



## DEPARTMENT OF MECHANICAL ENGINEERING

Haldia, Purba Medinipur, West Bengal  
HALDIA INSTITUTE OF TECHNOLOGY

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### PRACTICAL MANUAL

(Assessment Instrument and Instruction Items)

|                  |                                                   |
|------------------|---------------------------------------------------|
| Course Name      | Machine Drawing                                   |
| Course Code      | PC-ME 393                                         |
| Laboratory Name  | Machine Drawing Laboratory                        |
| Program          | <b>B. Tech in Mechanical Engineering</b>          |
| Semester / Year  | [3 <sup>rd</sup> Semester / 2 <sup>nd</sup> Year] |
| Academic Session | 2026–27                                           |

#### Faculty-in-Charge & Technical Staff

|                     |                                                 |
|---------------------|-------------------------------------------------|
| Faculty-in-Charge   | Prof. (Dr) Bikash Bepari, Dr. Bipradas Bairagi, |
| Co-Faculty (if any) | Dr. Rahul Das and Mr. Soumik Dutta,             |
| Technical Staffs    | Mr. Soumen Roy                                  |
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## **Vision**

To impart quality, industry-relevant teaching-learning that blends knowledge and skill to produce industry-ready mechanical engineering graduates.

## **Mission Statements**

**M1:** To create qualified and proficient technocrats having contemporary skills through outcome-based and self-learning strategies.

**M2:** To encourage innovation-oriented and problem-based research capabilities among young engineers through higher studies, in order to nurture the progress of society.

**M3:** To instill strong ethical values and good professional behaviour, enabling graduates to adopt and absorb emerging changes in the engineering profession.

## **Program Educational Objective**

Graduates of B. Tech. Mechanical Engineering program, four years after graduation will

**PEO1:** Specify, design, supervise, test, and evaluate engineering skills to design, develop, and implement innovative solutions, systems, and applications in Mechanical Engineering and allied industries.

**PEO2:** Utilize Mechanical Engineering knowledge to address real-world and societal challenges while pursuing higher studies, research, and professional development.

**PEO3:** Demonstrate effective individual and collaborative capabilities in multidisciplinary professional environments, with a commitment to lifelong learning and adaptability to evolving technological, industrial, and societal requirements.

## **Program Specific Outcomes (PSOs)**

**PSO1:** Design, analyze and evaluate mechanical components and systems such as thermal, fluid, manufacturing, design systems and allied engineering solutions.

**PSO2:** Utilize and evaluate modern engineering tools, software, and techniques to model, analyze, and solve real-world mechanical engineering problems.

**PSO3:** Demonstrate professional and ethical responsibility, effective communication, and the ability to work in multidisciplinary teams to address societal, industrial, and environmental challenges through sustainable mechanical engineering solutions.

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|                                                                                               |                                            |                    |            |
|-----------------------------------------------------------------------------------------------|--------------------------------------------|--------------------|------------|
| <b>Course Code : PC-ME 393</b>                                                                | <b>Category: Professional Core courses</b> | <b>PCIE Marks</b>  | <b>40</b>  |
| <b>Course Name : Machine Drawing</b>                                                          | <b>Semester : Third</b>                    | <b>PSEE Marks</b>  | <b>60</b>  |
| <b>L-T-P: 0-0-3</b>                                                                           | <b>Credit: 1.5</b>                         | <b>Total Marks</b> | <b>100</b> |
| <b>Pre-Requisites: Engineering Drawing (ES-ME 292)</b>                                        |                                            |                    |            |
| <b>Examination (PSEE): Theory/ Drawing Assignment/ Practical/ Viva-voce/Team work/ others</b> |                                            |                    |            |

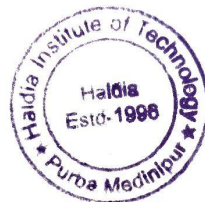
### Course Content:

Assignments and instruction items are to be framed based on these units:

| Unit            | Topics                                                                                                                                                                                                                                                                                                                                                                                                                             | Hours     | CO  |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|-----|
| <b>UNIT I</b>   | <b>Orthographic Projection:</b> First-angle projection. Front, top and side views from pictorial views and physical models. Hidden details, alignment of views, dimensioning of views. Identification of missing views.                                                                                                                                                                                                            | 9         | CO1 |
| <b>UNIT II</b>  | <b>Isometric Views and Projections:</b> Isometric axes and isometric scale. Difference between isometric view and isometric projection. Isometric drawing of simple objects with slots, holes, chamfers and rounded corners. Conversion of orthogonal views to isometric views and projections. Dimensioning of isometric drawings.                                                                                                | 6         | CO2 |
| <b>UNIT III</b> | <b>Sectional Views:</b> Purpose of sectioning, cutting-plane lines, section lines and hatching rules. Types of sections: full, half, offset, revolved, removed and partial. Sectioning of simple components such as blocks, brackets, bushes, pulleys and flanges. Treatment of ribs, shafts, keys and fasteners when cut lengthwise. Representation of threaded holes, countersunk (CSK) and counterbored (CBR) holes in section. | 9         | CO3 |
| <b>UNIT IV</b>  | <b>Screw Threads, Nuts and Bolts:</b> Thread terminology. Thread forms: metric, BSW, square and ACME, with profile construction from given dimensions. Conventional representation of external and internal threads. Hexagonal nut and bolt: proportions, views and sectional views.                                                                                                                                               | 6         | CO4 |
| <b>UNIT V</b>   | <b>Surface Roughness Representation:</b> Surface texture and its importance. Roughness parameters (Ra) and roughness grades. Standard surface roughness symbols and machining symbols. Indication of roughness values, machining process, lay and machining allowance on drawings. Selection of roughness for common machining processes.                                                                                          | 3         | CO5 |
| <b>UNIT VI</b>  | <b>Assembly Drawing:</b> Part drawing versus assembly drawing. Conventions for assembly drawings: sections, hatching of adjacent parts, and treatment of fasteners and standard parts. Bill of Materials (BOM) and part numbering. Assemblies of small mechanical systems such as machine vice, screw jack, stuffing box, plumber block, footstep bearing and tailstock.                                                           | 9         | CO6 |
| <b>Total</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>42</b> |     |

### Suggested Reference Books

1. N.D. Bhatt, Machine Drawing, Charotar Publishing House.
2. K.L. Narayana, P. Kannaiah and K. Venkata Reddy, Machine Drawing, New Age International.
3. P.S. Gill, Machine Drawing, S.K. Kataria & Sons.
4. R.K. Dhawan, A Textbook of Machine Drawing, S. Chand.
5. Bureau of Indian Standards, SP-46: Engineering Drawing Practice for Schools and Colleges.



### Course Outcomes:

Upon successful completion of the course, students will be able to:

| CO CODES    | CO Statement                                                                                                                                                                                                                                                                                  | Knowledge Categories | Cognitive Level |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|-----------------|
| PC-ME 393.1 | Draw the front, top and side orthogonal views of a given three-dimensional object, from its pictorial view or physical model, using first-angle projection convention, in accordance with BIS (SP-46) standard, with correct alignment of views, line types, hidden details and dimensioning. | P                    | Ap              |
| PC-ME 393.2 | Construct the isometric view and isometric projection of an object from its given orthogonal views (front, top and side), using the isometric scale (for Isometric projection), as per BIS conventions, with correct isometric axes, proportions, visible details and dimensioning.           | P                    | Ap              |

|             |                                                                                                                                                                                                                                                                                                                                               |    |    |
|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----|
| PC-ME 393.3 | Construct the sectional views (full, half, offset, revolved, removed, partial sections, threaded hole[CSK, CBR] and) of simple mechanical components, using first-angle projection, in accordance with BIS conventions, with correct cutting-plane lines, hatching, treatment of ribs, shafts and fasteners, hidden details and dimensioning. | P  | Ap |
| PC-ME 393.4 | Draw metric, BSW, square and ACME threads and sectional views of nut and bolt from given dimensions per BIS SP-46.                                                                                                                                                                                                                            | P  | Ap |
| PC-ME 393.5 | Indicate surface roughness on machine drawings using standard symbols for given machining processes and roughness values per BIS SP-46.                                                                                                                                                                                                       | CS | Ap |
| PC-ME 393.6 | Draw assemblies of multi-component mechanical systems from given part drawings per BIS SP-46, with sections and Bill of Materials (BOM).                                                                                                                                                                                                      | P  | Cr |

#### ALIGNING OF COS IN [CL × KC] METRIC

| Cognitive Levels (CL) | Knowledge Categories (KC) |            |                     |                |                               |                           |                       |                          |
|-----------------------|---------------------------|------------|---------------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
|                       | Factual                   | Conceptual | Procedural          | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design instrumentalities |
| Remember              |                           |            |                     |                |                               |                           |                       |                          |
| Understand            |                           |            |                     |                |                               |                           |                       |                          |
| Apply                 |                           |            | CO1, CO2, CO3 & CO4 |                |                               | CO5                       |                       |                          |
| Analyze               |                           |            |                     |                |                               |                           |                       |                          |
| Evaluate              |                           |            |                     |                |                               |                           |                       |                          |
| Create                |                           |            | CO6                 |                |                               |                           |                       |                          |

#### Assessment Pattern and Assessment Instruments for PCIE & PSEE

|                | PCIE      |    |    |        |            |    |    |         | PSEE (60) |             |
|----------------|-----------|----|----|--------|------------|----|----|---------|-----------|-------------|
|                | PCAI (40) |    |    |        | PCAII (40) |    |    |         |           |             |
| Marks allotted | 10        | 10 | 10 | 10     | 10         | 10 | 10 | 10      | 40        | 20          |
| CO             | A1        | A2 | A3 | VIVA I | A4         | A5 | A6 | VIVA II | GR-A      | GR-B (Viva) |
| CO1            | 10        |    |    | 10/3   |            |    |    |         | 40/6      | 20/6        |
| CO2            |           | 10 |    | 10/3   |            |    |    |         | 40/6      | 20/6        |
| CO3            |           |    | 10 | 10/3   |            |    |    |         | 40/6      | 20/6        |
| CO4            |           |    |    |        | 10         |    |    | 10/3    | 40/6      | 20/6        |
| CO5            |           |    |    |        |            | 10 |    | 10/3    | 40/6      | 20/6        |
| CO6            |           |    |    |        |            |    | 10 | 10/3    | 40/6      | 20/6        |

#### CO-PO & CO-PSO Articulation Matrix

| CO          | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PSO1 | PSO2 | PSO3 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|
| PC-ME 393.1 | 3   | 1   | 1   | –   | 2   | –   | –   | 3   | –   | –    | 2    | 1    | –    | 3    |
| PC-ME 393.2 | 3   | 1   | 1   | –   | 2   | –   | –   | 2   | –   | –    | 2    | 1    | –    | 3    |
| PC-ME 393.3 | 3   | 2   | 2   | –   | 2   | –   | –   | 3   | –   | –    | 2    | 1    | –    | 3    |
| PC-ME 393.4 | 2   | –   | 2   | –   | 2   | –   | –   | 2   | –   | –    | 2    | 1    | –    | 2    |
| PC-ME 393.5 | 1   | –   | 2   | –   | 1   | –   | –   | 3   | –   | –    | 2    | 1    | –    | 1    |
| PC-ME 393.6 | 3   | 2   | 3   | –   | 3   | –   | –   | 3   | 1   | –    | 3    | 2    | 1    | 3    |
| Average     | 2.5 | 1.5 | 1.8 | –   | 2.0 | –   | –   | 2.7 | 1.0 | –    | 2.2  | 1.2  | 1.0  | 2.5  |





### Assignment 1:

[CO1] [P × Ap]

#### Orthographic projections of Machine Elements

The isometric views of the three parts are given along with the direction of sight. Construct the orthographic views (Elevation, Plan, LSV & RSV) corresponding to the figures following first angle projection. [P, Ap]

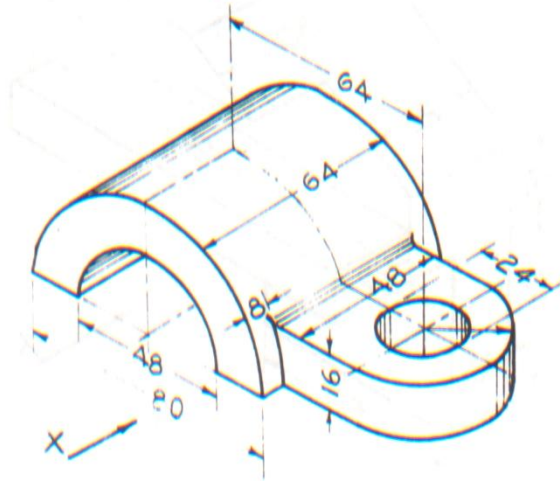


Fig - 1

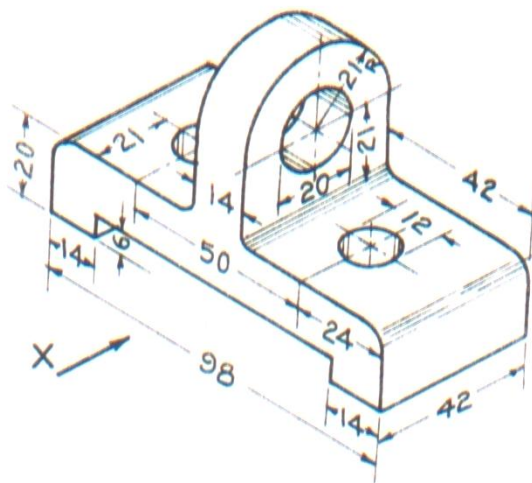


Fig - 2

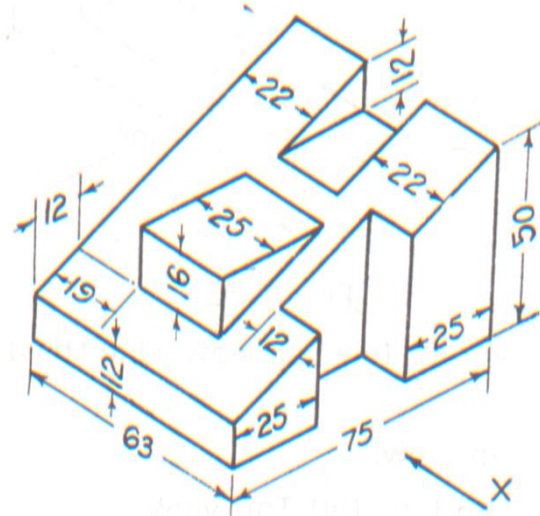


Fig - 3



## Instruction Material 1: Orthographic projections of elements

[CO1] [ P × Ap]

### Frequently asked Questions with Answer

**1. What is orthographic projection?**

It represents a 3D object on a 2D plane using parallel projectors perpendicular to the plane, so faces parallel to the plane show their true shape. The usual views are the front view, top view and side view.

**2. How are the views arranged in first-angle projection?**

The object lies between the observer and the plane. The top view goes below the front view, and the left side view goes to the right of the front view.

**3. How does first angle differ from third angle?**

In third angle the plane lies between the observer and the object, so the top view goes above the front view and the right side view goes to the right. BIS SP-46 prescribes first angle.

**4. Which line types are used?**

Thick continuous lines show visible edges, dashed lines show hidden edges, and thin chain lines show centres. When lines coincide, visible takes priority over hidden, and hidden over centre.

**5. How is the front view chosen?**

Choose the direction that shows the most shape detail, in the object's natural position, with the fewest hidden lines. Use only as many views as are needed to describe the object.

**6. What are the common mistakes?**

Misaligned views, wrong view placement, missing hidden or centre lines, and wrong depth transfer between the top and side views. To check a drawing, trace any point through all the views along its projection lines.

**7. Why are second-angle and fourth-angle projections not used in engineering drawing?**

In the second and fourth quadrants, the front view and top view overlap or fall on the same side of the XY line when the HP is rotated into the plane of the VP. This confuses the drawing and makes it hard to read, so only first-angle and third-angle projections are used.



**Assignment 2:**  
Draw the isometric views from these orthographic views.

[CO2] [P × Ap]

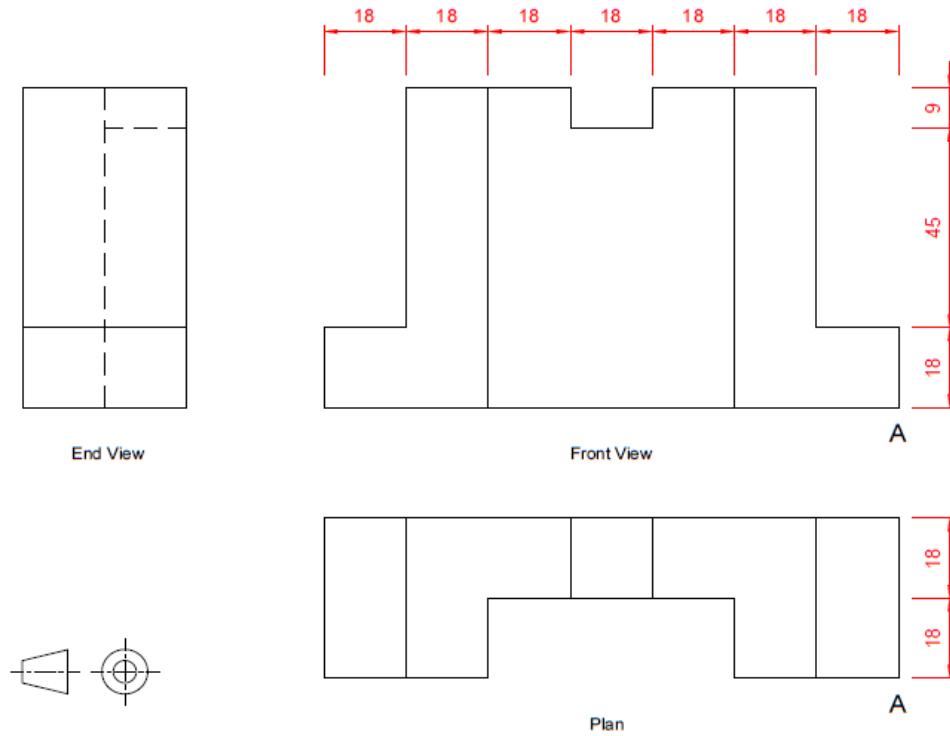


Fig - 1

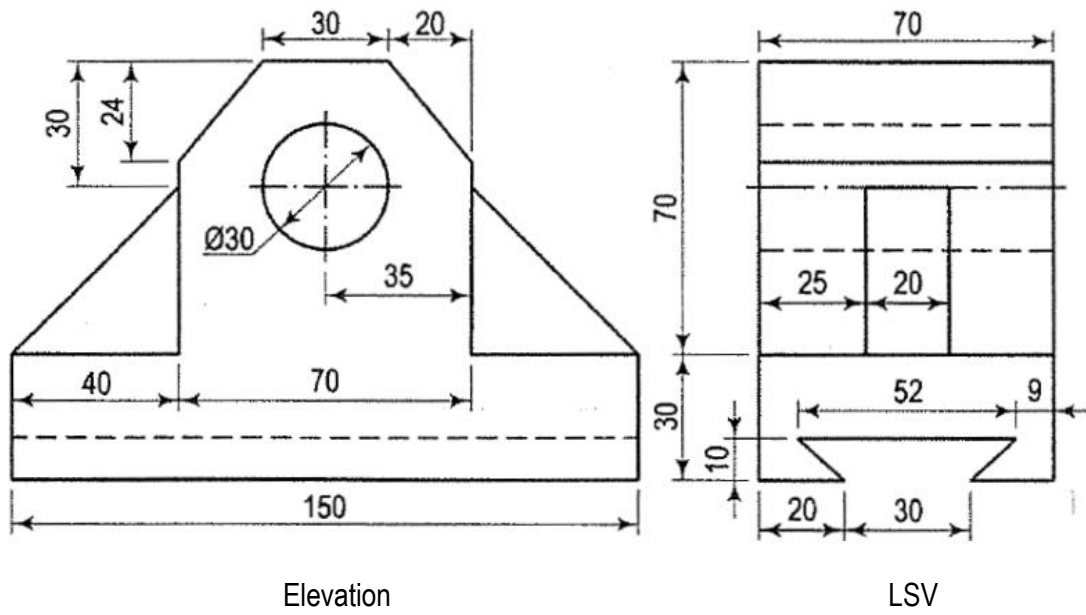


Fig - 2



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**MACHINE DRAWING**  
**PC-ME 393**

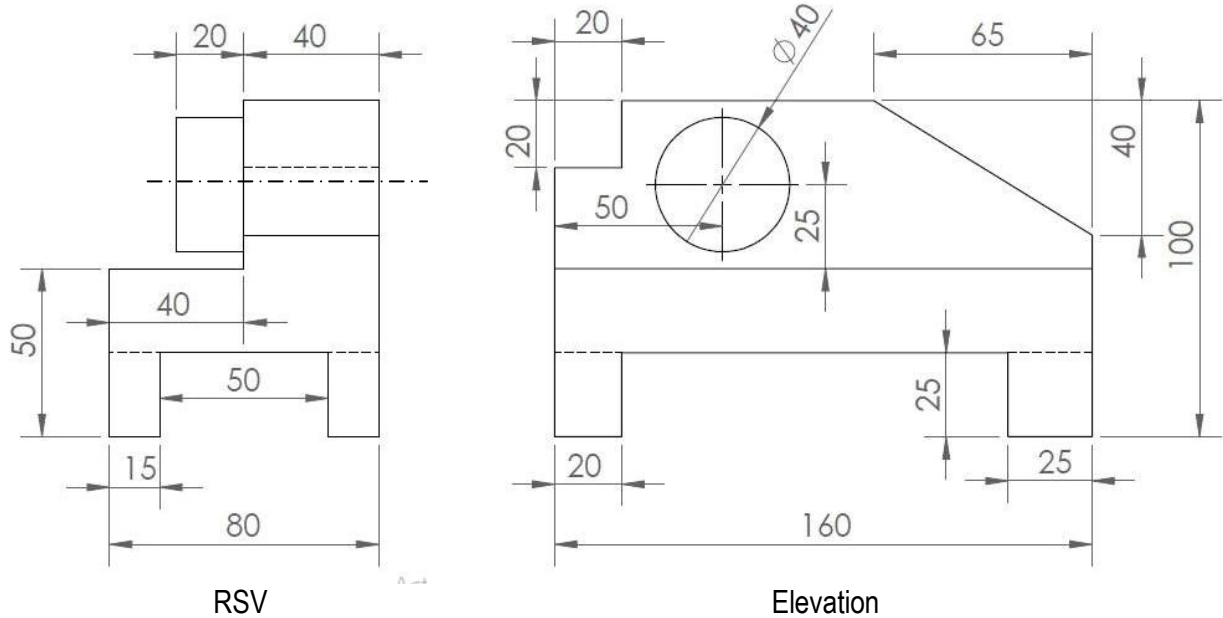


**Fig – 3**

**ALIGNING OF ASSIGNMENT IN [CL × KC] METRIC**

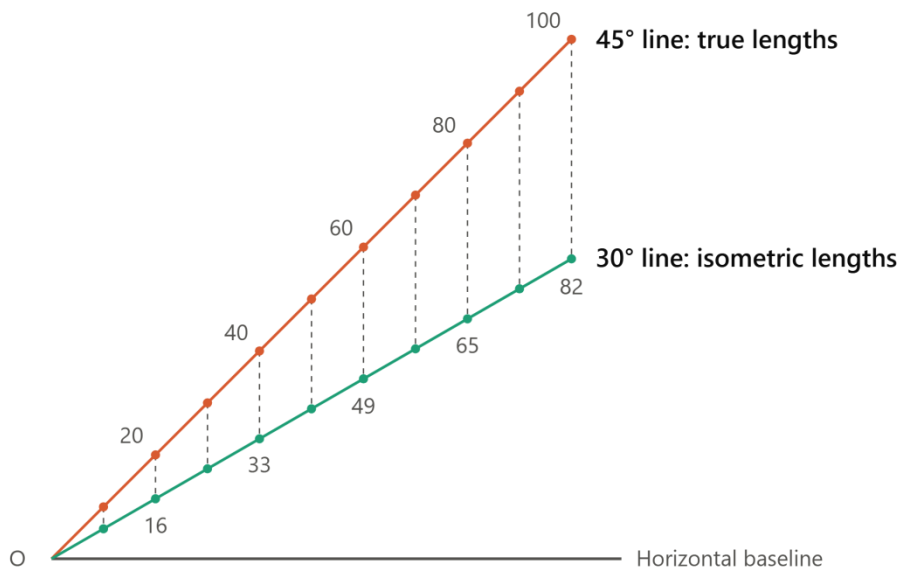
| Cognitive Levels (CL) | Knowledge Categories (KC) |            |            |                |                               |                           |                       |                          |
|-----------------------|---------------------------|------------|------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
|                       | Factual                   | Conceptual | Procedural | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design instrumentalities |
| Remember (R)          |                           |            |            |                |                               |                           |                       |                          |
| Understand (U)        |                           |            |            |                |                               |                           |                       |                          |
| Apply (Ap)            |                           |            | CO2, A2    |                |                               |                           |                       |                          |
| Analyze (An)          |                           |            |            |                |                               |                           |                       |                          |
| Evaluate (E)          |                           |            |            |                |                               |                           |                       |                          |
| Create (C)            |                           |            |            |                |                               |                           |                       |                          |



**Instruction Material 2:**  
**Fundamentals of isometric views from these orthographic views.**

**Frequently asked Questions with Answer**

- 1. What does "isometric" mean?**  
It means "equal measure". The three axes make equal angles of  $120^\circ$  with each other in the drawing, and the object's three principal directions are foreshortened equally.
- 2. How are the isometric axes drawn?**  
One axis is vertical, and the other two are inclined at  $30^\circ$  to the horizontal, on the left and right. Lines parallel to these axes are called isometric lines, and their lengths can be measured directly. Any other line is a non-isometric line.
- 3. What is the difference between isometric view and isometric projection?**  
An isometric projection is drawn with the isometric scale, so lengths are foreshortened to about 0.816 of true size. An isometric view is drawn with true lengths, otherwise identical in shape.
- 4. What is the isometric scale, and how is it built?**  
It is a scale on which true lengths are reduced by the ratio  $\cos 30^\circ / \cos 45^\circ$ , which is about 0.816. To construct it, draw a baseline at  $45^\circ$  and a second line at  $30^\circ$  from the same point. Mark true lengths on the  $45^\circ$  line, then project them vertically onto the  $30^\circ$  line to get the isometric lengths.



**Construction of the isometric scale**

- Draw a horizontal baseline through point O.
- From O, draw one line at  $45^\circ$  to the baseline and another at  $30^\circ$ .
- On the  $45^\circ$  line, mark equal divisions of true length (10 mm each in the figure).
- From each division, draw a vertical line down to meet the  $30^\circ$  line.



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**MACHINE DRAWING**  
**PC-ME 393**

- The lengths measured from O along the  $30^\circ$  line are the isometric lengths. These are the ones used to draw an isometric projection.

**5. How are non-isometric lines drawn?**

They cannot be measured directly. Fit the object in an enclosing box, locate the end points by coordinates measured along the isometric axes, then join the points. This is called the box or coordinates method. Angles are handled the same way, because they do not appear true in an isometric drawing.

**6. How does a circle appear in isometric?**

It appears as an ellipse on each isometric plane. For a circle of diameter  $d$  in an isometric view, the major axis is about  $1.22 d$  and the minor axis about  $0.71 d$ . In true isometric projection the major axis equals  $d$  and the minor axis is about  $0.58 d$ . In practice, the four-centre method draws a good approximation of this ellipse.



**Assignment 3:**

[CO3] [ P × Ap]

The ideations of different sections are shown hereunder. Understand them and depict them as per drawing norms.

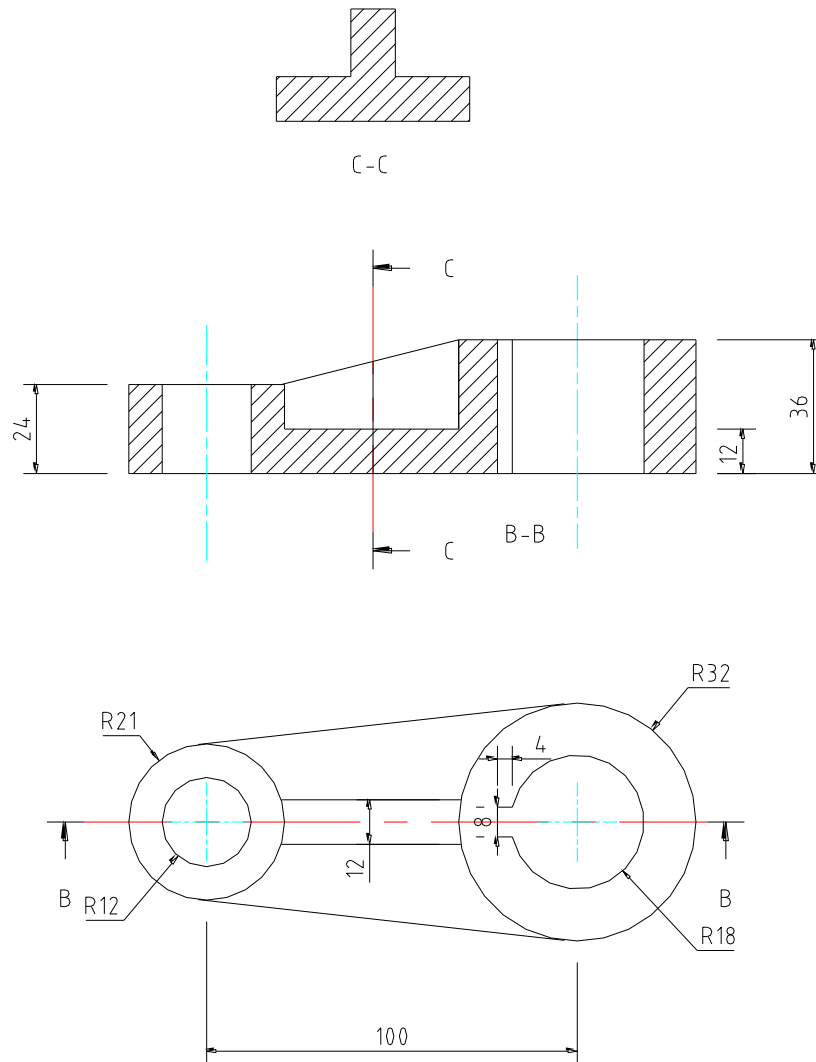


**Fig - 1**

**Ideation of Full Section, Removed Section of Ribs /Stiffeners**



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**PC-ME 393**

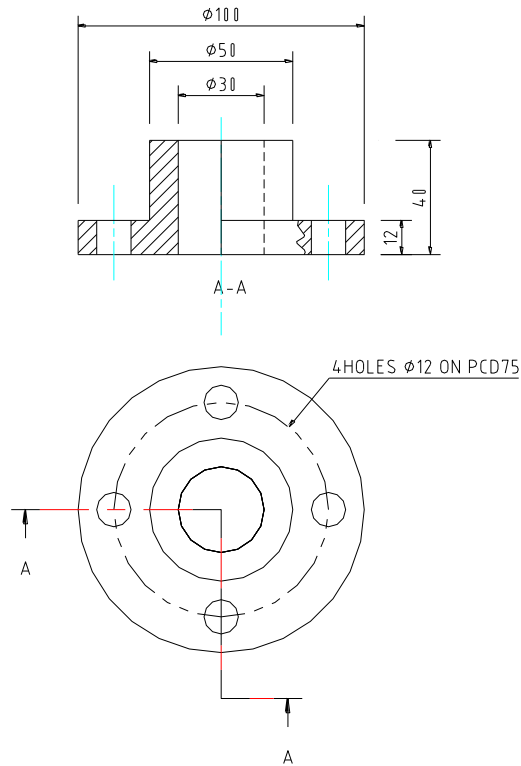


**Fig -2**  
**Ideation of Half Section & Broken Section**

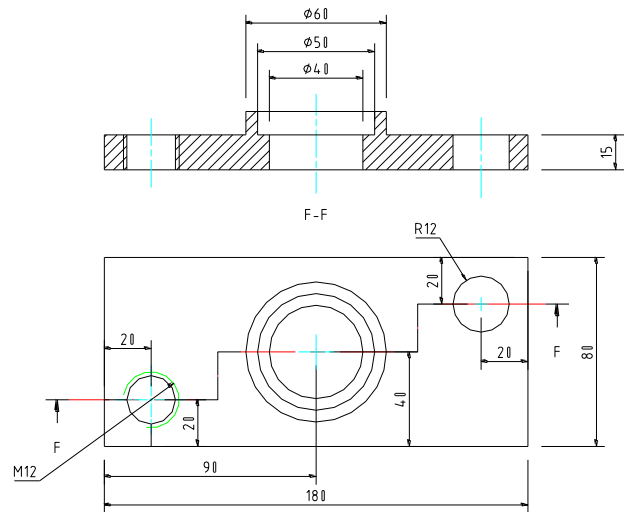


**Fig - 3**  
**Ideation of Offset Section & Section of Threaded hole**

**ALIGNING OF ASSIGNMENT IN [CL × KC] METRIC**

| Cognitive Levels (CL) | Knowledge Categories (KC) |            |            |                |                               |                           |                       |                          |
|-----------------------|---------------------------|------------|------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
|                       | Factual                   | Conceptual | Procedural | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design instrumentalities |
| Remember (R)          |                           |            |            |                |                               |                           |                       |                          |
| Understand (U)        |                           |            |            |                |                               |                           |                       |                          |
| Apply (Ap)            |                           |            | C03, A3    |                |                               |                           |                       |                          |
| Analyze (An)          |                           |            |            |                |                               |                           |                       |                          |
| Evaluate (E)          |                           |            |            |                |                               |                           |                       |                          |
| Create (C)            |                           |            |            |                |                               |                           |                       |                          |



## Frequently asked Questions with Answer

### 1. What is a sectional view, and why is it used?

The object is imagined cut by a plane, the portion in front is removed, and the remaining part is drawn. It shows internal details clearly, without the many hidden lines of an ordinary view.

### 2. How is the cutting plane shown?

By a thin chain line, thick at the ends and at changes of direction, with arrows pointing in the viewing direction and letters at both ends. The resulting view is labelled "Section A-A".

### 3. How is the cut surface shown?

By hatching: thin continuous lines at 45° and equally spaced (about 2 to 3 mm). The direction and spacing stay the same for one component across all its cut areas. Adjacent parts use different directions.

### 4. What are the main types of section?

- Full: the plane cuts the whole object.
- Half: used for symmetrical parts, with half in section and half external.
- Offset: the plane is bent to pass through features that are not in a line.
- Revolved: the section is turned through 90° and drawn on the view.
- Removed: the section is drawn away from the view.
- Partial: a local portion is broken out, bounded by a break line.

### 5. What is not hatched when cut lengthwise?

Solid parts and thin features: shafts, bolts, nuts, screws, rivets, keys, pins, ribs, webs and spokes, per BIS SP-46.

### 6. Are hidden lines shown in a sectional view?

Normally not, because the section exposes the interior. They are drawn only where needed to make the shape clear.



**Assignment 4:**

[CO4] [P × Ap]

Draw an assembled view of a hexagonal headed bolt with nut and washer. Take, D as 30mm. Consider length of the bolt is 100mm and thread length is 60mm.

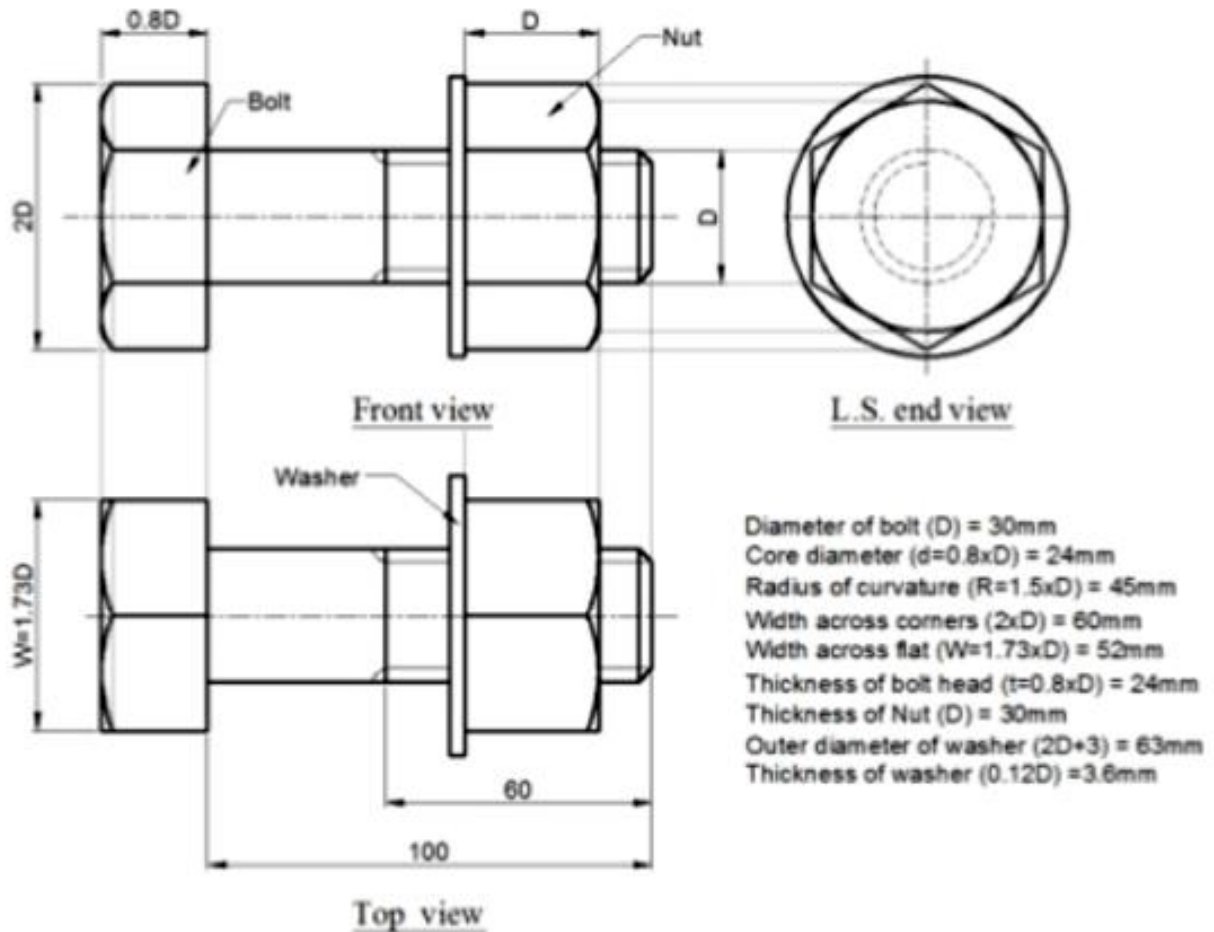


Fig - 1  
Hexagonal Nut Bolt assembly a/w Washer



The diagram illustrates the design of a screw thread profile, showing the internal and external threads, the basic profile, and the design profile. The diagram includes dimensions such as pitch ( $P$ ), major diameter ( $D_4$ ), minor diameter ( $D_1, d$ ), and thread height ( $H$ ). It also shows the  $29^\circ$  thread angle and the  $90^\circ$  axis of the screw thread.

**Internal Threads:** The top part of the diagram shows the internal thread profile. The basic profile is shown in blue, and the design profile is shown in red. The design profile includes a fillet radius  $R_1$  at the crest and a fillet radius  $R_2$  at the root. The thread angle is  $29^\circ$ . The pitch is  $P$ . The major diameter is  $D_4$ . The minor diameter is  $D_1, d$ . The thread height is  $H$ . The design profile includes a fillet radius  $R_1$  at the crest and a fillet radius  $R_2$  at the root. The thread angle is  $29^\circ$ . The pitch is  $P$ . The major diameter is  $D_4$ . The minor diameter is  $D_1, d$ . The thread height is  $H$ .

**External Threads:** The bottom part of the diagram shows the external thread profile. The basic profile is shown in blue, and the design profile is shown in red. The design profile includes a fillet radius  $R_1$  at the crest and a fillet radius  $R_2$  at the root. The thread angle is  $29^\circ$ . The pitch is  $P$ . The major diameter is  $D_4$ . The minor diameter is  $D_1, d$ . The thread height is  $H$ . The design profile includes a fillet radius  $R_1$  at the crest and a fillet radius  $R_2$  at the root. The thread angle is  $29^\circ$ . The pitch is  $P$ . The major diameter is  $D_4$ . The minor diameter is  $D_1, d$ . The thread height is  $H$ .

**Dimensions:**

- $P$ : Pitch
- $D_4$ : Major diameter
- $D_1, d$ : Minor diameter
- $H$ : Thread height
- $H_0/2$ : Thread height from the pitch line to the crest
- $H_0$ : Thread height from the pitch line to the root
- $H_4$ : Thread height from the pitch line to the crest
- $H_3$ : Thread height from the pitch line to the root
- $a_c$ : Addendum
- $a_r$ : Root radius
- $R_1$ : Fillet radius at the crest
- $R_2$ : Fillet radius at the root
- $29^\circ$ : Thread angle
- $90^\circ$ : Axis of screw thread

**Fig - 3 ACME THREAD INTERNAL (NUT) AND EXTERNAL (BOLT) SPECIFICATION**

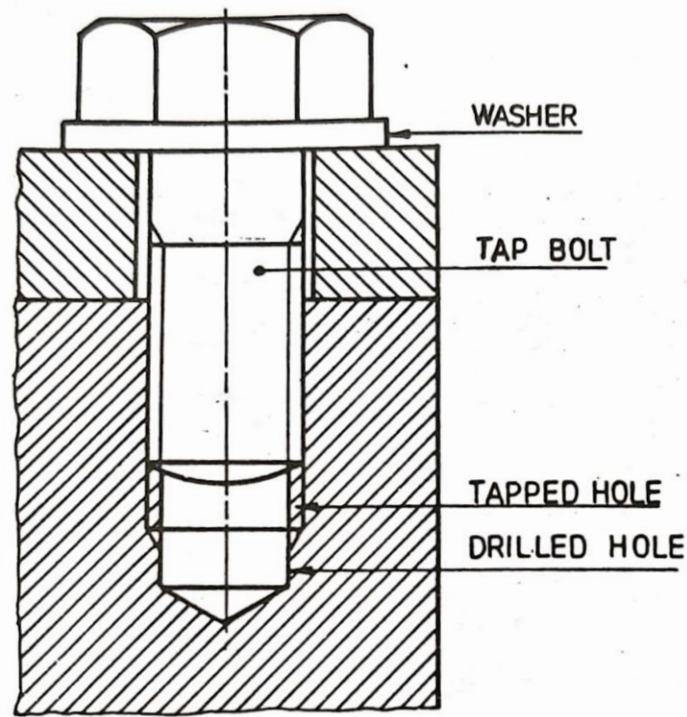


**FIG.4 SECTIONAL FRONT VIEW OF A TAP BOLT (HEXAGONAL HEAD) WITH WASHER, FASTENING A PLATE TO A TAPPED HOLE IN THE MATING PART**

| ALIGNING OF ASSIGNMENT IN [CL × KC] METRIC |                           |            |            |                |                               |                           |                       |                          |
|--------------------------------------------|---------------------------|------------|------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
| Cognitive Levels (CL)                      | Knowledge Categories (KC) |            |            |                |                               |                           |                       |                          |
|                                            | Factual                   | Conceptual | Procedural | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design instrumentalities |
| Remember (R)                               |                           |            |            |                |                               |                           |                       |                          |
| Understand (U)                             |                           |            |            |                |                               |                           |                       |                          |
| Apply (Ap)                                 |                           |            | CO4, A4    |                |                               |                           |                       |                          |
| Analyze (An)                               |                           |            |            |                |                               |                           |                       |                          |
| Evaluate (E)                               |                           |            |            |                |                               |                           |                       |                          |
| Create (C)                                 |                           |            |            |                |                               |                           |                       |                          |

### Frequently asked Questions with Answer

#### 1. What are the main terms used for a screw thread?

The pitch (p) is the distance between corresponding points on adjacent threads. The crest is the outer top of a thread and the root is the bottom of the groove, joined by the flanks. The major diameter is the largest diameter, and the minor (core) diameter is the smallest.

#### 2. What is the metric (ISO) thread profile?



It is a  $60^\circ$  V-thread with flat crest and root. The thread depth is about  $0.61p$ , and the minor diameter of the bolt is about  $d - 1.226p$ . It is the general-purpose fastening thread, written for example as  $M20 \times 2.5$ .

### 3. What is the BSW thread profile?

It is a  $55^\circ$  V-thread with rounded crest and root. The depth is about  $0.64p$  and the rounding radius about  $0.137p$ . It is designated by its diameter in inches, for example BSW  $\frac{3}{4}$ ".

### 4. What is the square thread profile?

The flanks are perpendicular to the axis, and the depth and the width both equal  $p/2$ . It transmits power efficiently with very little radial thrust, as in screw jacks and presses. It is harder to make and cannot be adjusted for wear.

### 5. What is the ACME thread profile?

It is a trapezoidal thread with a  $29^\circ$  included angle, a depth of about  $p/2$  plus a small clearance, and a flat crest about  $0.37p$  wide. It is easier to make than the square thread and works with a split nut that can be adjusted for wear, as in lathe lead screws.

### 6. What is the difference between pitch and lead?

Lead is the axial distance moved in one turn, and it equals the pitch multiplied by the number of starts. For a single-start thread they are the same. A fine thread has a smaller pitch than a coarse thread of the same diameter.



## Assignment 5:

[CO5] [CS × Ap]

## Machine Drawing: Surface Texture, Roughness and Surface-Finish

### Surface Integrity and Surface Texture

**Surface texture** refers to the geometric characteristics and irregularities present on a manufactured surface. Surface texture is important because it influences the functional performance of machine components, including friction, wear, and lubrication, sealing and fitting.

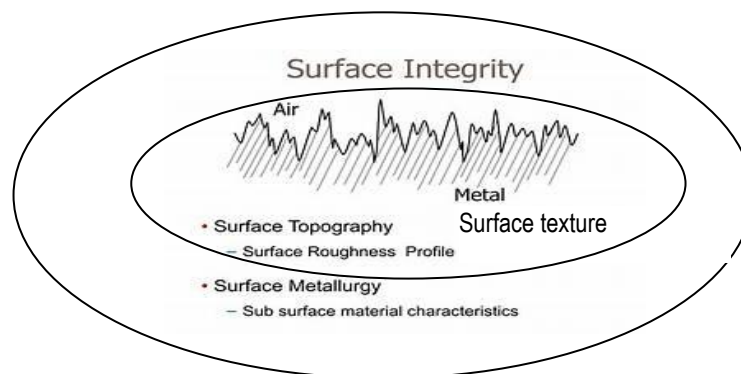
It mainly includes:

- Roughness
- Waviness
- Lay

**Surface Integrity** is a much broader concept that covers not just the geometric texture but also the physical, mechanical, chemical, and metallurgical condition of the surface and sub-surface layers after machining. It includes:

- Surface texture (as a subset)
- Residual stresses (tensile or compressive) induced by machining
- Micro-structural changes (grain deformation, phase transformations, recrystallization)
- Micro-hardness variations near the surface
- Presence of micro-cracks
- Metallurgical burn or heat-affected zones
- Work hardening effects

**Machine Drawing Note:** In engineering drawings, the required surface texture is indicated using standardized **surface-texture symbols** and appropriate roughness parameters.





## Waviness

Waviness is the periodic or relatively widely spaced variation in the surface profile of a manufactured component. It is larger in wavelength than surface roughness and generally results from machine-tool vibration, workpiece deflection, run out, deflection of the workpiece or machine, thermal effects, or improper alignment. Waviness may result from:

## Surface Roughness

Surface roughness consists of relatively fine and closely spaced irregularities present on manufactured surface. These irregularities are generally produced by the manufacturing process and tool workpiece interaction (tool marks, abrasive action, and chip formation). Therefore it is closely-spaced irregularities and generally measured by  $R_a$ ,  $R_z$ ,  $R_{max}$ . Surface roughness is mainly influenced by Cutting-tool geometry, Feed rate, Cutting speed, Machine-tool condition, Workpiece material, Type of manufacturing process, Tool wear and Machine vibration.

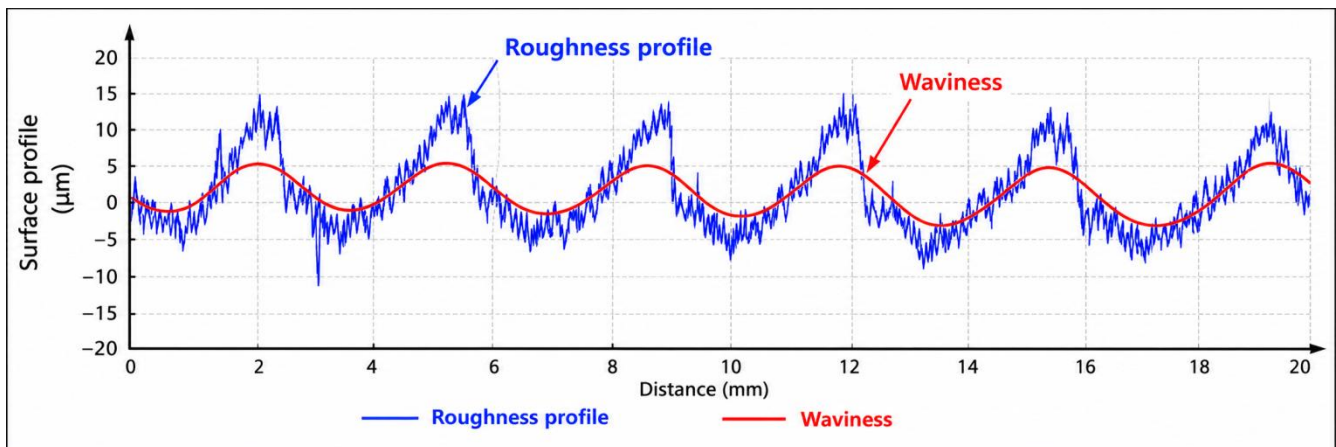


Figure 2: Waviness and Surface Roughness Profiles

## Difference between Waviness and Roughness

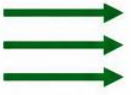
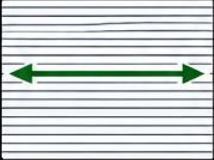
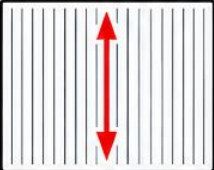
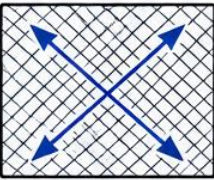
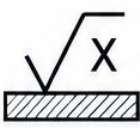
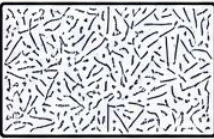
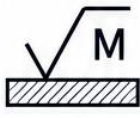
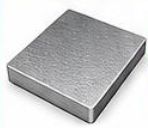
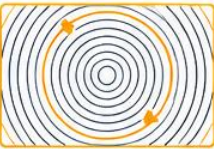
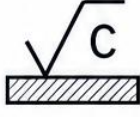
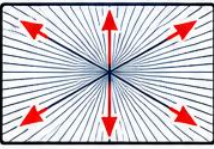
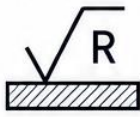
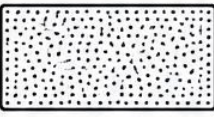
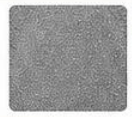
A real engineering surface contains irregularities of different scales. Two important components are **waviness** and **roughness**. The basic differences are shown hereunder.

| Feature               | Waviness                                       | Roughness                                         |
|-----------------------|------------------------------------------------|---------------------------------------------------|
| Spacing               | Relatively large                               | Relatively small                                  |
| Appearance            | Long, gradual variations                       | Fine, closely spaced variations                   |
| Typical causes        | Vibration, deflection, runout, thermal effects | Tool marks, feed, material and process effects    |
| Scale                 | Larger                                         | Smaller                                           |
| Functional importance | May affect form, contact and motion            | Important for friction, wear, sealing and fitting |



## Lay

Lay is the predominant direction or orientation of the surface irregularities (surface texture) produced by a manufacturing process.

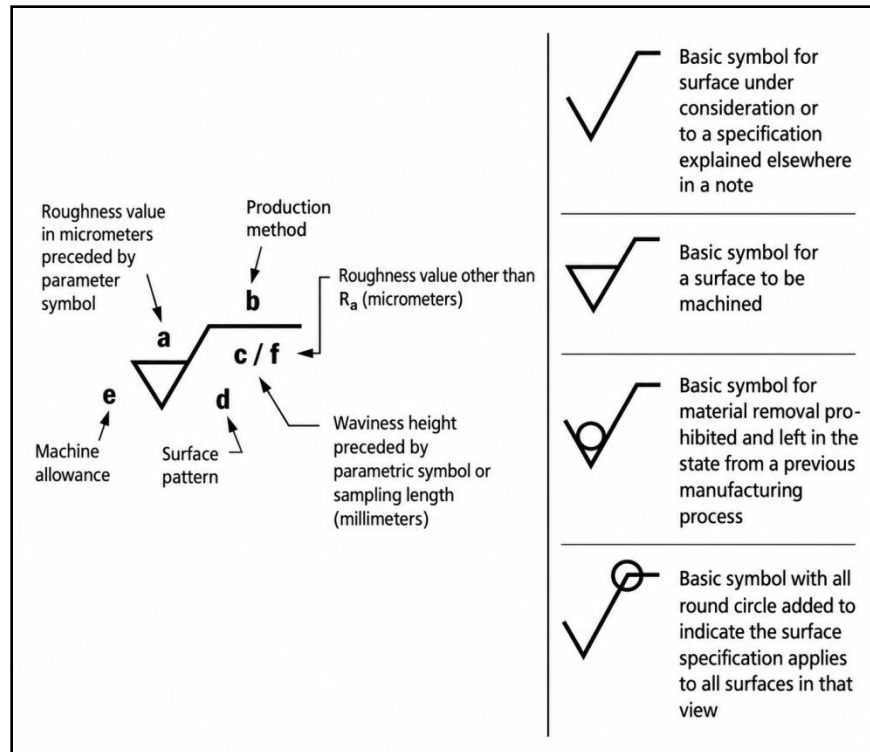
| LAY SYMBOL                                                                                                      | MEANING                                                                                              | DIAGRAM SHOWING DIRECTION OF TOOL MARKS                                                                                                                                     | TYPICAL APPLICATION (EXAMPLE)                                                                                                                                 |
|-----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <br><b>PARALLEL</b>            | Lay approximately parallel to the line representing the surface to which the symbol is applied.      | <br>     | <br><b>Slipping, turning</b><br>(Axial movement)                           |
| <br><b>ACROSS</b>              | Lay approximately perpendicular to the line representing the surface to which the symbol is applied. | <br>     | <br><b>Milling, facing</b><br>(Radial movement)                            |
| <br><b>CROSSED</b>            | Lay angular in both directions to the line representing the surface to which the symbol is applied.  | <br>   | <br><b>Lapping or shot-blasting</b><br>(Two directions at right angles)   |
| <br><b>MULTI-DIRECTIONAL</b> | Lay multidirectional.                                                                                | <br> | <br><b>Lapping or shot-blasting</b><br>(Random pattern in any direction) |
| <br><b>CIRCULAR</b>          | Lay approximately circular, relative to the centre of the surface to which the symbol is applied.    | <br> | <br><b>Face turning</b><br>(Circle operation on flat faces)              |
| <br><b>RADIAL</b>            | Lay approximately radial, relative to the centre of the surface to which the symbol is applied.      | <br> | <br><b>Radial turning</b><br>(Circle operation on rotating faces)        |
| <br><b>PERPENDICULAR</b>     | Lay particulate, perpendicular, or predominant.                                                      | <br> | <br><b>Sandblasting, etching</b><br>(Coating, etch, random matte finish) |

**Machine Drawing Instruction:** The direction of surface lay is important to the function of a component, it should be indicated using the appropriate standardized surface-texture notation.



## Positioning Surface Finish Symbols in Machine Drawing

Surface characteristics are communicated on engineering drawings using **standardized surface-texture symbols**. The appropriate surface-texture symbol is used to indicate the required surface condition on a component drawing.



## Roughness Grade Numbers

Roughness grade numbers provide standardized designations for surface roughness requirements.

| $R_a$<br>micrometer<br>$\mu m$ | $R_a$<br>micro-inch<br>$\mu in$ | Roughness<br>Grade Numbers<br>(New)*** | Roughness<br>Grade Numbers<br>(Old)*** |
|--------------------------------|---------------------------------|----------------------------------------|----------------------------------------|
| 50                             | 2000                            | N12                                    |                                        |
| 25                             | 1000                            | N11                                    |                                        |
| 12.5                           | 500                             | N10                                    |                                        |
| 6.3                            | 250                             | N9                                     |                                        |
| 3.2                            | 125                             | N8                                     |                                        |
| 1.6                            | 63                              | N7                                     |                                        |
| 0.8                            | 32                              | N6                                     |                                        |
| 0.4                            | 16                              | N5                                     |                                        |
| 0.2                            | 8                               | N4                                     |                                        |
| 0.1                            | 4                               | N3                                     |                                        |
| 0.05                           | 2                               | N2                                     |                                        |
| 0.025                          | 1                               | N1                                     |                                        |



## Surface Roughness Parameters

Surface roughness can be described quantitatively using different parameters. The commonly encountered parameters are:

- **R<sub>a</sub>** — Arithmetic Average Roughness
- **R<sub>z</sub>** — Peak-to-Valley/Profile Height Parameter
- **R<sub>max</sub>** — Maximum Roughness Depth/Height Parameter

### R<sub>a</sub>: Arithmetic Average Roughness (CLA)

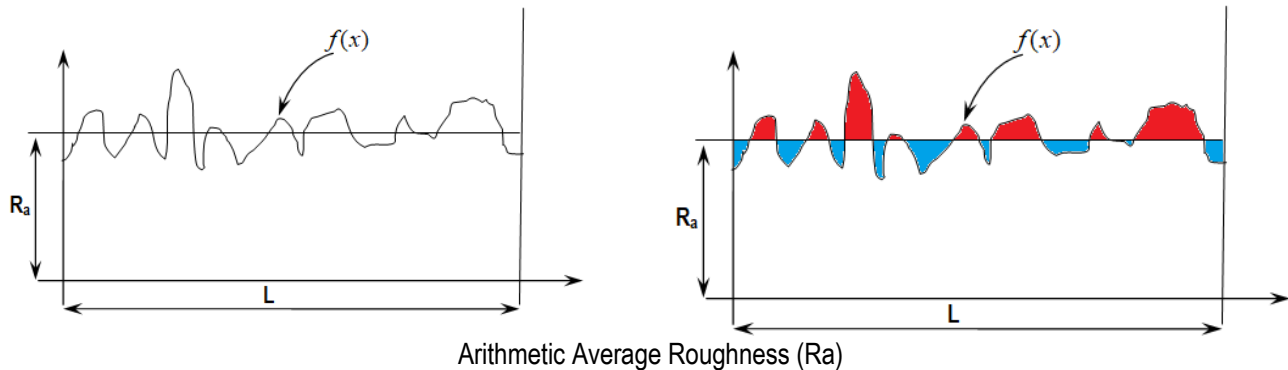
The **arithmetical average roughness (R<sub>a</sub>)** is the average of the absolute deviations of the surface profile from the **mean line** over a specified **sampling/evaluation length**. It is the most commonly used parameter for quantifying surface texture. It is usually measured in  $\mu\text{m}$ . Sometimes, it is known as Centre Line Average value of roughness.

Mathematically, the expression is:

$$R_a = \frac{1}{L} \int_0^L f(x) dx$$

Where,

- $R_a$  = average absolute value of  $f(x)$  over the length  $L$
- $L$  = total length of the interval
- $f(x)$  = the function/profile being measured



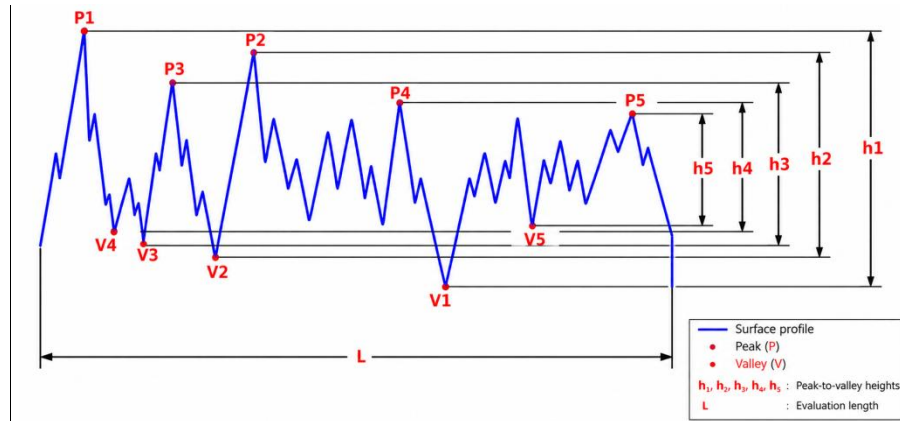
The  $R_a$  refers to a center line so set, with respect to which the overshoot area (**Represented in red colour**) is equal to the undershoot area (**Represented in blue colour**). Therefore area under the curve is equal to the area under the center line (Rectangular area) representing  $R_a$ .

Mathematically this can be written as:  $R_a \cdot L = \int_0^L f(x) dx \Rightarrow R_a = \frac{1}{L} \int_0^L f(x) dx$



## R<sub>z</sub> (Ten point Average value of Roughness) and R<sub>max</sub> (Maximum Roughness) Depth

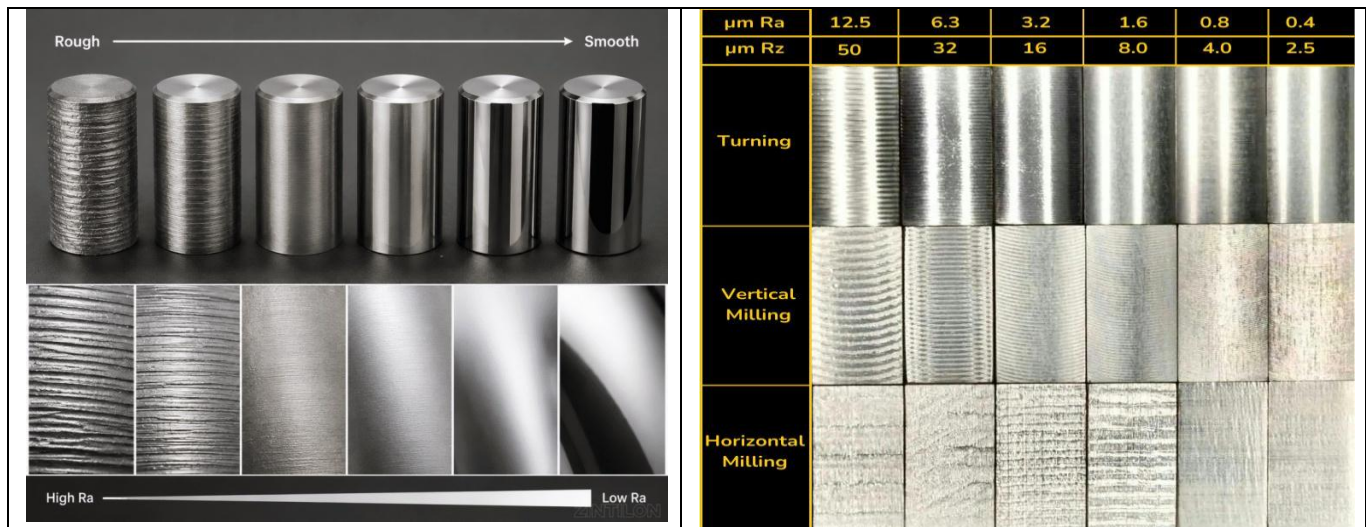
R<sub>z</sub> and R<sub>max</sub> are the two commonly used surfaces roughness parameters. R<sub>z</sub> represents 10 points average of (Five highest peaks in descending order and five deepest valleys in ascending order; whereas, the maximum Roughness, R<sub>max</sub> implies the difference between the highest Peak and the deepest valley.



R<sub>z</sub> & R<sub>max</sub> Roughness

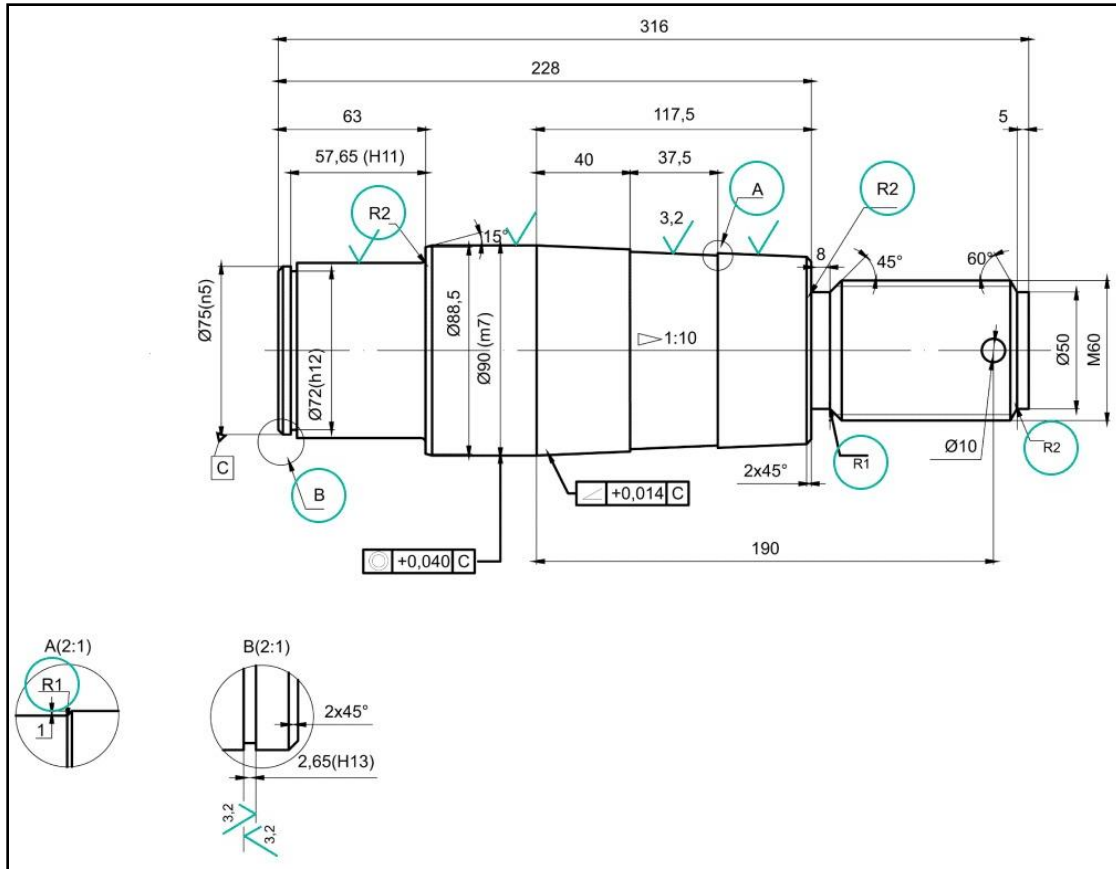
$$R_z = \frac{(h_1 + h_2 + h_3 + h_4 + h_5)}{5} \text{ and } R_{\max} = h_1$$

## Example of Lay





## Machine Drawing Exercise



Detailed Working Drawing of a Stepped/Tapered Shaft with Thread, Grooves, Chamfers and Geometrical Tolerances

The drawing contains features like, Steps and shoulders, Taper, Grooves, Chamfers, Radii/fillets, Threaded portion, Surface-finish indications, Datums, Geometrical tolerances and Enlarged details.

## Instructions to Students

1. Study the given component drawing carefully and identify all linear, angular and diameter dimensions before starting the drawing.
2. Prepare the drawing using the standard conventions of machine drawing and the prescribed drawing-sheet format.
3. Draw the component to the indicated scale while maintaining the proportions and dimensional accuracy shown in the figure.
4. Represent all steps, shoulders, taper, grooves, chamfers, radii and threaded portions clearly.
5. Use the specified dimensions such as  $\varnothing 75$ ,  $\varnothing 72$ ,  $\varnothing 90$ ,  $\varnothing 88.5$ ,  $\varnothing 50$ , M60 and  $\varnothing 10$  exactly as given.
6. Pay particular attention to the specified surface-finish symbols, datum references B and C, and geometrical tolerances.
7. Construct details A and B using the enlarged views A (2:1) and B (2:1) provided in the figure.
8. Indicate the specified R1 and R2 radii, 45° and 60° chamfers, and 2 × 45° chamfers correctly.
9. Construct and dimension the 1:10 taper accurately as specified.
10. Use standard ISO/BIS line conventions, lettering, dimensioning, section conventions, thread conventions and tolerance notation.
11. Ensure that extension lines, dimension lines, arrowheads and leader lines are clear and do not overlap unnecessarily.
12. Complete the drawing neatly. Check all dimensions and symbols and erase unnecessary construction lines before submission.



## Knowledge Categories (KC) and Cognitive Levels (CL)

| Cognitive Level | Factual | Conceptual | Procedural | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design Instrumentalities |
|-----------------|---------|------------|------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
| Remember (R)    |         |            |            |                |                               |                           |                       |                          |
| Understand (U)  |         |            |            |                |                               |                           |                       |                          |
| Apply (Ap)      |         |            |            |                |                               | CO5, A5                   |                       |                          |
| Analyze (An)    |         |            |            |                |                               |                           |                       |                          |
| Evaluate (E)    |         |            |            |                |                               |                           |                       |                          |
| Create (C)      |         |            |            |                |                               |                           |                       |                          |

### Frequently Asked Questions

#### 1. What is surface texture?

**Answer:** Surface texture refers to the geometric irregularities present on a manufactured surface. It mainly includes **roughness, waviness, lay and surface flaws**.

#### 2. What is surface integrity?

**Answer:** Surface integrity refers to the overall condition of a manufactured surface and the material immediately below it. It includes surface texture as well as changes such as residual stresses, hardness changes, plastic deformation and microstructural changes.

#### 3. What is surface roughness?

**Answer:** Surface roughness is the fine, closely spaced irregularity present on a manufactured surface. It is commonly specified using **Ra**, generally expressed in **micrometres ( $\mu\text{m}$ )**.

#### 4. What is waviness?

**Answer:** Waviness consists of relatively larger and more widely spaced surface irregularities. It may be caused by machine vibration, deflection, runout, thermal effects or improper alignment.

#### 5. What is lay?

**Answer:** Lay is the predominant direction or pattern of surface irregularities produced by a manufacturing process. It can be represented using standardized surface-texture symbols on engineering drawings.

#### 6. What are roughness grade numbers?

**Answer:** Roughness grade numbers are standardized designations used to specify required surface roughness. In systems using the **N-grade designation**, grades such as N1–N12 correspond to specified surface-roughness values or ranges according to the applicable standard.

#### 7. What is Ra?

**Answer:** Ra is the **arithmetic average roughness**. It represents the arithmetic mean of the absolute deviations of the roughness profile from the mean line over the evaluation length.

#### 8. Are Ra and Rz the same?

**Answer:** No. Ra and Rz describe different characteristics of the surface profile and should not be treated as interchangeable.

#### 9. Why is surface finish important in machine components?

**Answer:** Surface finish can affect friction, wear, lubrication, sealing, fatigue performance, fitting and overall functional performance. Therefore, the required surface condition should be selected according to the function of the component.

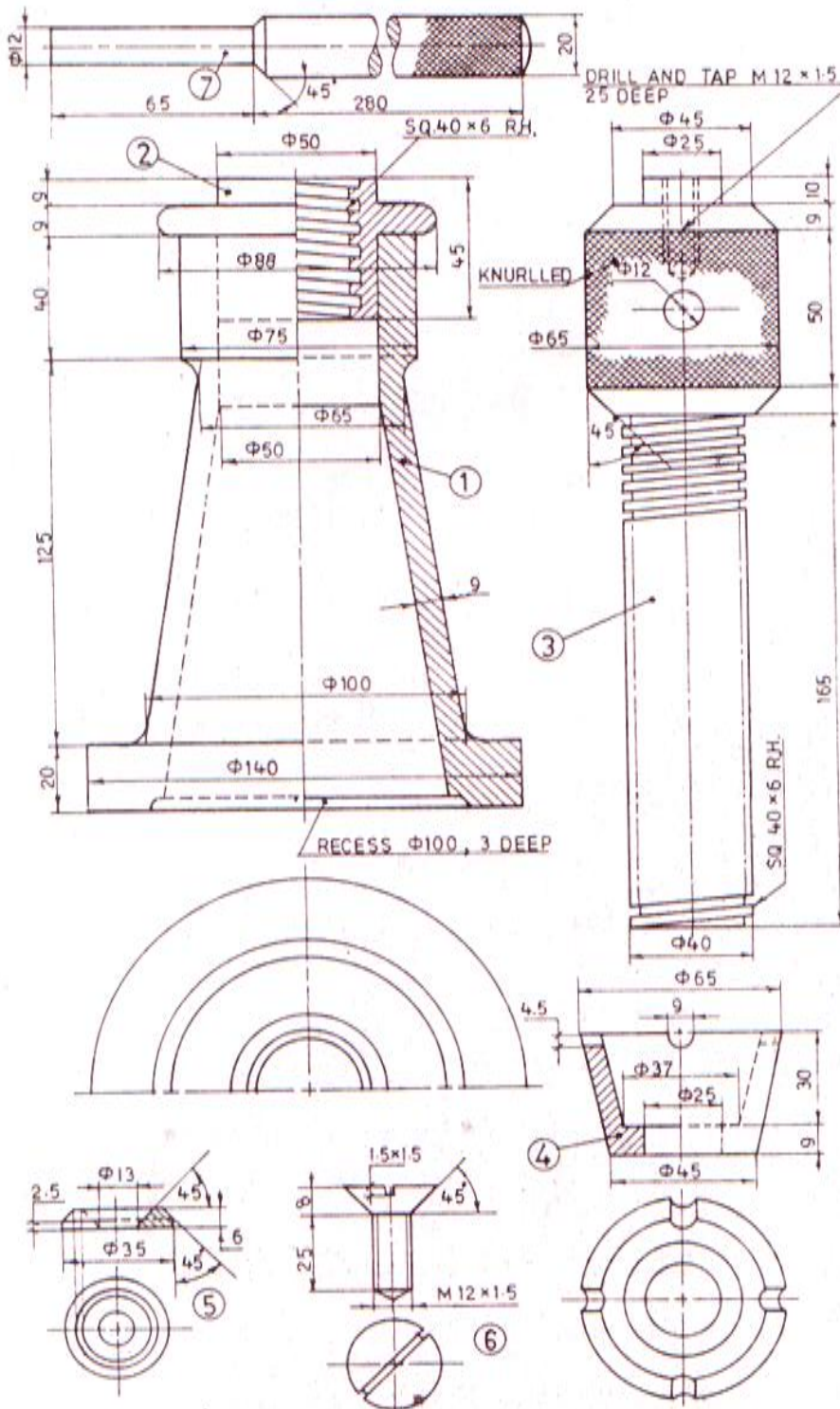


**HALDIA INSTITUTE OF TECHNOLOGY**  
**DEPARTMENT OF MECHANICAL ENGINEERING**  
**MACHINE DRAWING**  
**PC-ME 393**

**Assignment 6A:**

**[CO6] [P × Cr]**

The details of a screw jack are given hereunder. Draw the assembled sectional view of the same and balloon them. Also make a complete Bill of material.



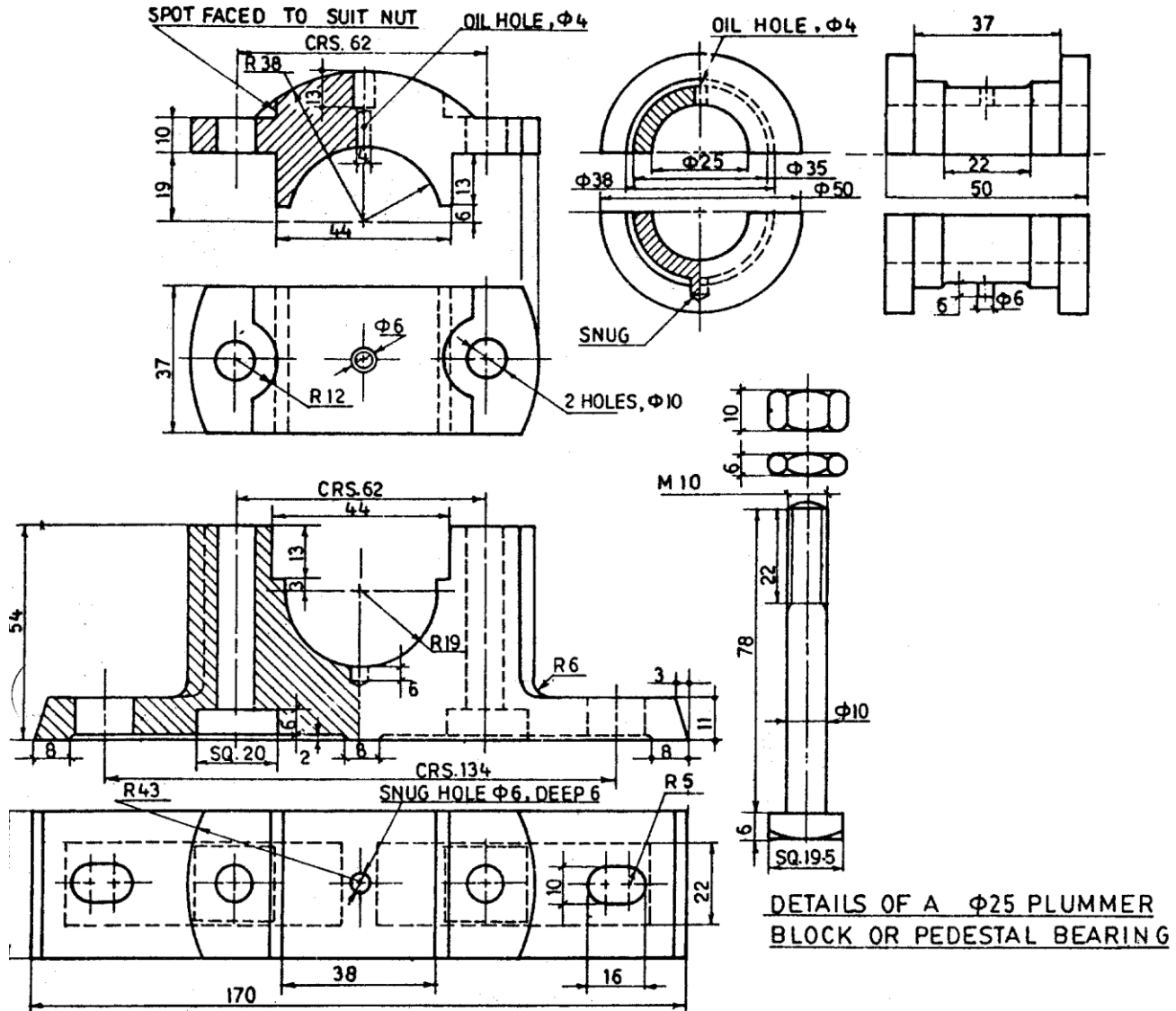


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**MACHINE DRAWING**  
**PC-ME 393**

**Assignment 6B:**

[CO6] [P × Cr]

The details of a Plummer Block have been shown hereunder. Draw the sectional assembled view of the same. Also make a bill of material and balloon them.



| Knowledge Categories (KC) |         |            |               |                |                               |                           |                       |                          |
|---------------------------|---------|------------|---------------|----------------|-------------------------------|---------------------------|-----------------------|--------------------------|
| Cognitive Levels (CL)     | Factual | Conceptual | Procedural    | Meta-cognitive | Fundamental Design Principles | Criteria & Specifications | Practical Constraints | Design instrumentalities |
| Remember (R)              |         |            |               |                |                               |                           |                       |                          |
| Understand (U)            |         |            |               |                |                               |                           |                       |                          |
| Apply (Ap)                |         |            |               |                |                               |                           |                       |                          |
| Analyze (An)              |         |            |               |                |                               |                           |                       |                          |
| Evaluate (E)              |         |            |               |                |                               |                           |                       |                          |
| Create (C)                |         |            | CO6, A6A, A6B |                |                               |                           |                       |                          |