SCALES

Engineering Graphics and Design (BTME-101-21)

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.)

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

$$= \sqrt{\frac{\text{AREA OF DRAWING in cm}^2}{\text{ACTUAL AREA in cm}^2}}$$

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

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

BE FRIENDLY WITH THESE UNITS.

1 KILOMETRE	= 10 HECTOMETRES =	10^5cm
1 HECTOMETRE	= 10 DECAMETRES =	10^4cm
1 DECAMETRE	= 10 METRES =	10^3 cm
1 METRE	= 10 DECIMETRES =	10^2 cm
1 DECIMETRE	= 10 CENTIMETRES =	10 cm
1 CENTIMETRE	= 10 MILIMETRES	

Area

1HECTARE = 10000 m^2

$1m^2 = 10^4\ cm^2$

Volume

$1m^3 = 10^6\ cm^3$

TYPES OF SCALES:

1. PLAIN SCALES (FOR DIMENSIONS UP TO SINGLE DECIMAL)
2. DIAGONAL SCALES (FOR DIMENSIONS UP TO TWO DECIMALS)

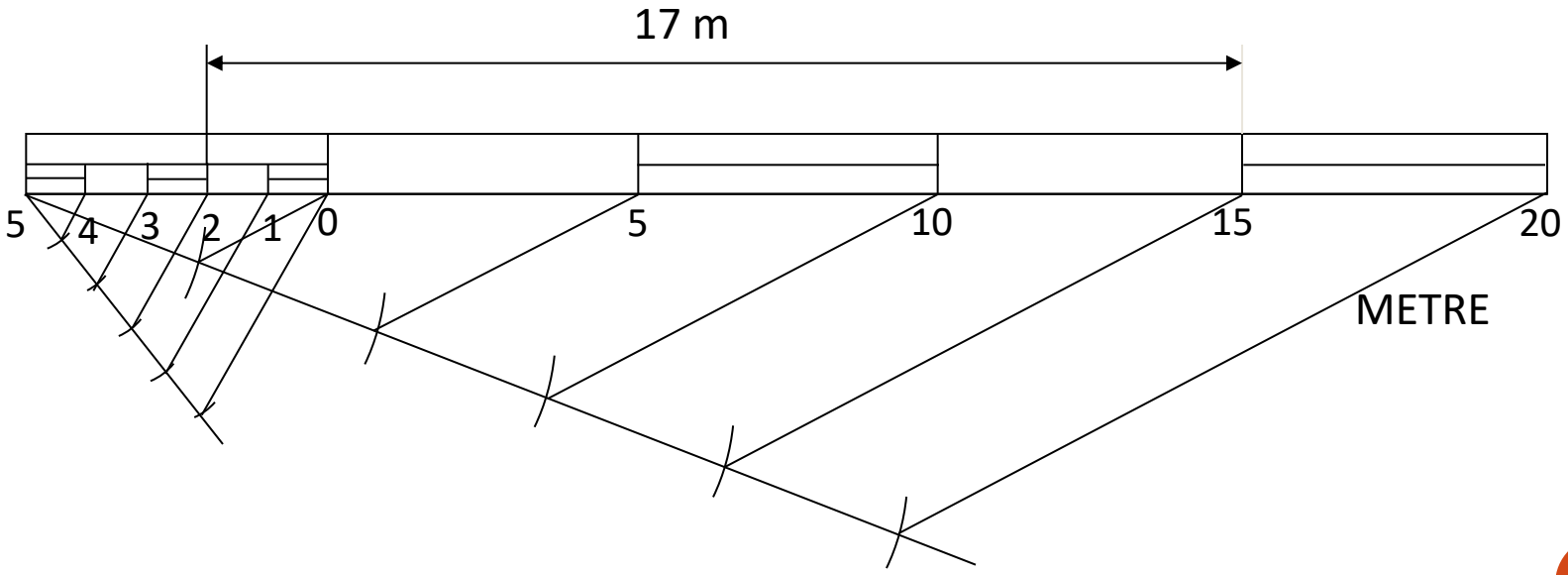
Problem 6: A 3.2 cm long line represents a length of 4 metres. Extend this line to measure lengths up to 25 metres and show on it units of metre and 5 metres. Show the length of 17 metre on this line.

$$\text{R.F} = \frac{\text{Length on drawing in cm}}{\text{Actual length of object in cm}} = \frac{3.2\text{ cm}}{4\text{ m}} = \frac{3.2\text{ cm}}{4 \times 100\text{cm}} = \frac{8}{1000} = \frac{1}{125}$$

$$\text{L.O.S.} = \text{R.F.x Max. Length in cm} = \frac{1}{125} \times 25 \times 100\text{ cm} = 20\text{ cm}$$

Hint: As we have to show units of 5 metre, so a 25 m long line should be divided in to 5 equal parts

As the first division represents 5 metre, so it should be divided in to 5 equal parts to represent a single metre



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

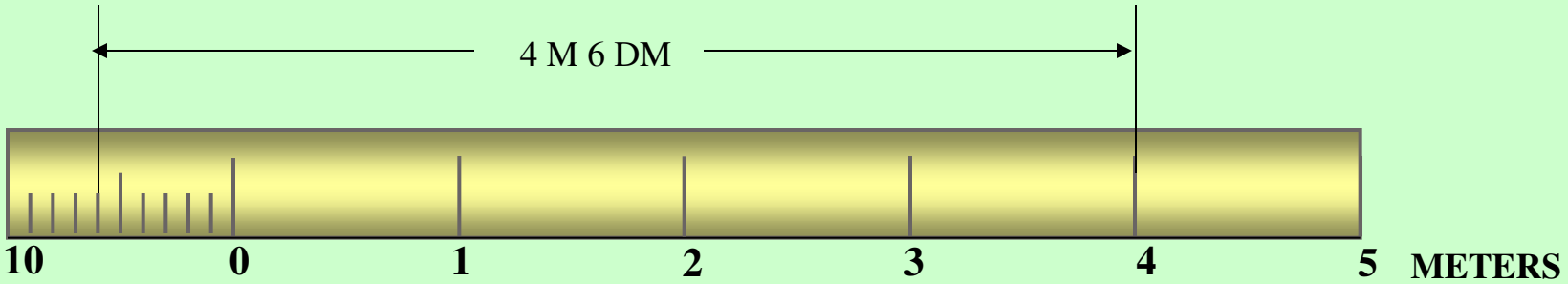
b) Draw a line 6 cm long and divide it in 6 equal parts. Each part will represent larger division unit.

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 cm/ 36 km = 45/ 36 . 1000 . 100 = 1/ 80,000

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

= 1/ 80000 × 12 km

= 15 cm

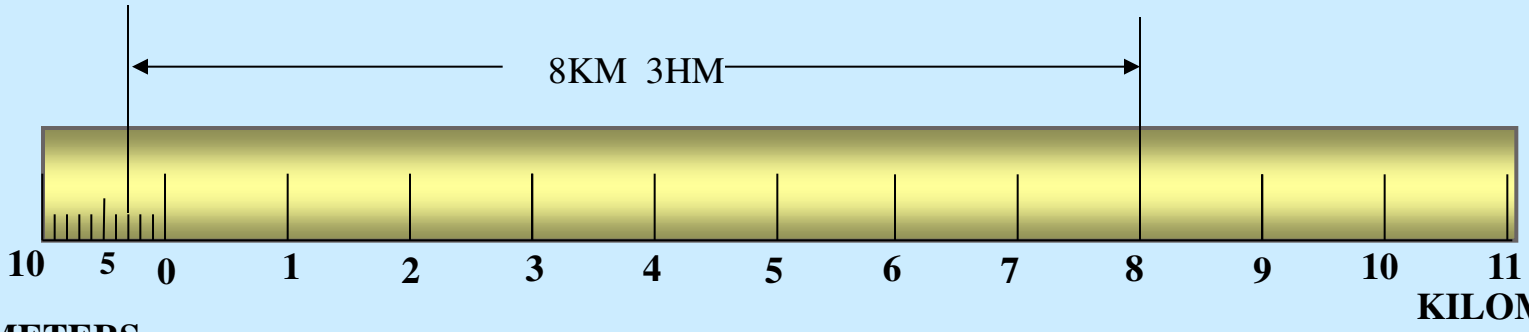
b) Draw a line 15 cm long and divide it in 12 equal parts. Each part will represent larger division unit.

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.



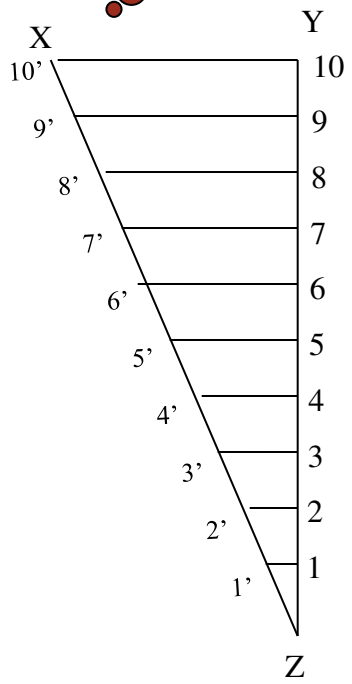
R.F. = 1/80,000

PLANE SCALE SHOWING KILOMETERS AND HECTOMETERS

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.

DIAGONAL SCALE



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.

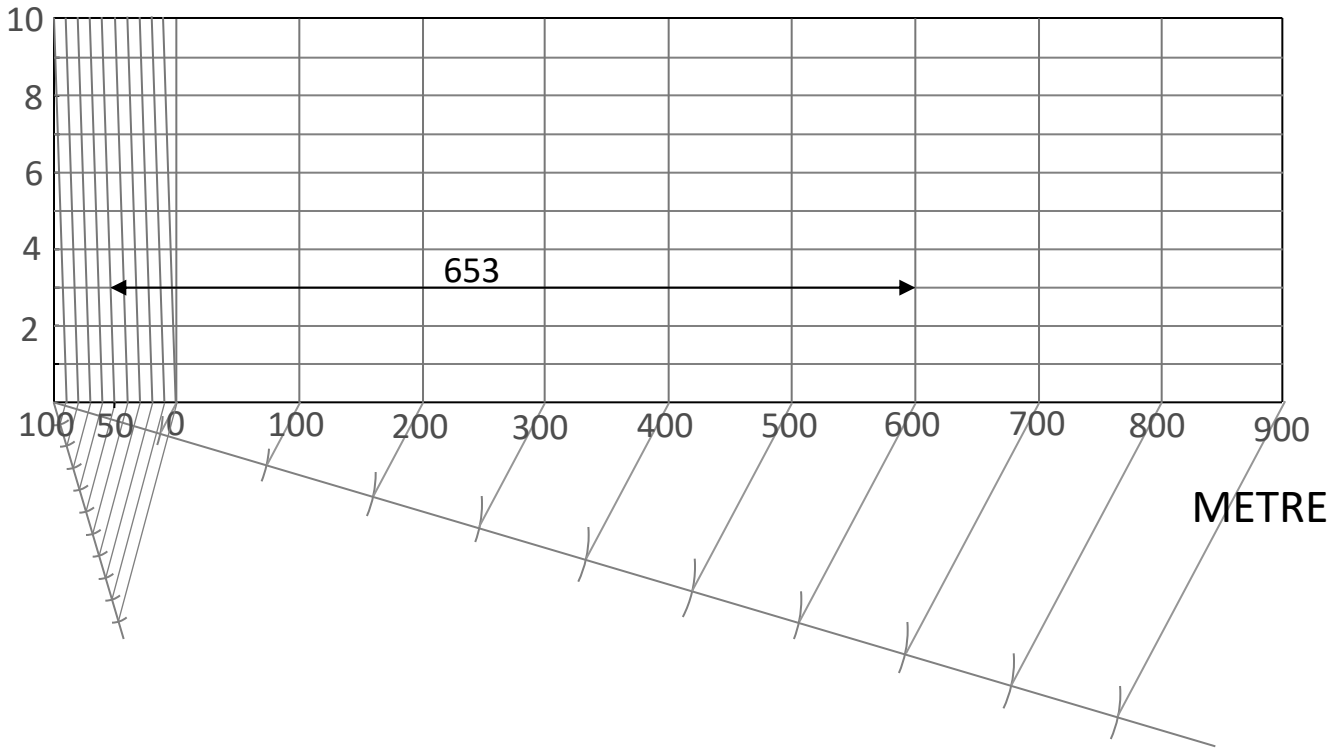
The solved examples ON NEXT PAGES will make the principles of diagonal scales clear.

Problem 7: Construct a diagonal scale of R.F. = 1/6250 to read up to 1 kilometre and to read metres on it. Show a length of 653 metre on it.

R.F = $\frac{1}{6250}$, Max. Length = 1 km

L.O.S.= R.F.x Max. Length in cm $= \frac{1}{6250} \times 1 \times 10^5$ cm = 16 cm

Hint: As the maximum length is 1 km, the line should be divided in to 10 equal parts, so as to represent a division of 100 m

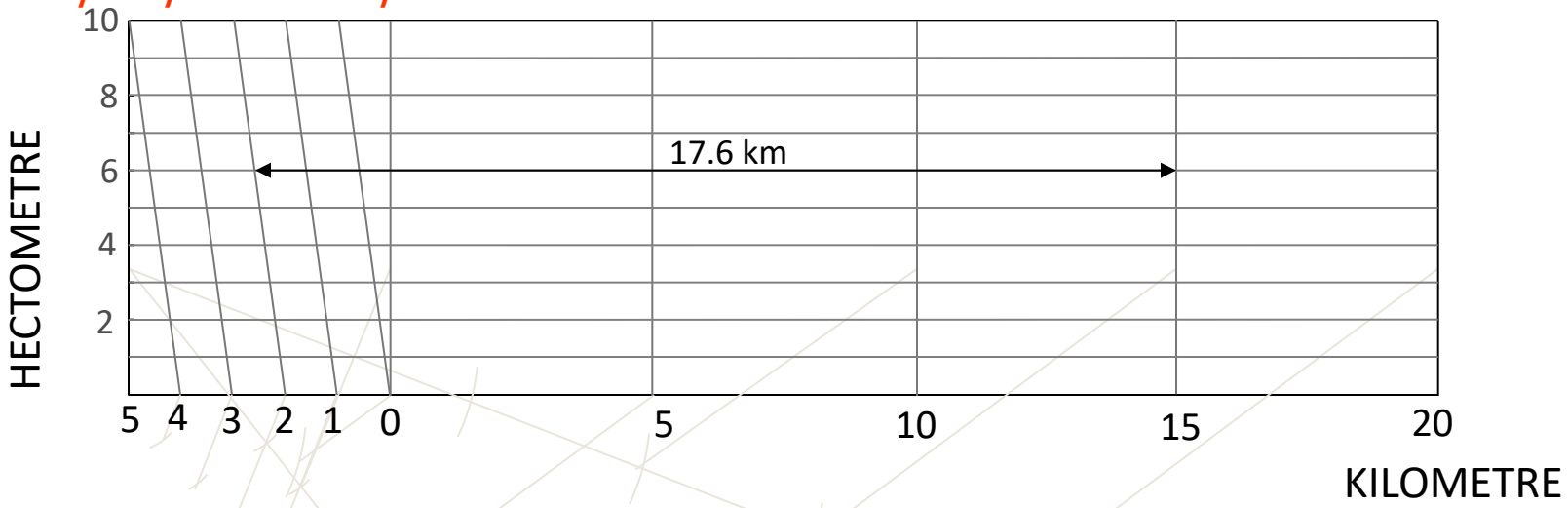


Problem 8: On a map, the distance between two points is 14 cm. The real distance between them is 20 km. draw the diagonal scale of this map to read kilometre and hectametres, and to measure up to 25 kilometre. Show a distance of 17.6 kilometre on this scale.

$$\text{R.F} = \frac{\text{Length on drawing in cm}}{\text{Actual length of object in cm}} = \frac{14\text{ cm}}{20\text{ km}} = \frac{14\text{ cm}}{20\text{X}10^5\text{ cm}} = \frac{7}{10^6}$$

$$\text{L.O.S.} = \text{R.F.x Max. Length in cm} = \frac{7}{10^6}\text{ X }25\text{X}10^5\text{ cm} = 17.5\text{ cm}$$

Hint: As the maximum length is 25 km, the line should be either be divided in to 25 equal parts to represent 1 km or first, in 5 equal parts so as to represent a division of 5 km, then the first division in further 5 equal parts to represent 1 km.

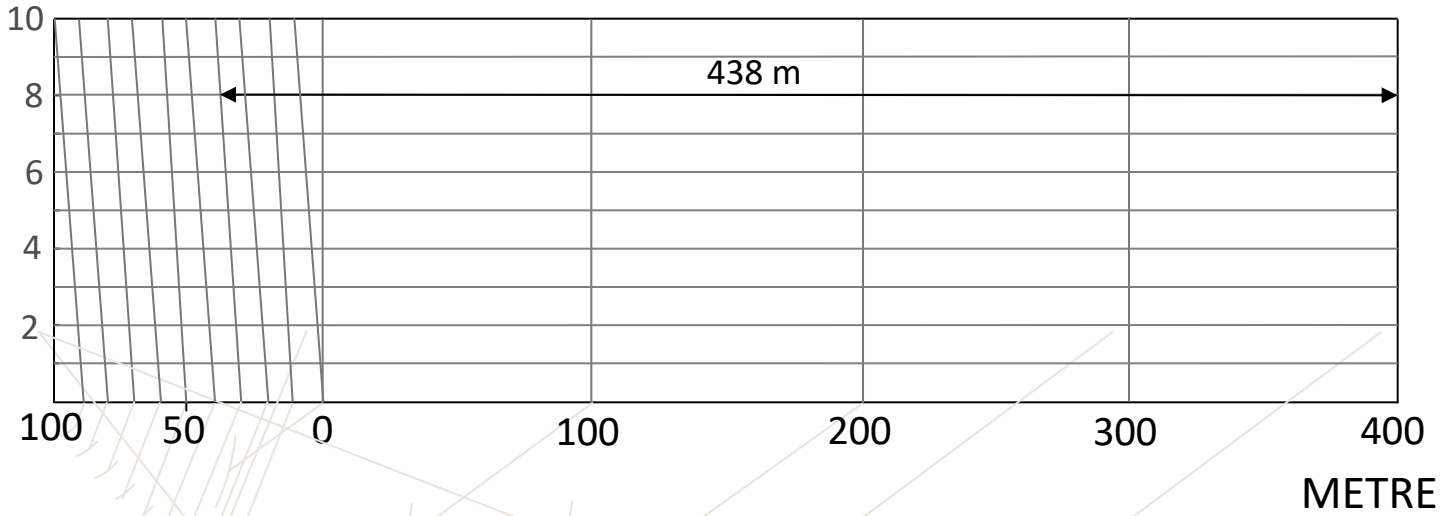


Problem 8: A rectangular plot of land measuring 1.28 hectors is represented on a map by a similar rectangle of 8 sq.cm. Calculate RF of the scale. Draw a diagonal scale to read single meter. Show a distance of 438 m on it. 1 hector = 10^4 m^2

$$R.F = \sqrt{\frac{\text{Area on drawing in } cm^2}{\text{Actual area of object in } cm^2}} = \sqrt{\frac{8\ cm^2}{1.28X10^4x10^4\ cm^2}} = \sqrt{\frac{4}{64X10^6}} = \frac{1}{4000}$$

$$L.O.S. = R.F. \times \text{Max. Length in cm} = \frac{1}{4000} X\ 500\ X\ 100\ cm = 12.5\ cm$$

Here maximum length is not given. But we have to show a distance of 438 m on the scale. That will be possible only when maximum length is taken as 500 m



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

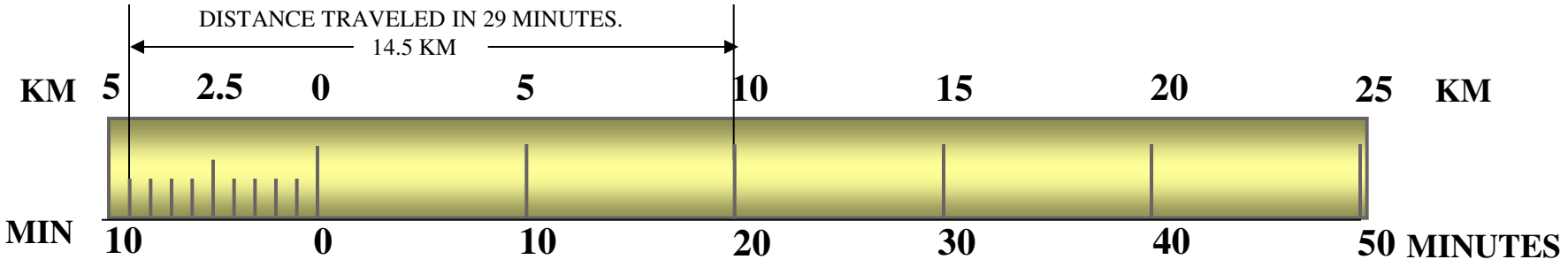
b) 15 cm length will represent 30 km and 1 hour i.e. 60 minutes.
Draw a line 15 cm long and divide it in 6 equal parts. Each part will represent 5 km and 10 minutes.

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.

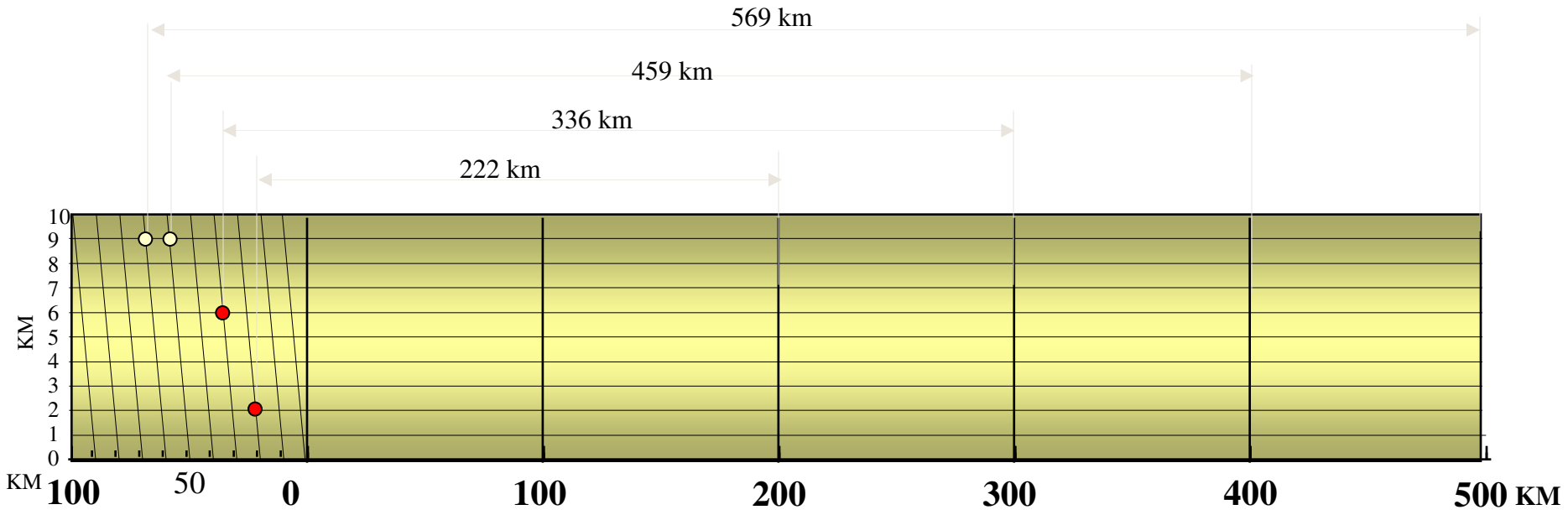
PROBLEM NO. 4 : The distance between Delhi and Agra is 200 km.
In a railway map it is represented by a line 5 cm long. Find it's R.F.
Draw a diagonal scale to show single km. And maximum 600 km.
Indicate on it following distances. 1) 222 km 2) 336 km 3) 459 km 4) 569 km

DIAGONAL SCALE

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

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

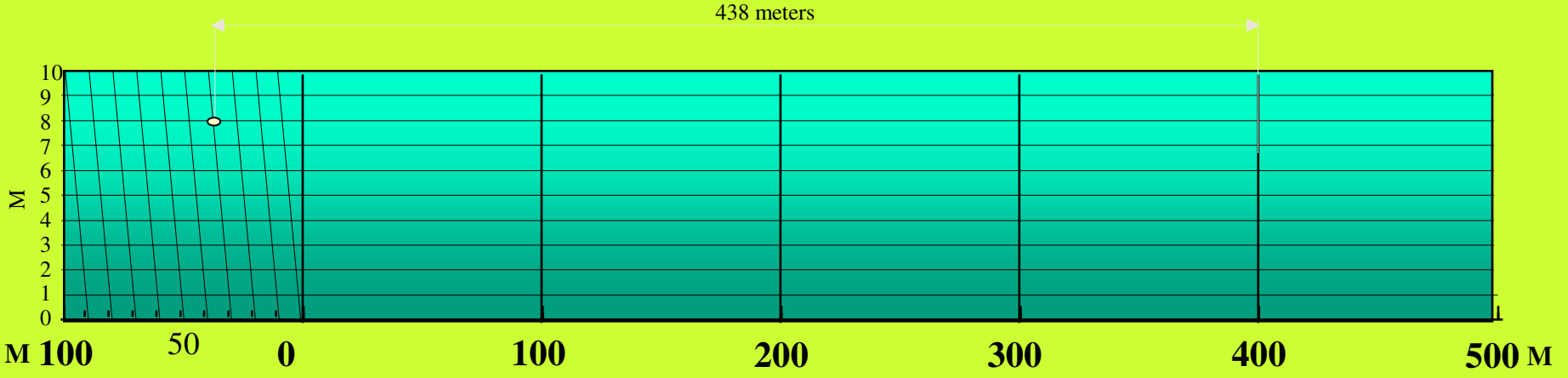
$= 4,000$ cm

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

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

DIAGONAL SCALE

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.

DIAGONAL SCALE

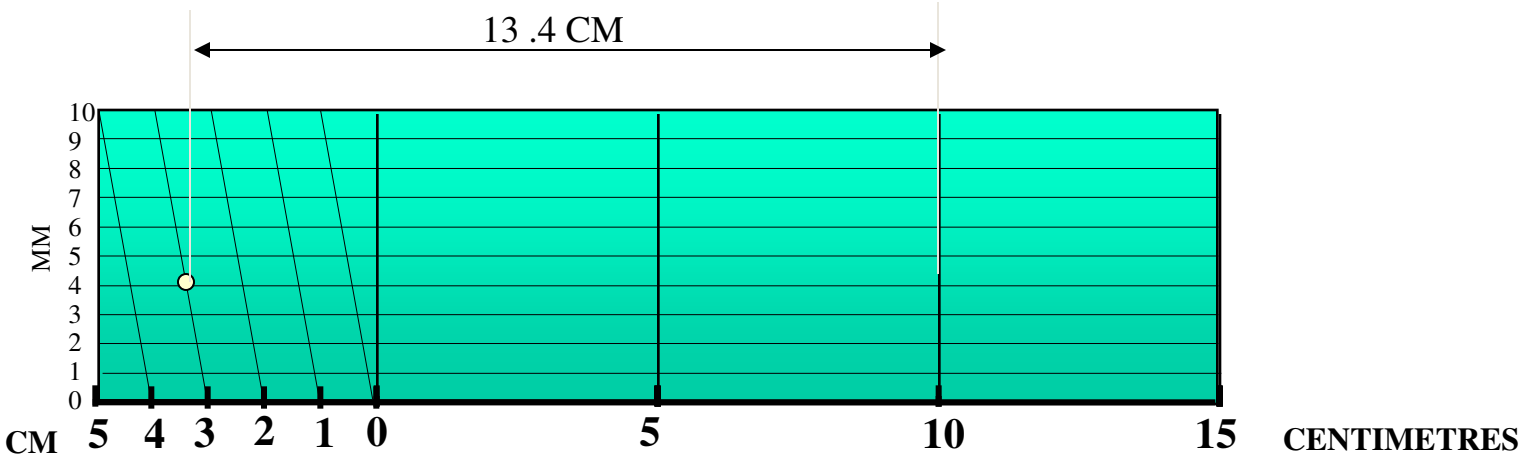
SOLUTION STEPS:

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.



R.F. = 1 / 2.5

DIAGONAL SCALE SHOWING CENTIMETERS.

Questions on Plain Scale

1. Construct a scale of 1 cm = 0.5 m to show single metre and single decimetre and long enough to measure up to 8 m. Also show the distances of 7 m 5 dm and 6 m 4 dm.
2. The distance between two towns is 120 km. A passenger train covers this distance in 4 hours. Construct a plain scale to measure time up to a single minute. The RF of the scale is 1/200000. Indicate on this scale, the distance covered by the train is 34 minutes.
3. Construct a scale having RF = 1/400 to show metres and long enough to measure up to 60 metres. Measure a distance of 44 metres on the scale.
4. A room of 1000 m^3 volume is shown by a cube of 5 cm side. Find its RF and draw a plain scale to measure up to 30 metres. Also show a distance of 24 metres on it.

Questions on Diagonal Scale

1. Construct a diagonal scale of RF = 1/5000 to show hundred metres, ten metres and single metre and long enough to measure up to 500 metres. Also show the distances of 375 m and 467 m on it.
2. A rectangular plot of area 50,000 square metre, is represented on a map by a similar rectangle of 80 square centimetre. Calculate the RF of the scale of the map. Construct a diagonal scale which can read up to single metre. Also show a distance of 234 m on it.
3. Draw a diagonal scale of 1 : 2.5 showing centimetres and millimetres and long enough to measure up to 20 centimetres. Show a distance of 13.4 cm on it.
4. A cube of 4 cm side represents a tank of 1728 m^3 volume. Find its RF and draw a diagonal scale to measure up to 60 m. Also show a distance of 54.4 m on it.
5. A rectangular field of 0.81 hectare is represented on a map by a square of 3 cm × 3 cm. Calculate its RF. Draw a diagonal scale to show hundred metres, ten metres and single metre and long enough to measure upto 600 metres. Also show the distances of 475 m and 567 m on it.