RAKESH JALLA

B.Tech (ME), M.Tech (CAD/CAM)
Assistant Professor
Department Of Mechanical Engineering
CMR INSTITUTE OF TECHNOLOGY

SCALES

Definition: A Scale is defined as the ratio of the drawing size of an object to its actual size.

Designation of scales:

Full size 1:1
e.g.: Drawing a pen profile on the drawing sheet.
Here the objects are represented by lines of length equal to the actual size of the objects.

Reducing size 1: X
e.g.: Drawing the building plans on the drawing sheet.
Here the objects are represented by lines of length smaller than the actual size of the objects.

Increasing (or) enlarging size X: 1
e.g.: Drawing the small ornaments on the drawing sheet.
Here the objects are represented by lines of length greater than the actual size of the objects.

1m = 100cm = 1000mm

$\frac{1}{10}th\ m = 0.1$m = decimeter (dm)

$\frac{1}{100}th\ m = 0.01$m = centimeter (cm)

$\frac{1}{1000}th\ m = 0.001$m = millimeter (mm)

10m = 1decameter (dam)

100m = 1hectometer (hm)

1000m = 1kilometer (km)

1yard = 3feet (or) 3’

1feet = 12inches (or) 12’’

1inch = 2.54cm

1 cm = 10 mm

Note: Many students get confused between **dm** and **dam**. They must know the difference between them clearly.

Types of scales:

1. **Plain or Simple scale**
2. **Diagonal scale**
3. **Vernier scale**

1. **Plain or Simple scale:**
   - Accuracy to read up to two measurements
   - E.g.: Km ⟶ hm (here hm is immediate below measurement to Km)
     dm ⟶ cm (here dm is immediate below measurement to cm)

     Km ⟶ dam (it is **not possible** to indicate the value in plain scale because km to dam in middle hm is there. i.e. here Km is not immediate below measurement to dam)
     Km ⟶ dam (it is not possible to indicate the value in plain scale
     dm ⟶ mm (it is not possible to indicate the value in plain scale because dm to mm in middle cm is there.)

2. **Diagonal scale**:
   - Accuracy to read up to three measurements
   - E.g.: Km ⟶ hm ⟶ dam
     dm ⟶ cm ⟶ mm

3. **Vernier scale:**
   - Accuracy to read up to three measurements

Steps to solve a Scale Problem:

1. **Decide the type of a scale (if not mention the type scale in the problem):** Based on the indicated value. i.e. "by seeing the mark/indicate the distance value" in the problem.
   e.g.: (a) Name the scale and indicate a distance of 4.5m on it. (Or) Name the scale and indicate a distance of 4m and 5 decimeters.

   Here 4.5m can be split in to 4m + 0.5 m
   i.e., 4.5 m = 4m + 5 dm
   Here dm is immediate below measurement to m.

   4.5 m = 4m + 0.5m
   ↓ 1st Step ↓ 2nd Step

   So the indicated value 4.5m is two steps.
   I.e. Two measurements are m and dm. Therefore it is a plain scale.

   (b) Name the scale, and mark a distance of 36km on it.
   Here 36km can be split in to 36km + 6km

   36km = 30km + 6km
   ↓ 1st Step ↓ 2nd Step

   So the indicated value 36km is two steps. Therefore it is a plain scale.

   (c) Name the scale, and mark a distance of 349km
   Here 349km can be split in to 300km + 40km + 9km

   349km = 300km + 40km + 9km
   ↓ 1st Step ↓ 2nd Step ↓ 3rd Step

   So the indicated value 349km is three steps. Therefore it is a Diagonal scale.

(d) Name the scale, and indicate a distance of 3.24m

Here 3.24m can be split in to 3m + 0.2m + 0.04m

3.24m = 3m + 0.2m + 0.04m
3.24m = 3m + 2dm + 4cm
↓ ↓ ↓
1st Step 2nd Step 3rd Step

So the indicated value 3.24m is three steps.
I.e. Three measurements are m, dm and cm. Therefore it is a Diagonal scale.

2. **Finding RF :**

To draw a scale, need to know the "Representative Factor (RF)". Or it is also called Scale factor.

Representative Factor or Scale Factor = $\frac{\boldsymbol{drawing\ size}}{\boldsymbol{actual\ size}}$ (in same units)

Case1: RF will be given directly as a ratio or as a fraction. Take the value to find the length of the scale.

E.g.; RF = 1**:** 20,000

RF = $\frac{1}{500}$

Case 2: RF will be given not directly, Possible ways of giving RF.

(a) The distance between Hyderabad and Mangalagiri is 300km and its equivalent distance on map is 10cm. Find RF.

Representative Factor = $\frac{drawing\ size}{actual\ size}$ (in same units)

RF = $\frac{10cm}{300km}$

Note: The numerator and denominator should be same units.

$= \frac{10cm}{300X\ 1000m}$ (since 1km = 1000m)

$= \frac{10cm}{300X\ 1000X100cm}$

RF = $\frac{1}{3000000}$

(b) 1sq.cm represents a 25sq.m.

(Or)

$1cm^2$ represents a $25m^2$. Find RF.

Representative Factor = $\frac{drawing\ size}{actual\ size}$ (in same units)

RF = $\frac{1\ sq.cm}{25sq.m}$

RF = $\sqrt[2]{\frac{1\ sq.cm}{25\ sq.m}}$

RF = $\frac{1\ cm}{5m}$

RF = $\frac{1\ cm}{5X\ 100cm}$

RF = $\frac{1}{500}$

Note: Change the square (area) units into linear measurements by taking square root.

(c) 1cubic.cm represents a 64cu.m. Find RF.

(Or)

$1cm^3$ represents a $64m^3$. Find RF.

R F = $\frac{drawing\ size}{actual\ size}$ (in same units)

$$RF = \frac{1\ cu.cm}{64cu.m}$$

$$RF = \sqrt[3]{\frac{1\ cu.cm}{64\ cu.m}}$$

$$RF = \frac{1\ cm}{4m}$$

$$RF = \frac{1\ cm}{4X\ 100cm}$$

$$RF = \frac{1}{400}$$

Note: Change the cubic (volume) units into linear measurements by taking cubic root.

(d) A cube of side 10m, its volume is represented by a block volume of $125cm^3$. Find RF.

Solution:

Let a cube of side = S = 10m

Volume of a cube = S^3 = $1000m^3$

Representative Factor = $\frac{drawing\ size}{actual\ size}$ (in same units)

$$RF = \frac{125cm^3}{1000m^3}$$

$$RF = \sqrt[3]{\frac{125cm^3}{1000m^3}}$$

$$RF = \frac{5\ cm}{10m}$$

$$RF = \frac{5\ cm}{10X100cm}$$

$$RF = \frac{1}{200}$$

3. Length of scale(L):

Length of scale to draw on drawing sheet is determined by

L = RF X Maximum length

Note:

1. Maximum length depends on the value of "mark a distance value' in the problem.

2. When maximum length is not given in the problem, Consider maximum length is the next round off integer to the 'mark a distance value' in the problem.
3. When 'mark a distance value' is not given in the problem, take the length of the scale is 15cm by default.
4. The width of the scale is usually taken 2cm and do not mention 2cm on the drawing sheet.

Plain Scale (or) Simple Scale

1. Plain Scale of RF is 1:40 .To read meters and $\frac{1}{10}$ th meter and long enough to measure up to 8m. Show the lengths of 4.3m and 6.2m on the scale.

Solution:

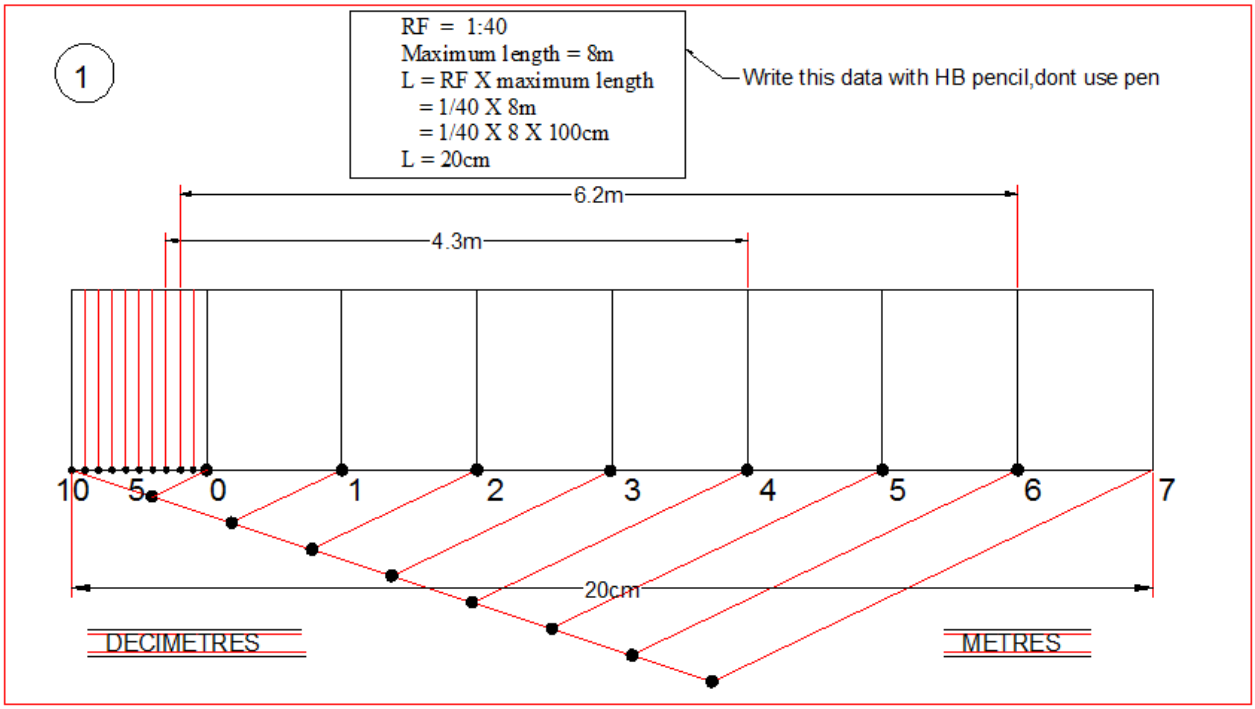
Step1: Which scale?
Plain Scale, mentioned in the problem. And also 4.3m and 6.2m are two measurements i.e. meter and deci meter. So it is a plain scale.

Step2: RF?
RF given directly in the problem as 1:40

Step3: Maximum Length?
Given in the problem as 8m

Note: Based on the maximum length, divide the scale in to required no. of parts.

Step4: Length of the scale?
L = RF X maximum length
L = 1/40 X 8m
L = 1/40 X 8 X 100cm
L = 20cm



2. A cube of 5cm sides represent a tank of 1000 m^3 volume. Find the RF and construct a scale to measure up to 30m & mark a distance of 27m on it.

Solution:

Step1: Which scale?

Which scale didn't mention in the problem. So decide based on the 'mark a distance value'. i.e. 27m, i.e. 20meter + 7meter. 27m is two steps. So it is a plain scale.

Step2: RF?

RF is not given directly in the problem as X: X

So calculate by using RF formula

Let a cube of side = S = 5cm

Volume of a cube = S^3 = $1000m^3$

$$\text{Representative Factor} = \frac{drawing\ size}{actual\ size} \text{ (in same units)}$$

$$\text{RF} = \frac{125cm^3}{1000m^3}$$

$$RF = \sqrt[3]{\frac{125cm^3}{1000m^3}}$$

$$RF = \frac{5\ cm}{10m}$$

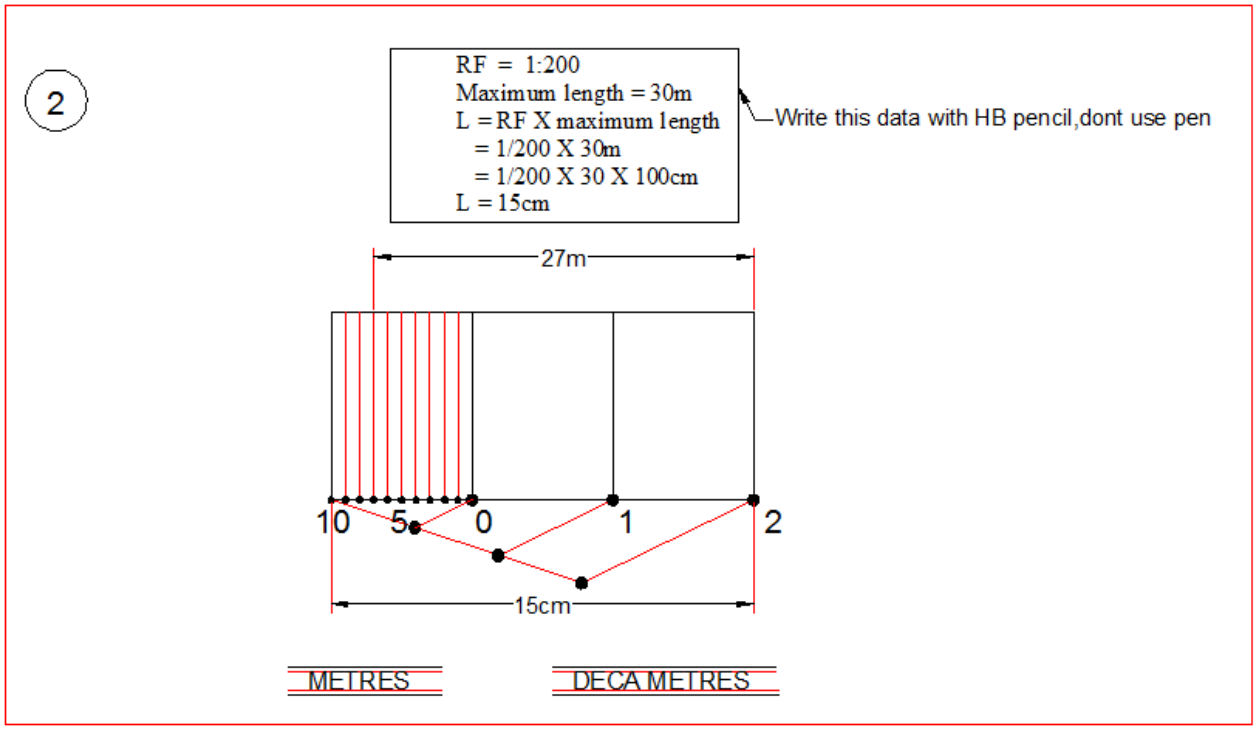
$$RF = \frac{5\ cm}{10X100cm}$$

$$RF = \frac{1}{200}$$

Step3: Maximum Length?
Given in the problem as 30m

Note: Based on the maximum length, divide the scale in to required 3 no. of parts; it is not possible to divide into 30 parts. So the each part is 10m i.e. 1 decameter (1dam)

Step4: Length of the scale?
L = RF X maximum length
L = 1/200 X 30m
L = 1/200 X 30 X 100cm
L = 15cm



Diagonal scale

1. Construct & name the scale of RF 1:250 to show decimeter & long enough to measure up to 30m. Indicate a distance of 28.9m on it.

Solution:

Step1: Which scale?

Which scale did not mention in the problem. So see the 'mark the value' as given 28.9m. It is three measurements i.e. decameter, meters and deci meter. So it is a Diagonal scale.

I.e. 28.9 m = 20m + 8m + 0.9m

28.9m = 2 dam + 8m + 9decimetre

Step2: RF?

RF given directly in the problem as 1:250

Step3: Maximum Length?

Given in the problem is 30m.

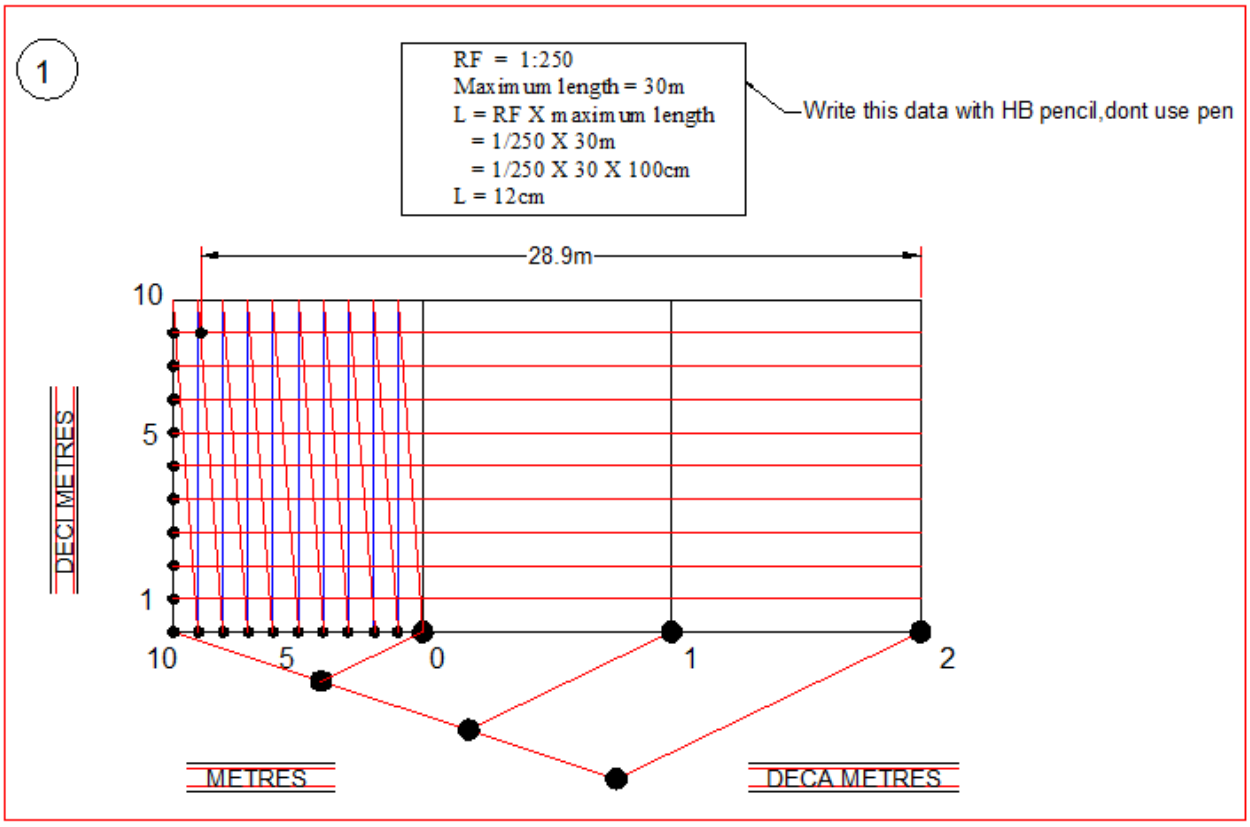
Note: Based on the maximum length, divide the scale in to required no. of parts

Step4: Length of the scale?

L = RF X maximum length

L = 1/250 X 30m

L = 1/250 X 30X 100cm
L = 12cm



Note: In the above problem don't draw blue lines while drawing. They are mentioned for understanding purpose.

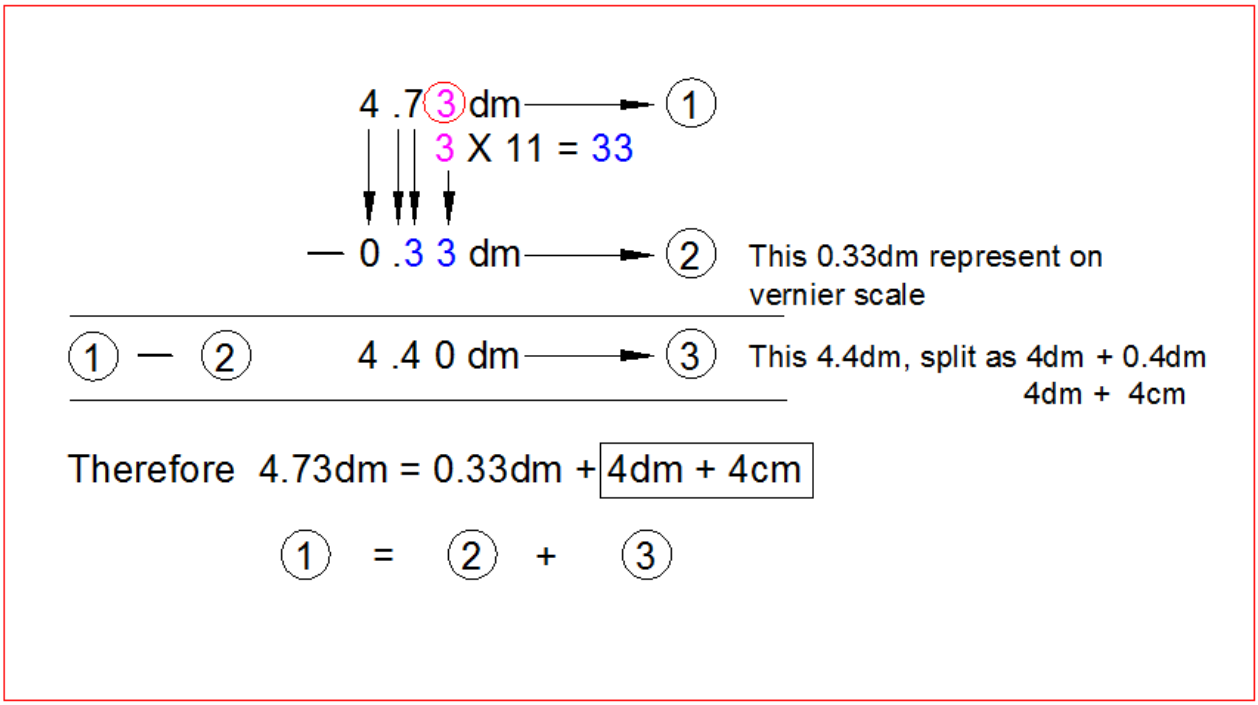
Vernier scale

1. Draw a vernier scale of RF = $\frac{1}{5}$ to read decimeters, centimeters & millimeters and to measure up to 6 decimeters. Show the lengths of 4.73dm, 2.99dm on it.

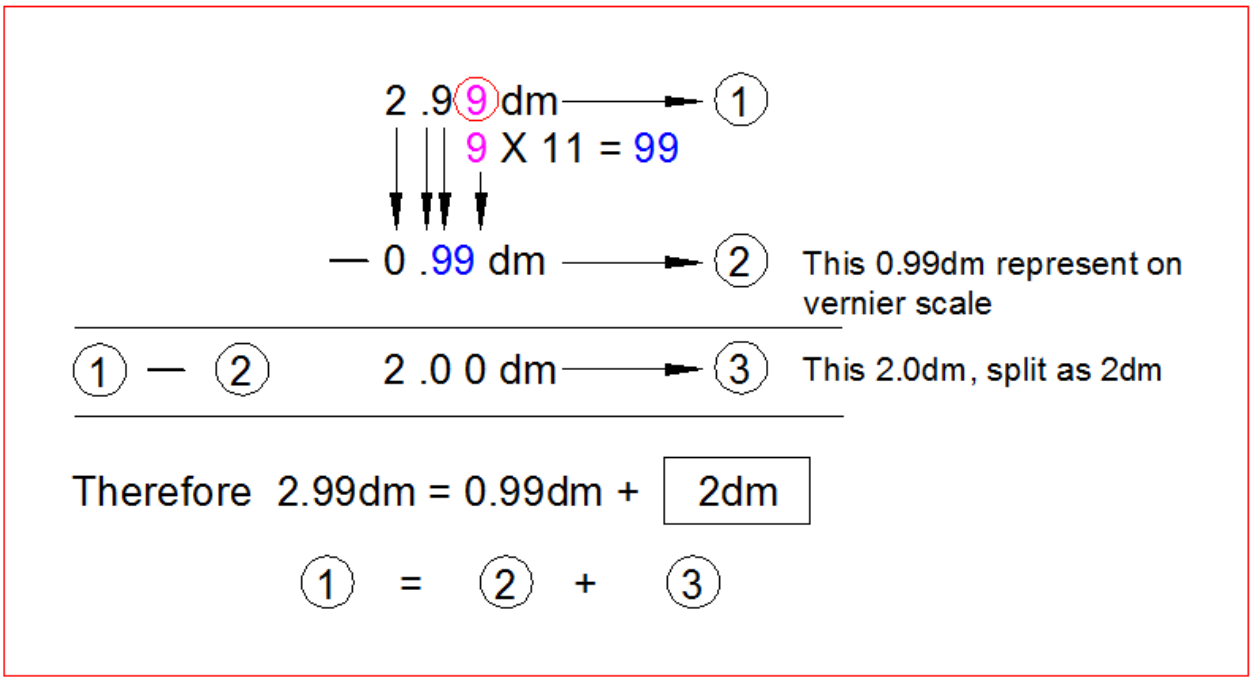
Solution:

Step1: Which scale?

It is a Vernier scale, mentioned in the problem.
In the vernier scale how to divide the 'indicate a value' is important.
To divide the 4.73dm, see the explanation below



The 'mark the value' is given 4.73m. It is three measurements i.e. meters, deci meter and centi meters. So it is a Vernier scale.
Note: 0.33 dm = 3.3 cm



Note: 0.99 dm = 9.9 cm

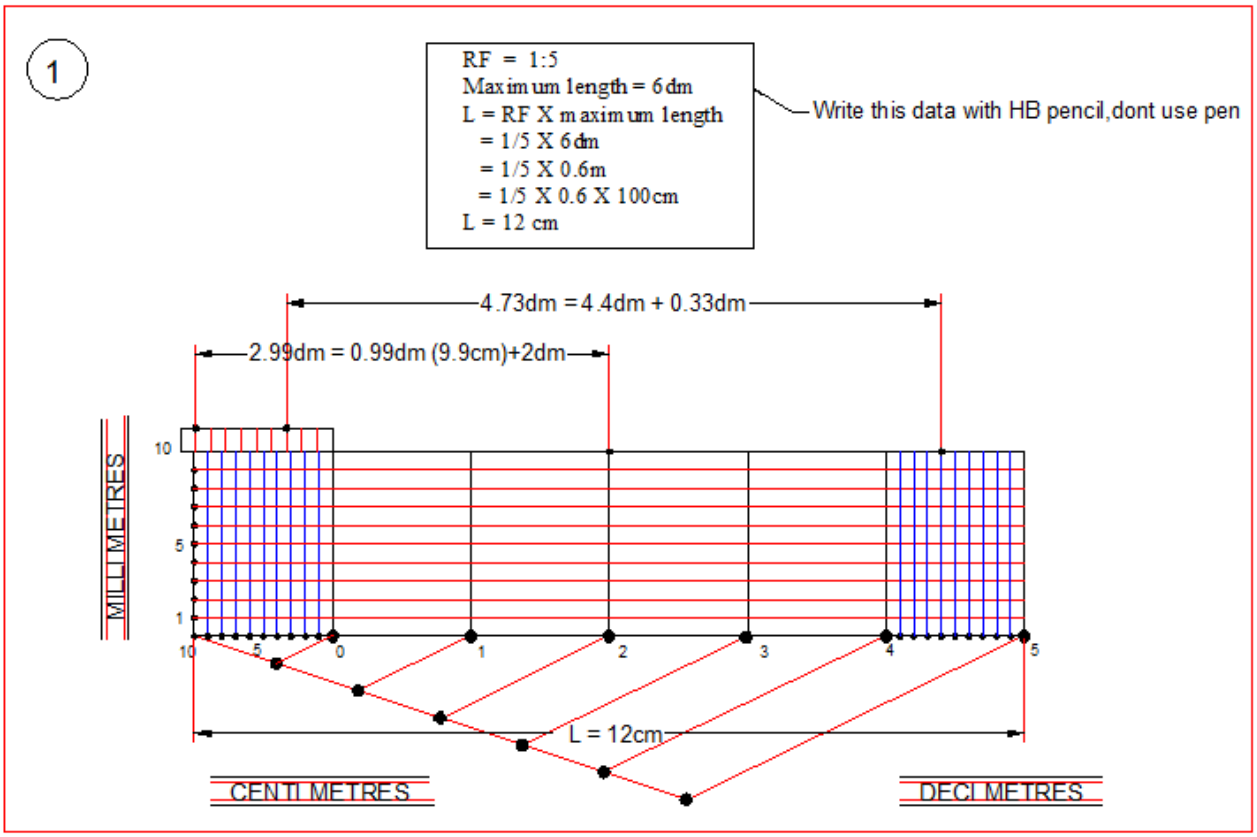
Step2: RF?
RF given directly in the problem is 1:5

Step3: Maximum Length?
Given in the problem is 6dm.

Note: Based on the maximum length, divide the scale in to required no. of parts. i.e. 6 parts

Step4: Length of the scale?

L = RF X maximum length
L = 1/5 X 6dm
L = 1/5 X 0.6m
L = 1/5 X 0.6X 100cm
L = 12cm



Note: Usually take vernier scale height as 1 cm.