Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

APPLIED MECHANICS

HOD/O.I (Mechanical) **: ER .SHALANDER MOR**

Subject Teacher: Er. Amit Kumar

Semester: 1st Year

By: Er. Amit Kumar
Designed, Mechanical Editing & Developmental Editing

LEARNING OUTCOMES

After undergoing this course, the students will be able to:

Interpret various types of units and their conversion from one to another.

Analyze different types of forces acting on a body and draw free body diagrams.

Determine the resultant of coplanar concurrent forces.

Use the principle of movement in various applications.

Calculate the co-efficient of friction for different types of surfaces.

Calculate the least force required to maintain equilibrium on an inclined plane.

Determine the centroid/centre of gravity of plain and composite laminar and solid bodies.

Determine velocity ratio, mechanical advantage and efficiency of simple machines

Mechanics

The branch of science which deals with the forces and their effects on the bodies on which they act is called mechanics

Applied Mechanics

Applied mechanics also known as engineering mechanics is the branch of engineering which deals with the laws of mechanics as applied to the solution of engineering problems.

Application of applied mechanics

Some of the important practical applications of the principals and laws of mechanics are given below:

1. The motion of vehicles such as trains, buses etc.
2. The design of building and forces on columns and walls.

Branch of applied mechanics

The subject of applied mechanics is broadly divided into the following two branches:

1. **Statics**: The branch of applied mechanics which deals with the forces and their effects while acting upon bodies which are at rest is called statics.
2. **Dynamics**: The branch of applied mechanics which deals with the forces and their effects while acting upon bodies which are in motion is called dynamics.
   It is further divided into two types:

   Kinetics: The branch of dynamics which deals with the relationship between motion of bodies and forces causing motion is called kinetics.

   Kinematics: The branch of dynamics which deals with motion of bodies without considering the forces which cause motion is called kinematics.

Physical Quantity

Any quantity which can be measured is called physical quantity. There are two types of physical quantities:

1. ***Fundamental or basic quantities:*** The mutually independent quantities are called fundamental or basic quantities.

2. **Derived Quantities:** The quantities which can be expressed in terms of fundamental or basic quantities are called derived quantities e.g.

- Velocity = Displacement/ Time = Length/Time
- Linear momentum = Mass x velocity

  Mass x Length/ Time

Fundamental or Basic Units

Quantity	**Unit**
Mass	kilogram(Kg)
Length	metre(m)
Time	Second(s)
Electric current	Ampere(A)
Absolute temperature	Kelvin(K)
Amount of substance	Mole(mol.)
Luminous intensity	Candela(cd)

SYSTEMS OF UNITS

There are four systems of units recognized universally:

1. **C.G.S. Systems:** In this system, the units of length, mass and time are centimetre, gram and second respectively.
2. **F.P.S. Systems:** In this system, the units of length, mass and time are foot, pound and second respectively.
3. **M.K.S. Systems:** In this system, the units of length, mass and time are metre, kilogram and second respectively.
4. **S.I. Systems:** In this systems, the units of length, mass and time are metre(m), kilogram(kg) and second(s) respectively. The S.I. units of various derived units are as under:

Rigid Body

A rigid body may be defined as a body which does not changes in shape and size under the effect of forces acting on it. In fact , no body is perfectly rigid. Every body when acted upon by external forces will undergo certain changes.

Scalar and vector quantities

Scalar quantities have only magnitude but no direction. e.g. mass, length, density, work, pressure, heat, current etc.

Vector quantities have both magnitude as well as direction. E.g. velocity, acceleration, moment, impulse, force etc.

Unit - 2

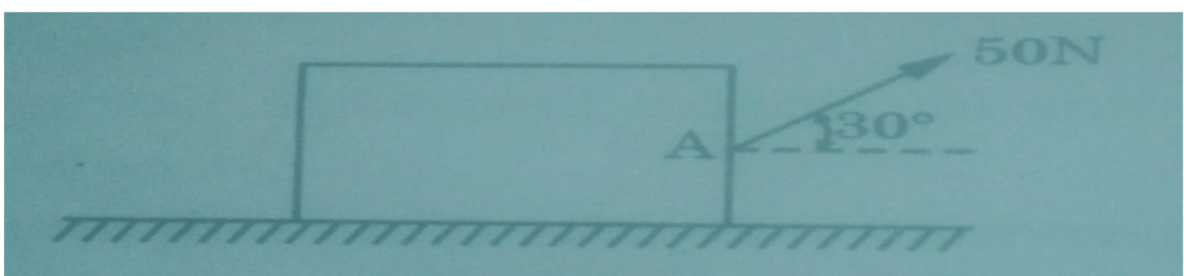
Force

Thus force may be defined as a push or pull which either changes or tend to change the state of rest or of uniform motion of a body. Force is a vector quantity.

Characteristics of force

The followings are the characteristics of a force:

1. **Magnitude:** The quantity of a force is called its magnitude such as 50 N, 80 N, 25 kg etc.
2. **Direction:** The direction of a force is the direction of the line along which it acts.
3. **Nature of the force or sense:** Nature of the force means whether the force is a push or a pull at the point of application.



Effects of a force

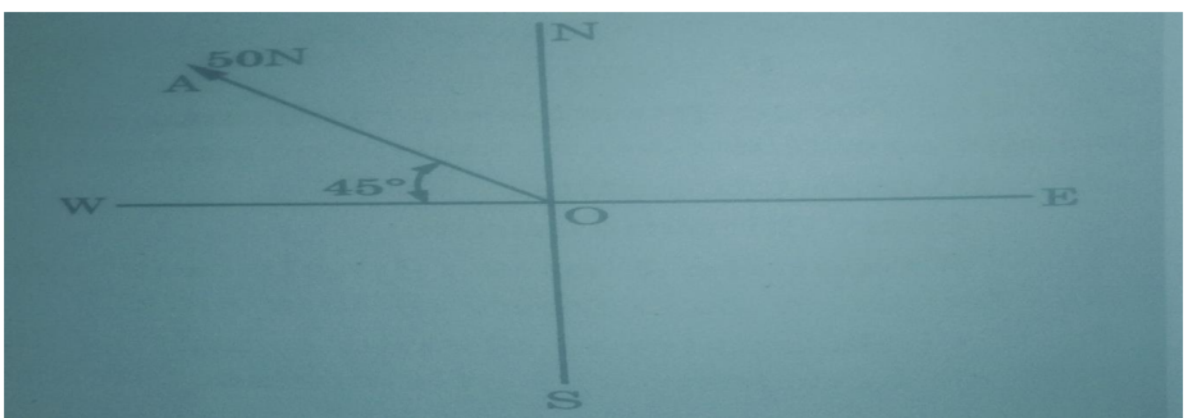
A force acting on body may have the following effects on the body:

1. It may change the state of rest or of uniform motion of a body.
2. It may change the direction of motion of a moving body.
3. It may change the shape internal stresses in the body.
4. It may produce internal stresses in the body.

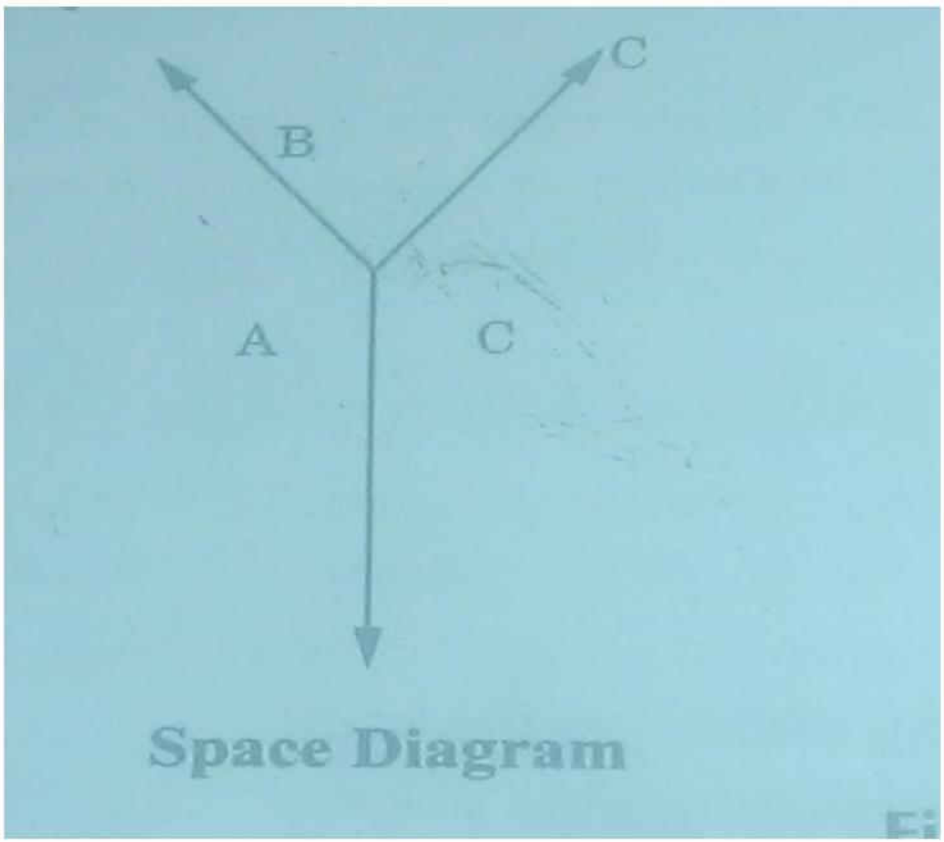
Representation of a force

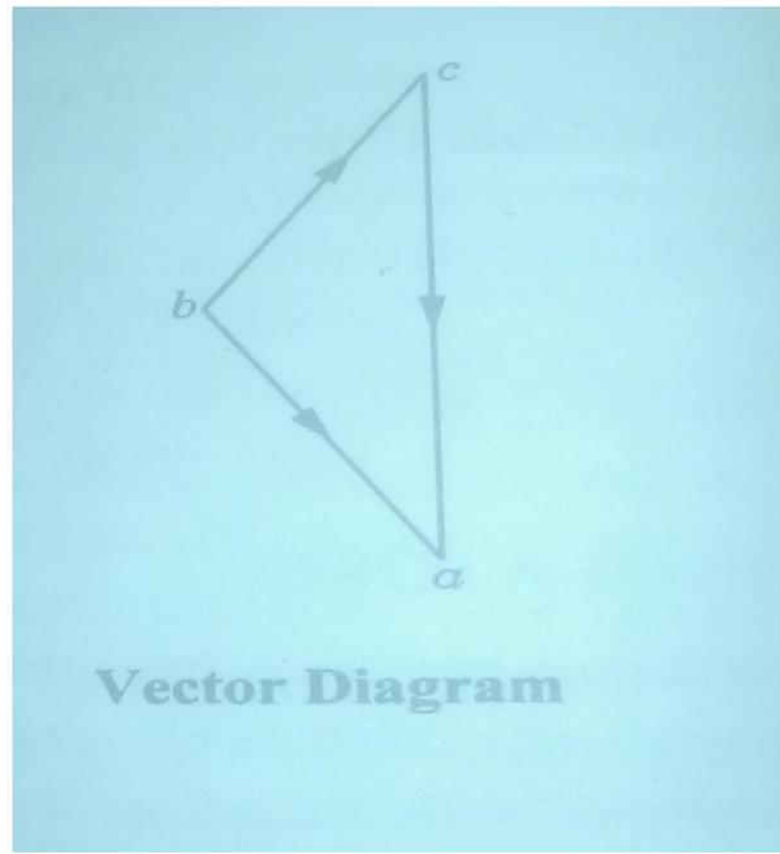
There are two different methods of representing a force:

1. **Vector representation:** In this method, a force is graphically represented by a straight line drawn parallel to the line of action of force on any suitable scale.



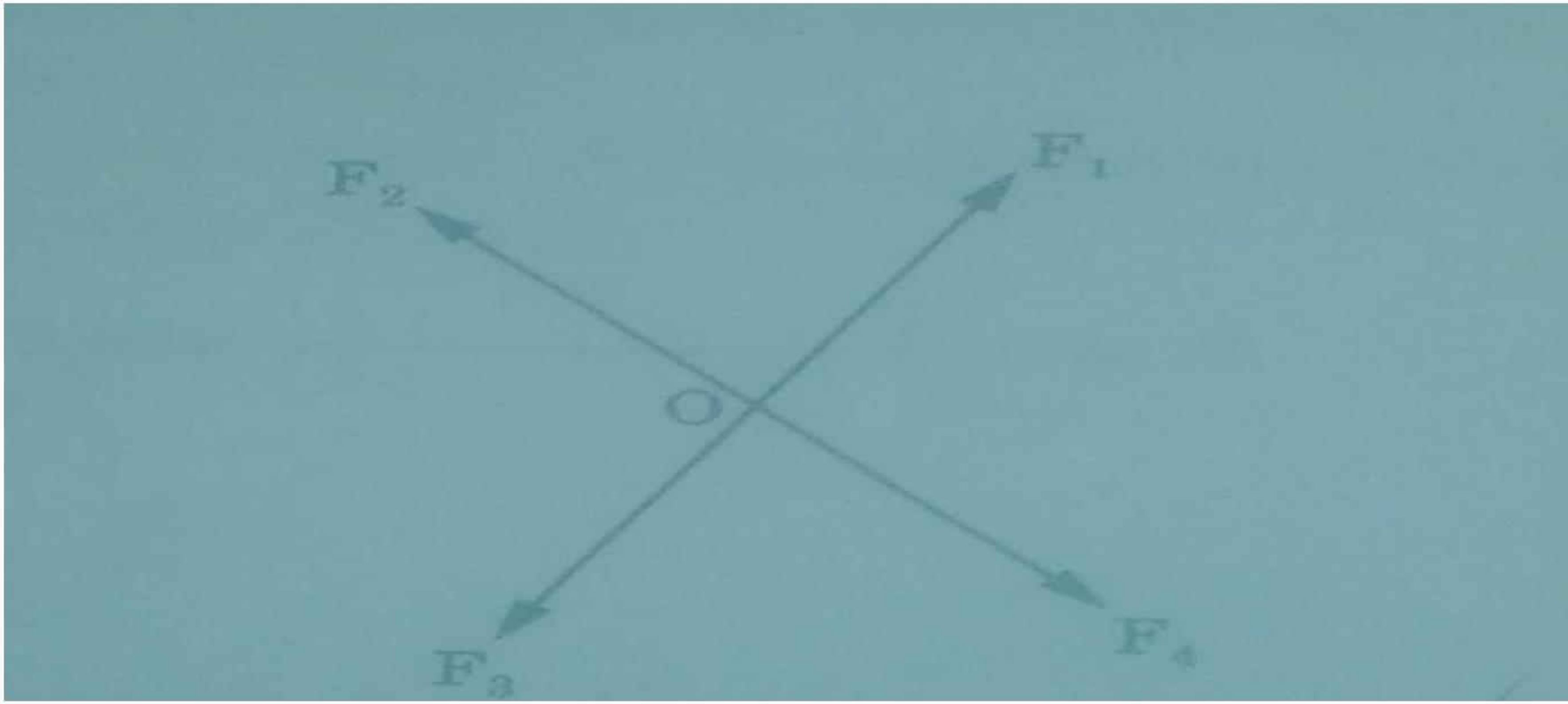
2. ***Bow's Notation:*** Bow's notation is a method of designation a force by writing two capital letters on either side of the line of action of force. The marking of capital letters can be done either in clockwise or anti-clockwise direction.





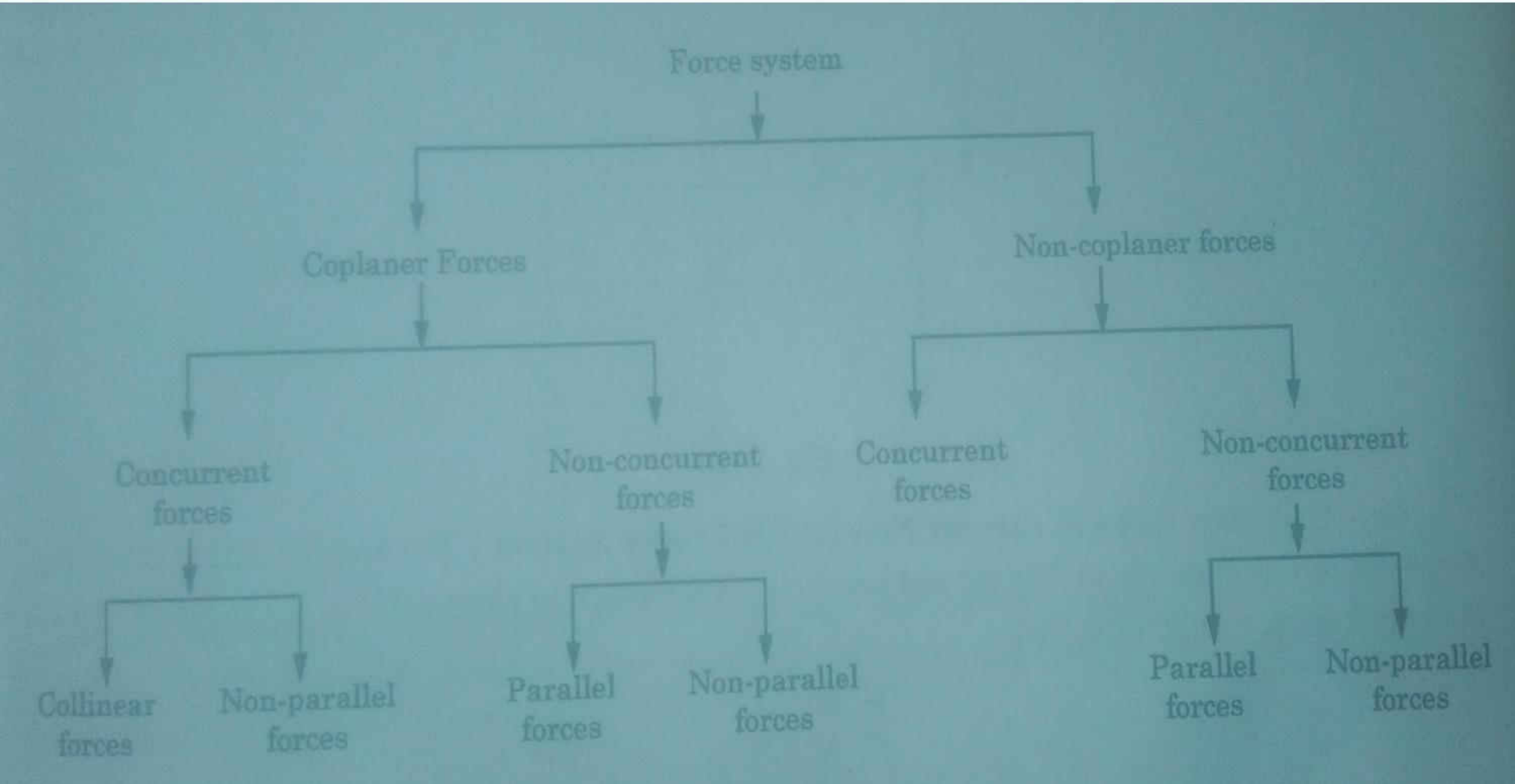
Force system

A force system is a collection of several forces acting simultaneously on a body in one or more planes. In fig the forces F1, F2, F3, and F4 constitute a force system.



Coplaner force system

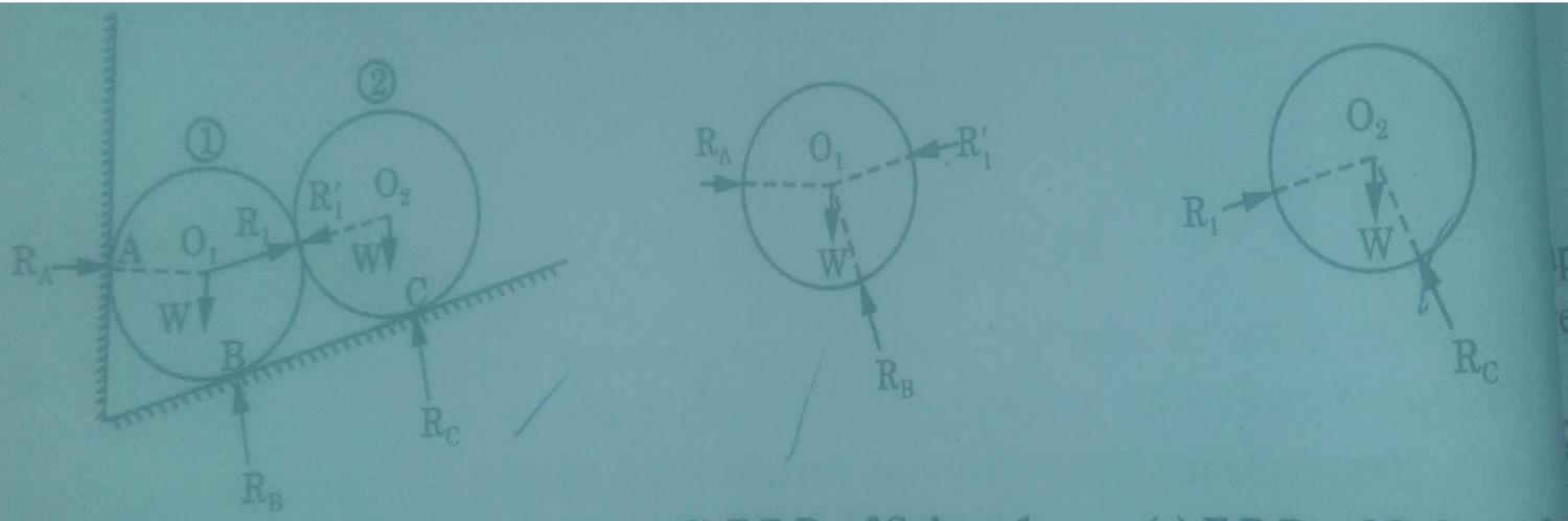
The force constituting the given system lie in the same plane. Coplaner force system may be classified as under:



Free Body Diagram

To study the equilibrium of a body, it is imagined that the supports are replaced by the reaction exerted on body. A diagram of an isolated body which show only the reactions acting on the body is called a free body diagram (F.B.D).

The following steps are followed for drawing a free body diagram:



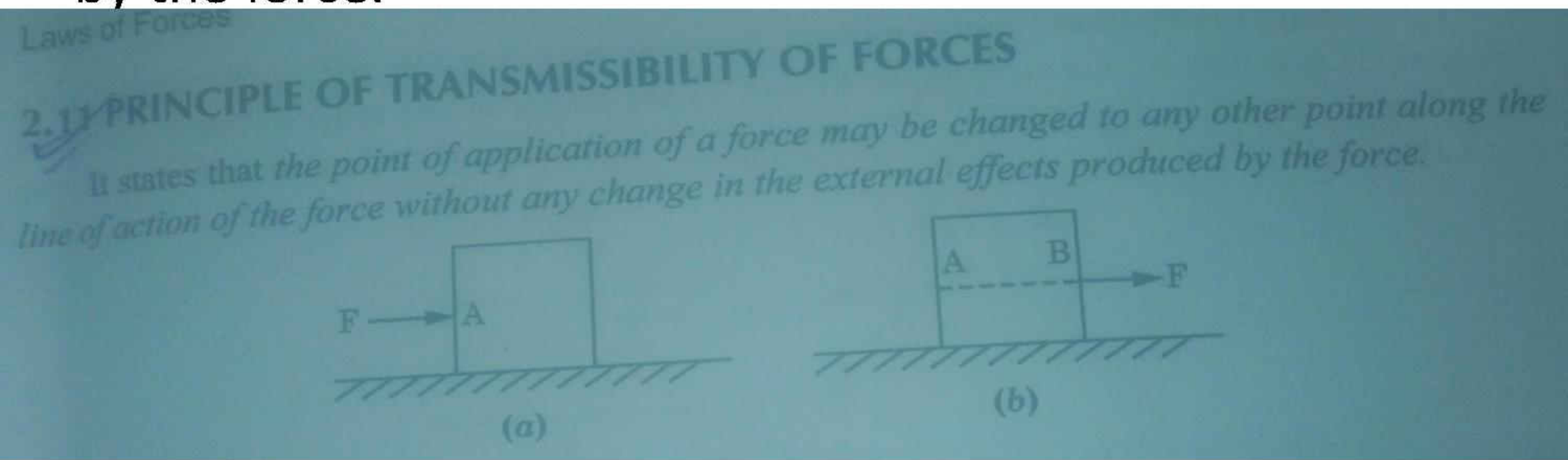
(*a*) Space Diagram (*b*) F.B.D. of Sphere 1 (*c*) F.B.D. of Sphere 2

Law of superposition of forces

It states that the action of a given system of forces on a rigid body will remain same even if we add or subtract from them another system of forces in equilibrium.

Principal of transmissibility of forces

It states that the point of application of a force may be changed to any other point along the line of action of the force without any change in the external effects produced by the force.

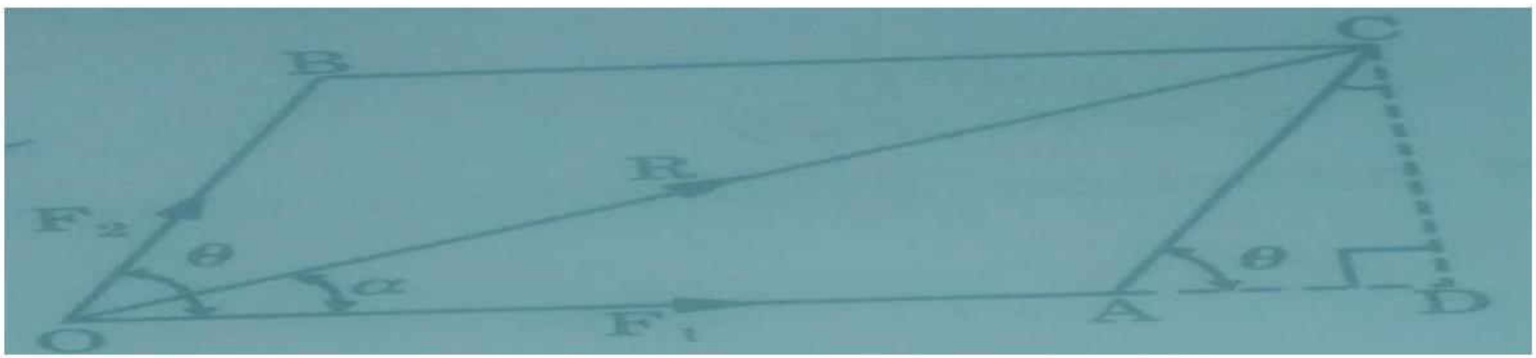

Laws of Forces

2.11 PRINCIPLE OF TRANSMISSIBILITY OF FORCES

It states that *the point of application of a force may be changed to any other point along the line of action of the force without any change in the external effects produced by the force.*

Parallelogram law of forces

Parallelogram law of forces states that if two forces acting simultaneously on a particle are represented in magnitude and direction by the two adjacent sides of a parallelogram, them their resultant is represented in magnitude and direction by the diagonal of the parallelogram passing through their point of intersection.



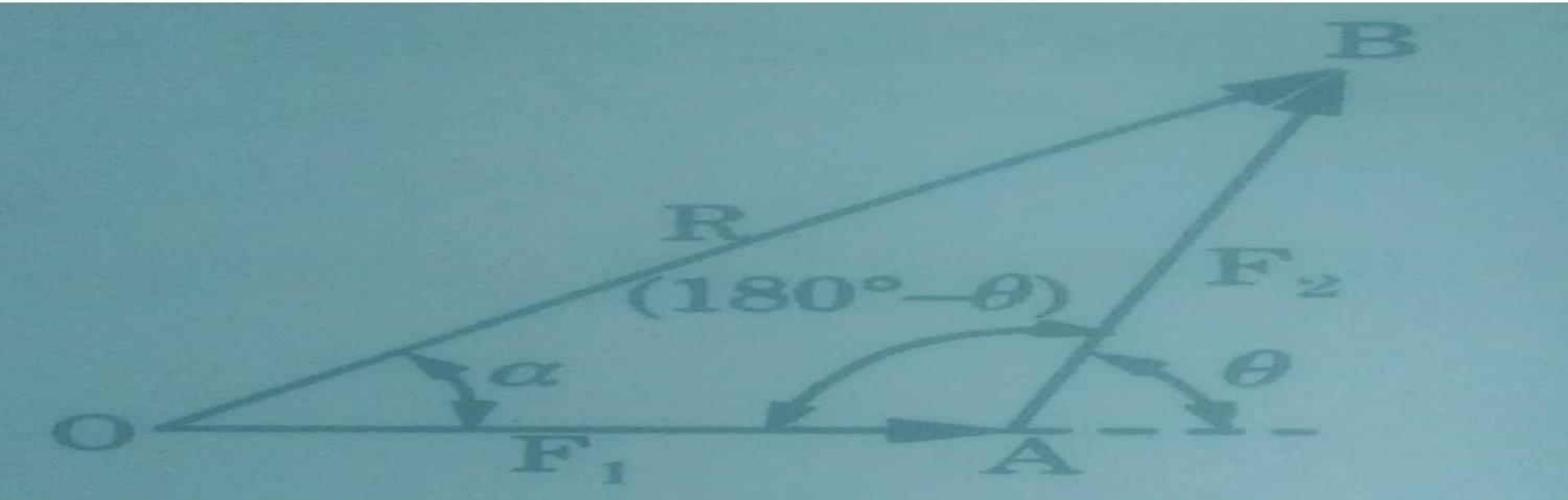
Hence, the magnitude and direction of resultant R can be found out by the formulae :

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

and $$\tan\alpha = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$

Triangle law of forces

Triangle law of forces states that if two forces acting simultaneously on a particle are represented in magnitude and direction by the two sides of a triangle taken in order, then their resultant is represented in magnitude and direction by the third side of the triangle taken in opposite order.



or $$\frac{F_1}{\sin(\theta-\alpha)} = \frac{F_2}{\sin\alpha} = \frac{R}{\sin\theta}$$ [∵ sin (180°

Resultant of a number of coplaner concurrent forces by polygon law of forces

Polygon law of forces is applied for finding the resultant of a number of coplaner forces acting at a point. It is a graphical method. It states that if a number of forces acting simultaneously on a particle are represented in magnitude and direction by the side of a polygon taken in order, then their resultant in represented in magnitude and direction by the closing side of polygon taken in opposite order.

(*a*) Space Diagram

(*b*) Vector Diagram

Lami's Theorem

Lami's Theorem states that if three coplaner forces acting at a point are in equilibrium, then each force is proportional to the sine of the angle between the other two forces.

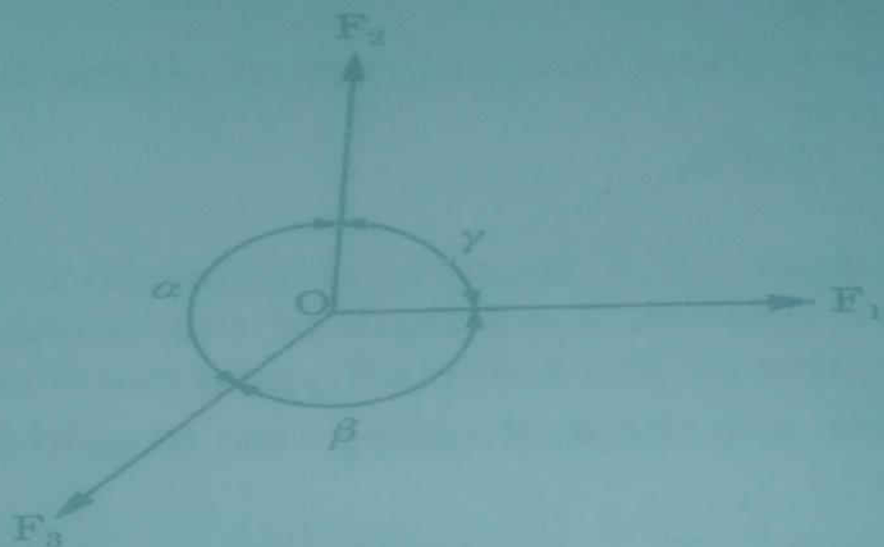


Fig. 2.48

Then as per Lami's theorem,

$$\frac{F_1}{\sin \alpha} = \frac{F_2}{\sin \beta} = \frac{F_3}{\sin \gamma}$$

Laws of forces

Objectives

- Define force, and describe how forces are measured.
- Describe what happens when forces on an object are balanced and when they are unbalanced.
- Explain the meaning of Newton's first law of motion.
- Define scalar, vector, weight, mass, and torque.
- Determine the resultant force on an object when two or more forces act on it.
- Solve problems involving force, lever arm, and torque.

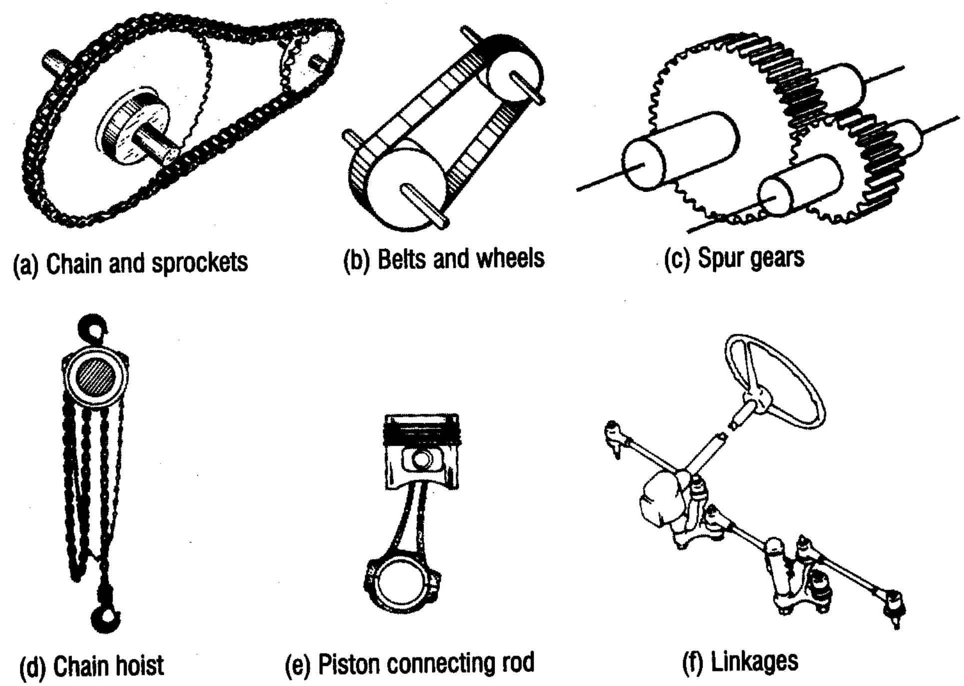


Figure 1.1

Ways to transmit mechanical forces!

Measuring Force

- Metric System (SI- Systems International)
- English

Quantity	Unit	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	Kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Units

- English
  - Length – foot (ft)
  - Force - Pound (lb)
- SI
  - Length – meter (m)
  - Force - Newton (N)

Conversions

1 pound = 16 ounces

1 pound = 4.45 newtons

1 kilogram = 1000 grams

1 kg = 9.8 N = 2.2 lb

1 slug = 32.2 lb

1 slug = 14.59 kg

Definitions

- Force
- Weight
- Mass

Takes into account gravity

Not the same thing

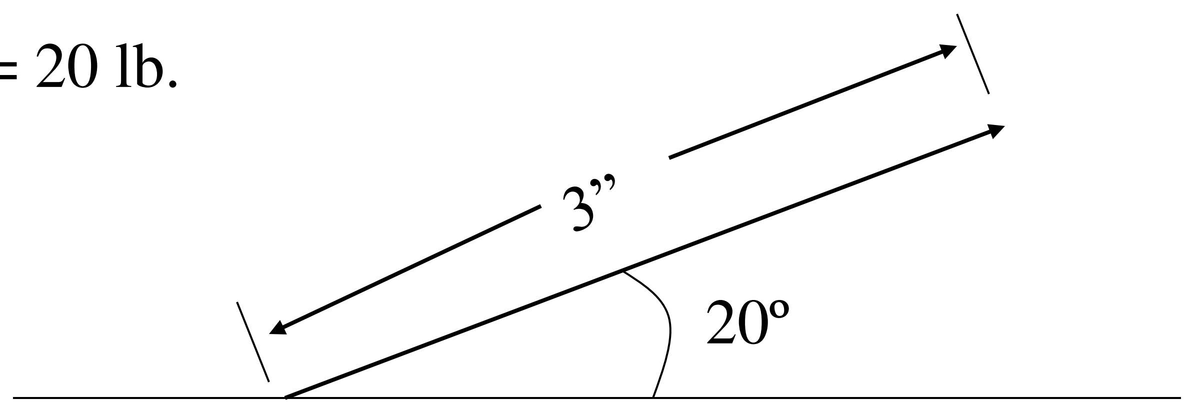
Amount of matter in an object

- Vector – has magnitude and direction
- Scalar – quantity described by only a magnitude. (temp., time, pressure, mass)

Drawing Forces

- Draw as an arrow.
- Length of the arrow is proportional to the magnitude of the vector.
- Head points in the direction of the vector.

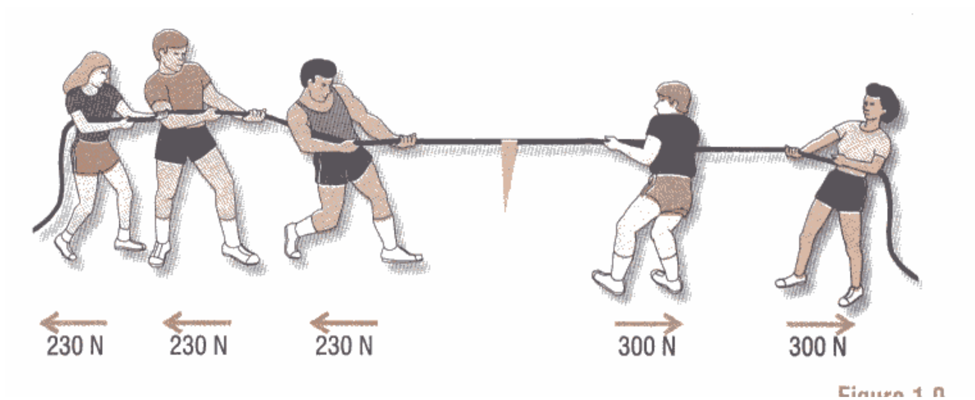
1 inch = 20 lb.

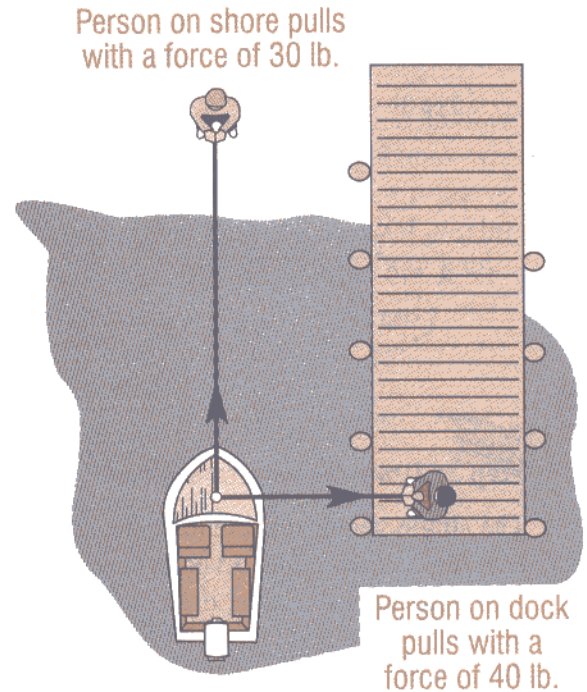


Terms

- Balanced forces
- Unbalanced forces
- Net force
- Equilibrium
- Newton's First Law of Motion (law of inertia)
  - Every object will remain at rest, or will continue to move in a straight line with constant speed, unless the object is acted on by a net force.
- Inertia – the property of an object to resist changes in its motion.

Adding Forces



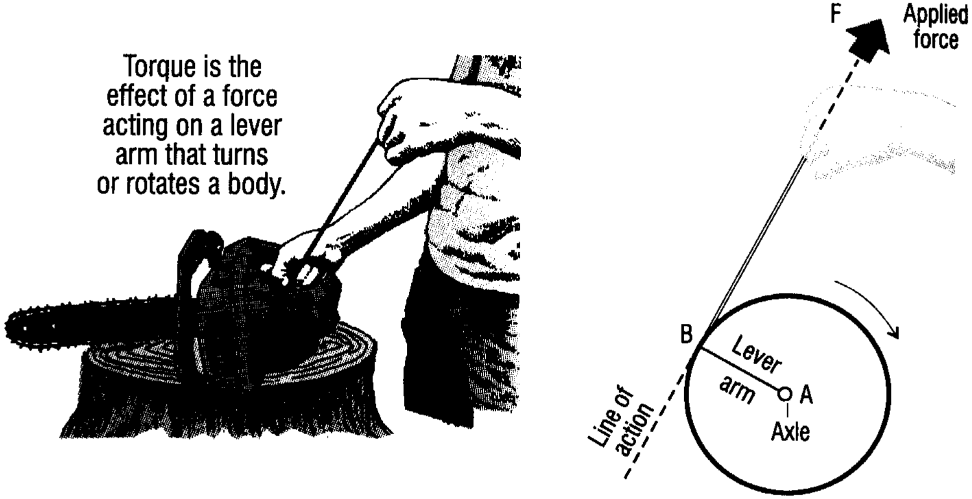


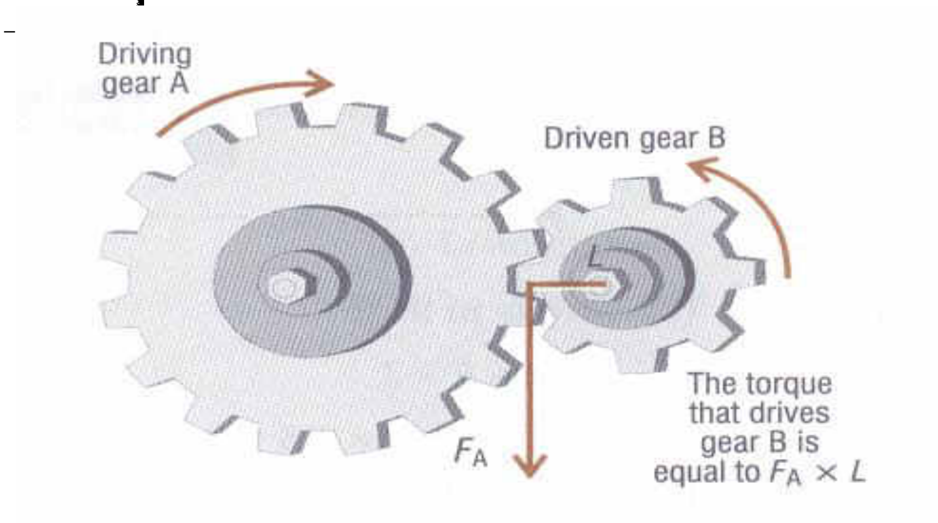
1. Draw the 40 lb. Force
2. Add the 30 lb. Force to the 40 lb. Force (head to tail method)
3. Draw the resultant force
4. Determine magnitude and direction of resultant
5. Form conclusion.

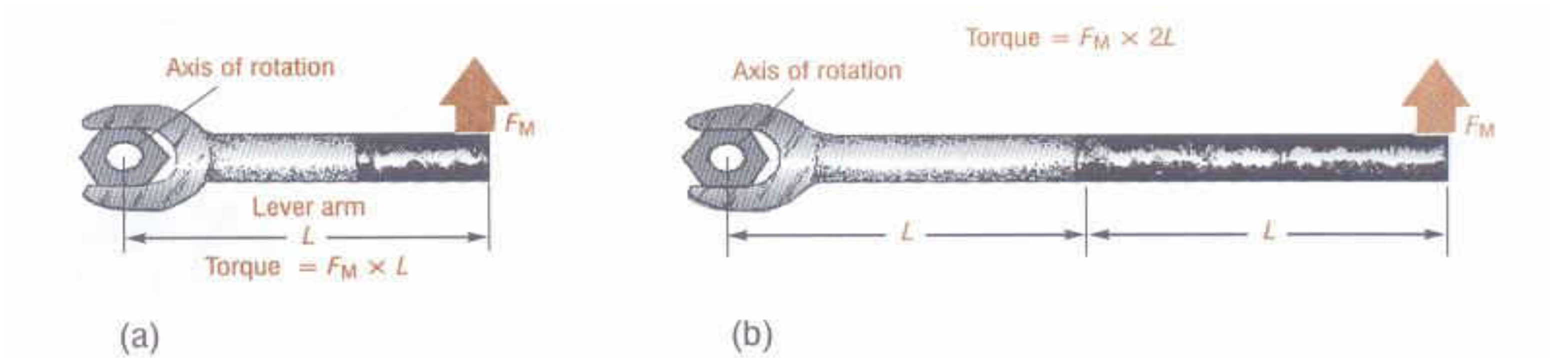
Terms

- Torque – the quantity that causes rotation in mechanical systems. (cw or ccw)
- τ =F x L (Greek letter "tau")

  Torque = Applied Force x length of lever arm


Torque is the effect of a force acting on a lever arm that turns or rotates a body.
F
Applied force
B
Lever arm
A
Axle
Line of action


Driving gear A
Driven gear B
F_A
The torque that drives gear B is equal to $F_A \times L$


Axis of rotation
F_M
Lever arm
L
Torque $= F_M \times L$
(a)
Torque $= F_M \times 2L$
Axis of rotation
F_M
L
L
(b)

Summary

- A force is a push or a pull.
- Force is a vector. It has both magnitude and direction. Its magnitude is measured in pounds or in newtons.
- Newton's first law says that an object will remain at rest or will continue to move in a straight line unless it is acted on by a net force.
- Unbalanced forces result in a net force acting on an object. Balanced forces result in no net force acting on an object.
- If two forces act on an object and the forces act in a straight line, the magnitude of the resultant is either the sum of or the difference between the two forces' magnitudes.

Summary (cont.)

- If two forces act on an object and the forces do not act in a straight line, the resultant can be found using the head-to-tail method of vector addition.
- The mass of an object is a measure of the object's inertia. The weight is a measure of the force exerted on the object by gravity.
- A torque is exerted on a body when a force is applied and the line of action of the force does not pass through the body's axis of rotation. The torque equals the force times the lever arm
- If no net torque is exerted on a body, it will remain at rest or will continue to rotate at a constant rate.

(TLS # 16)

Moments

Moments

The moment of a force is a measure of the force's capacity to rotate an object around a fixed point (pivot) or axis.

Moment = Force × Perpendicular distance

'Perpendicular distance' refers to the perpendicular distance between the line of action of the force and the centre of the rotation.

The moment of a force is measured in **Newton-metres (Nm)**.

Adding and subtracting moments

Moments can act in a clockwise or anti-clockwise direction.

↻ is used to represent **clockwise** and ↺, **anti-clockwise**.

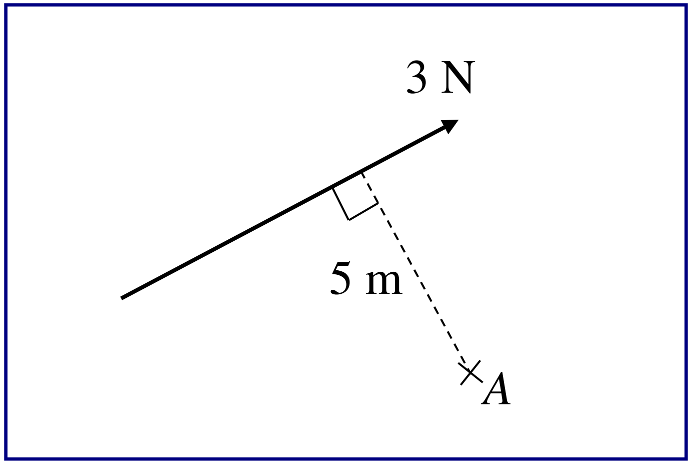
If two or more moments are acting on an object, the **overall moment** is the **difference** between the total clockwise moment and the total anti-clockwise moment.

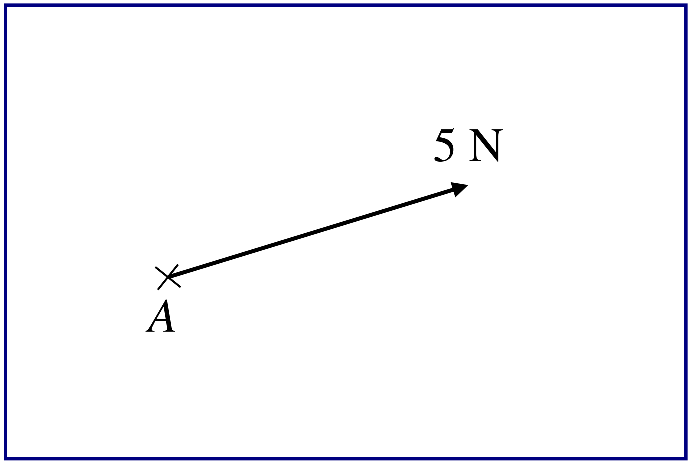
If an object is in **equilibrium** then:

total clockwise moments = total anti-clockwise moments

Calculating moments

Calculate the moment about *A* for each of the following forces:





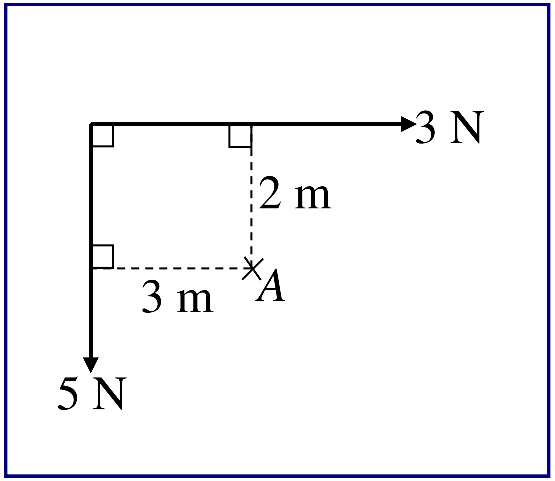
Moment = 3 N × 5 m

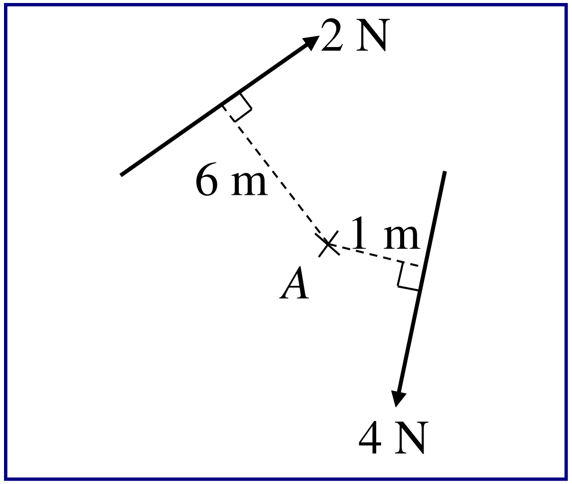
= **15 Nm** ↻

The moment is **zero** since the perpendicular distance is zero.

Calculating moments

Calculate the sum of the moments about *A* for each diagram.





↻ moment = 3 N × 2 m
= 6 Nm

↺ moment = 5 N × 3 m
= 15 Nm

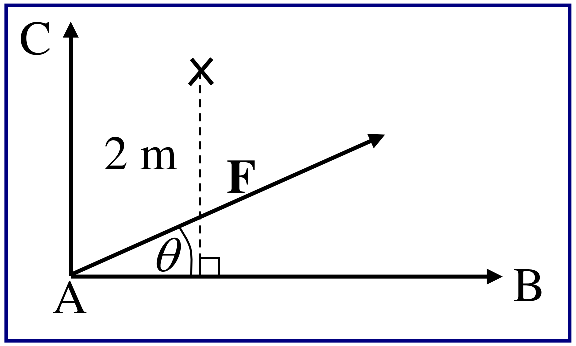
Resultant moment
= 15 Nm – 6 Nm
= **9 Nm ↺**

Both forces are acting in a clockwise direction.

Resultant moment
= (2 × 6) + (4 × 1)
= **16 Nm ↻**

Non-perpendicular forces

If the distance given is not perpendicular to the force, you can use **trigonometry** to work out the perpendicular distance.



Force F is not perpendicular to its given distance to X. The line AB is. You can work out the component of F that is exerted in the direction AB.

The component of force F in the direction AB is equal to the magnitude of F, multiplied by the **cosine** of the angle between the force and the direction AB.

The component of the force in the direction AB = $\mathbf{F\cos\theta}$.

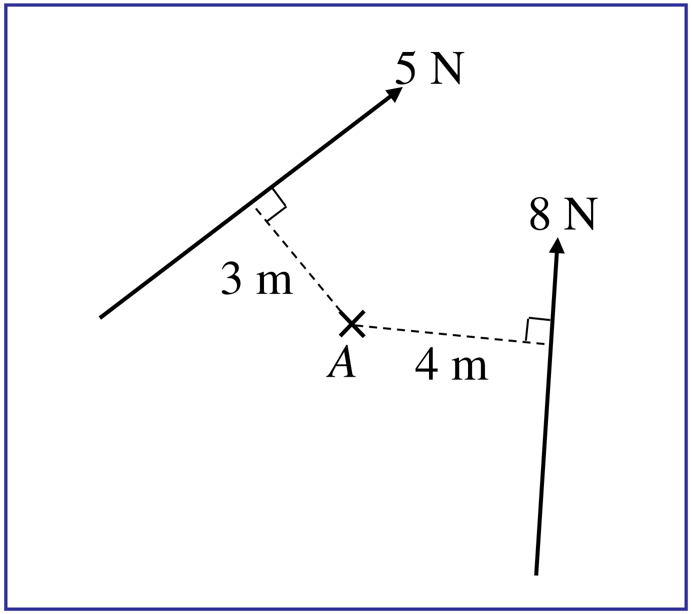
The component of the force in the direction AC = $F\cos(90-\theta)$

= $\mathbf{F\sin\theta}$.

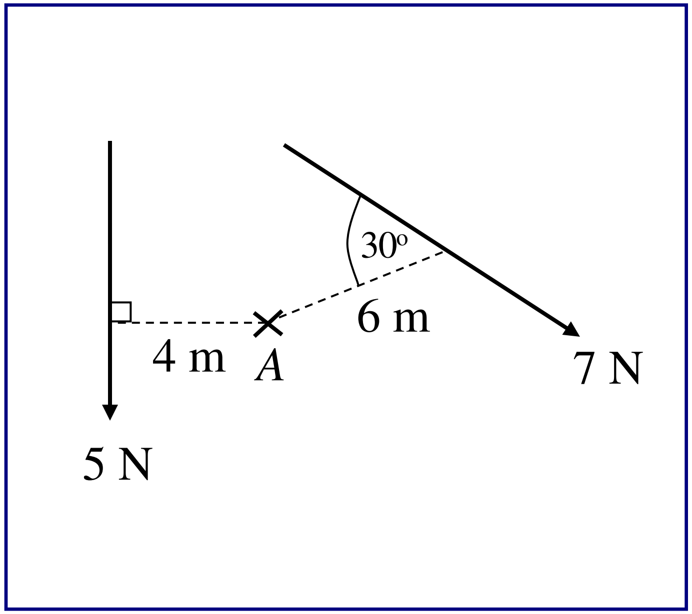
Calculating moments questions

For each of the following diagrams, calculate the sum of the moments about *A*. Remember to state whether the resulting moments are acting in a clockwise or anti-clockwise direction.

1.



2.



Calculating moments solutions

1. The 5 N force is acting in a clockwise direction and the 8 N force is acting in an anti-clockwise direction.

↻ moment $= 5\text{ N} \times 3\text{ m} = 15\text{ Nm}$

↺ moment $= 8\text{ N} \times 4\text{ m} = 32\text{ Nm}$

Resultant moment $= 32\text{ Nm} - 15\text{ Nm} = 17\text{ Nm}$ ↺

2. The 5 N force is acting in an anti-clockwise direction whilst the 7 N force is acting in a clockwise direction.

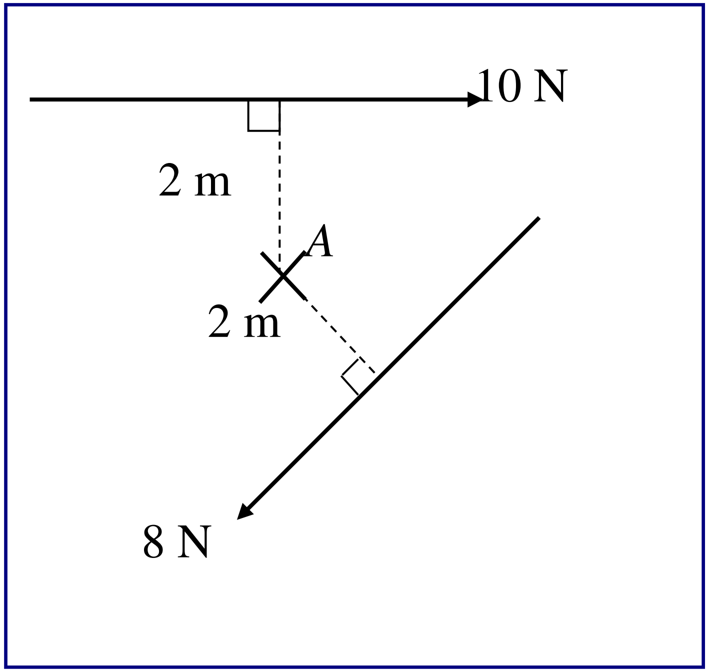
↺ moment $= 5\text{ N} \times 4\text{ m} = 20\text{ Nm}$

↻ moment $= 7\sin 30°\text{ N} \times 6\text{ m} = 21\text{ Nm}$

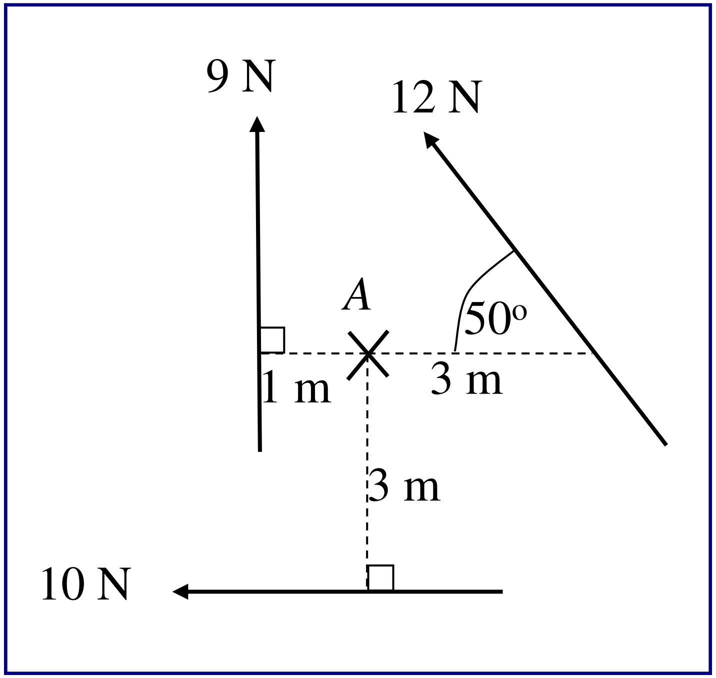
Resultant moment $= 21\text{ Nm} - 20\text{ Nm} = 1\text{ Nm}$ ↻

Calculating moments questions

3.



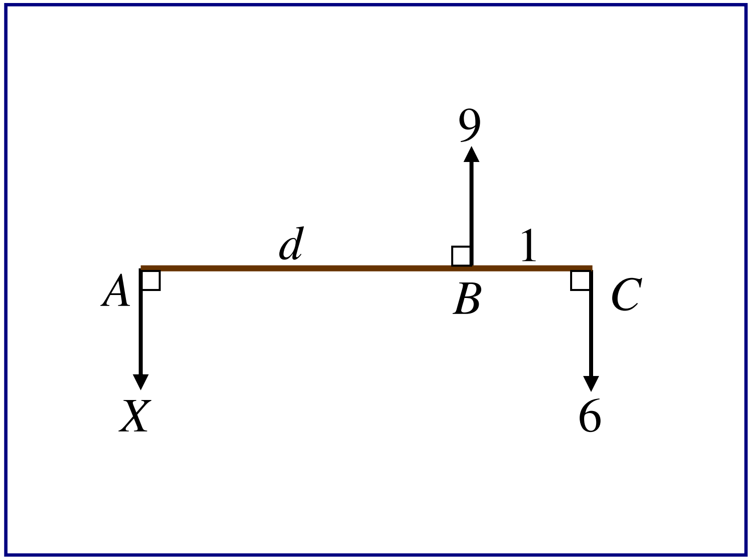
4.



Light uniform rods

A **light rod** may have a mass so small compared to the masses acting on it, that its own mass can be **ignored**.

1. The light rod shown below is in equilibrium.
   Calculate the size of the force X and the value of d.



Resolving forces vertically:

$$X + 6 = 9$$

so, $\mathbf{X = 3}$

Taking moments about *C*

$$9 \times 1 = 3(d + 1)$$

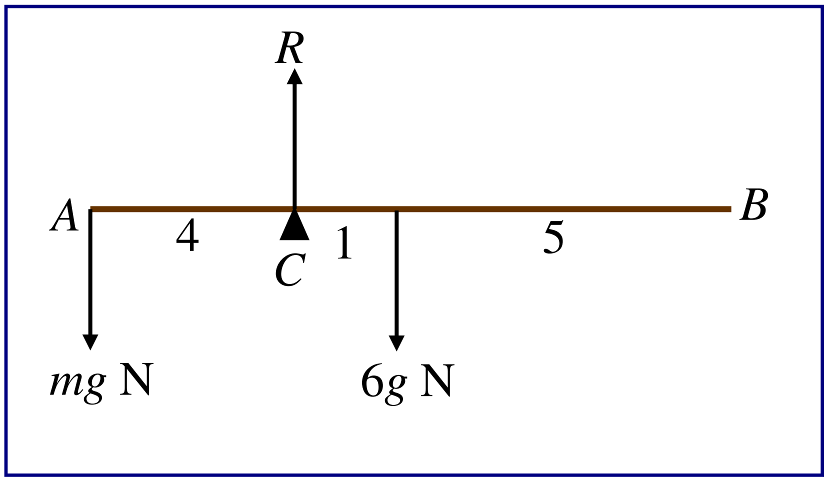
$$9 - 3 = 3d$$

$$\mathbf{2 = d}$$

Uniform rod questions

2. A uniform rod AB has mass of 6 kg and is pivoted at C. The length of the rod is 10 m and distance $AC = 4$ m.

   Calculate the mass of the weight that must be attached at A to keep the rod in equilibrium.



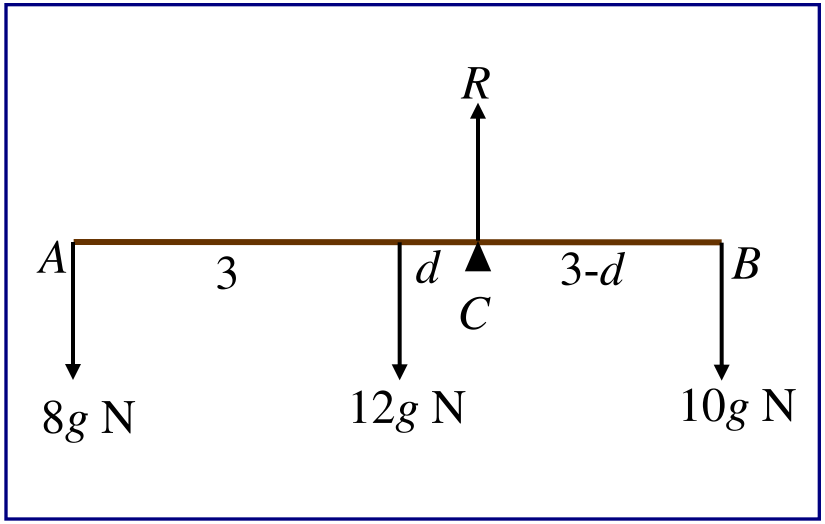
Taking moments about C:

$$m \times 4 = 6 \times 1$$
$$4m = 6$$
$$m = 1.5$$

Therefore, the mass of the weight that must be attached at A is **1.5 kg**.

Uniform rod questions

3. A uniform rod *AB* has length of 6 m and mass of 12 kg. A weight of mass 8 kg is attached at *A* and a weight of mass 10 kg is attached at *B*. The beam is pivoted at *C* and is in equilibrium. Find the distance *AC*.



Taking moments about *C*:

↻ moment

$= 10 \times (3 - d)$

$= 30 - 10d$

↺ moment

$= 8 \times (3 + d) + 12d$

$= 24 + 8d + 12d$

$= 24 + 20d$

So, $30 - 10d = 24 + 20d$

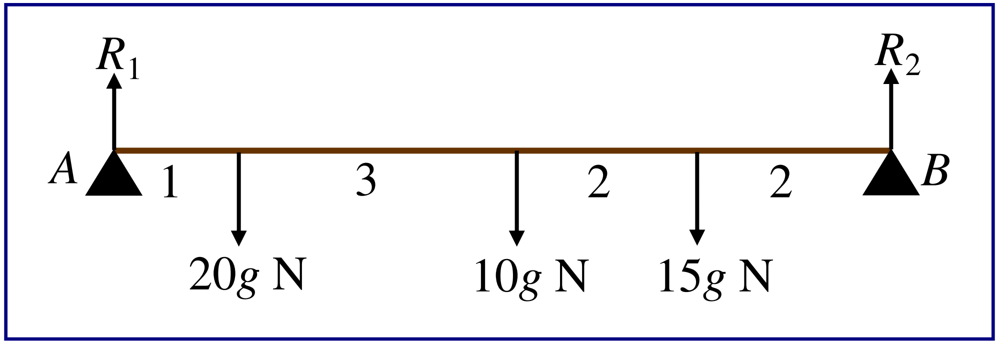
$6 = 30d$

$d = 0.2$ m

∴ The distance *AC* = **3.2 m**

Uniform rod questions

4. A uniform beam *AB* of mass 10 kg is 8 m long and is resting on two supports at *A* and *B*. A mass of 20 kg is placed on the beam 1 m from *A*. A mass of 15 kg is placed on the beam 2 m from *B*. Calculate the reaction forces at *A* and *B*.



Resolving forces vertically:

$R_1 + R_2 = 45g$ N

Taking moments about *A*:

$$20 \times 1 + 10 \times 4 + 15 \times 6 = R_2 \times 8$$
$$150 = 8R_2$$
$$R_2 = \mathbf{18.75g\ N}\ (183.75\ \text{N})$$

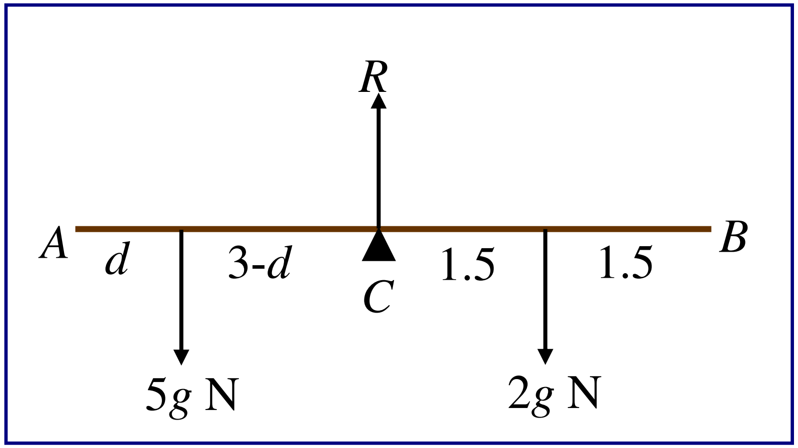
So, $R_1 = 45 - R_2 = 45 - 18.75$

$= \mathbf{26.25g\ N}$ (257.25 N)

Non-uniform rod questions

The centre of mass of a **non-uniform** rod is not necessarily at the rod's mid-point.

1. A non-uniform beam *AB* of length 6 m and mass 5 kg rests on a pivot at the mid-point *C*. When a mass of 2 kg rests on the beam 1.5 m from *B*, the system is in equilibrium. Find the distance between *A* and the centre of mass of the beam.



Taking moments about *C*:

$$5 \times (3 - d) = 2 \times 1.5$$

$$15 - 5d = 3$$

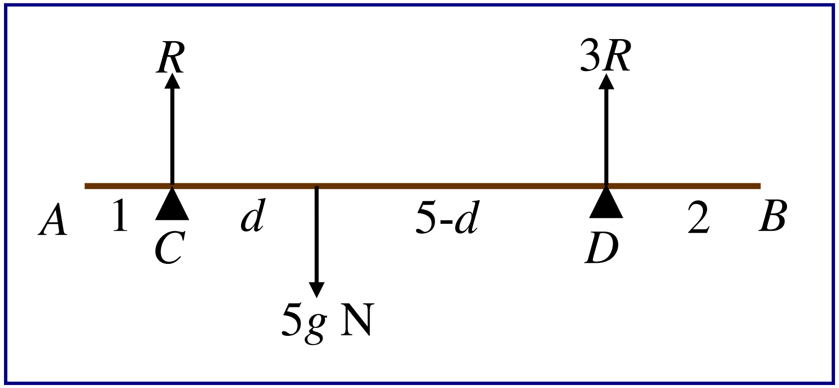
$$\text{So, } 5d = 12$$

$$d = 2.4 \text{ m}$$

Therefore, the centre of mass of the beam is **2.4 m** from *A*.

Non-uniform rod questions

2. A non-uniform rod AB has length 8 m and mass 5 kg. It is resting on two supports at C and D, where C is 1 m from A and D is 2 m from B. The reaction force at C is a third of that at D. Calculate the distance between A and the centre of mass of the rod.



Resolving vertically:

$$4R = 5g \text{ N}$$
$$R = 1.25g \text{ N}$$

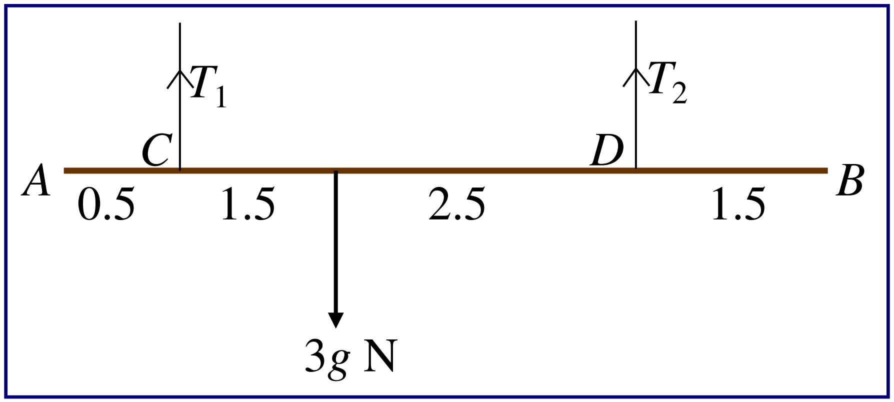
Taking moments about *D*:

$$5R = 5(5 - d)$$
$$6.25 = 25 - 5d$$
$$5d = 18.75$$
$$d = 3.75 \text{ m}$$

So, the centre of mass is **4.75 m** from A.

Non-uniform rod questions

3. A non-uniform rod *AB* of length 6 m and mass 3 kg, has its centre of mass 2 m from *A*. It is suspended from the ceiling by two vertical strings attached at *C* and *D*, where C is 0.5 m from *A* and *D* is 1.5 m from *B*.
Calculate the tension in the strings at *C* and *D*.



Resolving forces vertically:

$$T_1 + T_2 = 3g \text{ N}$$

Taking moments about *C*:

$$3 \times 1.5 = T_2 \times 4$$

$$4T_2 = 4.5$$

$$T_2 = 1.125g \text{ N}$$

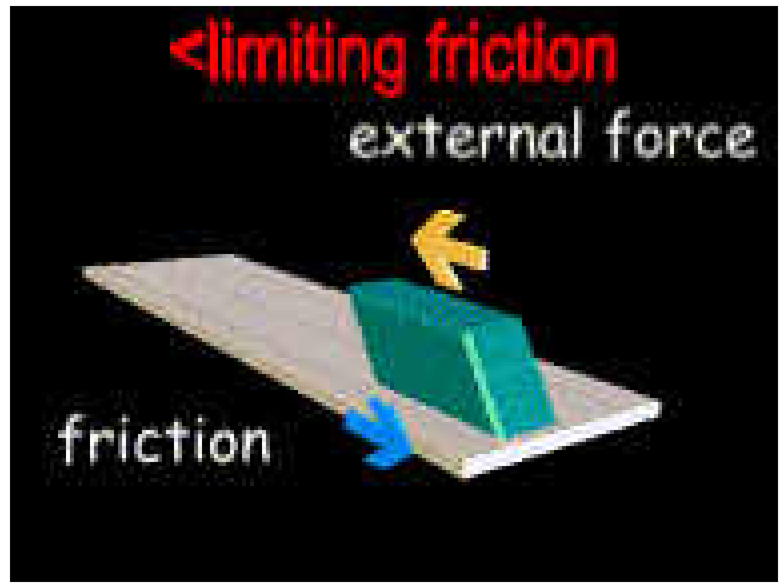
So, $T_1 = 1.875g$ N

So, the tension in the string at ***C*** is **1.875*g* N** (18.375 N) and the tension in the string at ***D*** is **1.125*g* N** (11.025 N)

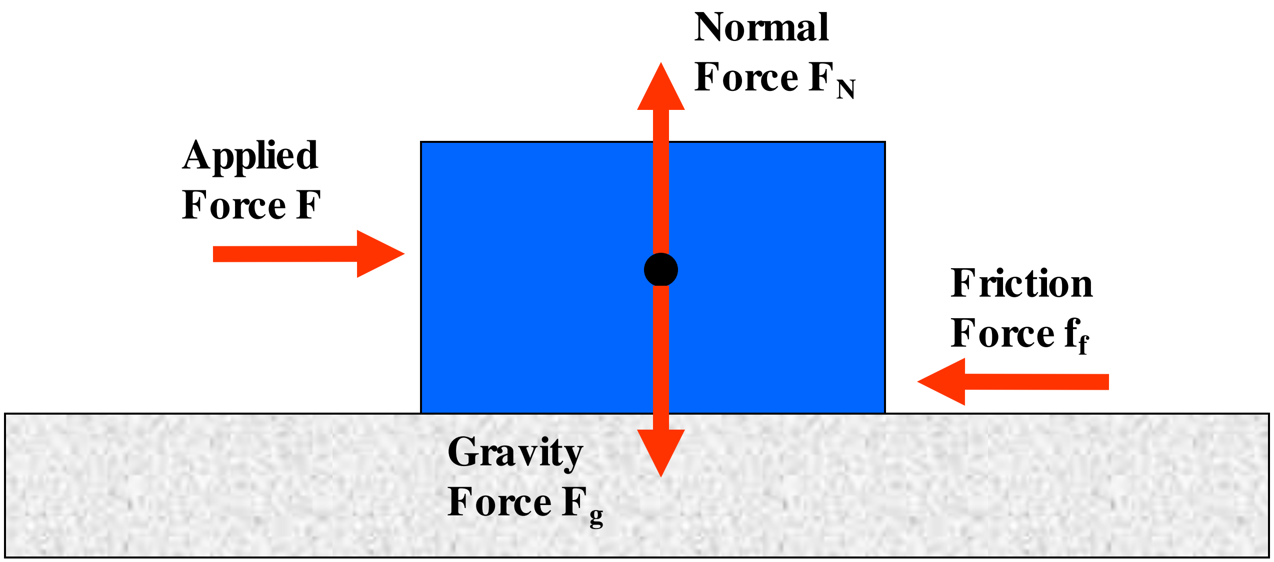
Friction

What is Friction?

- Force that acts oppose the relative motion of two surfaces
- High for dry and rough surfaces
- Low for smooth and wet surfaces



Free Body Diagram



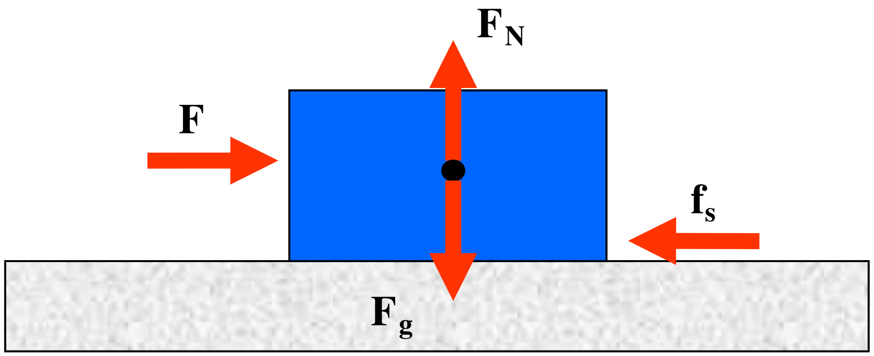
$F_g = mg$

$F_N = F_g$

$f_f = F$

Static Friction

The Force of Static Friction keeps a stationary object at rest!

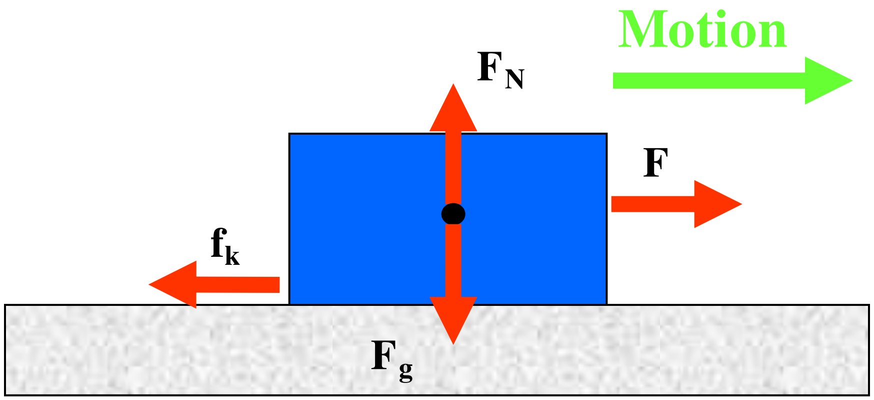


$$f_s = F_N \times \mu_s$$

$$\mu_s = coefficient\ \ of\ \ static\ \ friction$$

Kinetic Friction

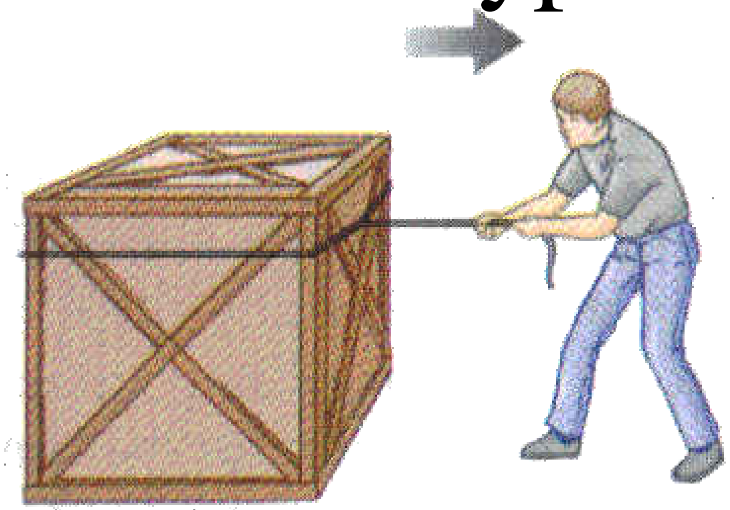
Once the Force of Static Friction is overcome, the Force of Kinetic Friction is what slows down a moving object!



$$f_k = F_N \times \mu_k$$

$$\mu_k = coefficient\ \ of\ \ kinetic\ \ friction$$

Types of Friction



To initiate motion of the box the man must overcome the Force of *Static Friction*

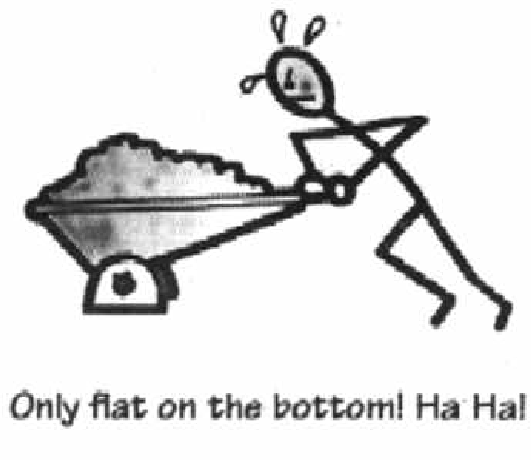
I better be safe Ump!!

Upon sliding, the baseball player will come to a complete stop due to the Force of *Kinetic Friction*

Static & Kinetic Friction Coefficients

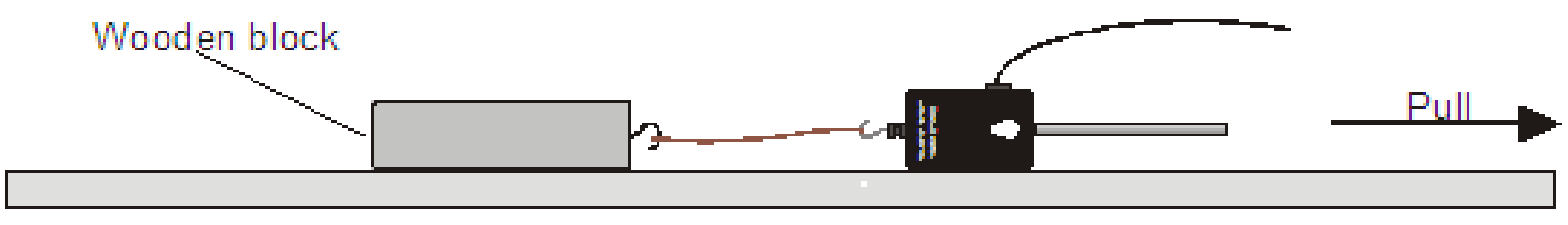
Material	Coefficient of Static Friction μ_S	Coefficient of Kinetic Friction μ_S
Rubber on Glass	2.0+	2.0
Rubber on Concrete	1.0	0.8
Steel on Steel	0.74	0.57
Wood on Wood	0.25 – 0.5	0.2
Metal on Metal	0.15	0.06
Ice on Ice	0.1	0.03
Synovial Joints in Humans	0.01	0.003

Static VS. Kinetic Friction



Static Friction Lab Procedure

- Connect the force detector to a block of wood
- Pull gently on the force sensor unit the block begins to move
- Move the block slowly with constant force



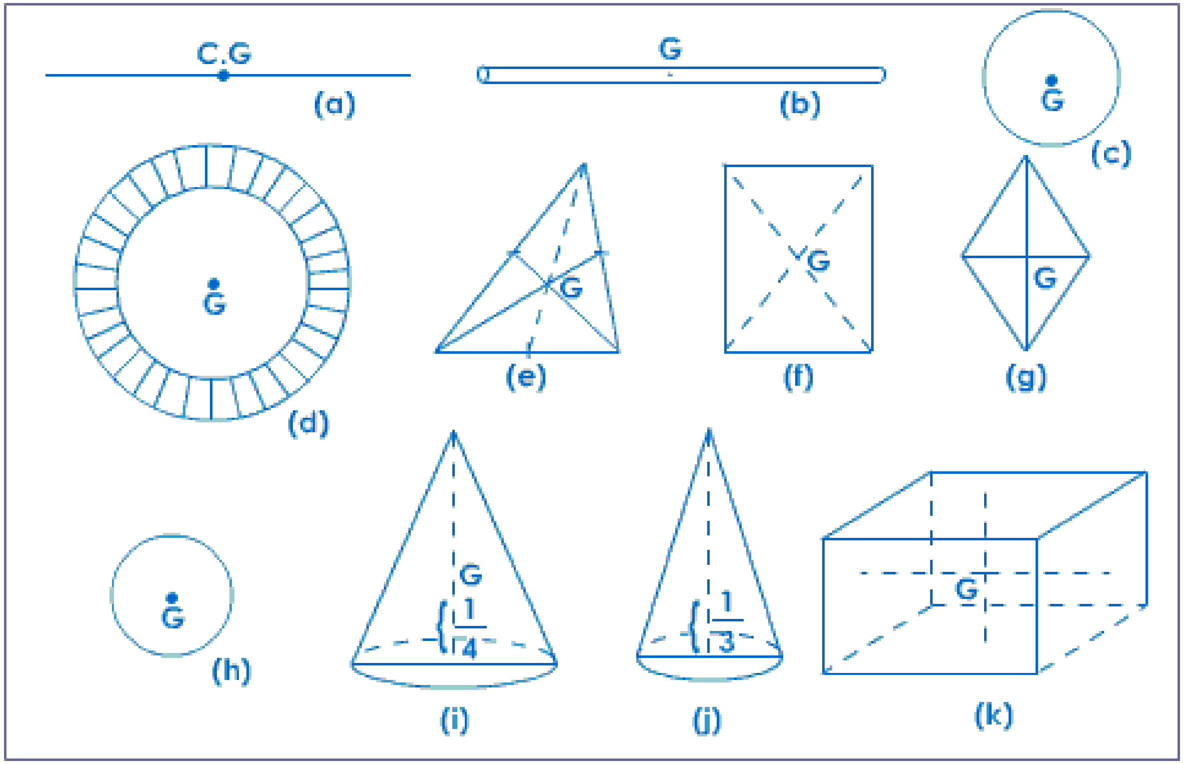
Kinetic Friction Lab Procedure

- Line up the block with the motion detector
- Push the block gently toward the motion detector so that it comes to a stop approximately 1 foot away from it
- From the velocity curve determine the deceleration of the block
- Calculate the Force of Kinetic Friction
- Determine the coefficient of Kinetic Friction

Centroids & the Center of Gravity

Centroids

The centroid of an area is situated at its geometrical centre. In each of the following figures 'G' represents the centroid, and if each area was suspended from this point it would balance.



Center of gravity

The centre of gravity of a body is:

- The point at which all the mass of the body may be assumed to be concentrated.

- The point through which the force of gravity is considered to act vertically downwards, with a force equal to the weight of the body.

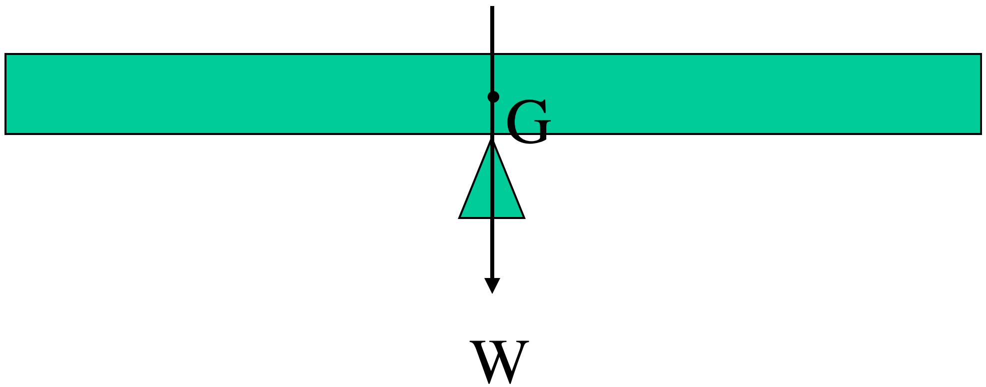
- The point about which the body would balance.

The centre of gravity of a homogeneous body is at its geometrical centre.

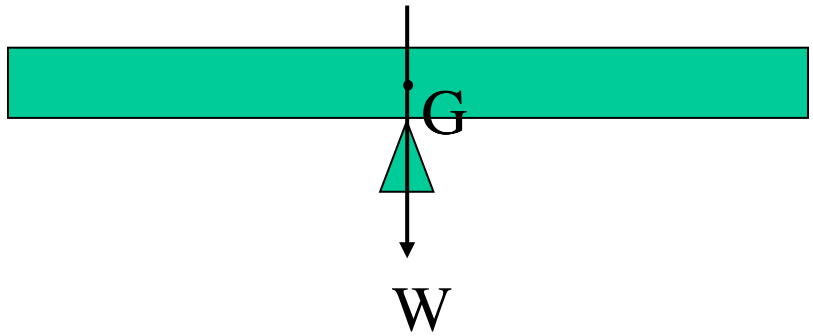
Consider a homo. Block of wood, its center of gravity will be its geometrical center,

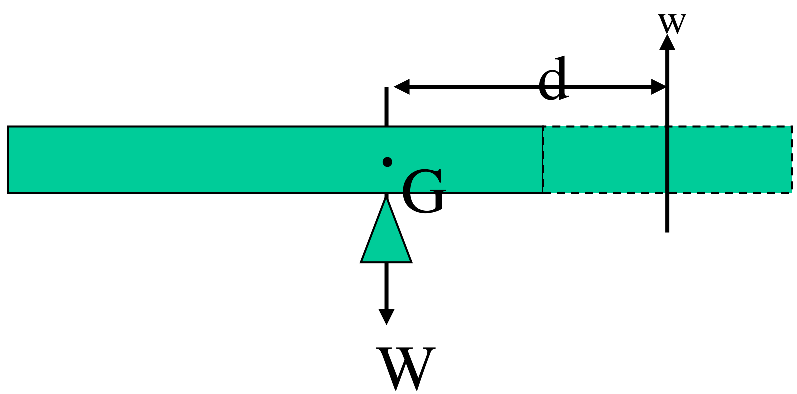
- half way of its length,
- half way of its breadth, and
- half way of its depth

Place a wedge under its C.G, the block will balance

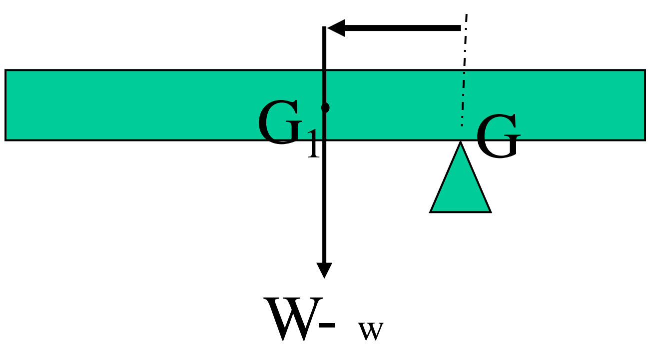


Effect of removing or discharging mass





Moment = w x d



And also moment $= (W - w) \times GG_1$

$w \times d = (W - w) \times GG_1$

$$\text{Moment} = w \times d$$

$$\& \text{ Moment} = (W-w) \times GG_1$$

$$w \times d = (W-w) \times GG_1$$

$$\text{Therefore } GG_1 = \frac{w \times d}{W-w}$$

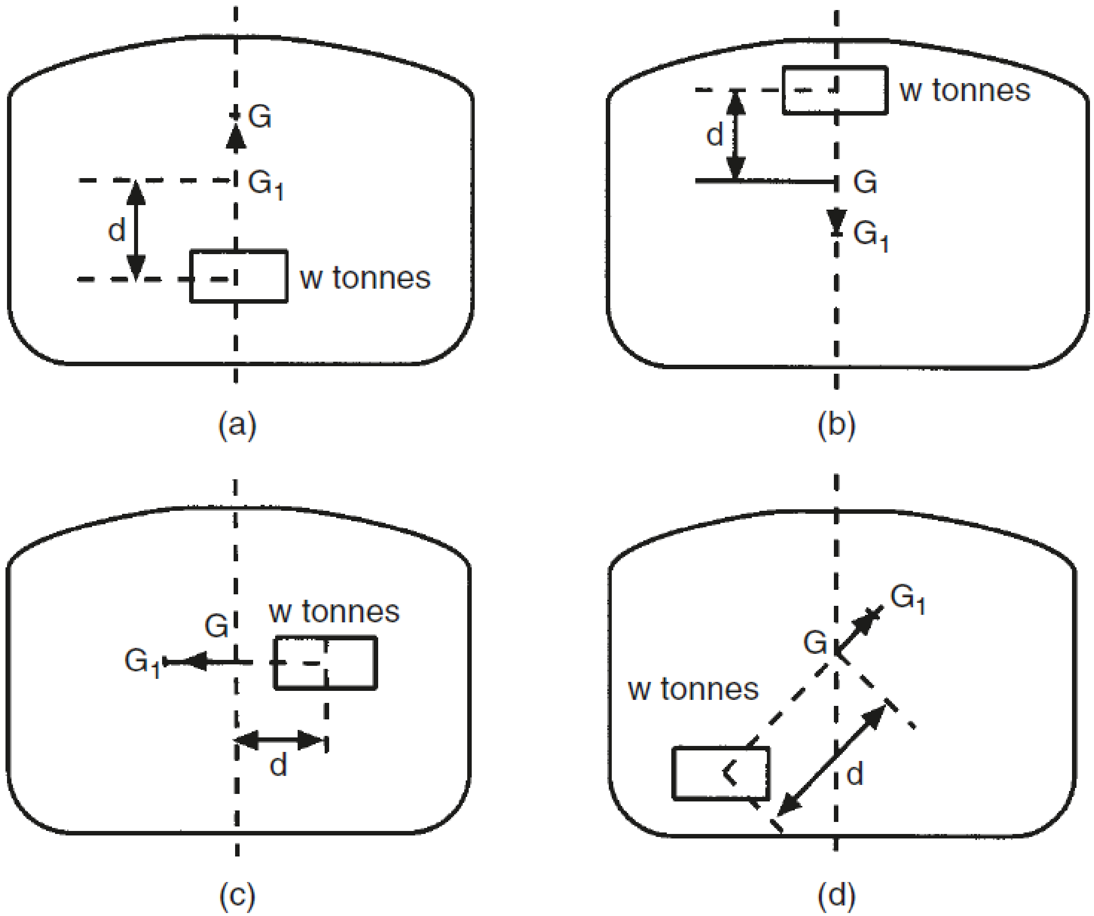
Where, GG_1 is the shift of the C.G of the body

w is the mass removed

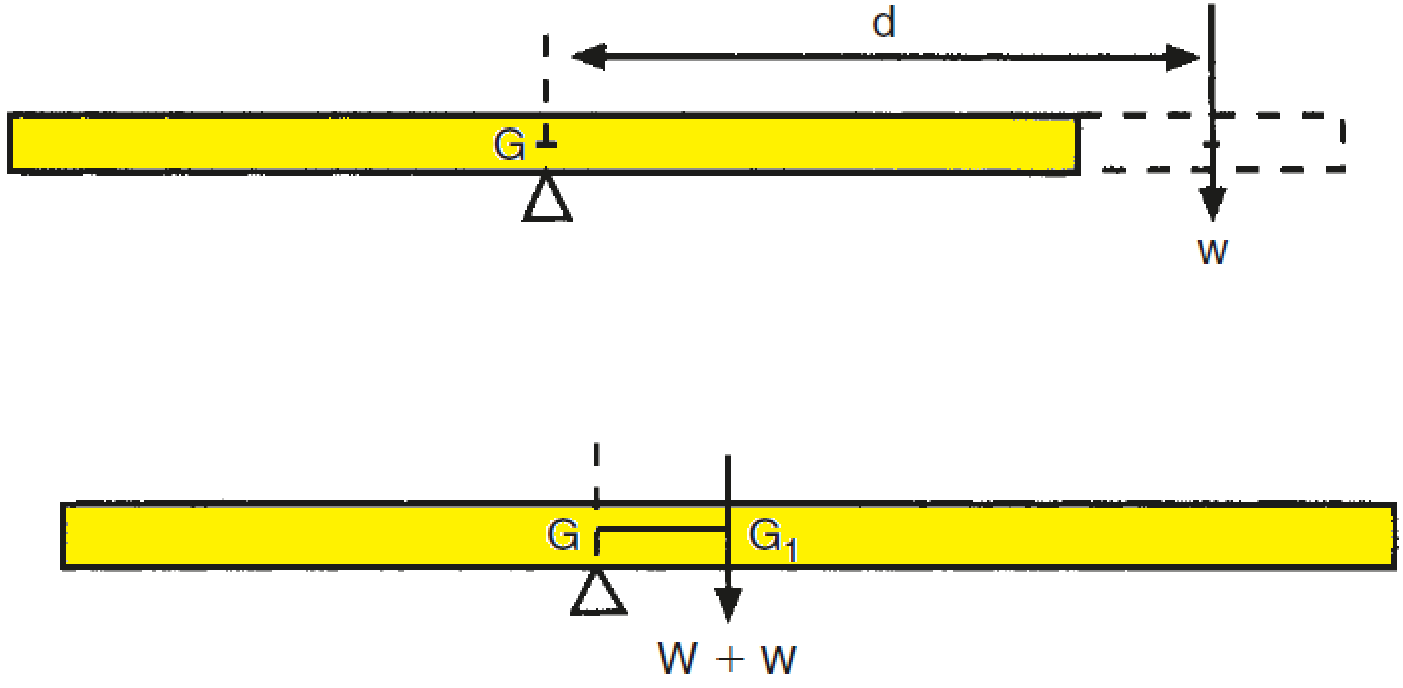
d is the distance between the c.g of the mass removed and the C.G of the body

(W –w) is the final mass

Application to a ship Discharging



$$GG_1 = \frac{w \times d}{W - w}$$



d
G
w
G
G1
W + w

5. No matter where the weight ‘w’ was initially in the ship relative to G, when this weight is moved upwards in the ship, then the ship’s overall G will also be moved upwards to a higher position. Consequently, the ship’s stability will be decreased.

6. The shift of the centre of gravity of the body in each case is given by the formula: where

w is the mass of the weight added, removed or shifted,

W is the final mass of the body, and

d is, in 1 and 2, the distance between the centres of gravity, and in 3, the distance through which the weight is shifted.

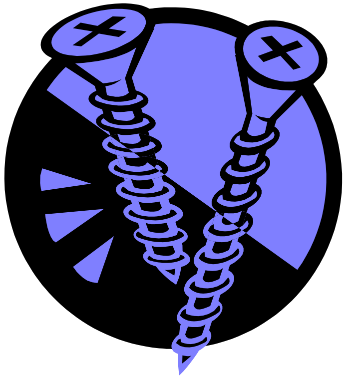
7. When a weight is suspended its centre of gravity is considered to be at the point of suspension.

Simple Machines

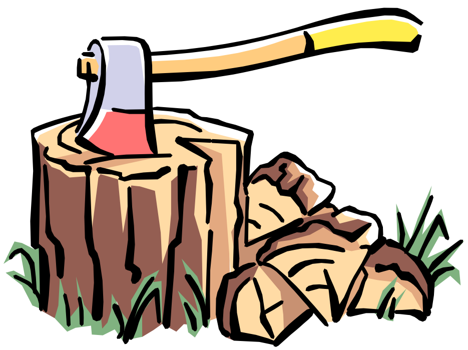
The 6 Simple Machines

Inclined Plane

Screw

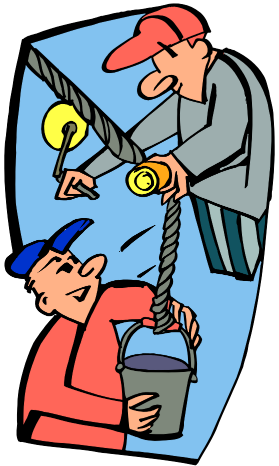


Wedge



Lever

Pulley



Wheel and Axle

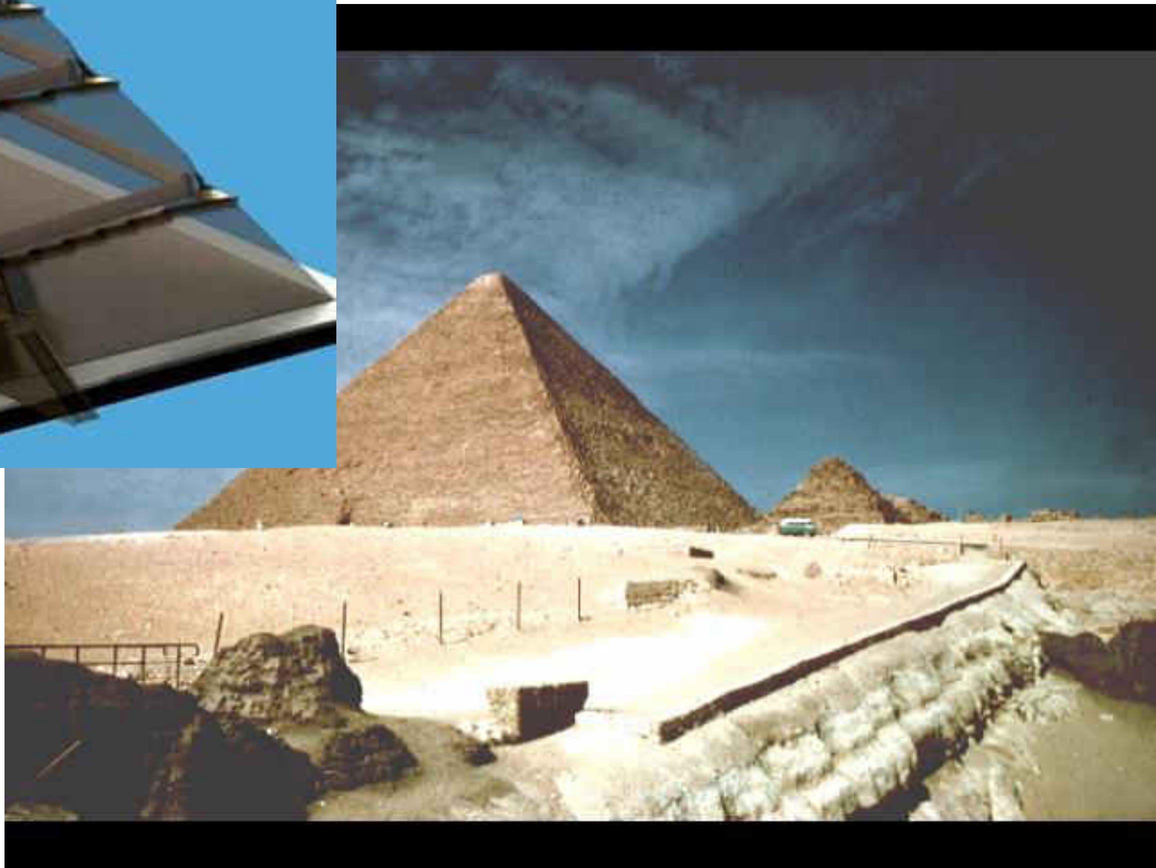
Definitions:

Energy: Ability to do work

Work=Force x Distance

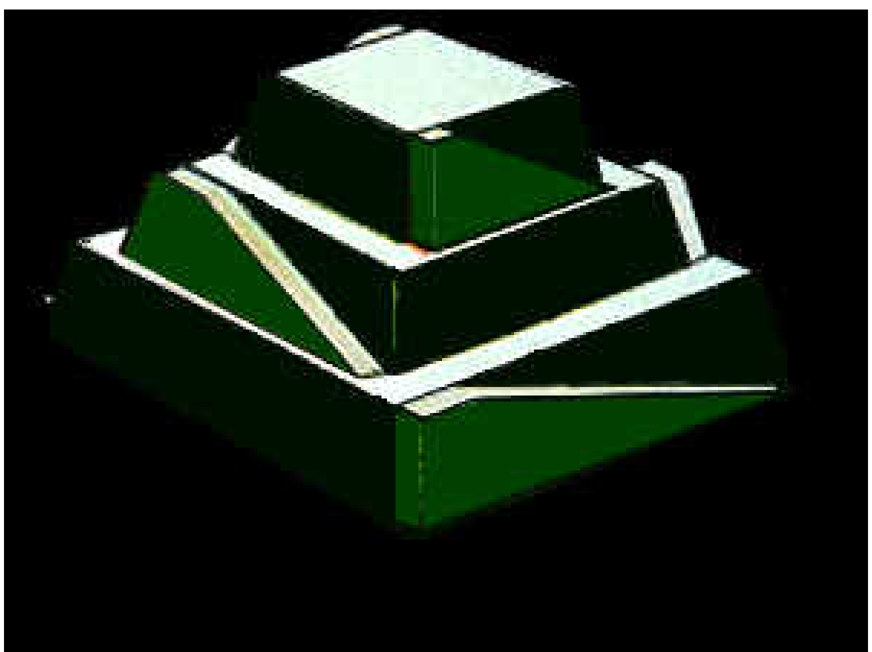
Force: A Push or a Pull

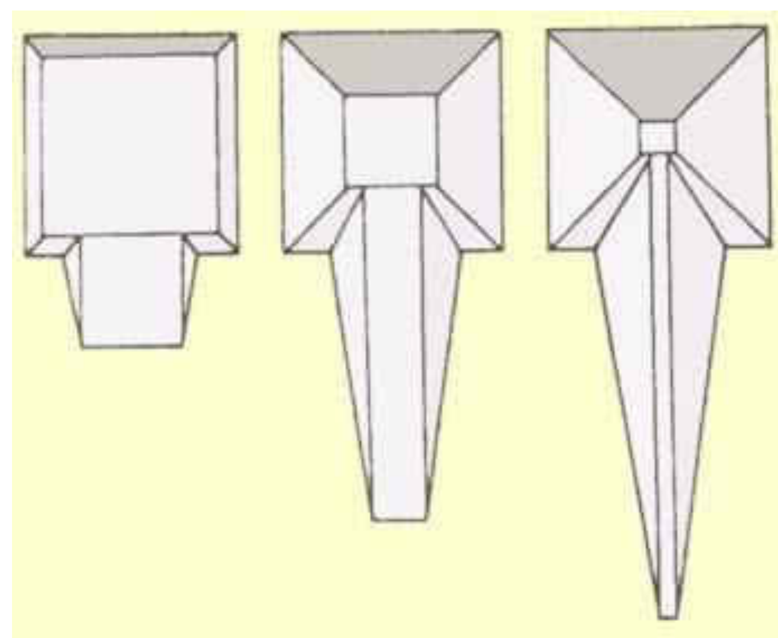
Inclined Plane



Inclined Plane

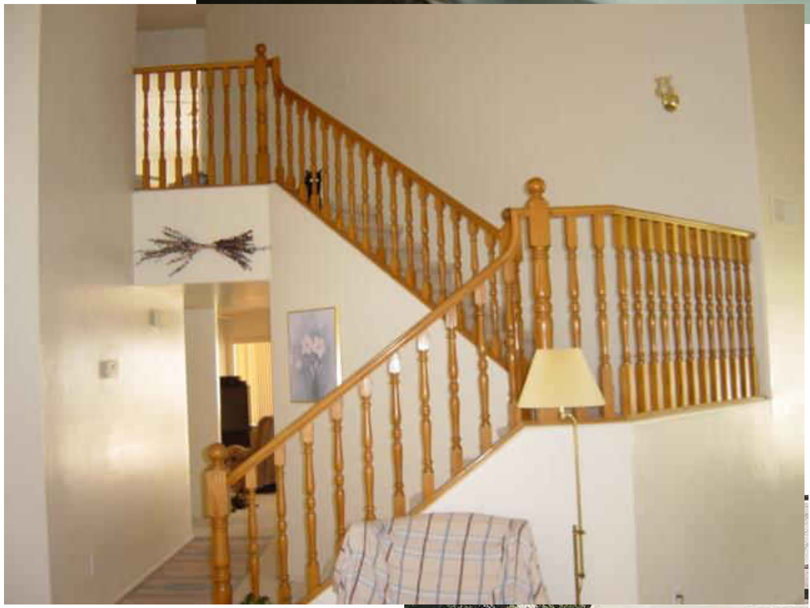
- The Egyptians used simple machines to build the pyramids. One method was to build a very long incline out of dirt that rose upward to the top of the pyramid very gently. The blocks of stone were placed on large logs (another type of simple machine - the wheel and axle) and pushed slowly up the long, gentle inclined plane to the top of the pyramid.





Inclined Pla

- An inclined plane is a flat surface that is higher on one end
- Inclined planes make the work of moving things easier



Work input and output

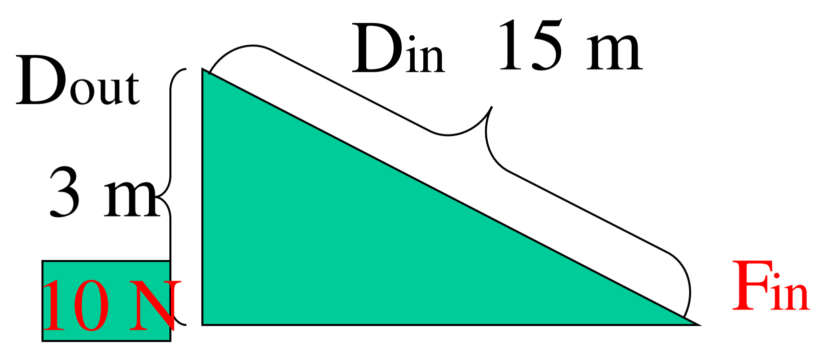
- **Work input is the amount of work done <u>on</u> a machine.**
  - **Input force x input distance**

- **Work output is the amount of work done <u>by</u> a machine.**
  - **Output force x output distance**

$W_{out} = W_{in}$

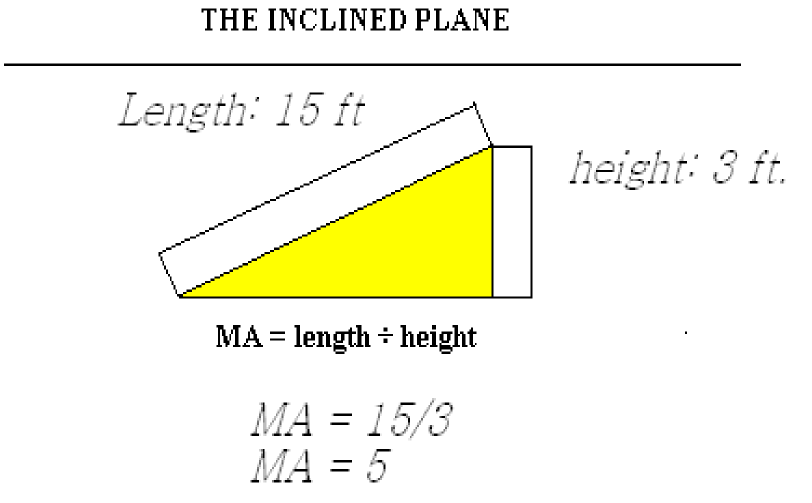
$F_{out} \times D_{out} = F_{in} \times D_{in}$

$10N \times 3m = 2N \times 15m$

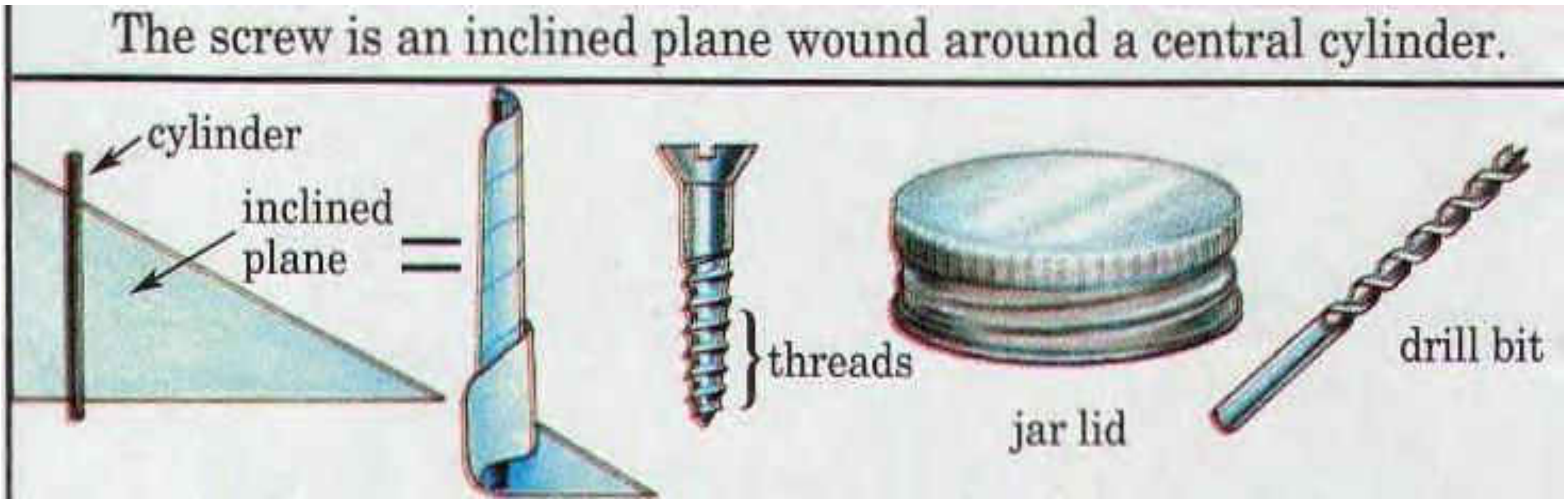


Inclined Plane - Mechanical Advantage

- The mechanical advantage of an inclined plane is equal to the length of the slope divided by the height of the inclined plane.
- While the inclined plane produces a mechanical advantage, it does so by increasing the distance through which the force must move.



Screw



The mechanical advantage of an screw can be calculated by dividing the circumference by the pitch of the screw.

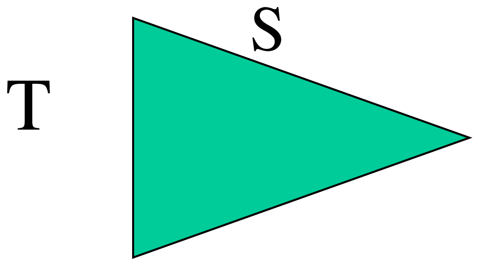
Pitch equals 1/ number of turns per inch.

Wedges

- Two inclined planes joined back to back.
- Wedges are used to split things.

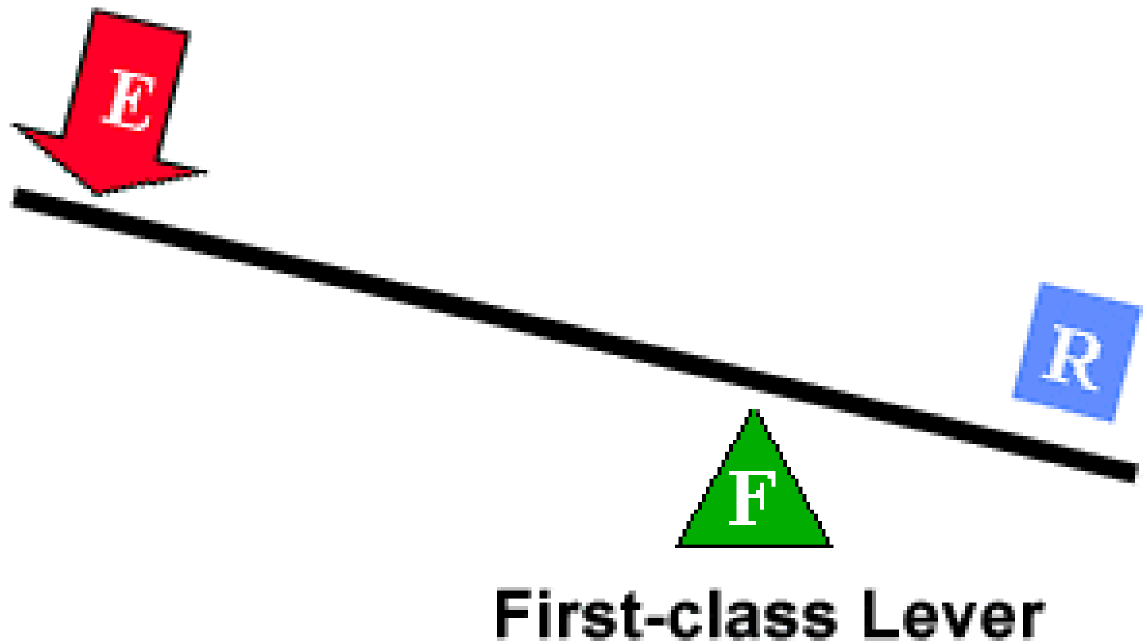
Wedge – Mechanical Advantage

- The mechanical advantage of a wedge can be found by dividing the length of either slope (S) by the thickness (T) of the big end.



- As an example, assume that the length of the slope is 10 inches and the thickness is 4 inches. The mechanical advantage is equal to 10/4 or 2 1/2. As with the inclined plane, the mechanical advantage gained by using a wedge requires a corresponding increase in distance.

First Class Lever



Fulcrum is between EF (effort) and RF (load)
Effort moves farther than Resistance.
Multiplies EF and changes its direction

The mechanical advantage of a lever is the ratio of the length of the lever on the applied force side of the fulcrum to the length of the lever on the resistance force side of the fulcrum.

First Class Lever

-
  - Common examples of first-class levers include crowbars, scissors, pliers, tin snips and seesaws.

Second Class Lever

RF (load) is between fulcrum and EF

Effort moves farther than Resistance.

Multiplies EF, but does not change its direction

The mechanical advantage of a lever is the ratio of the distance from the applied force to the fulcrum to the distance from the resistance force to the fulcrum.

Second Class Lever

- Examples of second-class levers include nut crackers, wheel barrows, doors, and bottle openers.

Third Class Lever

Does not multiply force

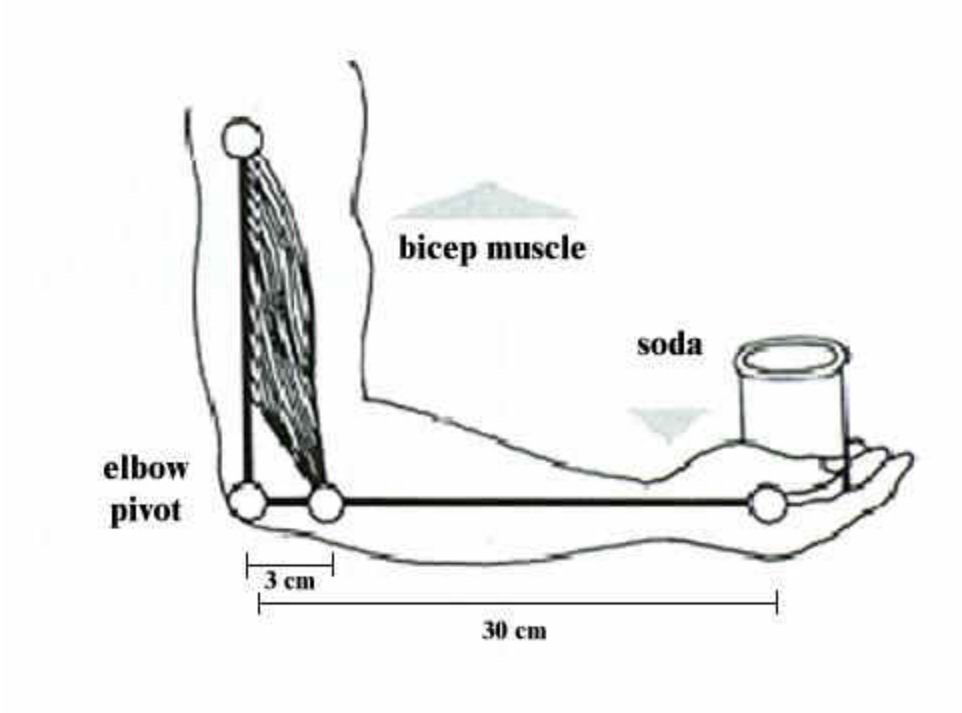
Resistance moves farther than Effort.

Multiplies the distance the effort force travels

The mechanical advantage of a lever is the ratio of the distance from the applied force to the fulcrum to the distance of the resistance force to the fulcrum

Third Class Lever

- Examples of third-class levers include tweezers, arm hammers, and shovels.

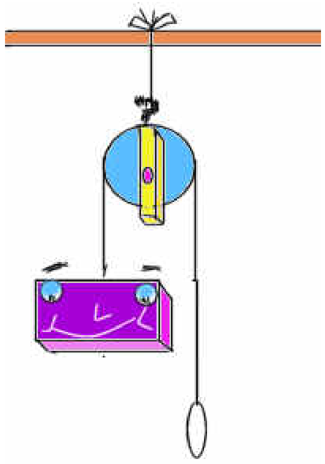


Pulleys

- Pulley are wheels and axles with a groove around the outside
- A pulley needs a rope, chain or belt around the groove to make it do work

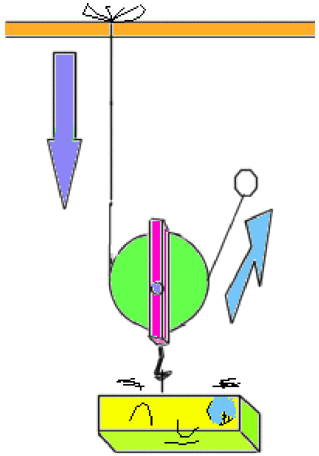
Diagrams of Pulleys

Fixed pulley:



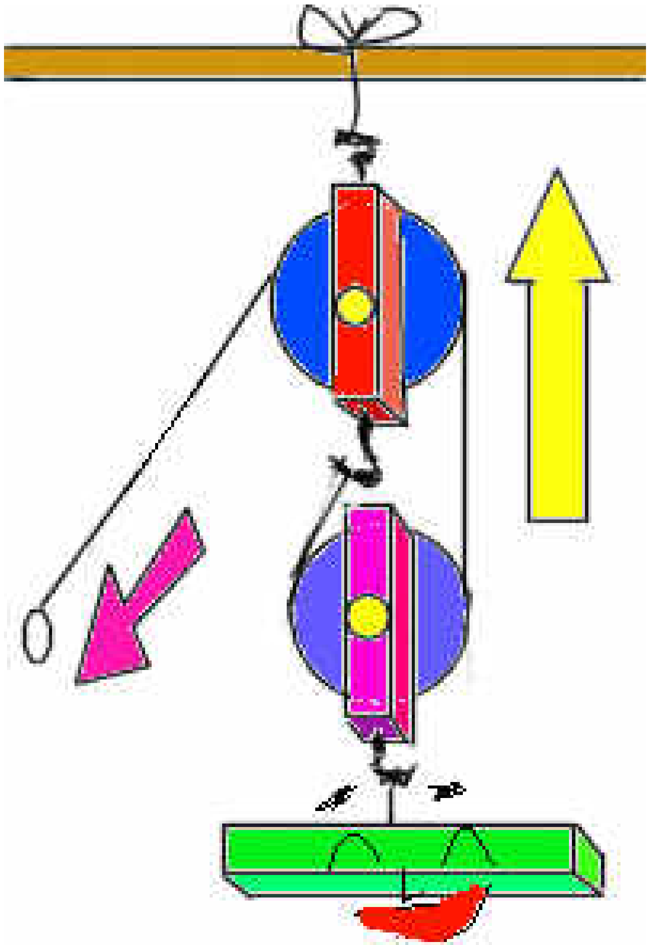
A fixed pulley changes the direction of a force; however, it does not create a mechanical advantage.

Movable Pulley:



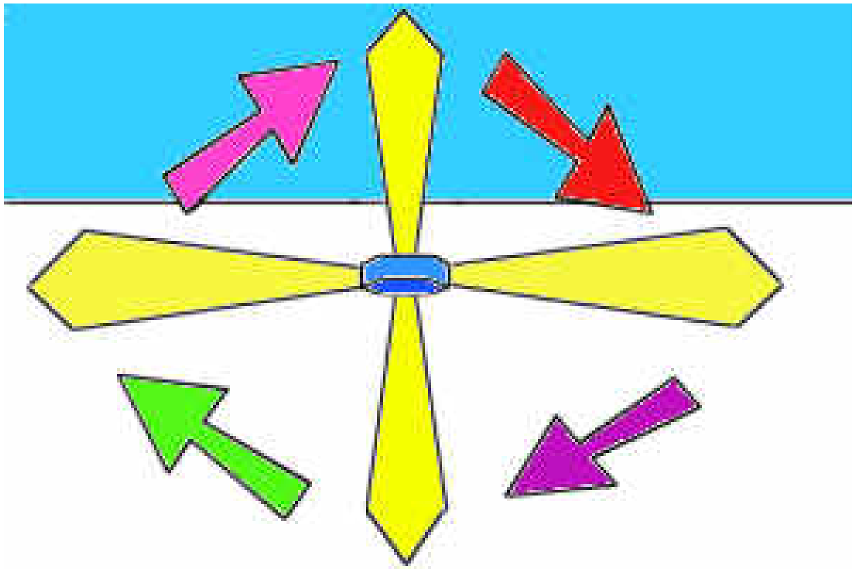
The mechanical advantage of a moveable pulley is equal to the number of ropes that support the moveable pulley.

COMBINED PULLEY



- The effort needed to lift the load is less than half the weight of the load.
- **The main disadvantage is it travels a very long distance.**

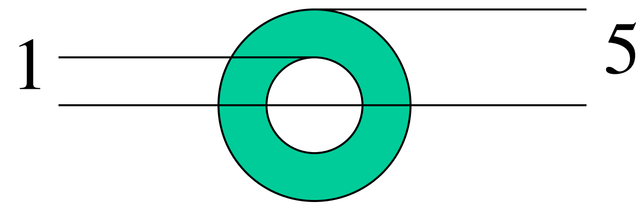
WHEEL AND AXEL



- The axle is stuck rigidly to a large wheel. Fan blades are attached to the wheel. When the axel turns, the fan blades spin.

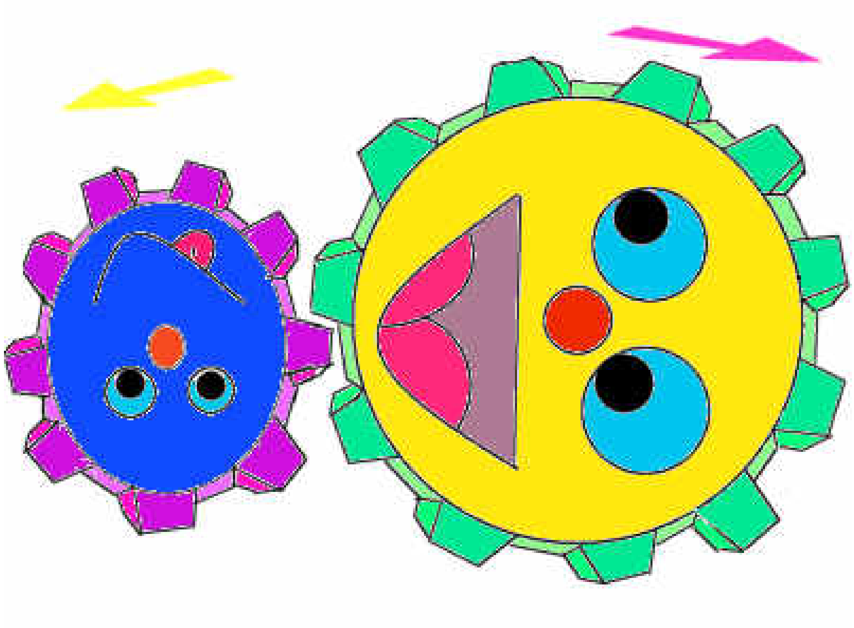
Wheel and Axel

- The mechanical advantage of a wheel and axle is the ratio of the radius of the wheel to the radius of the axle.



- In the wheel and axle illustrated above, the radius of the wheel is five times larger than the radius of the axle. Therefore, the mechanical advantage is 5:1 or 5.
- The wheel and axle can also increase speed by applying the input force to the axle rather than a wheel. This increase is computed like mechanical advantage. This combination would increase the speed 5 times.

GEARS-Wheel and Axel



- **Each gear in a series reverses the direction of rotation of the previous gear. The smaller gear will always turn faster than the larger gear.**

Thank You

Government Polytechnic Nanakpur

DEPARTMENT OF MECHANICAL ENGINEERING

E - NOTES

ENGINEERING GRAPHICS

HOD/O.I (Mechanical) : **Er. SHALANDER MOR**

Subject Teacher: Er. Amit Kumar

Semester: 1st Year

By: Er. Amit Kumar
Designed, Mechanical Editing & Developmental Editing

LEARNING OUTCOMES

After undergoing the subject, the students will be able to:

Identify and use of different grades of pencils and other drafting instruments which are used in engineering field

Draw free hand sketches of various kinds of objects.

Utilize various types of lines used in engineering drawing.

Read and apply different dimensioning methods on drawing of objects.

Draw 2 - dimensional view of different objects viewed from different angles (orthographic views)

Draw and interpret complete inner hidden details of an object which are otherwise not visible in normal view

Generate isometric (3D) drawing from different 2D (orthographic) views/sketches

Identify conventions for different engineering materials, symbols, sections of regular objects and general fittings used in Civil and Electrical household appliances

·Use AutoCAD or other drafting software for making fast engineering drawings and

even animating the assembly drawings.

Introduction to Engineering Drawing

&

Common Symbols and conventions used in Engineering

Drawing

Describing any object/ information diagrammatically

Engineering Drawing

Graphical means of expression of technical details without the barrier of a language.

Universal language for engineers

Diagrams/sketches/pictures - communication skills

- We grasp information easily if it is illustrated with diagrams, sketches, pictures, etc.

LCA - the world's smallest, light weight, multi-role supersonic combat aircraft of the world

Source: http://img.stern.de/_content/53/96/539645/A380_500_artikel_500.jpg

AIRBUS A380

Details: largest passenger jet. 80m wingspan and a tail that stands as high as a seven-storey building, carries more than 550 passengers.

It would just be impossible to communicate all necessary details about the LCA/ Airbus A380 verbally or in writing – Illustration (picture/drawing) is useful.

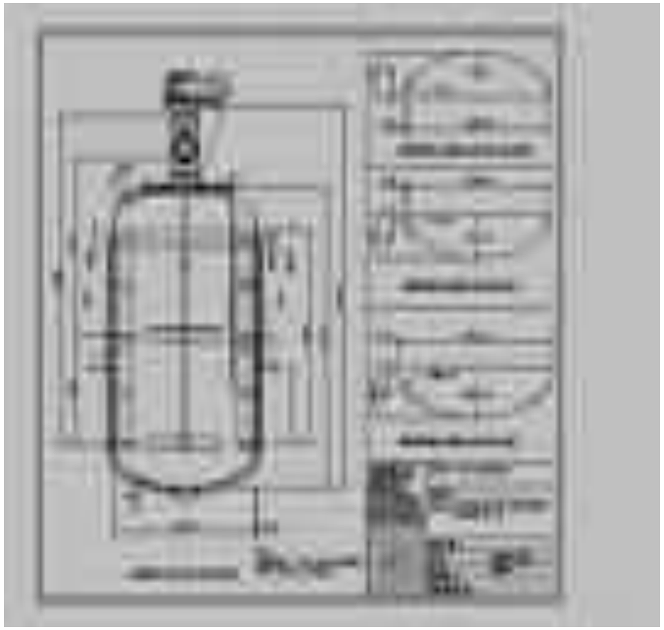
- A picture/drawing is worth a thousand words.

- The LCA/Airbus A380 would be impossible to create without computer graphics and drawing models.

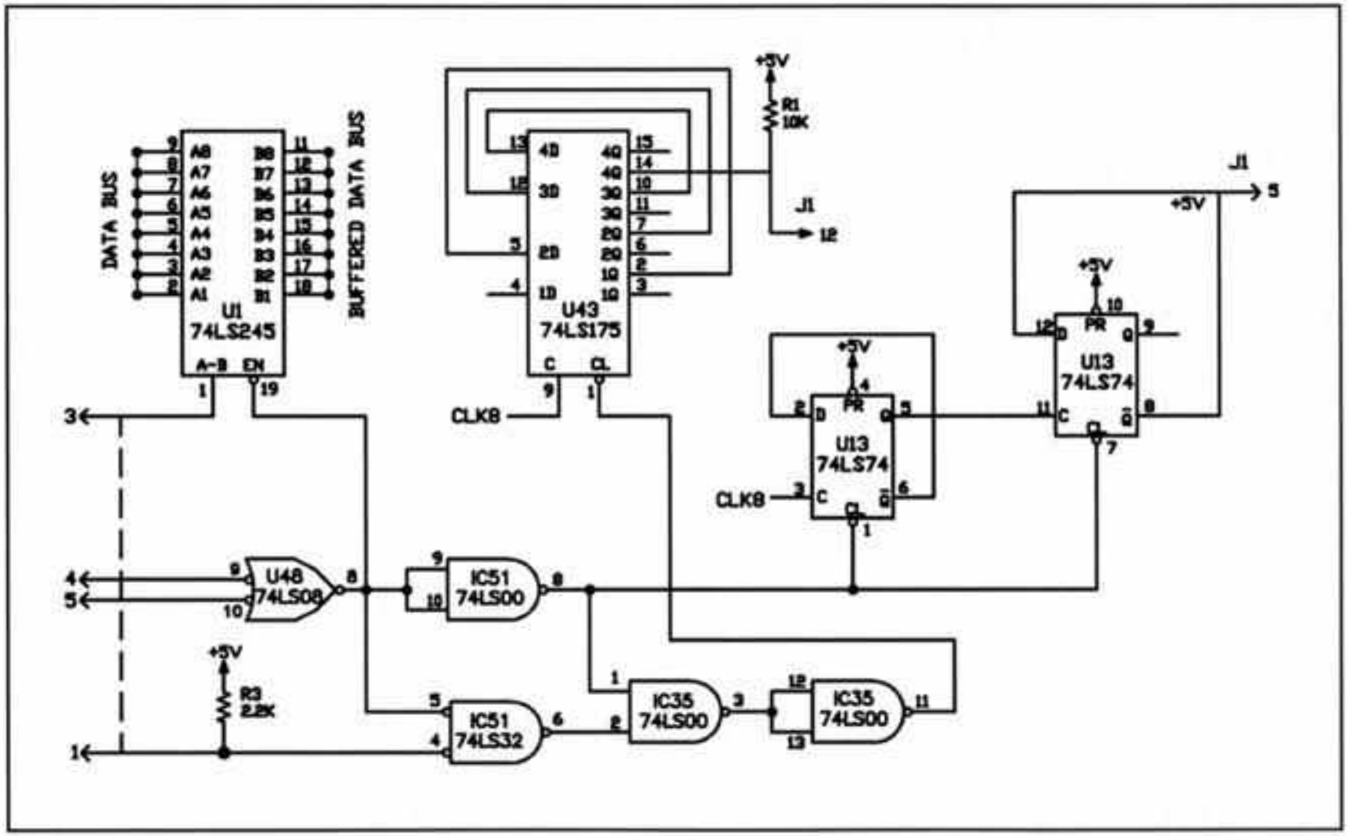
- Drawings are the road maps which show how to manufacture products and structures.

Impossible to describe the details of the building

Difficult to describe the details of the machine



Chemical reactor



Electrical circuit

Drawing is important for all branches of engineering.

Graphical representation of an object – **Drawing**

- **Engineering drawing** – A drawing of an object that contains all information

-like **actual shape**, accurate size,**manufacturing methods**, etc., required for its construction.

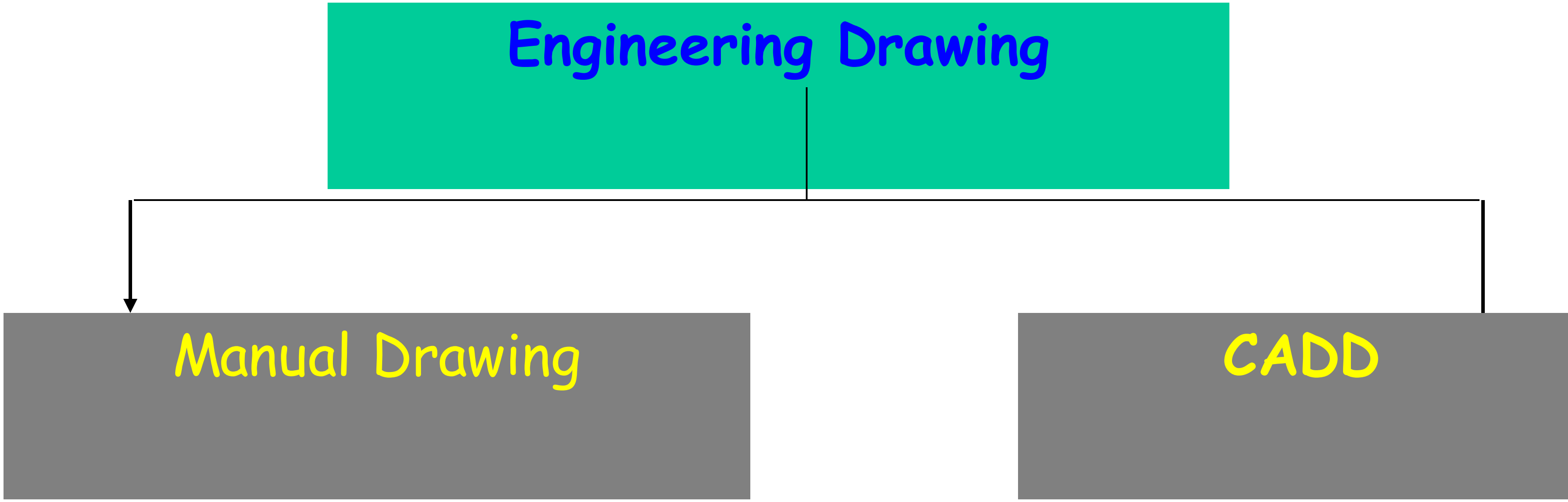
-No construction/manufacturing of any (man - made) engineering objects is possible without engineering drawing.

What will you learn in this course?

You will learn - How industry communicates technical information.

- Visualization – the ability to mentally control visual information.
- **Graphics theory** – geometry and projection techniques.
- Standards – set of rules that govern how parts are made and technical drawings are represented.
- **Conventions** – commonly accepted practices and methods used for technical drawings.
- **Tools** – devices used to create technical drawings and models.
- Applications – the various uses for technical drawings.

Engineering drawing is completely different from artistic drawing, which are used to express aesthetic, philosophical, and abstract ideas.



Computer has a major impact on the methods used to design and create technical drawings.

Design and drafting on computer are cheap and less time consuming.

Why we go for manual drawing?

Why we go for manual drawing?

Computer cannot replace the drafting board and equipment as a learning tool.

Once you have learned the basics of mathematics, now after class 12, you are allowed the use of calculator and computer.

If basic fundamentals are clear, better use can be made of the power of the software.

To be an expert in technical drawing, this first course on Engineering (manual) Drawing is the first step.

Items required for drawing Items required for drawing

Drawing board

Drawing sheet

Mini-drafter/drafting machine/ T- sqaure

Instrument box containing compass, divider, etc.

Scales

Protractor

French curves

Drawing pencils

Eraser

Drawing clip/pin/adhesive tape

Sharpener

Duster

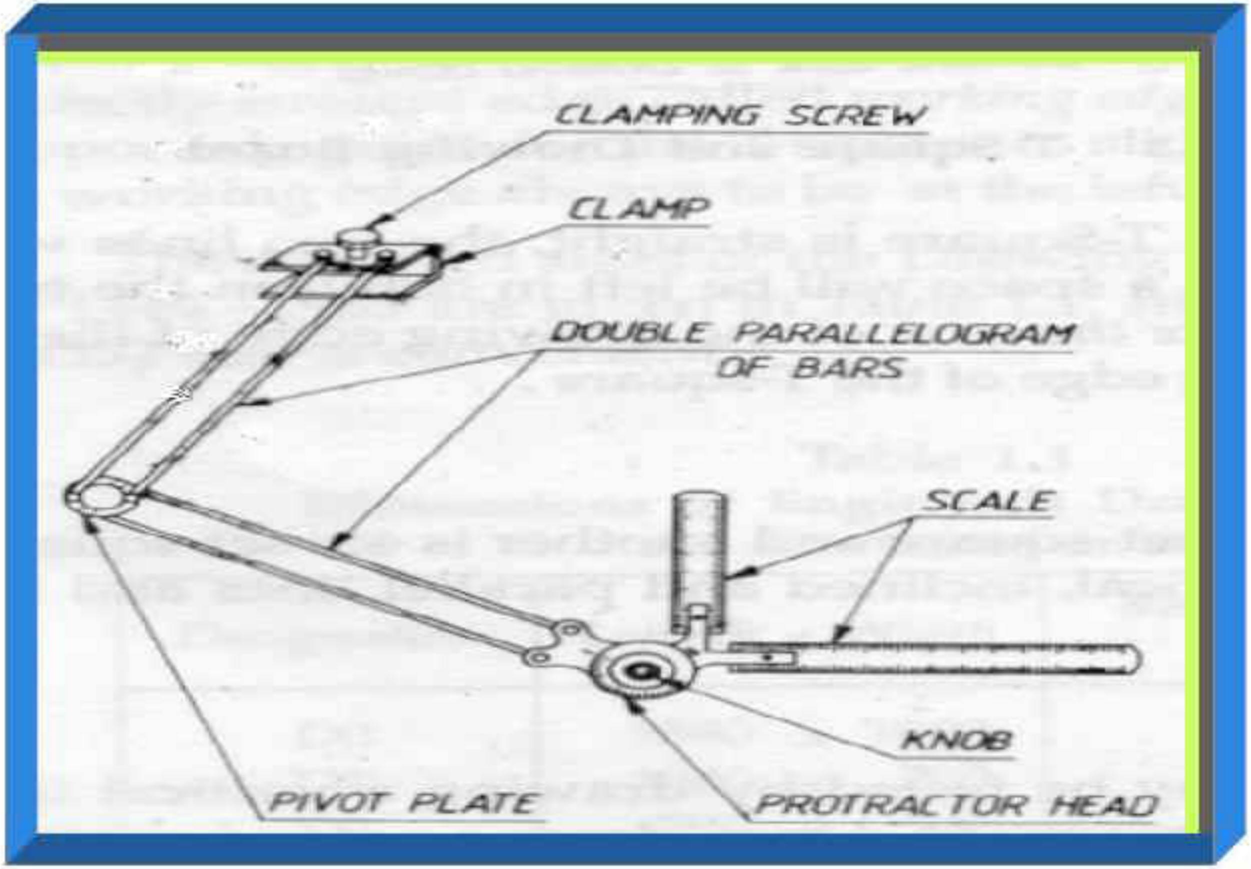
Working edge

Drawing board must be placed on the table with working edge always to be at the left side.

TABLE 1-1
SIZES OF DRAWING BOARDS

Designation	Size (mm)
B0	1000 × 1500
B1	700 × 1000
B2	500 × 700
B3	350 × 500

Last two sizes are normally used for student drawing



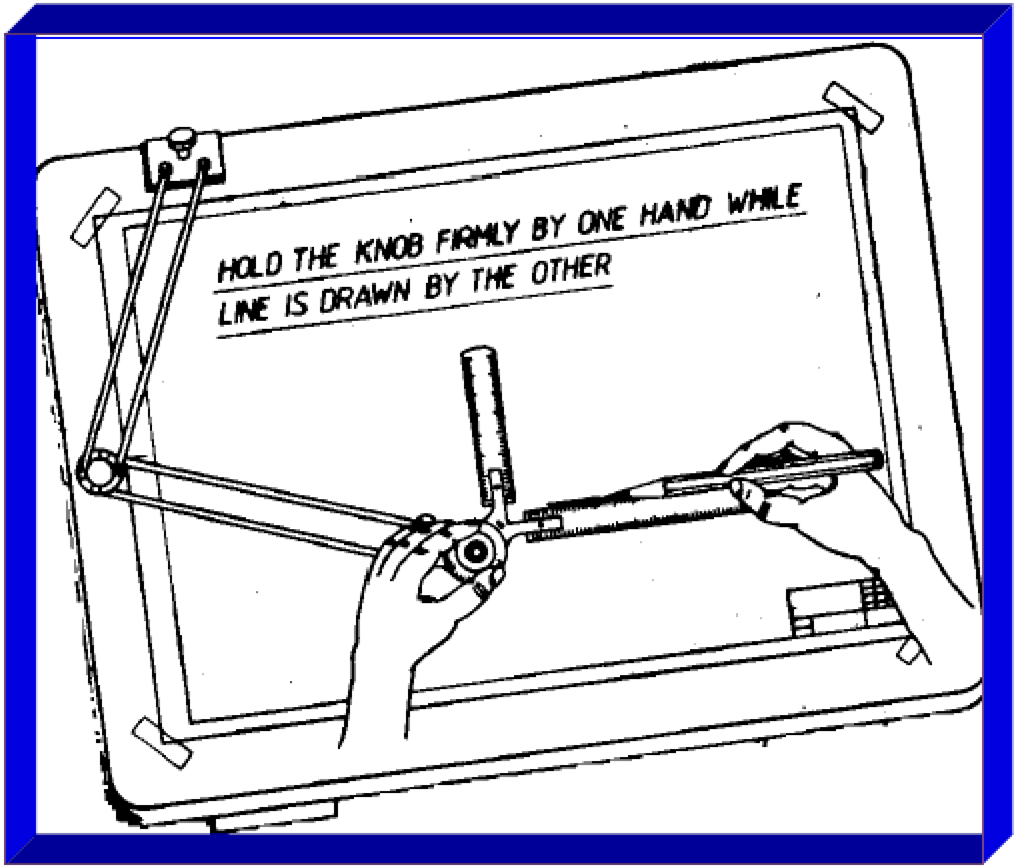
Mini-drafter – a miniature version of the drafting machine

Mini-drafter fixed on drawing board

Clamping mini drafter

Set the protractor head with reference mark indexing zero degree.

Fix the clamp of the mini-drafter at the top left corner either along the top horizontal edge of the board or along the left vertical edge of the board.



….contd

Clamping mini drafter….. contd

- Place the drawing sheet underneath the scales of the mini-drafter,
- Fix the drawing sheet to the drawing board with the scales of the mini-drafter aligned either with the vertical or the horizontal borderlines of the drawing sheet.

Another tool…

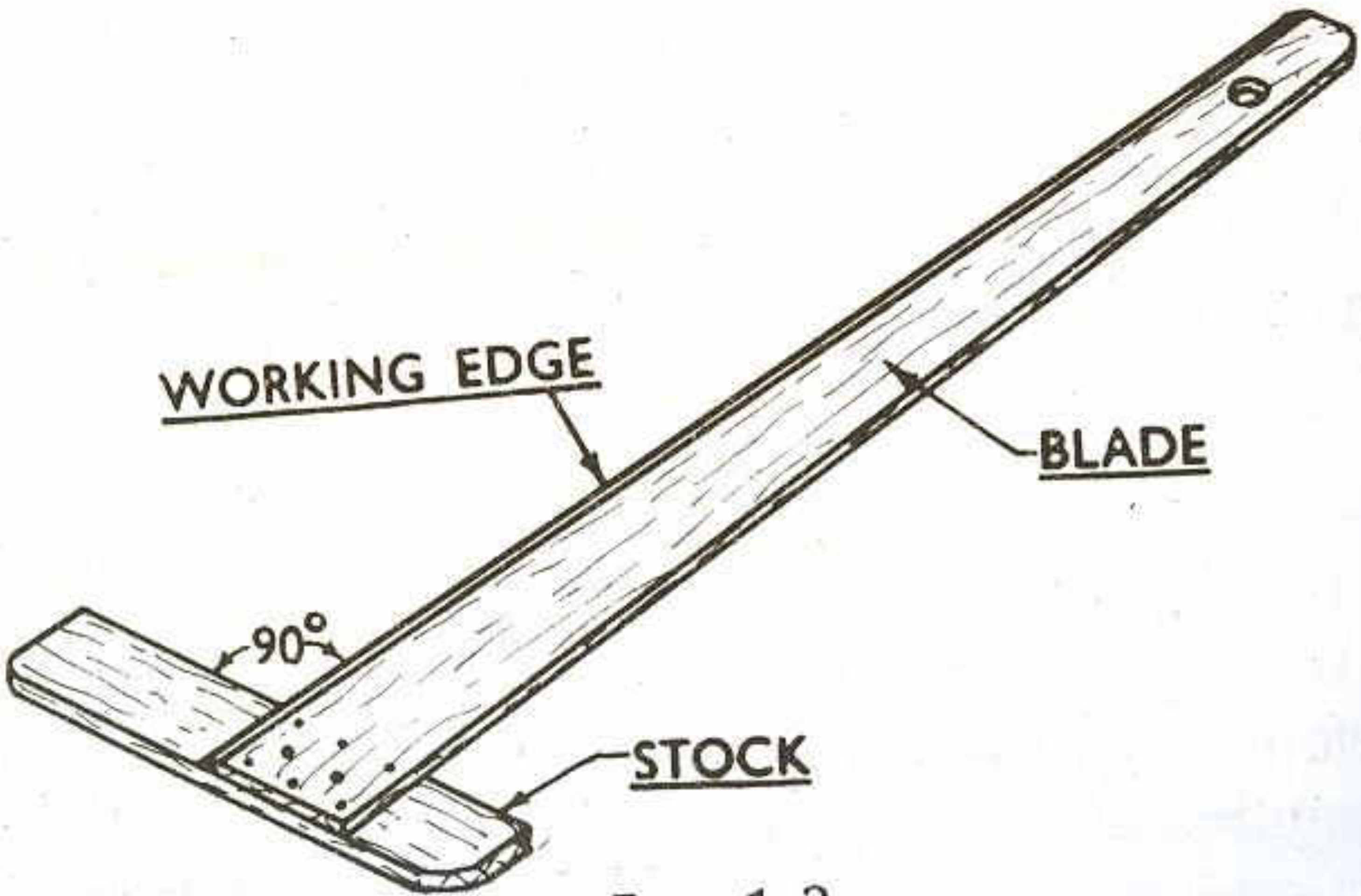
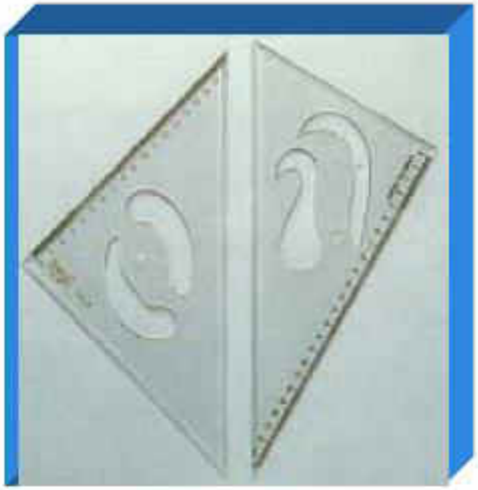
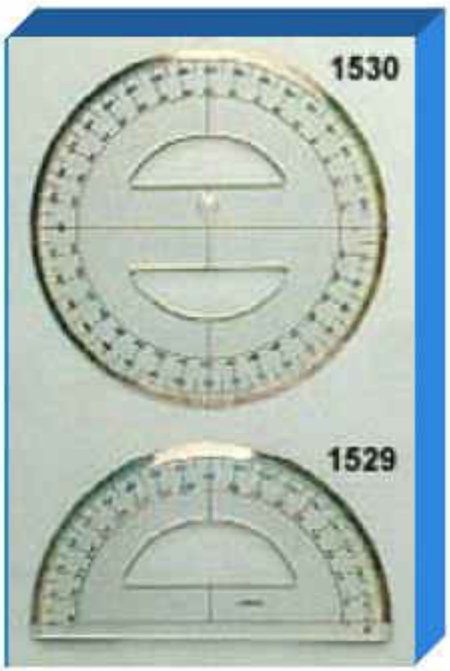


FIG. 1-2

T- square





Some drawing instruments

Standard sizes of drawing sheets as per BIS

Designation	Trimmed Size (mm)	Untrimmed size (mm)
A0	841 x 1189	880 x 1230
A1	594 x 841	625 x 880
A2	420 x 594	450 x 625
A3	297 x 420	330 x 450
A4	210 x 297	240 x 330

A2 size

Layout of drawing sheets

- Standard form of arrangement
- Important particulars are included
- Facilitate quick reading of important particulars – quick references are located easily – **drawings are prepared at various locations and shared**

Grids along the horizontal edges – Numerals

- Grids along vertical edges – Capital letters
- 25 mm < Length of the grid < 75 mm
-

Numbering and lettering start from the corner of

the sheet opposite to the title box and are repeated on the opposite sides

Numbers and letters are written upright

- Repetition of letters or numbers like AA, BB, etc.,

if they exceed that of the alphabets.

Borders – space left all around in between the

trimmed edges of the sheet- A minimum of 10 mm

Grid reference system –

For all sizes of drawing sheets for easy location of drawing within the frame. The length and the width of the frames are divided into even number of divisions.

Number of divisions for a particular sheet depends on complexity of the drawing – Not to be followed in this course.

Title box – An important feature – a must in every drawing sheet – for technical and administrative details

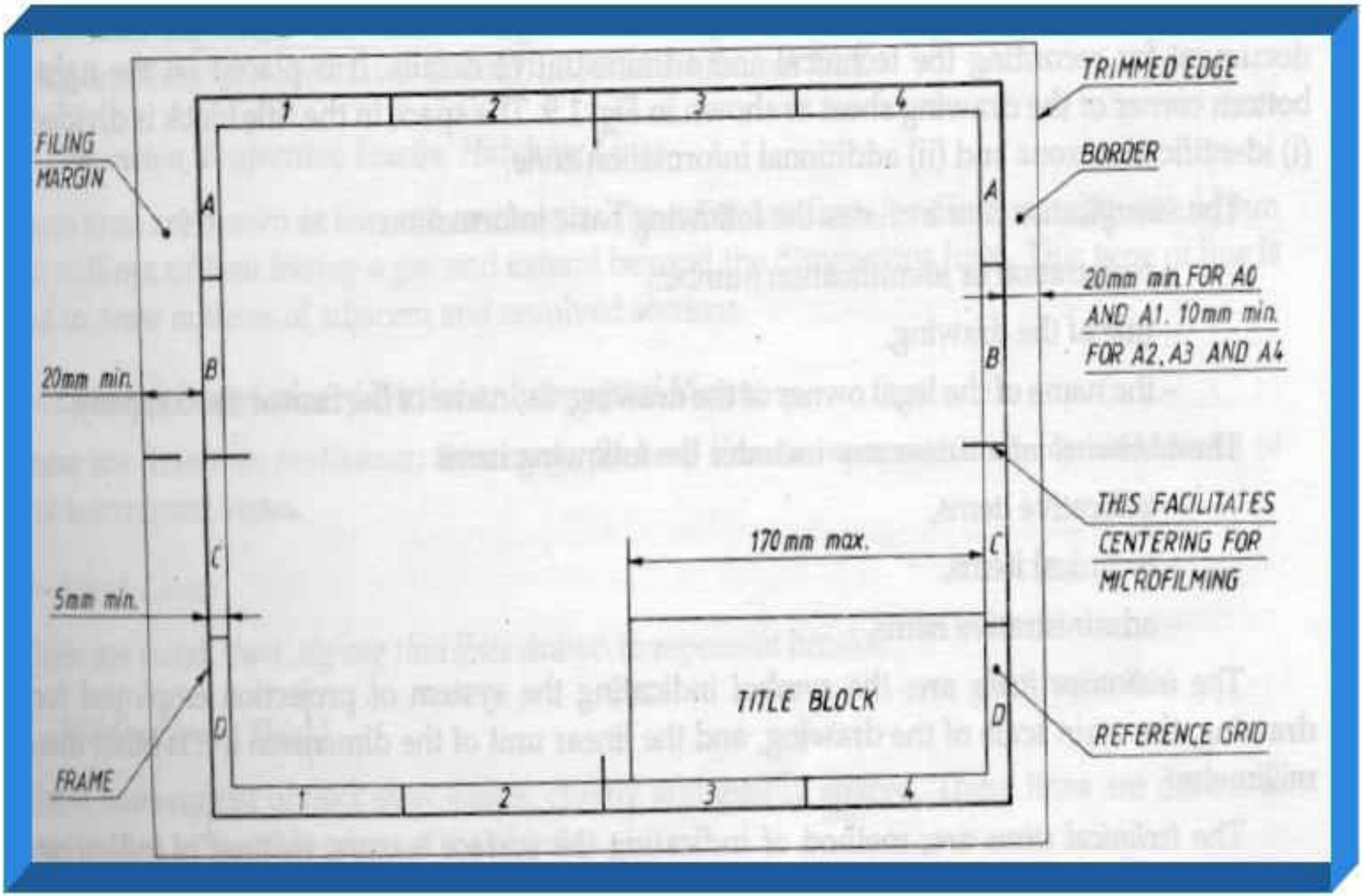
- Location - Bottom right corner – **185 mm x 65 mm (BIS)**
- **Divided into two zones**
- **Identification zone**
- Registration or identification number
- Drawing title
- Name of the legal owner of the drawing, i.e., name of the firm or the company

Contd…

Title box….. contd

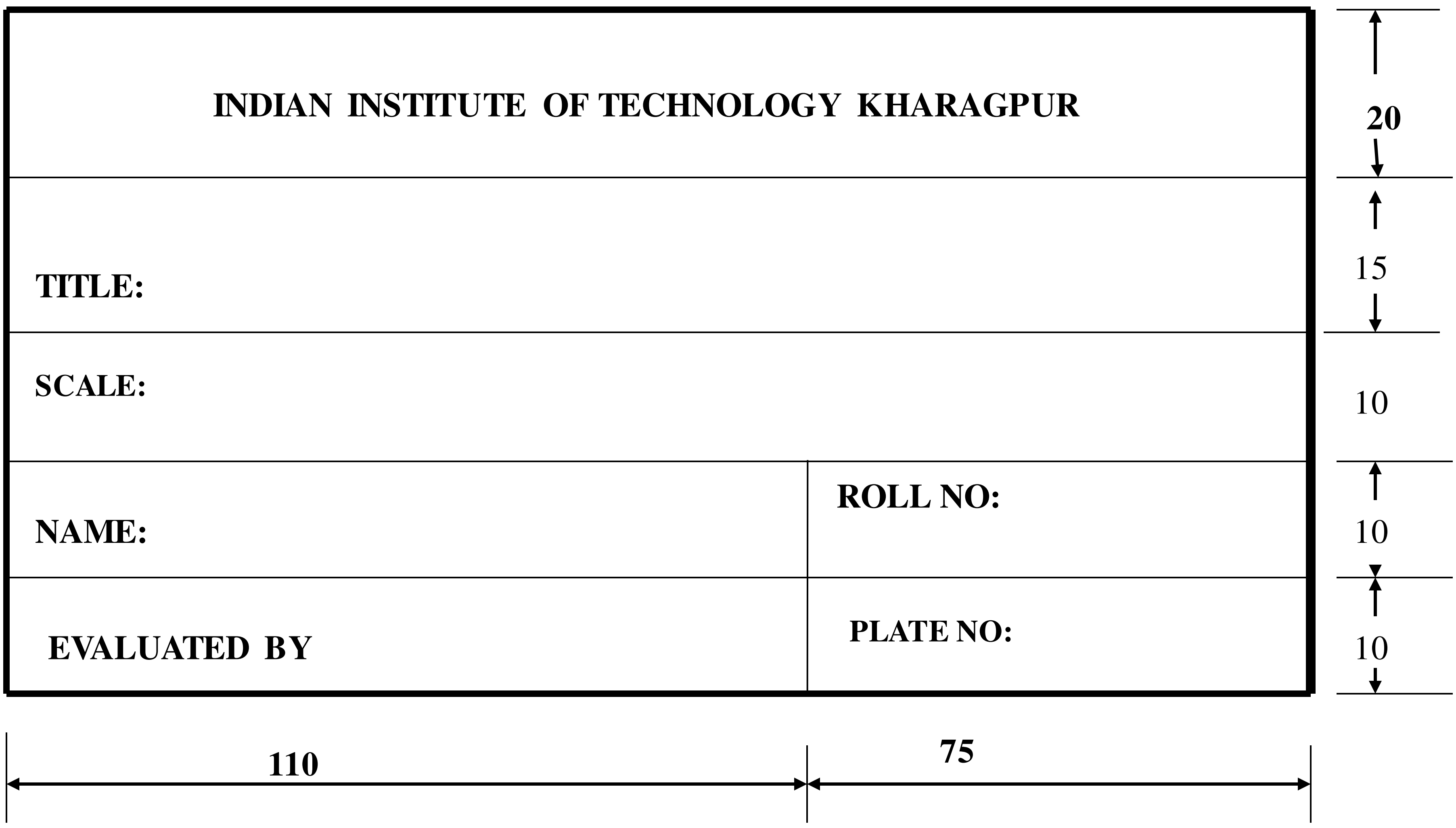
Additional information zone

- Indicative items –symbol indicating the system of projection, main scale of drawing, etc.
- Technical items – method of indicating surface texture, geometric tolerances, etc.
- Administrative items



Lay out of a drawing sheet

Layout of the title box to be adopted in this course



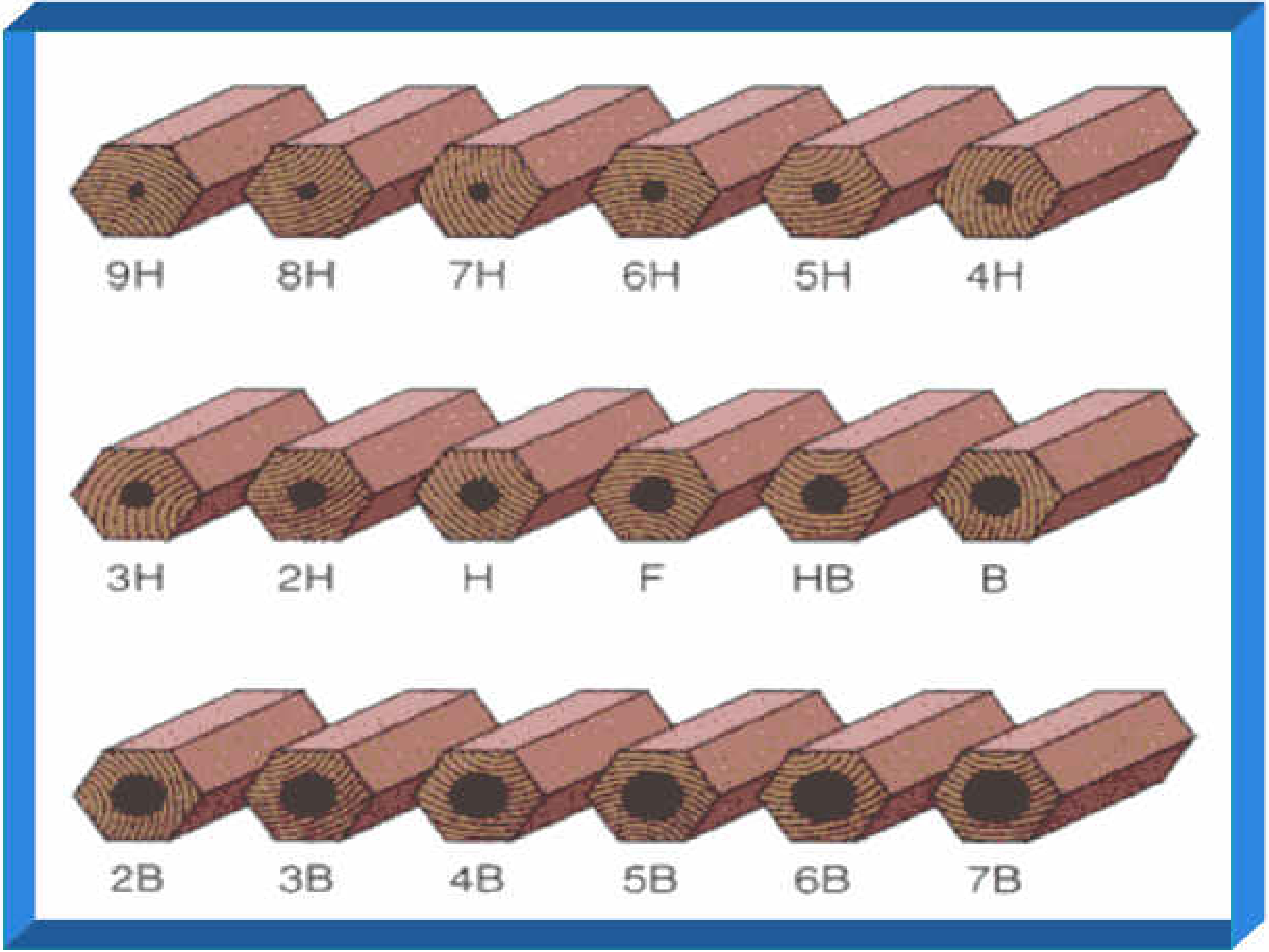
Drawing Pencils

Wooden pencils – are graded and designated by numbers and letters

Mechanical clutch pencils – **Not allowed**

- 7B, 6B, 5B, 4B, 3B, 2B, B - in decreasing order of softness and blackness
- **HB** to F – Medium grade
- **H, 2H,** 3H, 4H, 5H, 6H, 7H, 8H, 9H – increasing order of hardness.

Drawings are done using 2H pencils and finished with H and HB pencils – to be practiced in this course.



Grades and designation of wooden pencils

Pencil drawing –

In finished drawing, all lines (except construction lines- used to construct the drawing) should be dense, clean and uniform.

Construction line should be drawn very thin and should be hardly visible in the finished drawing **(they should not be erased).**

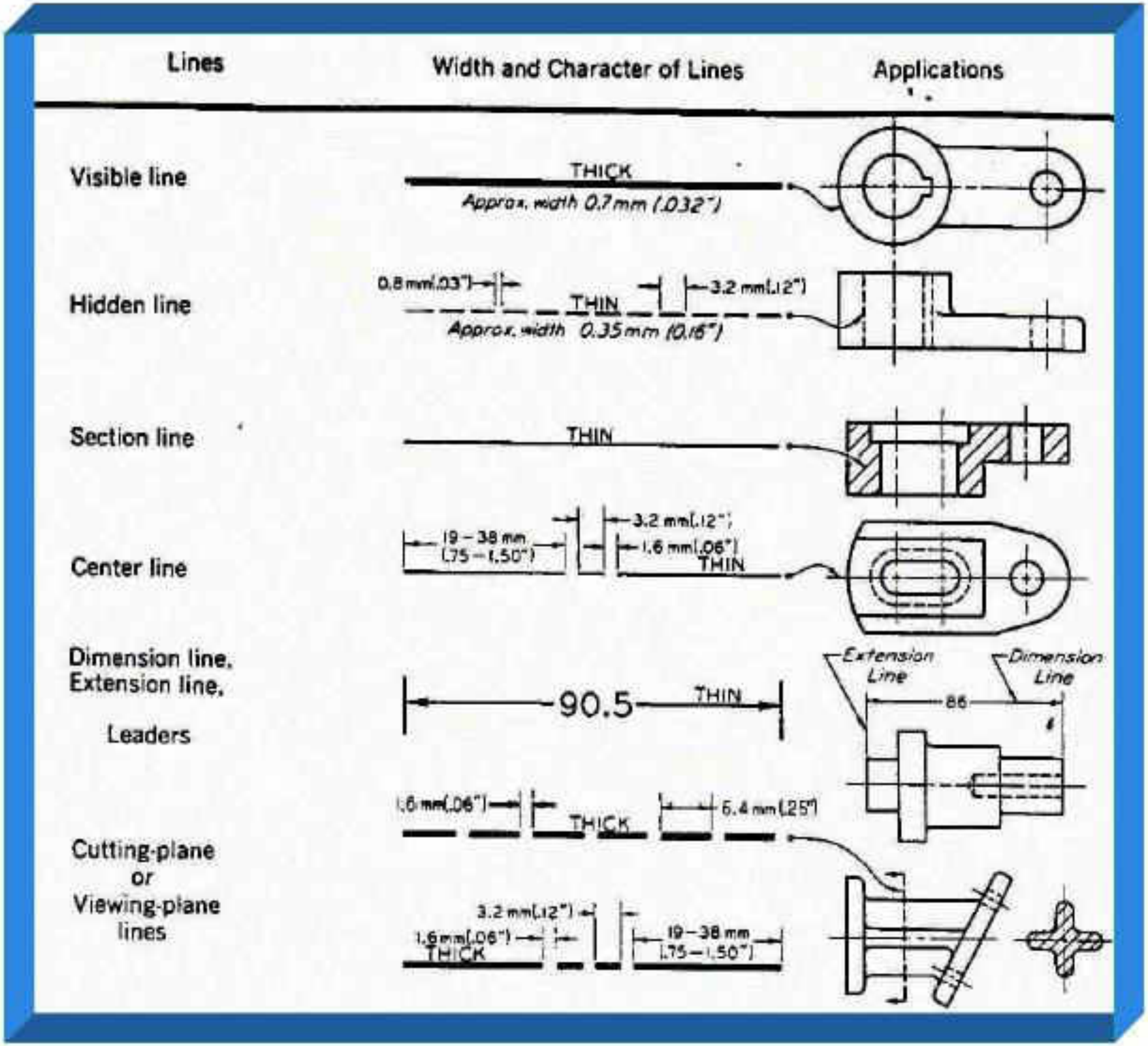
Line group, mm	Thickness	Lines
0.2	Medium	Outlines, dotted lines, cutting plane lines
0.1	Thin	Center lines, section lines, dimension lines, extension lines, construction lines, leader lines, short-break lines, long-break lines

Line types

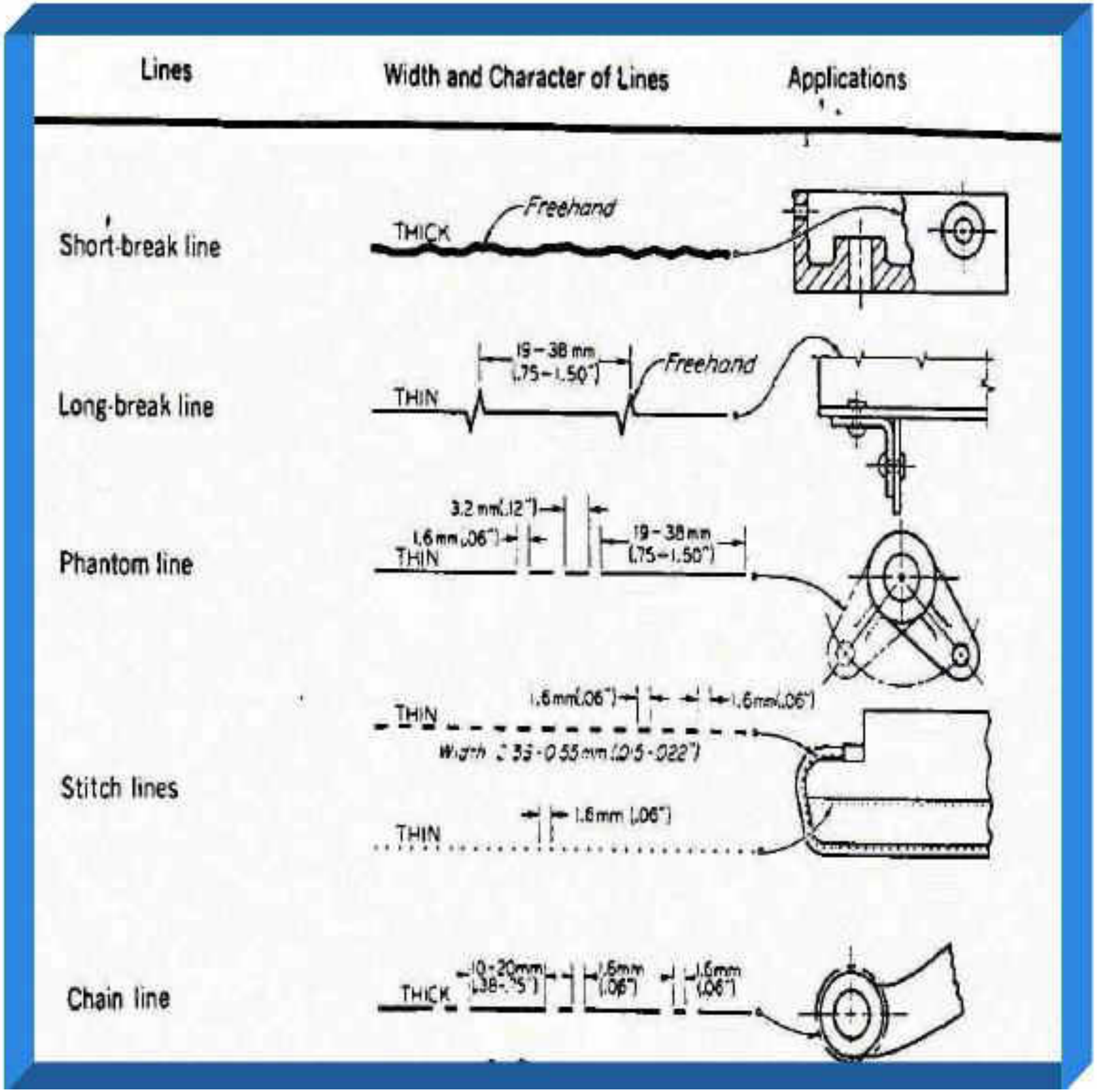
Illustration	Application	Pencil
Thick	Outlines, visible edges, surface boundaries of objects, margin lines	H
Continuous thin	Dimension lines, extension lines, section lines leader or pointer lines, construction lines, boarder lines	2H
Continuous thin wavy 	Short break lines or irregular boundary lines – drawn freehand	2H
Continuous thin with zig-zag 	Long break lines	2H
Short dashes, gap 1, length 3 mm	Invisible or interior surfaces	H

Line types….CONTD

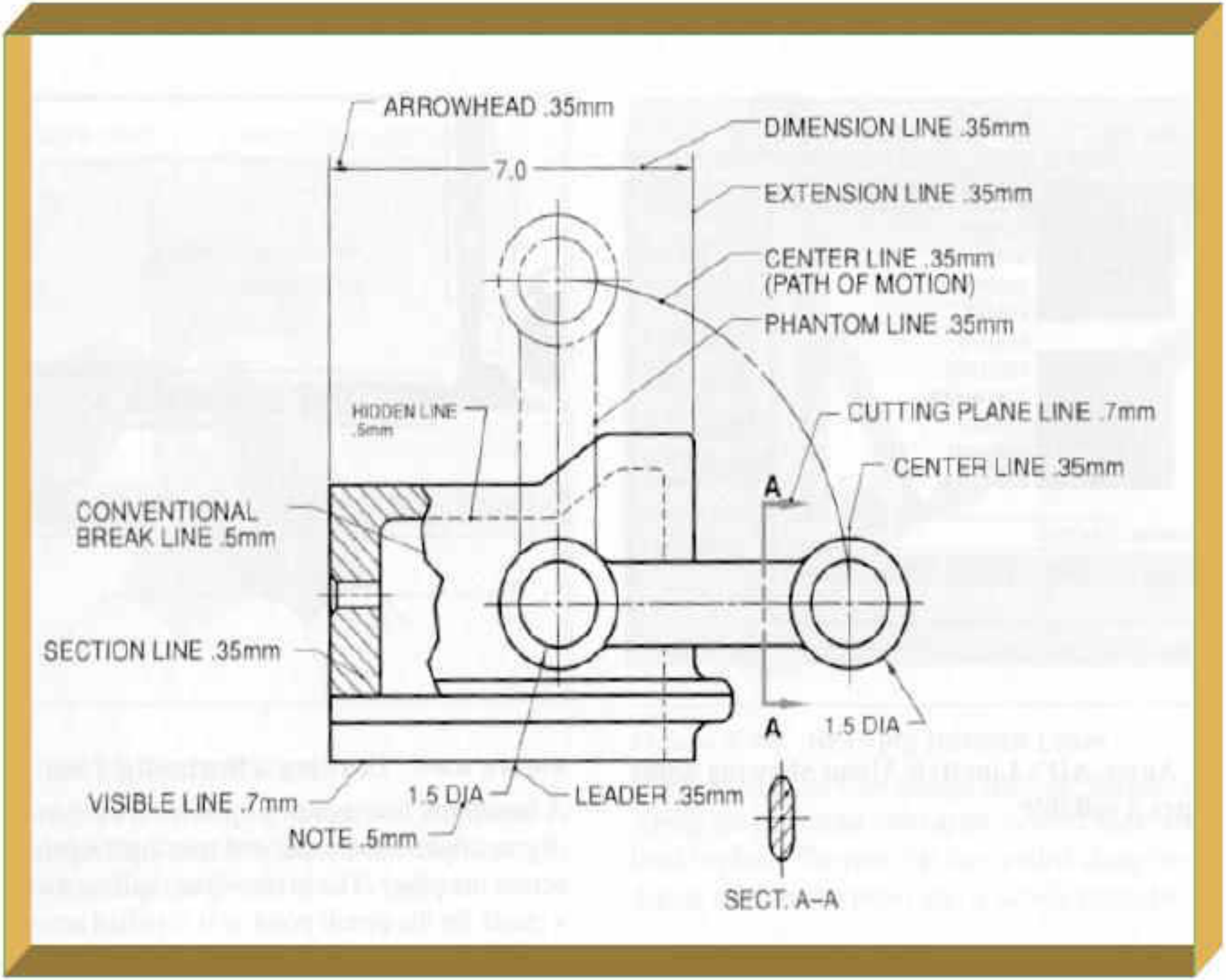
Illustration	Application	Pencil
Short dashes	Center lines, locus lines Alternate long and short dashes in a proportion of 6:1,	2H
Long chain thick at end and thin elsewhere	Cutting plane lines	H / 2H
Continuous thick border line	Border	HB



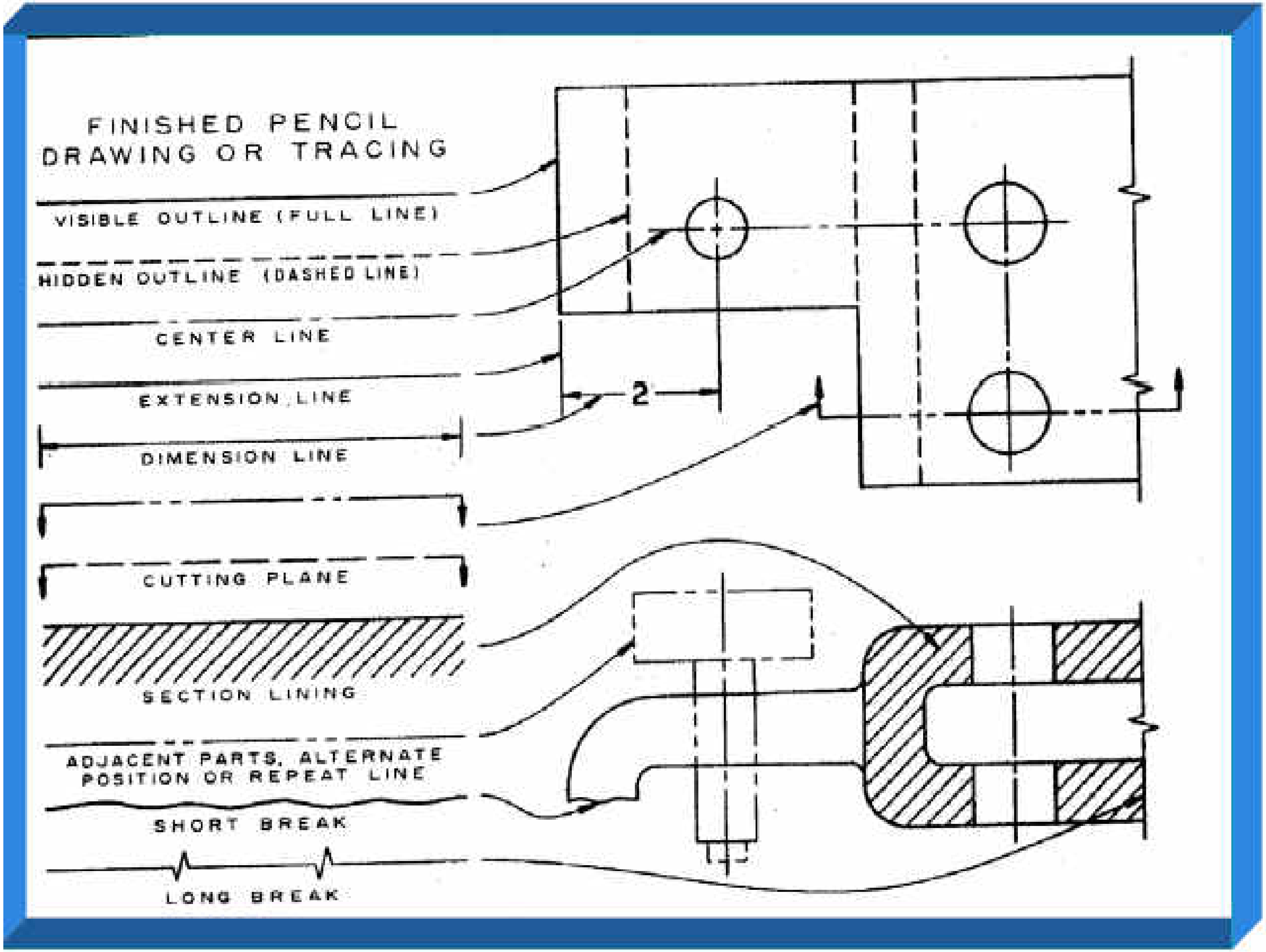
Uses of different types of lines in a given drawing

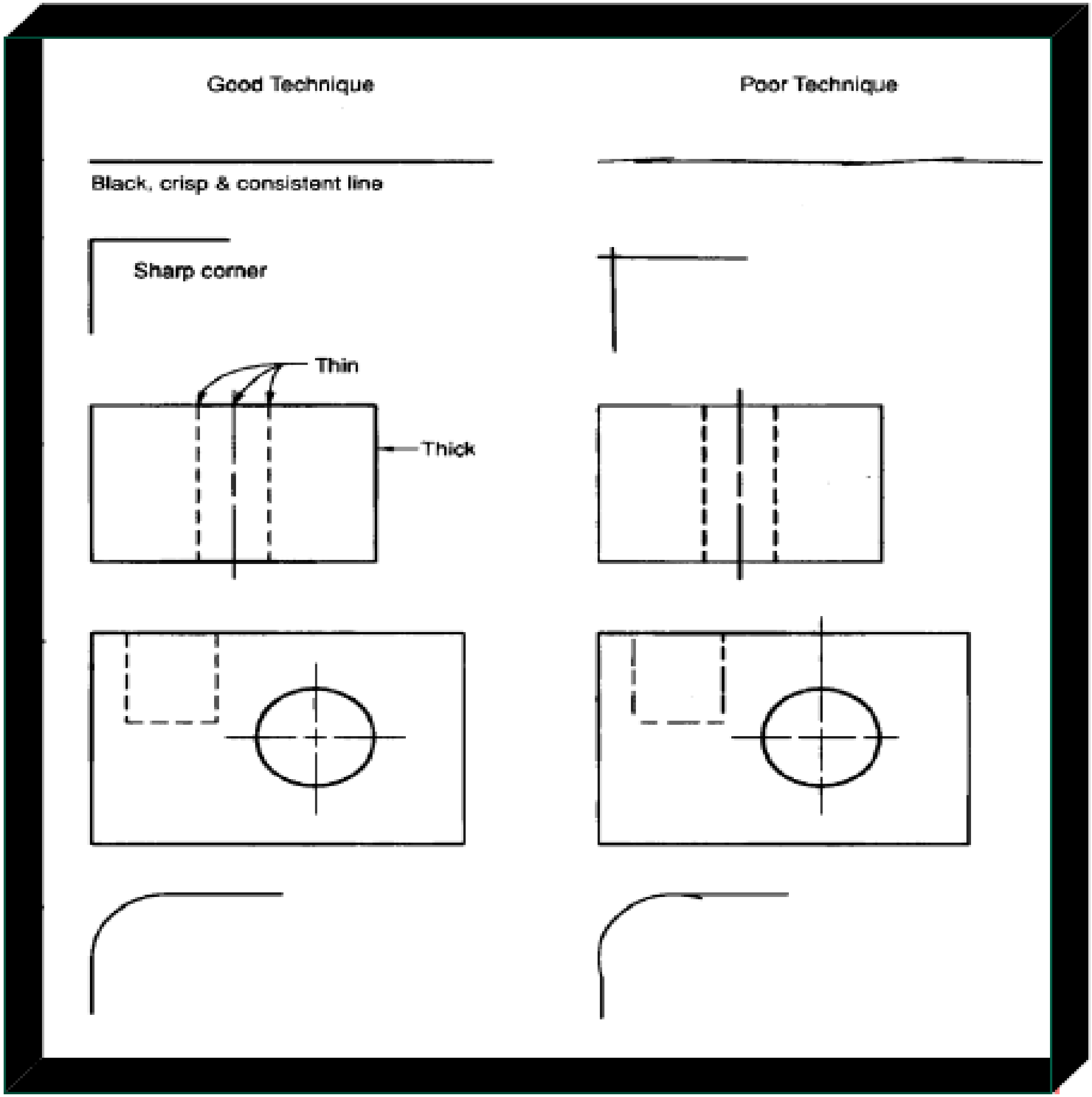


Uses of different types of lines in a given drawing



Uses of different types of lines in a given drawing


FINISHED PENCIL DRAWING OR TRACING
VISIBLE OUTLINE (FULL LINE)
HIDDEN OUTLINE (DASHED LINE)
CENTER LINE
EXTENSION LINE
DIMENSION LINE
CUTTING PLANE
SECTION LINING
ADJACENT PARTS, ALTERNATE POSITION OR REPEAT LINE
SHORT BREAK
LONG BREAK
2



Examples of good and poor drawing techniques for lines and arcs

Lettering – Writing of titles, sub-titles, dimensions, scales and other details on a drawing

- Essential features of lettering – legibility, uniformity, ease, rapidity, and suitability for microfilming/ photocopying/any other photographic processes
- No ornamental and embellishing style of letter

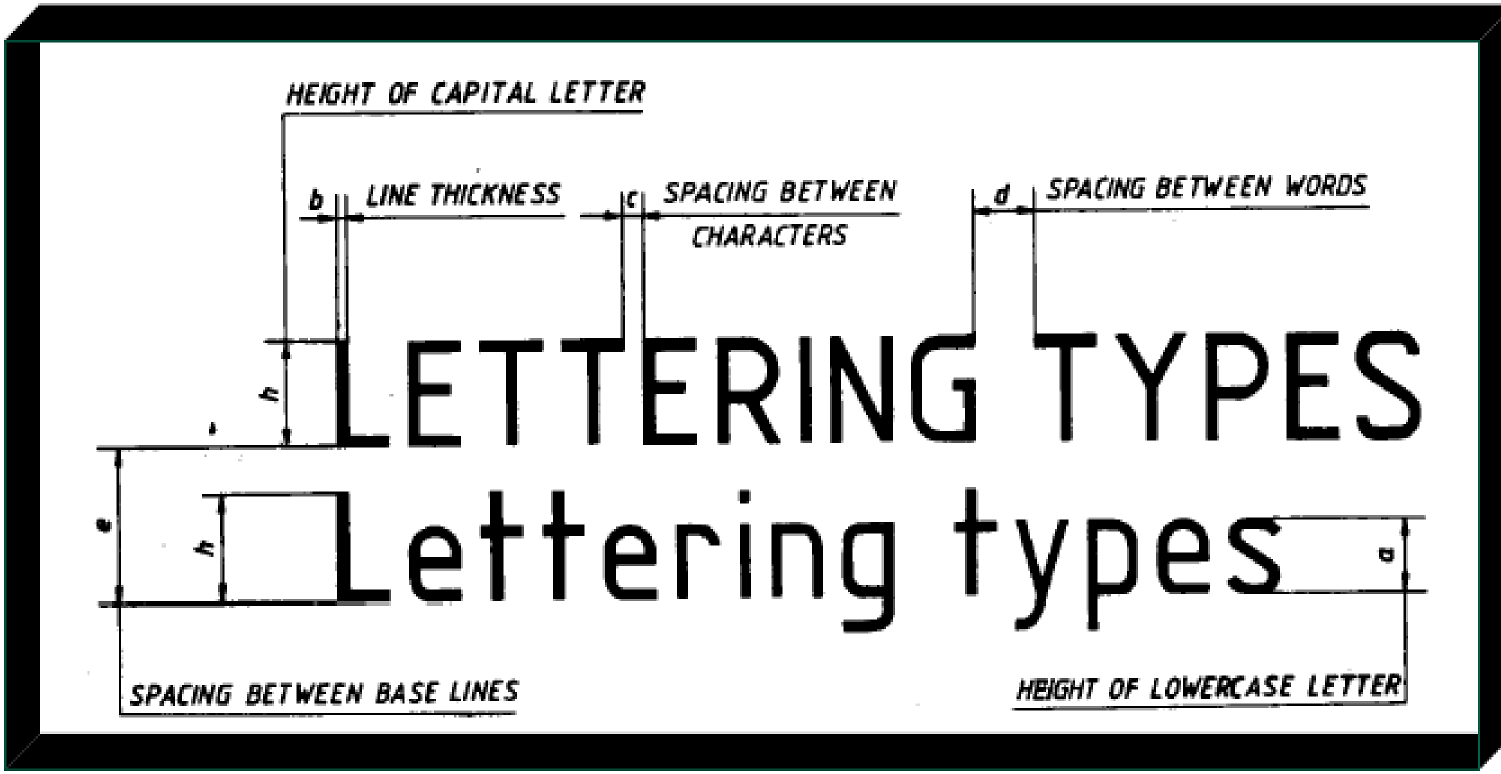
Plain letters and numerals which are clearly distinguishable from each other in order to avoid any confusion even in case of slight mutilations

Lettering – BIS: 9609

- Single stroke lettering for use in engineering drawing – width of the stem of the letters and numerals will be uniformly thick equal to thickness of lines produced by the tip of the pencil.
- **Single stroke does not mean – entire letter written without lifting the pencil/pen**

Lettering types

- **Lettering A** – Height of the capital letter is divided into 14 equal parts
- **Lettering B** – Height of the capital letter is divided into 10 equal parts



Heights of Letters and Numerals

- Height of the capital letters is equal to the height of the numerals used in dimensioning

- Height of letters and numerals – different for different purposes

Sr. No.	Item	Size (mm)
1	Name of the company	**10**, 14, 20
2	Drawing numbers, letters denoting section planes	**10**, 14
3	Title of the Drawing	**7**, 10
4	Sub-titles and heading	5, **7**
5	Dimensioning, Notes, Schedules, Material list	3.5, **7**
6	Alteration entries and tolerances	3.5

Specifications of A -Type Lettering

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	a = (5/7)h	-	2.5	3.5	5	7	10	14
Thickness of lines	b = (1/14)h	0.18	0.25	0.35	0.5	0.7	1	1.4
Spacing between characters	c = (1/7)h	0.35	0.5	0.7	1	1.4	2	2.8
Min. spacing b/n words	d = (3/7)h	1.05	1.5	2.1	3	4.2	6	8.4
Min. spacing b/n baselines	e = (10/7)h	3.5	5	7	10	14	20	28

Specifications of B -Type Lettering

Specifications	Value	Size (mm)						
Capital letter height	h	2.5	3.5	5	7	10	14	20
Lowercase letter height	a = (7/10)h	-	2.5	3.5	5	7	10	14
Thickness of lines	b = (1/10)h	0.25	0.35	0.5	0.7	1	1.4	2
Spacing between characters	c = (1/5)h	0.5	0.7	1	1.4	2	2.8	4
Min. spacing b/n words	d = (3/5)h	1.5	2.1	3	4.2	6	8.4	12
Min. spacing b/n baselines	e = (7/5)h	3.5	5	7	10	14	20	28

Standards and Conventions

Standards and Conventions

No effective communication without an agreed upon standard of signs or symbols.

Standards and conventions are the alphabet of technical drawing, and plane, solid, and descriptive geometry are the science(grammar) which underlies the graphics language.

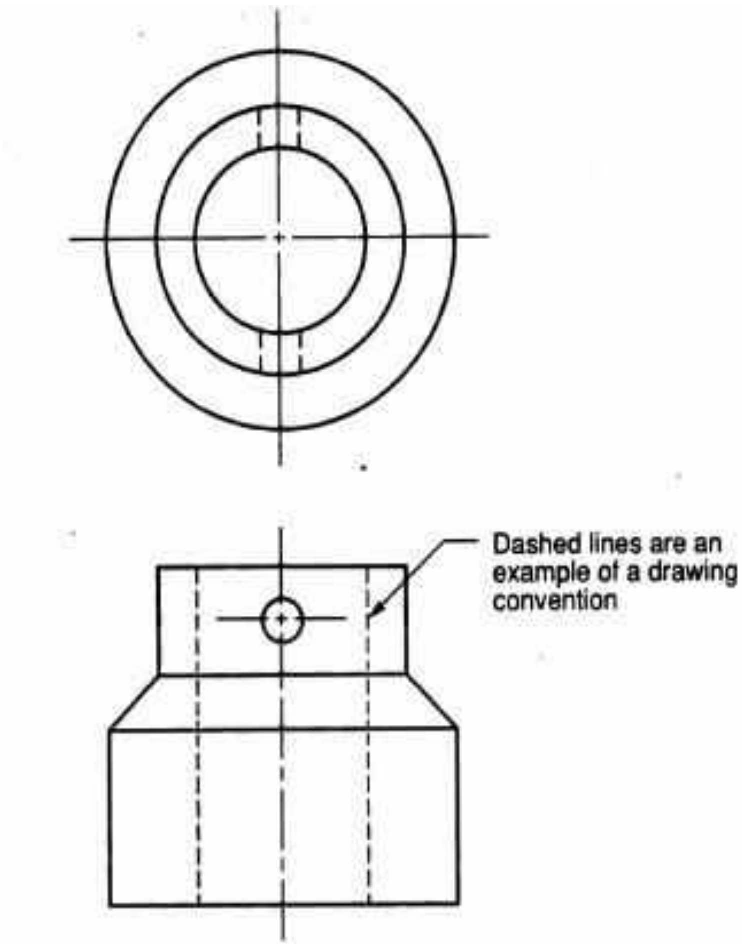
Following the standard rules **(grammar)** of any language (Hindi/English) – **communication** of thought between people becomes **easier**.

If words in a sentence were presented randomly – understanding becomes very difficult.

For effective communication of technical (graphics) information– set of standards and conventions **– a must.**

Standards and Conventions – very important

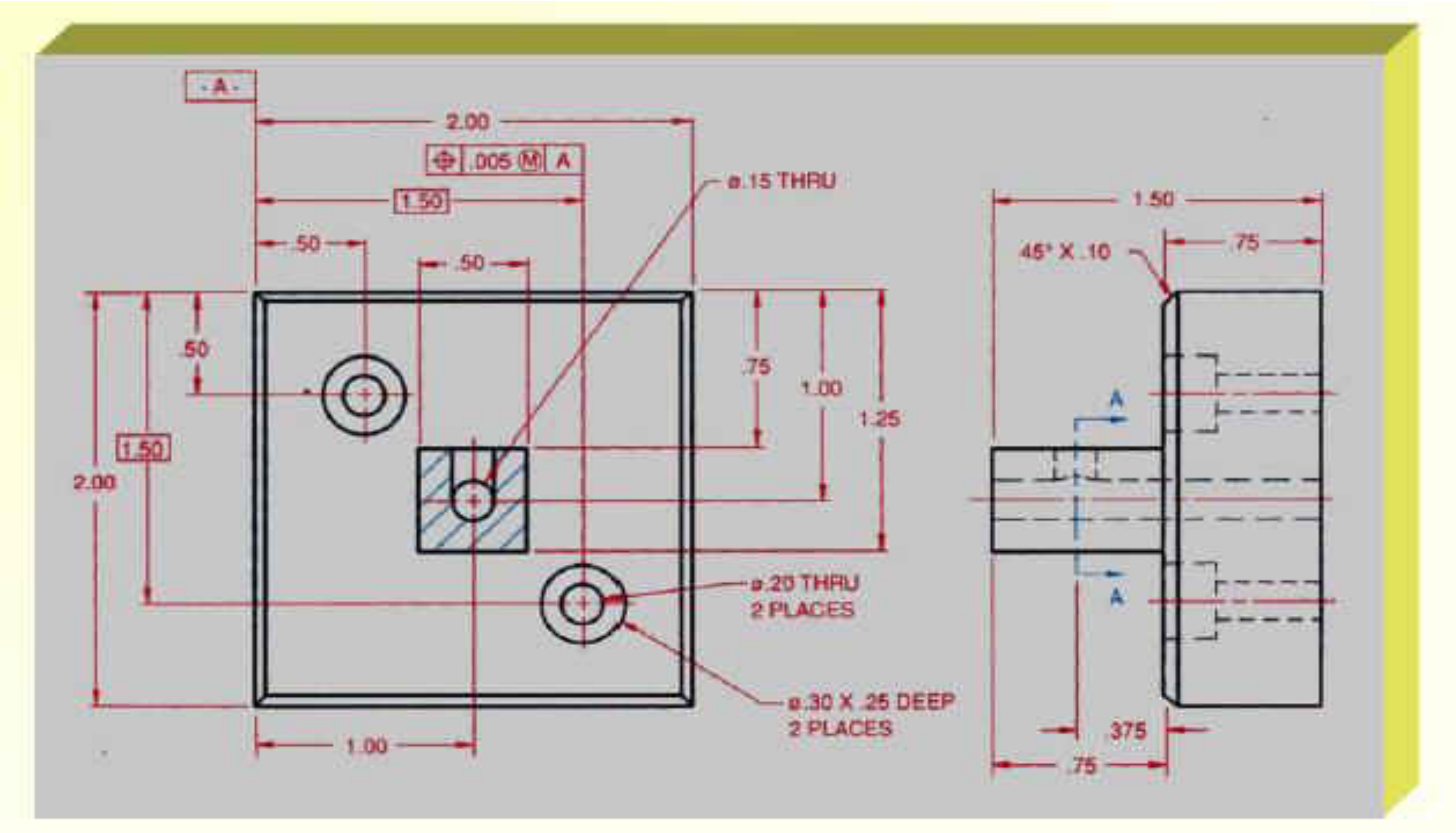
Conventions – commonly accepted practices, rules, or methods.



Dashed lines are used to represent hidden features of an engineering drawing.

Hidden lines – location of drilled hole's diameter, in a view where the hole cannot be directly seen.

Standards – set of rules that govern how technical drawings are represented.



Drawings are dimensioned using an accepted set of standards such as placing the dimension text such that it is read from the bottom of the sheet.

Drawing standards

ANSI – American National Standards Institute

ANSI Y14.1 1980 (R1987) – Drawing sheet size and format

ANSI Y 14.2M-1979 (R1987) – Line conventions and lettering

ANSI Y14.5M-1982(R1988) – Dimensioning and tolerances

ANSI Y 14.3-1975(R1987) – Multi view and sectional view drawings

ISO – International Standards Organization

JIS – Japanese Standards

BIS – Bureau of Indian Standards

Units of Measure

International systems of units (SI) – which is based on the meter.

Millimeter (mm) - The common SI unit of measure on engineering drawing.

Individual identification of linear units is not required if all dimensions on a drawing are in the same unit (mm).

The drawing shall however contain a note:

ALL DIMENSIONS ARE IN MM. (Bottom left corner outside the title box)

Dimensioning

Indicating on a drawing, the size of the object and other details essential for its construction and function, using lines,numerals, symbols, notes, etc.

Dimensions indicated on a drawing should be those that are essential for the production, inspection and functioning of the object and should not be mistaken as those that are required to make the drawing of an object.

Dimensioning of an object is accomplished by dimensioning each element to indicate its size (**size dimensions**) and relative location (**location dimensions**) from a center line, base line or finished surface.

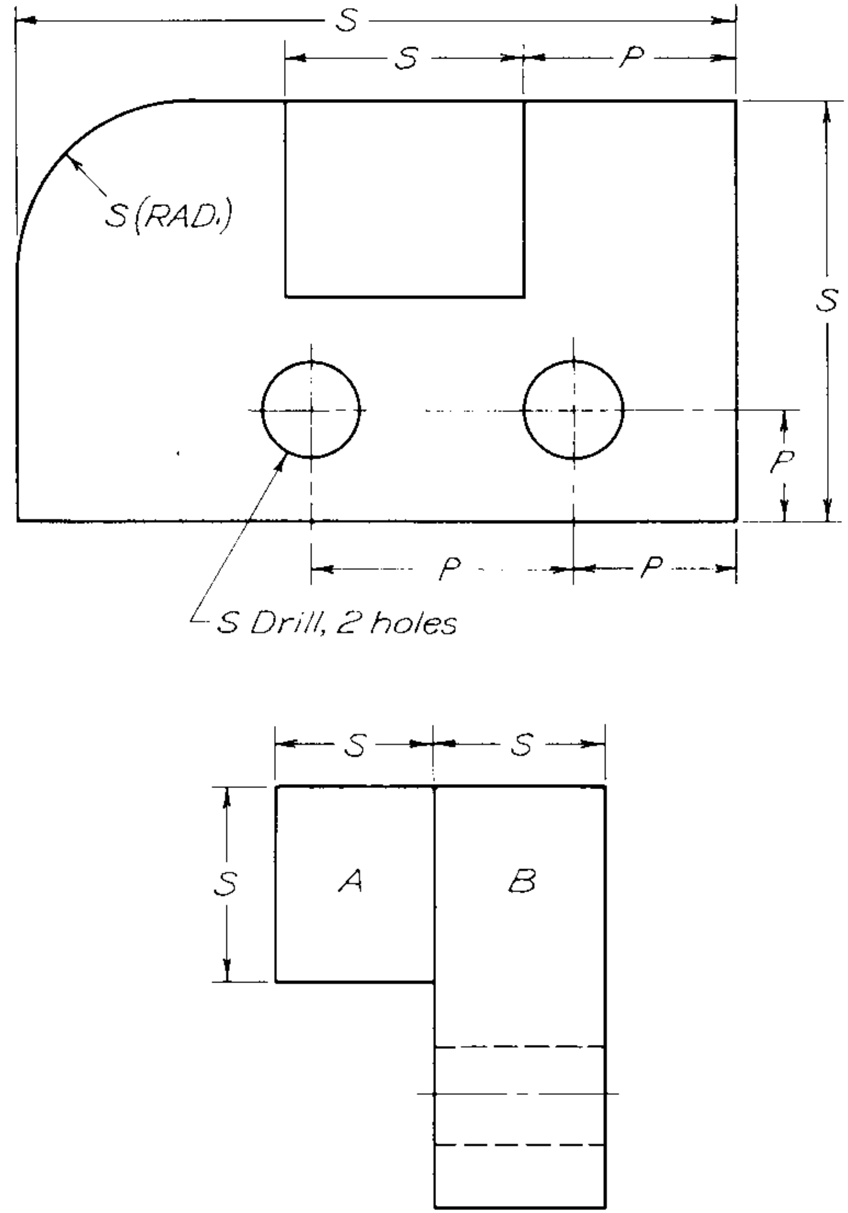


FIG. 19. Dimensions of size and position. S indicates size, P position.

Each feature is dimensioned and positioned only once.

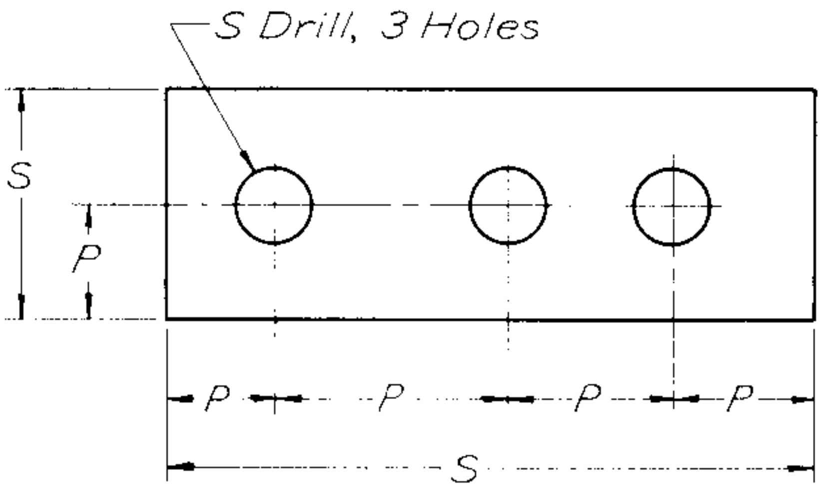


FIG. 24. One unnecessary dimension.

Each feature is dimensioned and positioned where its shape shows.

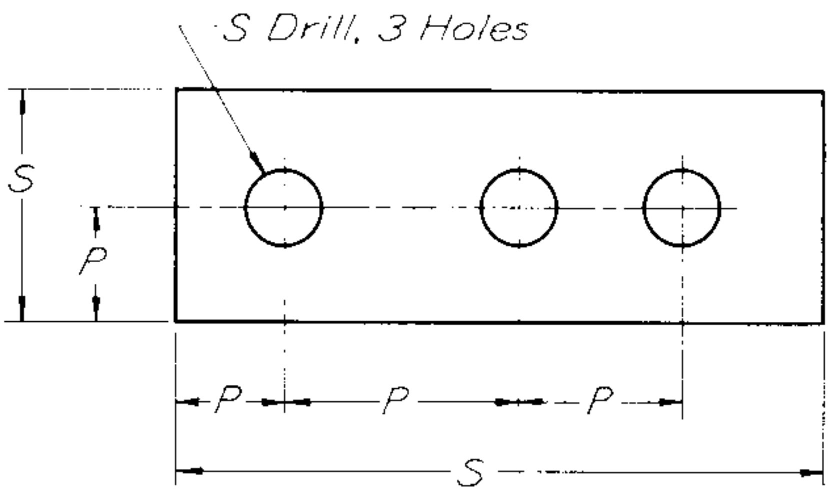


FIG. 25. Unnecessary dimension omitted.

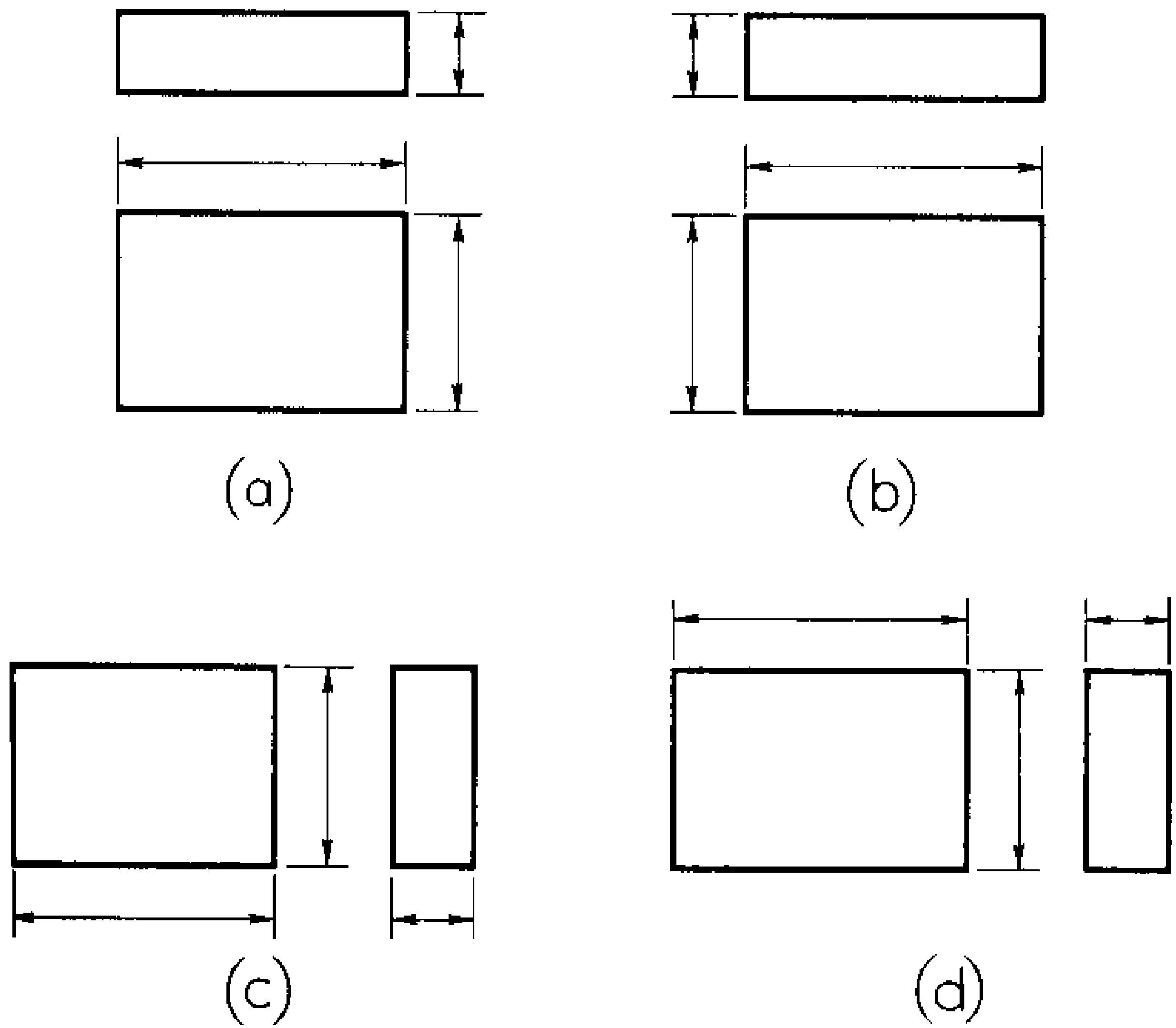
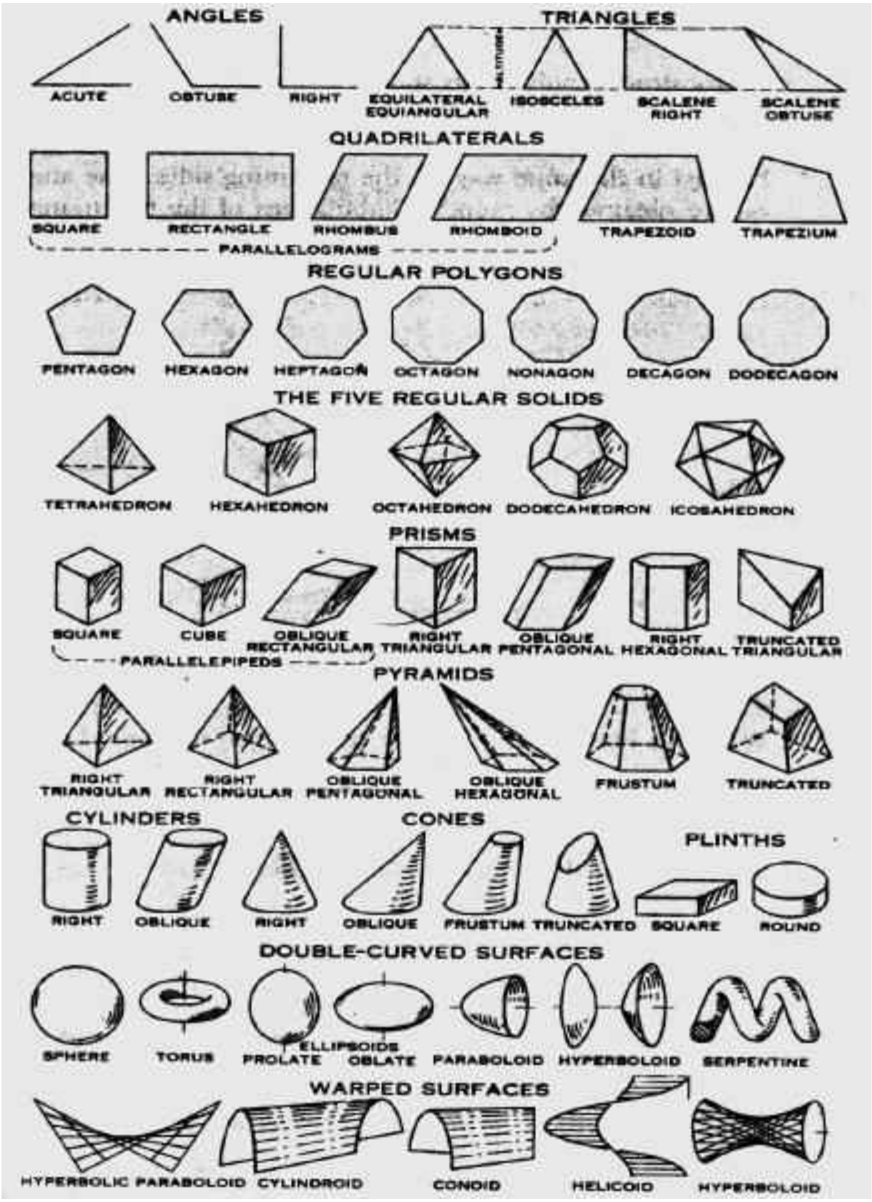


Fig. 11.24 **Dimensioning Rectangular Prisms.**

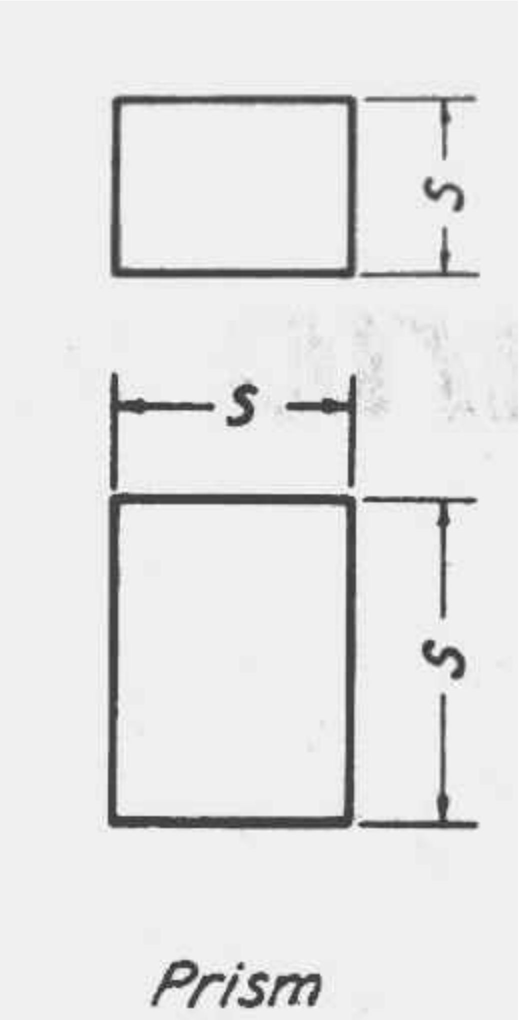
Size dimensions – give the size of the component.

Solid:

Every solid has three dimensions,each of the geometric shapes making up the object must have its height, width, and depth indicated in the dimensioning.



Basic geometric shapes used in drawing



Prism – most common shape

requires **three dimensions** -
give two dimensions on the

principal view and one
dimension on the other
views.

Cylinder

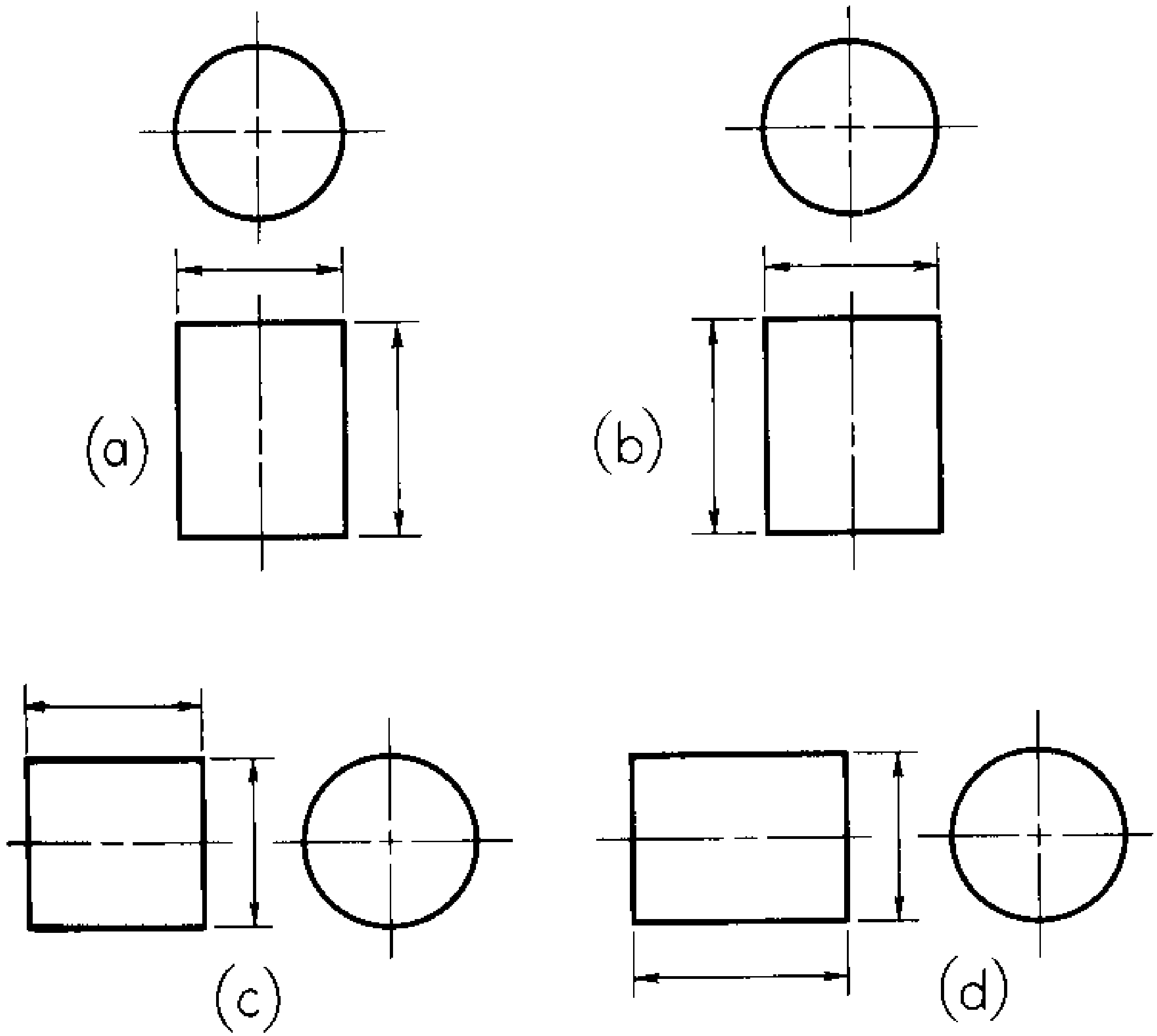


Fig. 11.26 Dimensioning Cylinders.

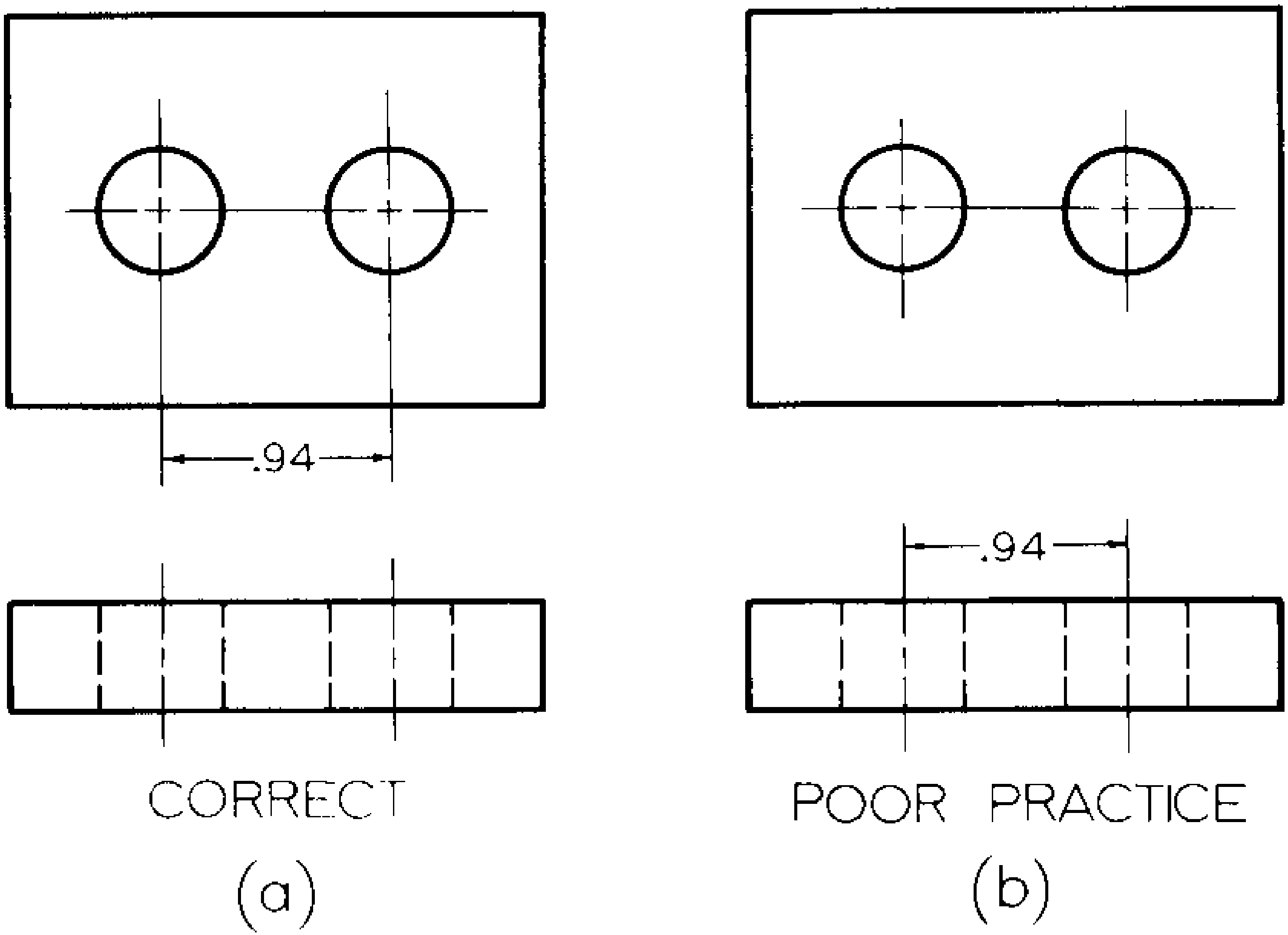


Fig. 11.32 Locating Holes.

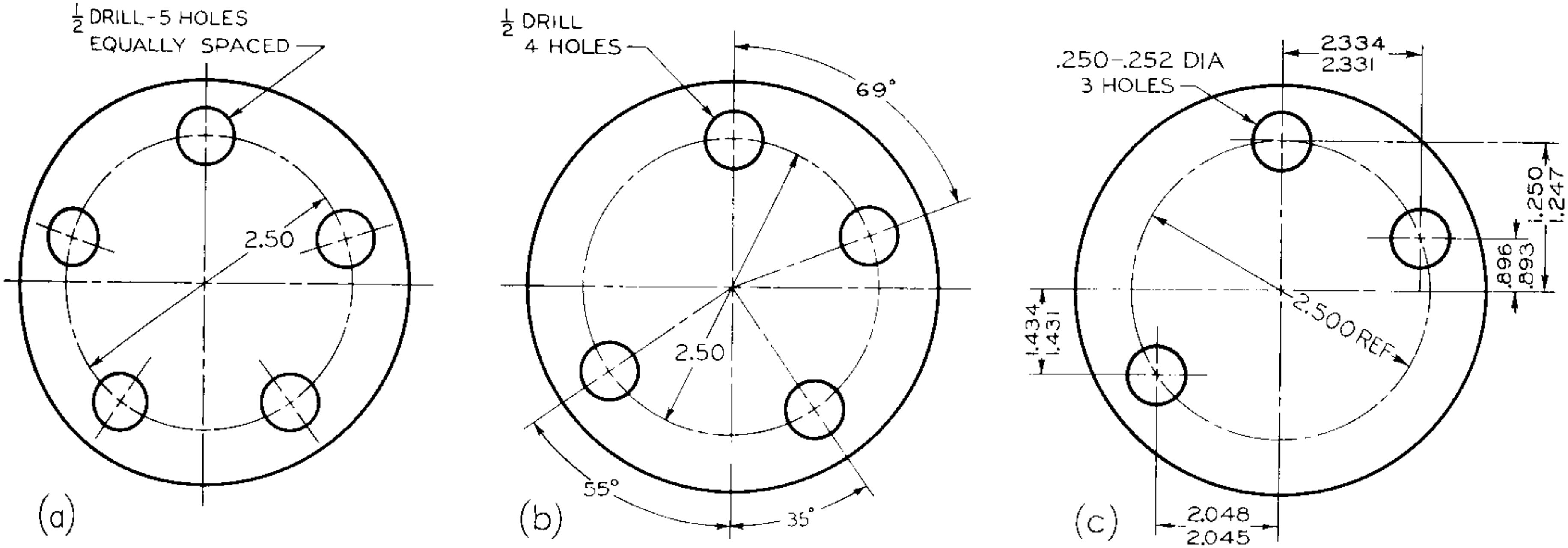


Fig. 11.34 Locating Holes About a Center.

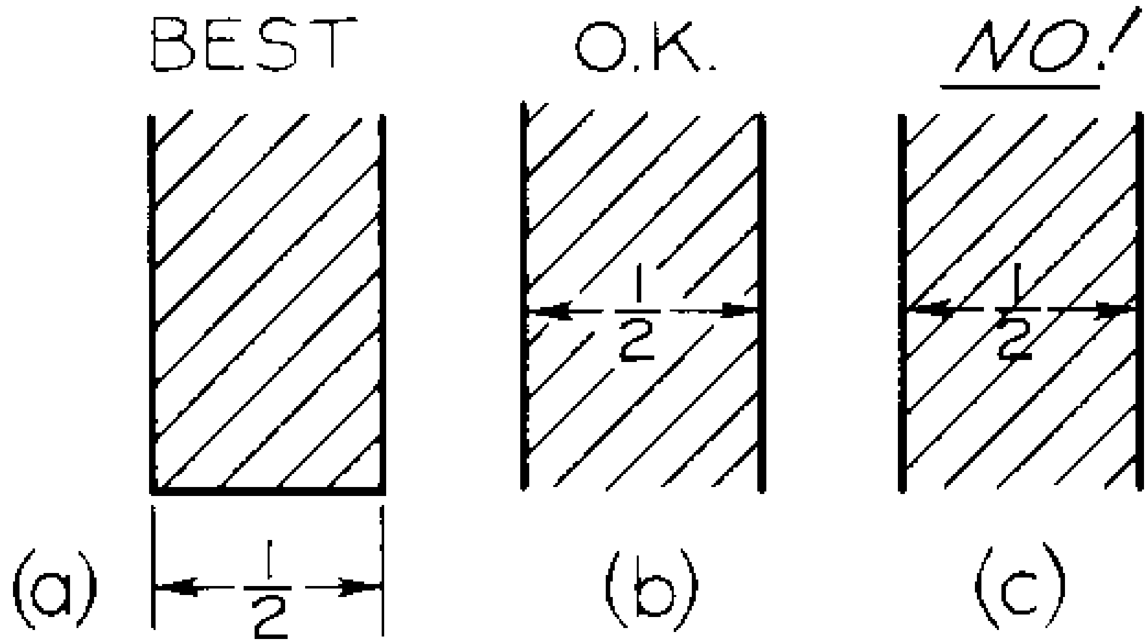


Fig. 11.13 Dimensions and Section Lines.

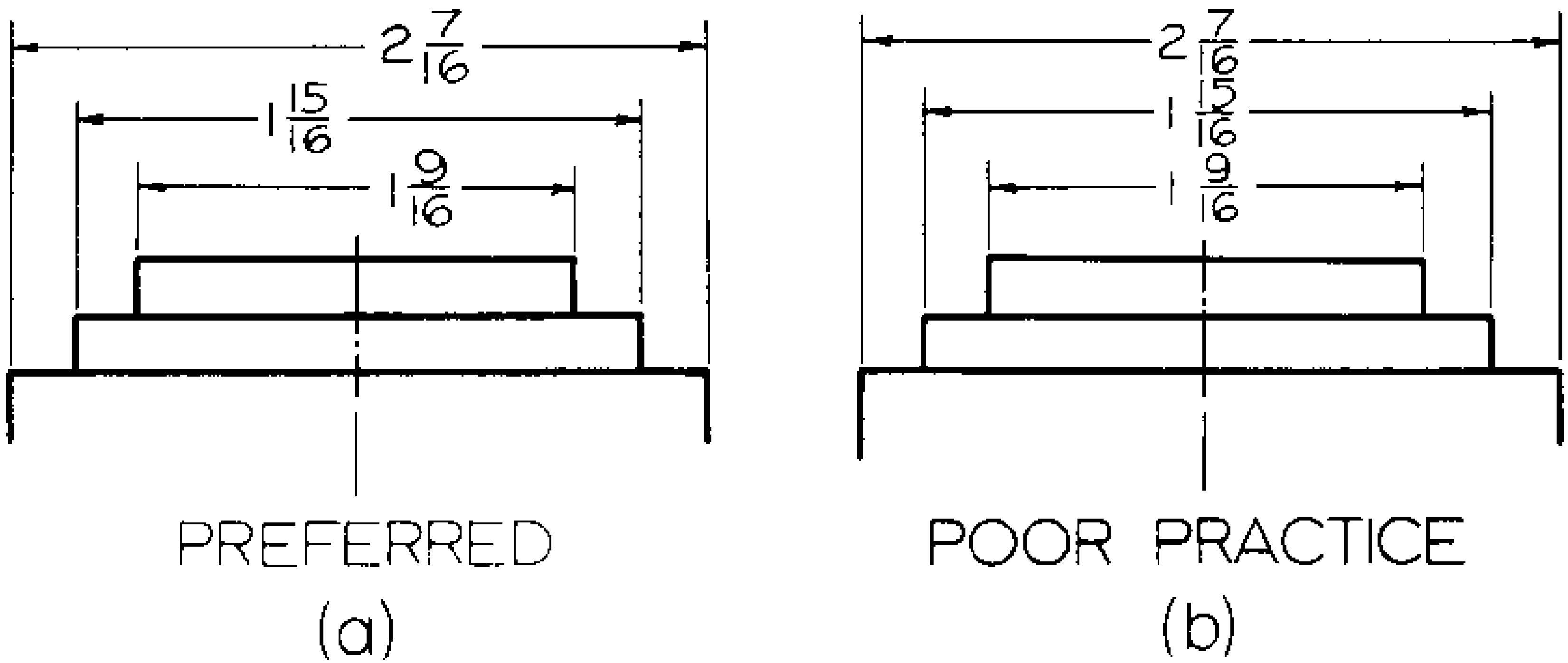
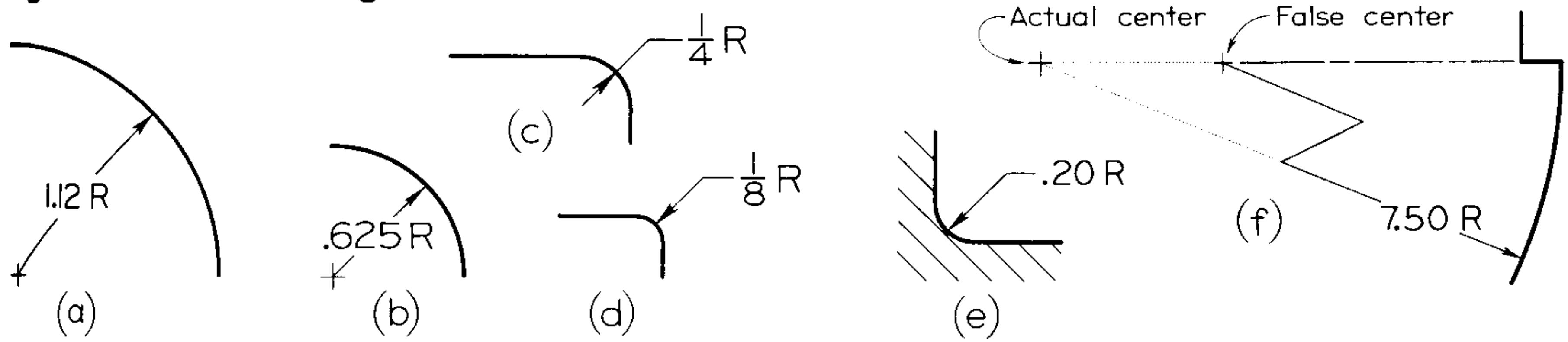
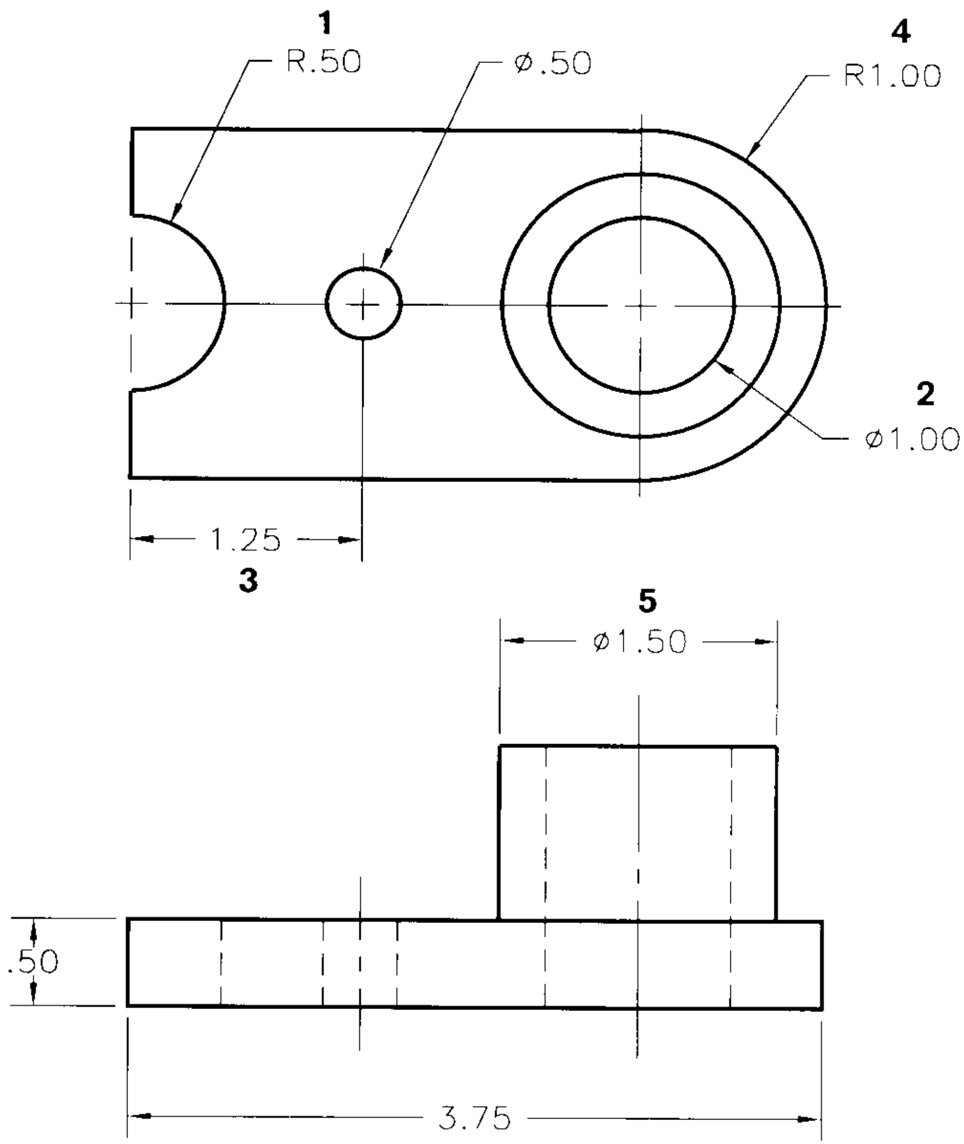


Fig. 11.14 Staggered Numerals.

Fig. 11.19 Dimensioning Arcs.





1. Give radius of arcs.
2. Give diameters of circles.
3. Locate holes where you see their circular shapes.
4. Rounded ends are self locating.
5. Dimension the diameters of cylinders where they appear rectangular.

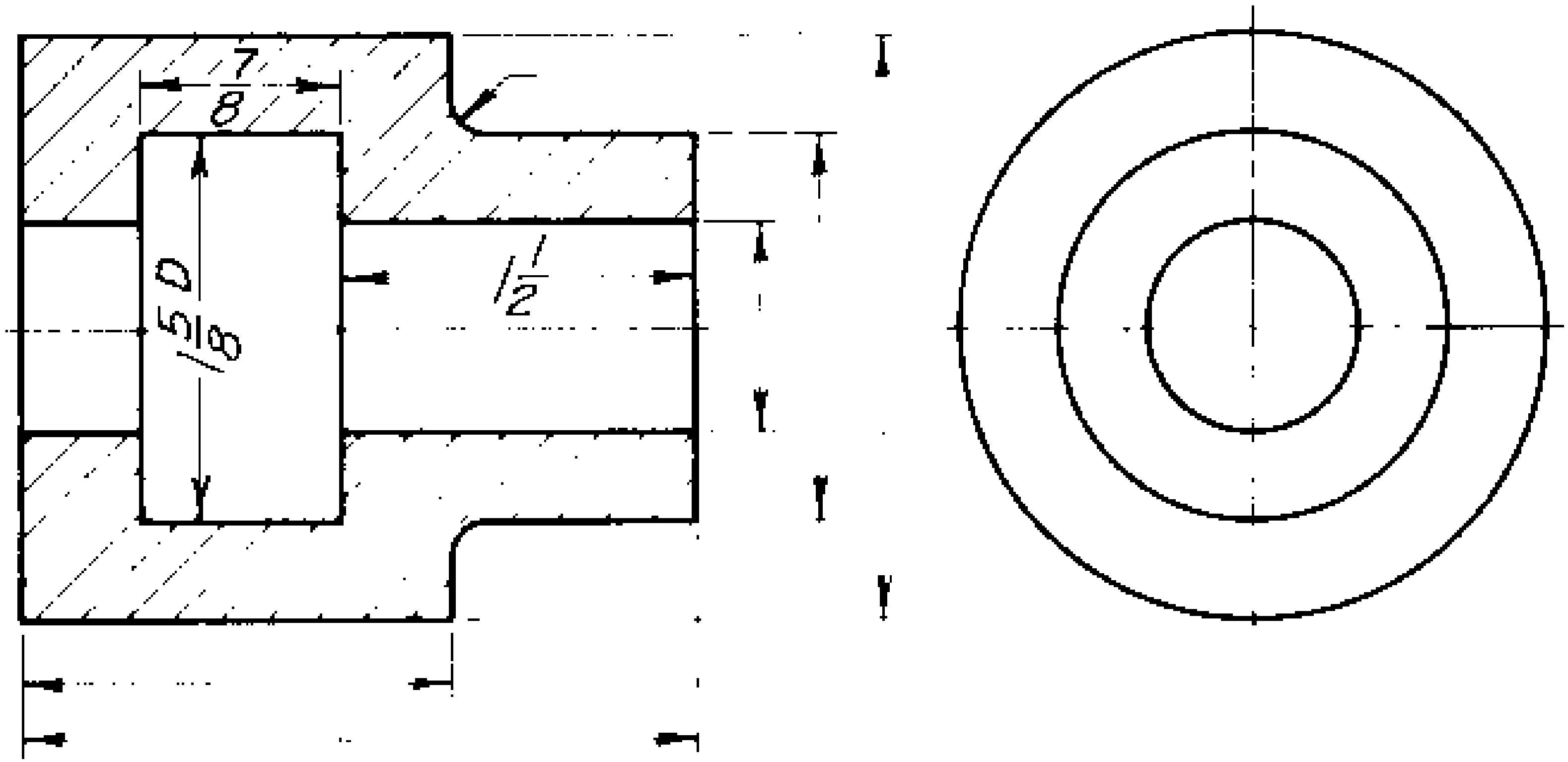


FIG. 31. Dimensions inside the view.

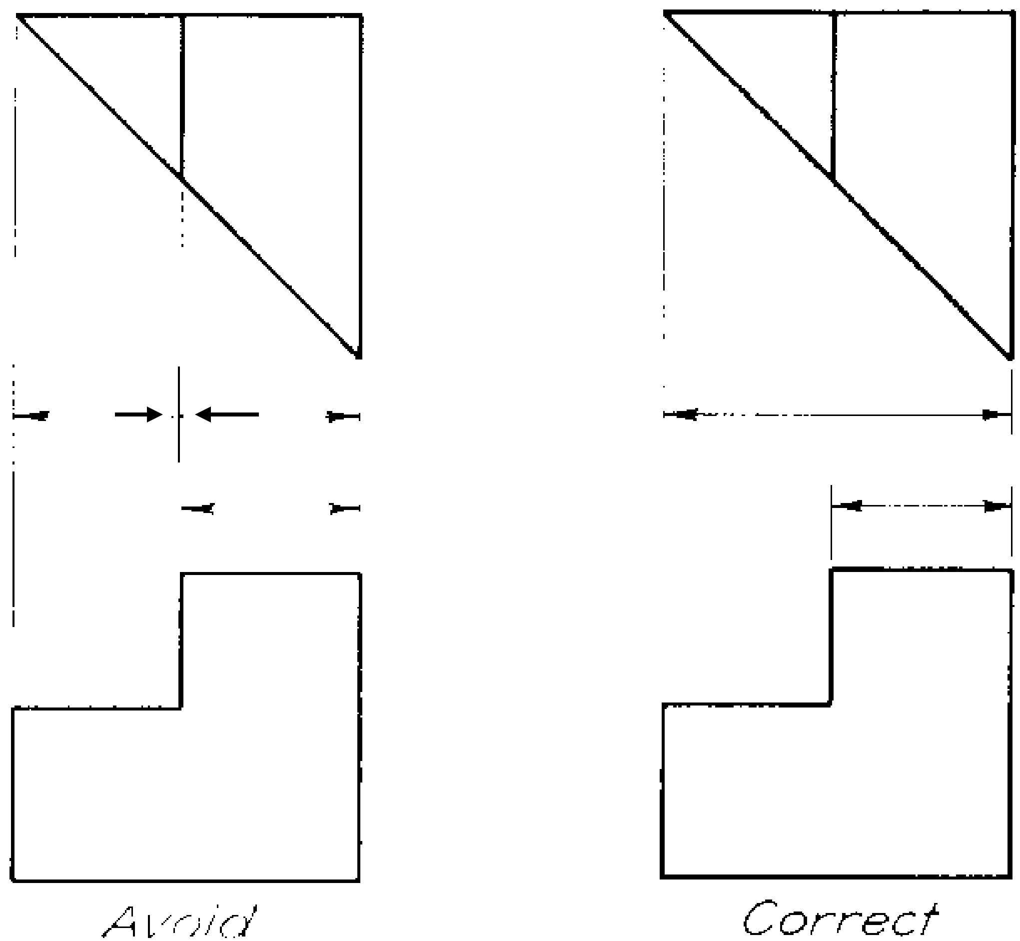


FIG. 32. Dimensions applied to one view only.

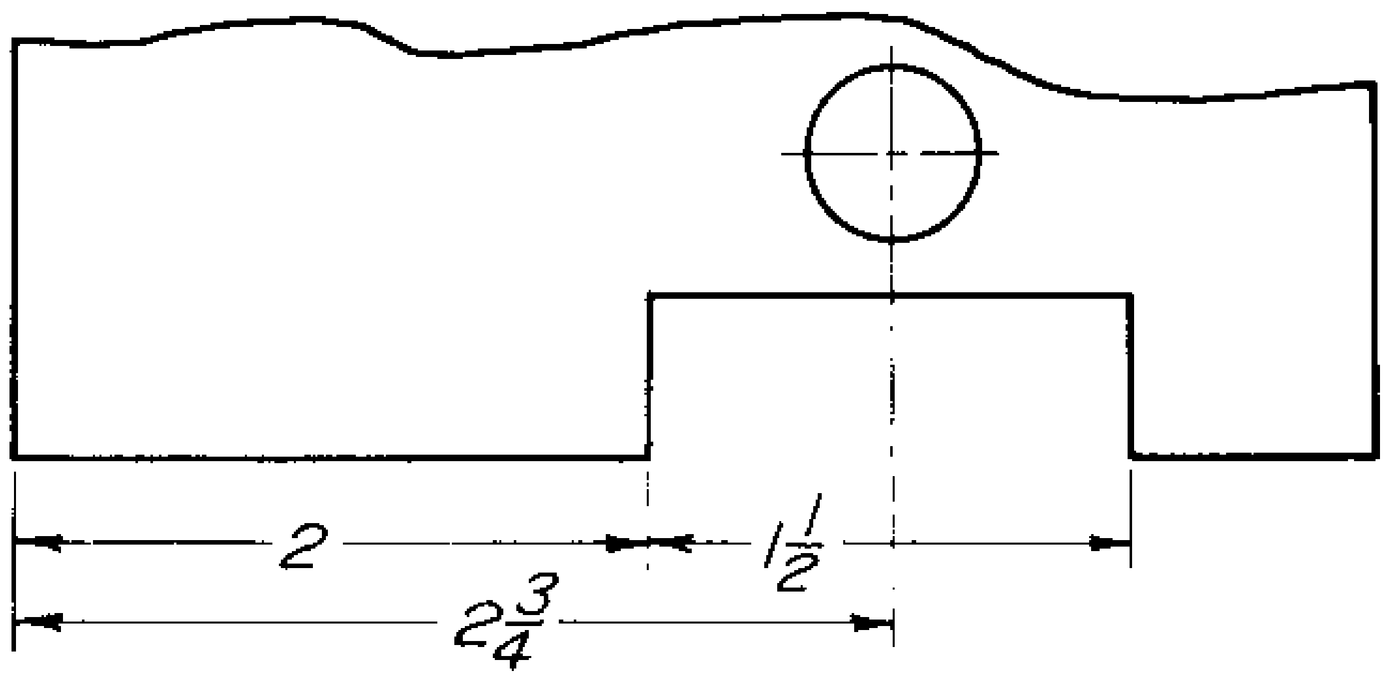


FIG. 34. Values midway between arrowheads.

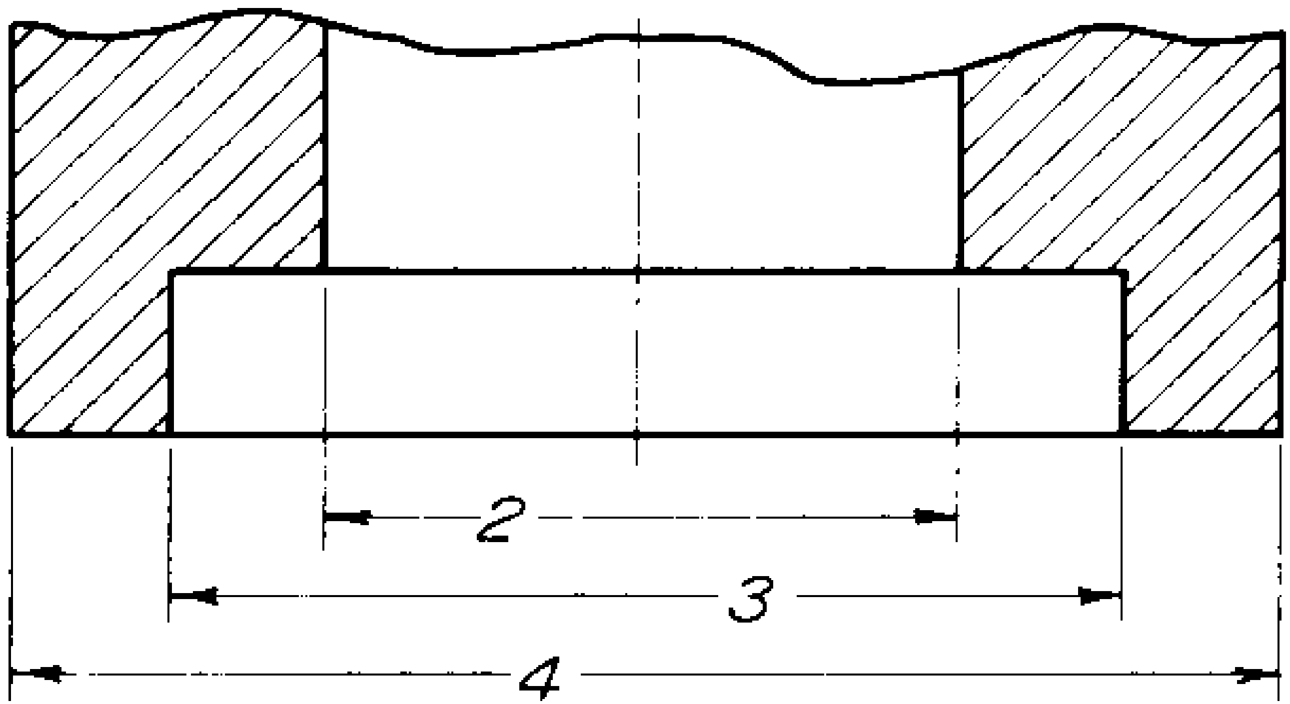
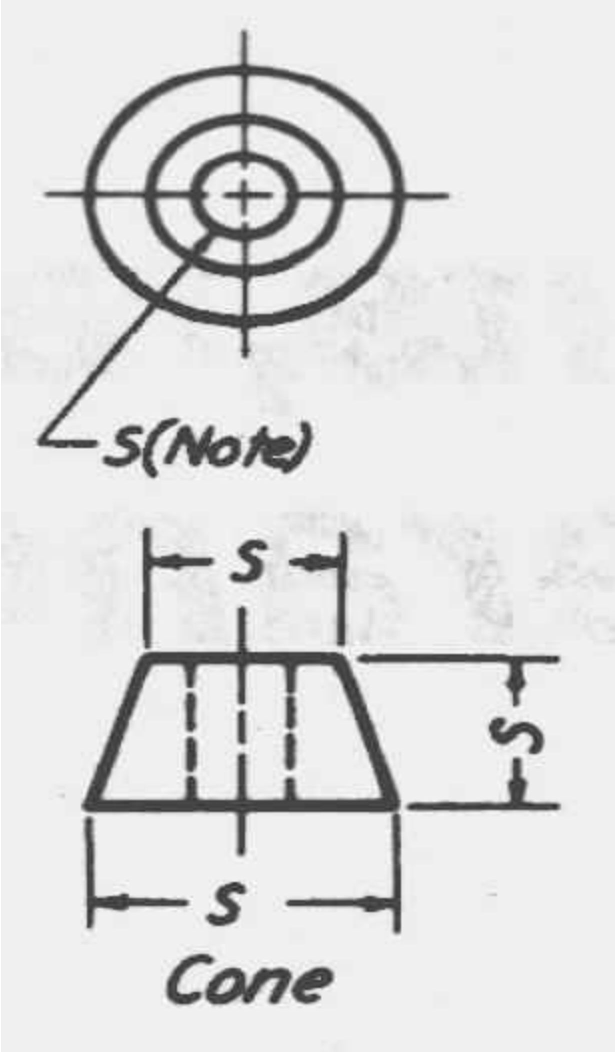
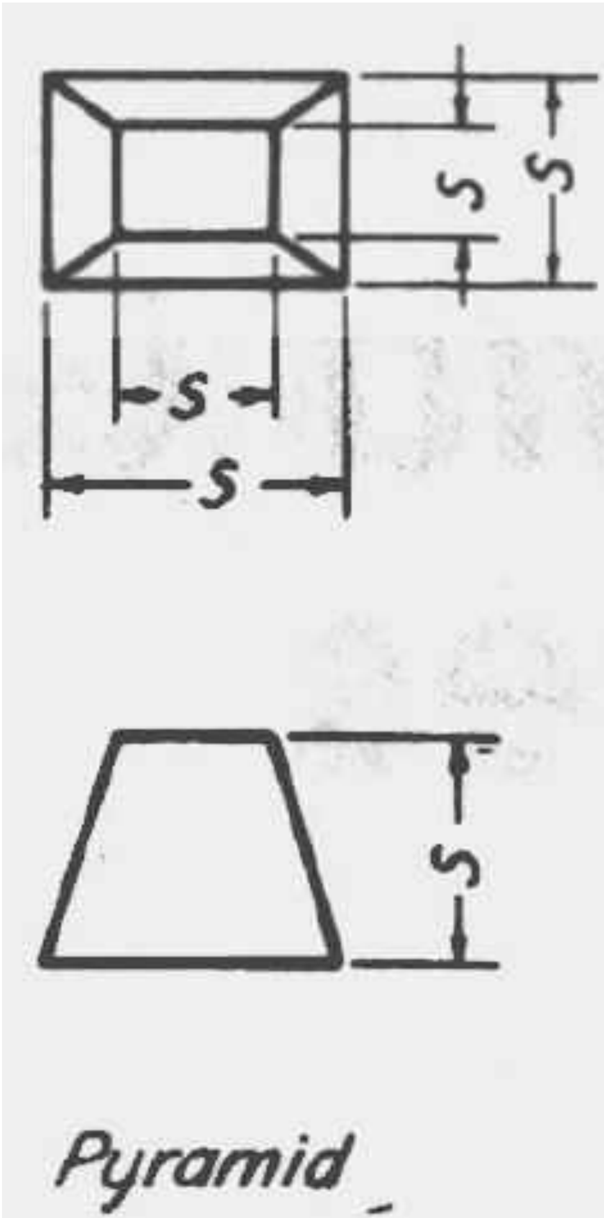


FIG. 35. Values staggered for clarity.



Cone – requires two dimensions – **diameter of the base** and altitude on the same view and length – both are shown preferably on the rectangular view.



Right pyramids – requires three dimensions – dimensions of the base and altitude.

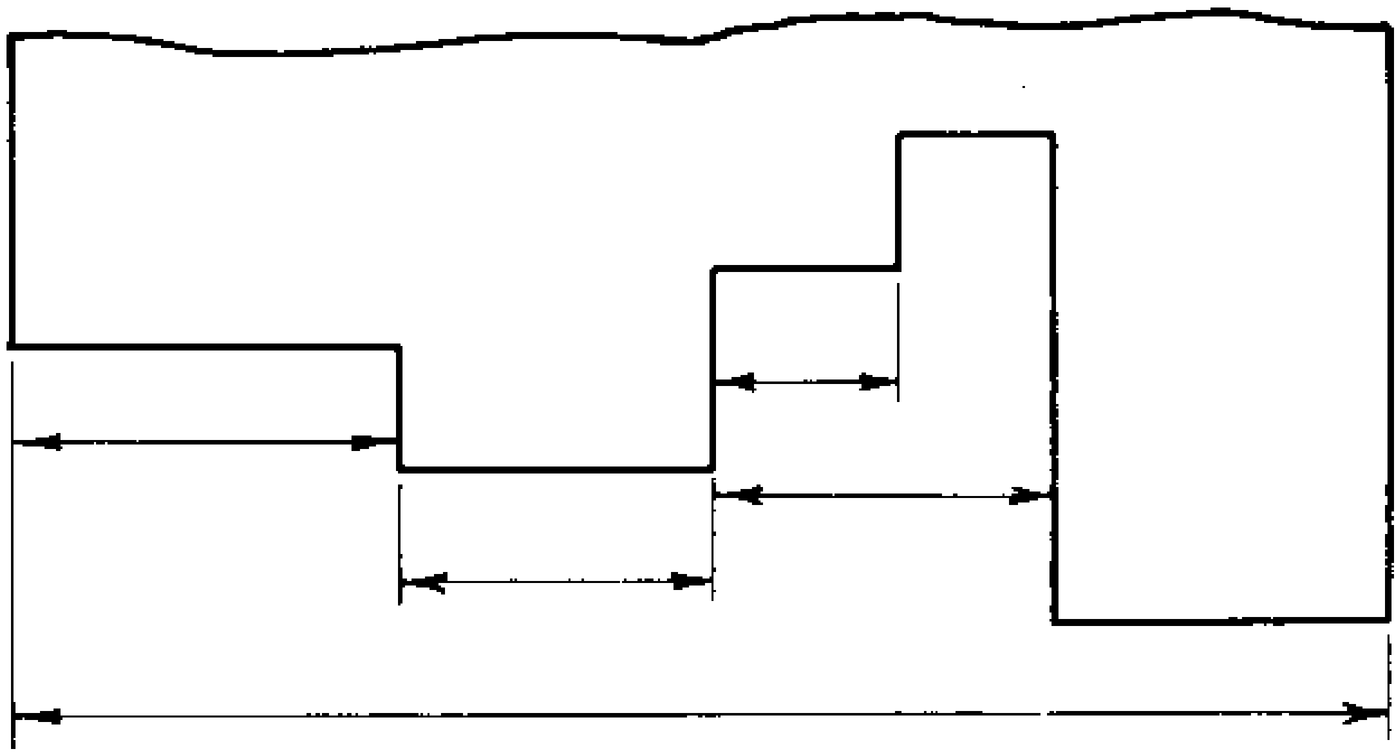
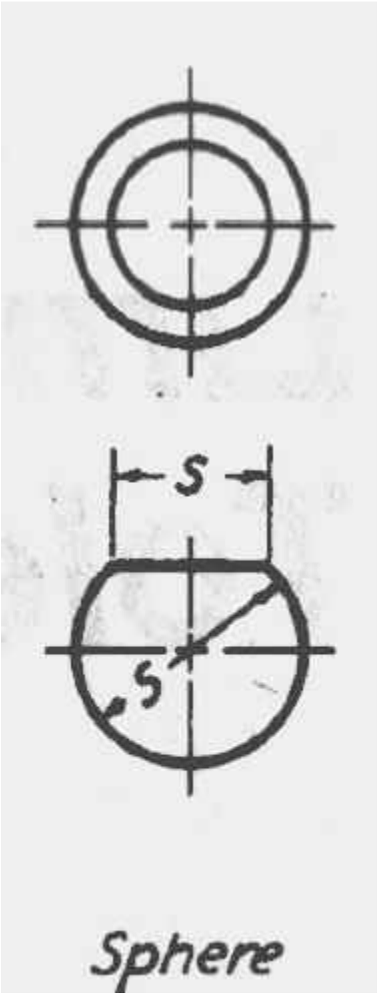


FIG. 37. Dimensions staggered.



Spheres – requires only one dimension – diameter.

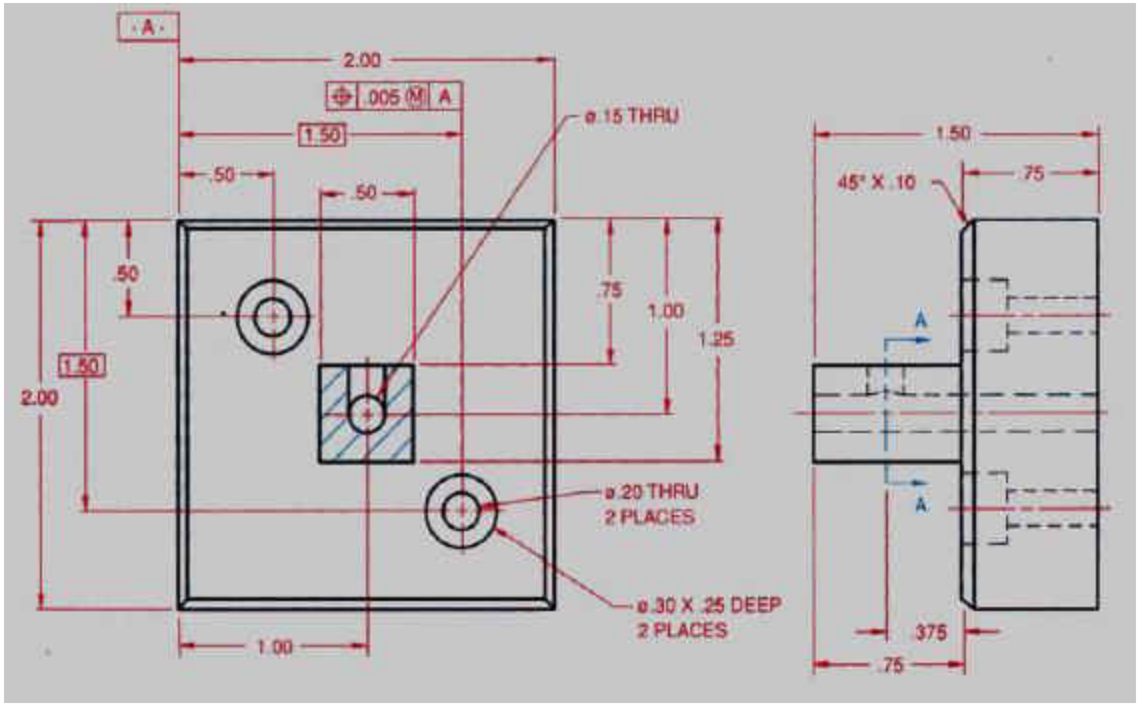
Location dimensioning

After the basic geometric shapes have been dimensioned for size, the location of each relative to the others must be given.

Locations must be established in height, width and depth directions.

Rectangular faces are positioned with reference to their faces, cylinder and conic shapes with reference to their center lines and their ends.

Size and Location dimensioning



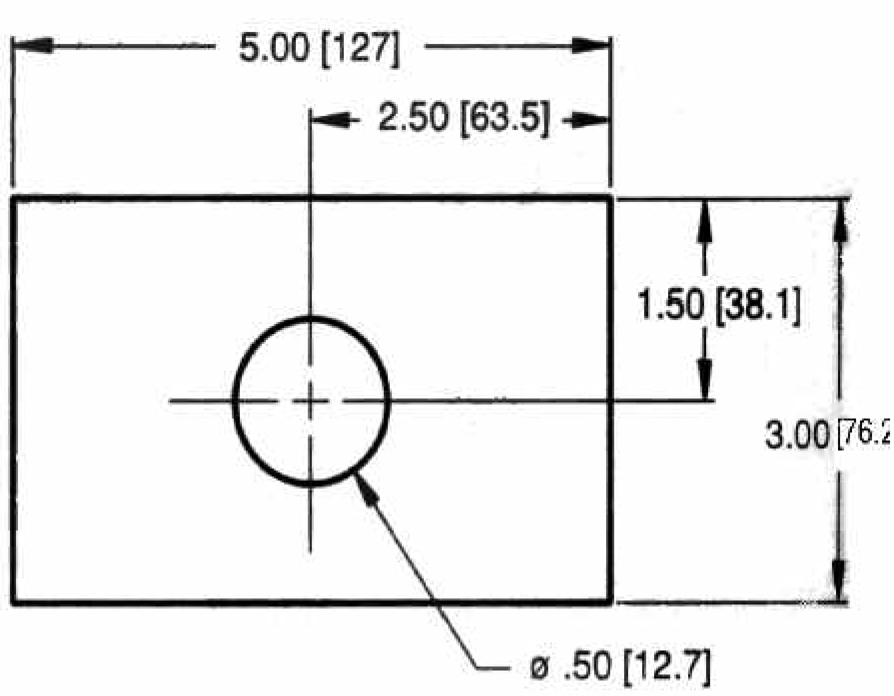
Terminology for dimensioning practice

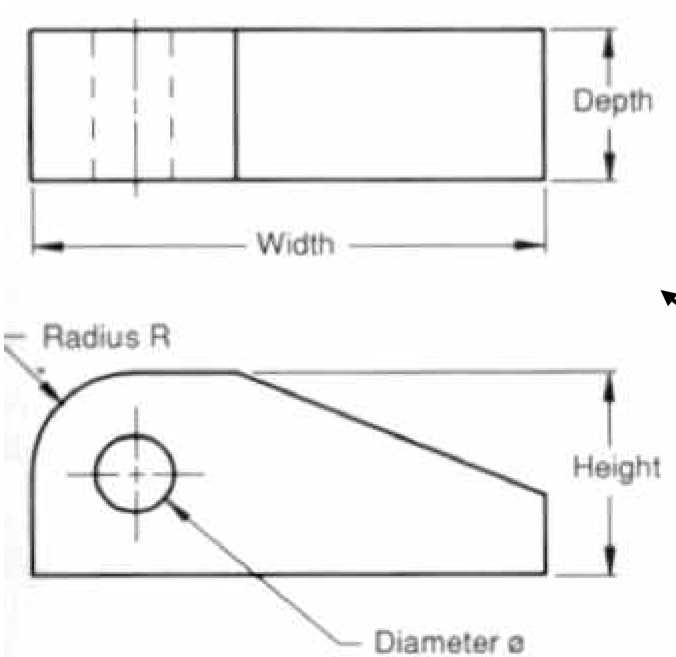
Dimension – numerical value that defines

the size or geometric characteristics of a

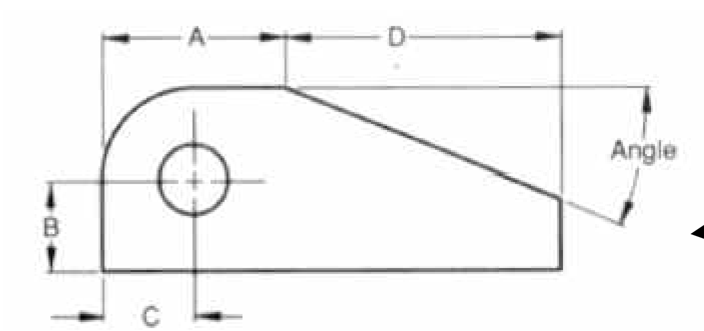
feature – **size 3.5 mm and space between**

lines of text 1.5 mm.





Dimensions showing the sizes of features, such as width, height and depths of the parts and the diameter of the hole



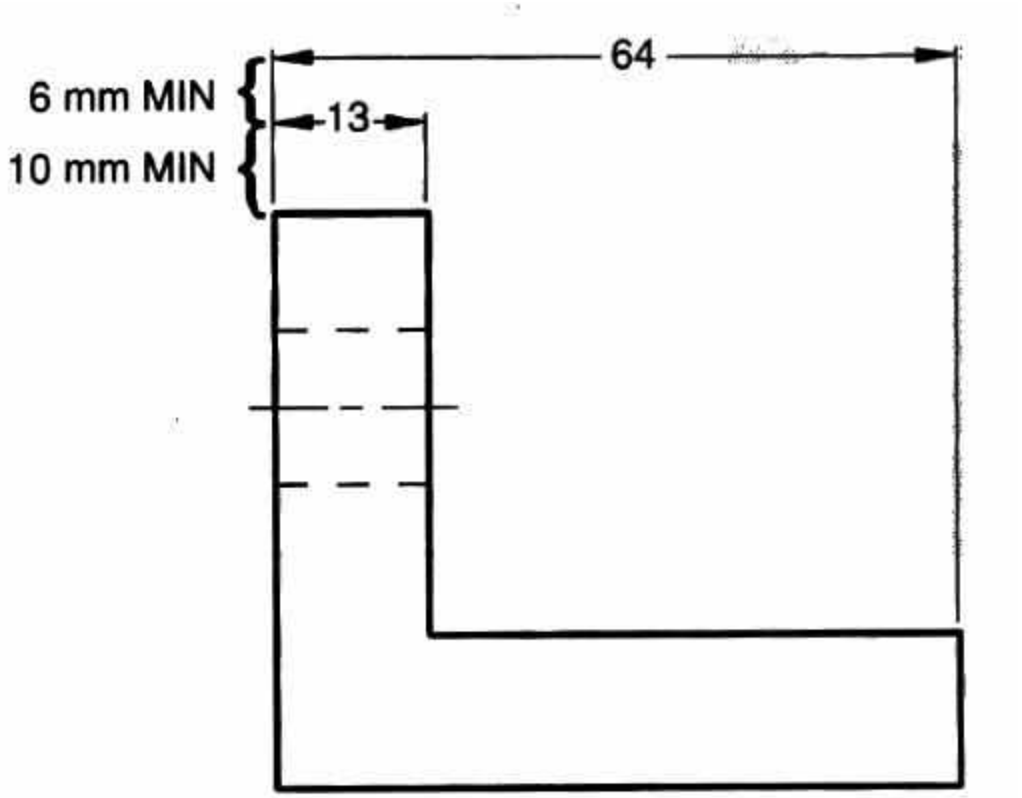
Dimensions showing the location and orientations of features, such as location of the center of the hole

Basic dimension – a numerical value defining theoretically exact size of a feature.

Reference dimension – a numerical value enclosed in parenthesis, provided for information only and not directly used in the fabrication of the part – is a calculated size used to show the intended design size of a part.

Dimension line

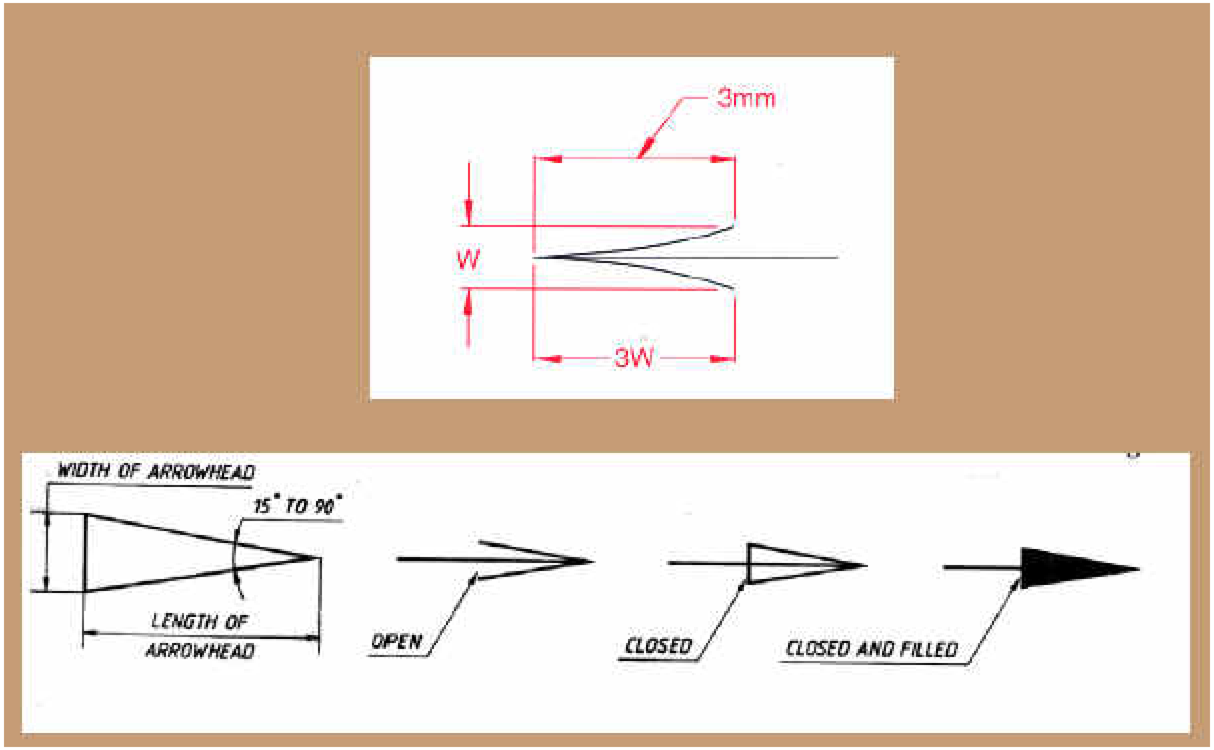
A thin, solid line that shows the extent and direction of a dimension. Dimension lines are broken for insertion of the dimension numbers.



Should be placed at least 10 mm away from the outline and all other parallel dimensions should

be at least 6 mm apart, or more if space permits

Arrows – 3 mm wide and should be 1/3rd as wide as they are long - symbols placed at the end of dimension lines to show the limits of the dimension. Arrows are uniform in size and style, regardless of the size of the drawing.



Extension line – a thin, solid line perpendicular to a dimension line, indicating which feature is associated with the dimension.

Visible gap – there should be a visible gap of **1.5 mm** between the feature's corners and the end of the extension line.

Leader line

- A thin, solid line used to indicate the feature with which a dimension, note, or symbol is associated.

- Generally a straight line drawn at an angle that is neither horizontal nor vertical.

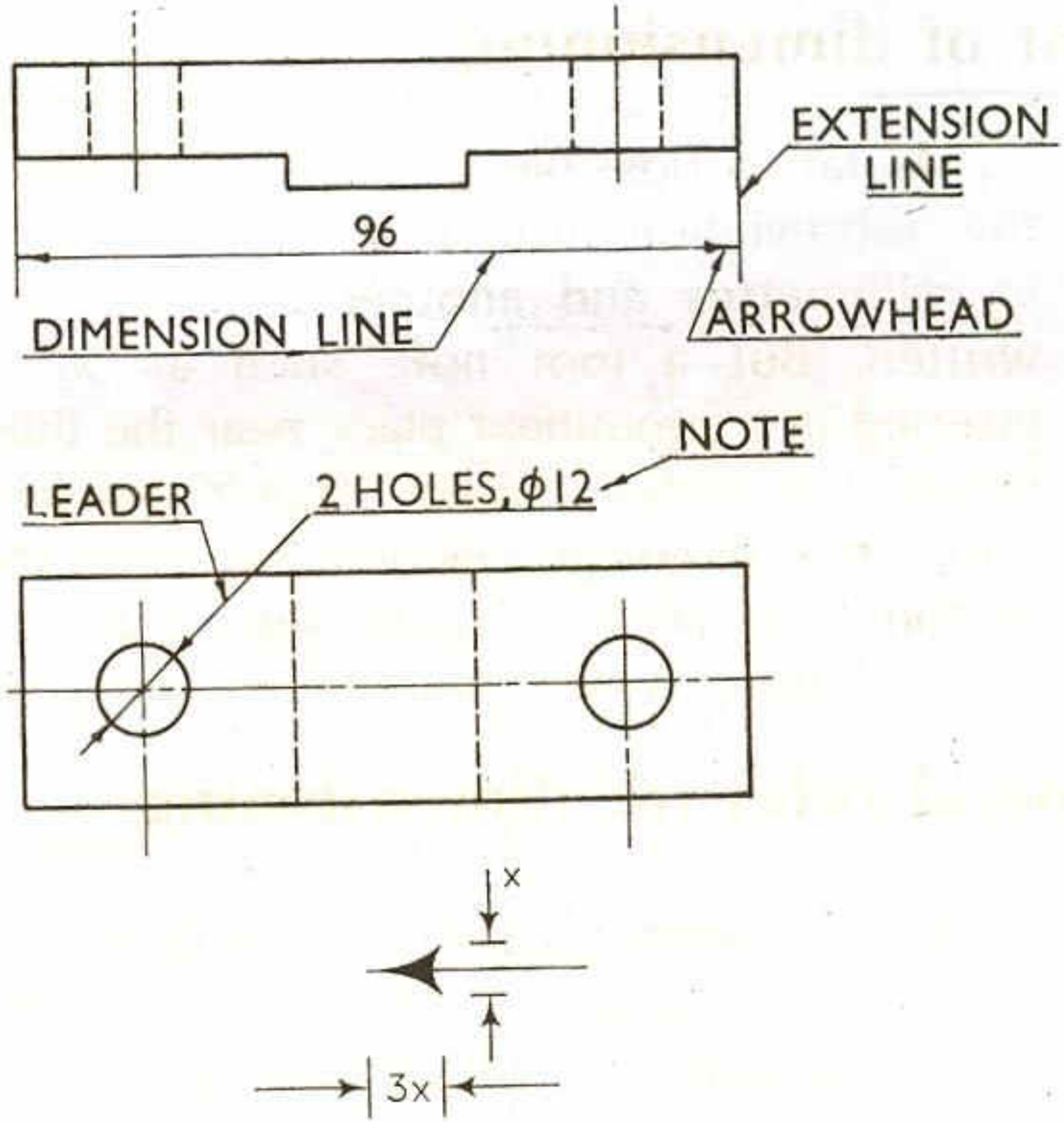
- Terminated with an arrow touching the part or detail.

- On the end opposite the arrow, the leader line will have a short, horizontal shoulder. Text is extended from this shoulder such that the text height is centered with the shoulder line.

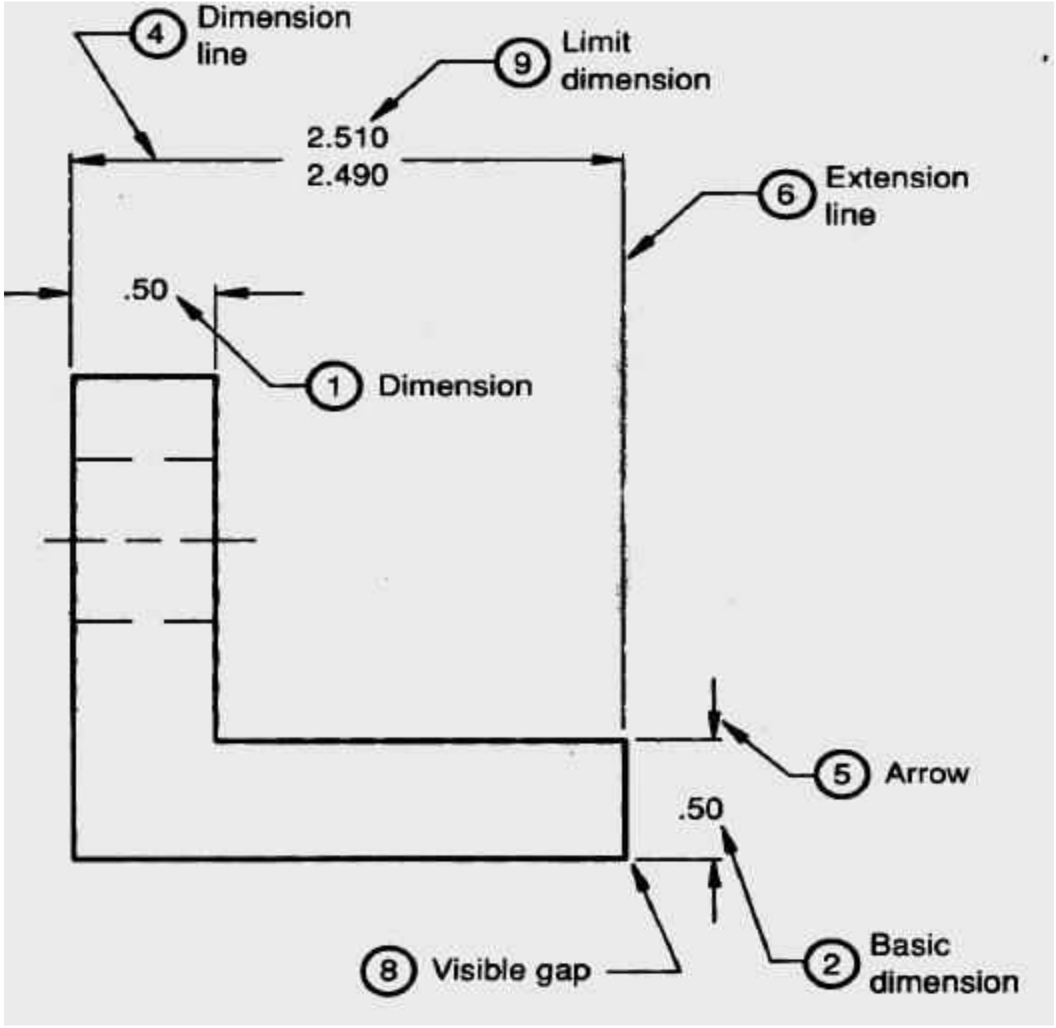
Diameter symbol – φ - a symbol which precedes a numerical value, to indicate that the dimension shows the diameter of a circle.

Radius symbol – R 0.5

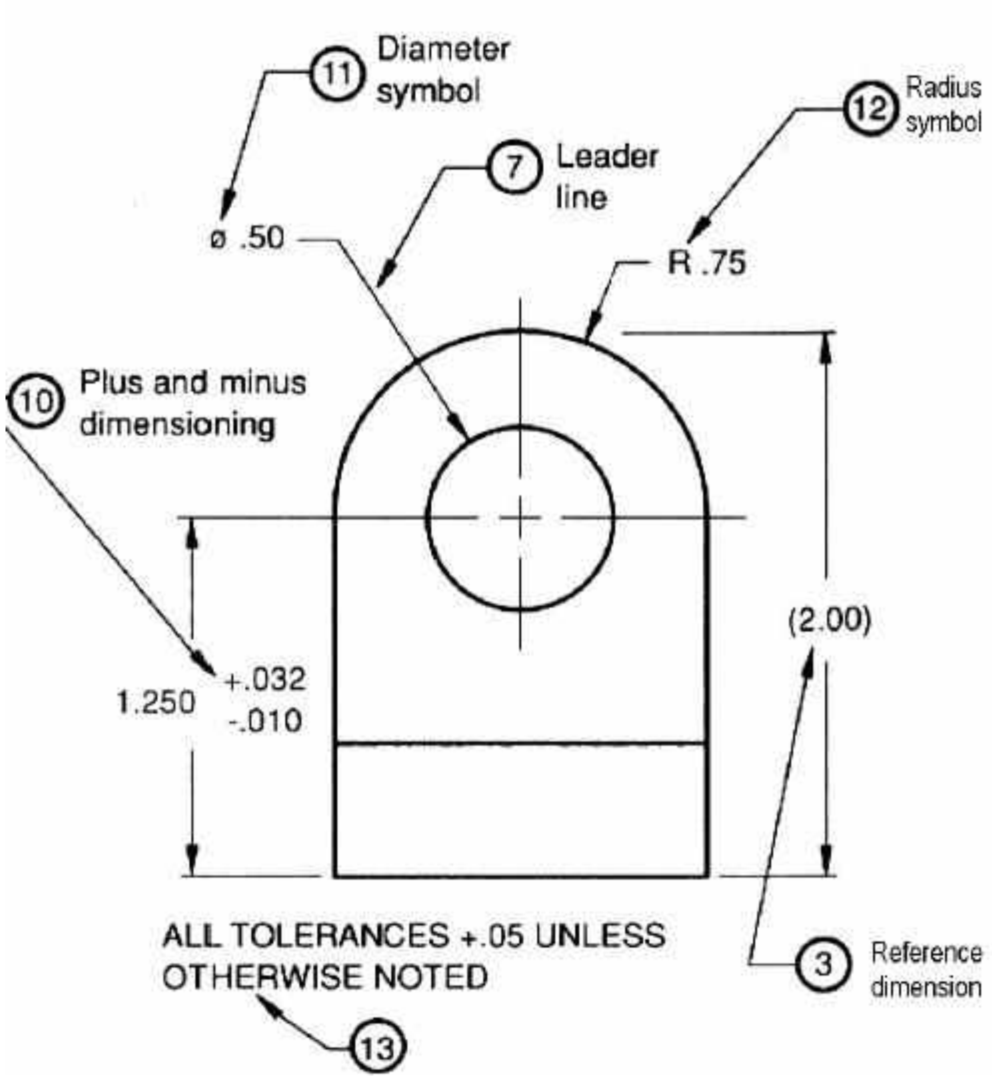
er be made.



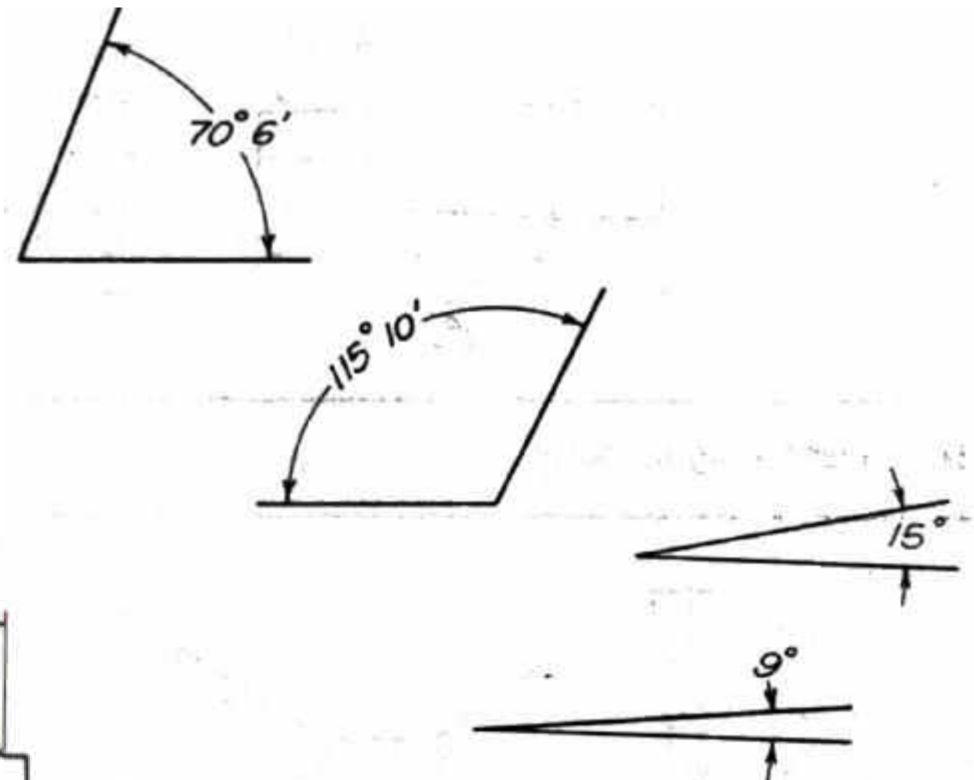
Various types of dimension lines

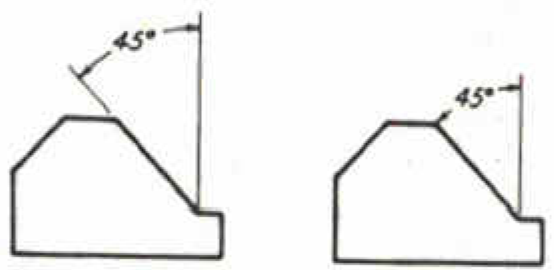


Important elements of a dimensioning



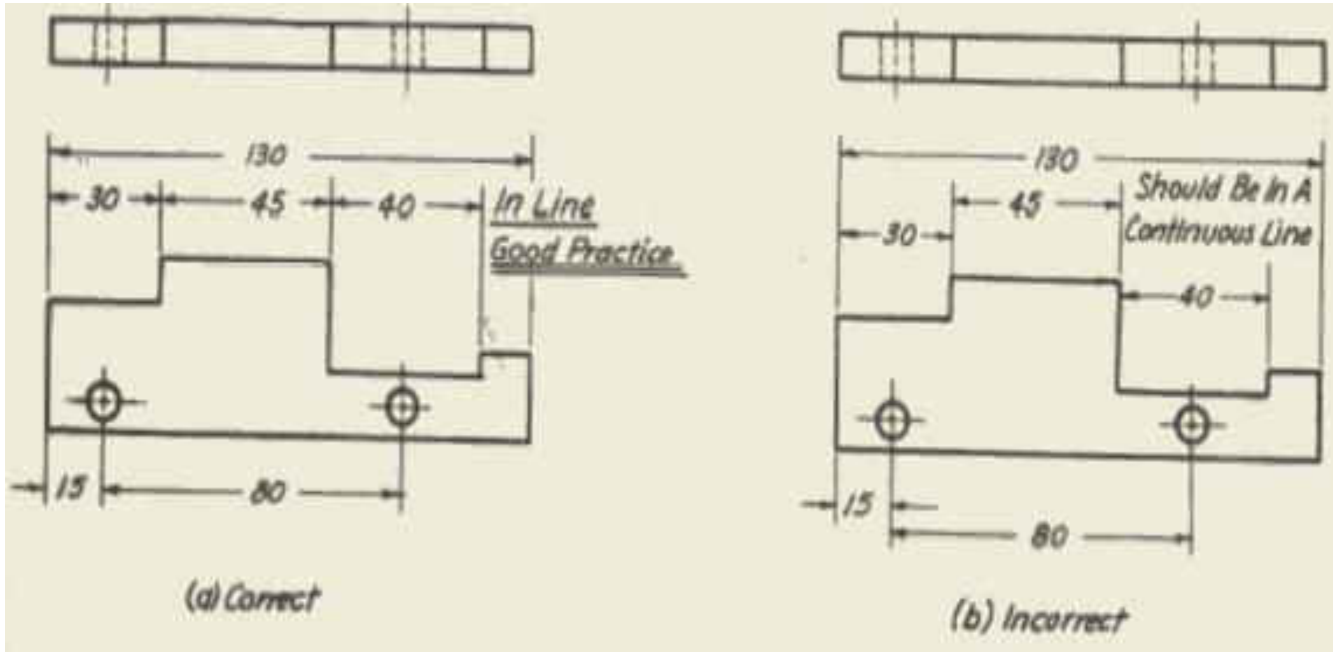
Important elements of a dimensioning

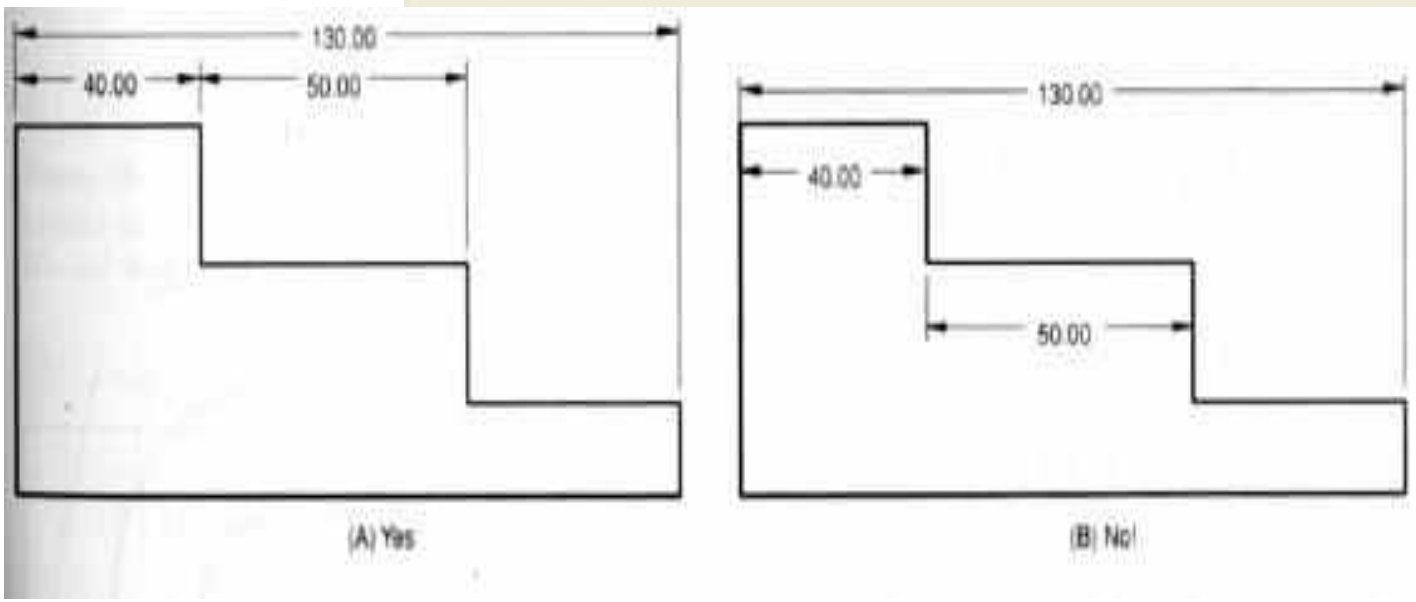




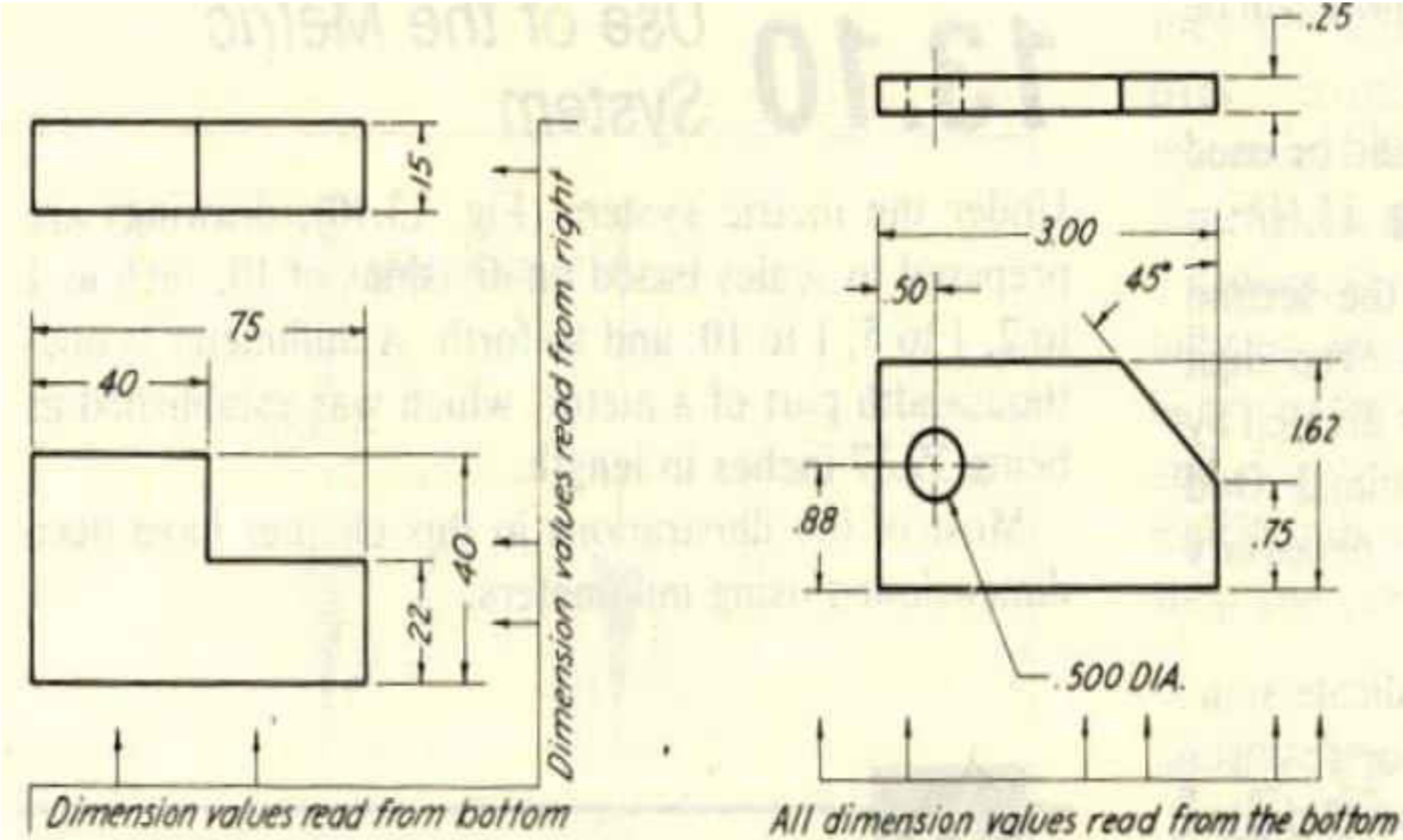
Correct   Not Recommended

Dimensioning of angles





Correct way of dimensioning



Aligned method

Unidirectional method

How to begin your drawing?

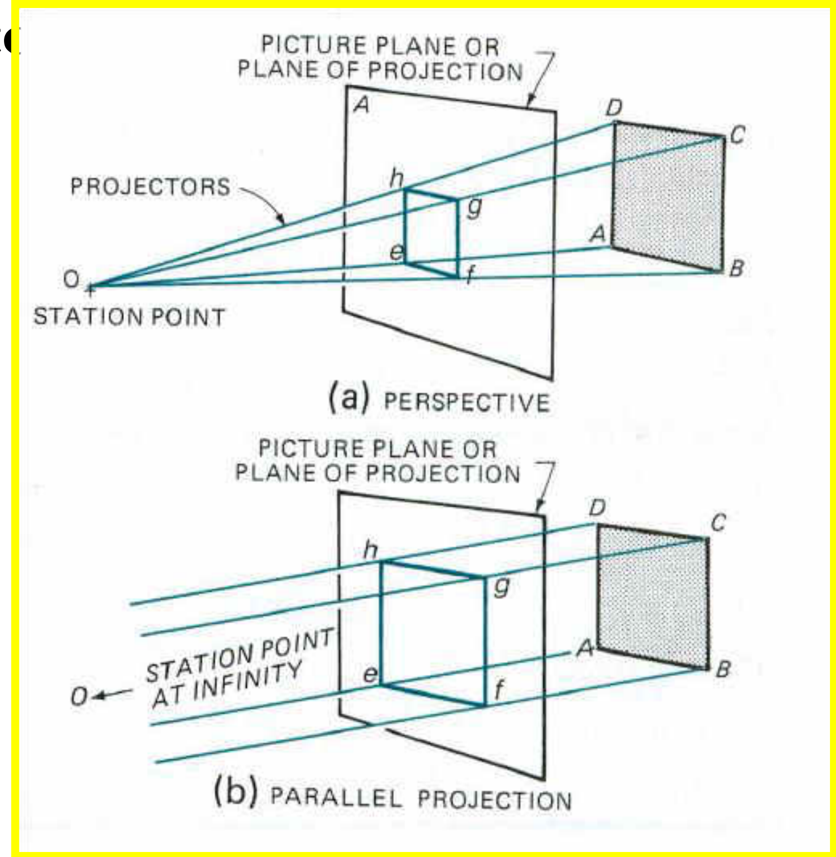
- Clean the drawing board and all the drawing
- instruments using duster.
- Fix the drawing sheet on the drawing board.
- Fix the mini-drafter in a convenient position.
- Draw border lines using HB pencil..
- Complete the title box using HB pencil .
- Plan spacing of drawings b/n two problems/views beforehand.
- Print the problem number on the left top and then
- commence the drawing work.

Isometric Views

Recap

In engineering drawing, the word 'projection' means

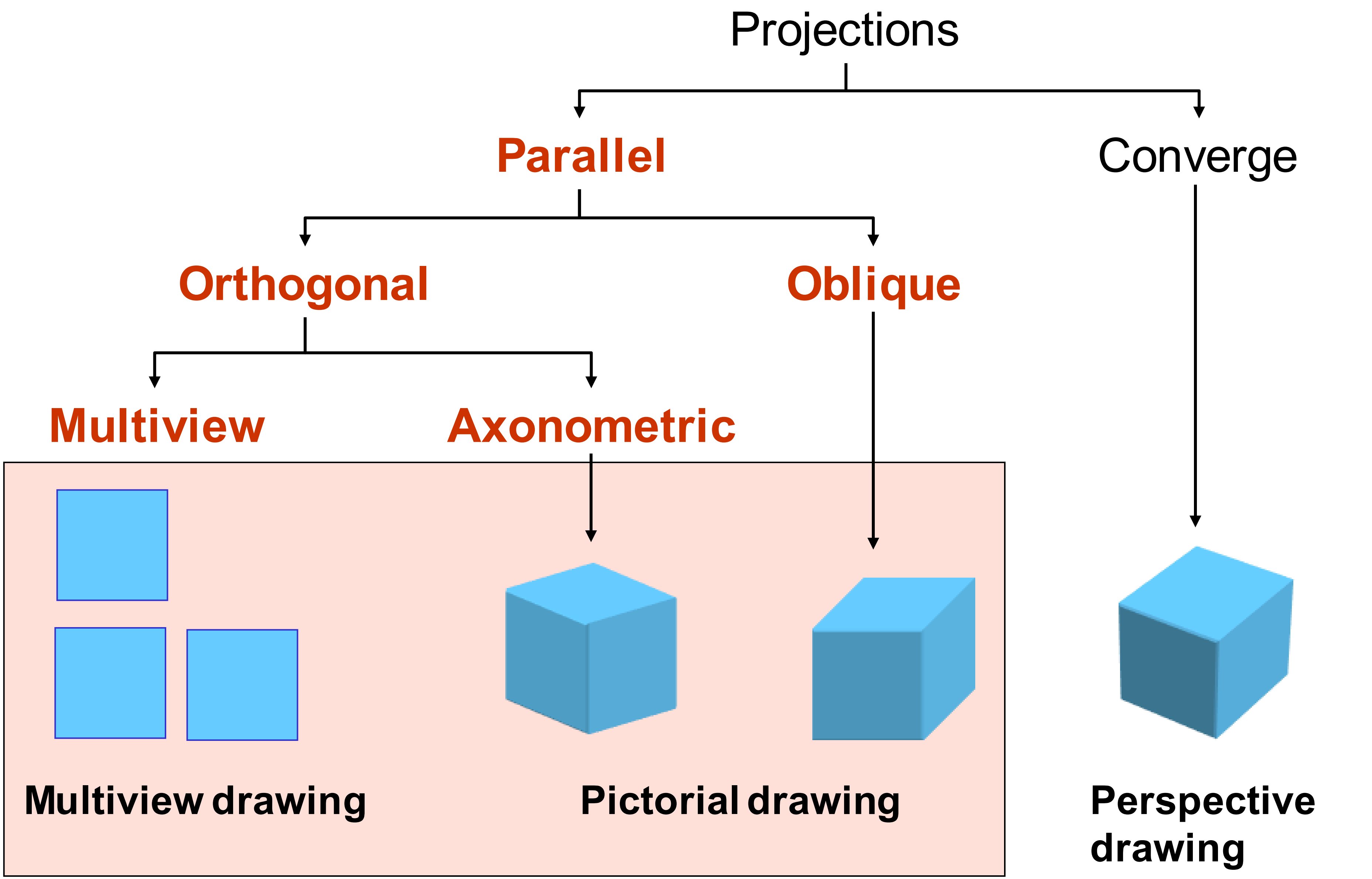
- **an image or the act of obtaining the image of an object.**
- **Technical people often refer t**



Projection System

1. **Observer or stationary point**
2. **Object**
3. **Projectors**
4. **Plane of projections (POP)**

Types of views

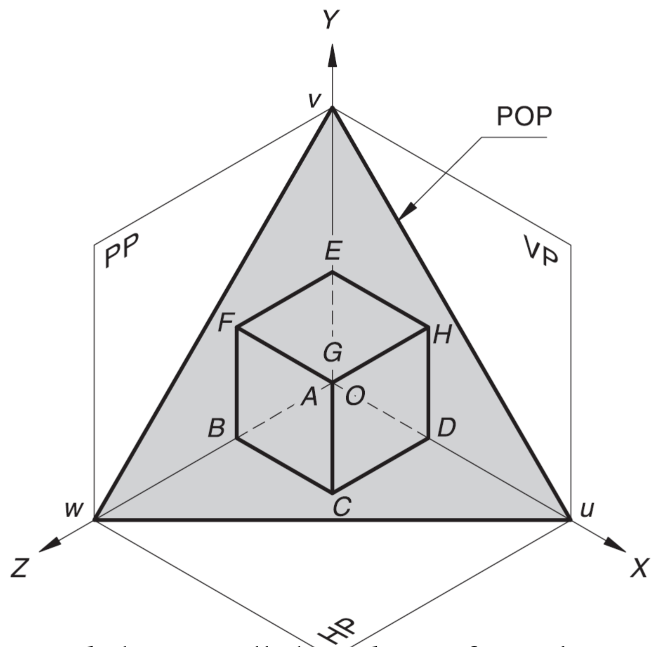


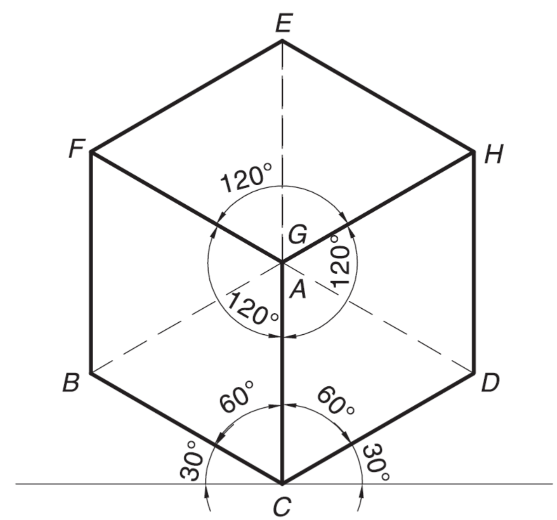
Introduction

- Isometric projection is a type of an axonometric projection (or pictorial projection).
- Isometric means ‘equal measure’.
- In isometric projection,
  – all the mutually perpendicular plane surfaces of an object and the edges formed by these surfaces are equally inclined to a POP.
- In isometric projection, only one view on a plane is drawn to represent the three dimensions of an object.
- This provides a pictorial view with a real appearance.

Principle of Isometric Projection

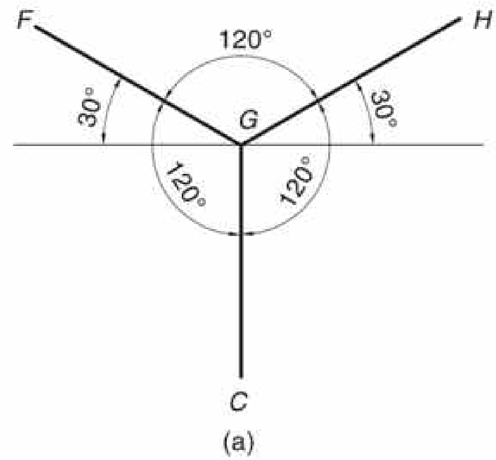
- Consider a cube *ABCDEFGH* resting on one of its corners, say *A*, at origin '*O*' and the body diagonal through that corner, i.e., *AG*, equally inclined to the three axes—*X*, *Y* and *Z*
- POP (*UVW*) makes approximately 54°44' to each RP.
- *AG* is perpendicular to the plane *UVW*
- *UVW* is called an isometric projection





Isometric Projection of a Cube

It should be noted that, as all the edges of a cube are equally inclined to the POP, they get equally foreshortened in isometric projection. Thus, the isometric projection is smaller than the real object.



Isometric Axes and Isometric Lines

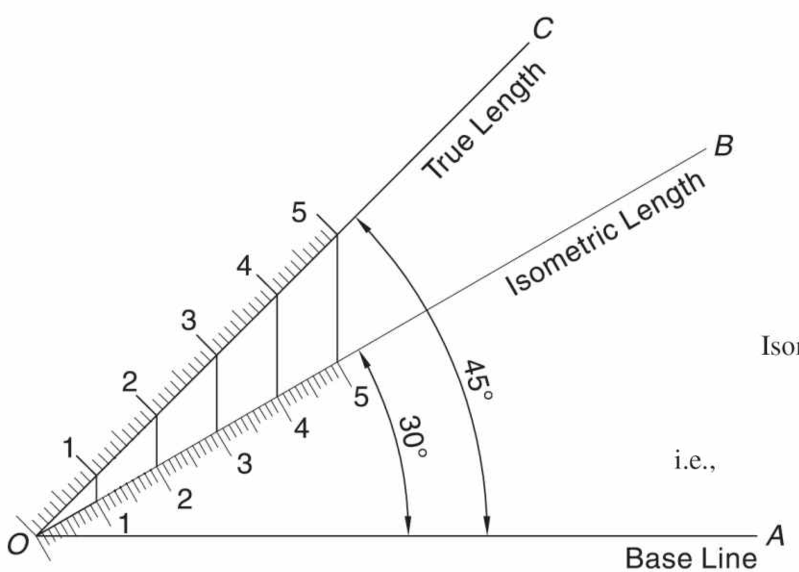
- **Isometric axes:** The three lines *GH*, *GF* and *GC* meeting at point *G* and making 120° angles with each other are termed *isometric axes*.
- **Isometric lines:** The lines parallel to the isometric axes are called isometric lines or isolines. A line parallel to the X-axis may be called an x-isoline. So are the cases of y-isoline and z-isoline.

Terminology

- **Non-Isometric lines:** The lines which are not parallel to isometric axes are called non-isometric lines or non-isolines.
- **Isometric planes:** The planes representing the faces of the cube as well as other faces parallel to these faces are called isometric planes or isoplanes. Note that isometric planes are always parallel to any of the planes formed by two isometric axes.
- **Non-Isometric planes:** The planes which are not parallel to isometric planes are called nonisometric planes or non-isoplanes (or non-isometric faces).
- **Origin or Pole Point:** The point on which a given object is supposed to be resting on the HP or ground such that the three isometric axes originating from that point make equal angles to POP is called an origin or pole point.

Isometric Scale

- The isometric projection appears smaller that the real object.
- Because all the isometric lines get equally foreshortened.
- The proportion by which isometric lines get foreshortened in an isometric projection is called *isometric scale*.
- It is the ratio of the isometric length to the actual length.



$$\text{Isometric scale} = (\text{Isometric length/True length}) = \frac{\cos 45°}{\cos 30°} = \frac{1}{\sqrt{2}} \div \frac{\sqrt{3}}{2} = \frac{\sqrt{2}}{\sqrt{3}} = 0.8165$$

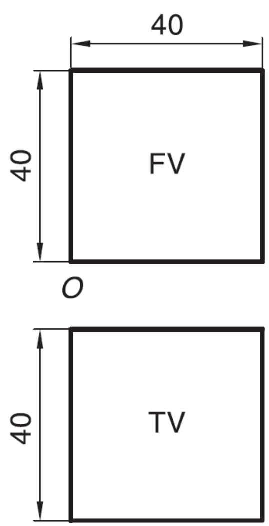
$$= 82\% \text{ (approximately)}$$

i.e.,

$$\boxed{\text{Isometric length} = 0.82^* \text{ True length}}$$

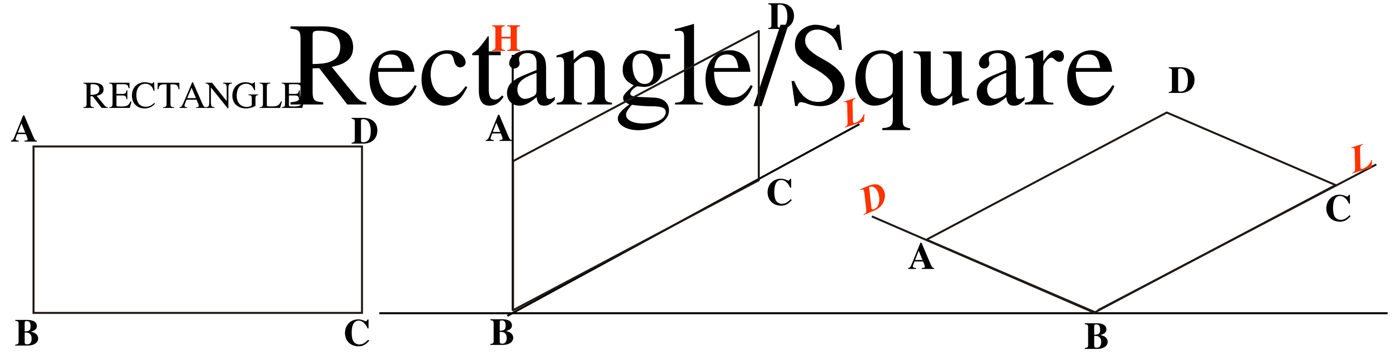
Isometric Projections and Isometric Views

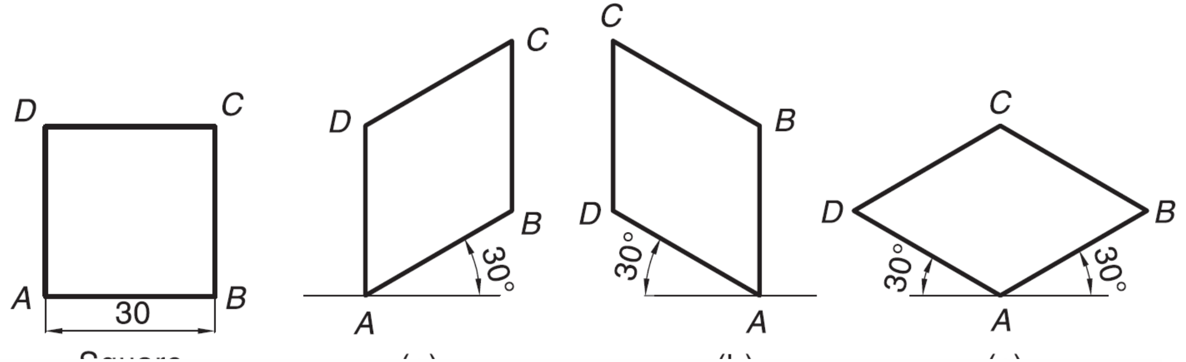
- Isometric projection is often constructed using isometric scale which gives dimensions smaller than the true dimensions.
- However, to obtain isometric lengths from the isometric scale is always a cumbersome task.
- Standard practice is to keep all dimensions as it is. The view thus obtained is called *isometric view* or *isometric drawing*.
- As the isometric view utilizes actual dimensions, the isometric view of the object is seen larger than its isometric projection.

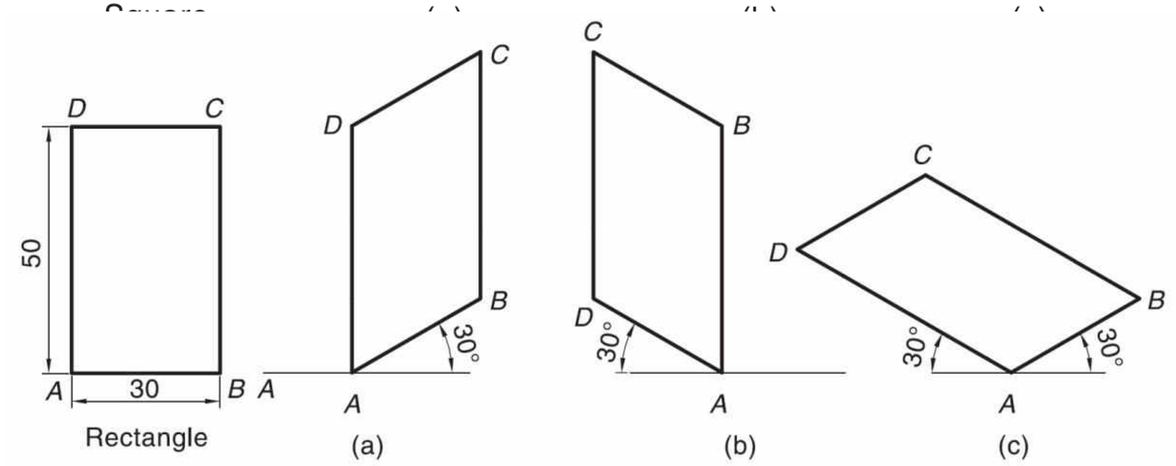


Orthographic Views

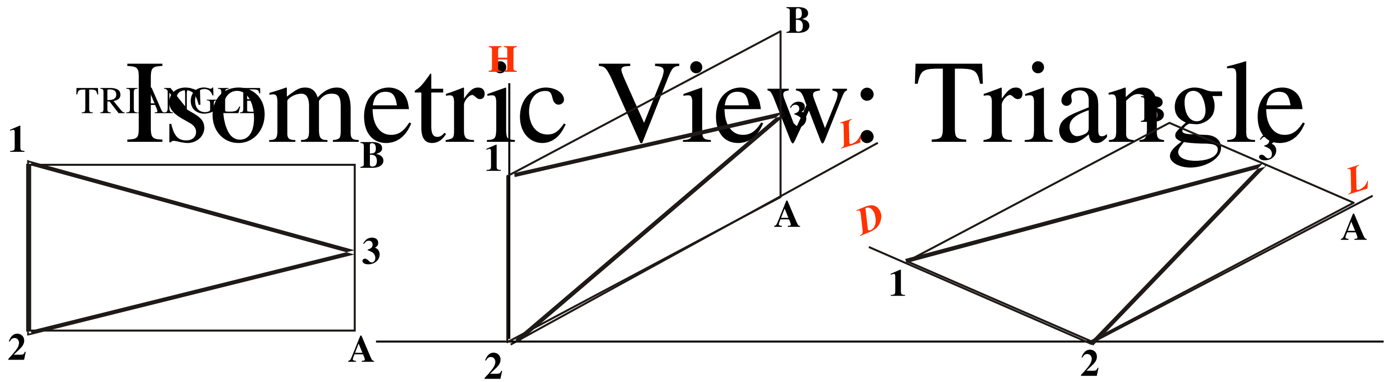
Isometric View: Rectangle/Square

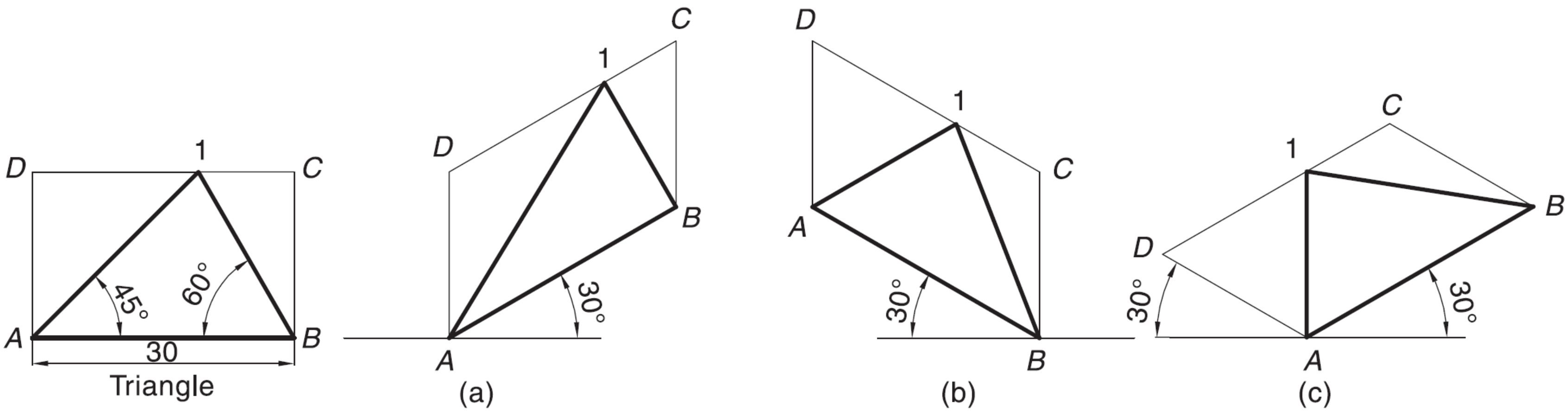




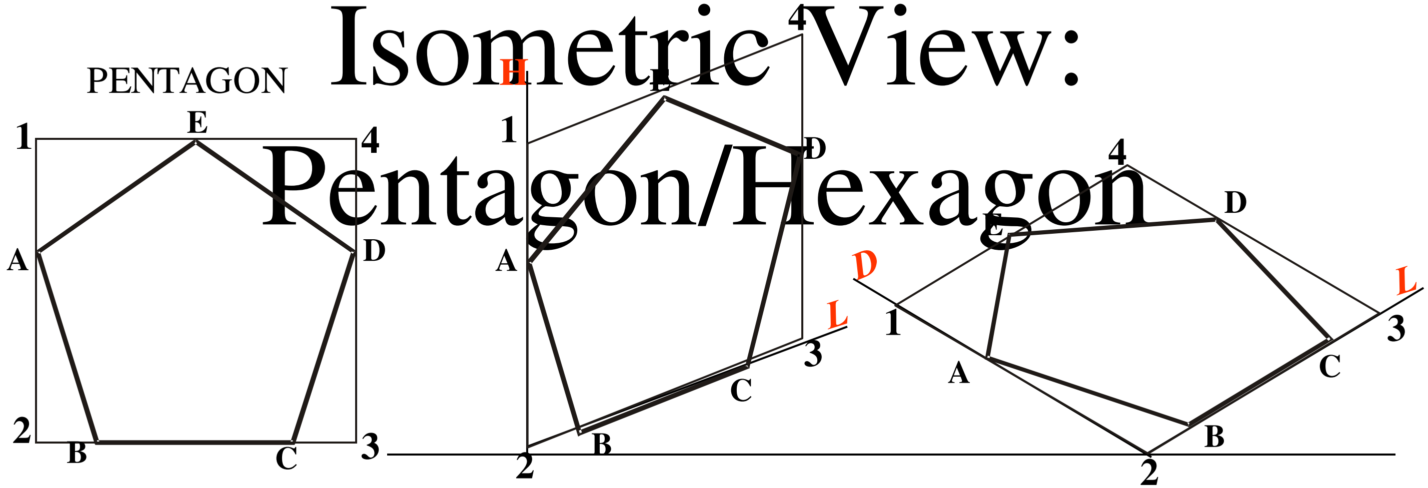


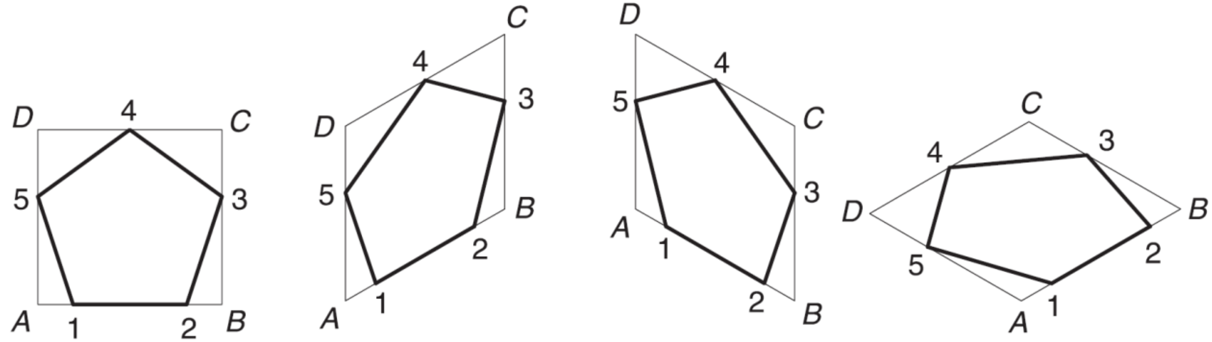
Isometric View: Triangle



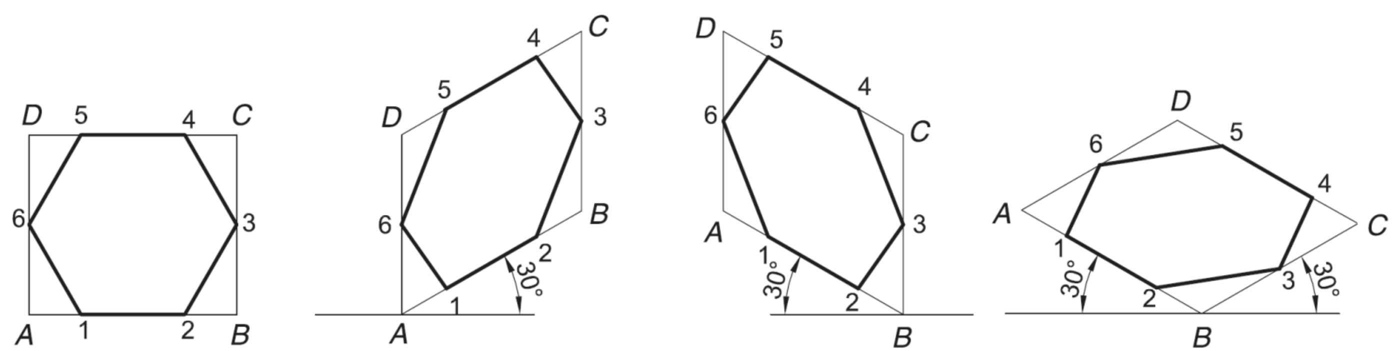


Isometric View: Pentagon/Hexagon



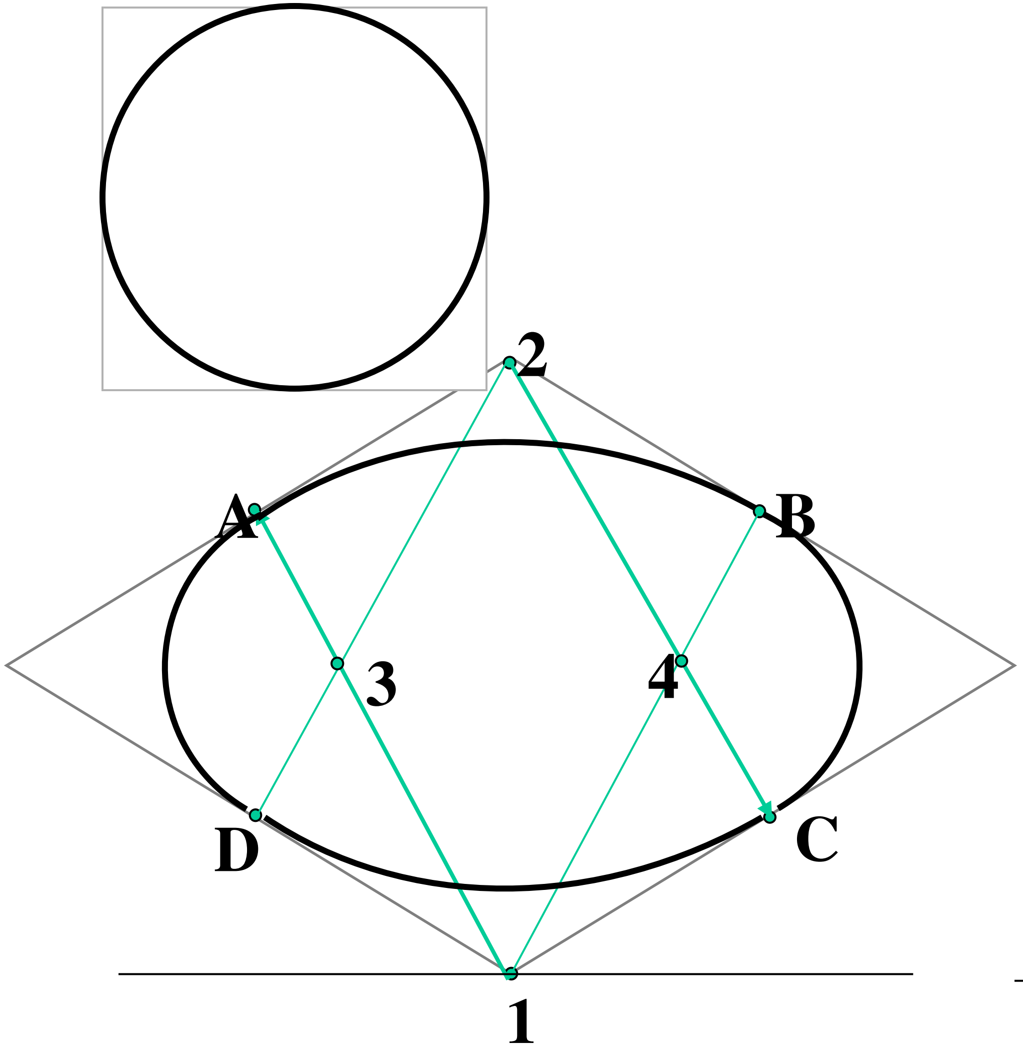


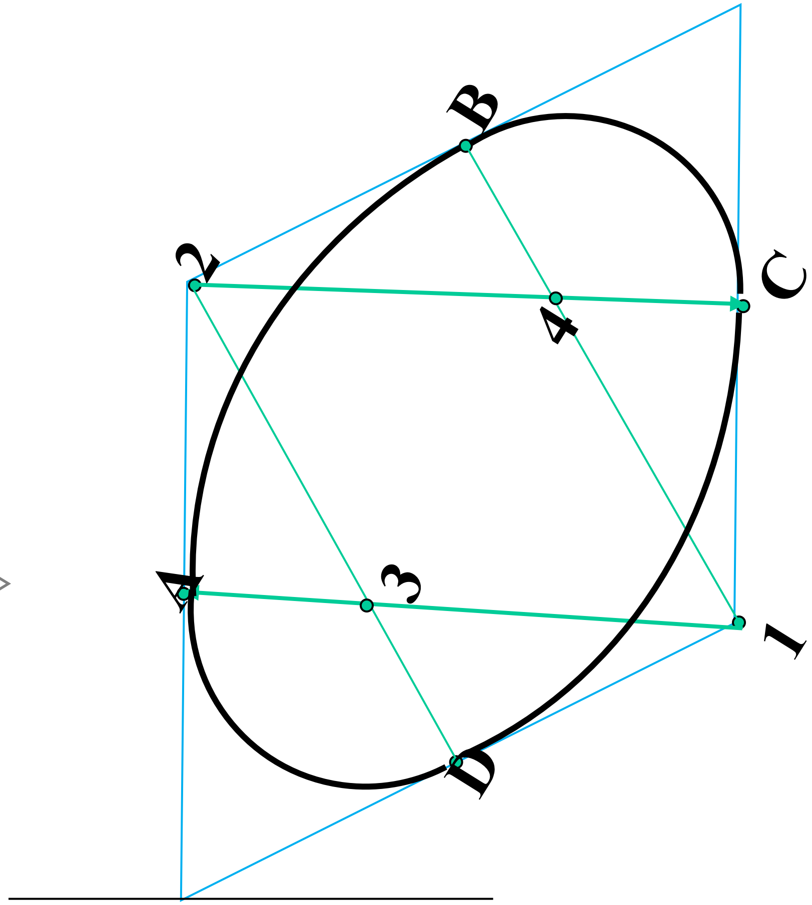
Pentagon (a) (b) (c)



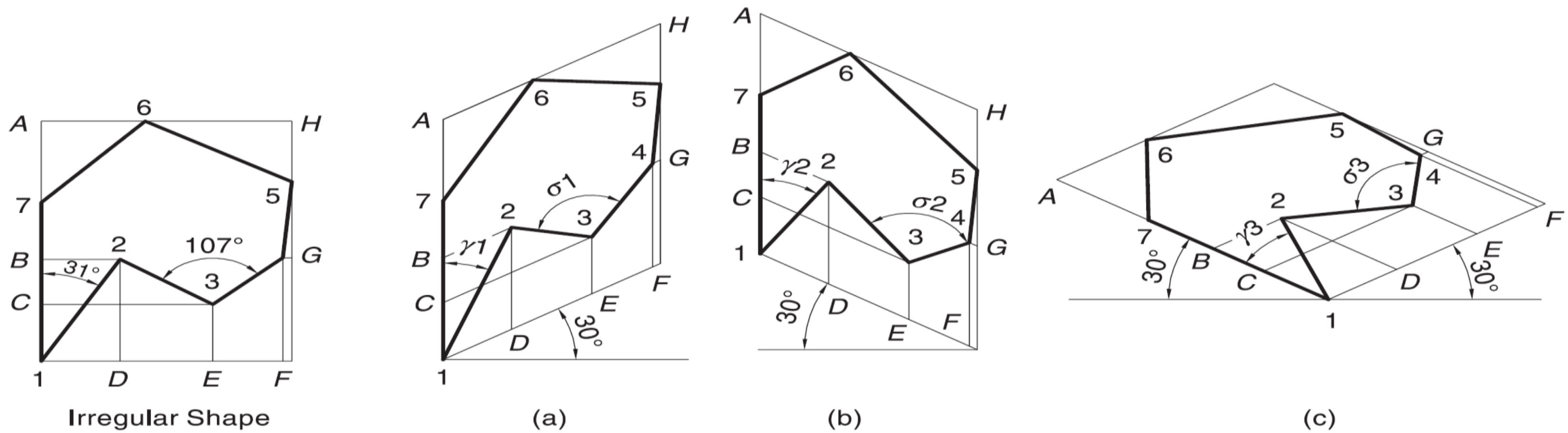
HEXAGON (a) (b) (c)

Isometric View: Circle





Isometric View: Irregular Shape

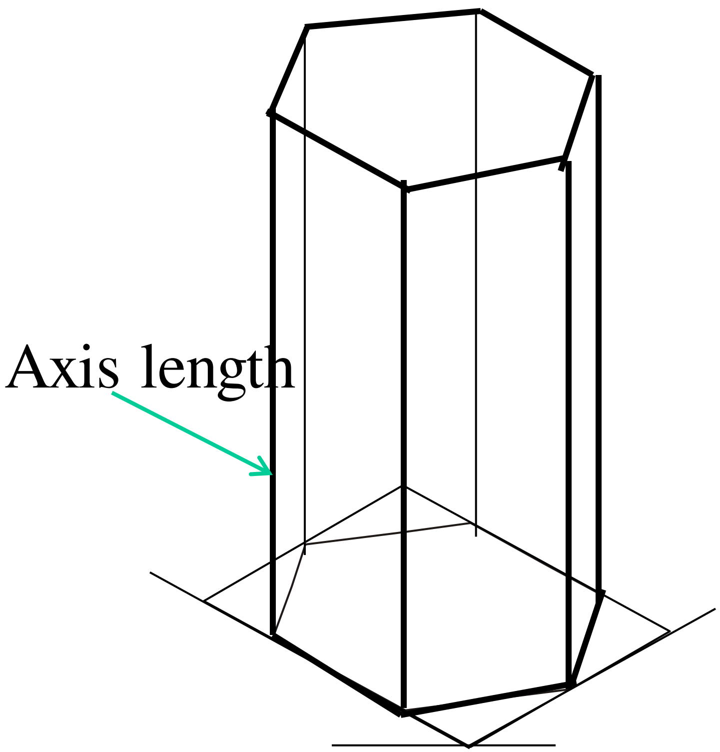


The isolines *B*–2, *D*–2, *C*–3, *E*–3, *G*–4, *F*–4, *H*–5, *H*–6 and *A*–7 has the same length as in original shape, e.g., *B*–2 in isometric = *B*–2 in irregular shape.

1. Non-isometric line can be located by its end points.

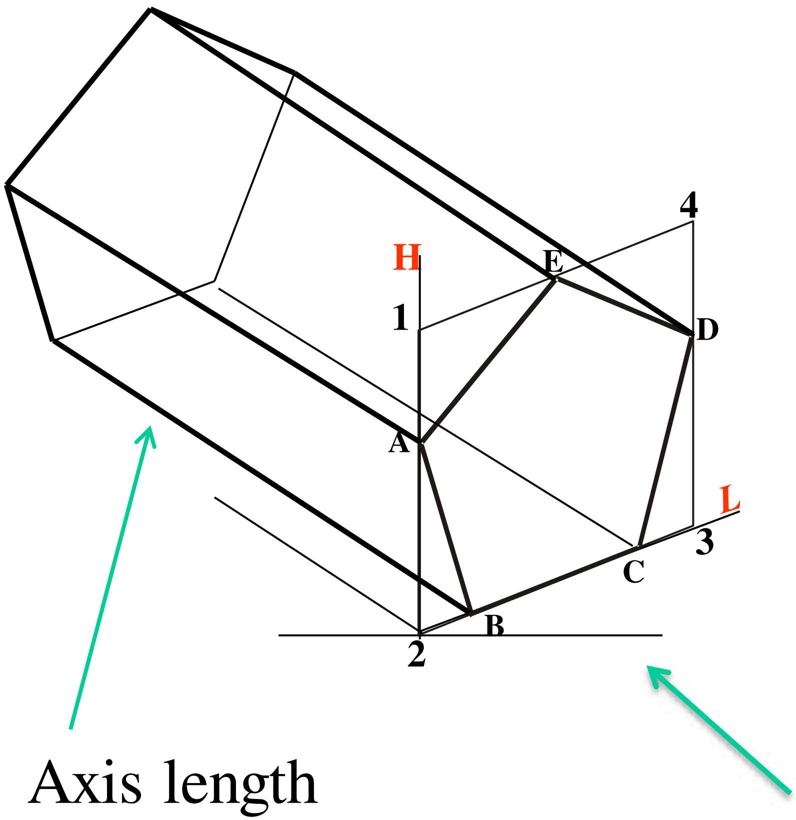
2. Similarly, an angle in orthographic view is never seen in its isometric.

Isometric View: Prism



ISOMETRIC VIEW OF
HEXAGONAL PRISM
STANDING ON H.P.

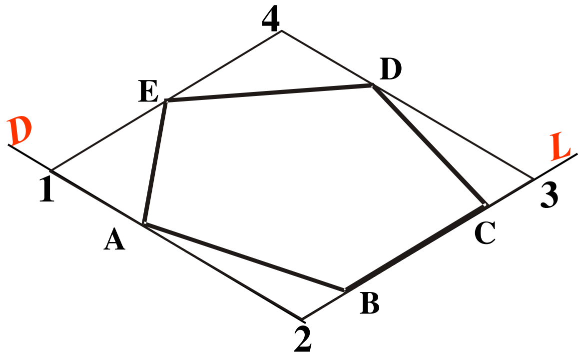
ISOMETRIC VIEW OF
PENTAGONAL PRISM
LYING ON H.P.

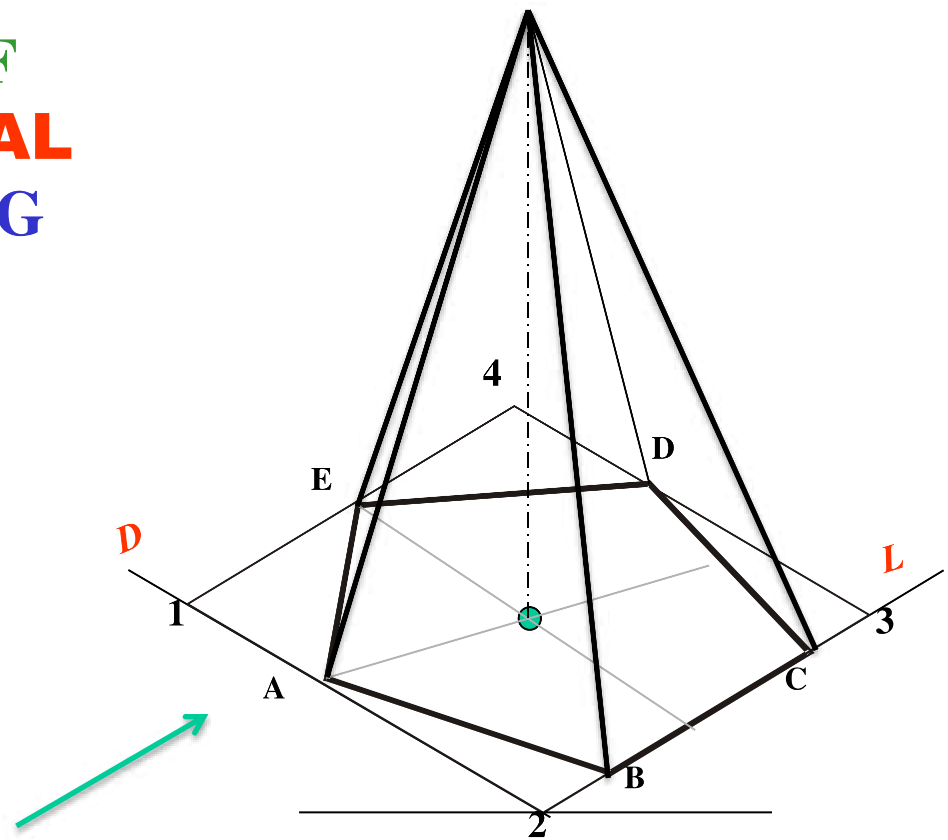


ISOMETRIC VIEW OF **PENTAGONAL PYRAMID** STANDING ON H.P. (Height is added from center of pentagon)

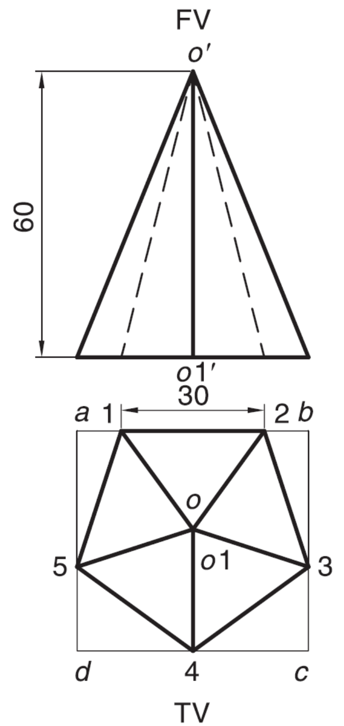
Isometric View: Pyramid

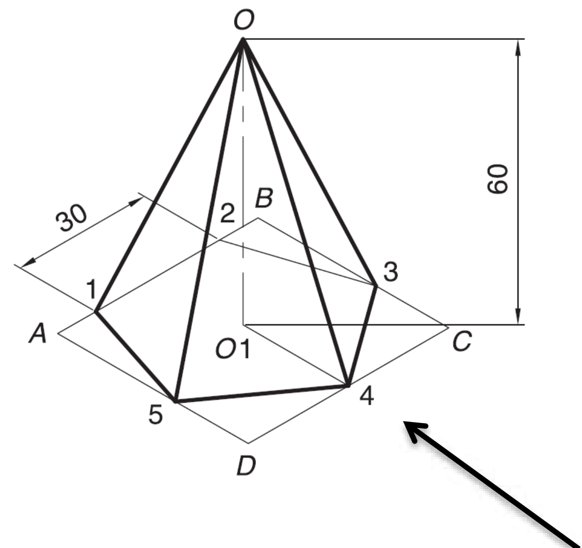
ISOMETRIC VIEW OF BASE OF PENTAGONAL PYRAMID STANDING ON H.P.



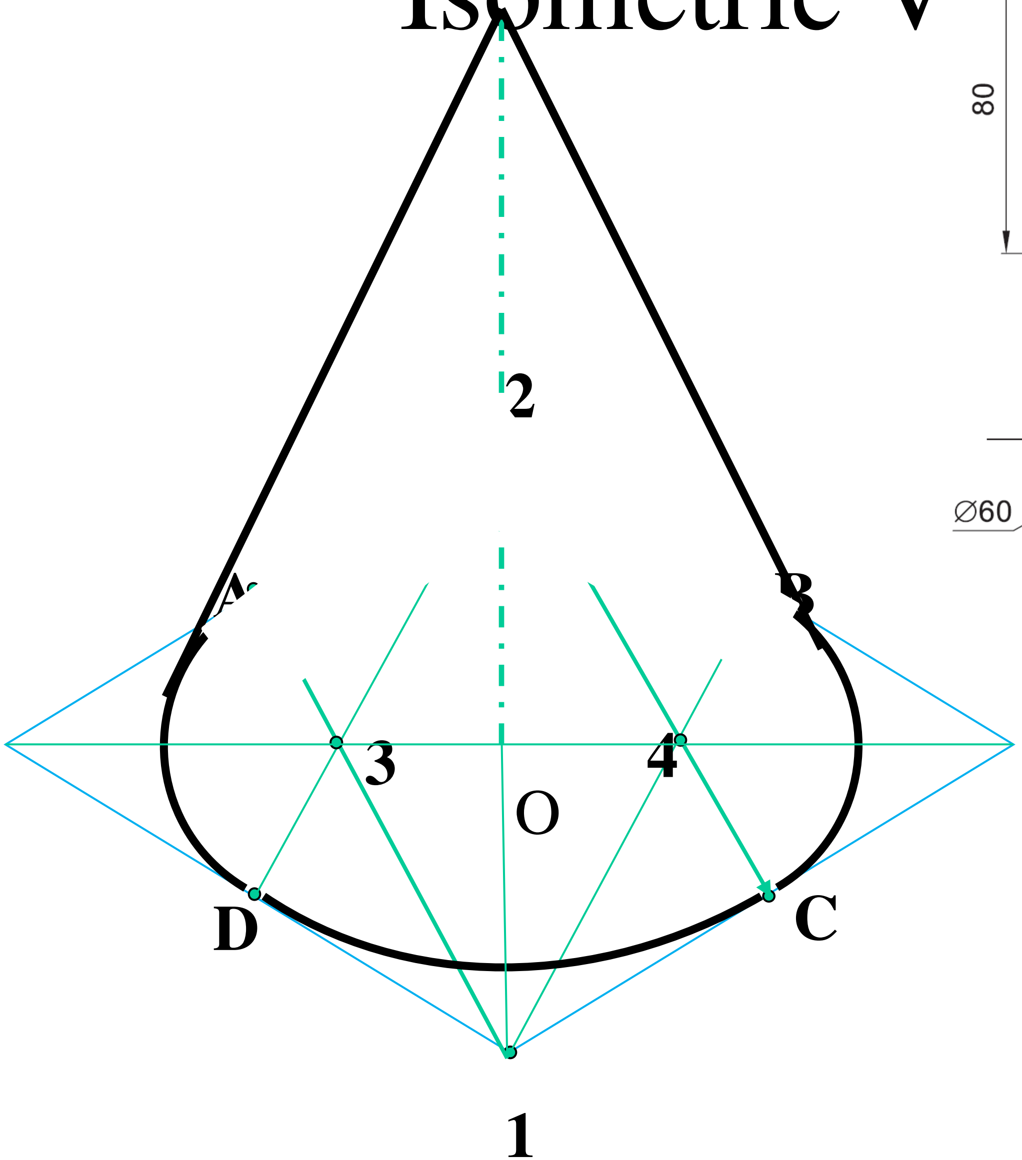


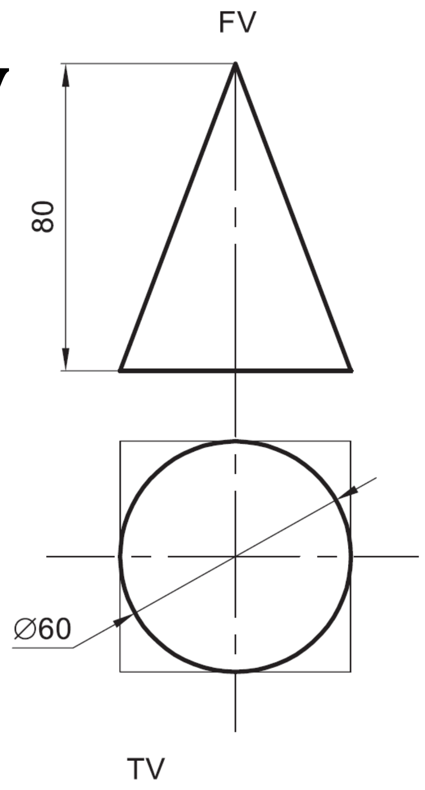
Isc nid

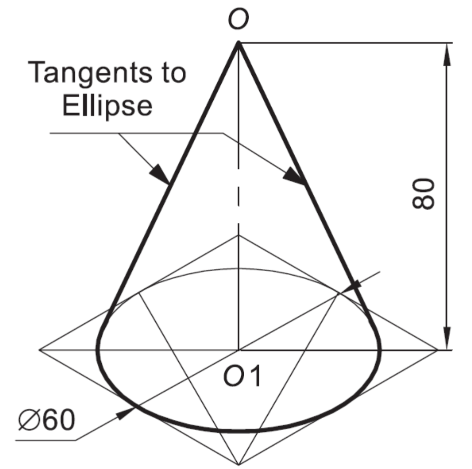




Isometric V

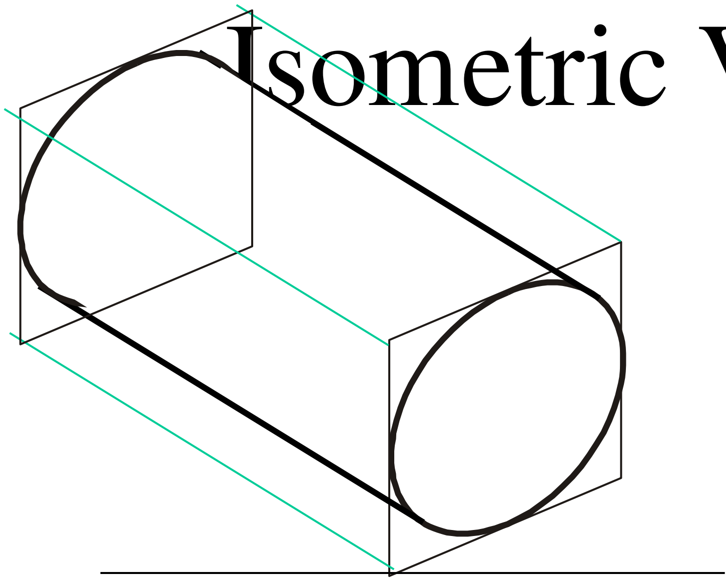


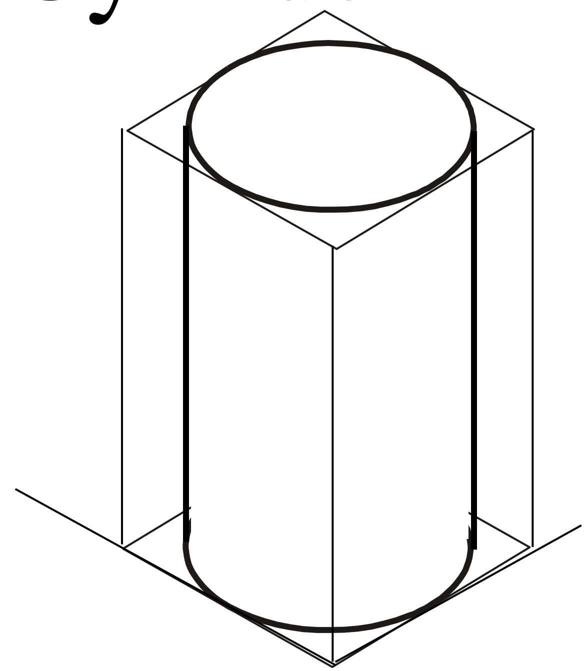




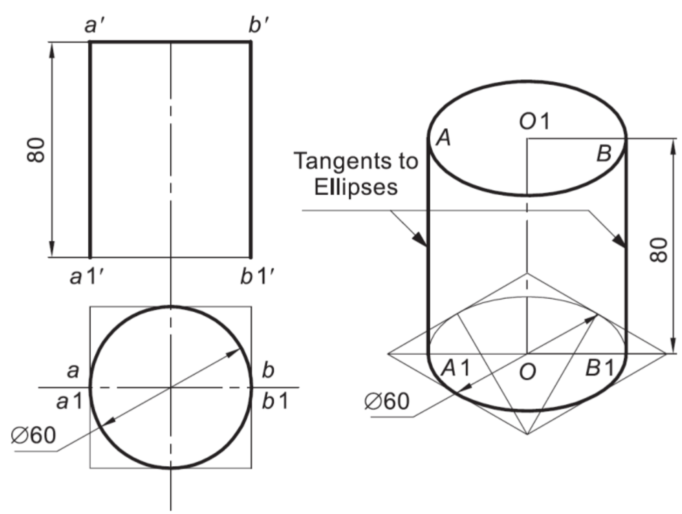
Isometric View: Cylinder

CYLINDER STANDING ON H.P.

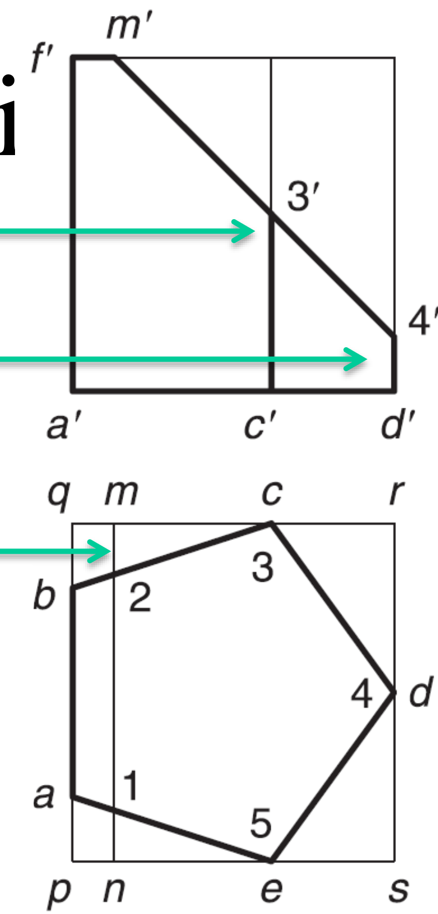




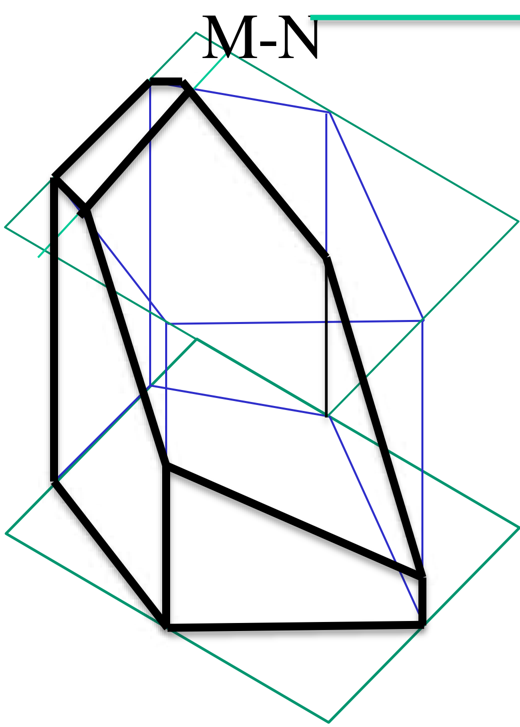
CYLINDER LYING ON H.P.



Solids with Non-Isometri

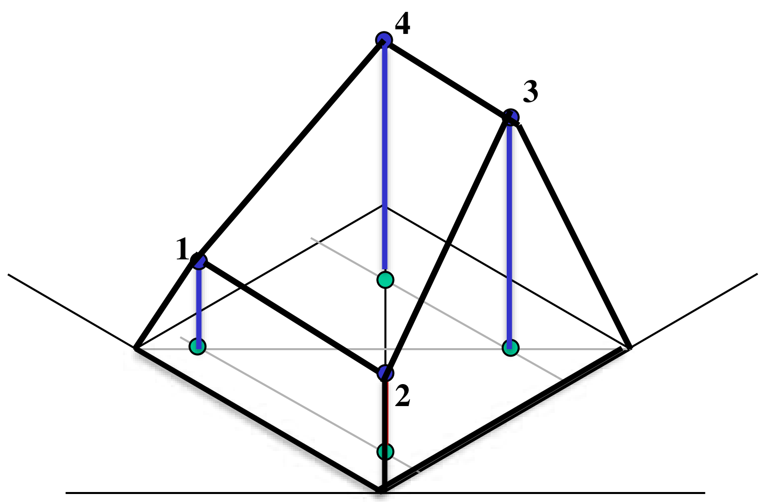


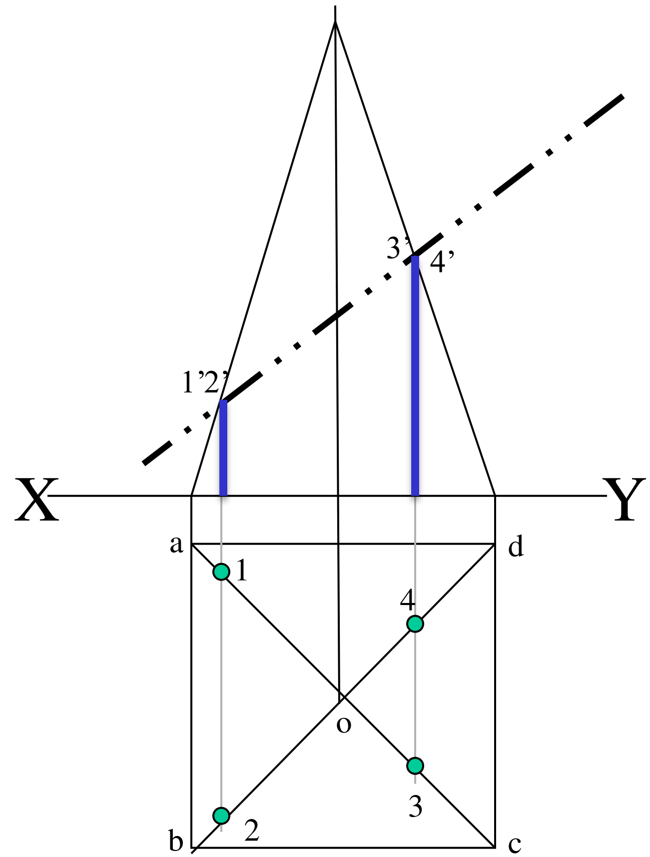
- C-3=E-5=c’-3’
- D-4=d’-4’



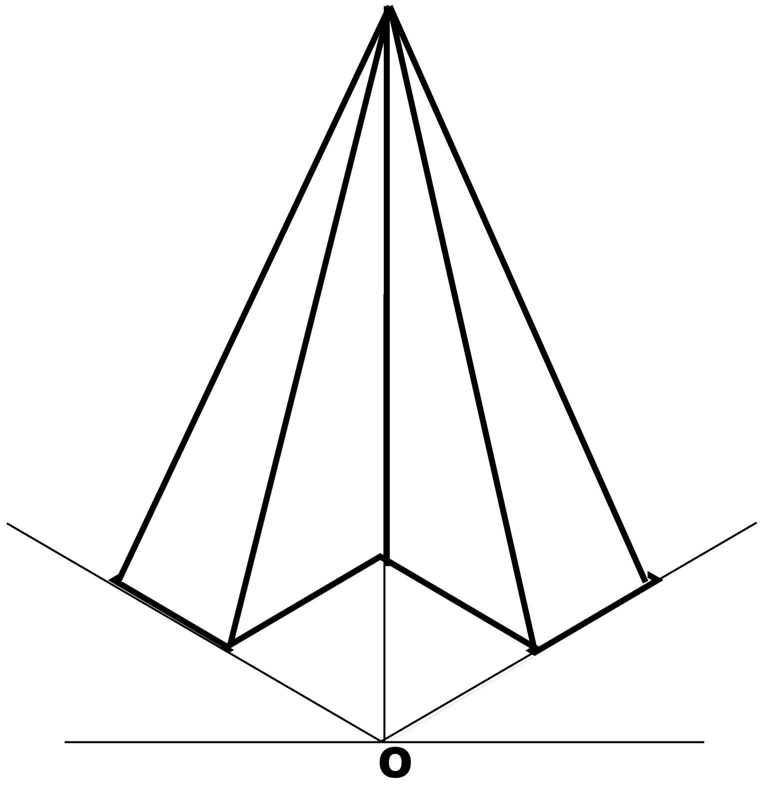
Solids with Non-Isometric Faces

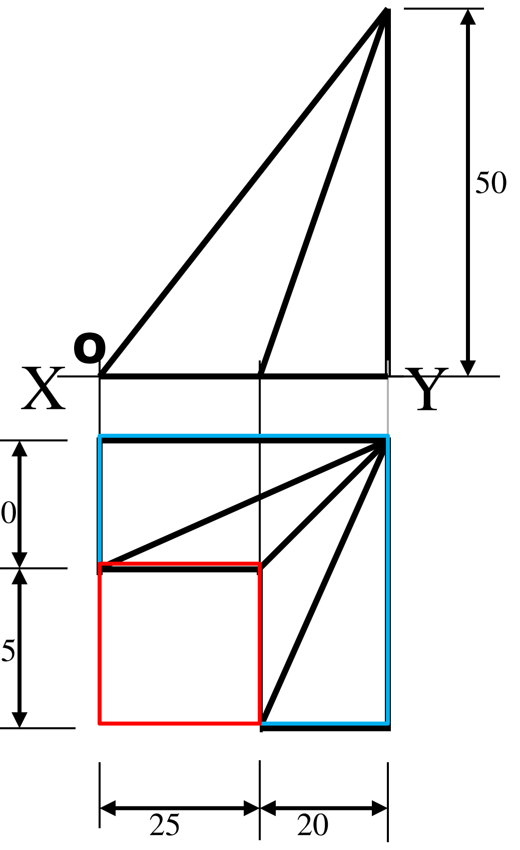
A SQUARE PYRAMID OF 40 MM BASE SIDES AND 60 MM AXIS IS CUT BY AN INCLINED SECTION PLANE THROUGH THE MID POINT OF AXIS AS SHOWN. DRAW ISOMETRIC VIEW OF SECTION OF PYRAMID.





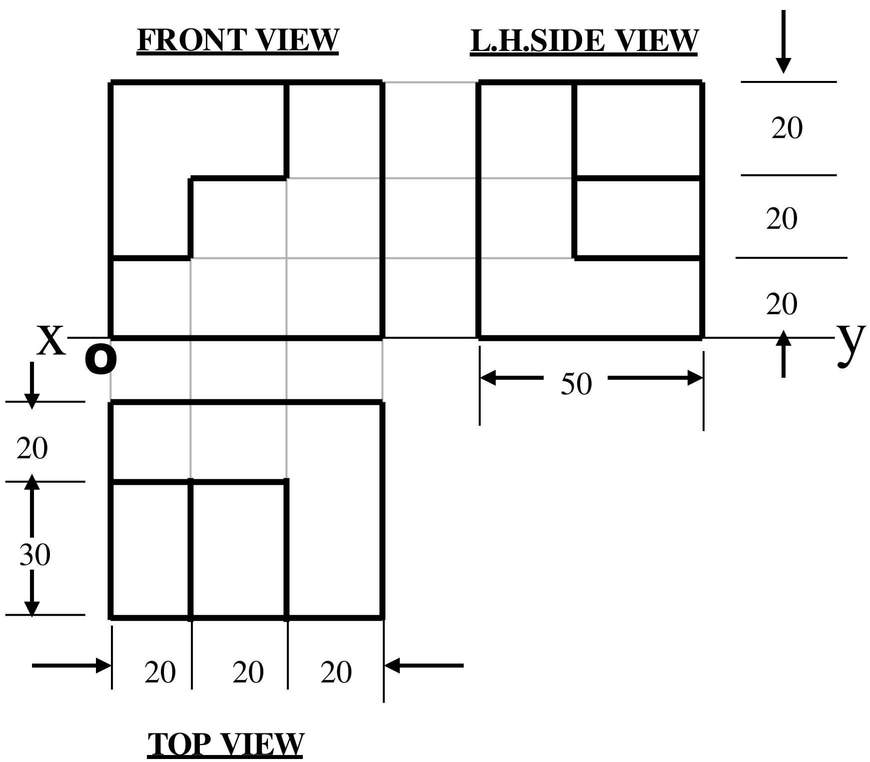
F.V. & T.V. of a solid are given. Draw it's isometric view.

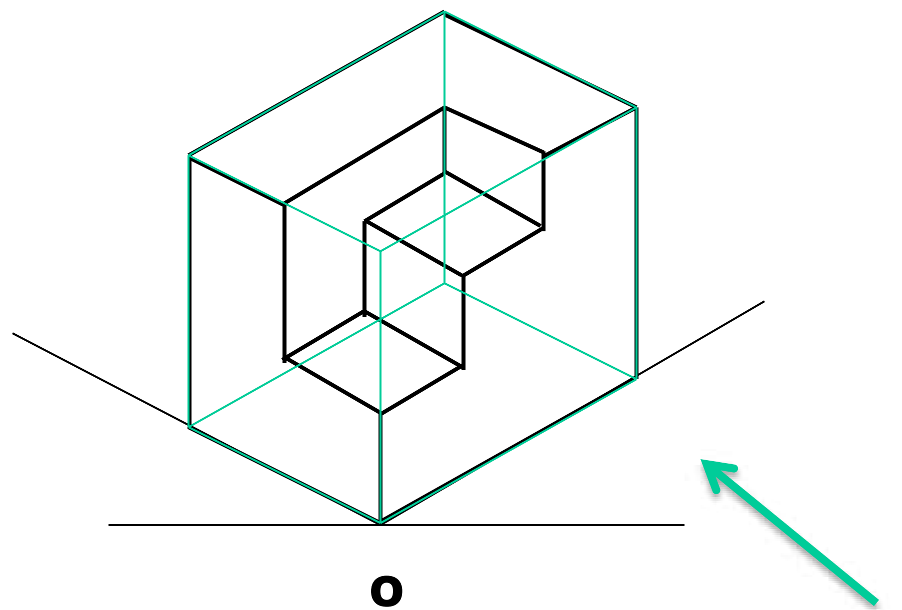




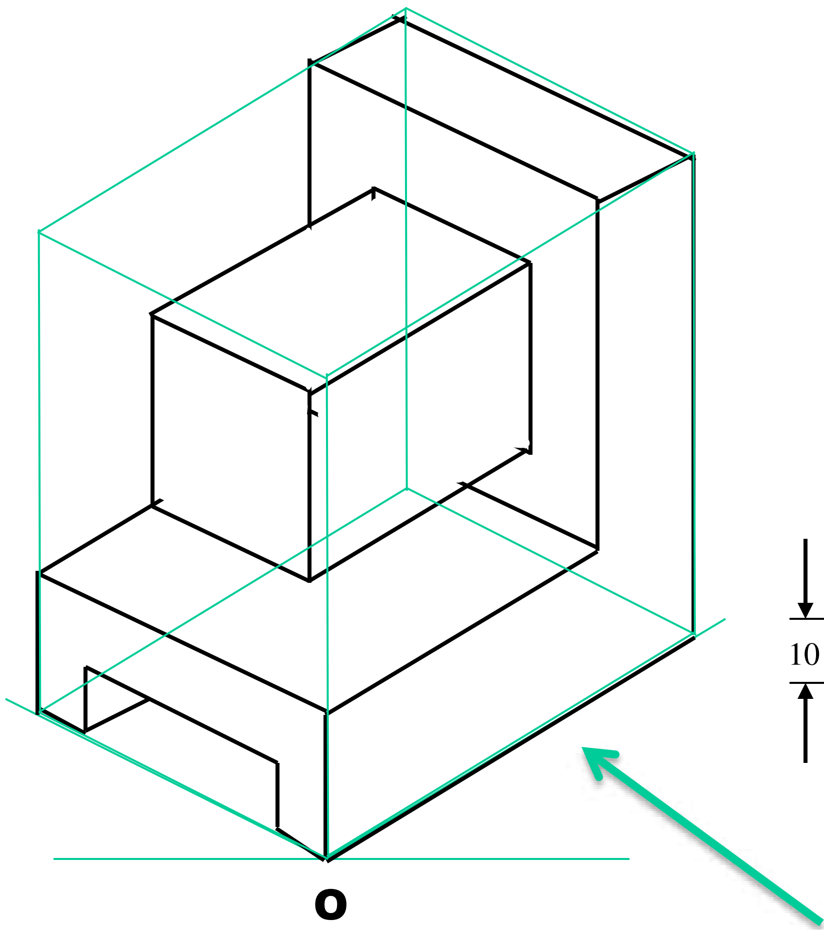
F.V. & T.V. and S.V. of a solid are given. Draw it's isometric view.

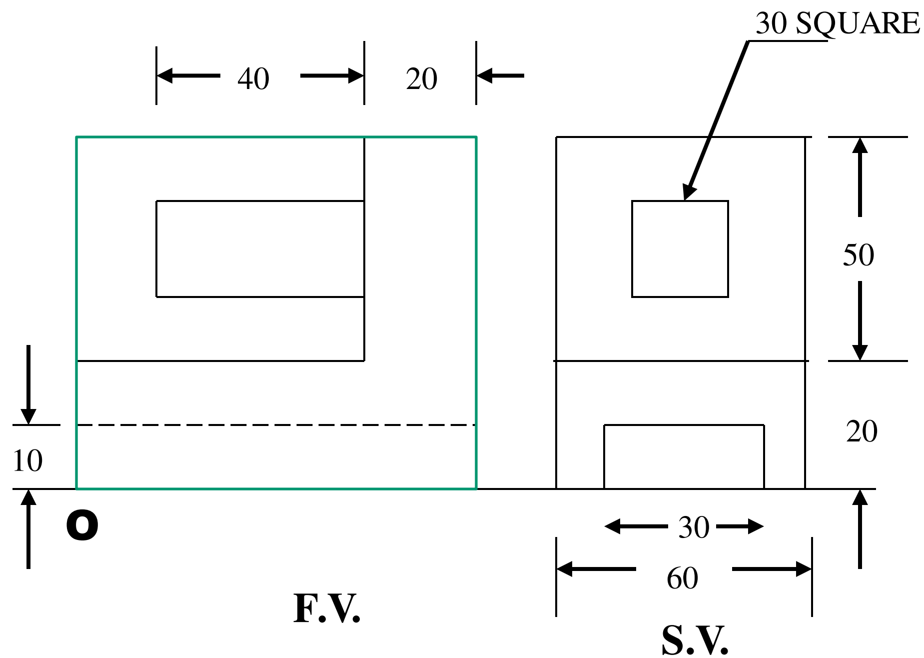
ORTHOGRAPHIC PROJECTIONS



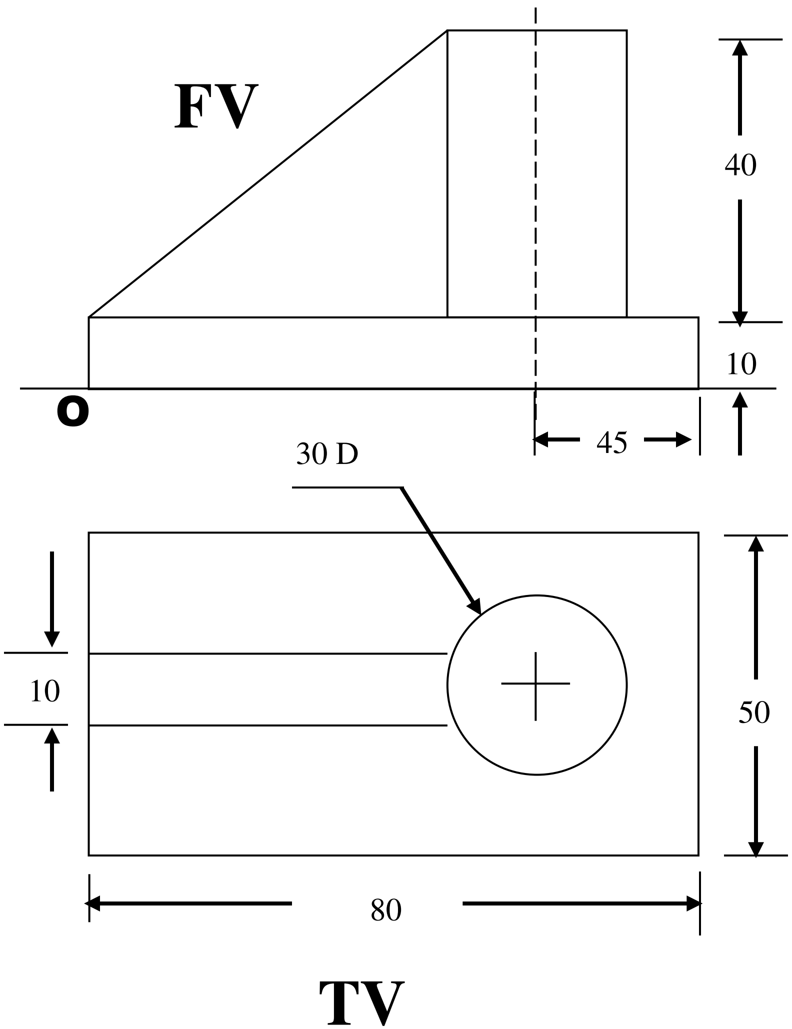


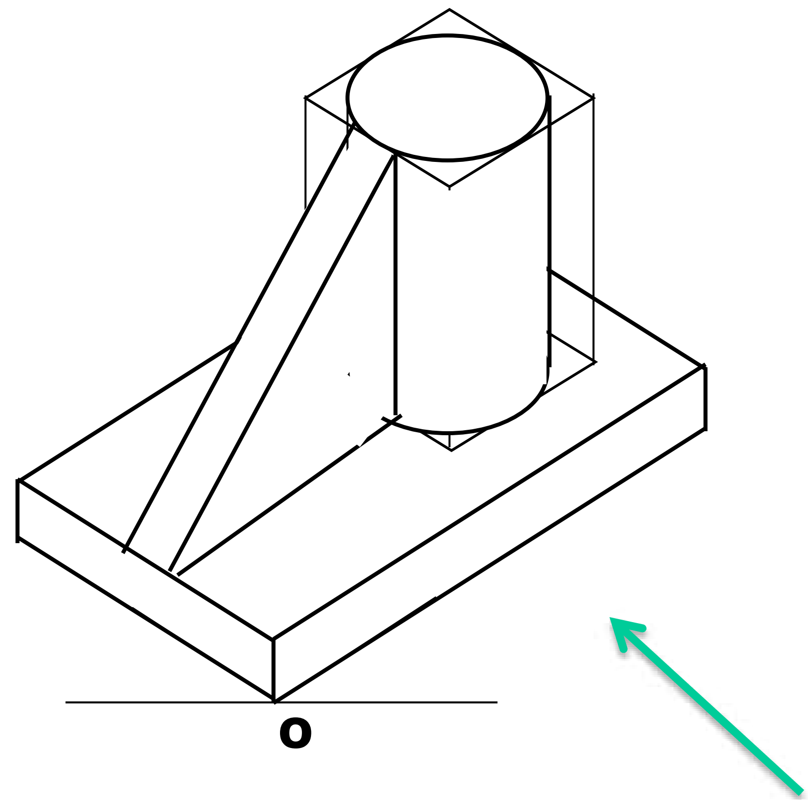
F.V. and S.V. of a solid are given.
Draw it's isometric view.



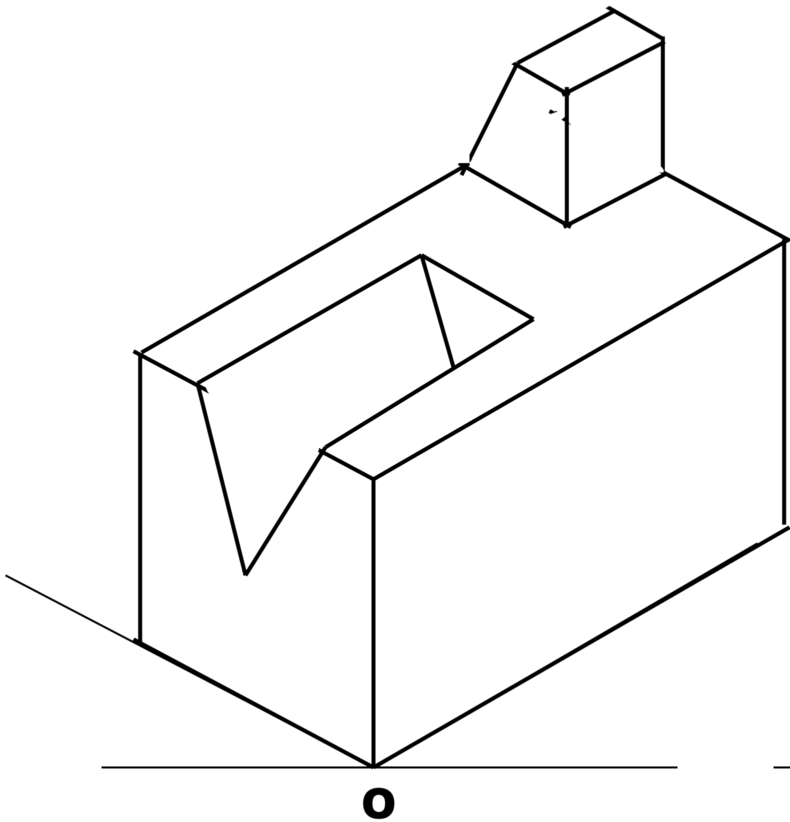


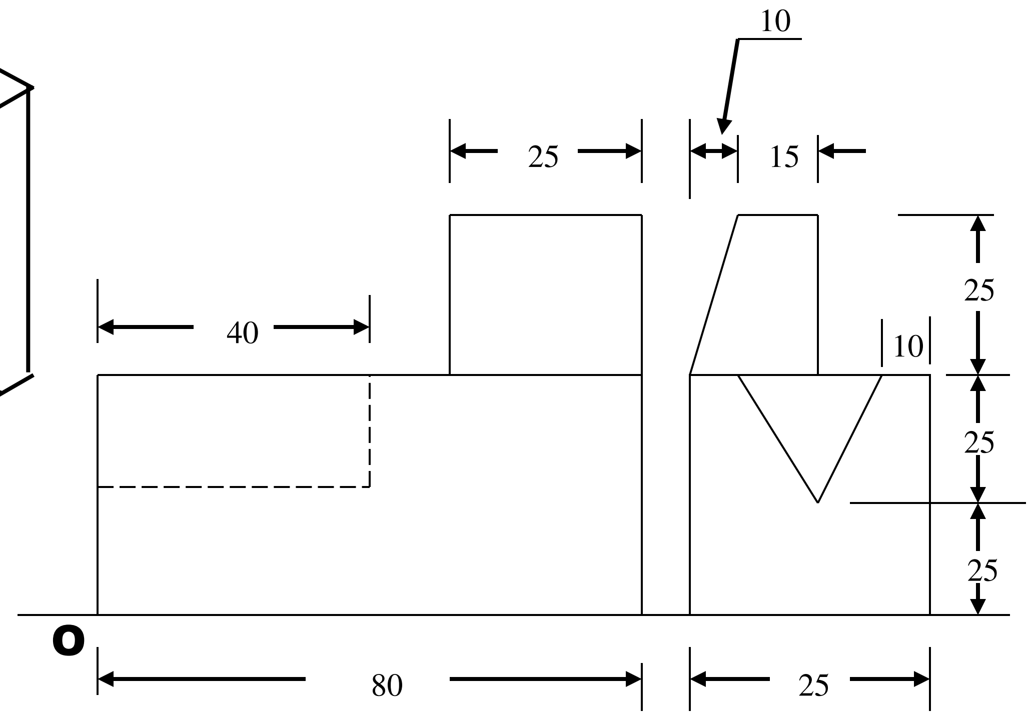
F.V. & T.V. of a solid are given. Draw it's isometric view.





F.V. and S.V. of a solid are given. Draw it’s isometric view.

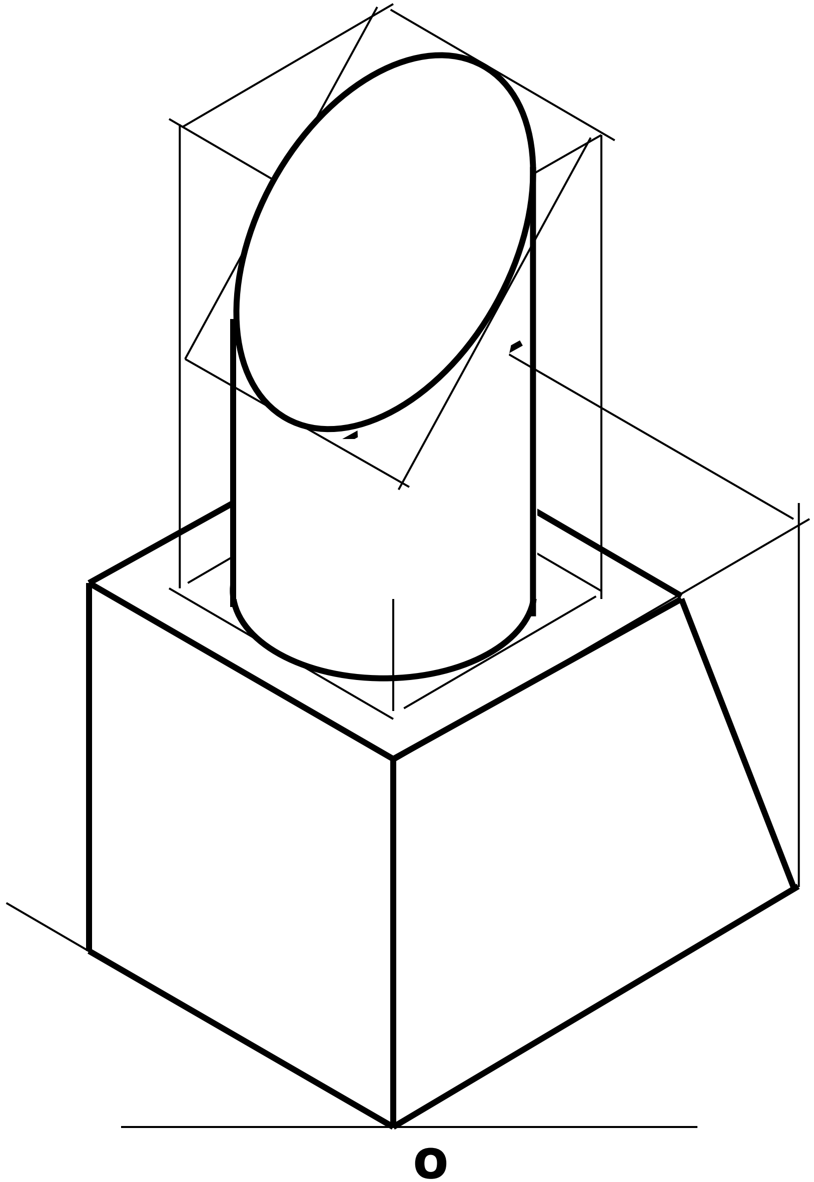


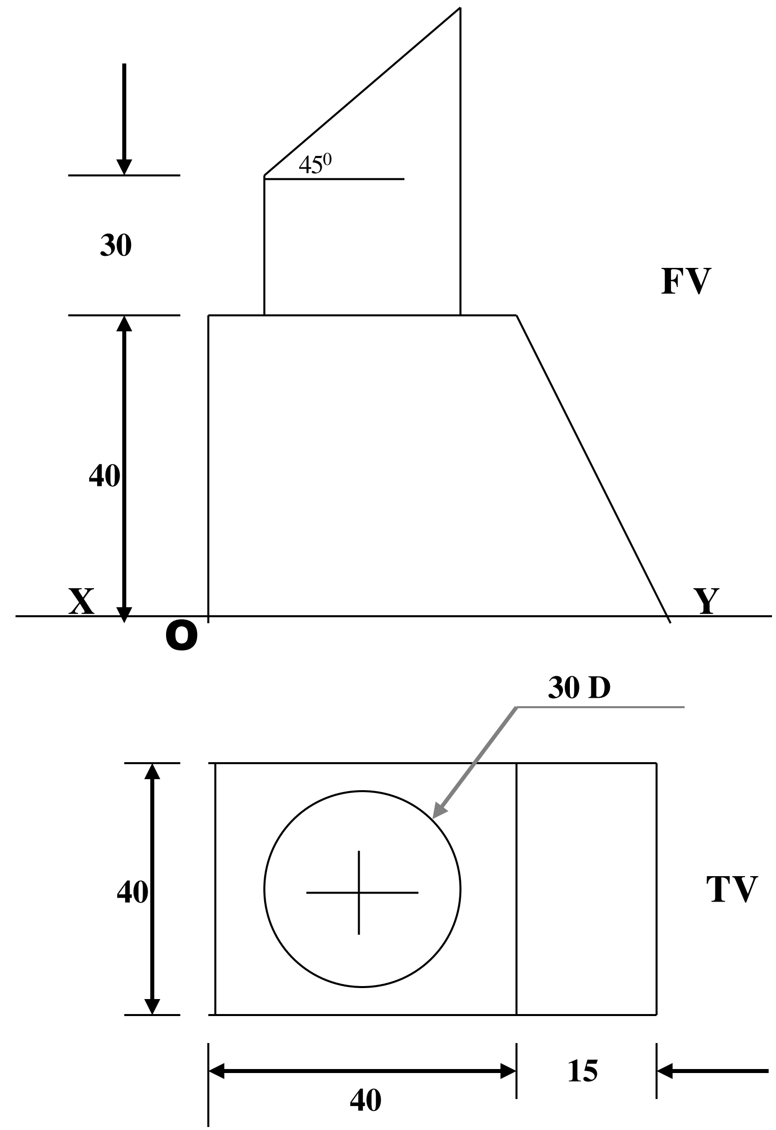


F.V.

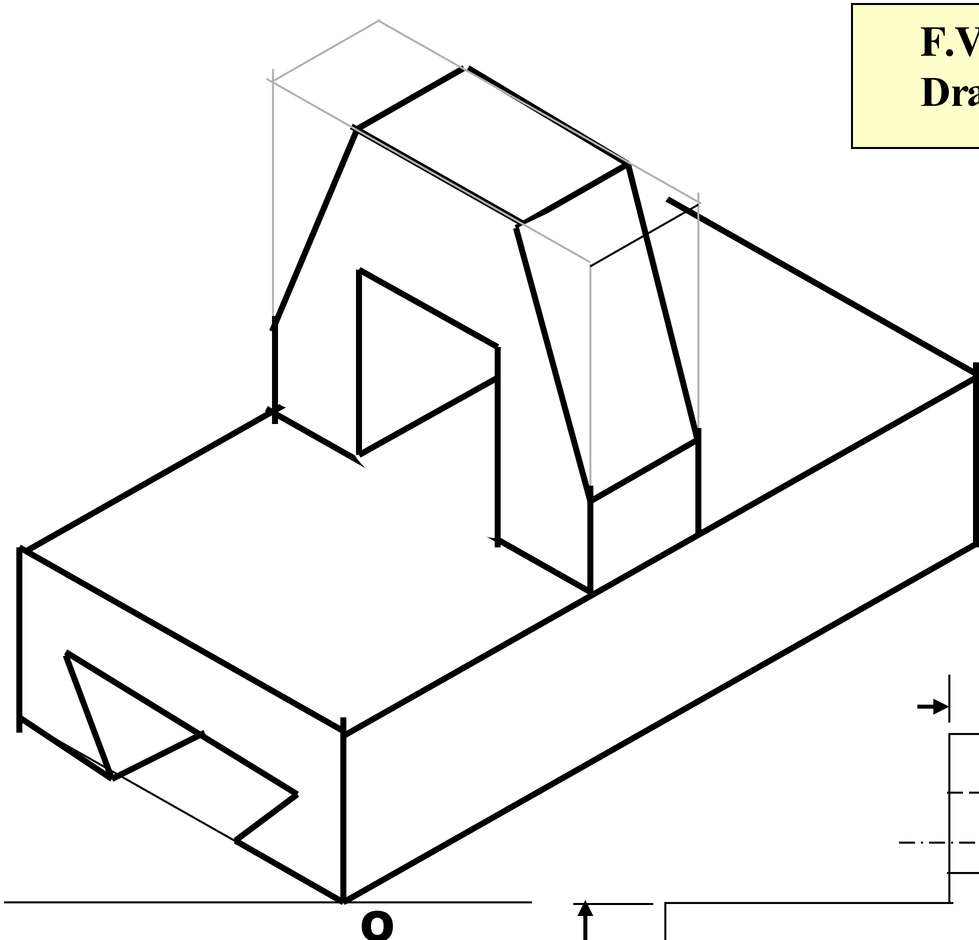
S.V.

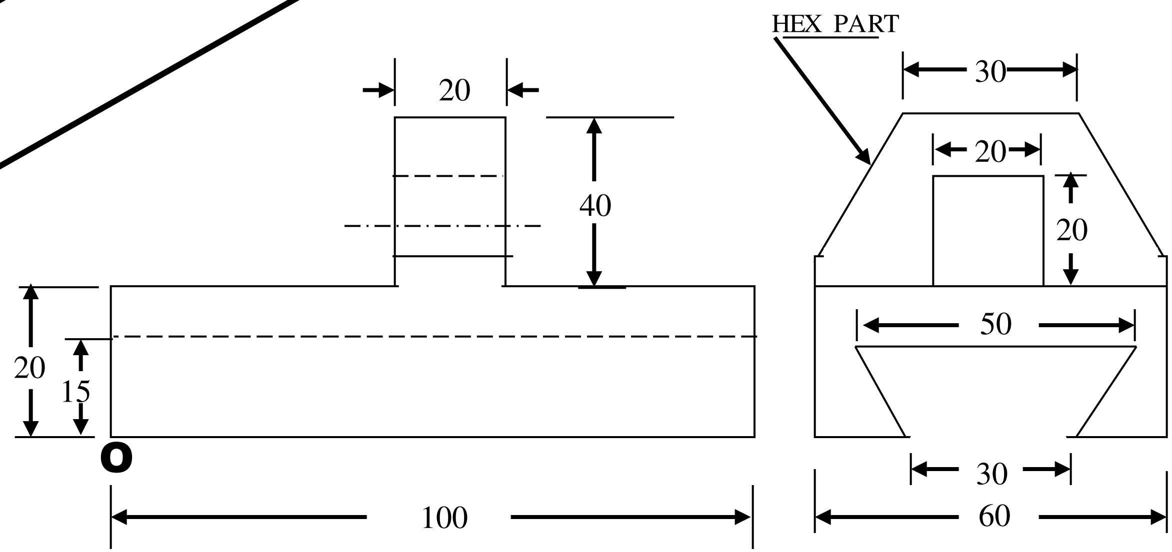
F.V. & T.V. of a solid are given. Draw it's isometric view.



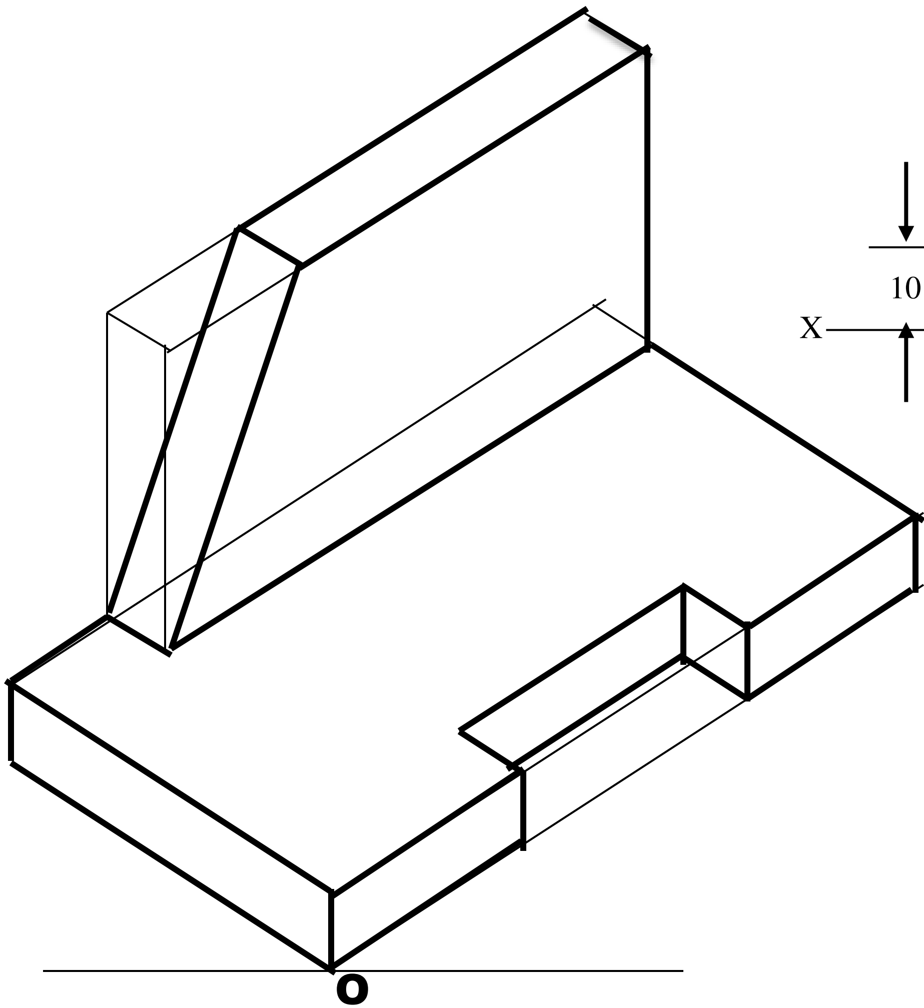


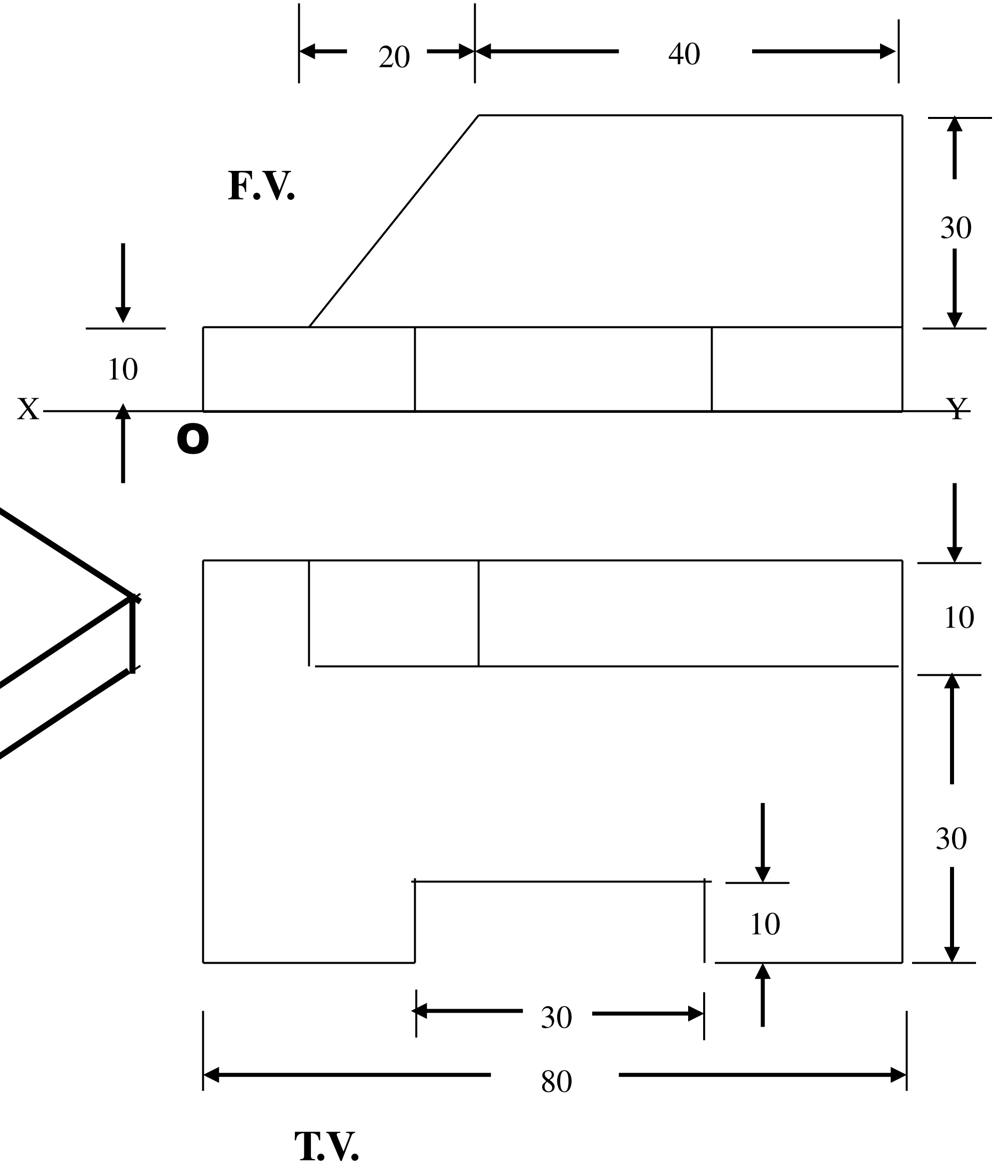
F.V. and S.V. of a solid are given.
Draw it's isometric view.



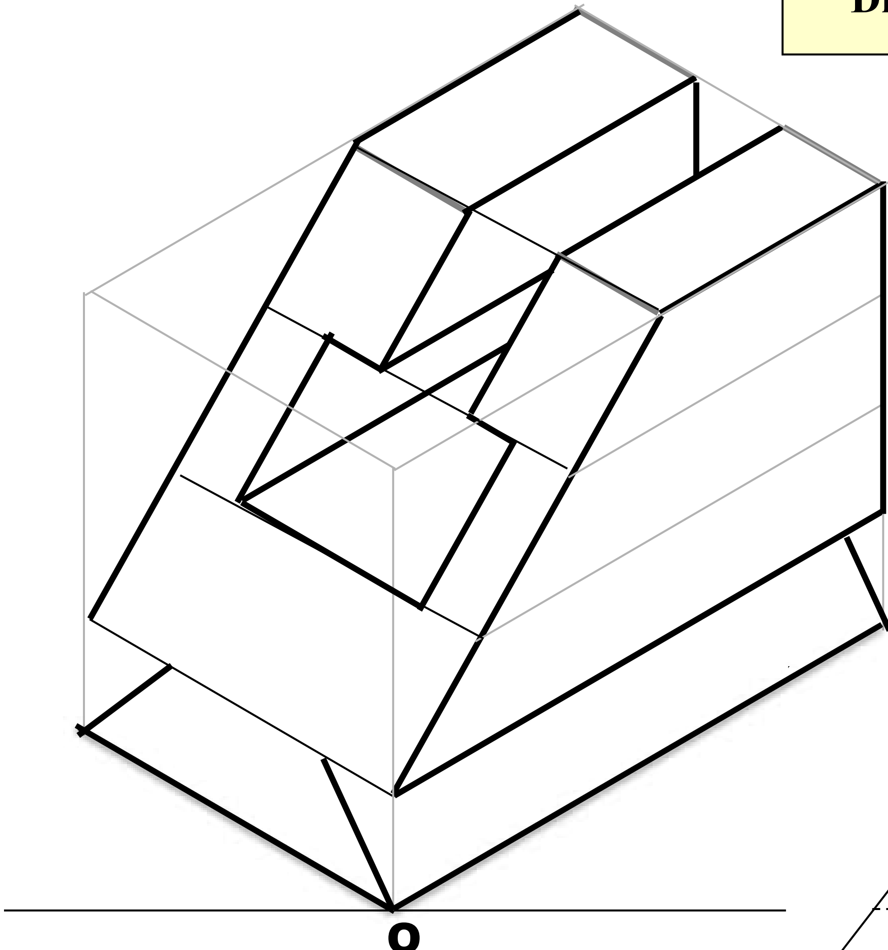


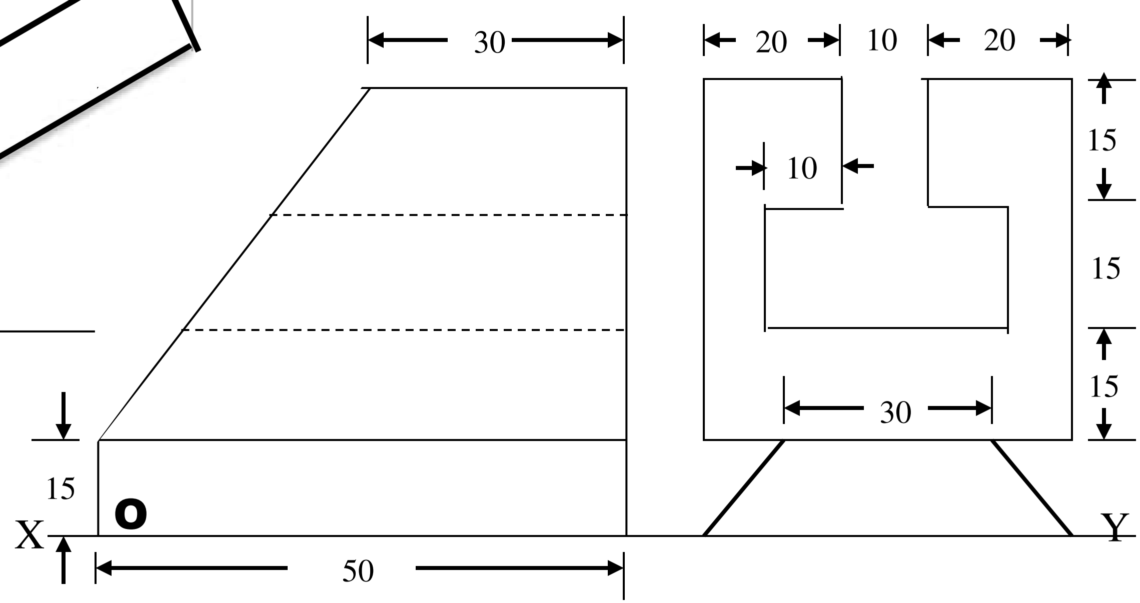
F.V. & T.V. of an object are given. Draw it's isometric view.





**F.V. and S.V. of a solid are given.
Draw it's isometric view.**

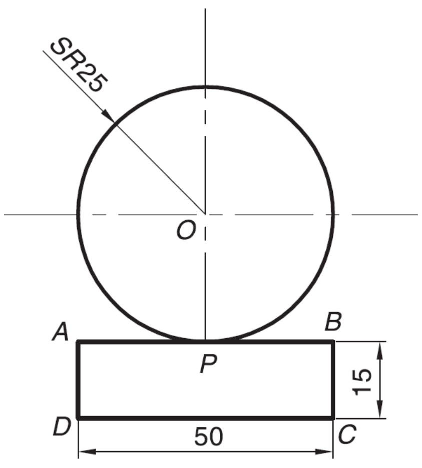




F.V. **LEFT S.V.**

Isometric Projections: Sphere

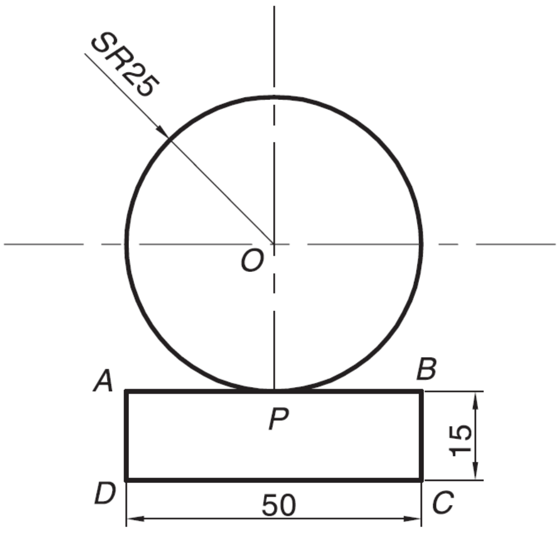
- Radius of sphere remains same in isometric projection
- Use isometric scale and draw solid attached to sphere and distance O-P
- Identify center O and draw a circle of radius=radius of sphere



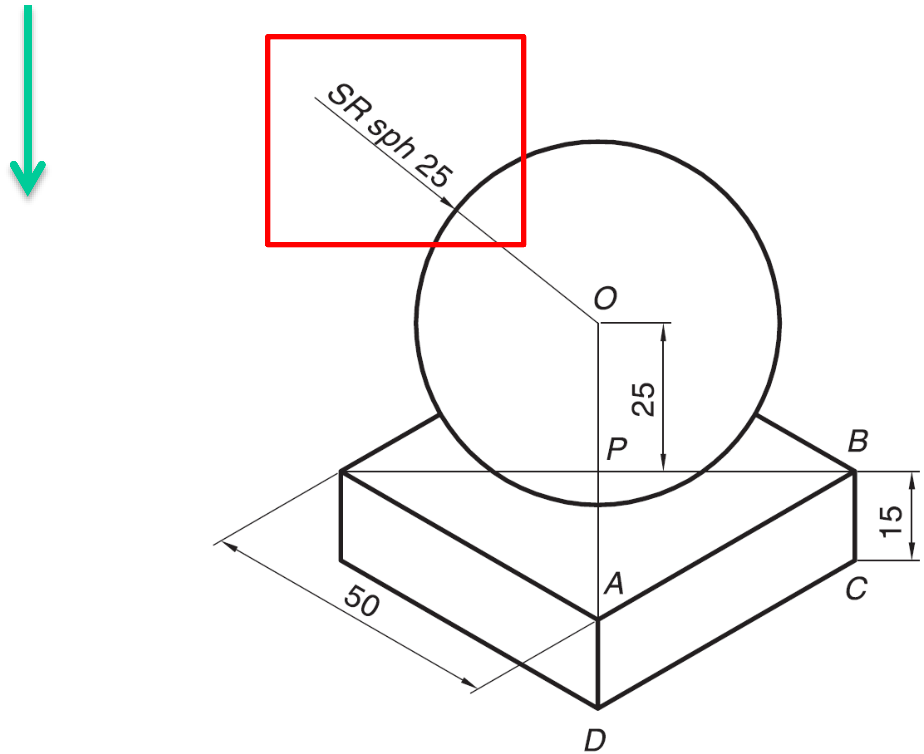
Orthographic View

Isometric View: Sphere

- Radius of sphere in isometric view is more than actual radius of sphere



Orthographic View



Isometric View

Development of surfaces
(cylinder, cuboid, cone)

SCALE

SCALES

DIMENSIONS OF LARGE OBJECTS MUST BE REDUCED TO ACCOMMODATE ON STANDARD SIZE DRAWING SHEET. THIS REDUCTION CREATES A SCALE OF THAT REDUCTION RATIO, WHICH IS GENERALLY A FRACTION..

SUCH A SCALE IS CALLED REDUCING SCALE

AND

THAT RATIO IS CALLED REPRESENTATIVE FACTOR.

SIMILARLY IN CASE OF TINY OBJECTS DIMENSIONS MUST BE INCREASED FOR ABOVE PURPOSE. HENCE THIS SCALE IS CALLED ENLARGING SCALE.
HERE THE RATIO CALLED REPRESENTATIVE FACTOR IS MORE THAN UNITY.

FOR FULL SIZE SCALE R.F.=1 OR (1:1) MEANS DRAWING & OBJECT ARE OF SAME SIZE.
Other RFs are described as
1:10, 1:100,
1:1000, 1:1,00,000

USE FOLLOWING FORMULAS FOR THE CALCULATIONS IN THIS TOPIC.

(A) REPRESENTATIVE FACTOR (R.F.) =

$$\frac{\text{DIMENSION OF DRAWING}}{\text{DIMENSION OF OBJECT}}$$

$$= \frac{\text{LENGTH OF DRAWING}}{\text{ACTUAL LENGTH}}$$

$$= \sqrt{\frac{\text{AREA OF DRAWING}}{\text{ACTUAL AREA}}}$$

$$= \sqrt[3]{\frac{\text{VOLUME AS PER DRWG.}}{\text{ACTUAL VOLUME}}}$$

(B) LENGTH OF SCALE = R.F. X MAX. LENGTH TO BE MEASURED.

PLAIN SCALE:- This type of scale represents two units or a unit and it's sub-division.

PROBLEM NO.1:- Draw a scale 1 cm = 1m to read decimeters, to measure maximum distance of 6 m. Show on it a distance of 4 m and 6 dm.

PLAIN SCALE

CONSTRUCTION:-

a) Calculate R.F.= $\frac{\text{DIMENSION OF DRAWING}}{\text{DIMENSION OF OBJECT}}$

R.F.= 1cm/ 1m = 1/100

Length of scale = R.F. X max. distance

= 1/100 X 600 cm

= 6 cms

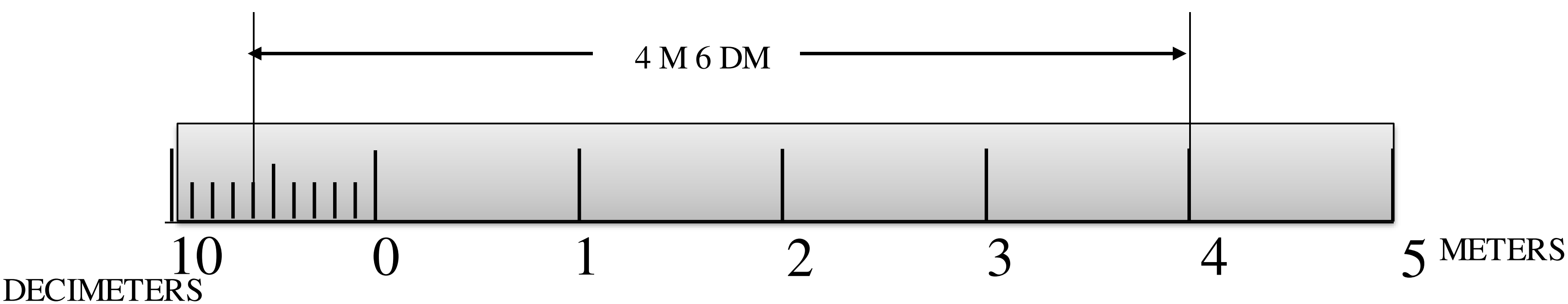
b) Draw a line 6 cm long and divide it in 6 equal parts. Each part will represent larger division unit.

c) Sub divide the first part which will represent second unit or fraction of first unit.

d) Place (0) at the end of first unit. Number the units on right side of Zero and subdivisions on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a look of scale.

e) After construction of scale mention it's RF and name of scale as shown.

f) Show the distance 4 m 6 dm on it as shown.



R.F. = 1/100

PLANE SCALE SHOWING METERS AND DECIMETERS.

PROBLEM NO.2:- In a map a 36 km distance is shown by a line 45 cms long. Calculate the R.F. and construct a plain scale to read kilometers and hectometers, for max. 12 km. Show a distance of 8.3 km on it.

PLAIN SCALE

CONSTRUCTION:-

a) Calculate R.F.

$$R.F. = 45\text{ cm}/36\text{ km} = 45/36 \cdot 1000 \cdot 100 = 1/80{,}000$$

Length of scale = R.F. $\times$ max. distance

= 1/ 80000 $\times$ 12 km

= 15 cm

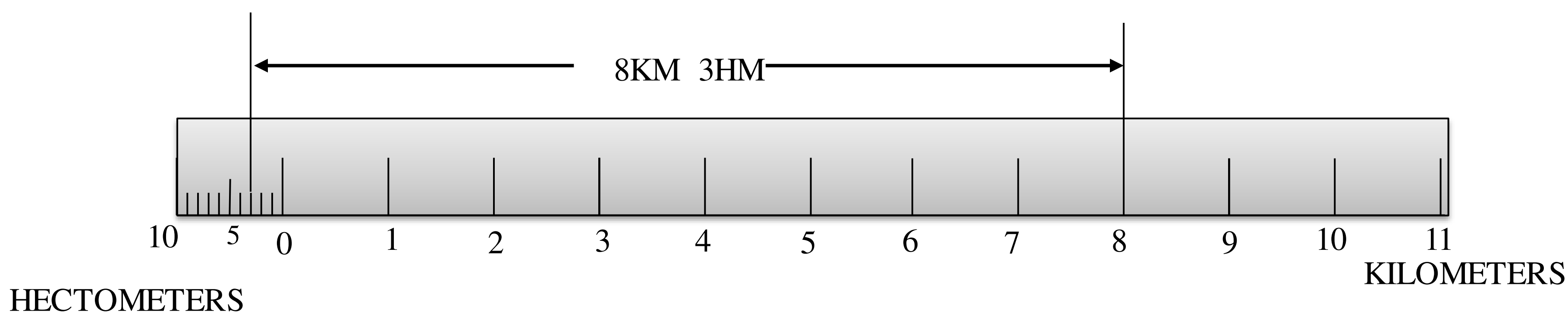
b) Draw a line 15 cm long and divide it in 12 equal parts. Each part will represent larger division unit.

c) Sub divide the first part which will represent second unit or fraction of first unit.

d) Place (0) at the end of first unit. Number the units on right side of Zero and subdivisions on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a look of scale.

e) After construction of scale mention it's RF and name of scale as shown.

f) Show the distance 8.3 km on it as shown.



R.F. = 1/80,000

PLANE SCALE SHOWING KILOMETERS AND HECTOMETERS

PROBLEM NO.3:- The distance between two stations is 210 km. A passenger train covers this distance in 7 hours. Construct a plain scale to measure time up to a single minute. RF is 1/200,000 Indicate the distance traveled by train in 29 minutes.

PLAIN SCALE

CONSTRUCTION:-

a) 210 km in 7 hours. Means speed of the train is 30 km per hour (60 minutes)

Length of scale = R.F. × max. distance per hour
= 1/ 2,00,000 × 30km
= 15 cm

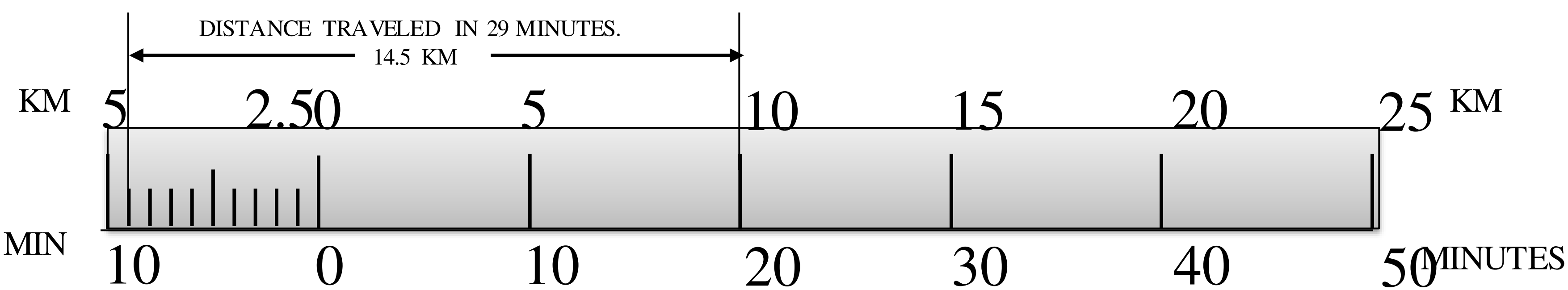
b) 15 cm length will represent 30 km and 1 hour i.e. 60 minutes.
Draw a line 15 cm long and divide it in 6 equal parts. Each part will represent 5 km and 10 minutes.

c) Sub divide the first part in 10 equal parts,which will represent second unit or fraction of first unit.
Each smaller part will represent distance traveled in one minute.

d) Place (0) at the end of first unit. Number the units on right side of Zero and subdivisions on left-hand side of Zero. Take height of scale 5 to 10 mm for getting a proper look of scale.

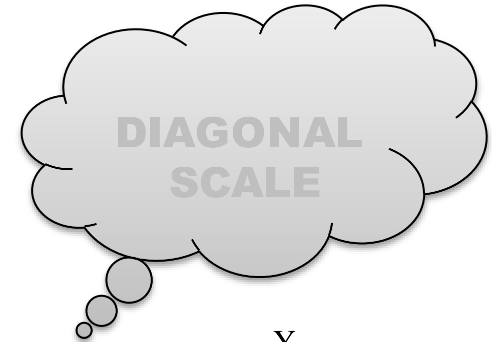
e) Show km on upper side and time in minutes on lower side of the scale as shown.
After construction of scale mention it's RF and name of scale as shown.

f) Show the distance traveled in 29 minutes, which is 14.5 km, on it as shown.



R.F. = 1/100

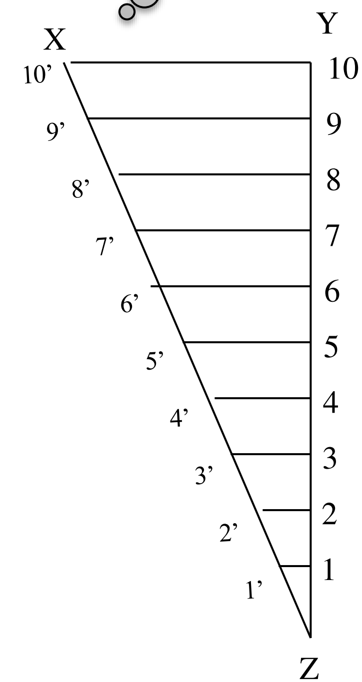
PLANE SCALE SHOWING METERS AND DECIMETERS.



We have seen that the plain scales give only two dimensions, such as a unit and it's subunit or it's fraction.

The diagonal scales give us three successive dimensions that is a unit, a subunit and a subdivision of a subunit.

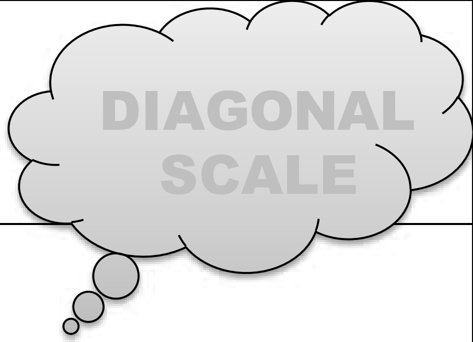
The principle of construction of a diagonal scale is as follows.
Let the XY in figure be a subunit.
From Y draw a perpendicular YZ to a suitable height.
Join XZ. Divide YZ in to 10 equal parts.
Draw parallel lines to XY from all these divisions and number them as shown.
From geometry we know that similar triangles have their like sides proportional.



Consider two similar triangles XYZ and 7' 7Z,
we have 7Z / YZ = 7'7 / XY (each part being one unit)
Means 7' 7 = 7 / 10. x X Y = 0.7 XY
:.
Similarly
1' – 1 = 0.1 XY
2' – 2 = 0.2 XY
Thus, it is very clear that, the sides of small triangles, which are parallel to divided lines, become progressively shorter in length by 0.1 XY.

The solved examples ON NEXT PAGES will make the principles of diagonal scales clear.

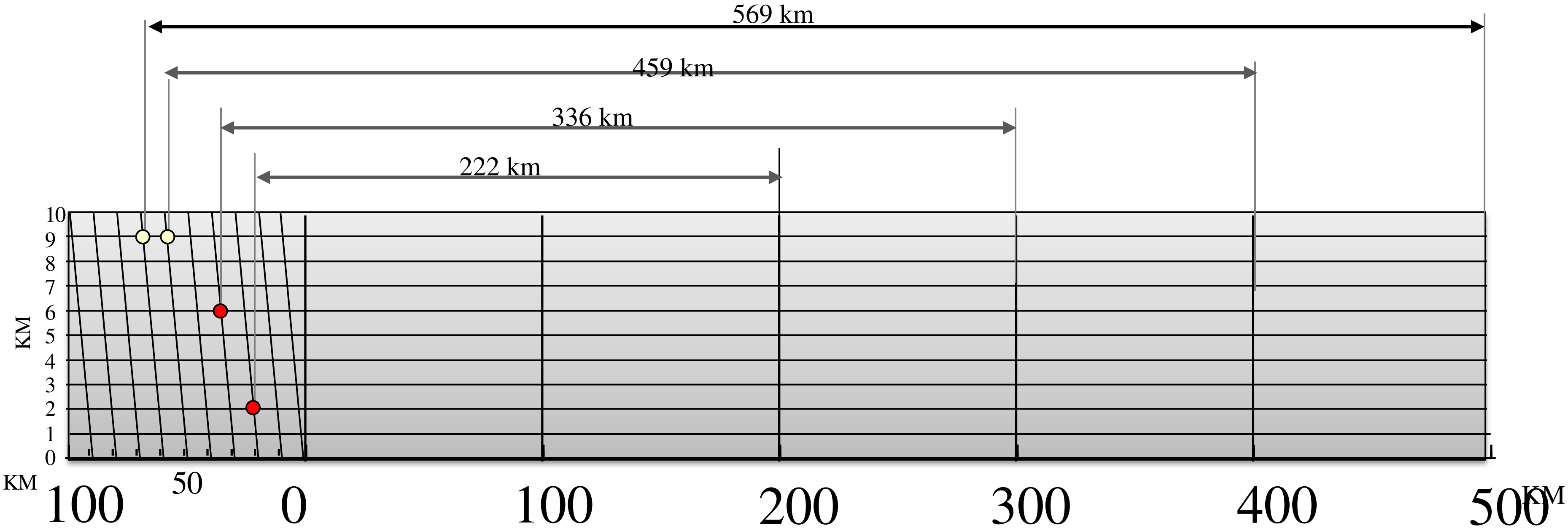
PROBLEM NO. 4 : The distance between Delhi and Agra is 200 km. In a railway map it is represented by a line 5 cm long. Find it's R.F. Draw a diagonal scale to show single km. And maximum 600 km. Indicate on it following distances. 1) 222 km 2) 336 km 3) 459 km 4) 569 km



SOLUTION STEPS: RF = 5 cm / 200 km = 1 / 40, 00, 000

Length of scale = 1 / 40, 00, 000 X 600 X 10^5 = 15 cm

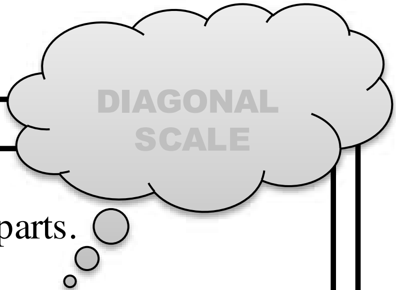
Draw a line 15 cm long. It will represent 600 km.Divide it in six equal parts.(each will represent 100 km.) Divide first division in ten equal parts. Each will represent 10 km.Draw a line upward from left end and mark 10 parts on it of any distance. Name those parts 0 to 10 as shown.Join 9th sub-division of horizontal scale with 10th division of the vertical divisions. Then draw parallel lines to this line from remaining sub divisions and complete diagonal scale.



R.F. = 1 / 40,00,000

DIAGONAL SCALE SHOWING KILOMETERS.

PROBLEM NO.5: A rectangular plot of land measuring 1.28 hectors is represented on a map by a similar rectangle of 8 sq. cm. Calculate RF of the scale. Draw a diagonal scale to read single meter. Show a distance of 438 m on it.



SOLUTION :

1 hector = 10, 000 sq. meters

1.28 hectors = 1.28 X 10, 000 sq. meters

$= 1.28 \times 10^4 \times 10^4$ sq. cm

8 sq. cm area on map represents

$= 1.28 \times 10^4 \times 10^4$ sq. cm on land

1 cm sq. on map represents

$= 1.28 \times 10^4 \times 10^4 / 8$ sq cm on land

1 cm on map represent

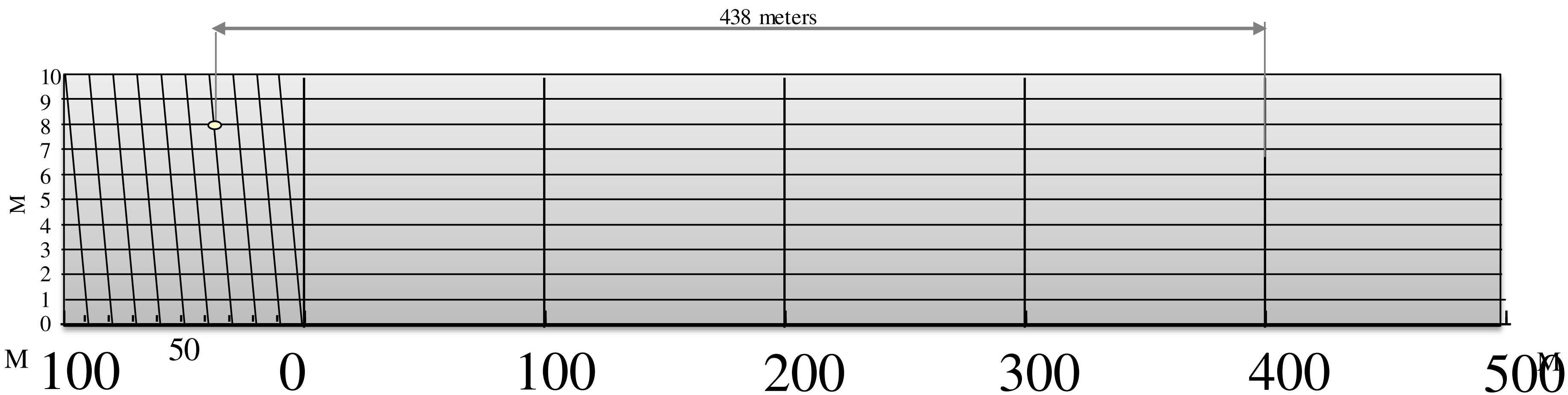
$$= \sqrt{1.28 \times 10^4 \times 10^4 / 8} \text{ cm}$$

= 4, 000 cm

1 cm on drawing represent 4, 000 cm, Means RF = 1 / 4000

Assuming length of scale 15 cm, it will represent 600 m.

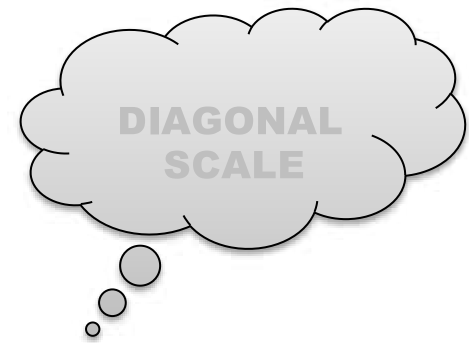
Draw a line 15 cm long.
It will represent 600 m.Divide it in six equal parts.
(each will represent 100 m.)
Divide first division in ten equal parts.Each will represent 10 m.
Draw a line upward from left end and mark 10 parts on it of any distance.
Name those parts 0 to 10 as shown.Join 9th sub-division of horizontal scale with 10th division of the vertical divisions.
Then draw parallel lines to this line from remaining sub divisions and complete diagonal scale.



R.F. = 1 / 4000

DIAGONAL SCALE SHOWING METERS.

PROBLEM NO.6:. Draw a diagonal scale of R.F. 1: 2.5, showing centimeters and millimeters and long enough to measure up to 20 centimeters.



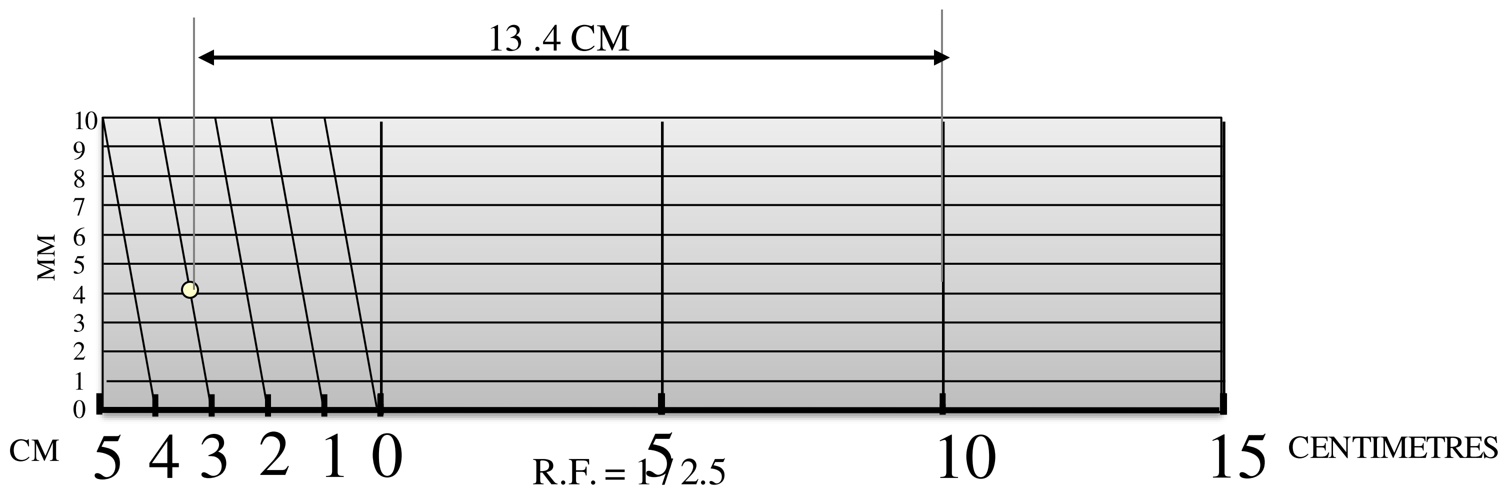
SOLUTION STEPS:

R.F. = 1 / 2.5

Length of scale = 1 / 2.5 X 20 cm.

= 8 cm.

1. Draw a line 8 cm long and divide it in to 4 equal parts.
   (Each part will represent a length of 5 cm.)
2. Divide the first part into 5 equal divisions.
   (Each will show 1 cm.)
3. At the left hand end of the line, draw a vertical line and on it step-off 10 equal divisions of any length.
4. Complete the scale as explained in previous problems.
   Show the distance 13.4 cm on it.



DIAGONAL SCALE SHOWING CENTIMETERS.

COMPARATIVE SCALES:

These are the Scales having same R.F. but graduated to read different units.

These scales may be Plain scales or Diagonal scales and may be constructed separately or one above the other.

EXAMPLE NO. 7 :

A distance of 40 miles is represented by a line 8 cm long. Construct a plain scale to read 80 miles. Also construct a comparative scale to read kilometers upto 120 km (1 m = 1.609 km)

SOLUTION STEPS:

Scale of Miles:

40 miles are represented = 8 cm

: 80 miles = 16 cm

R.F. = 8 / 40 X 1609 X 1000 X 100

= 1 / 8, 04, 500

CONSTRUCTION:

Take a line 16 cm long and divide it into 8 parts. Each will represent 10 miles. Subdivide the first part and each sub-division will measure single mile.

Scale of Km:

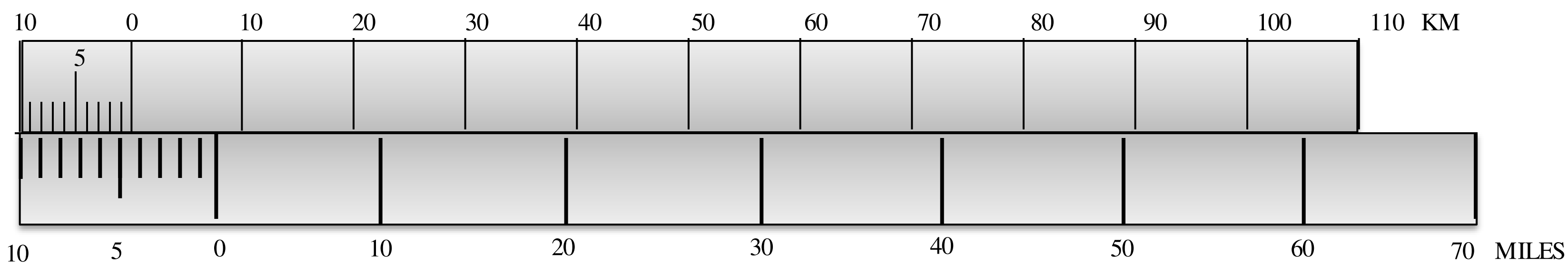
Length of scale

= 1 / 8,04,500 X 120 X 1000 X 100

= 14. 90 cm

CONSTRUCTION:

On the top line of the scale of miles cut off a distance of 14.90 cm and divide it into 12 equal parts. Each part will represent 10 km. Subdivide the first part into 10 equal parts. Each subdivision will show single km.



R.F. = 1 / 804500

COMPARATIVE SCALE SHOWING MILES AND KILOMETERS

COMPARATIVE SCALE:

EXAMPLE NO. 8 :

A motor car is running at a speed of 60 kph.
On a scale of RF = 1 / 4,00,000 show the distance traveled by car in 47 minutes.

SOLUTION STEPS:

Scale of km.

length of scale = RF X 60 km

= 1 / 4,00,000 X 60 X 10^5

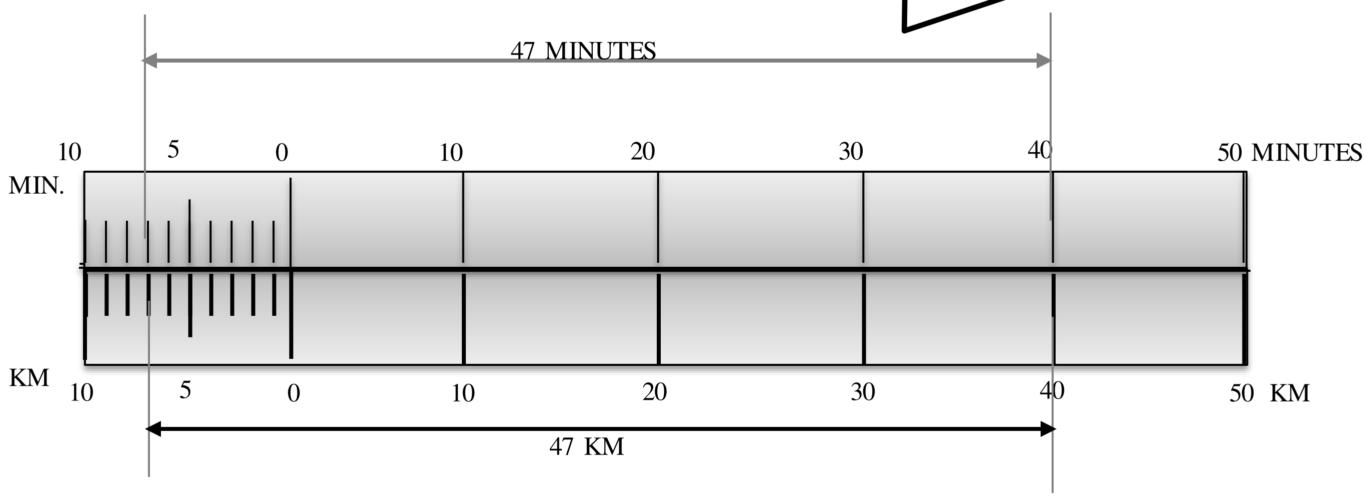
= 15 cm.

CONSTRUCTION:

Draw a line 15 cm long and divide it in 6 equal parts.
(each part will represent 10 km.)
Subdivide 1st part in `0 equal subdivisions.
(each will represent 1 km.)

Time Scale:

Same 15 cm line will represent 60 minutes.
Construct the scale similar to distance scale.
It will show minimum 1 minute & max. 60min.



R.F. = 1 / 4,00,000

COMPARATIVE SCALE SHOWING MINUTES AND KILOMETERS

COMPARATIV SCALE:

EXAMPLE NO. 9 :

A car is traveling at a speed of 60 km per hour. A 4 cm long line represents the distance traveled by the car in two hours. Construct a suitable comparative scale up to 10 hours. The scale should be able to read the distance traveled in one minute. Show the time required to cover 476 km and also distance in 4 hours and 24 minutes.

SOLUTION:

4 cm line represents distance in two hours , means for 10 hours scale, 20 cm long line is required, as length of scale.This length of scale will also represent 600 kms. (as it is a distance traveled in 10 hours)

CONSTRUCTION:

Distance Scale (km)

Draw a line 20 cm long. Divide it in TEN equal parts.(Each will show 60 km)

Sub-divide 1st part in SIX subdivisions.(Each will represent 10 km)

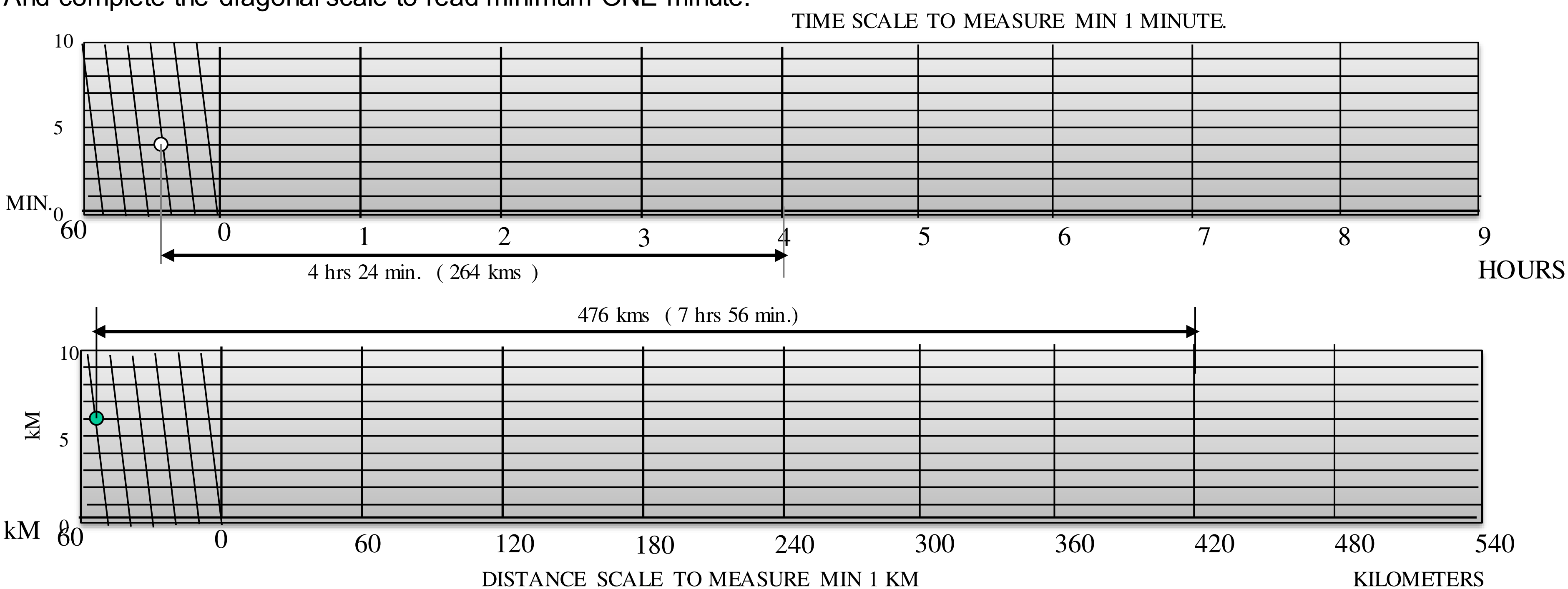
At the left hand end of the line, draw a vertical line and on it step-off 10 equal divisions of any length.

And complete the diagonal scale to read minimum ONE km.

Time scale:

Draw a line 20 cm long. Divide it in TEN equal parts.(Each will show 1 hour) Sub-divide 1st part in SIX subdivisions.(Each will represent 10 minutes) At the left hand end of the line, draw a vertical line and on it step-off 10 equal divisions of any length.

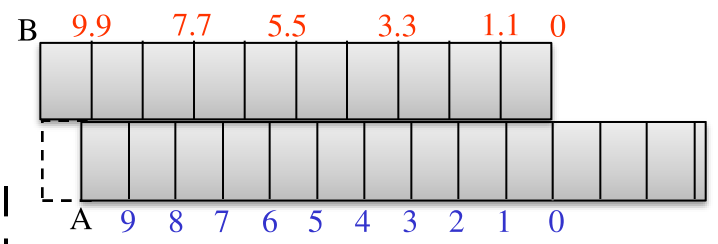
And complete the diagonal scale to read minimum ONE minute.



Vernier Scales:

These scales, like diagonal scales , are used to read to a very small unit with great accuracy.
It consists of two parts – a primary scale and a vernier. The primary scale is a plain scale fully divided into minor divisions.
As it would be difficult to sub-divide the minor divisions in ordinary way, it is done with the help of the vernier.
The graduations on vernier are derived from those on the primary scale.

Figure to the right shows a part of a plain scale in which length A-O represents 10 cm. If we divide A-O into ten equal parts, each will be of 1 cm. Now it would not be easy to divide each of these parts into ten equal divisions to get measurements in millimeters.



Now if we take a length BO equal to 10 + 1 = 11 such equal parts, thus representing 11 cm, and divide it into ten equal divisions, each of these divisions will represent 11 / 10 – 1.1 cm.

The difference between one part of AO and one division of BO will be equal 1.1 – 1.0 = 0.1 cm or 1 mm.

This difference is called Least Count of the scale.

Minimum this distance can be measured by this scale.

The upper scale BO is the vernier.The combination of plain scale and the vernier is vernier scale.

Example 10:

Draw a vernier scale of RF = 1 / 25 to read centimeters upto 4 meters and on it, show lengths 2.39 m and 0.91 m

Vernier Scale

SOLUTION:

Length of scale = RF X max. Distance
= 1 / 25 X 4 X 100
= 16 cm

CONSTRUCTION: *(Main scale)*

Draw a line 16 cm long.

Divide it in 4 equal parts.

(each will represent meter)

Sub-divide each part in 10 equal parts.

(each will represent decimeter)

Name those properly.

CONSTRUCTION: *(vernier)*

Take 11 parts of Dm length and divide it in 10 equal parts.

Each will show 0.11 m or 1.1 dm or 11 cm and construct a rectangle Covering these parts of vernier.

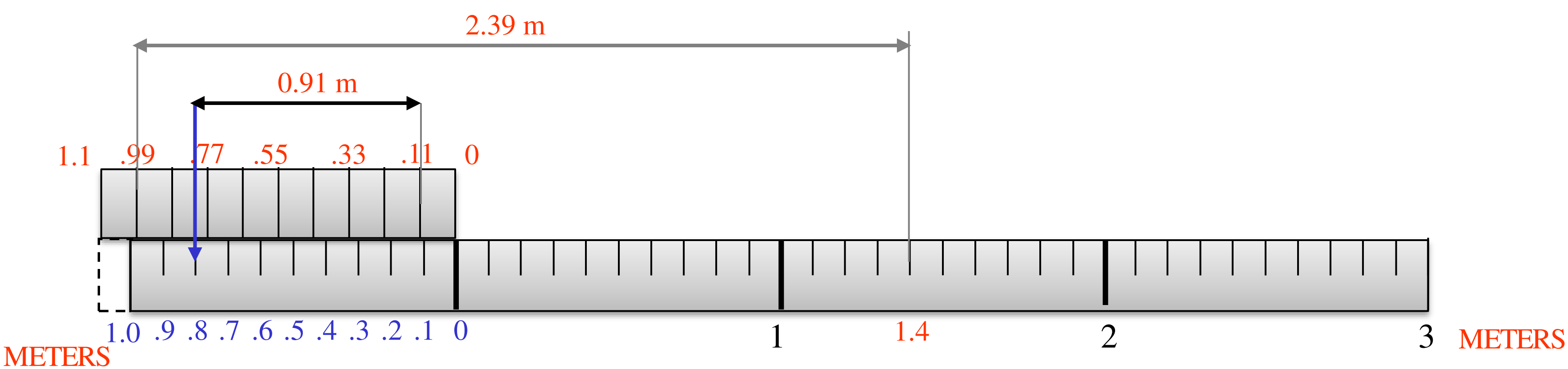
TO MEASURE GIVEN LENGTHS:

(1) For 2.39 m : Subtract 0.99 from 2.39 i.e. 2.39 - .99 = 1.4 m

The distance between 0.99 (left of Zero) and 1.4 (right of Zero) is 2.39 m

(2) For 0.91 m : Subtract 0.11 from 0.91 i.e. 0.91 – 0.11 =0.80 m

The distance between 0.11 and 0.80 (both left side of Zero) is 0.91 m



Example 11: A map of size 500cm X 50cm wide represents an area of 6250 sq.Kms. Construct a vernier scaleto measure kilometers, hectometers and decameters and long enough to measure upto 7 km. Indicate on it a) 5.33 km b) 59 decameters.

Vernier Scale

SOLUTION:

$$RF = \sqrt{\frac{\text{AREA OF DRAWING}}{\text{ACTUAL AREA}}} = \sqrt{\frac{500 \text{ X } 50 \text{ cm sq.}}{6250 \text{ km sq.}}} = 2 / 10^5$$

Length of scale = RF X max. Distance

$= 2 / 10^5$ X 7 kms

= 14 cm

CONSTRUCTION: *(Main scale)*

Draw a line 14 cm long.
Divide it in 7 equal parts.
(each will represent km)
Sub-divide each part in 10 equal parts.
(each will represent hectometer)
Name those properly.

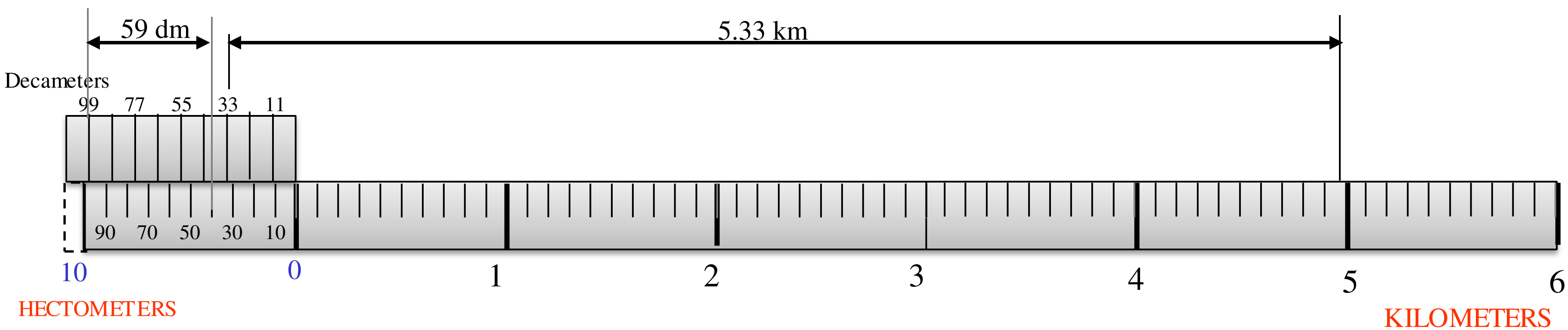
CONSTRUCTION: *(vernier)*

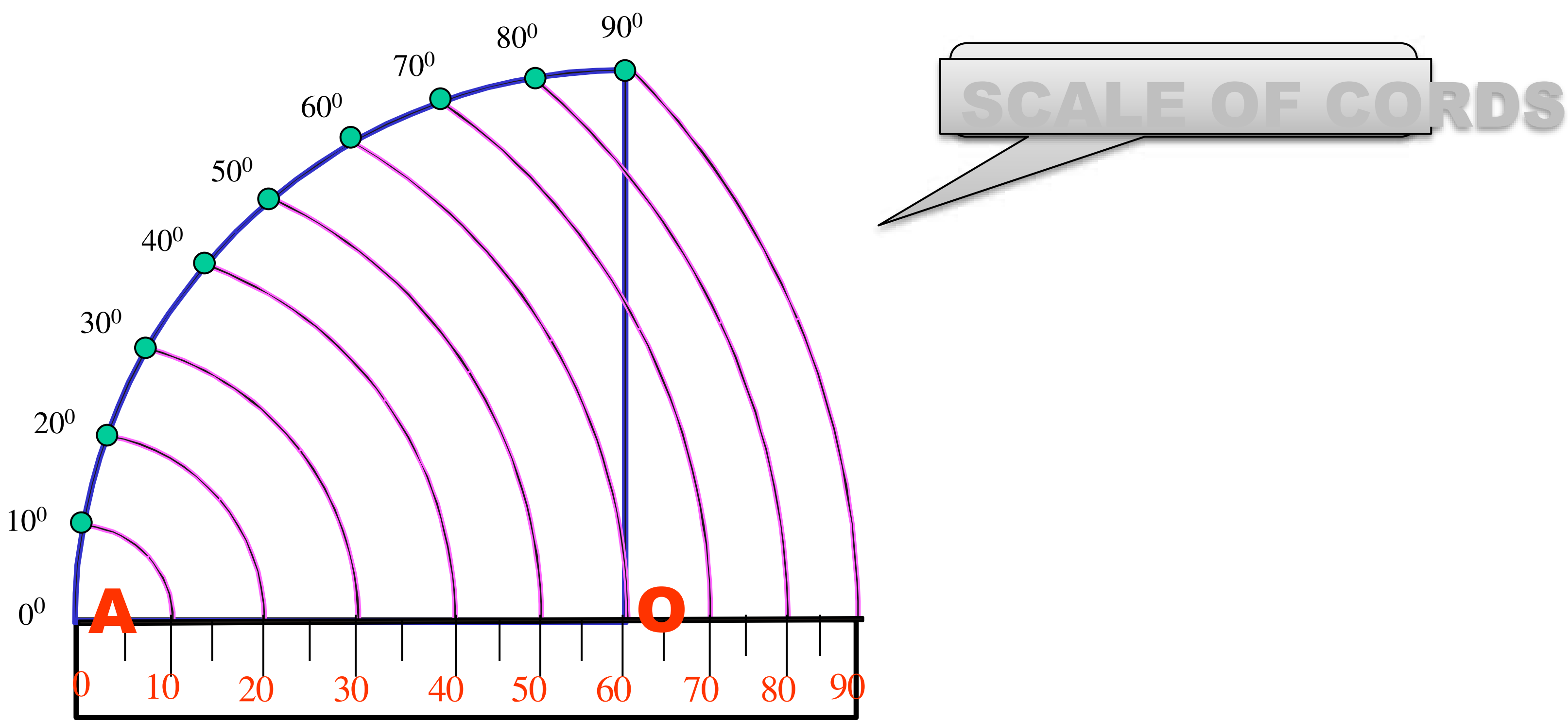
Take 11 parts of hectometer part length and divide it in 10 equal parts.
Each will show 1.1 hm m or 11 dm and
Covering in a rectangle complete scale.

TO MEASURE GIVEN LENGTHS:

a) For 5.33 km :
Subtract 0.33 from 5.33
i.e. 5.33 - 0.33 = 5.00
The distance between 33 dm (left of Zero) and 5.00 (right of Zero) is 5.33 k m

(b) For 59 dm :
Subtract 0.99 from 0.59
i.e. 0.59 – 0.99 = - 0.4 km
(- ve sign means left of Zero)
The distance between 99 dm and - .4 km is 59 dm
(both left side of Zero)





CONSTRUCTION:

1. DRAW SECTOR OF A CIRCLE OF 90^0 WITH 'OA' RADIUS.
   ('OA' ANY CONVINIENT DISTANCE)
2. DIVIDE THIS ANGLE IN NINE EQUAL PARTS OF 10^0 EACH.
3. NAME AS SHOWN FROM END 'A' UPWARDS.
4. FROM 'A' AS CENTER, WITH CORDS OF EACH ANGLE AS RADIUS DRAW ARCS DOWNWARDS UP TO 'AO' LINE OR IT'S EXTENSION AND FORM A SCALE WITH PROPER LABELING AS SHOWN.

AS CORD LENGTHS ARE USED TO MEASURE & CONSTRUCT DIFERENT ANGLES IT IS CALLED SCALE OF CORDS.

PROBLEM 12: Construct 25^0 and 115^0 angles with a horizontal line

CONSTRUCTION:

First prepare Scale of Cords for the problem.
Then Draw a horizontal line. Mark point O on it.

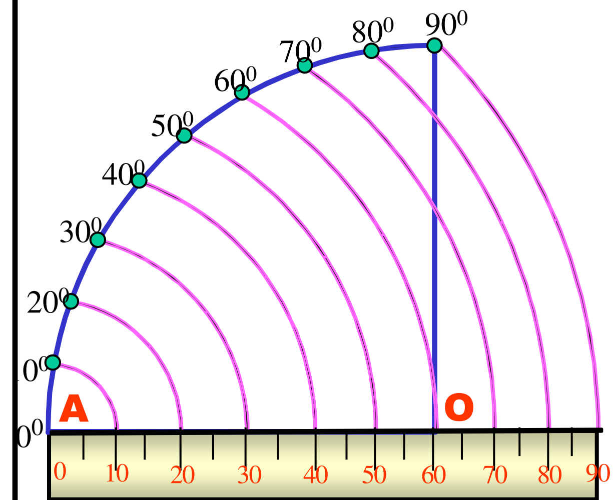
To construct 250 angle at O.

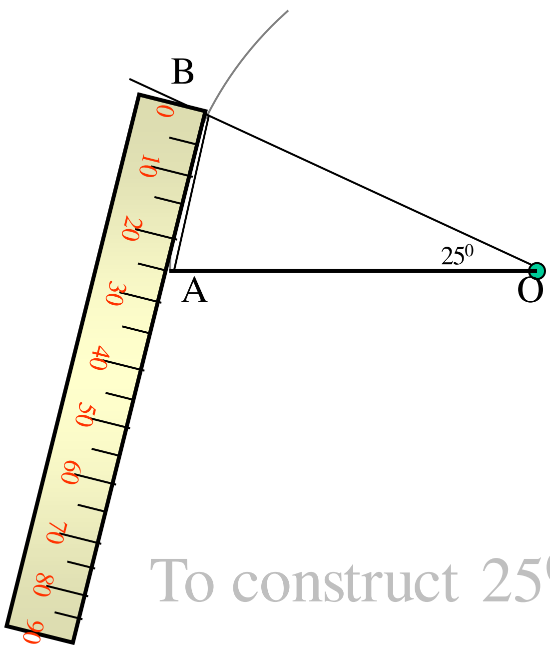
Take O-A distance in compass from cords scale and mark it on on the line drawn, from O Name O & A as shown. Then O as center, O-A radius draw an arc upward..
Take cord length of 25^0 angle from scale of cords in compass and from A cut the arc at point B.Join B with O. The angle AOB is thus 25^0

To construct 1150 angle at O.

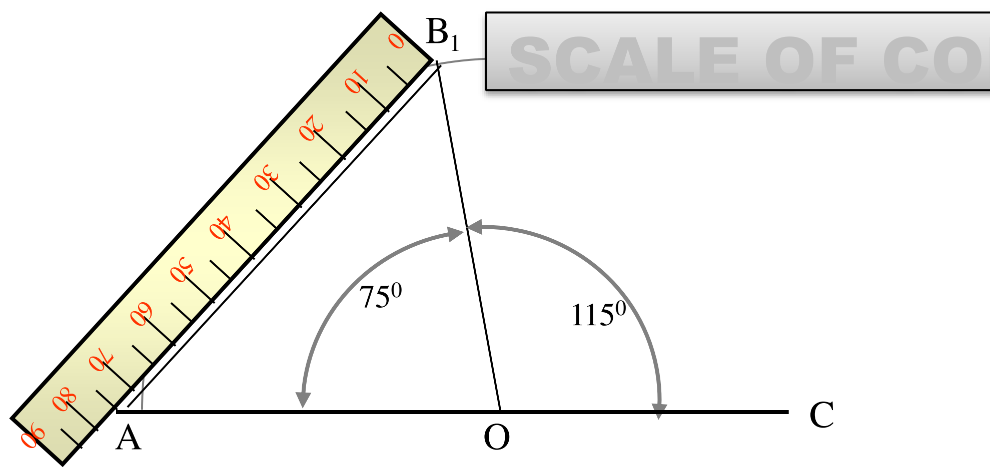
This scale can measure or construct angles upto 900 only directly.

Hence Subtract 115^0 from 180^0. We get 75^0 angle , which can be constructed with this scale.
Extend previous arc of OA radius and taking cord length of 75^0 in compass cut this arc at B_1 with A as center. Join B_1 with O. Now angle AOB_1 is 75^0 and angle COB_1 is 115^0.





To construct 25^0 angle at O.



To construct 115^0 angle at O.

Methods used to develop surfaces

1. **Parallel-line development:** Used for prisms, cylinders etc. in which parallel lines are drawn along the surface and transferred to the development.

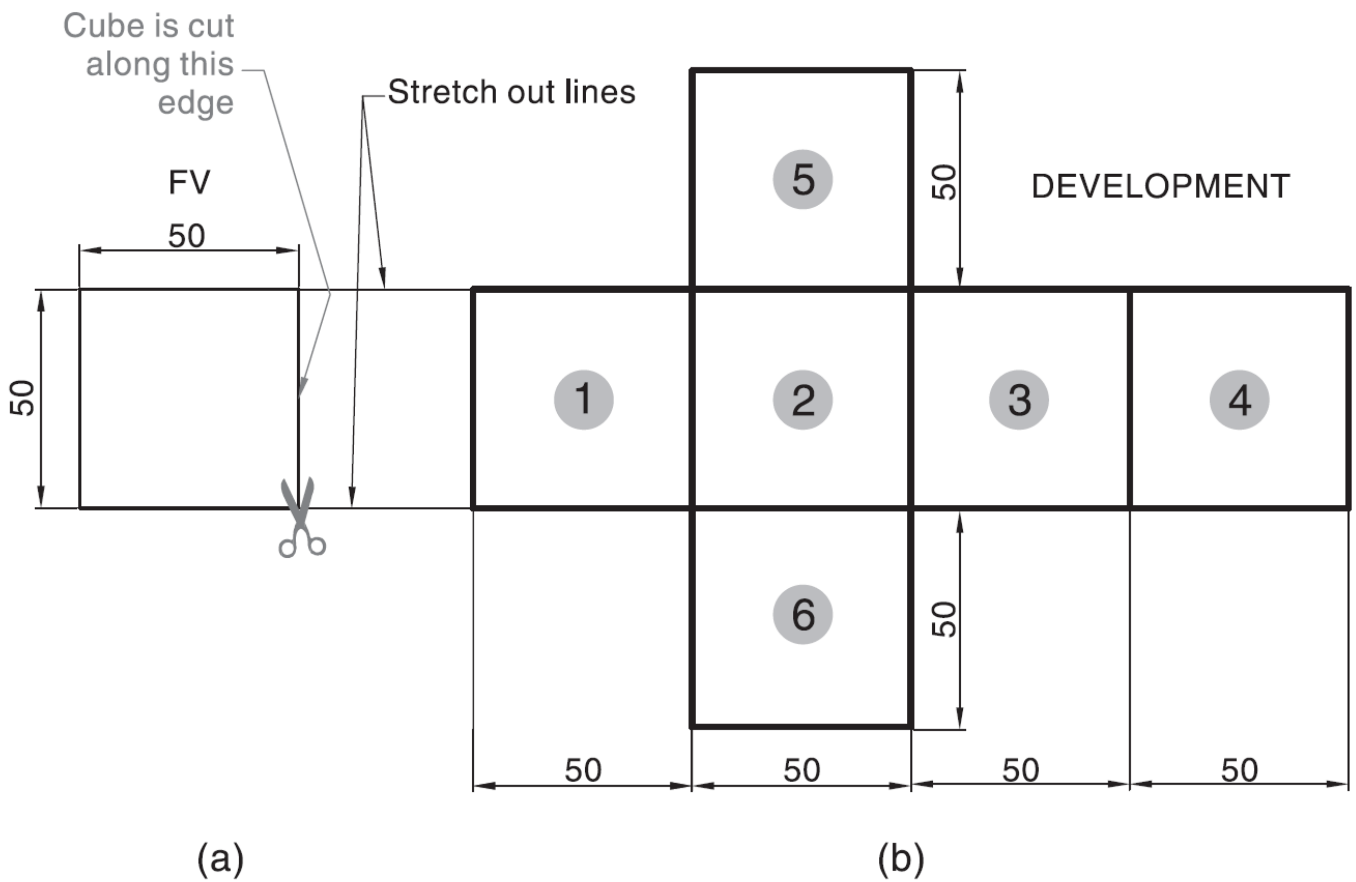
2. **Radial-line development:** Used for pyramids, cones etc. in which the true length of the slant edge or generator is used as radius.

3. **Triangulation development:** Complex shapes are divided into a number of triangles and transferred into the development (usually used for transition pieces).

4. **Approximate method:** Surface is divided into parts and developed. Used for surfaces such as spheres, paraboloids, ellipsoids etc.

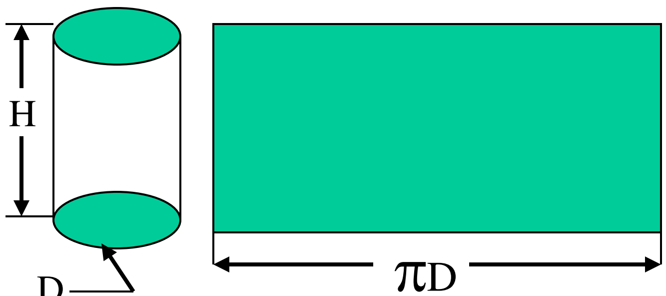
Note:- The surface is preferably cut at the location where the edge will be smallest such that welding or other joining procedures will be minimal.

Parallel line development: This method is employed to develop the surfaces of prisms and cylinders. Two parallel lines (called ***stretch-out lines***) are drawn from the two ends of the solids and the lateral faces are located between these lines.



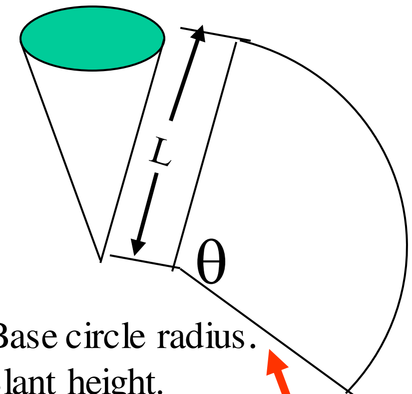
Development of lateral surfaces of different solids.
(Lateral surface is the surface excluding top & base)

Cylinder: A Rectangle



H= Height D= base diameter

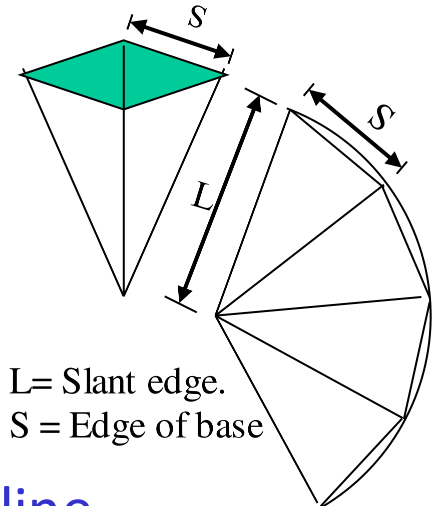
Cone: (Sector of circle)



R=Base circle radius.
L=Slant height.

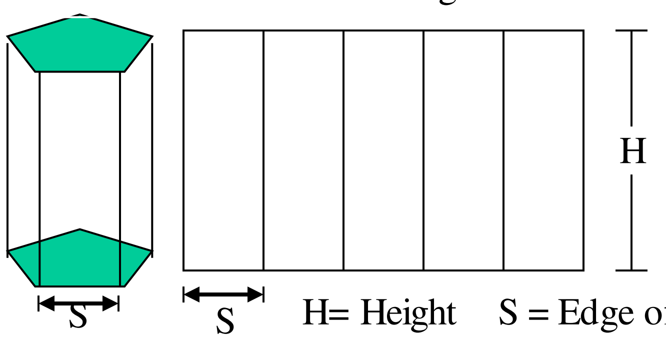
$$\theta = \frac{R}{L} \times 360^0$$

Pyramids: (No.of triangles)



L= Slant edge.
S = Edge of base

Prisms: No.of Rectangles

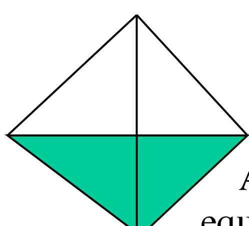


H= Height S = Edge of base

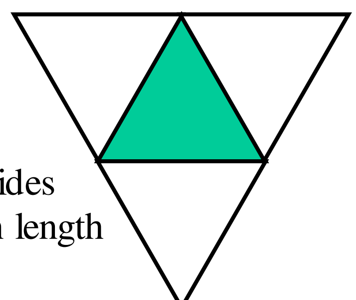
Parallel-line development

Radial-line development

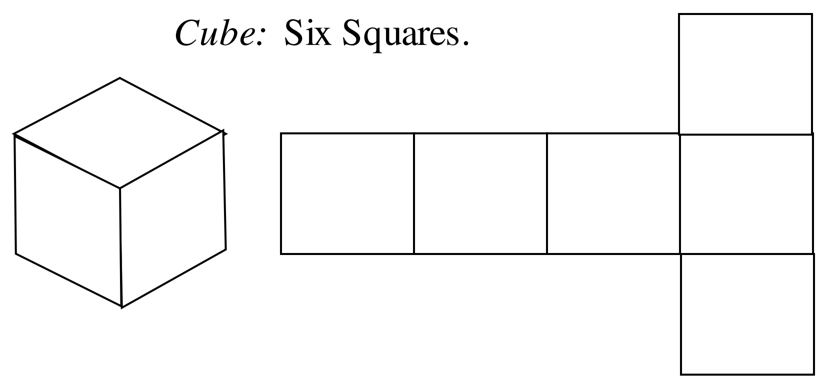
Tetrahedron: Four Equilateral Triangles



All sides equal in length

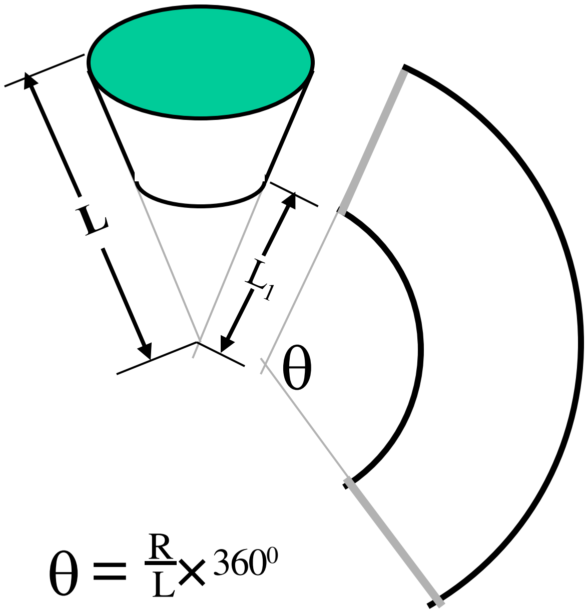


Cube: Six Squares.



FRUSTUMS

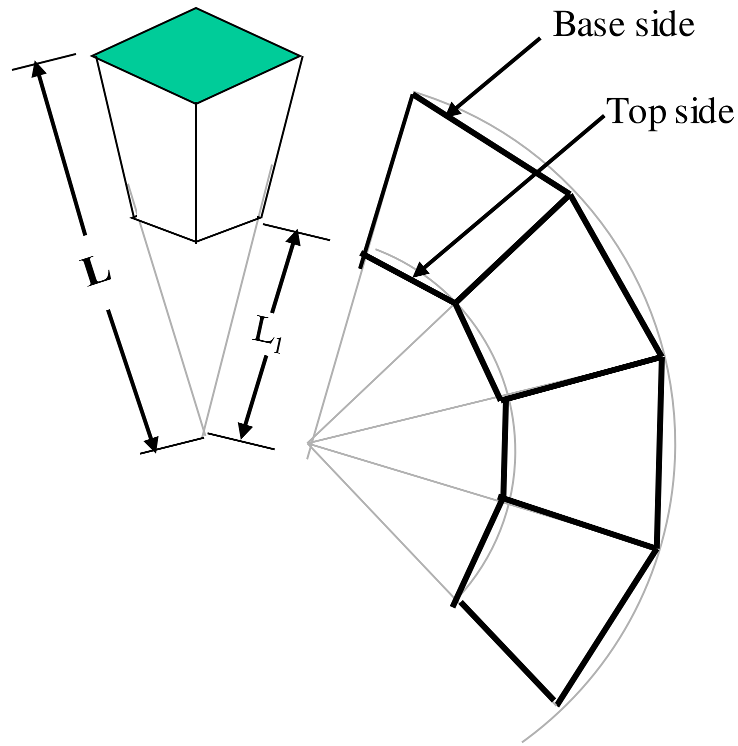
DEVELOPMENT OF
FRUSTUM OF CONE



$$\theta = \frac{R}{L} \times 360^0$$

R= Base circle radius of cone
L= Slant height of cone
L_1 = Slant height of cut part.

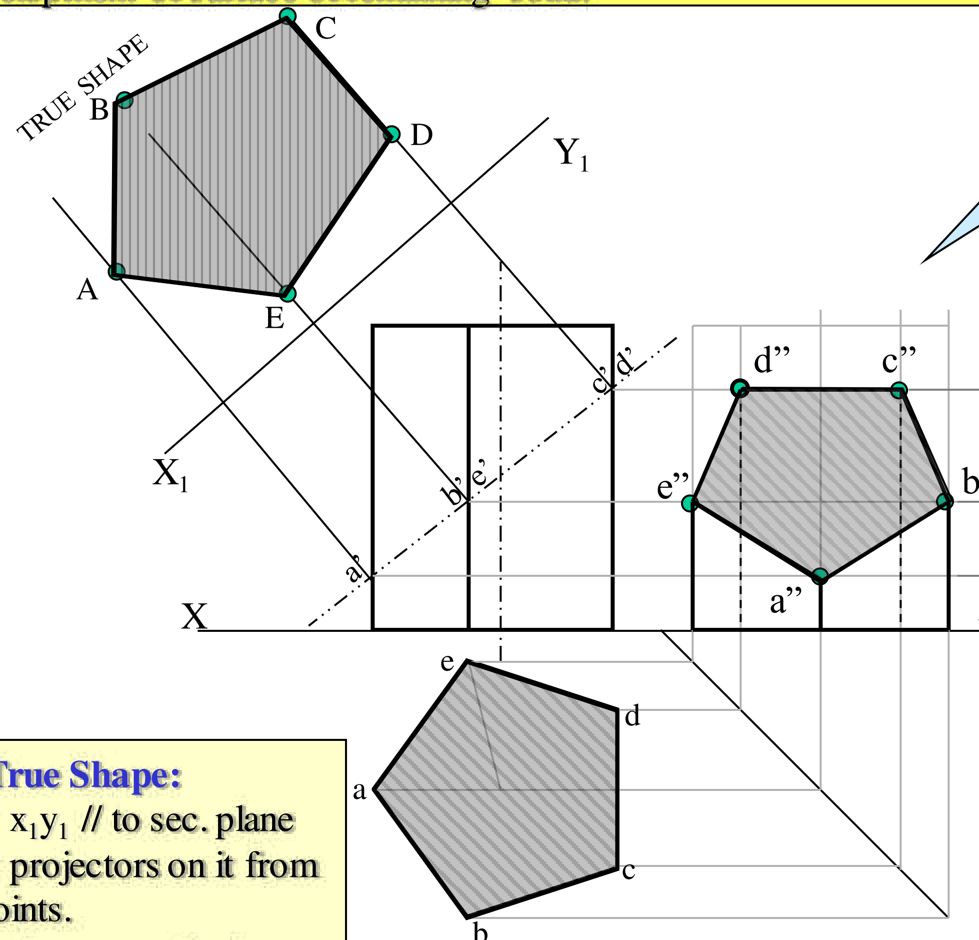
DEVELOPMENT OF
FRUSTUM OF SQUARE PYRAMID

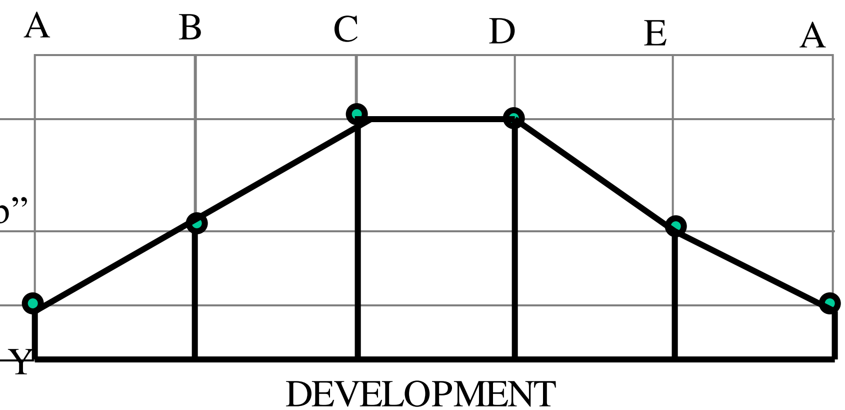


L= Slant edge of pyramid
L_1 = Slant edge of cut part.

Problem 1: A pentagonal prism , 30 mm base side & 50 mm axis is standing on Hp on it's base with one side of the base perpendicular to VP. It is cut by a section plane inclined at 45º to the HP, through mid point of axis. Draw Fv, sec.Tv & sec. Side view. Also draw true shape of section and Development of surface of remaining solid.

Solution Steps: *for sectional views:*
Draw three views of standing prism.
Locate sec.plane in Fv as described.
Project points where edges are getting Cut on Tv & Sv as shown in illustration.
Join those points in sequence and show Section lines in it.
Make remaining part of solid dark.



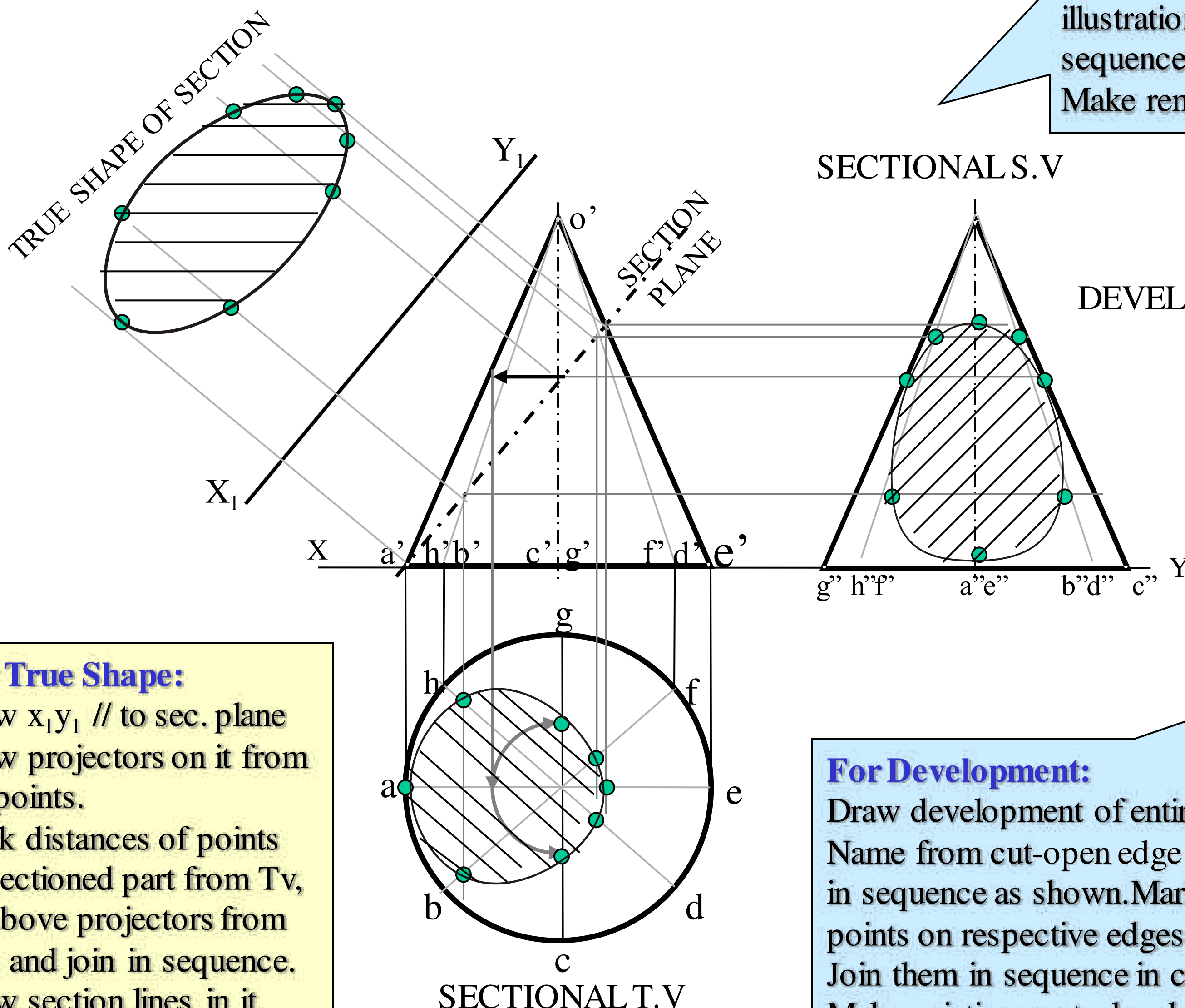


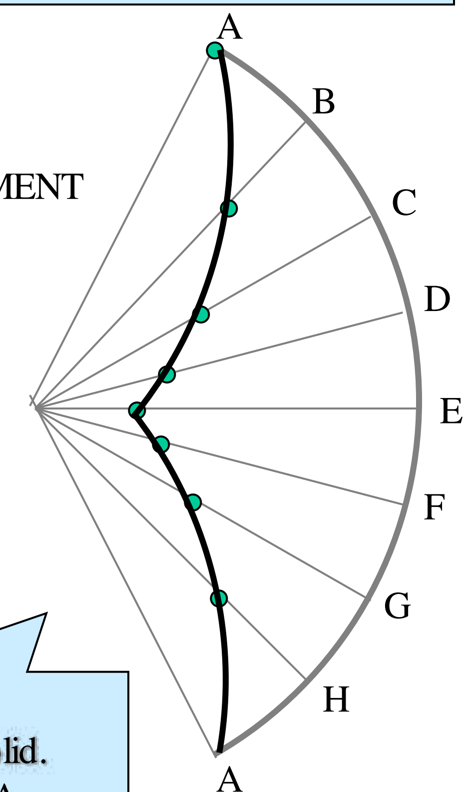
For True Shape:
Draw x_1y_1 // to sec. plane
Draw projectors on it from cut points.
Mark distances of points of Sectioned part from Tv, on above projectors from x_1y_1 and join in sequence.
Draw section lines in it.
It is required true shape.

For Development:
Draw development of entire solid. Name from cut-open edge I.e. A. in sequence as shown.
Mark the cut points on respective edges.
Join them in sequence in st. lines.
Make existing parts dev.dark.

Problem 2: A cone, 50 mm base diameter and 70 mm axis is standing on it's base on Hp. It cut by a section plane 45^0 inclined to Hp through base end of end generator.Draw projections, sectional views, true shape of section and development of surfaces of remaining solid.

Solution Steps: *for sectional views:*
Draw three views of standing cone.
Locate sec.plane in Fv as described.
Project points where generators are getting Cut on Tv & Sv as shown in illustration.Join those points in sequence and show Section lines in it.
Make remaining part of solid dark.



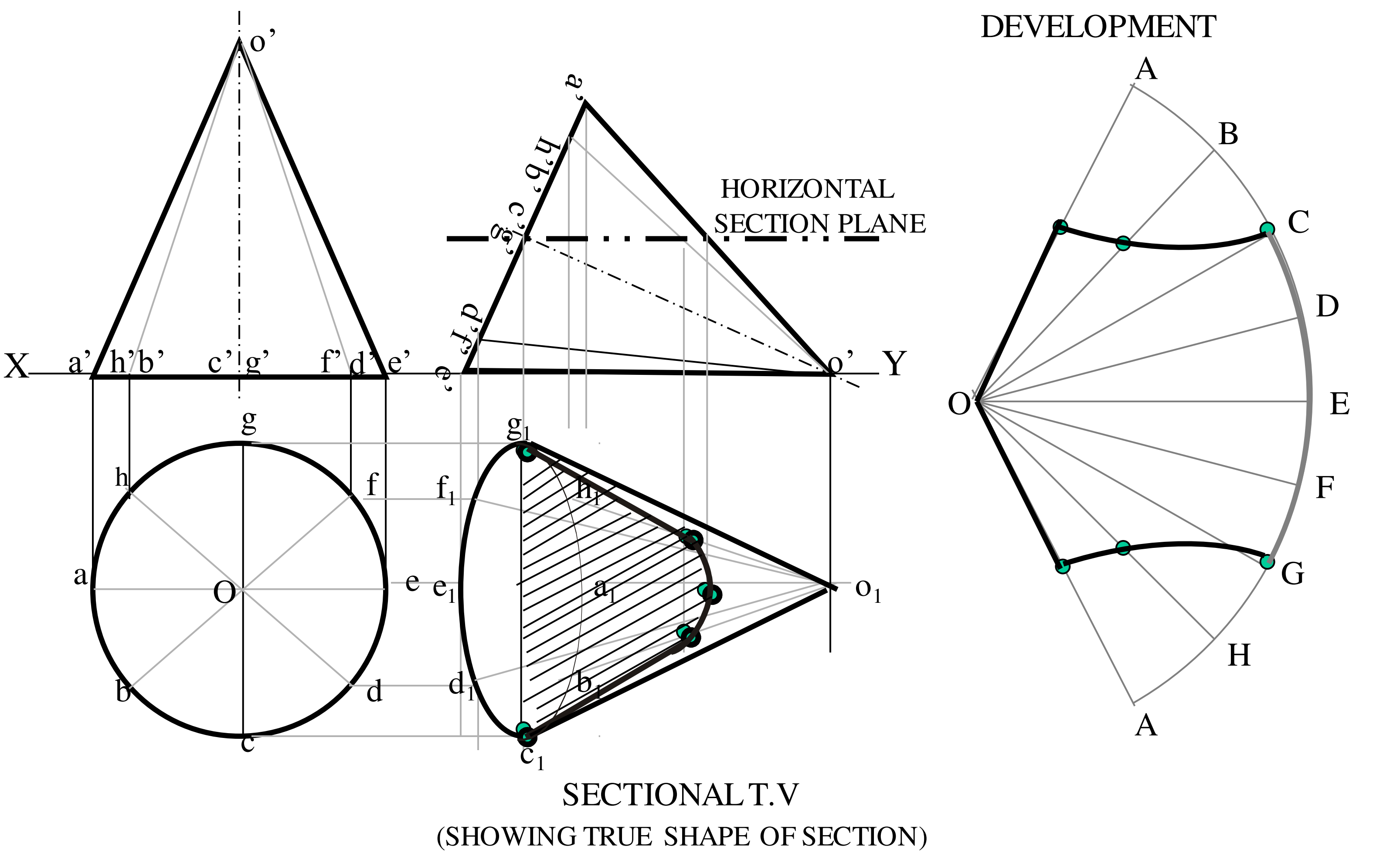


For True Shape:
Draw x_1y_1 // to sec. plane
Draw projectors on it from cut points.
Mark distances of points of Sectioned part from Tv, on above projectors from x_1y_1 and join in sequence.
Draw section lines in it.
It is required true shape.

For Development:
Draw development of entire solid.
Name from cut-open edge i.e. A.
in sequence as shown.Mark the cut points on respective edges.
Join them in sequence in curvature.
Make existing parts dev.dark.

Problem 3: A cone 40mm diameter and 50 mm axis is resting on one generator on Hp(lying on Hp) which is // to Vp.. Draw it's projections.It is cut by a horizontal section plane through it's base center. Draw sectional TV, development of the surface of the remaining part of cone.

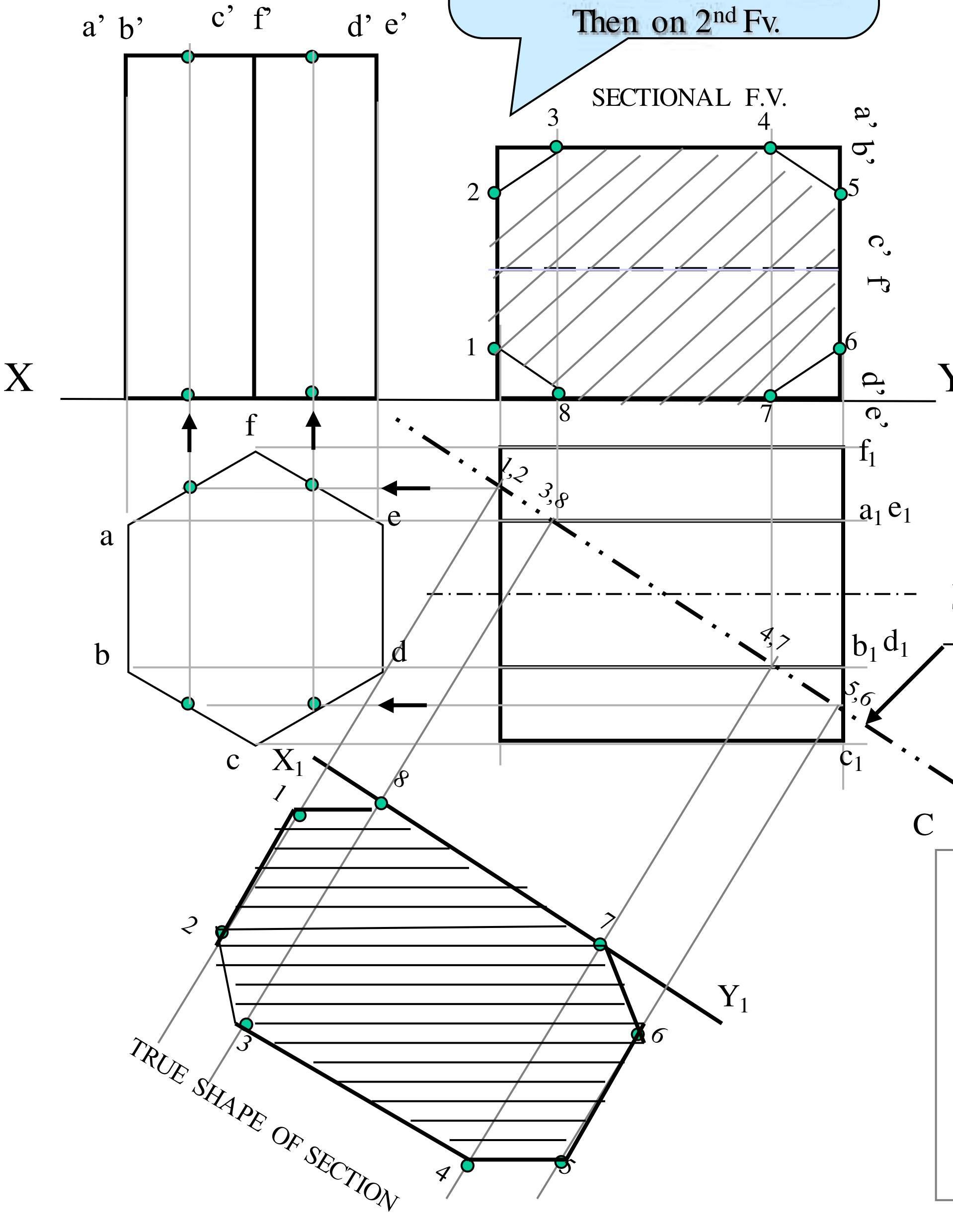
Follow similar solution steps for Sec.views - True shape – Development as per previous problem!



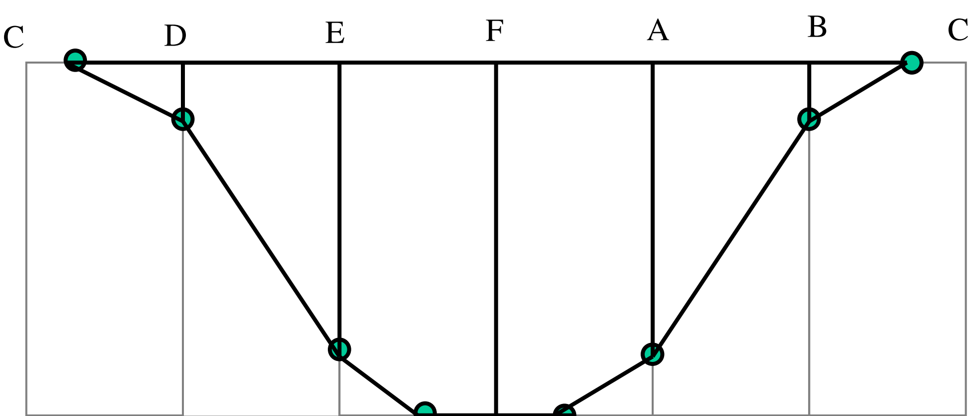
Problem 4: A hexagonal prism. 30 mm base side & 55 mm axis is lying on Hp on it's rect.face with axis // to Vp. It is cut by a section plane normal to Hp and 30^0 inclined to Vp bisecting axis.
Draw sec. Views, true shape & development.

Use similar steps for sec.views & true shape.
NOTE: for development, always cut open object from From an edge in the boundary of the view in which sec.plane appears as a line.
Here it is Tv and in boundary, there is c1 edge.Hence it is opened from c and named C,D,E,F,A,B,C.

Note the steps to locate Points 1, 2 , 5, 6 in sec.Fv: Those are transferred to 1st TV, then to 1st Fv and Then on 2nd Fv.

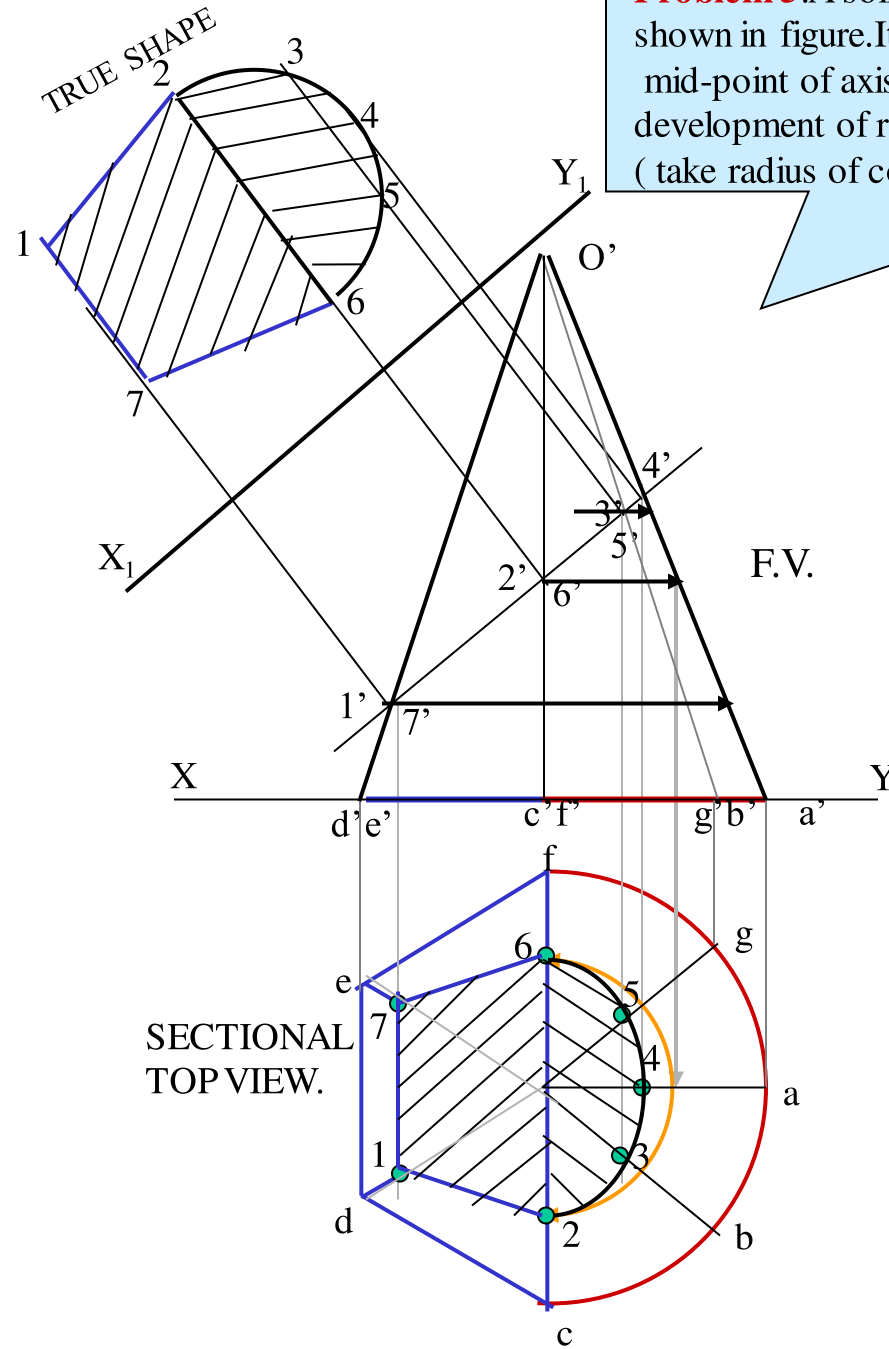


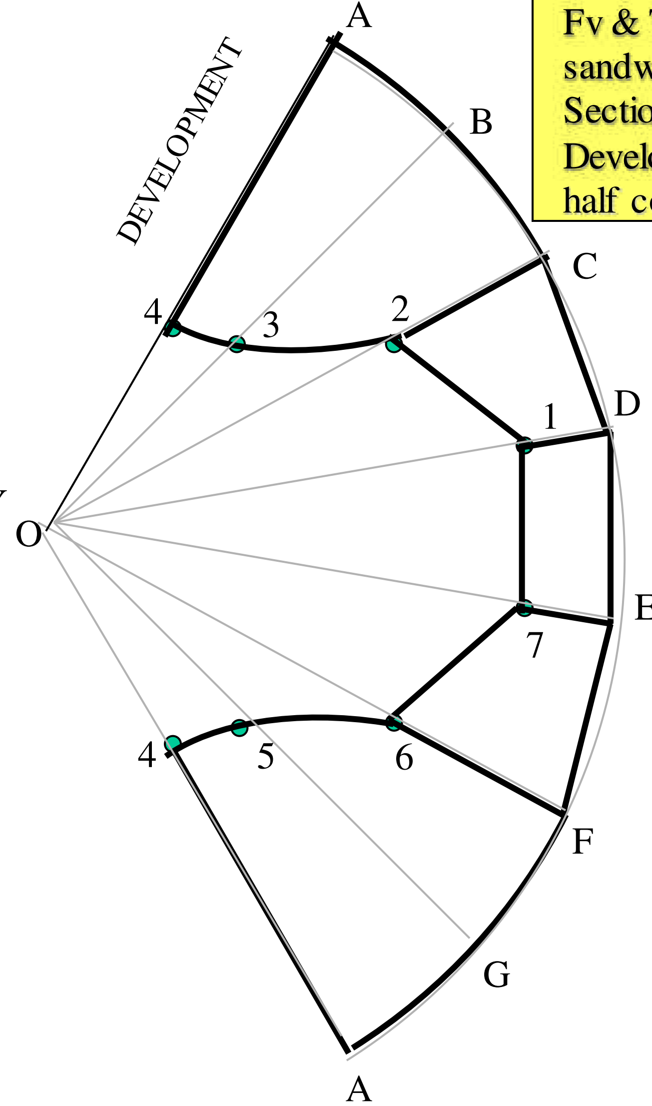
AS SECTION PLANE IS IN T.V.,
CUT OPEN FROM BOUNDRY EDGE C_1 FOR DEVELOPMENT.



DEVELOPMENT

Problem 5:A solid composed of a half-cone and half- hexagonal pyramid is shown in figure.It is cut by a section plane 45^0 inclined to Hp, passing through mid-point of axis.Draw F.v., sectional T.v.,true shape of section and development of remaining part of the solid.
(take radius of cone and each side of hexagon 30mm long and axis 70mm.)

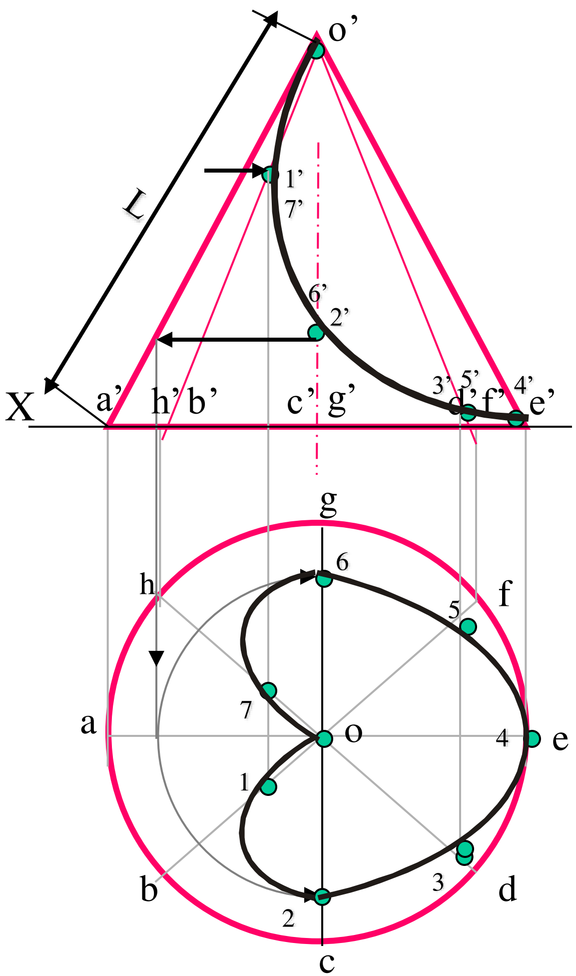




Note:
Fv & TV 8f two solids sandwiched
Section lines style in both:
Development of half cone & half pyramid:

Problem 6: Draw a semicircle 0f 100 mm diameter and inscribe in it a largest circle.If the semicircle is development of a cone and inscribed circle is some curve on it, then draw the projections of cone showing that curve.

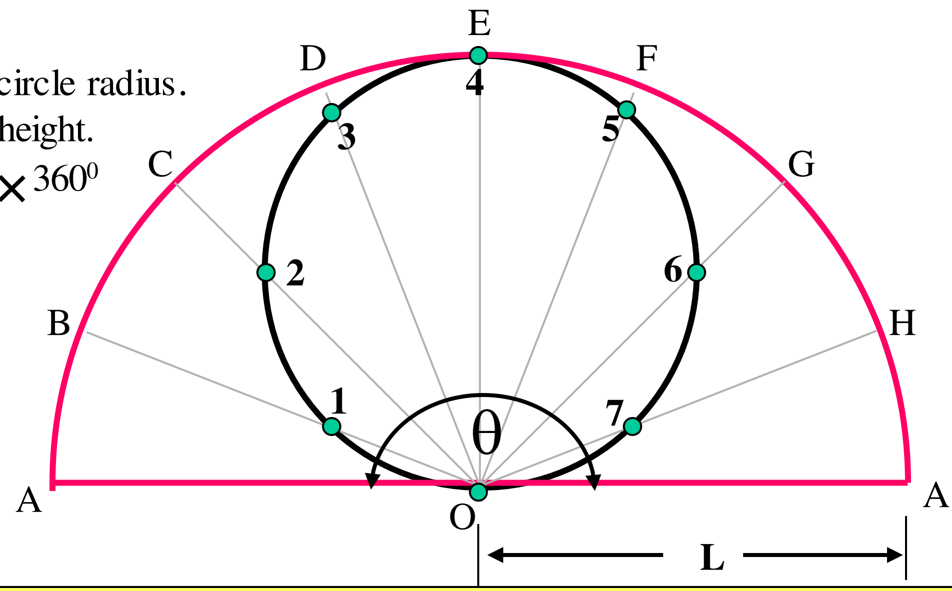
TO DRAW PRINCIPAL VIEWS FROM GIVEN DEVELOPMENT.



R=Base circle radius.

L=Slant height.

$$\theta = \frac{R}{L} \times 360^0$$



Solution Steps:

Draw semicircle of given diameter, divide it in 8 Parts and inscribe in it a largest circle as shown.Name intersecting points 1, 2, 3 etc.

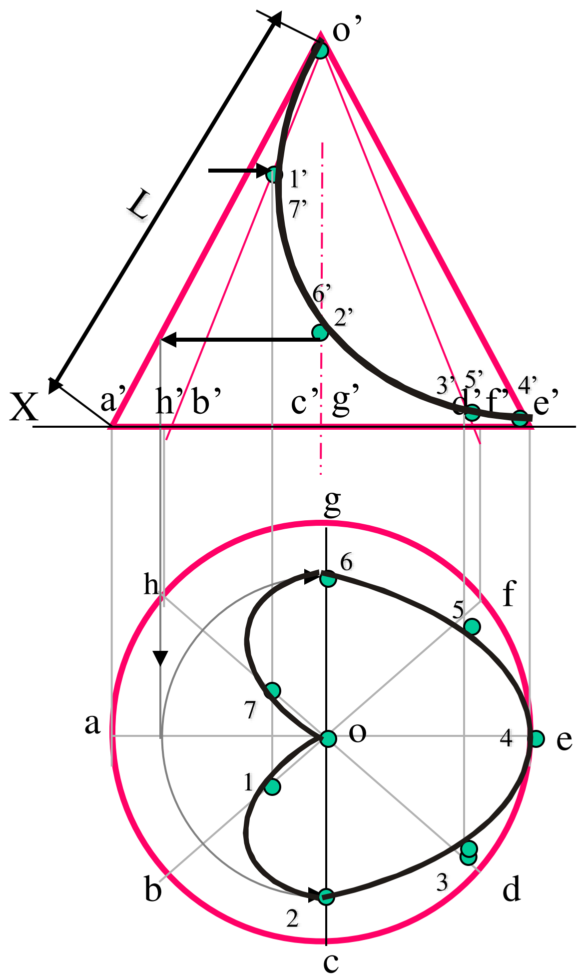
Semicircle being dev.of a cone it's radius is slant height of cone.(L)

Then using above formula find R of base of cone. Using this data draw Fv & Tv of cone and form 8 generators and name.

Take o -1 distance from dev.,mark on TL i.e.o'a' on Fv & bring on o'b' and name 1' Similarly locate all points on Fv. Then project all on Tv on respective generators and join by smooth curve.

Problem 6: Draw a semicircle 0f 100 mm diameter and inscribe in it a largest circle.If the semicircle is development of a cone and inscribed circle is some curve on it, then draw the projections of cone showing that curve.

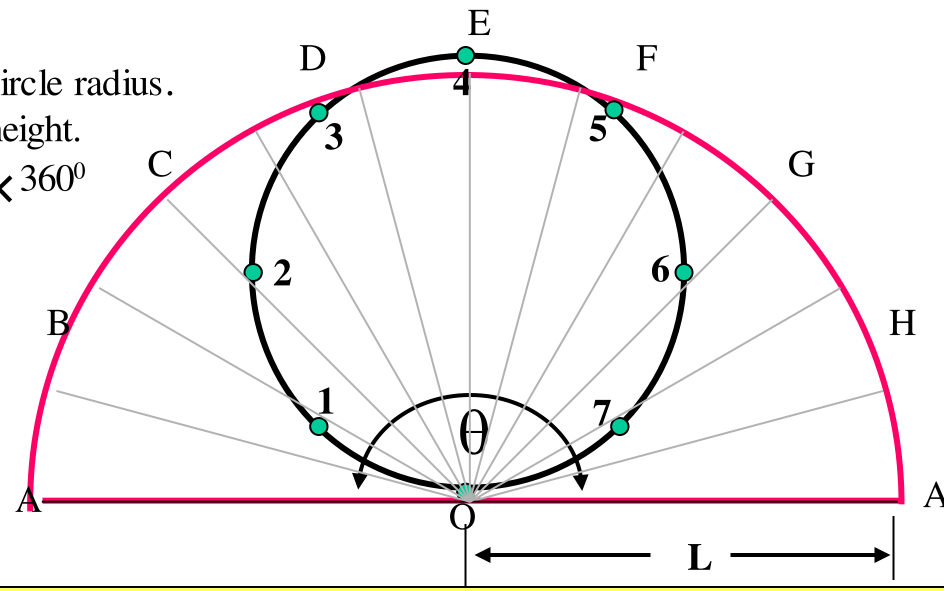
TO DRAW PRINCIPAL VIEWS FROM GIVEN DEVELOPMENT.



R=Base circle radius.

L=Slant height.

$$\theta = \frac{R}{L} \times 360^0$$



Solution Steps:

Draw semicircle of given diameter, divide it in 8 Parts and inscribe in it a largest circle as shown.Name intersecting points 1, 2, 3 etc.

Semicircle being dev.of a cone it's radius is slant height of cone.(L)

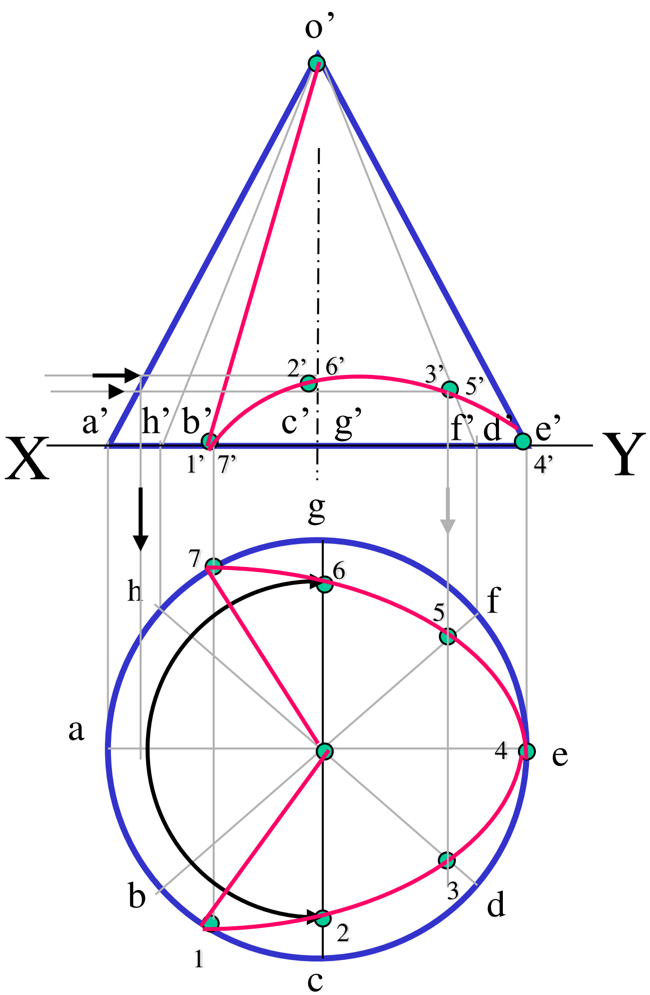
Then using above formula find R of base of cone. Using this data draw Fv & Tv of cone and form 8 generators and name.

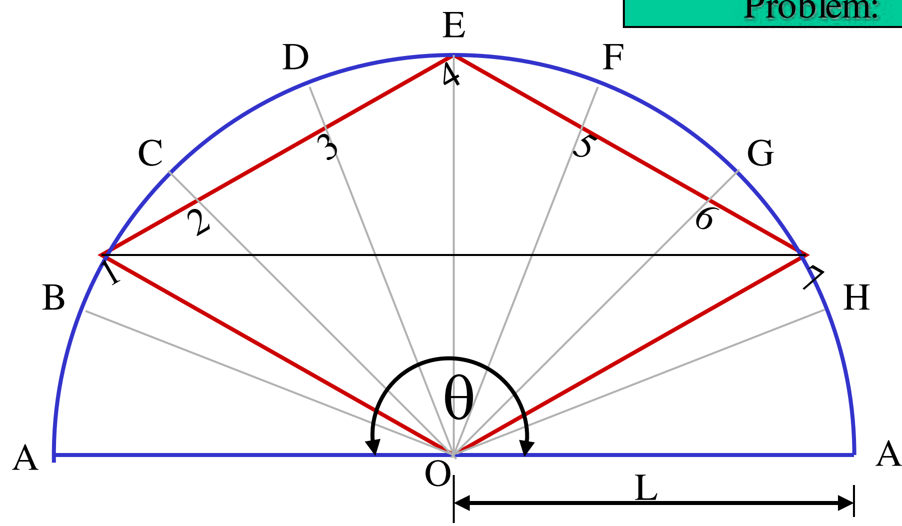
Take o -1 distance from dev.,mark on TL i.e.o'a' on Fv & bring on o'b' and name 1' Similarly locate all points on Fv. Then project all on Tv on respective generators and join by smooth curve.

Problem 7: Draw a semicircle 0f 100 mm diameter and inscribe in it a largest **rhombus**. If the semicircle is development of a cone and rhombus is some curve on it, then draw the projections of cone showing that curve.

TO DRAW PRINCIPAL VIEWS FROM GIVEN DEVELOPMENT.

Solution Steps:
Similar to previous Problem:



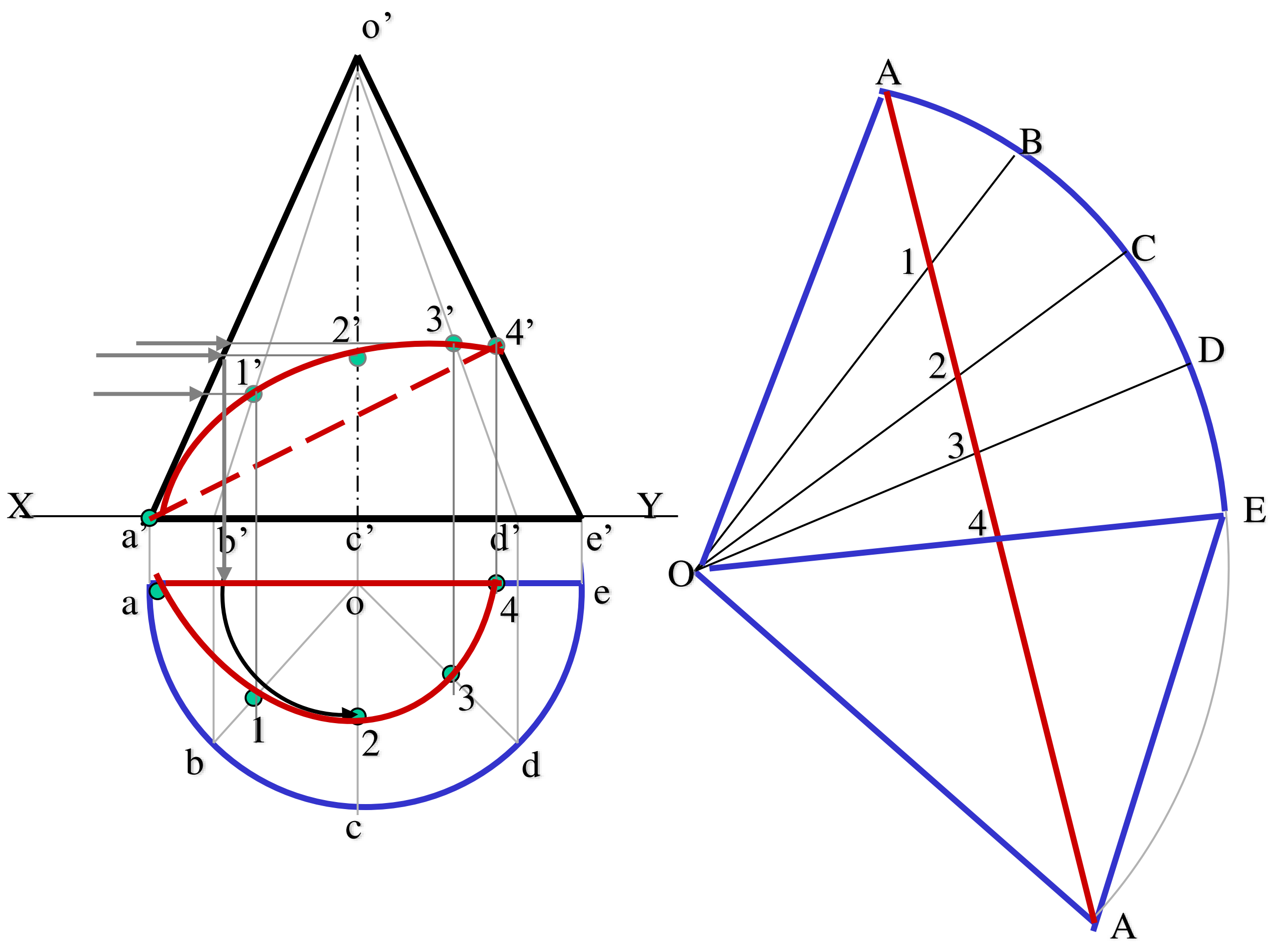


R=Base circle radius.
L=Slant height.

$$\theta = \frac{R}{L} \times 360^0$$

Problem 8: A half cone of 50 mm base diameter, 70 mm axis, is standing on it's half base on HP with it's flat face parallel and nearer to VP.An inextensible string is wound round it's surface from one point of base circle and brought back to the same point.If the string is of ***shortest length***, find it and show it on the projections of the cone.

TO DRAW A CURVE ON PRINCIPAL VIEWS FROM DEVELOPMENT.



Concept: A string wound from a point up to the same Point, of shortest length Must appear st. line on it's Development.

Solution steps:

Hence draw development, Name it as usual and join A to A This is shortest Length of that string. Further steps are as usual. On dev. Name the points of Intersections of this line with Different generators.Bring Those on Fv & Tv and join by smooth curves. Draw 4' a' part of string dotted As it is on back side of cone.

Detailed and assembly drawing

Wood Joints

- "joints"…this term is used to describe the close securing or fastening together of two or more smooth, even surfaces.

Wood Joints

- The **joint to select** for each kind of construction <u>depends to some extend</u> on the need for:
  - The **strength**
  - The **appearance**
  - The **difficulty of fabrication**
  - The **equipment available**

Wood Joints

- Most joints are permanently fastened together with **glue** and sometimes screws or nails.

Wood Joints

- The following are **common methods** of **strengthening joints**.
  - **Dowels**
  - **Splines and Biscuits**
  - **Key**
  - **Glue Blocks**
  - **Corner Blocks**

Wood Joints

- The following are **common methods** of **strengthening joints**.
  - **Dowels**

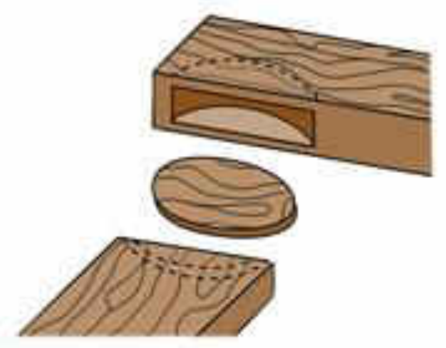
You can put a dowel into butt, miter, lap joints etc. to add strength to the joint.

Wood Joints

- The following are **common methods** of **strengthening joints**.

  – For a **Spline** to add strength to a joint, its **grain must run across the joint**, not parallel to it.

Wood



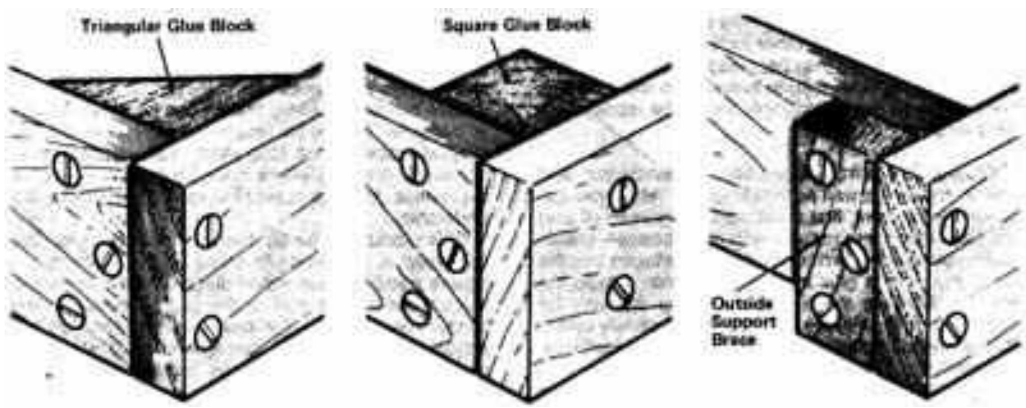
- The following are **common methods** of **strengthening joints**.
  - **Biscuits**
  - Using thin **wood wafers** called **biscuits** can strengthen wood joints by providing more glue bonding area. Biscuit will expand 2X.
  - You can use a biscuit joiner (also called a plate joiner) to cut precision mating slots in boards for the biscuits.

Wood Joints

- The following are **common methods** of **strengthening joints**.
  - **Key**

Wood Joints

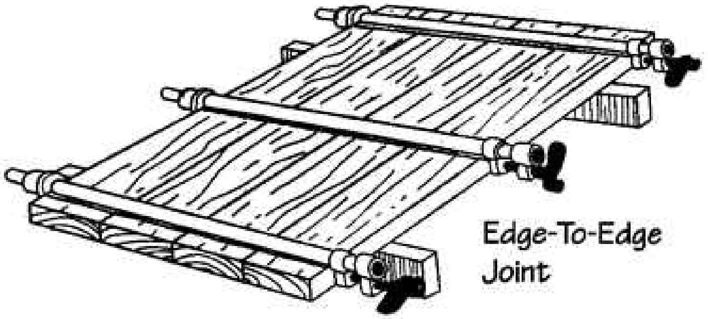
- The following are **common methods** of **strengthening joints**.
  - **Glue Block**-small triangular or square blocks
  - **Corner Blocks**-larger than a glue block



Eight basic wood joints

1. **Edge**
2. **Butt**
3. **Rabbet**
4. **Dado**
5. **Miter**
6. **Lap**
7. **Mortise and Tenon**
8. **Dovetail**

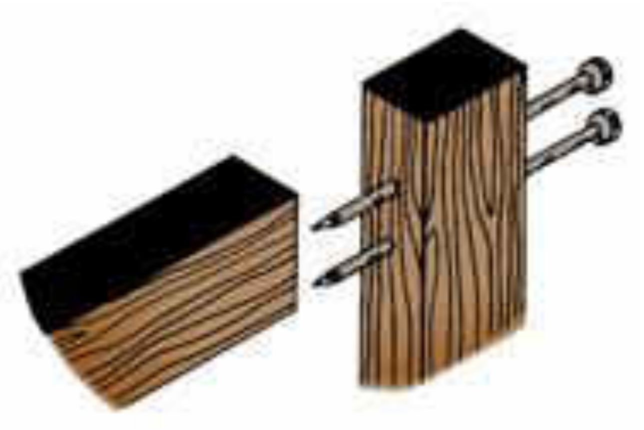
Eight basic wood joints



- **Edge-to-edge:**
- This joint is used when laminating boards together edge-to-edge to obtain a wider piece of wood.
- Used for table top, desktops and cabinet sides.

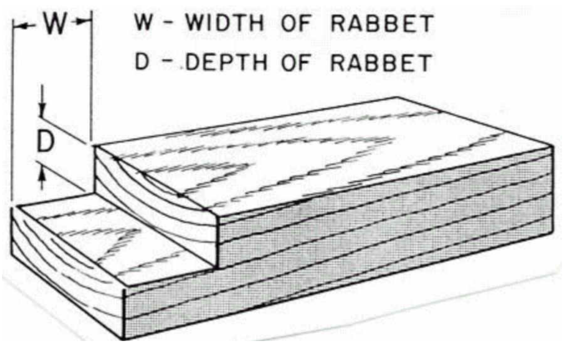
Eight basic wood joints

- **Butt**
- **For simple boxes, cases, cheap drawers, frames and chairs.**
- **Very weak joint.**



Eight basic wood joints

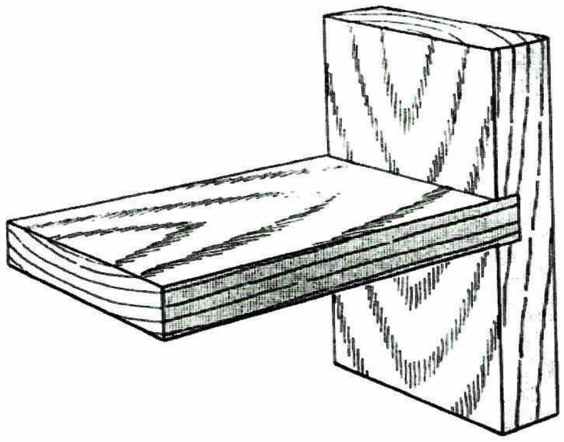
- **Rabbet-** A cut or groove along or near the edge of a piece of wood that allows another piece to fit into it to form a joint. L-shaped groove cut across the **edge** or **end** <u>of one piece</u>.
- **For simple boxes, cases, cheap drawers, frames and chairs**
  - It is usually reinforced with screws or nails.
  - Rabbet joints are easy to make and moderately strong.
  - They are used chiefly for boxes, drawers, shelving and at the corners of cabinet pieces.
  - Rabbet joints are sometimes made with a dado variation.



Eight basic wood joints

- **Dado-** is a groove **cut across the grain**.
- typically used in making book shelves, drawers, steps, and book cases. This is a strong joint.
- In very old furniture, a dovetail dado joint is a real work of art because of the time the

cabinetmaker had to spend to cut it.



Eight basic wood joints

- **Miter-** the joining pieces are cut at a 45-degree angle and joined to form a right angle.

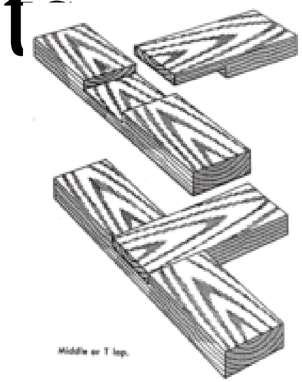
- Miters are used for decorative molding and for frames.

- They are very weak and are often reinforced with dowels, spline, or mechanical fasteners.

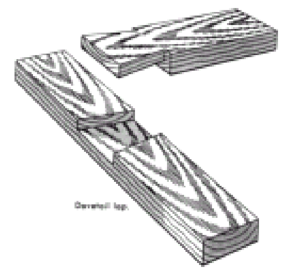
Polygon miters- cuts at angles of more or less than 45 degrees to form three- to ten-sided objects.

Eight basic wood joints

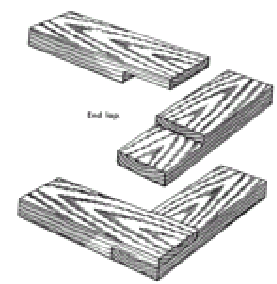
- **Lap** joints are really a large group of joints in which one side laps over the other.
- A cross-lap joint joins two pieces with flush faces.
- The pieces may cross at any angle.
- Cutting dadoes of equal width and depth on the two pieces so that the face surfaces are flush when they are assembled makes the joint.
- Used for legs of furniture, doors, furniture frames and braces. This joint is strong.



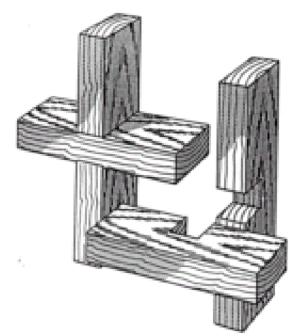
Middle or T lap.



Dovetail lap.



End lap.



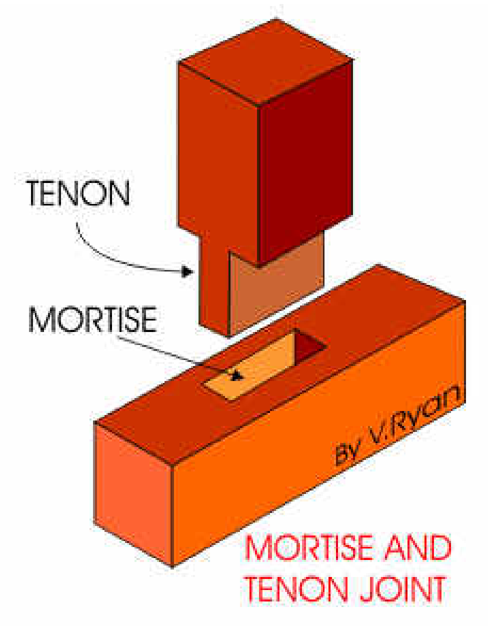
Edge cross lap.

Eight basic wood joints

Mortise and Tenon

- One of the most common joints used for joining the rails and legs of tables, chairs and other type of furniture is the **Mortise and Tenon** joint.

Mortise and '



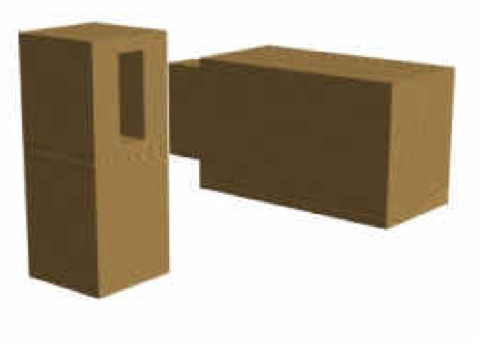
A large range of mortise and tenon joints exist and the most simple of these is shown.

The tenon is the part that fits into the mortise.

A glue is applied before the joint is pushed together.

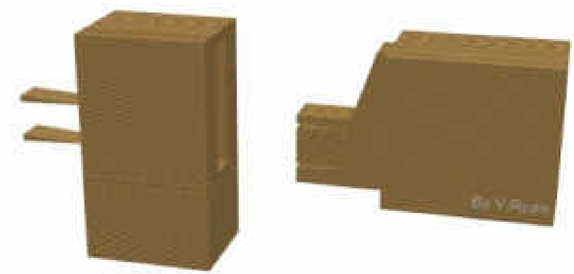
Clamps are used to hold the joint firmly together, usually for twenty-four hours.

Mortise and Tenon



- The **Plain Mortise and Tenon** joint (shown below) is very common and is widely used for the joints of tables.
- Although it is quite strong, if enough force is placed on the joint it will eventually break or come lose.

Mortise and Tenon



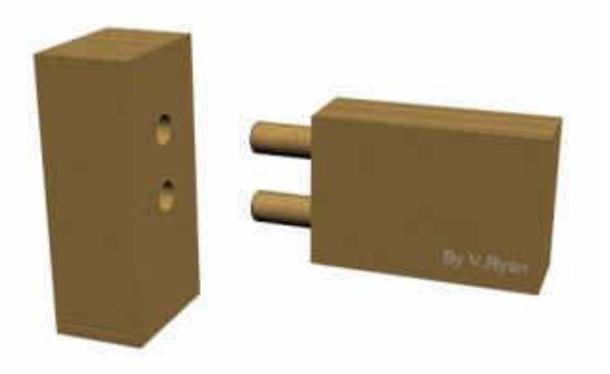
- The **Wedged Mortise and Tenon** joint is extremely strong because the tenon passes all the way through the mortise and is wedged at the other side.
- However, the **Wedged Mortise and Tenon** is more difficult to mark out and cut and requires much more technical skill.

Mortise and

- In this example, a piece of **dowel rod** is drilled through the mortise and the tenon.

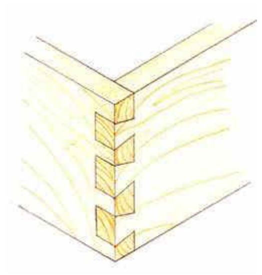
- This helps keep the joint together even when it is under great pressure.

- This is used as a joint on chairs and other pieces of furniture so that the joints do not break apart when extra weight is applied.

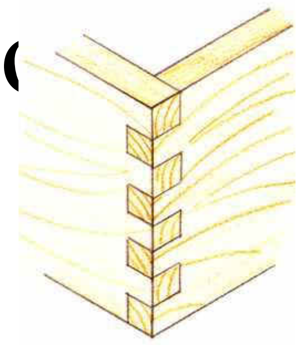


Eight basic wood joints

- The **DOVETAIL JOINT** is very strong because of the way the **tails and pins** are shaped.
- This makes it difficult to pull the joint apart and virtually impossible when glue is added.
- This type of joint is used in box constructions such as draws, jewellery boxes, cabinets and other pieces of furniture where strength is required.
- There are different types of dovetail joint and when cut accurately they are very impressive and attractive.

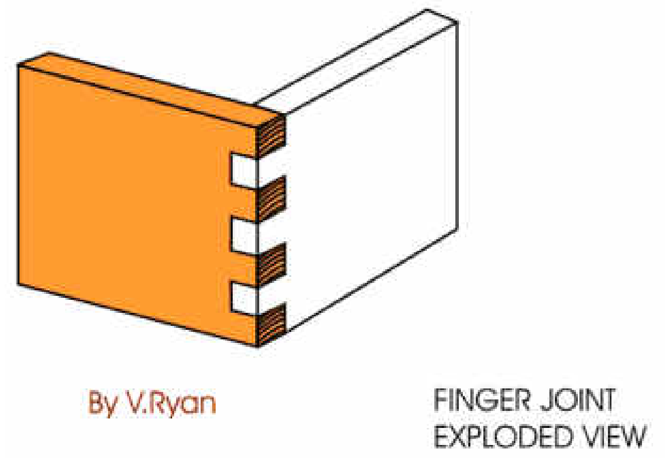


Finger Jo



- It is ideal for **box constructions** and is suitable for use with natural woods such as pine and mahogany or even manmade boards such as plywood and MDF.

- The **joint is strong** especially when used with a good quality glue.



Screw Threads & Threaded Fasteners

FASTENING TYPE

1. Permanent

Welding

Gluing

Riveting

FASTENING TYPE

2. Temporary

2.1 ***Threaded fastener***

- bolts
- studs
- screws

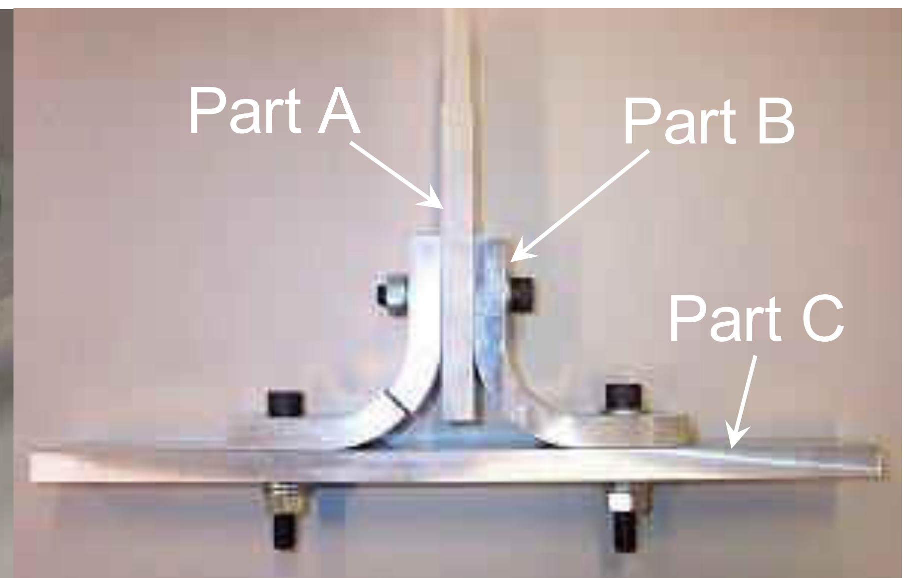
2.2 ***Non-threaded fastener***

- keys
- pin

THREAD APPLICATION

1. To hold parts together.

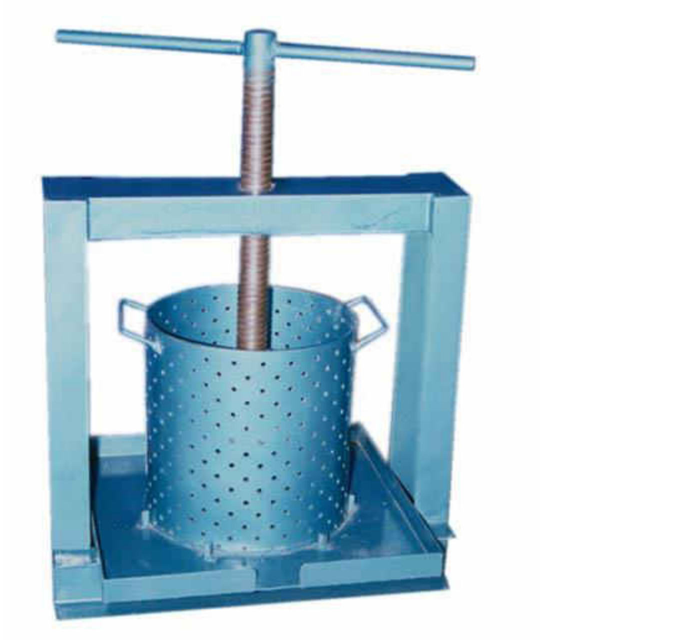
2. To move part(s) relative to others.



THREAD APPLICATION

1. To hold parts together.
2. To move part(s) relative to others.

Wood working vise

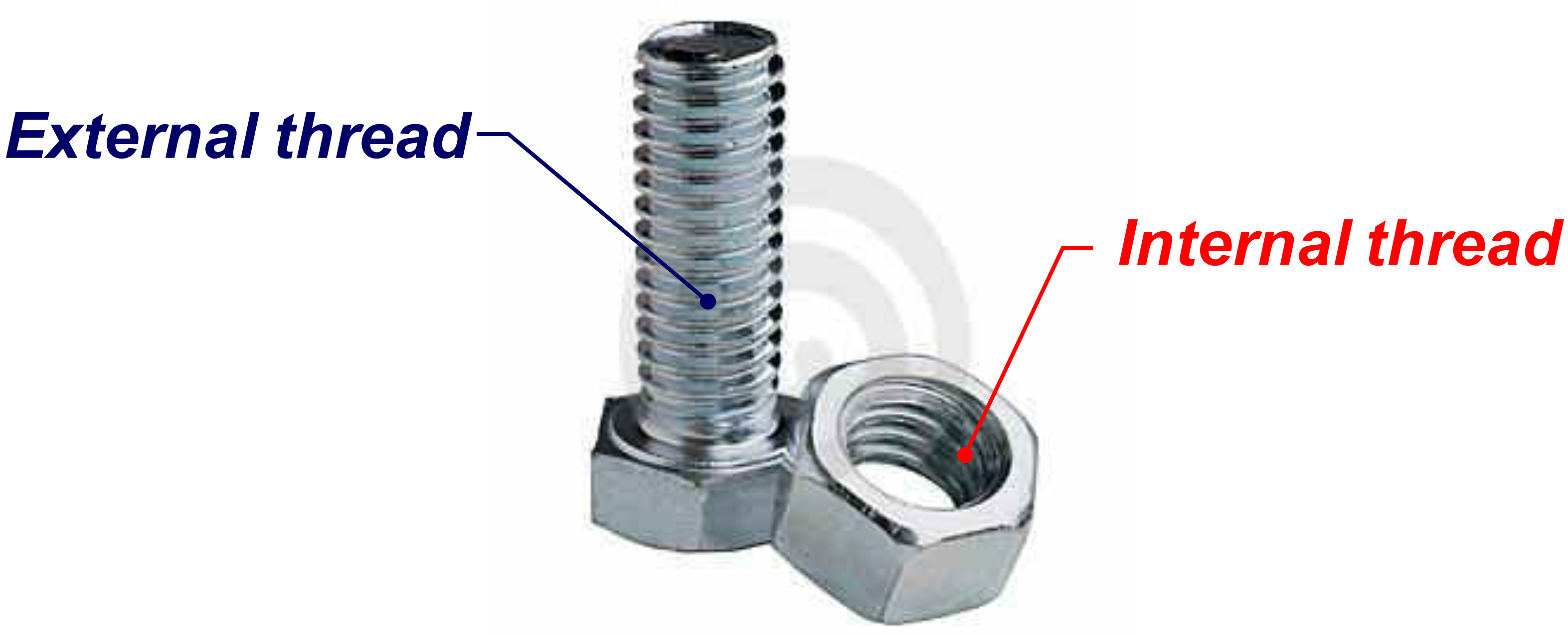


Palm fruit pressing machine

Thread Terminology

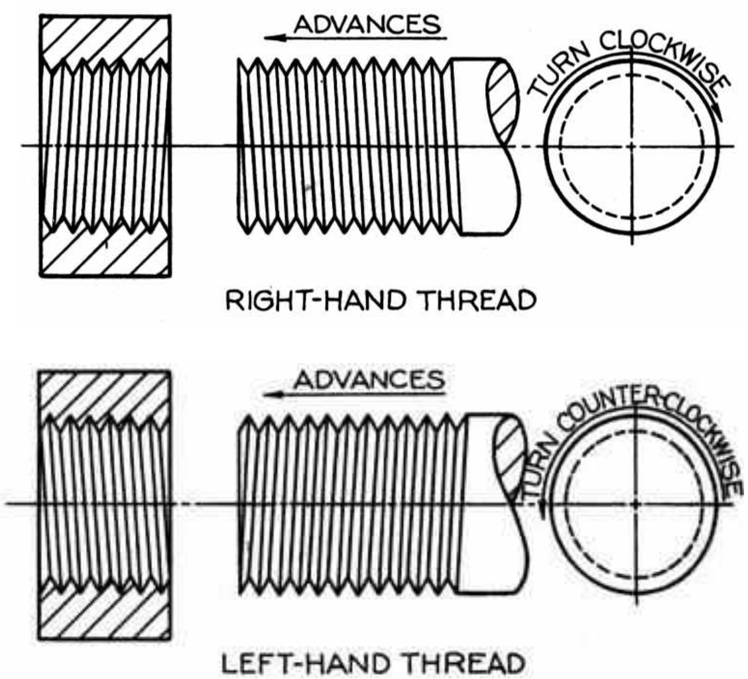
THREAD TERMINOLOGY

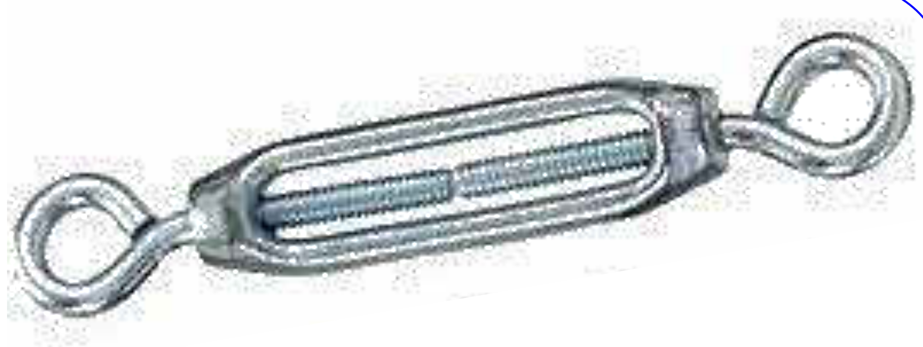
External (male) thread	A thread cut on the ***outside*** of a cylindrical body.
Internal (female) thread	A thread cut on the ***inside*** of a cylindrical body.



THREAD TERMINOLOGY

Right-hand thread	Thread that will ***assemble*** when turned ***clockwise***.
Left-hand thread	Thread that will ***assemble*** when turned ***counter-clockwise***.



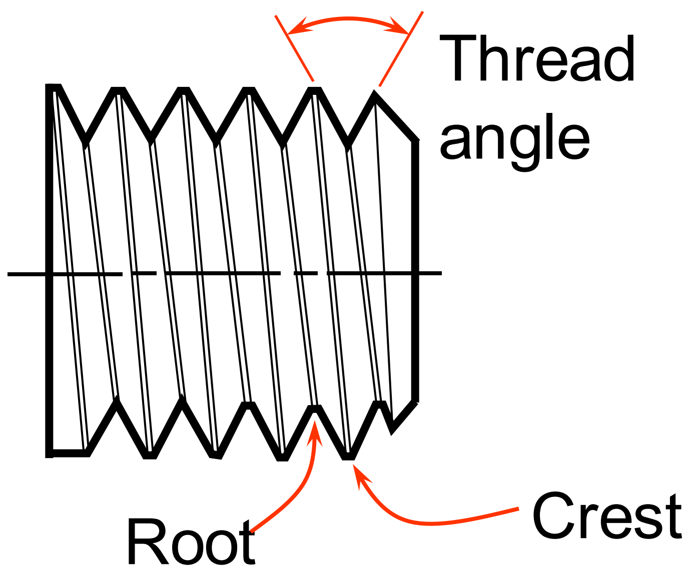


Turnbuckle use RH and LH thread at each end to double displacement.

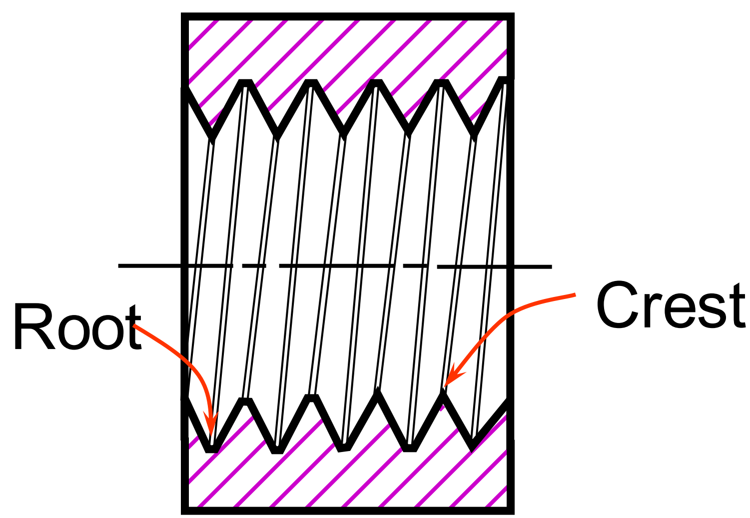
THREAD TERMINOLOGY

Crest	The ***peak edge*** of a thread.
Root	The ***bottom*** of the thread cut into a cylindrical body.
Thread angle	The angle between threads faces.

External Thread



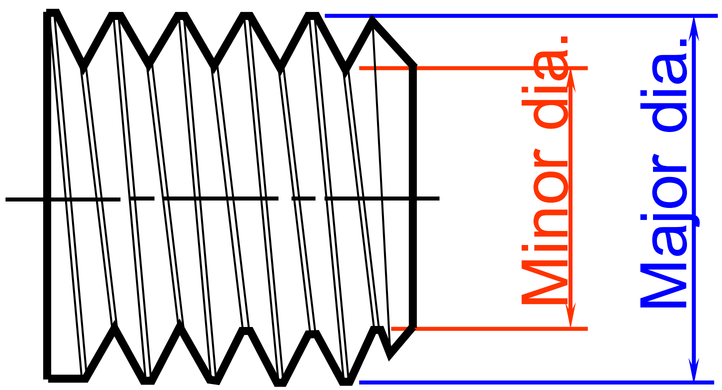
Internal Thread



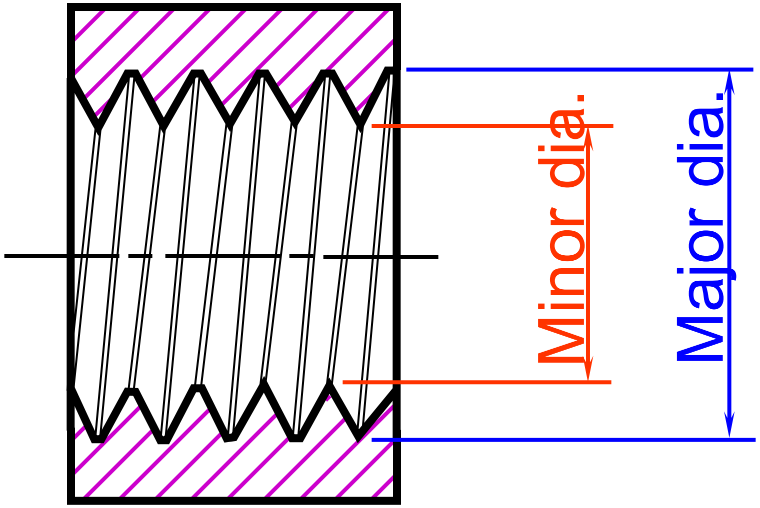
THREAD TERMINOLOGY

Major diameter	The ***largest diameter*** on an internal or external thread.
Minor diameter	The ***smallest diameter*** on an internal or external thread.

External Thread



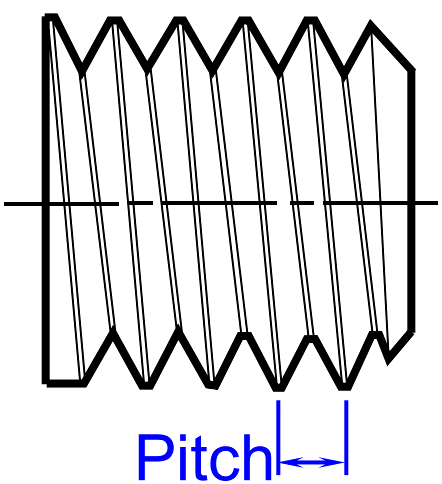
Internal Thread



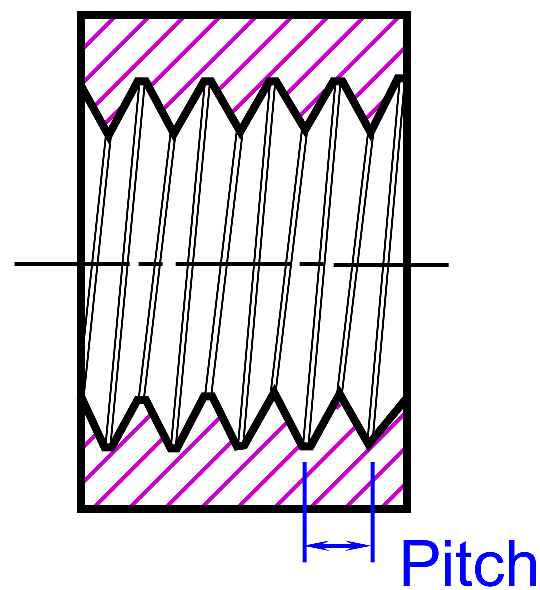
THREAD TERMINOLOGY

Pitch	The distance between crests of threads.
Lead	The distance a screw will advance when turned 360°.

External Thread

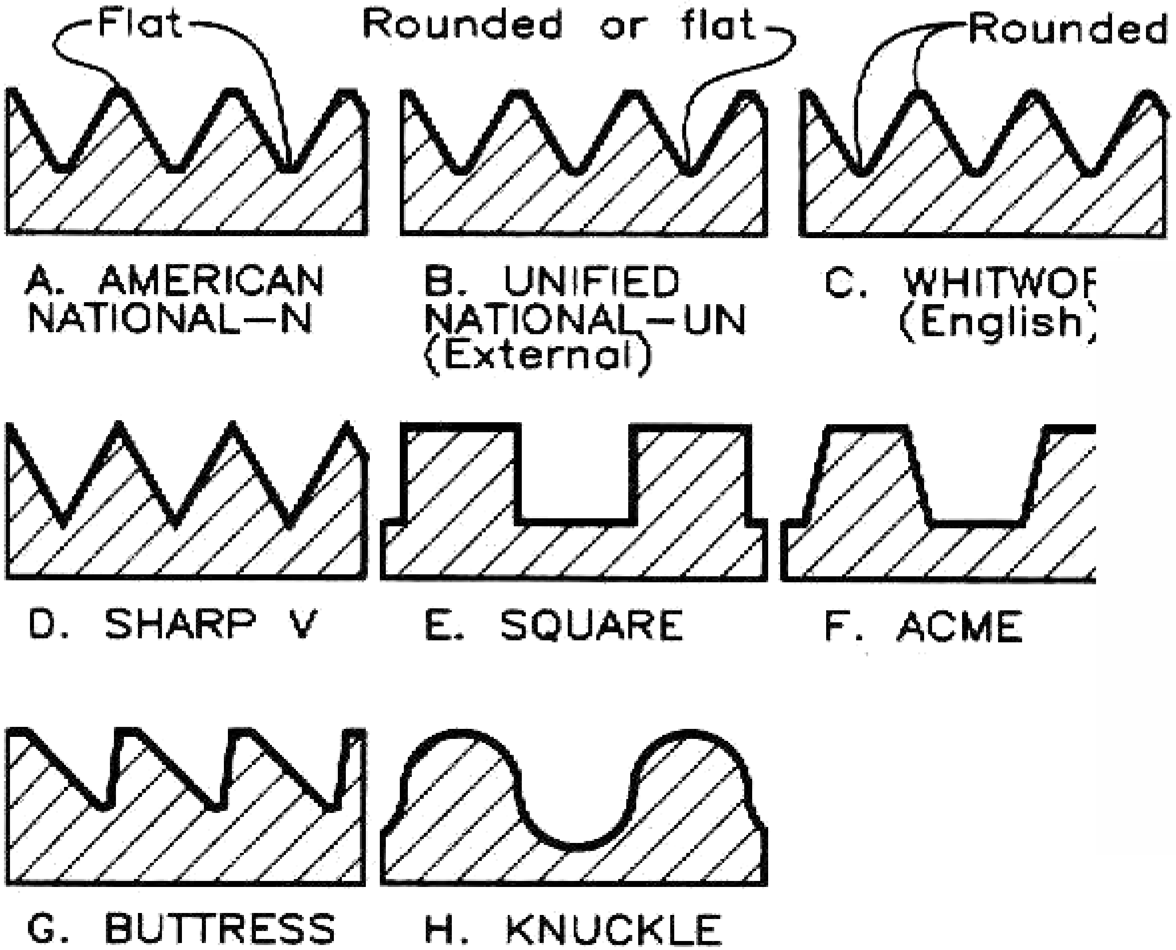


Internal Thread



THREAD TERMINOLOGY

Thread Form	Form is the profile shape of the thread.



Example :

"knuckle thread form"

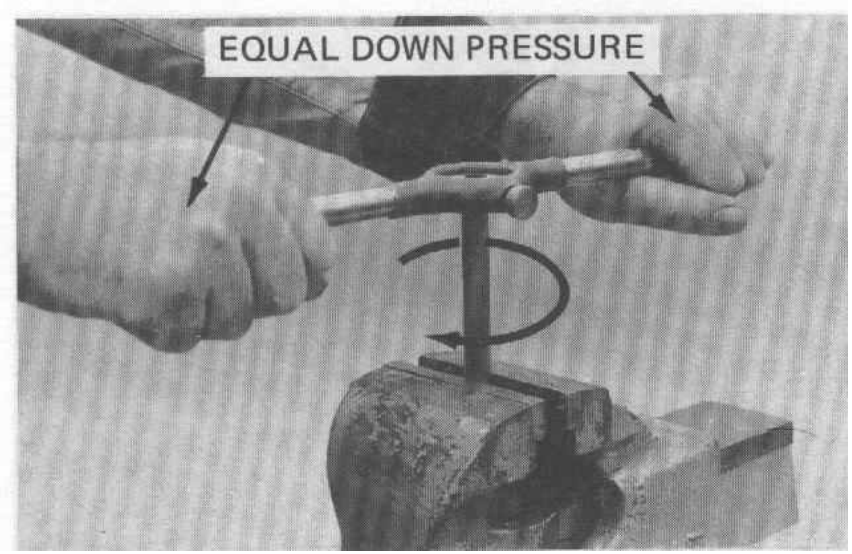
EXTERNAL THREAD CUTTING

Tools

- Threading Die

- Die stock

Operation



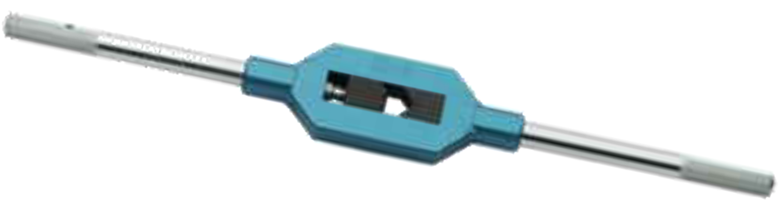
INTERNAL THREAD CUTTING

Tools

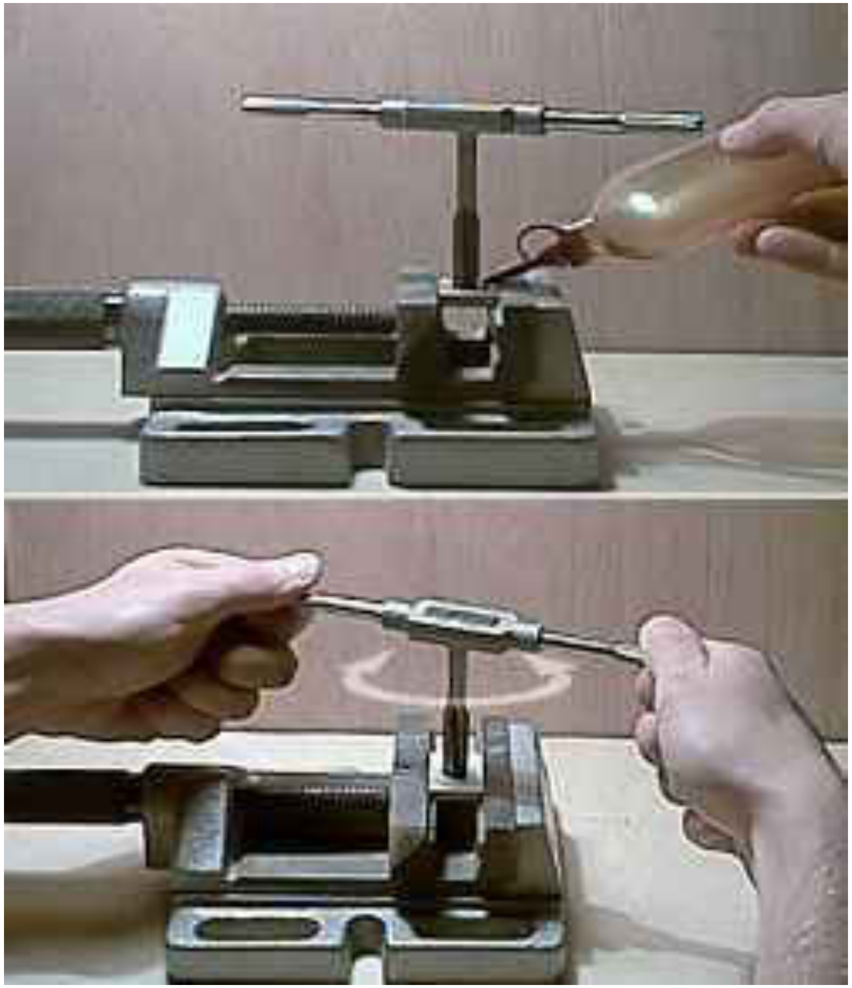
- Twist drill

- Tap

- Tap wrench

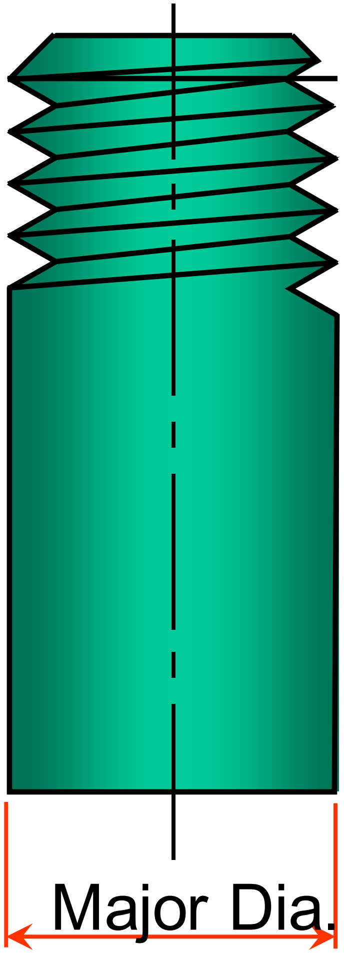


Operation

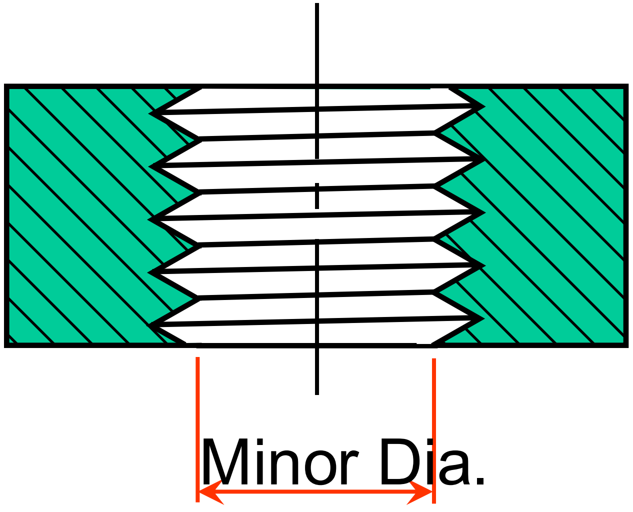


COMPARISON OF THREAD CUTTING

External Thread



Internal Thread



Thread Drawing

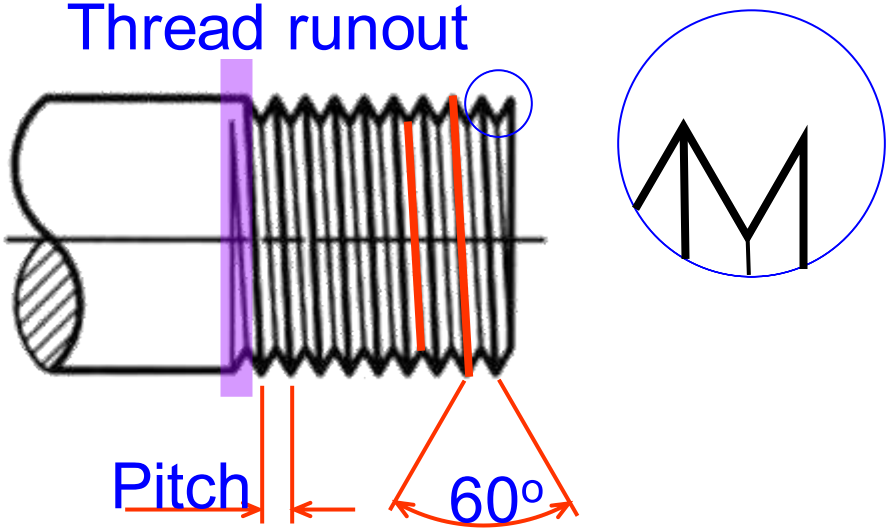
THREAD REPRESENTATION

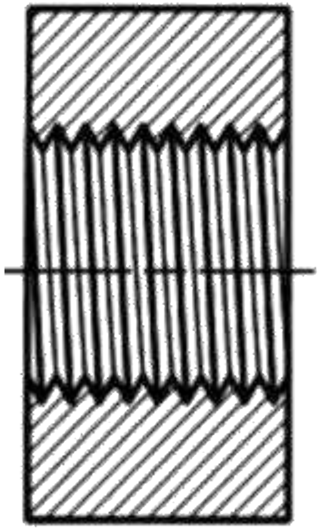
1. ***Detailed*** representation
2. ***Schematic*** representation
3. ***Simplified*** representation

DETAILED REPRESENTATION

- Use ***slanting lines*** to represent crest and root.
- Roots and crest are drawn in ***sharp*** Vs.

External thread **Internal thread**

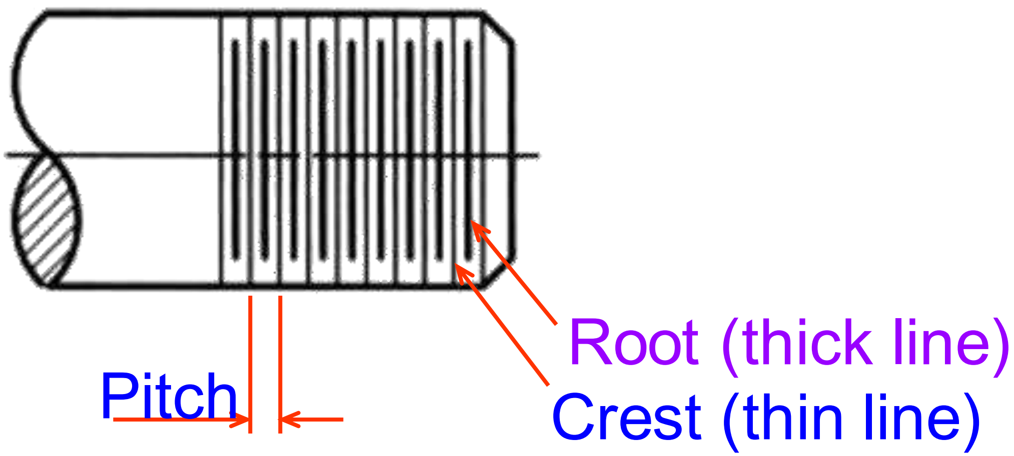




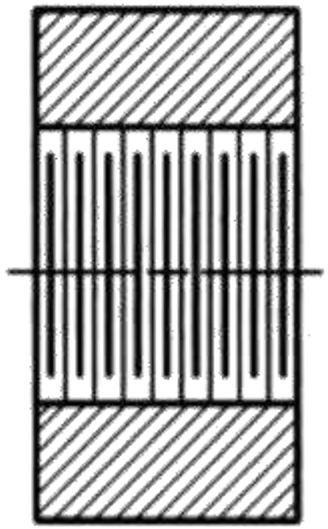
SCHEMATIC REPRESENTATION

- Use alternate ***long*** and ***short*** lines for representing ***crests*** and ***roots*** of the thread, respectively.

External thread



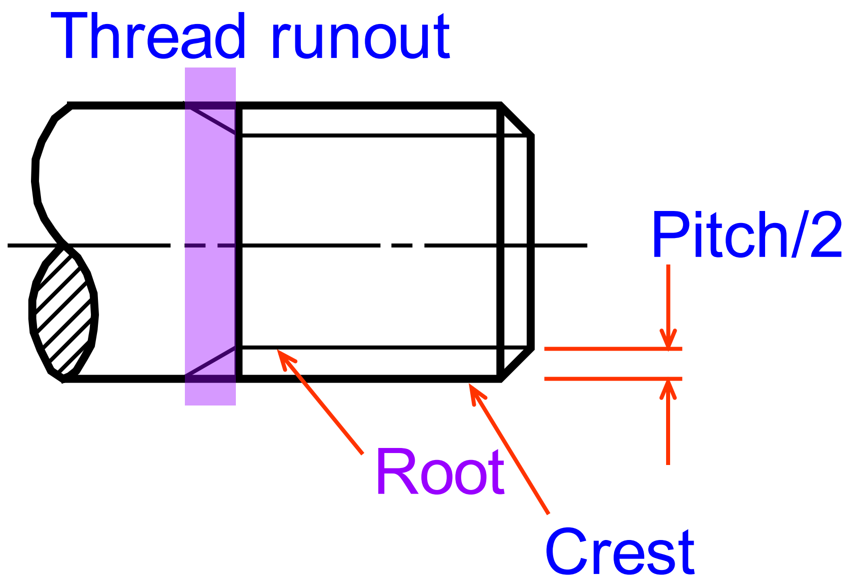
Internal thread



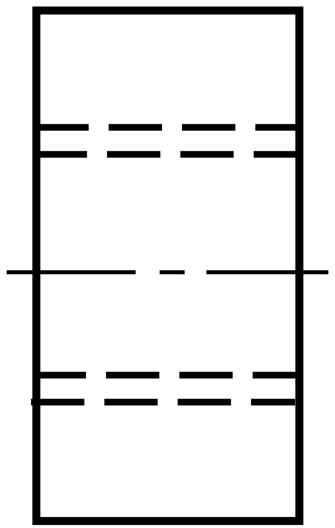
SIMPLIFIED REPRESENTATION

- Use ***thick continuous lines*** for representing ***crest*** and ***thin continuous lines*** for representing ***root*** of the thread, respectively.

External thread



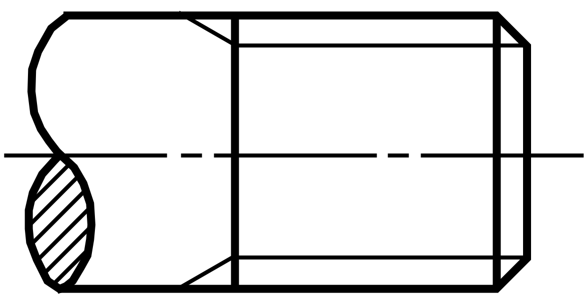
Internal thread



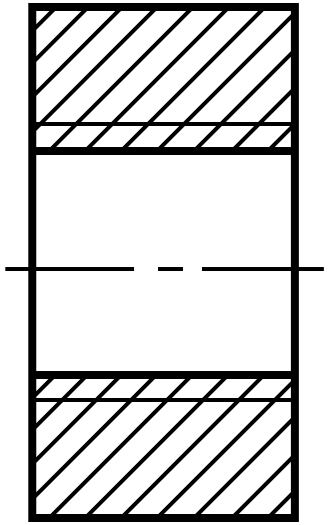
SIMPLIFIED REPRESENTATION

- Use ***thick continuous lines*** for representing ***crest*** and ***thin continuous lines*** for representing ***root*** of the thread, respectively.

External thread

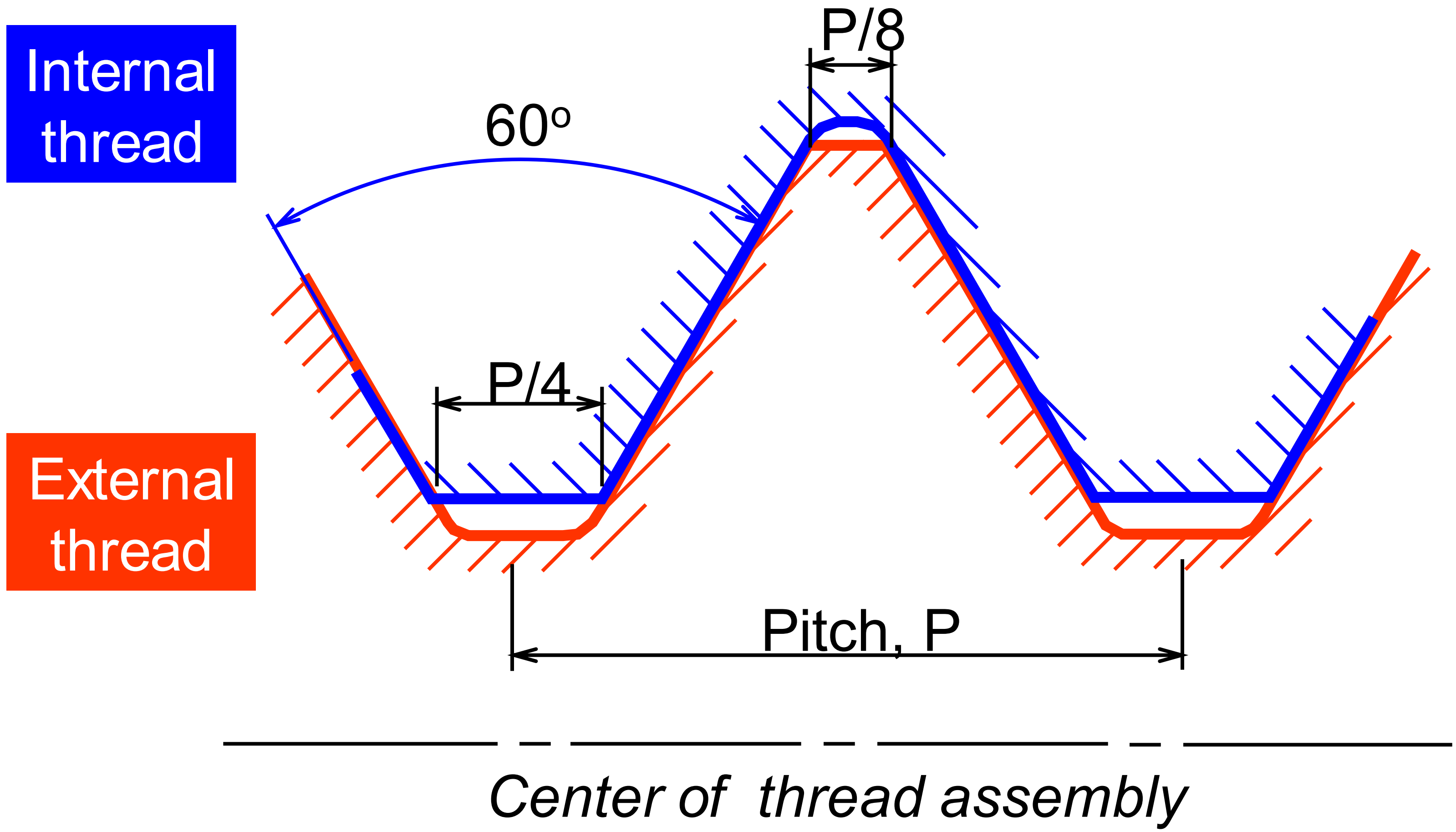


Internal thread



Sectional vie

ISO (METRIC) THREAD



Thread assemble occurs if and only if both (internal & external) thread have an equal ***nominal size*** *(or diameter)* and ***pitch***.

METRIC COARSE THREAD

[Table 9.1

Nominal size	**Major diameter**	**Pitch**	Minor diameter	Tap drill size
M6	6.00	1.00	4.92	5.00
M8	8.00	1.25	6.65	6.75
M10	10.00	1.50	8.38	8.50
M12	12.00	1.75	10.11	10.00

Metric thread

Minor diameter ≈ Tap drill size

In thread ***drawing***, the following relationship is used.

Minor diameter = ***Major*** diameter – Pitch

METRIC FINE THREAD

[Table 9.2

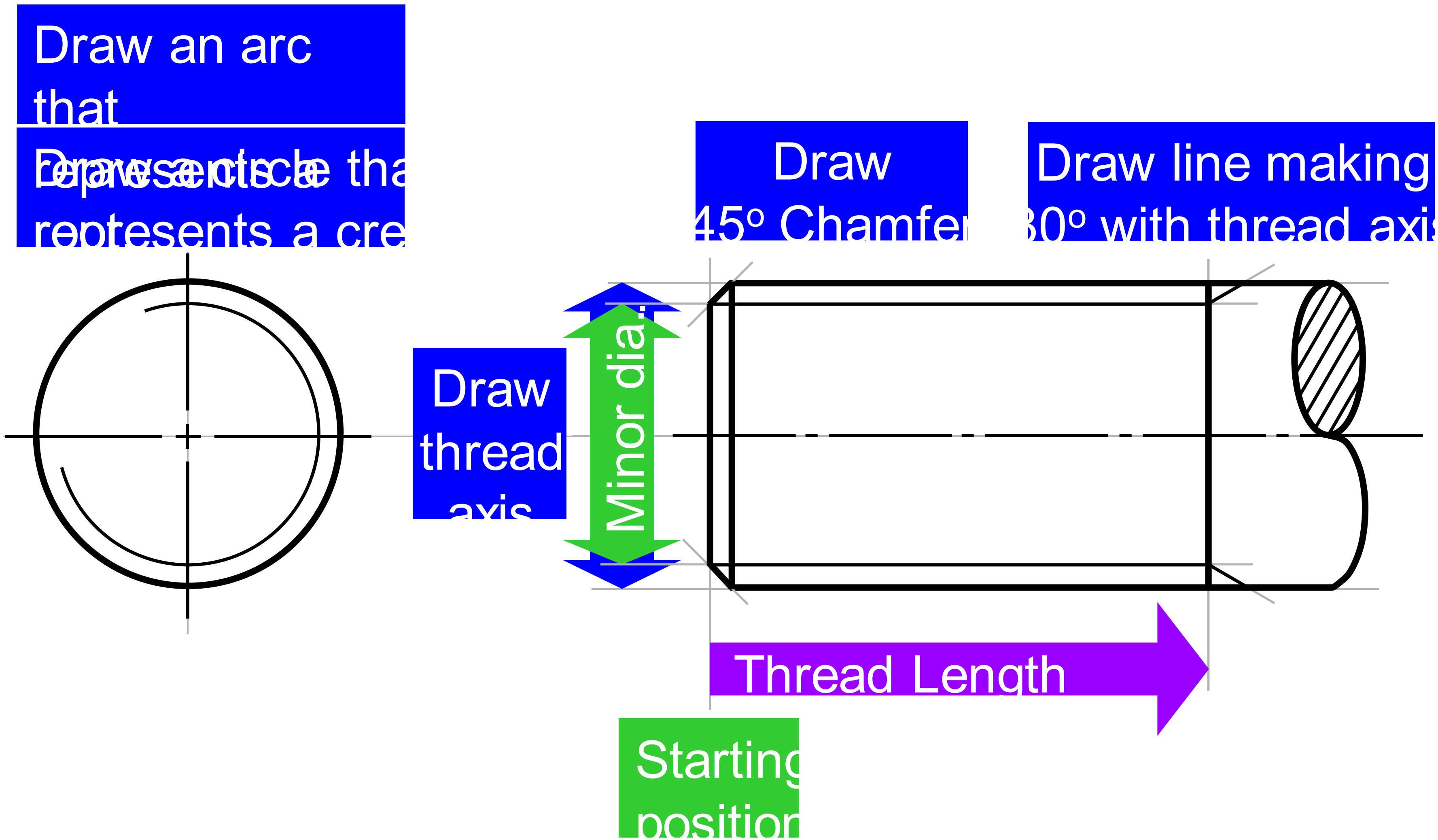
Nominal size	**Major diameter**	**Pitch**	Minor diameter	Tap drill size
M8	8.00	0.75	7.188	7.25
		1.00	6.917	7.00
M10	10.00	0.75	9.188	9.25
		1.00	8.917	9.00
		1.25	8.647	8.75

Minor diameter ≈ Tap drill size

In thread ***drawing***, the following relationship is used.

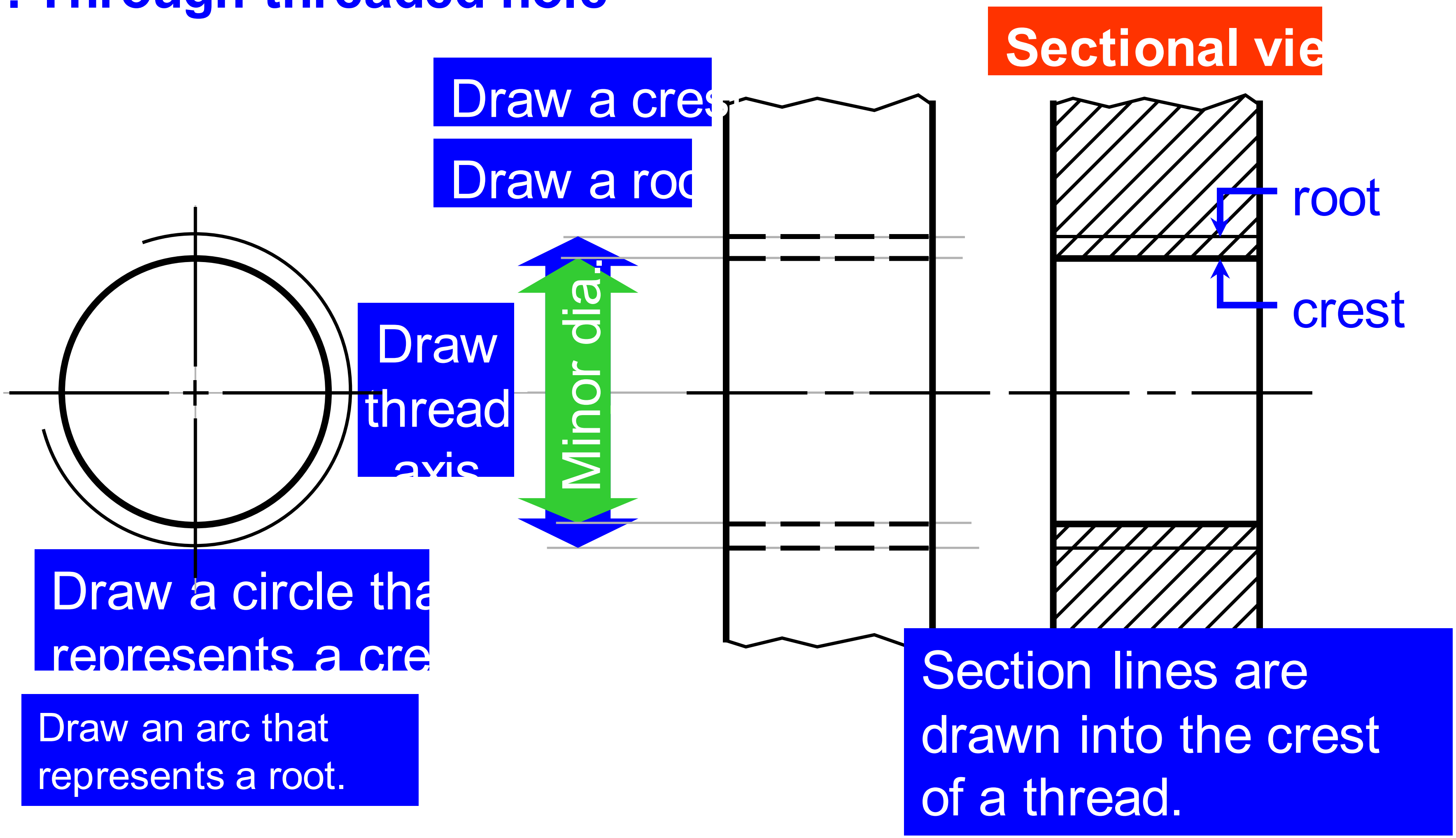
Minor diameter = ***Major*** diameter – Pitch

DRAWING STEPS OF
EXTERNAL THREAD



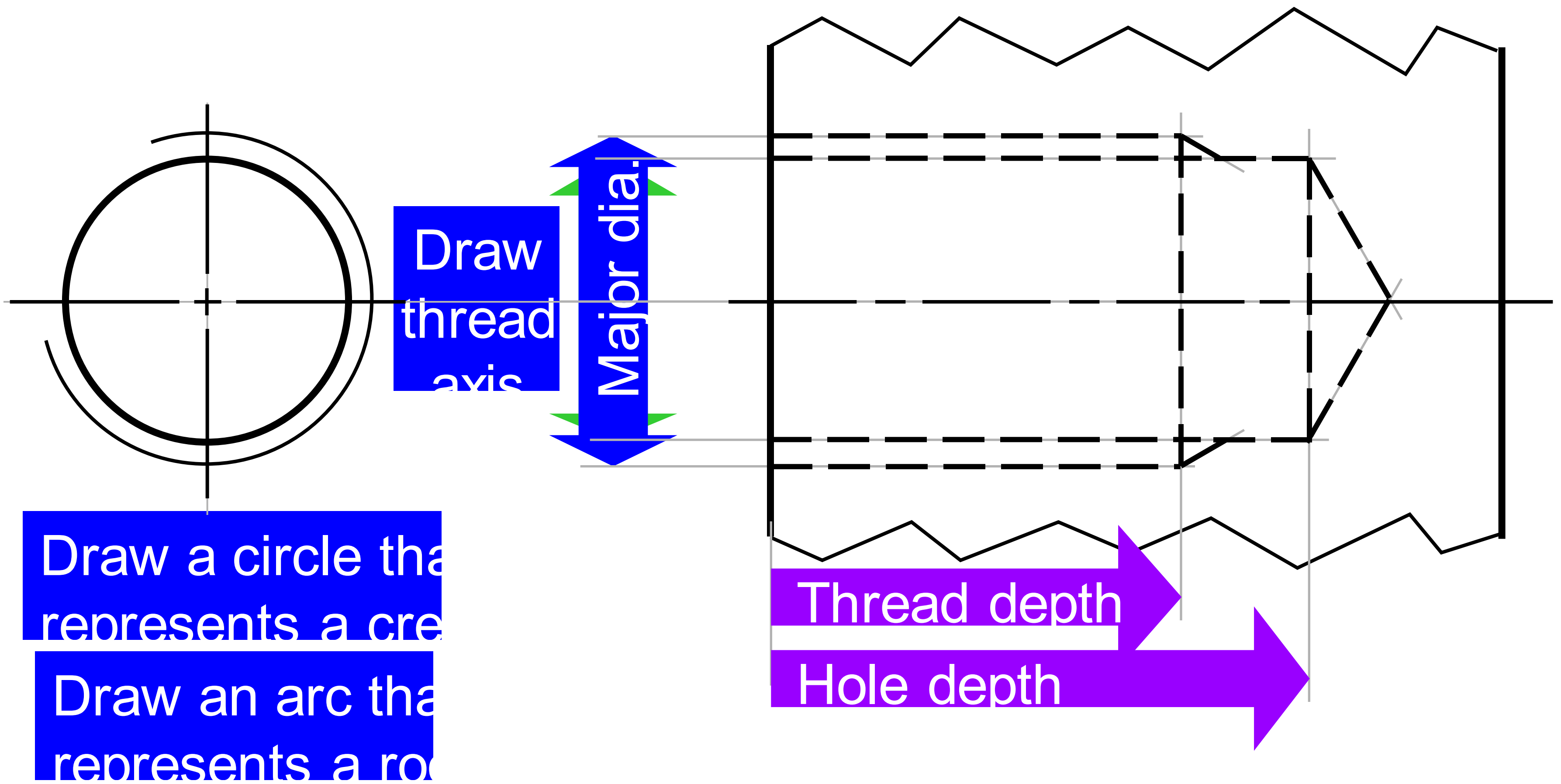
DRAWING STEPS OF THREADED HOLE

1. Through threaded hole



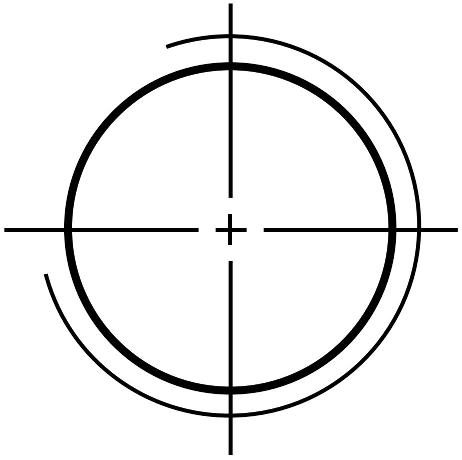
DRAWING STEPS OF THREADED HOLE

2. Blinded threaded hole

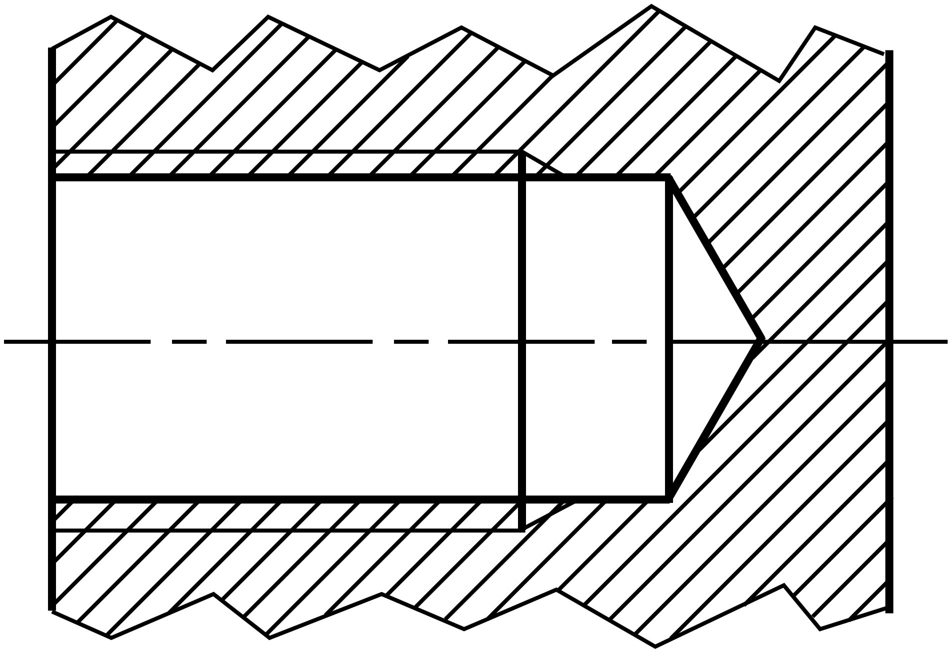


DRAWING STEPS OF THREADED HOLE

2. Blinded threaded hole

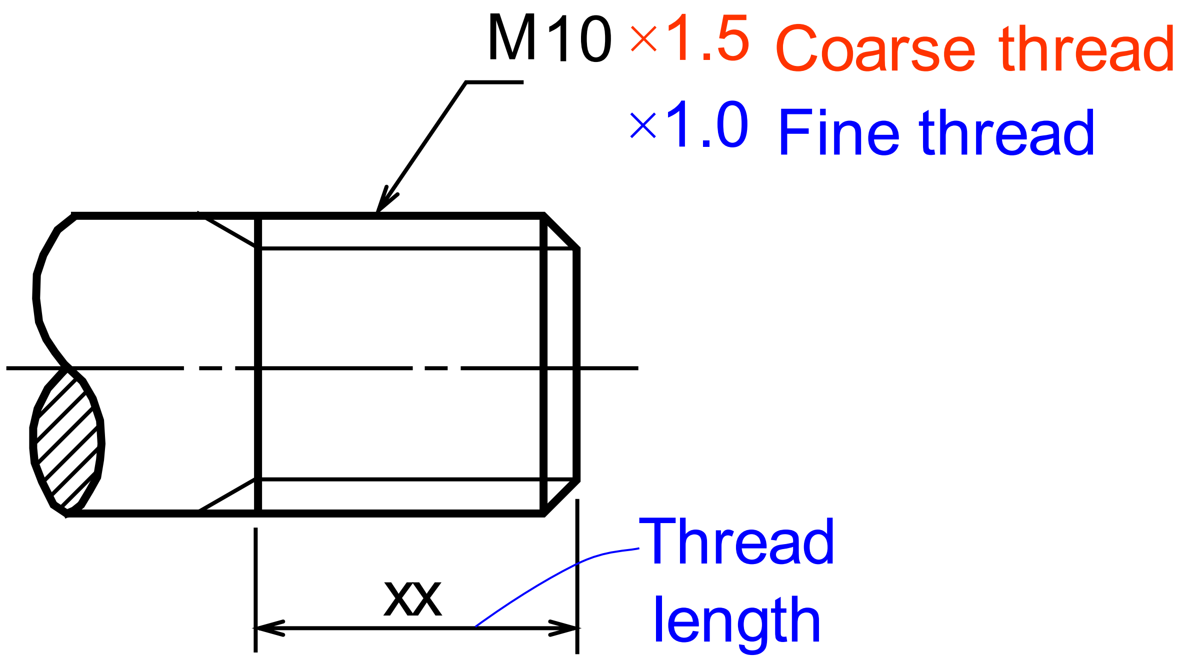


Sectional vie



DIMENSIONING EXTERNAL THREAD

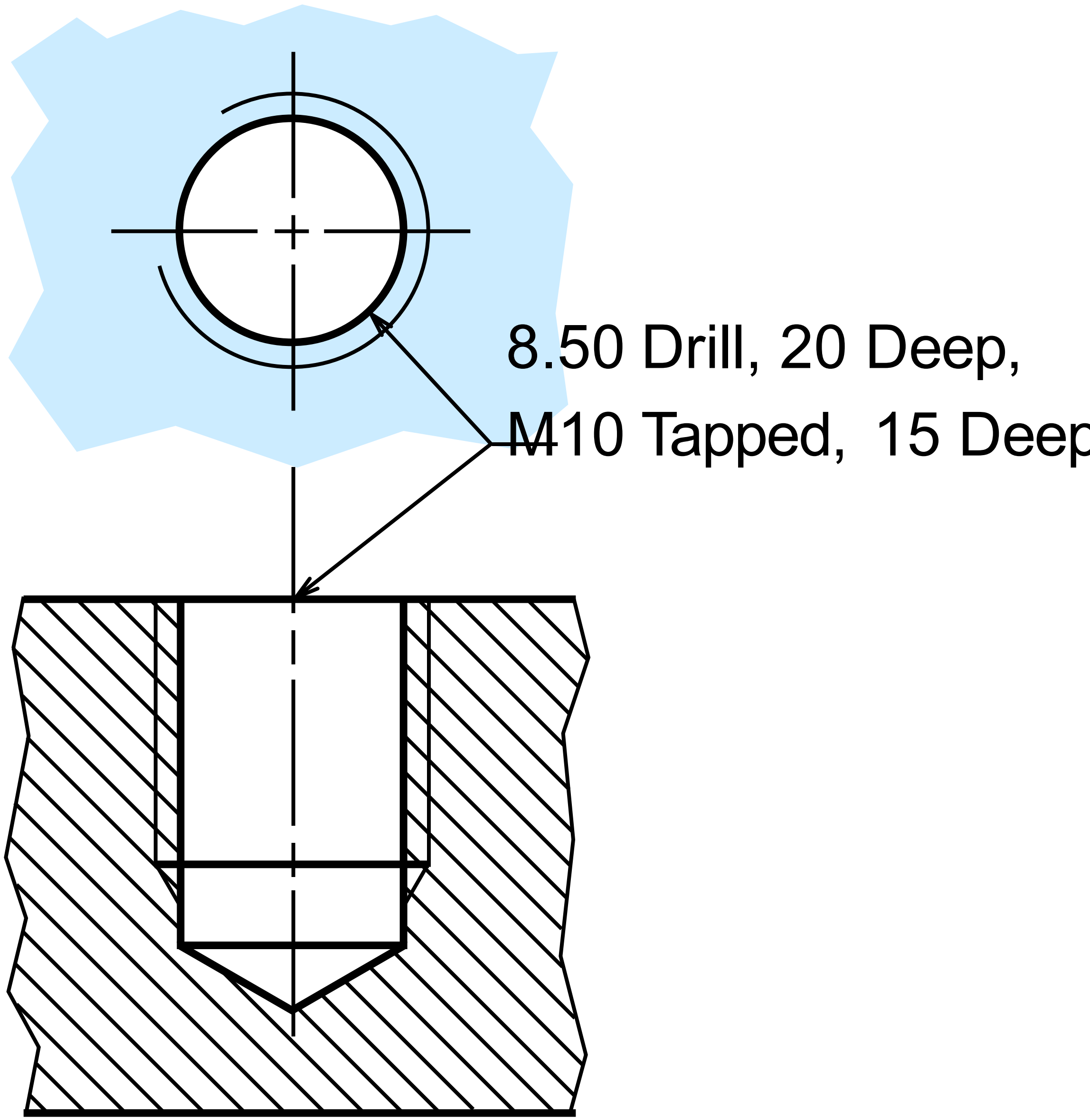
- Use ***local note*** to specify :- ***thread form***, ***nominal size***, ***pitch*** (if it is a fine thread)
- Use ***typical method*** to specify :- ***thread length***.



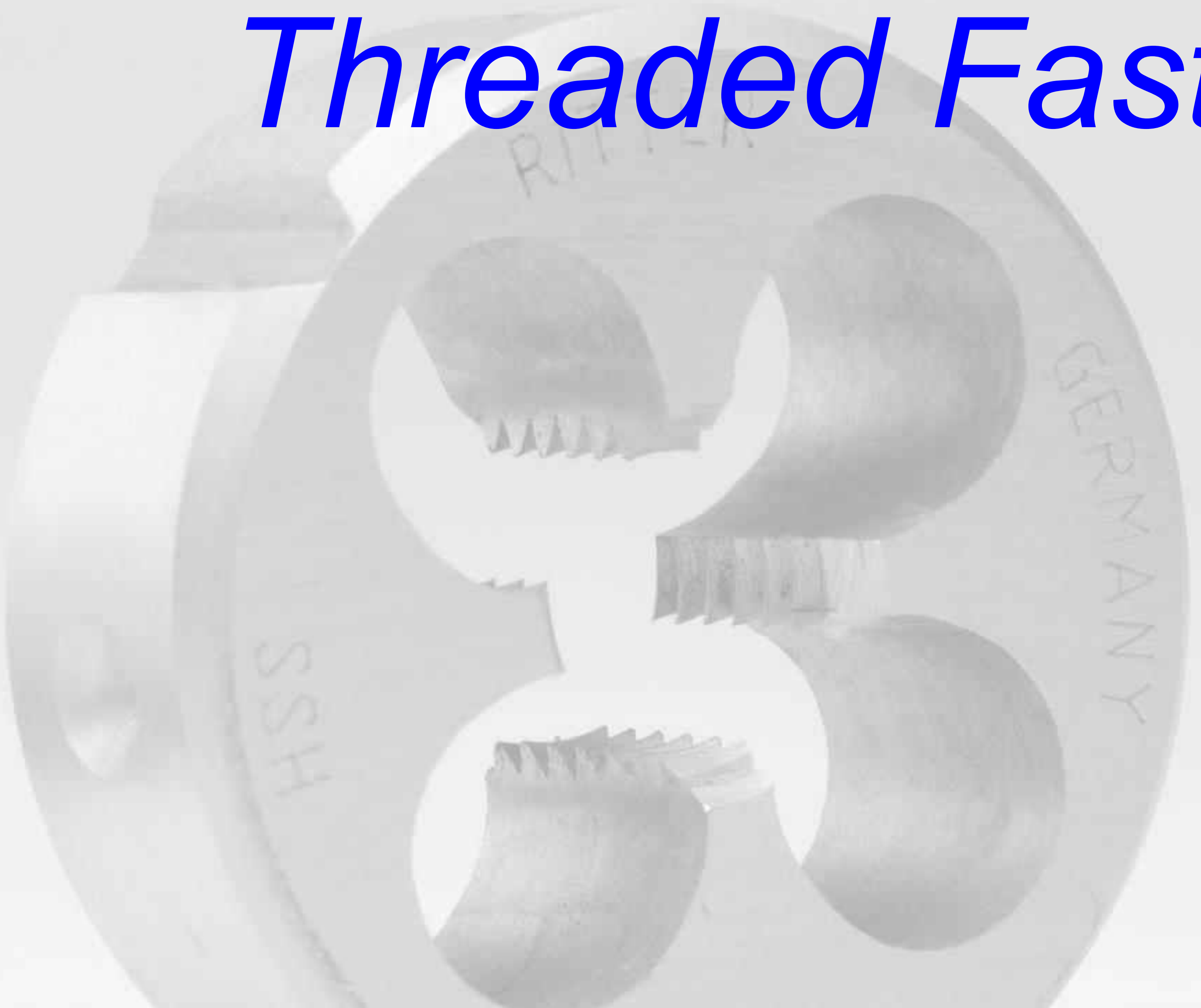
DIMENSIONING THREADED HOLE

Use ***local note*** to specify

1. Tap drill size
2. Drill depth
3. Thread form
4. Nominal size
5. Pitch
6. Thread depth



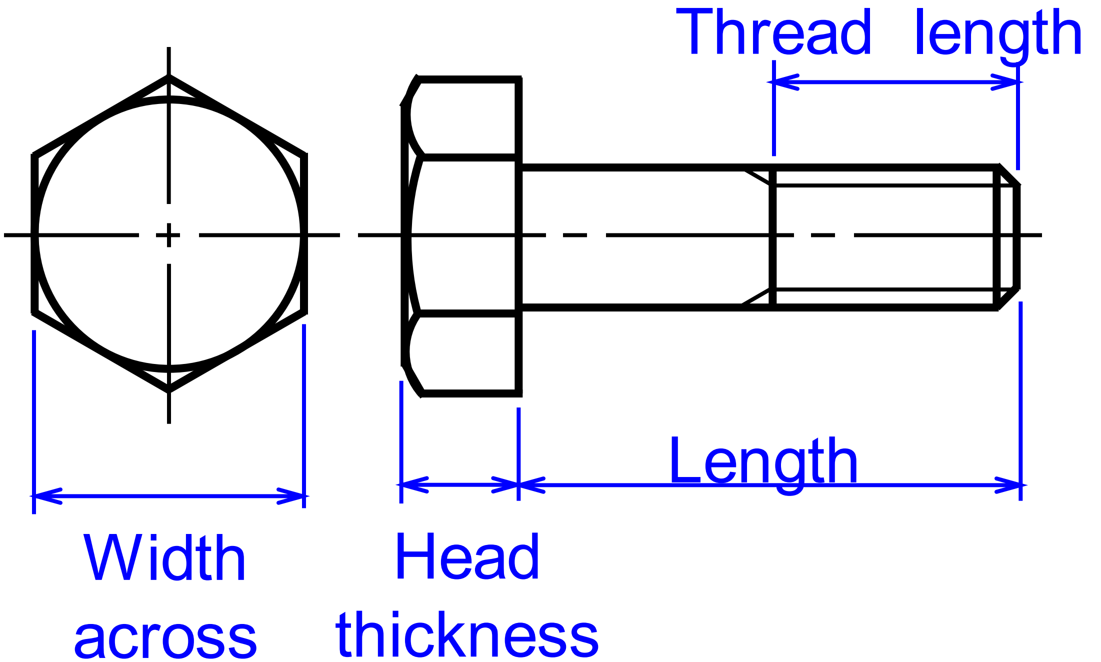
Threaded Fastener



BOLT : Terminology

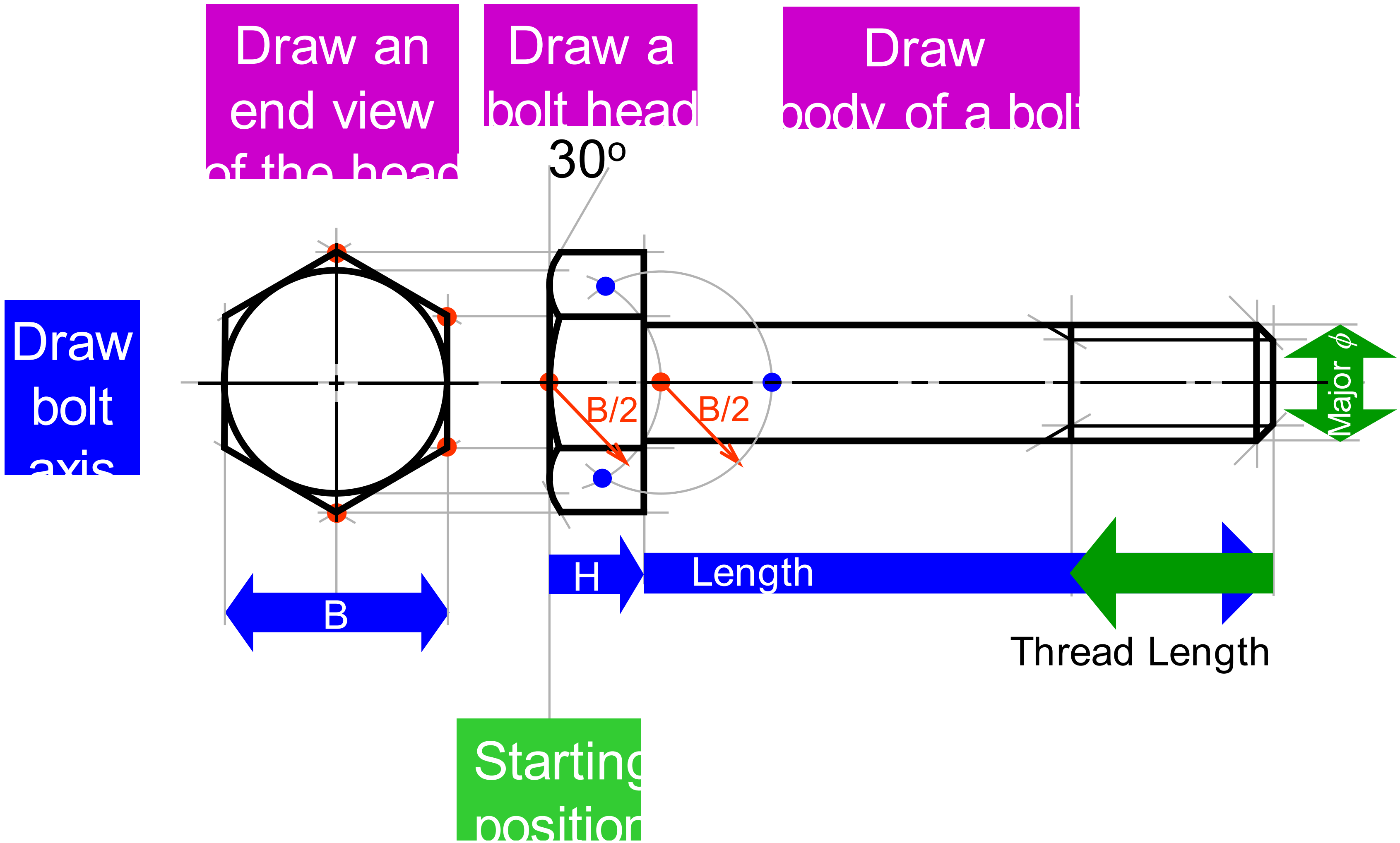
Bolt is a threaded cylinder with a head.

Hexagonal head bolt and nut



Dimensions of bolt's head are listed in table 9.4.

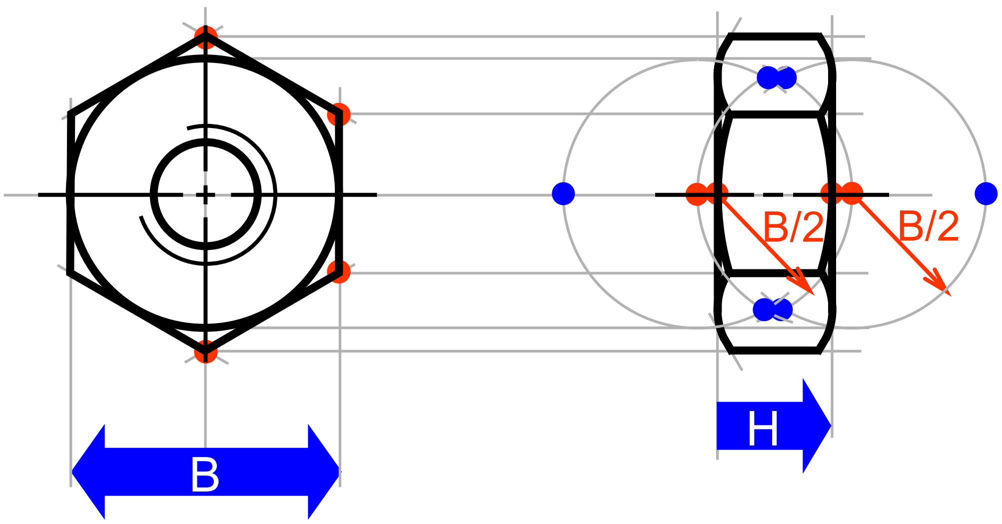
BOLT : Drawing steps



NUT : Drawing steps

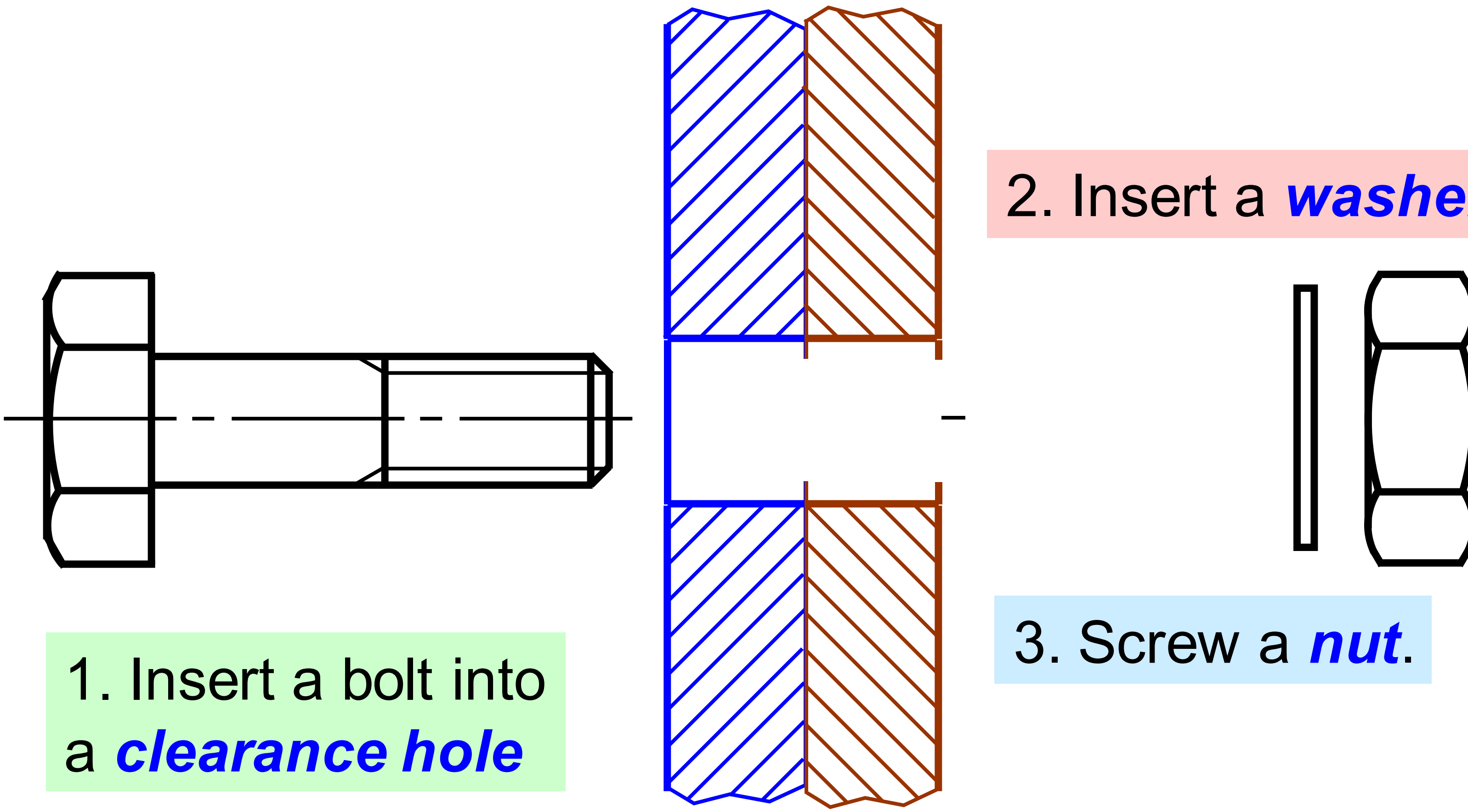
Dimensions of the nut are given in Table 9.14.

Draw an end view



Dash lines represent a threaded hole are omitted for clarity.

BOLT : Application



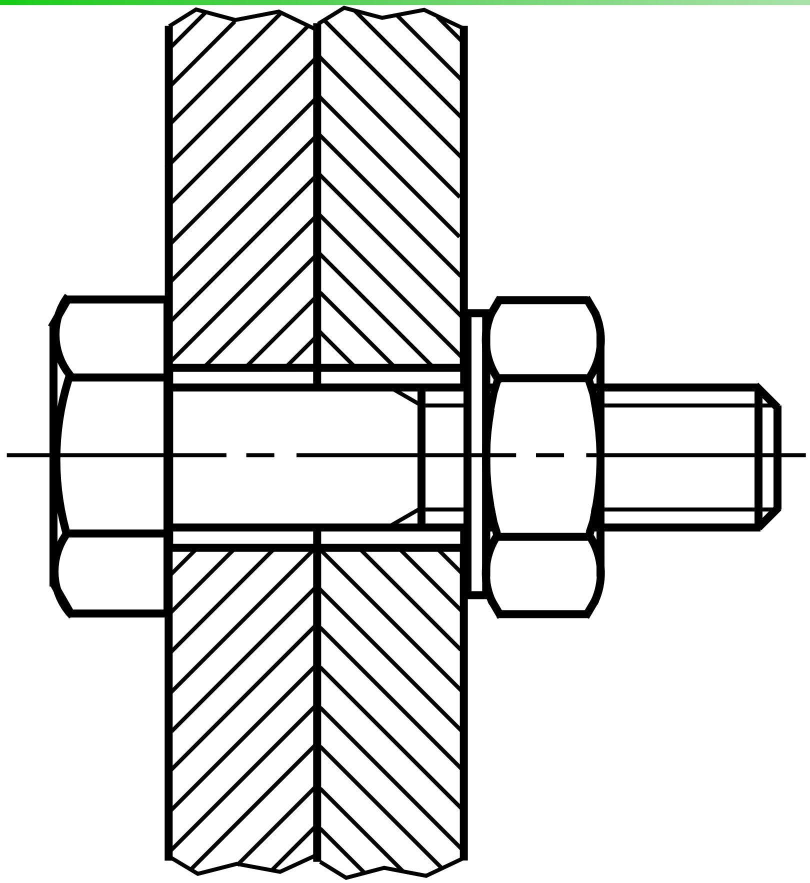
1. Insert a bolt into a ***clearance hole***

2. Insert a ***washer***.

3. Screw a ***nut***.

Let' s think together…

◈ What do you think about the following suggestions for design ***improvement***?



(A) Nothing have to be changed.

(B) Use shorter bolt with the same thread length.

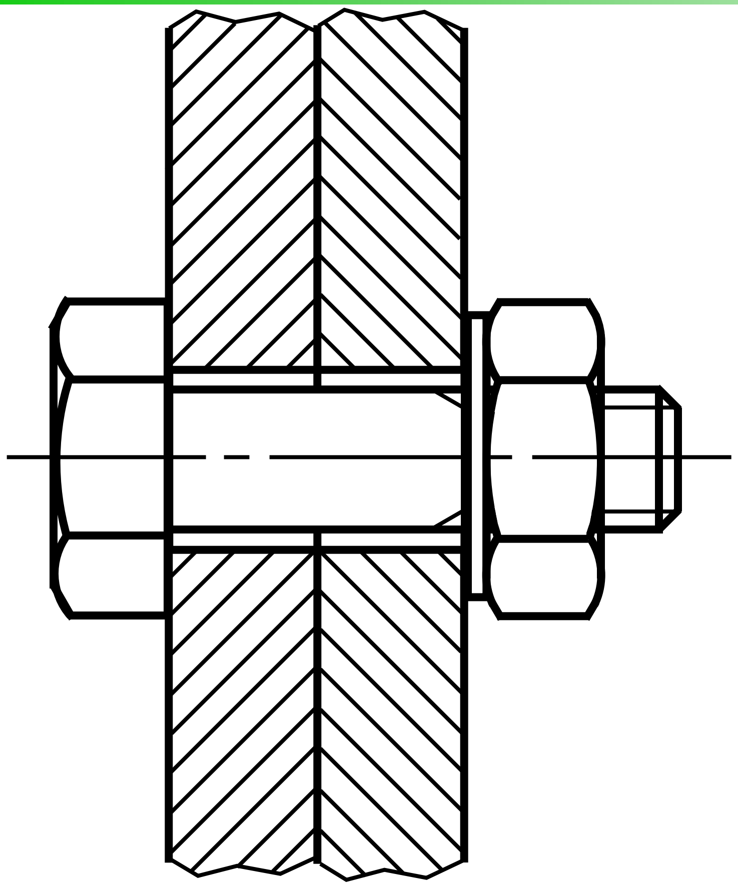
(C) Reduce the thread length.

(D) Add washer or nut.

Correct | Inappropriate | Wrong

Let' s think together…

- What do you think about the following suggestions for design ***improvement***?



(A) Nothing have to be changed.

(B) Use a bolt of this length but has a longer thread length.

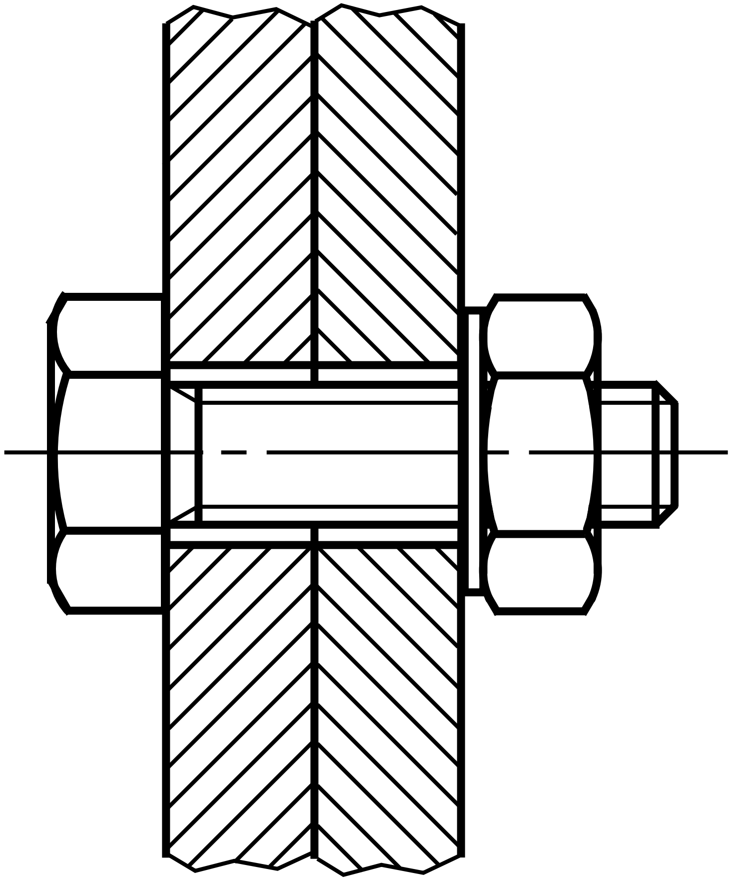
(C) Use a longer bolt with the same thread length.

(D) Add washer.

Correct | Inappropriate | Wrong

Let' s think together…

◈ What do you think about the following suggestions for design ***improvement*** ?



(A) Nothing have to be changed.

(B) Use a bolt of this length but has a shorter thread length.

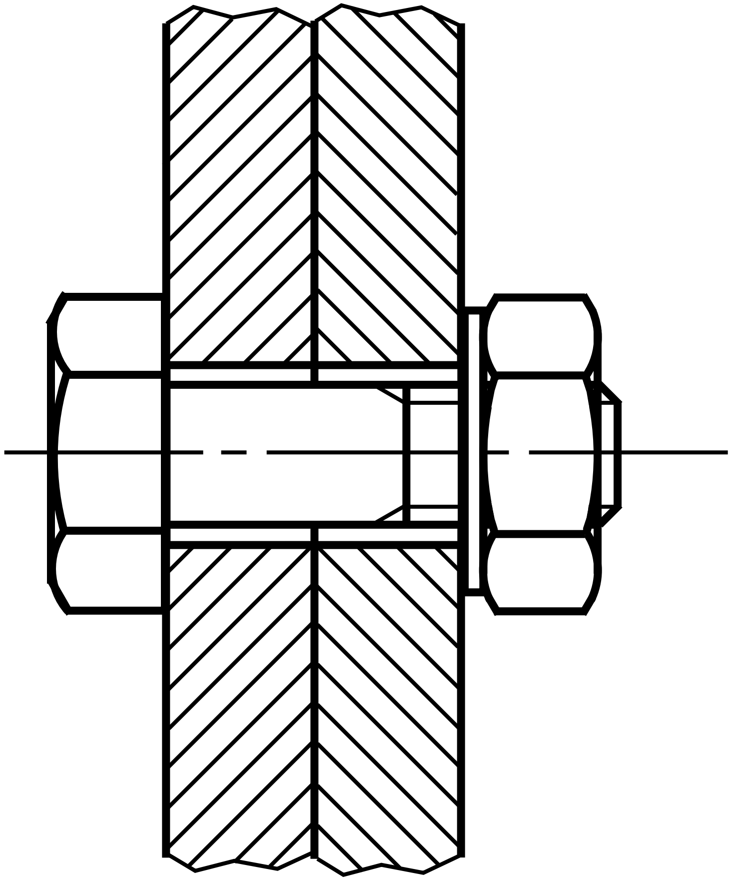
(C) Use a longer bolt with the same thread length.

(D) Add washer.

Correct | Inappropriate | Wrong

Let' s think together…

◈ What do you think about the following suggestions for design ***improvement***?



(A) Use a bolt of this length but has a shorter thread length.

(B) Use a longer bolt with the same thread length.

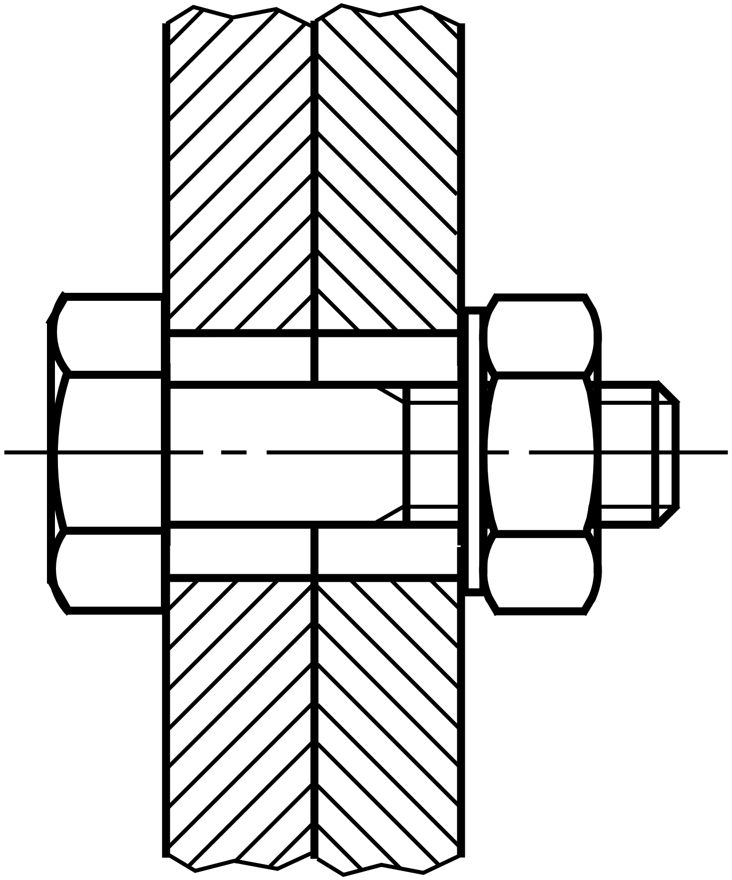
(C) Use a longer bolt by increasing a thread length

(D) Remove washer.

Correct | Inappropriate | Wrong

Let' s think together…

- What do you think about the following suggestions for design ***improvement*** ?



(A) Increase the bolt diameter.

(B) Use washer with larger outside diameter.

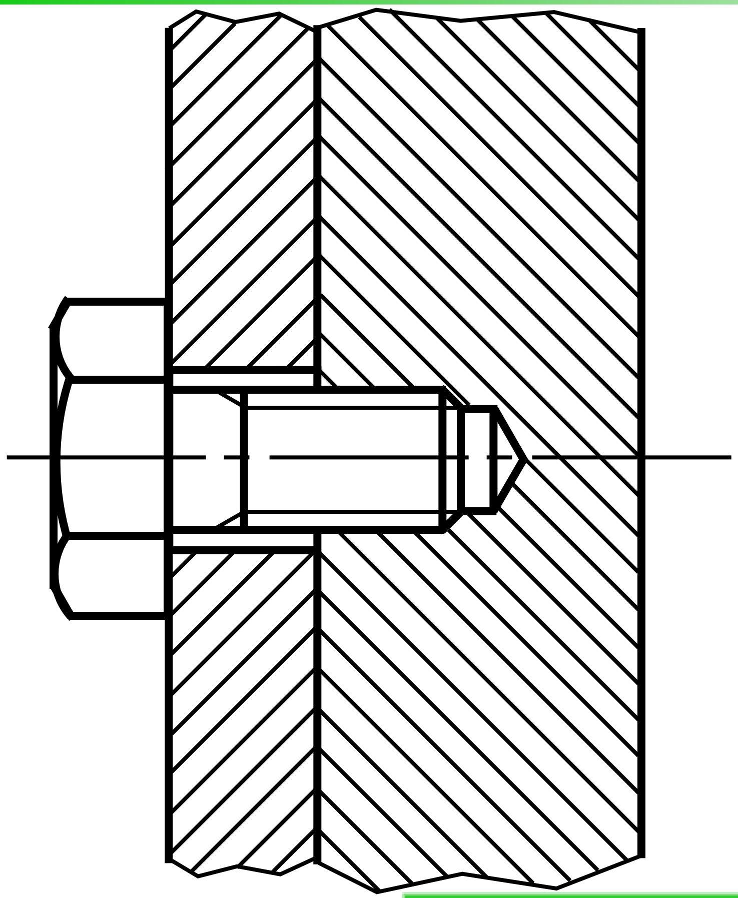
(C) Reduce the hole diameter.

(D) Add washer at bolt head.

Correct | Inappropriate | Wrong

Let' s think together…

◆ What do you think about the following suggestions for design ***improvement*** ?



(A) Nothing have to be changed.

(B) Use a bolt with shorter thread length.

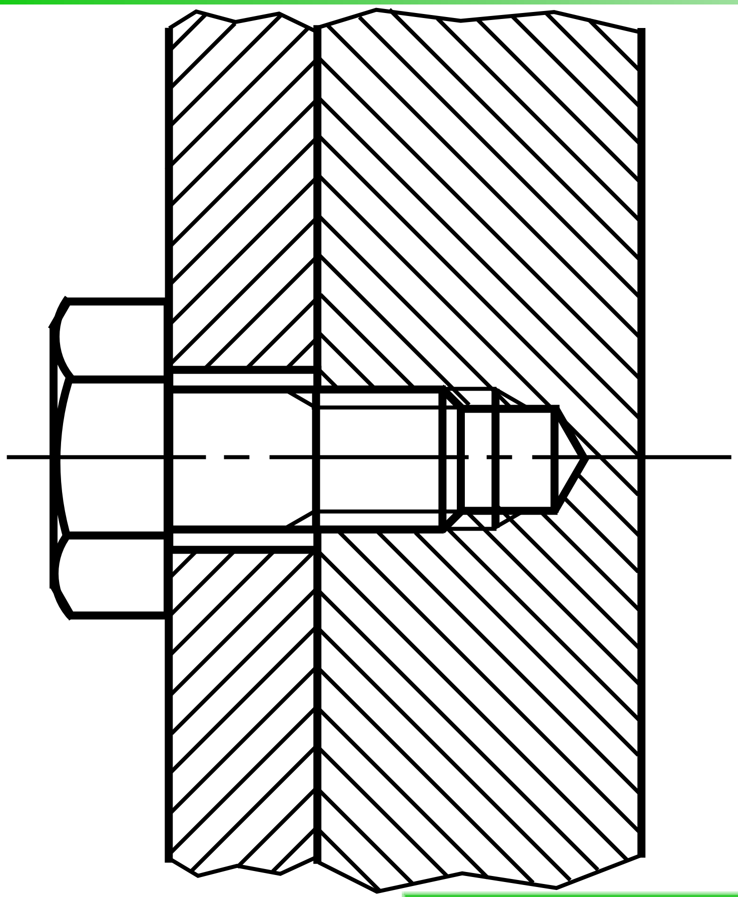
(C) Add washer.

(D) Increase drill and thread depths.

Correct | Inappropriate | Wrong

Let' s think together…

◈ What do you think about the following suggestions for design ***improvement*** ?



(A) Nothing have to be changed.

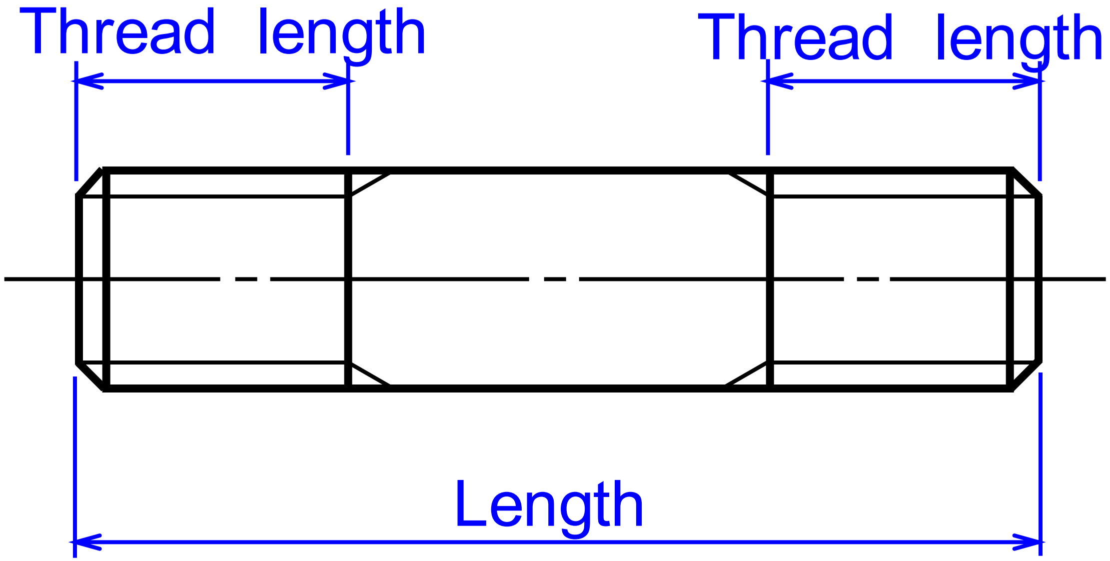
(B) Use a bolt with slightly longer thread length.

Correct | Inappropriate | Wrong

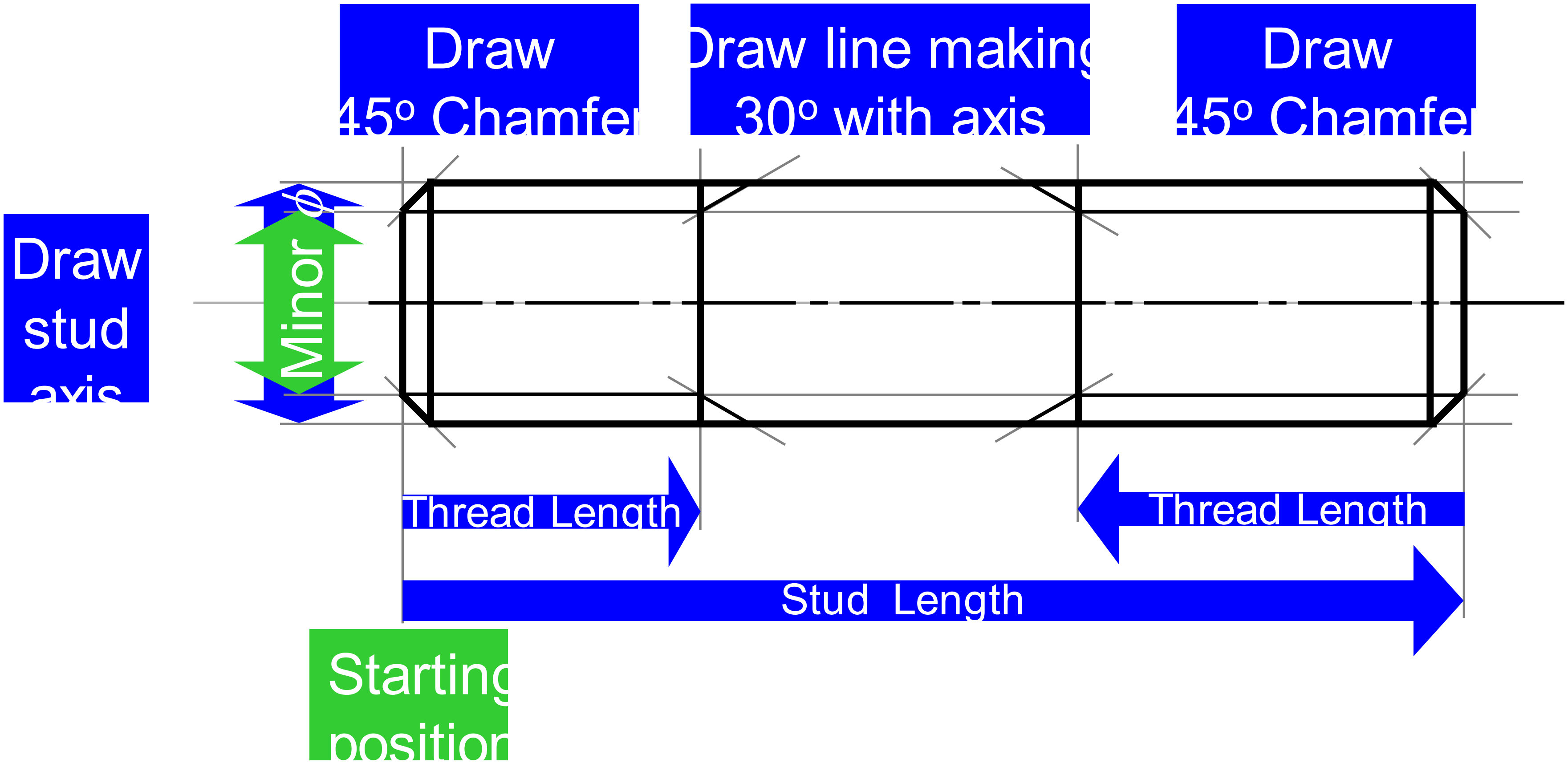
STUD : Terminology

Stud is a *headless* bolt, threaded at both ends.

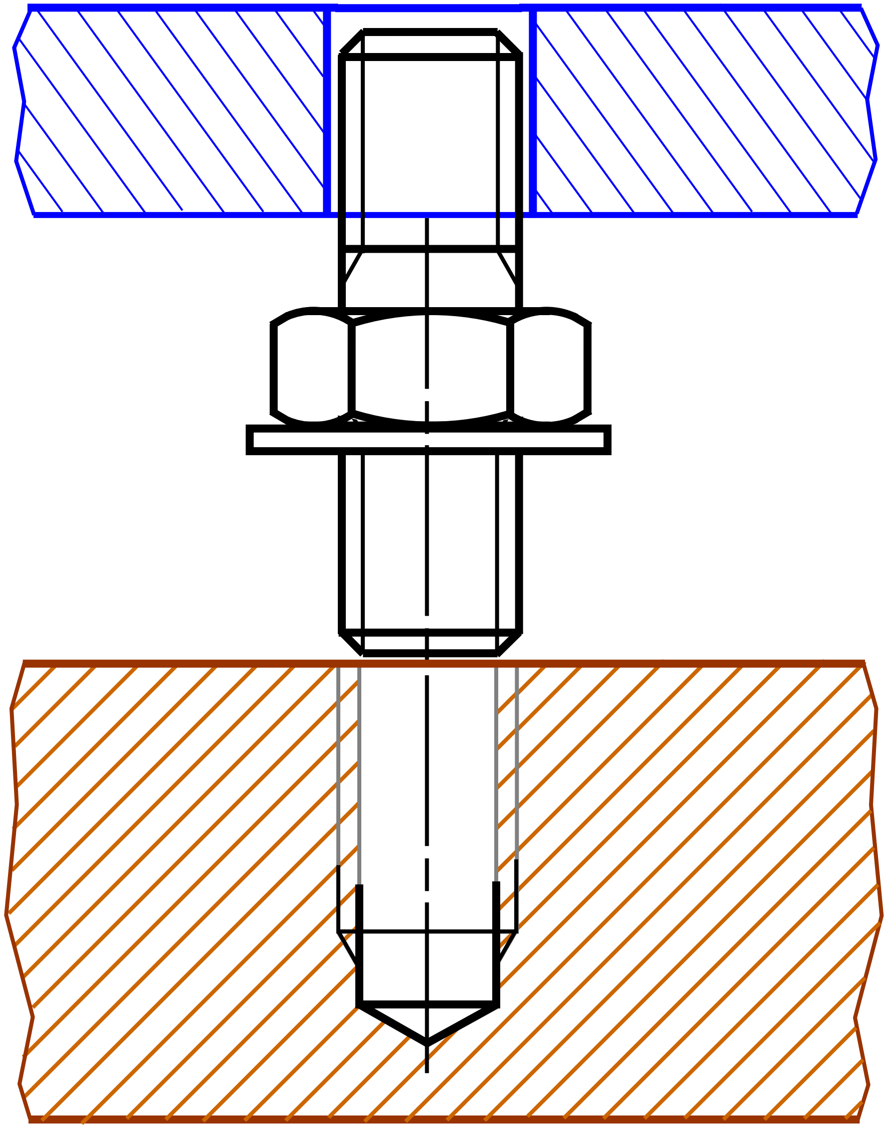
Drawing representation



STUD : Drawing steps



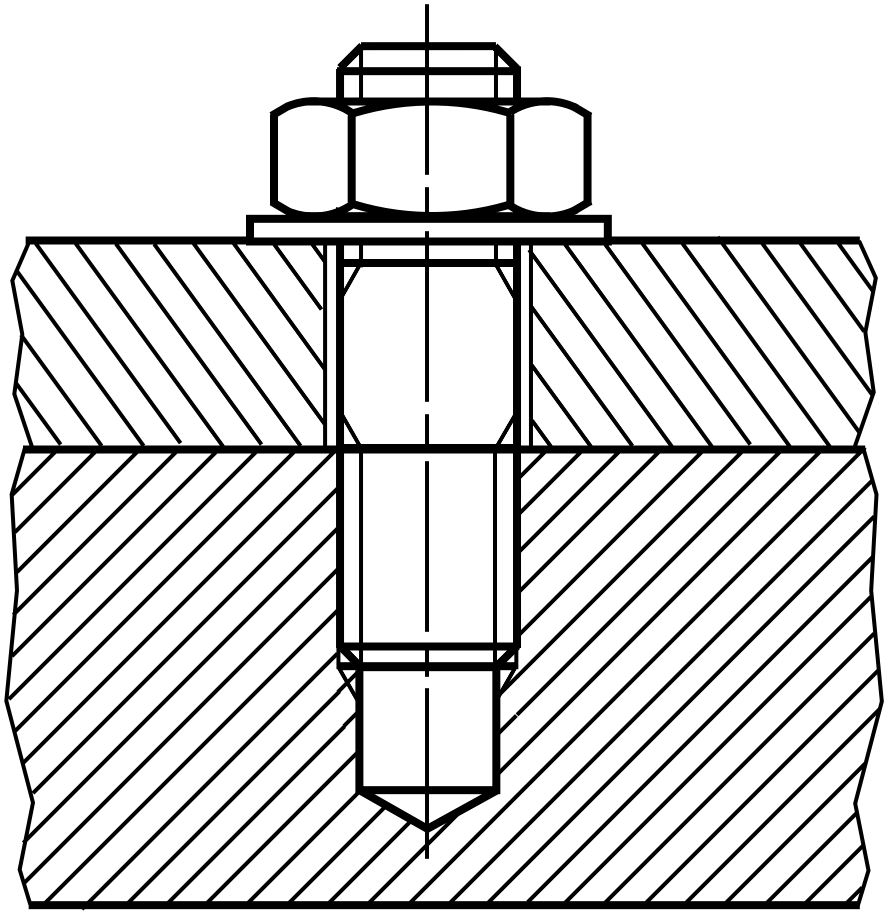
STUD : Application



1. Drill a hole.
2. Tap a hole.
3. Screw a stud.
4. Place the part to be fastened.
5. Insert washer and fastened a nut.

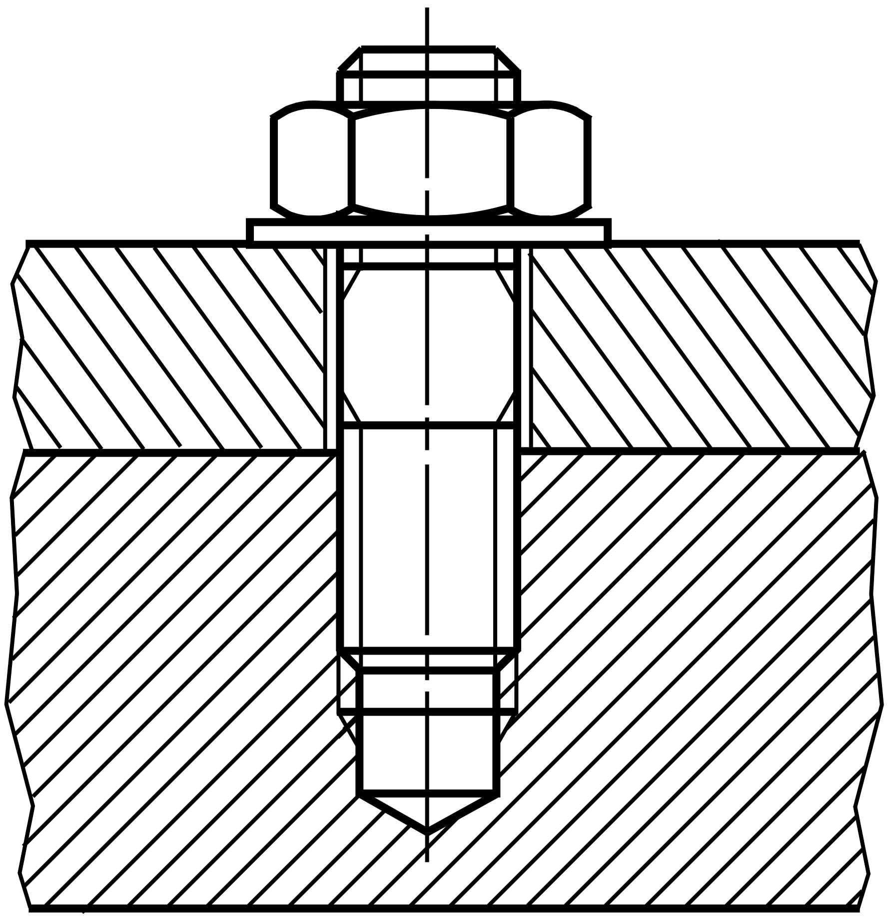
Let' s think together…

- What is the mistake in the following use of stud ?



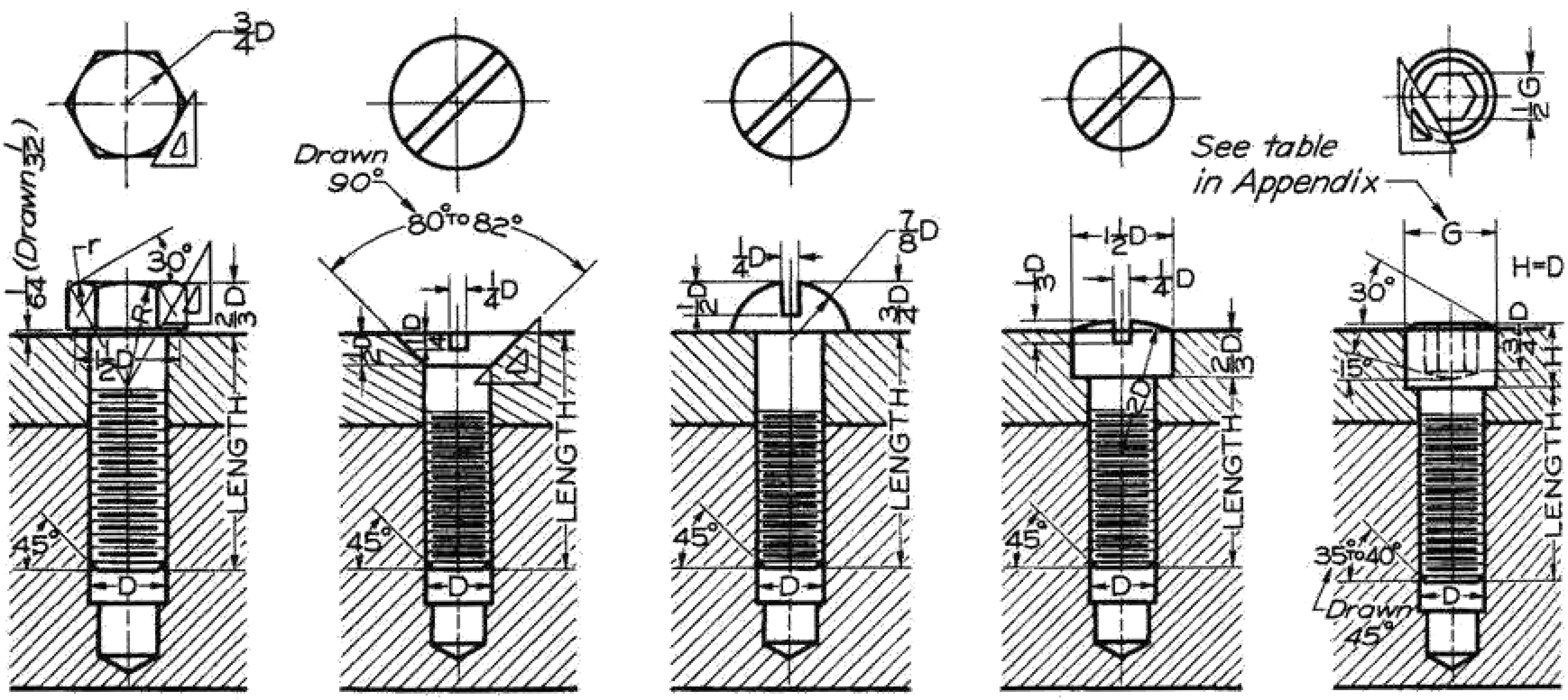
Let' s think together…

- What is the mistake in the following use of stud ?

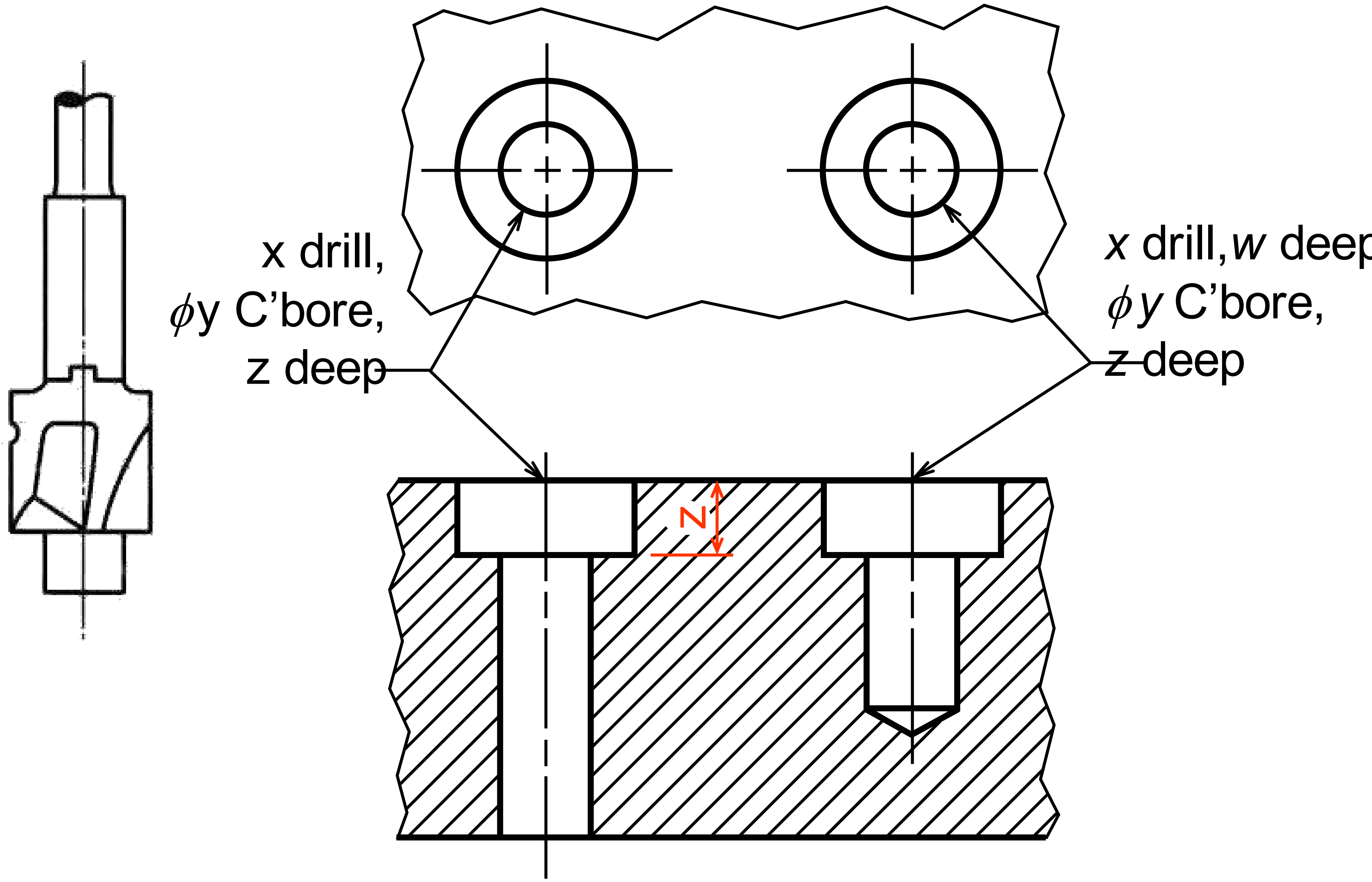


CAP SCREW : Terminology

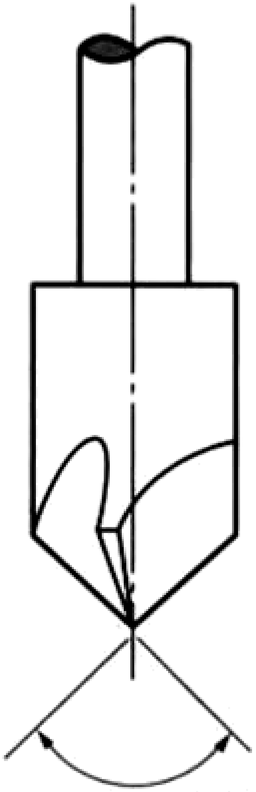
Cap screw is similar to bolt, but has a longer thread than a bolt.

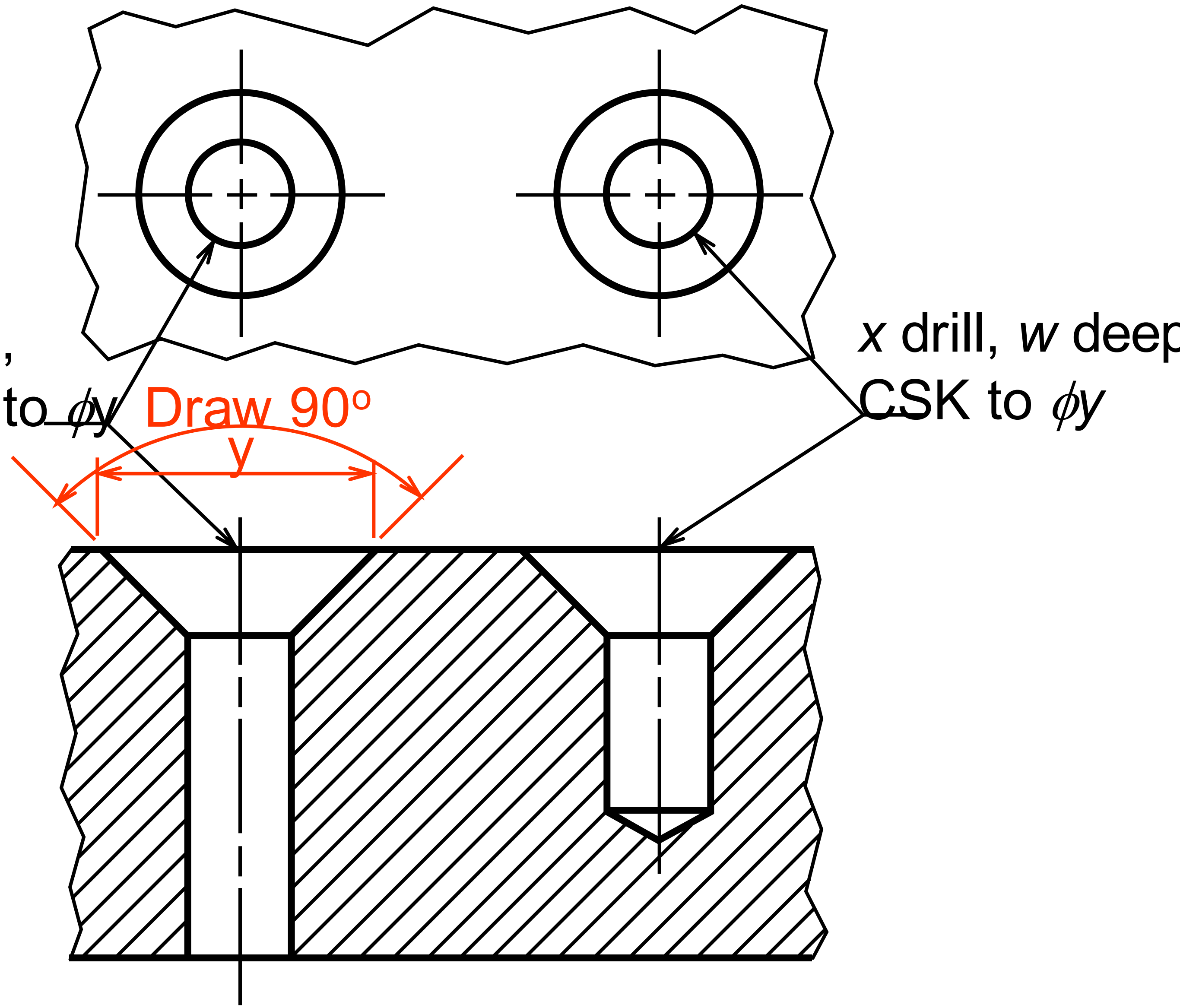


CAP SCREW : Counterbore hole



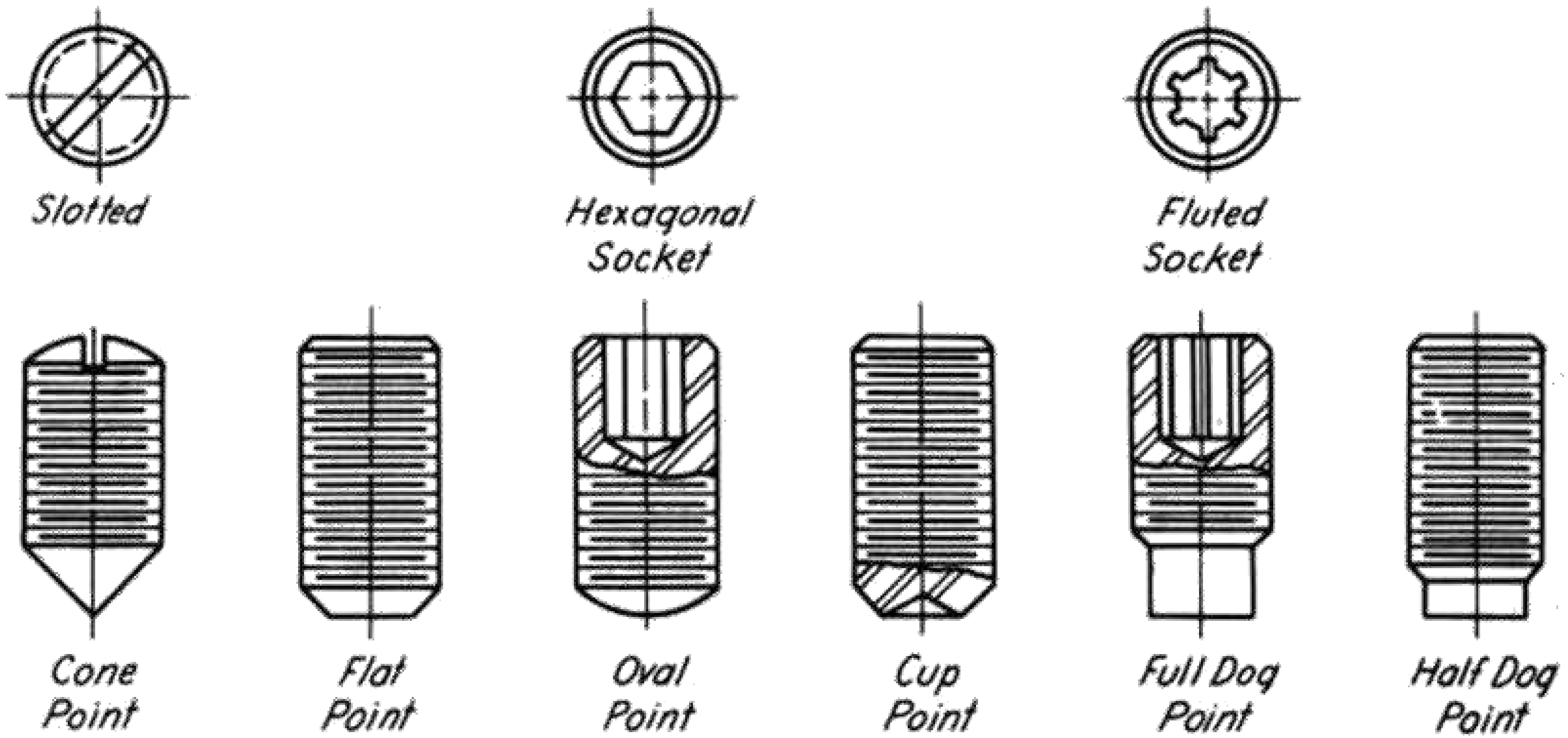
CAP SCREW : Countersink hole



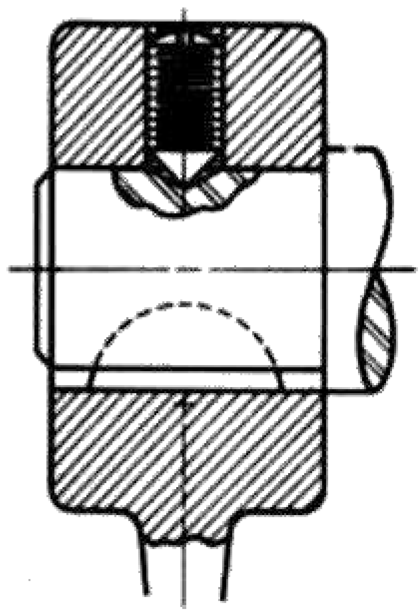


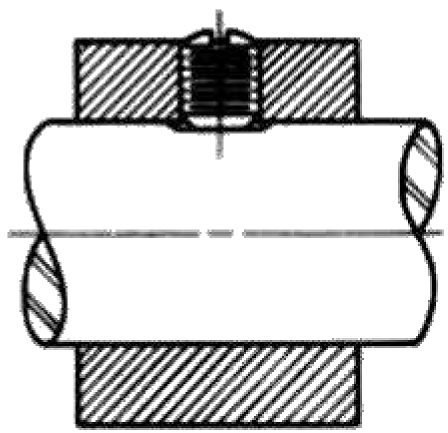
SET SCREW : Terminology

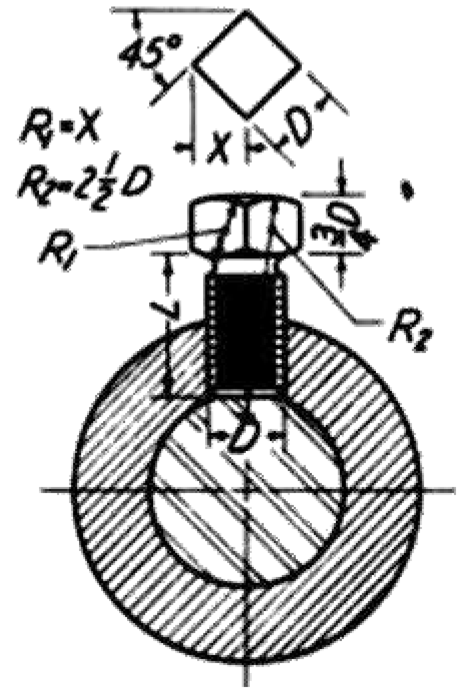
Set screw is a threaded cylinder used to prevent rotation or movement between parts.



SET SCREW : Application

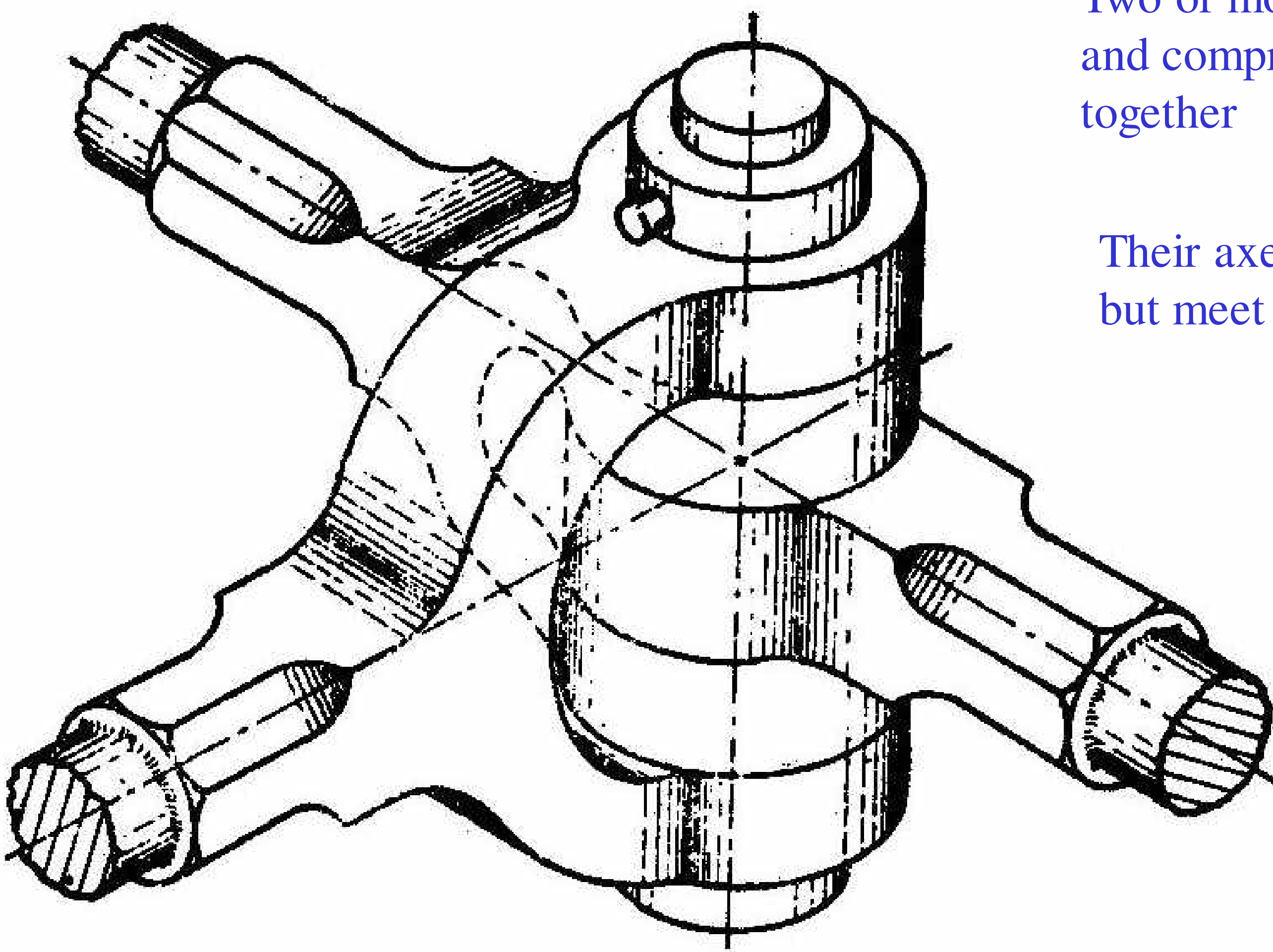






Knuckle joint

Knuckle joint



Two or more rods subjected to tensile and compressive forces are fastened together

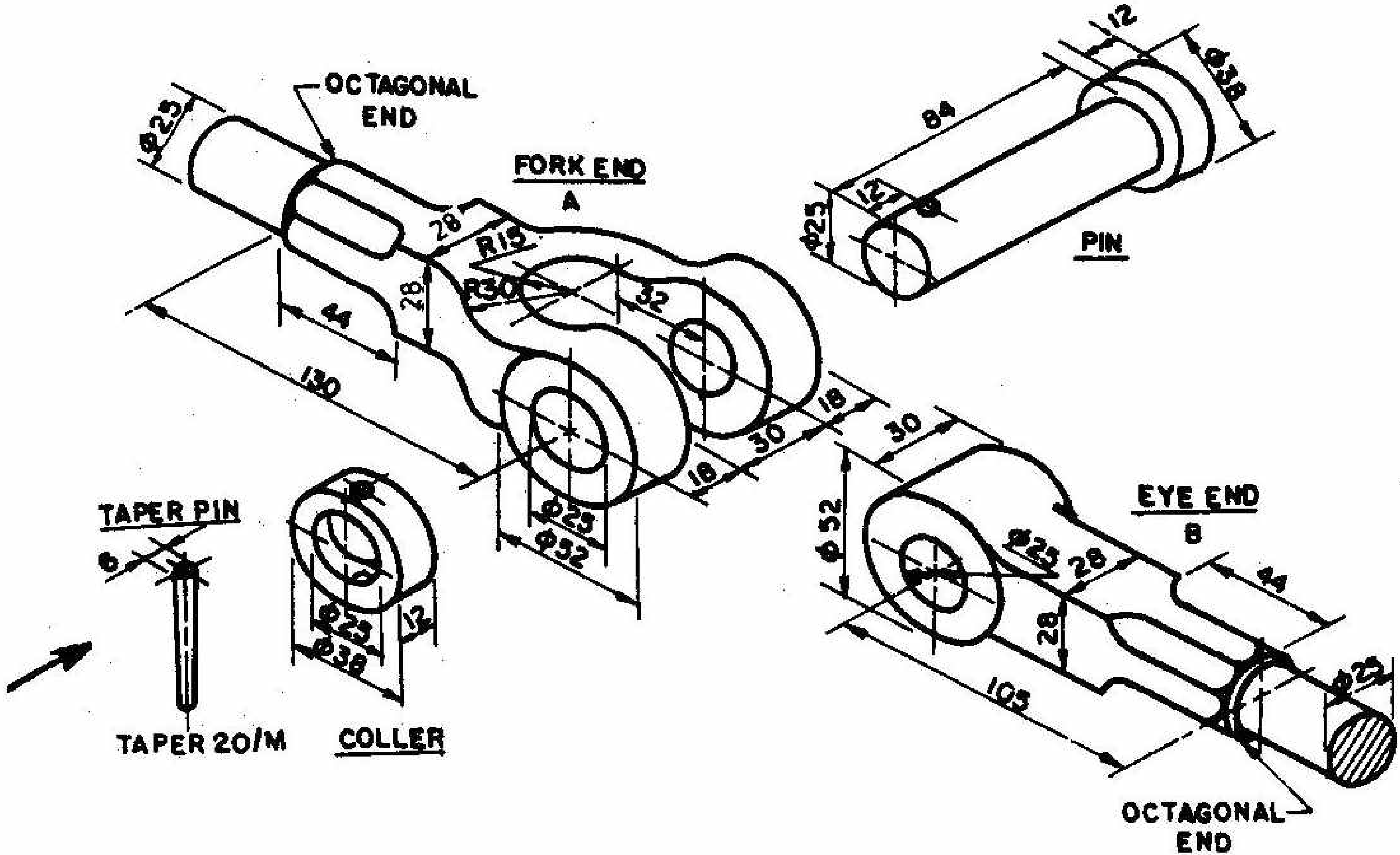
Their axes are not in alignments but meet in a point

The joint allows a small angular moment of one rod relative to another

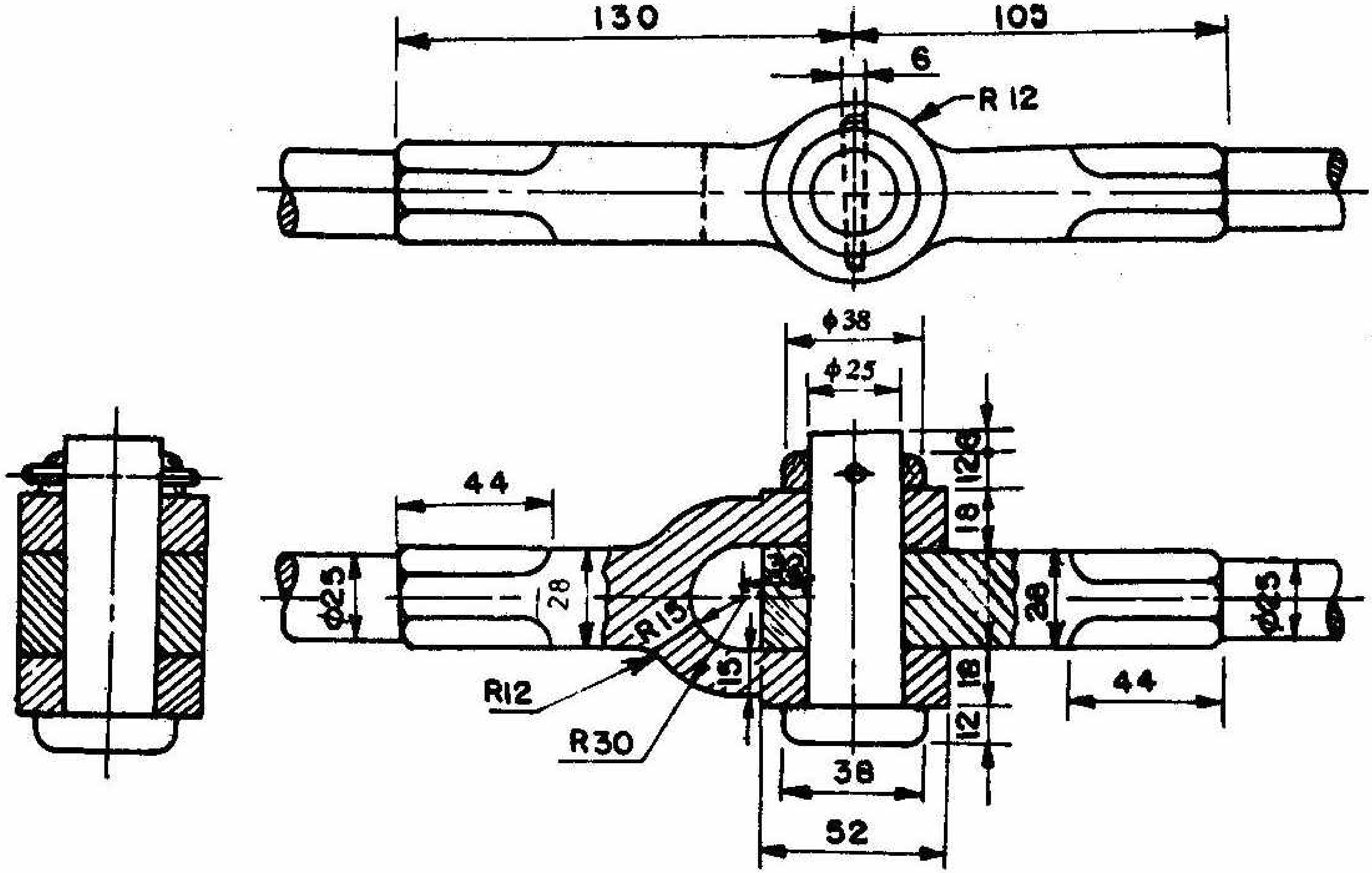
It can be easily connected and disconnected

Applications: Elevator chains, valve rods, etc

Knuckle joint



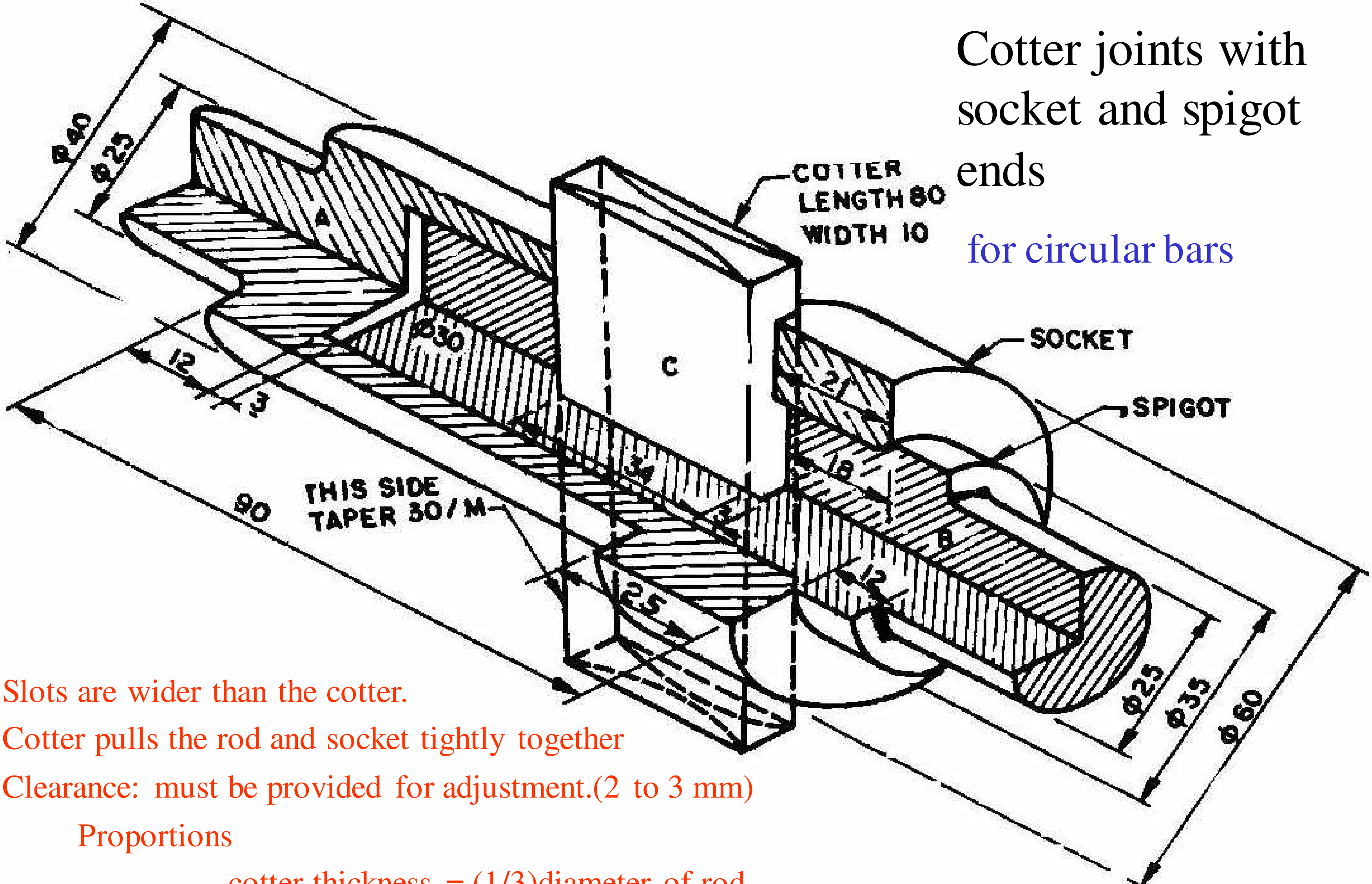
Knuckle joint



Cotter joints

- A cotter joints is a flat wedge link piece of steel of rectangular cross section which is inserted through the rods at high angle to their axes .It is uniform in thickness but tapering in width , generally on one side only. Usually the taper is 1 in 30. when a special arrangement like a set-screw is provided for keeping the cotter from slackening ,its taper may be as large as 1 in 7. the end of the cotter are made narrow to facilitate the hammering for fixing and removing.
- cotter joins are generally use to fasten rigidly two rod s which is subjected to tensile or compressive stress along their axes. this joint is used to connect two circular rods.
- This joint in not suitable where the member are subjected under rotation.
- Thus they differ from key joints which are used to fasten shaft and hubs subjected to tensional stress:

Cotter joint



Cotter joints with socket and spigot ends

for circular bars

Slots are wider than the cotter.

Cotter pulls the rod and socket tightly together

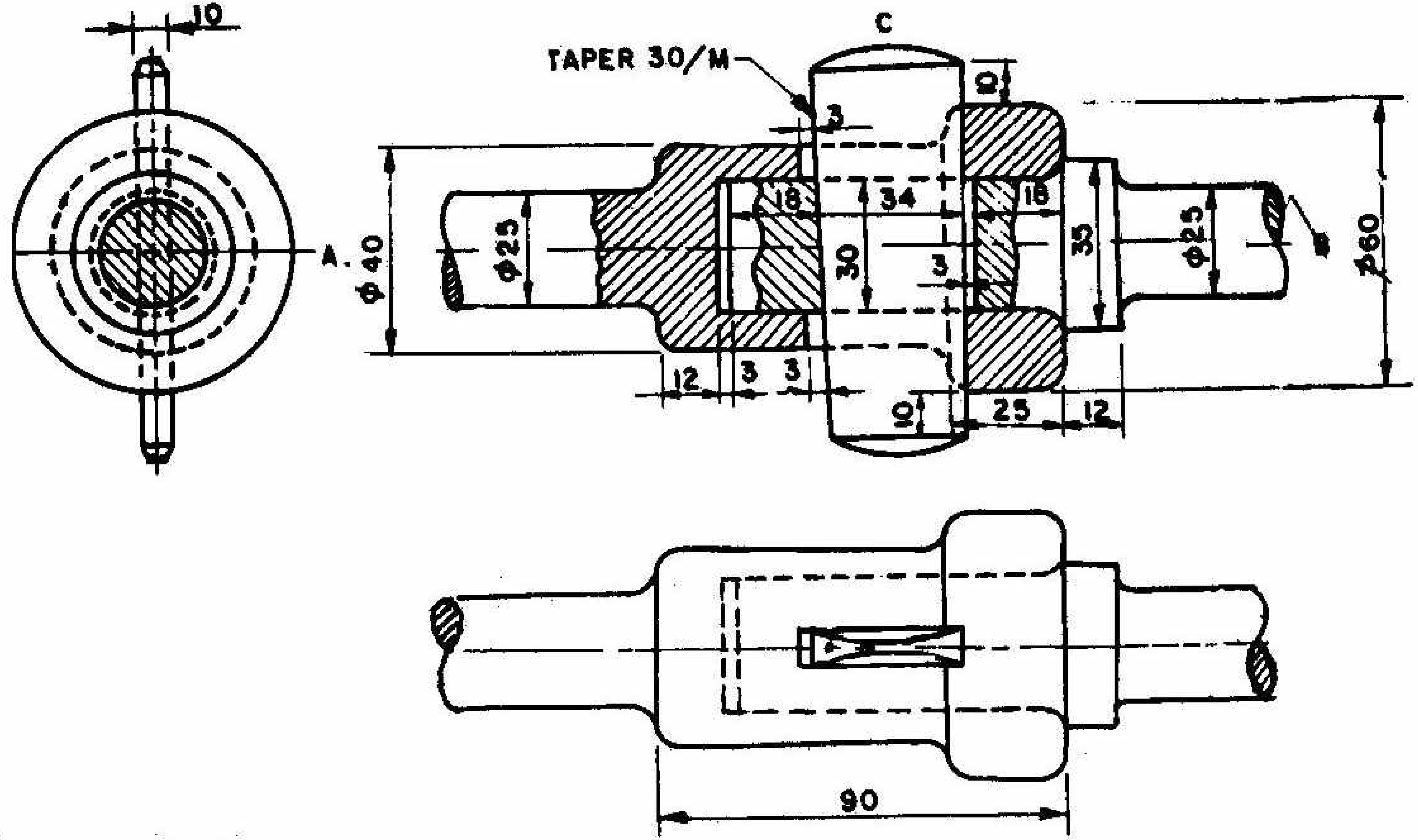
Clearance: must be provided for adjustment.(2 to 3 mm)

Proportions

cotter thickness = (1/3)diameter of rod

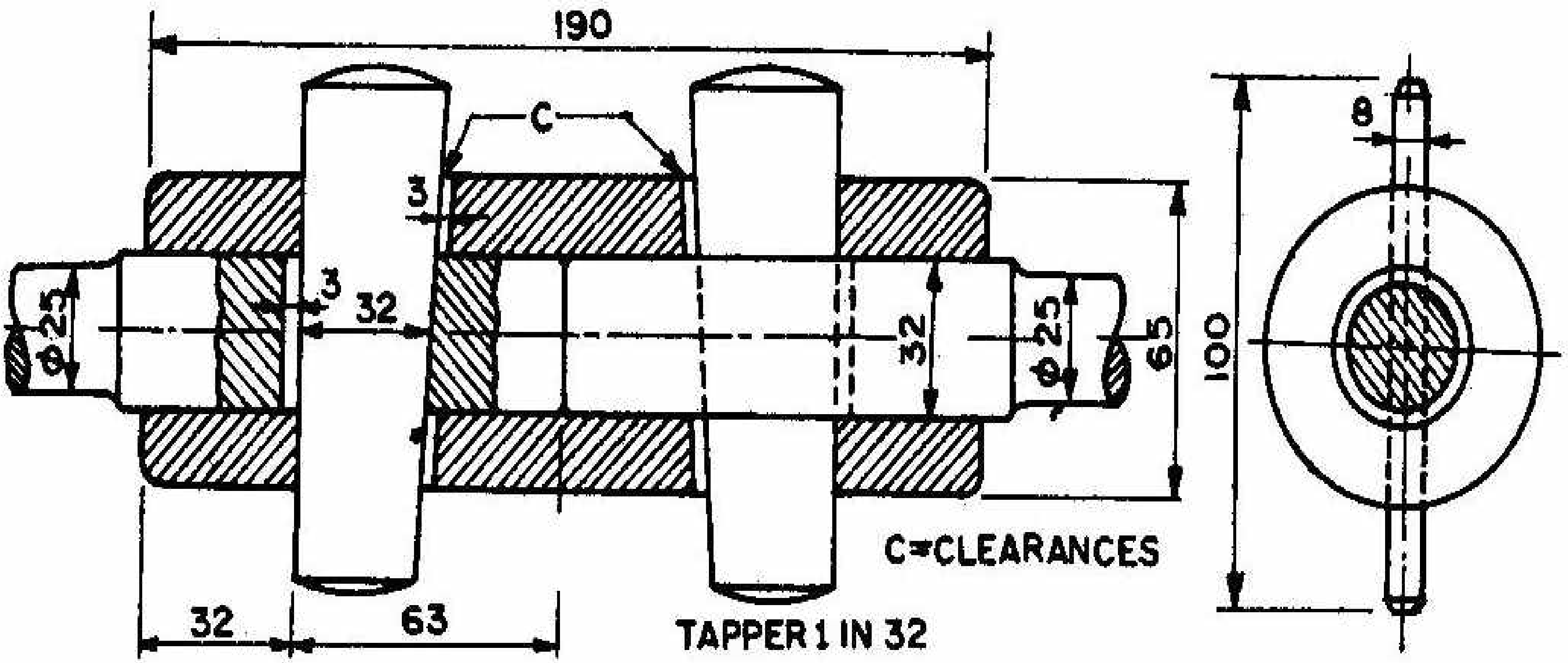
cotter width = rod diameter

Cotter joint



Sleeve and cotter joint

For circular rods



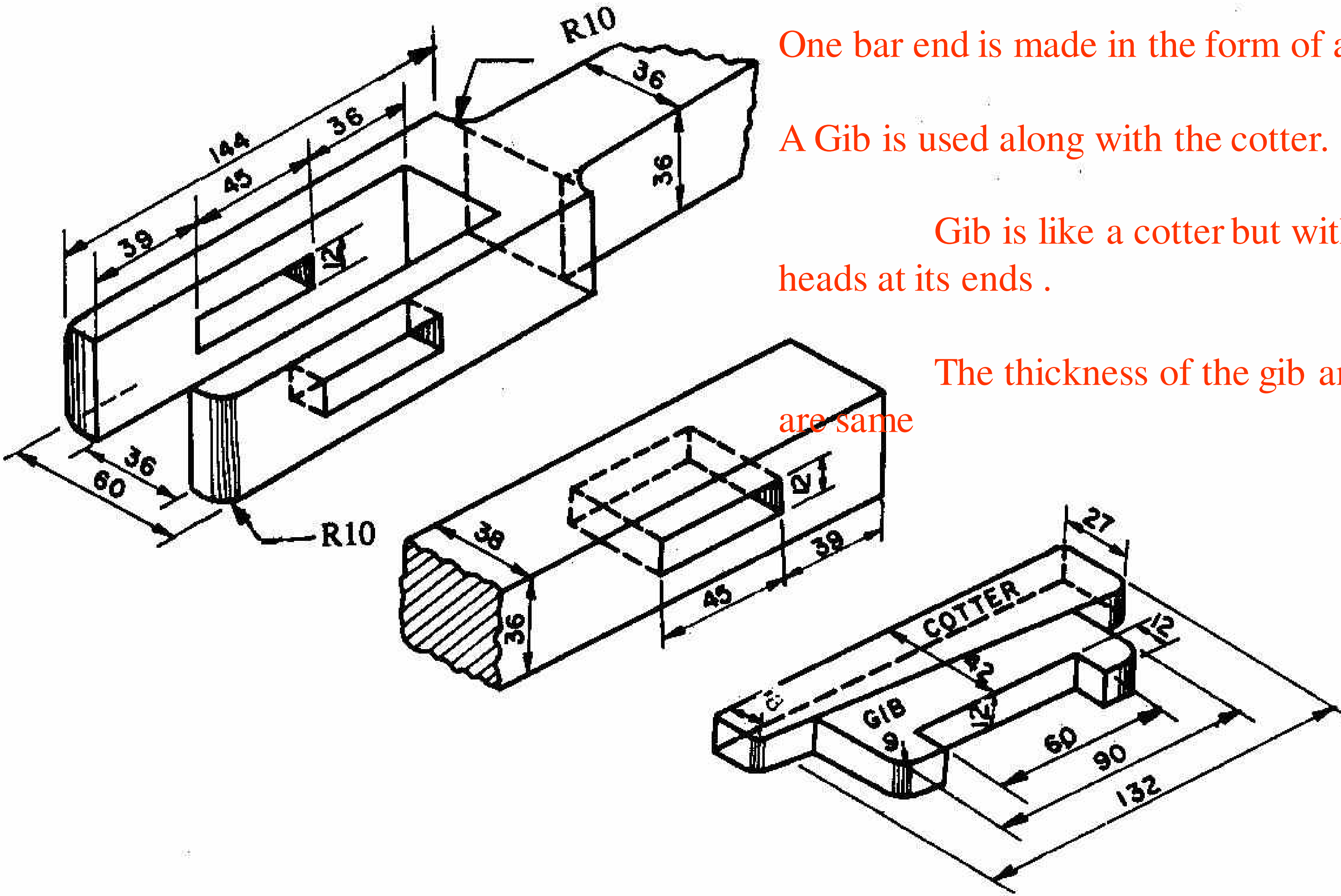
The enlarged ends of the rods butt against each other with a common sleeve over them

•The rod ends are enlarged to take care of the weakening effect caused by slots

Cotter joint with a gib

- Gib and cotter joints are used for rods of square or rectangular cross section .the end of one rod fits the end of the other rod which is made in the form of a strap. A gib is used along with the cotter to make this joint. Gib is likely a cotter but with two gib heads at its ends . The thickness of the gib and cotter are same.

Gib and cotter joint for rectangular rods



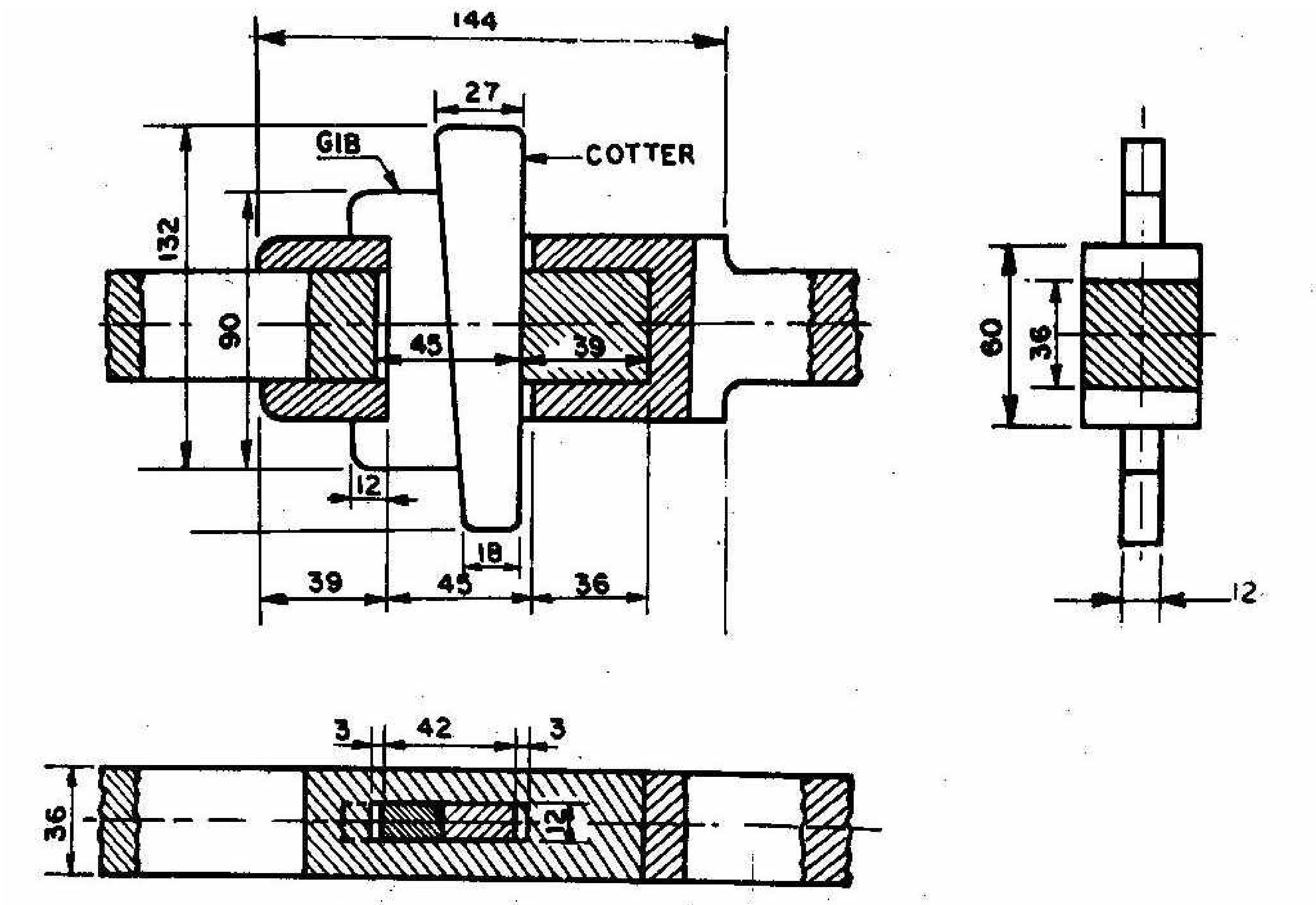
One bar end is made in the form of a strap

A Gib is used along with the cotter.

Gib is like a cotter but with two gib heads at its ends .

The thickness of the gib and cotter are same

Gib and cotter joint or rectangular rods



Couplings

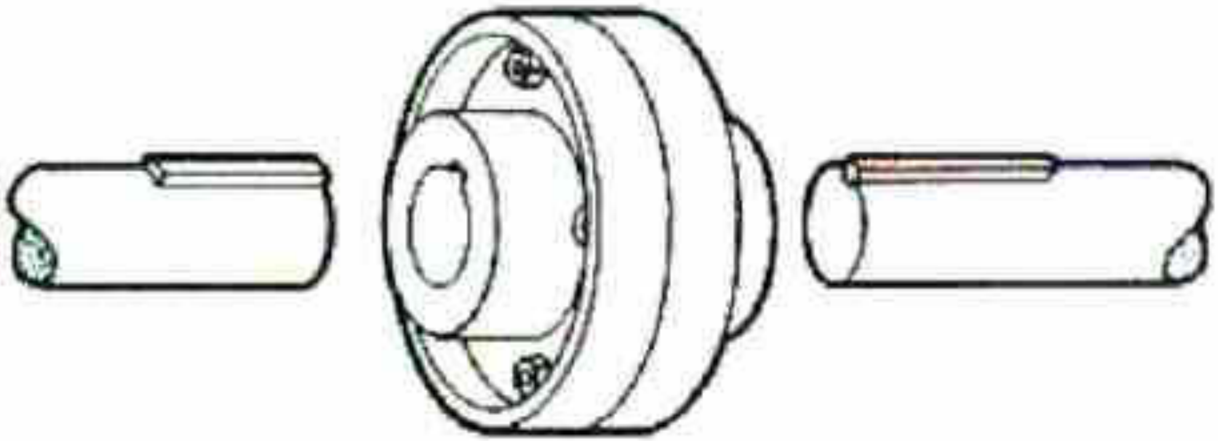
Couplings

- A device that is used to connect two shafts together for the purpose of power transmission.
- General types of couplings are:
  - rigid: for aligned shafts
  - flexible: for non-aligned shafts

Aligned Shaft Couplings

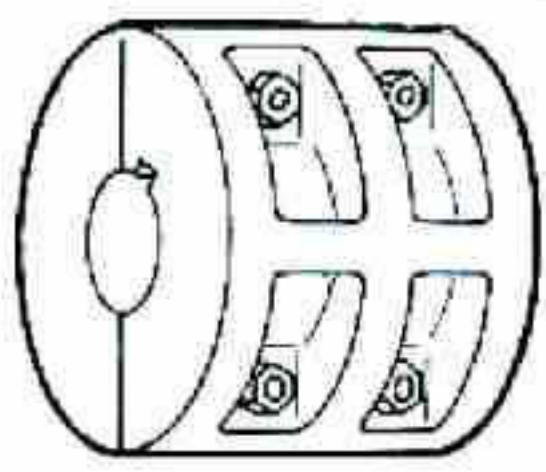
- Aligned shaft couplings are rigid couplings that are designed to draw two shafts together so that no motion can occur between them.
- Types
  - Flanged
  - Split Coupler
  - Keyed
  - Friction

Flanged Coupling



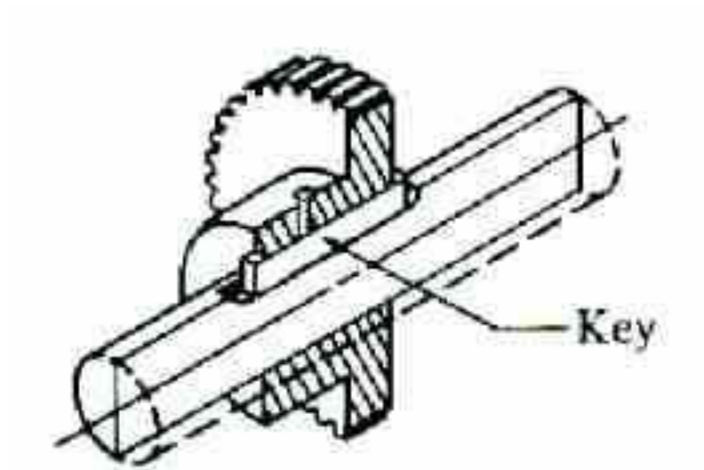
A key is used to to fix the coupling to the shaft, and then couplings are bolted together.

Split Coupler



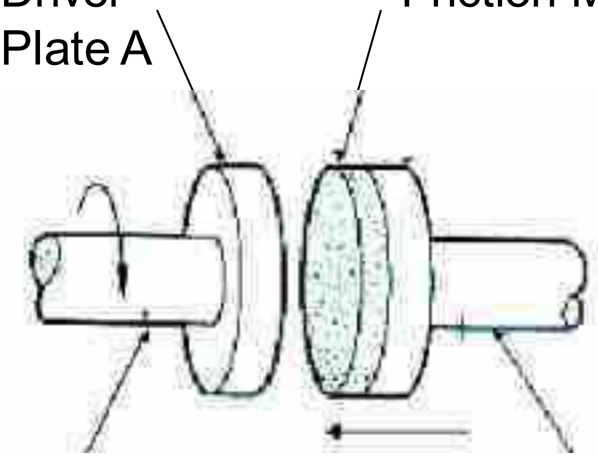
Again, a key is used to fix the coupling and the shaft and the two halves of the coupling are bolted together.

Keyed Coupler

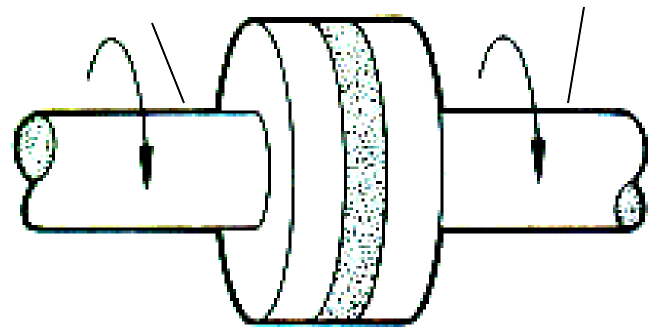


- Grooves are cut into the shaft and the fixed part.
- A key is put in the grooves to lock the two parts together.

Friction Coupling



Clutch Disengaged

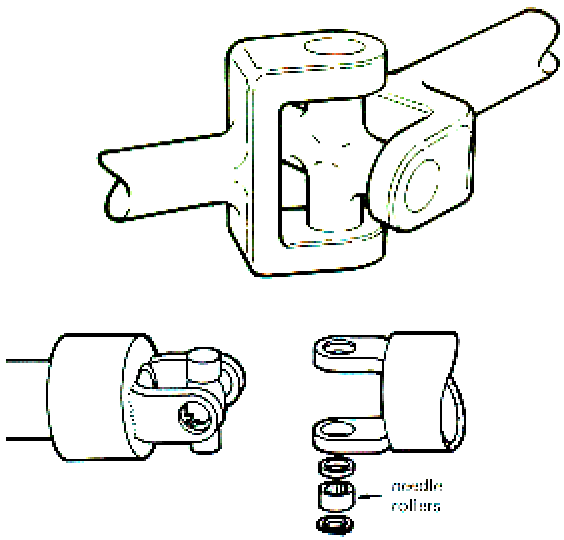


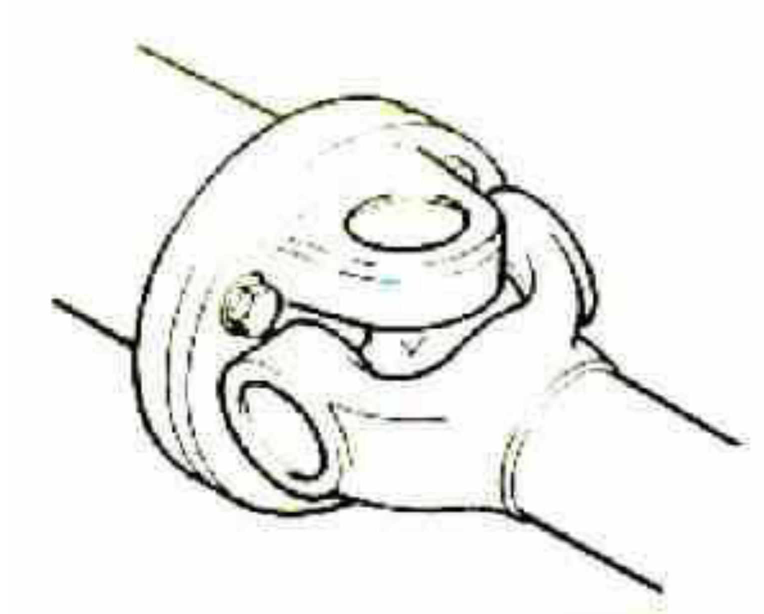
Clutch Engaged

Non-Aligned Shaft Couplings

- Used to join shafts that meet at a slight angle.
- Angle may still change while running due to vibration or load.
- Types:
  - Universal
  - Constant Velocity
  - Flexible

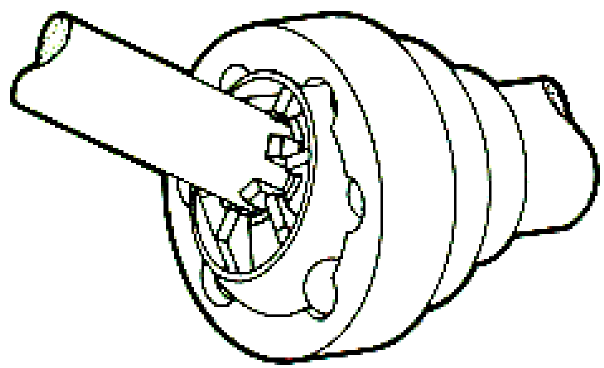
Universal Joint





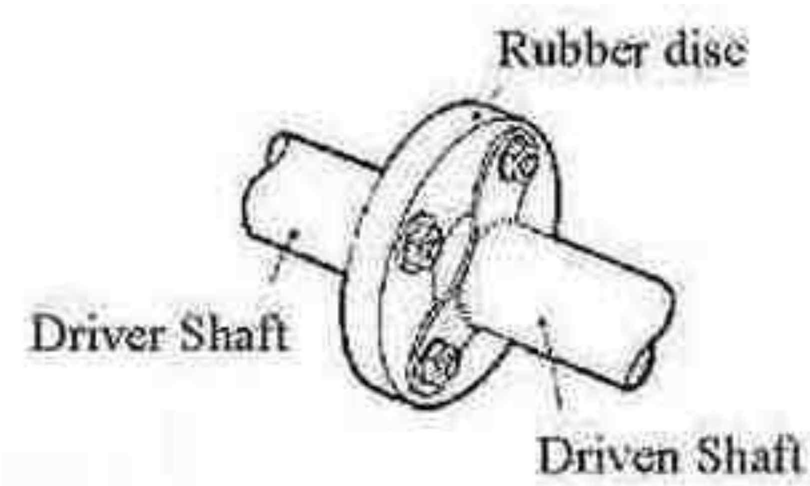
- Consist of two end yokes and a center bearing block.
- Provides for angular misalignment of up to 45 degrees.

Constant Velocity Joint



- Used where angles are greater than 20□ and there is no room to use two universal joints.
- Driven shaft maintains a constant speed regardless of driver shaft angle.
- Used on driveshafts on front wheel drive cars.

Flexible Coupling



- Both shafts are bolted to a rubber disc. The flexibility of the disc compensates for the change in angle.
- Can handle approximately 3 of angular misalignment.

Thank You