ARC, OFFSET, TRIM, EXTEND, MIRROR, ARRAY, HATCH, DIMENSION, LAYER.
- 3D: extrude, revolve, sweep, loft, fillet, chamfer, Boolean (union, subtract, intersect).
- Benefits: accuracy, easy changes, reuse of drawings, direct link to CNC and 3D printing.

9. Most Asked Questions (practice)

1. Explain types of lines and their uses with sketches as per BIS.
2. Compare aligned and unidirectional dimensioning.
3. Construct a diagonal scale for a given RF and show a given length.
4. Draw an ellipse by the concentric circle and eccentricity methods.
5. Draw a cycloid / involute of a circle and a tangent and normal at a point.
6. Compare first-angle and third-angle projection with the symbols.
7. Draw projections of a line inclined to both HP and VP; find TL and true inclinations.
8. Draw projections of a hexagonal prism / pentagonal pyramid with axis inclined to HP.
9. Draw a sectional view and true shape of a section of a cone or prism.
10. Draw the development of a cone / cylinder cut by an inclined plane, and an isometric view from given orthographic views.

TIP In exams, marks come from neat construction, correct line types and labels. Always write RF, mark first-angle symbol, show construction lines thin, and keep the final outlines thick. Practise projections of lines and solids the most.