


DS1005: Engineering Graphics

Engineering Scales

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**INDIAN INSTITUTE OF INFORMATION TECHNOLOGY,
 DESIGN AND MANUFACTURING JABALPUR**
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Engineering 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 fraction**

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 FRACTION (R.F.) = $\frac{\text{LENGTH OF DRAWING in cm}}{\text{ACTUAL LENGTH in cm}}$
 $= \frac{\sqrt{\text{AREA OF DRAWING in cm}^2}}{\sqrt{\text{ACTUAL AREA in cm}^2}}$
 $= \sqrt{\frac{\text{VOLUME AS PER DRWG in cm}^3}{\text{ACTUAL VOLUME in cm}^3}}$

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

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BE FRIENDLY WITH THESE UNITS.

Area
 1 HECTARE = 10000 m²
 1 m² = 10⁴ cm²

Volume
 1 m³ = 10⁶ cm³

1 KILOMETRE = 10 HECTOMETRES = 10⁵ cm
1 HECTOMETRE = 10 DECAMETRES = 10⁴ cm
1 DECAMETRE = 10 METRES = 10³ cm
1 METRE = 10 DECIMETRES = 10² cm
1 DECIMETRE = 10 CENTIMETRES = 10 cm
1 CENTIMETRE = 10 MILLIMETRES

TYPES OF SCALES:

1. Plain scales (for dimensions up to single decimal)
2. Diagonal scales (for dimensions up to two decimals)
3. Comparative scales (for comparing two different units)
4. Vernier scales (for dimensions up to two decimals)
5. Scale of chords (for measuring/constructing angles)

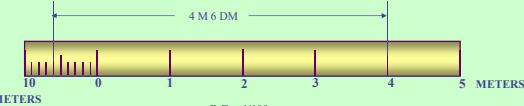
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PLAIN SCALE

PLAIN SCALE:- This type of scale represents two units or a unit and its sub-division.
PROBLEM:- 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.

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.



DECIMETERS 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 METERS

R.F. = 1/100
 PLANE SCALE SHOWING METERS AND DECIMETERS.

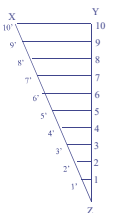
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We have seen that the plain scales give only two dimensions, such as a unit and its subunit or its fraction.

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 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' ZZ,
 we have $\frac{ZZ}{YZ} = \frac{7'Z}{XY}$ (each part being one unit)
 Means $7'Z = \frac{7}{10} \times XY = 0.7 XY$
 \therefore
 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.



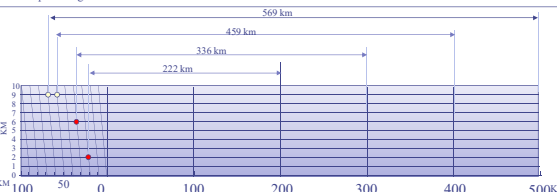
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DIAGONAL SCALE

PROBLEM 4:- The distance between Delhi and Agra is 200 km. In a railway map it is represented by a line 5 cm long. Find its 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 / 40,000
 Length of scale = 1 / 40,000 X 600 X 10³ = 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.



KILOMETERS 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 KILOMETERS

R.F. = 1 / 40,000
 DIAGONAL SCALE SHOWING KILOMETERS.

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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.

PROBLEM 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. = $8 / 40 \times 1609 \times 1000 \times 100$
= 1 / 8,04,500

Scale of Km:
Length of scale
= $1 / 8,04,500 \times 120 \times 1000 \times 100$
= 14.90 cm

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

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

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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.

Shown 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.

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PROBLEM 10:- Draw a vernier scale of R.F. = 1 / 25 to read centimeters upto 4 meters and on it, show lengths 2.39 m and 0.91 m

SOLUTION:
Length of scale = R.F. X max. Distance
= $1 / 25 \times 4 \times 100$
= 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

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SCALE OF CORDS

CONSTRUCTION:
1. Draw sector of a circle of 90° with 'oa' radius.
(Oa' any convenient distance)
2. Divide this angle in nine equal parts of 10° 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 its extension and form a scale with proper labeling as shown.

As cord lengths are used to measure & construct different angles it is called scale of cords.

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PROBLEM 12:- Construct any triangle and measure its angles by using scale of cords.

CONSTRUCTION:
First prepare Scale of Cords for the problem.
Then construct a triangle of given sides. (You are supposed to measure angles x, y and z)

To measure angle at x:
Take O-A distance in compass from cords scale and mark it on lower side of triangle as shown from corner x. Name O & A as shown. Then O as center, O-A radius draw an arc upto upper adjacent side. Name the point B.
Take A-B cord in compass and place on scale of cords from Zero.
It will give value of angle at x.

To measure angle at y:
Repeat same process from O₁. Draw arc with radius O₁A₁.
Place Cord A₁B₁ on scale and get angle at y.

To measure angle at z:
Subtract the SUM of these two angles from 180 to get angle at z.

Angle at z = $180 - (55 + 30) = 95^\circ$

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THANK YOU

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