

## Teaching Questions

(Fill in the blanks, circle the correct term within the brackets, and answer the questions)

A) All **physical quantities** (like height, weight, volume and etc.) **consist of a numerical magnitude and a unit**

A.1) the **height** of a boy is **1.62 metres**

The **height** would be the \_\_\_\_\_

"**1.62**" would be the \_\_\_\_\_

"**metres**" would be the \_\_\_\_\_

A.2) The colour of the car is RED:

The colour ( **is / is not** ) a physical quantity, because RED ( **is / is not** ) a numerical magnitude and there should ( **be / not be** ) a unit.

B) There are two types of physical quantities namely the **Base Quantities** and the **Derived Quantities**.

B.1) The **base quantities** and their respective units are

| <b><u>Base Quantity</u></b> | <b><u>Name of S.I. unit</u></b> | <b><u>Symbol</u></b> |
|-----------------------------|---------------------------------|----------------------|
| <b>Mass</b>                 | Kilogram                        | kg                   |
| <b>Length</b>               | Metre                           |                      |
|                             | Second                          | s                    |
| <b>Temperature</b>          |                                 | °K                   |
|                             | Ampere                          | A                    |
| <b>Amount of Substance</b>  | Molar mass                      | Mole                 |

B.2) Derived (non-base) Quantities are derived from base quantities.

Some examples of derived quantities are:

| <b><u>Derived Quantity</u></b> | <b><u>Name of S.I. unit</u></b> | <b><u>Symbol</u></b> |
|--------------------------------|---------------------------------|----------------------|
| <b>Area</b>                    | <b>Square metre</b>             | m <sup>2</sup>       |
| <b>Volume</b>                  |                                 | m <sup>3</sup>       |
|                                | <b>Metre per second</b>         | m/s                  |
| <b>Density</b>                 | <b>Kilogram per metre cube</b>  |                      |
| <b>Energy</b>                  | <b>Joules</b>                   |                      |
| <b>Force</b>                   | <b>Newton</b>                   |                      |
| <b>Voltage</b>                 |                                 | V                    |
| <i>And many more...</i>        | ....                            | ...                  |

B.3) Identify the base quantities from the following list of physical quantities and state their corresponding units:

Mass, Temperature, Force, Volume, length, Voltage, Time, Area, Colour, Heat, Energy, current, amount of substance, Density, Weight, speed.

B.4) Is the size (small, medium or large) of a milk shake a physical quantity? Why?

## C) Prefixes are symbols to indicate decimal and multiples of S.I. units

## C.1) (fill in the blanks)

| Prefix | Symbol               | Conversion                                                                                | Scale and order of                                                                                                          |
|--------|----------------------|-------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| nano   | <b>n</b> = $10^{-9}$ | $1\text{nm} = 1 \times 10^{-9} \text{ m}$<br>$1\text{m} = 1 \times 10^9 \text{ nm}$       | (virus, molecule, atom)<br>The diameter of an atom is about 0.1 ____ m                                                      |
| micro  | <b>μ</b> = $10^{-6}$ | $1\mu\text{m} = 1 \times 10^{-6} \text{ m}$<br>$1\text{m} = \text{_____} \mu\text{m}$     | (hair, bacteria, wave length of micro-waves)<br>The thickness of a hair is about 150 ____ m                                 |
| milli  | <b>m</b> = $10^{-3}$ | $1\text{mm} = 1 \times 10^{-3} \text{ m}$<br>$1\text{m} = 1 \times 10^3 \text{ mm}$       | (termites, pencil lead)                                                                                                     |
| centi  | <b>c</b> = $10^{-2}$ | $1\text{cm} = \text{_____} \text{ m}$<br>$1\text{m} = 1 \times 10^2 \text{ cm}$           | (Coin, size of paper)                                                                                                       |
| deci   | <b>d</b> = $10^{-1}$ | $1\text{dm} = 1 \times 10^{-1} \text{ m}$<br>$1\text{m} = \text{_____} \text{ dm}$        | (bottle container)<br>$1 \text{ litre} = 1 \text{ dm}^3 = 1 \times (\text{_____} \text{ cm})^3 = \text{_____} \text{ cm}^3$ |
| Kilo   | <b>K</b> = $10^3$    | $1 \text{ ____ m} = 1 \times 10^3 \text{ m}$<br>$1\text{m} = 1 \times 10^{-3} \text{ km}$ | (distance between towns and cities)                                                                                         |
| Mega   | <b>M</b> = $10^6$    | $1\text{Mm} = 1 \times 10^6 \text{ m}$<br>$1\text{m} = 1 \times 10^{-6} \text{ ____ m}$   | (diameter of earth, speed of PC in Hz)<br>The radius of earth is about 6.38 ____ m                                          |
| Giga   | <b>G</b> = $10^9$    | $1 \text{ ____ m} = 1 \times 10^9 \text{ m}$<br>$1\text{m} = \text{_____} \text{ Gm}$     | (distance between earth and moon)<br>The sun is 149 ____ m away from earth                                                  |

## C.2) Unit Conversion

Example) a) 1234 **M** byte =? **G** byte

$$\begin{aligned}
 1234 \text{ M byte} &= 1234 \times 1 \times 10^6 \text{ byte} \\
 &= 1.234 \times 10^9 \text{ byte} \\
 &= 1.234 \text{ ____ byte}
 \end{aligned}$$

b) 7.6 **g/cm<sup>3</sup>** =? **kg/m<sup>3</sup>**

$$\begin{aligned}
 7.6 \text{ g/cm}^3 &= 7.6 \times \frac{1 \text{ g}}{(1 \text{ cm})^3} \\
 &= 7.6 \times \frac{1}{\left(\frac{1}{100} \text{ m}\right)^3} \text{ kg} \\
 &= 7.6 \times 1000 \text{ Kg/m}^3 \\
 &= 7,600 \text{ kg/m}^3 \\
 &= 7.6 \times \text{_____} \text{ kg/m}^3
 \end{aligned}$$

## C.3) Unit Conversion II

|                                                  |                                                             |
|--------------------------------------------------|-------------------------------------------------------------|
| a) 40 cm = _____ km                              | l) 40 Mg = _____ kg                                         |
| b) 200 m <sup>3</sup> = _____ cm <sup>3</sup>    | m) 0.05 Km <sup>2</sup> = _____ m <sup>2</sup>              |
| c) 200 days = _____ hrs                          | n) 3200 s = _____ hrs                                       |
| d) 0.002km <sup>2</sup> = _____ cm <sup>2</sup>  | o) 40 l = 40 x (1 dm <sup>3</sup> ) = _____ cm <sup>3</sup> |
| e) 4 tons = 4 x 1000 Kg = _____ g                | p) 400 cm = _____ km                                        |
| f) 420 K = 420 - (273) = _____ °C                | q) 200 Kg = _____ tons                                      |
| g) 90 km/h = _____ m/s                           | r) 430 cm <sup>2</sup> = _____ mm <sup>2</sup>              |
| h) 40 °C = _____ °K                              | s) 40 Gs = _____ days                                       |
| i) 20 m/s = _____ km/h                           | t) 20,000 ns = _____ ms                                     |
| j) 1000 mm <sup>3</sup> = _____ km <sup>3</sup>  | u) -200 °C = _____ °K                                       |
| k) 4 g/cm <sup>3</sup> = _____ Kg/m <sup>3</sup> | v) 140 km = _____ Gm                                        |

D) The orders of magnitude of the sizes of common objects ranging from a typical atom to the Earth:

- D.1) i) The \_\_\_\_\_ of an atom is about 0.1 nm  
 ii) The thickness of a \_\_\_\_\_ is about 150  $\mu\text{m}$   
 iii) The diameter of earth is about  $2 \times 6.38$  \_\_\_\_\_ m  
 iv) The sun is 149 Gm away from \_\_\_\_\_

E) State what is meant by scalar and vector quantities and give common examples of each:

E.1) **Scalar** quantities are quantities that **have size but no direction** whereas **Vector** quantities are quantities that **have both size and direction**.

- i) Mass is a physical quantity that has a size but no \_\_\_\_\_, and therefore it is a scalar. On the other hand, weight is a physical quantity that has both size and direction (downward) and hence it is a \_\_\_\_\_.
- ii) Please determine if each of the following quantities is vector or scalar.

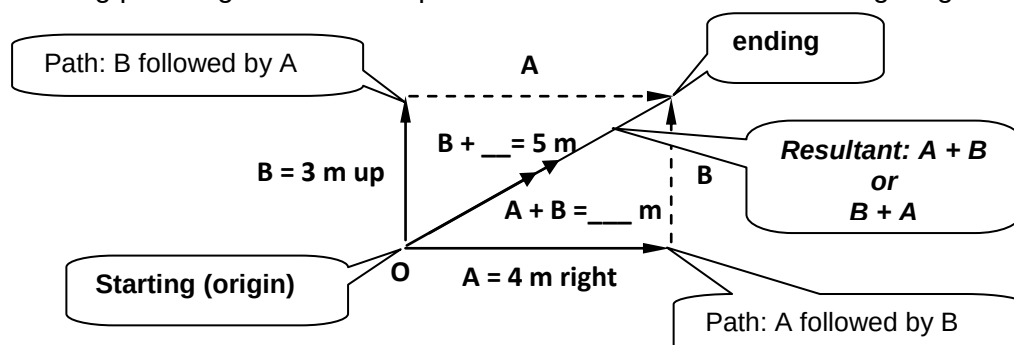
|                    |               |
|--------------------|---------------|
| Mass               | <b>Scalar</b> |
| Weight             | <b>Vector</b> |
| Distance           |               |
| Velocity           |               |
| Displacement       |               |
| Speed              |               |
| Acceleration       |               |
| Force (All kinds)  |               |
| Energy (All kinds) |               |
| Time               |               |
| Gravity            |               |

E.2) Is colour a vector or a scalar? Explain your answer.

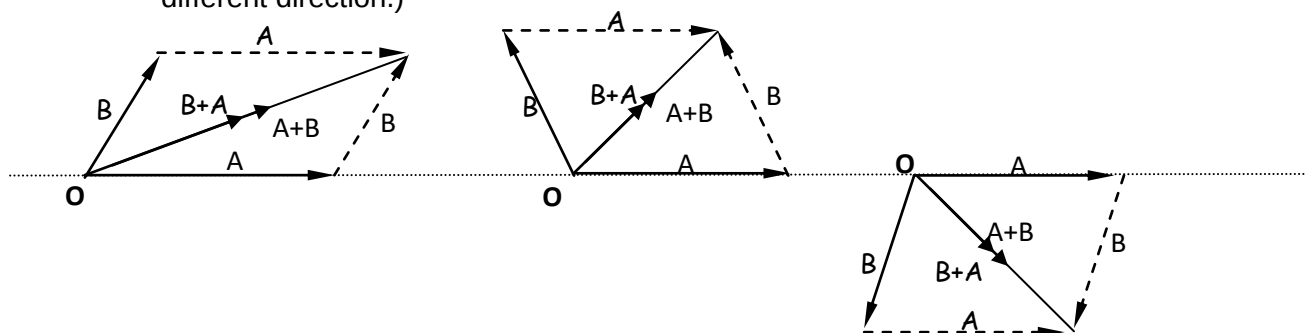
## F) Adding two scalars versus adding two vectors:

F.1) **The sum of two scalar quantities ( $A + B$  or  $B + A$ ) can be found by just adding the two quantities** without considering their directions. Hence the sum of two distances travelled by a person when he walks 3 metres in one direction (A) and another 4 metres in any direction (B) is always \_\_\_\_\_ metres (i.e.  $A + B$  or  $B + A$ )

F.2) **The sum of two vector quantities ( $A + B$  or  $B + A$ ) is found by drawing a scaled diagram** that represents the result of the two possible paths taken (i.e. A followed B or B followed A.) If A represents a displacement of 3 metres to the right and B represents another displacement of 4 metres upwards, then the vector sum of  $A + B = B + A$  (or the resultant vector) is measured from the starting point to the ending point regardless of the path taken as shown in the following diagram.

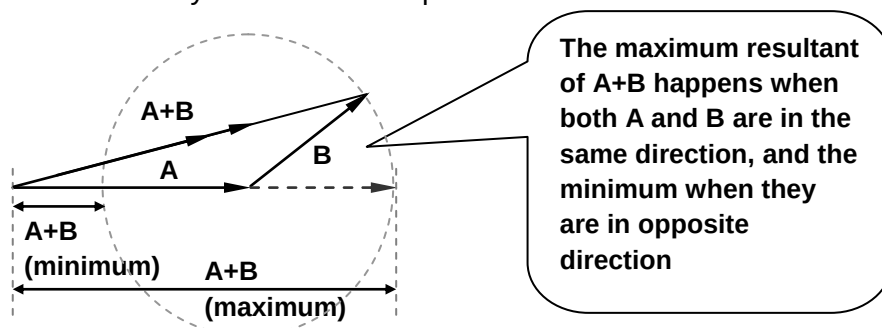


The following diagrams show three other possible examples of the resultant (or the vector sum  $A + B$ ) when a fixed vector A is followed by a vector B (that has a different direction.)



(note that the Vector sum or the resultant  $= A + B = B + A$ )

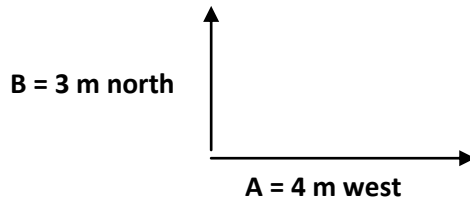
The following diagram shows the locus of all possibilities of the resultant ( $A+B$ ) of a fixed vector A followed by a vector B in all possible directions.



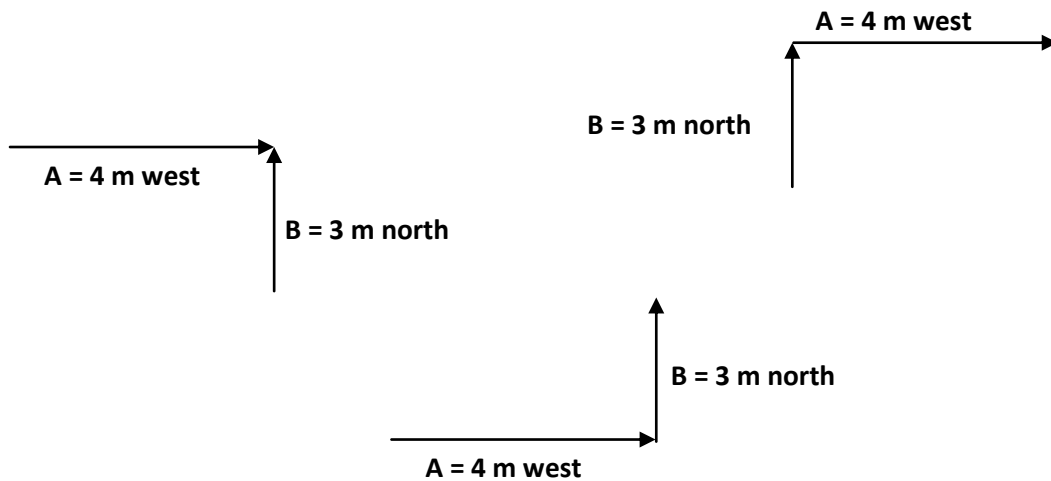
So if the size of vector A is 4 and the size of vector B is 3, then the maximum size of the resultant  $A+B$  would be \_\_\_\_\_ and the minimum size of the resultant  $A+B$  would be \_\_\_\_\_ in the direction of A.

F.3) The sum of two displacements (or the vector sum  $\mathbf{A} + \mathbf{B}$  or the resultant) travelled by a person when he walks 3 metres north and 4 metres west is \_\_\_\_\_ metres in the direction shown in the following vector diagram.

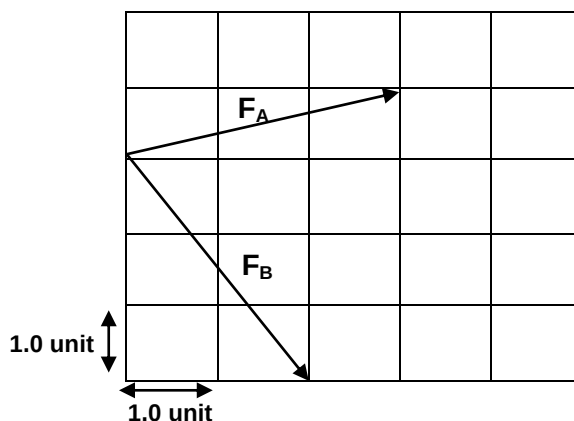
Complete the following vector diagrams: by showing the resultant  $\mathbf{A} + \mathbf{B}$



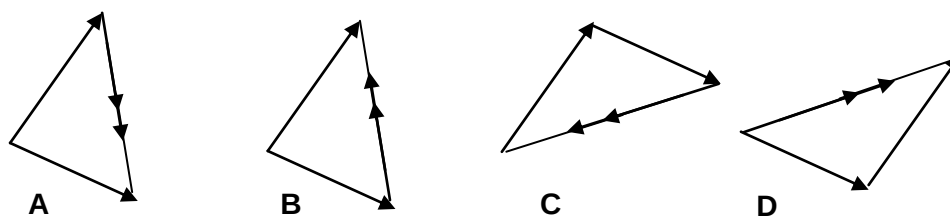
The following are equivalent to the vector diagram above. Complete the following by showing the resultant  $\mathbf{A} + \mathbf{B}$  or  $\mathbf{B} + \mathbf{A}$ :



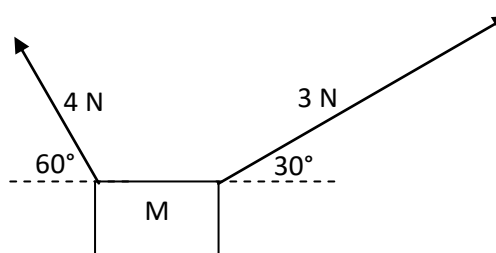
F.Q.4) Find the resultant of the following two forces acting on a body by drawing the resultant vector on the following scaled diagram:



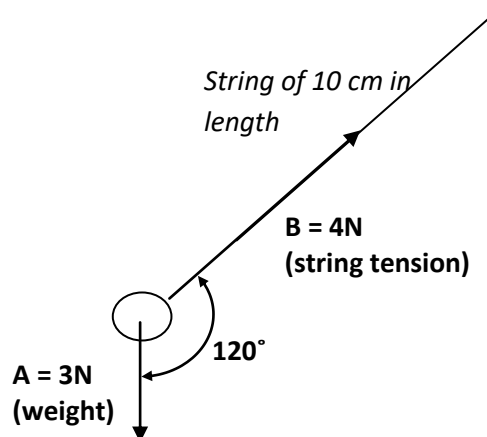
F.Q.5) Which of the following shows a proper vector diagram of two forces and the resultant (summation of two vectors)?



F.Q.6) Find the resultant force produced by the tension forces of the following two cables on the object M:



F.Q.7) Find the resultant of following two forces acting on the following swinging object in this particular instant by drawing a vector diagram to scale.. (hint: the length of the string does not affect the tension; the resultant should act in a direction that is somewhere between the two forces)

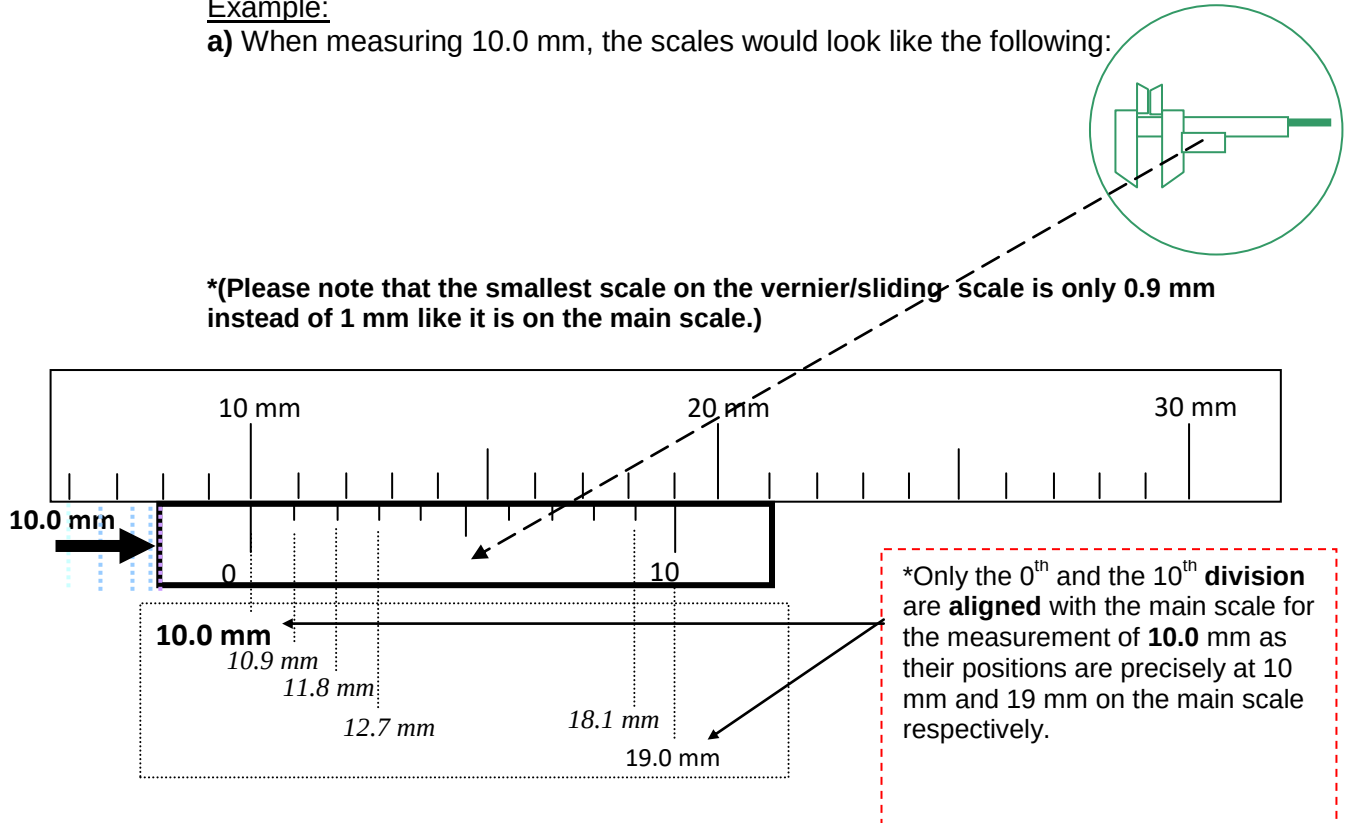


- G) Describe how to measure a variety of lengths with appropriate accuracy by means of tapes, rules, micrometers and callipers, using a vernier scale as necessary.

G.1) The vernier calliper has a precision of 0.1 mm and is appropriate to measure length between 1 cm and 10 cm. Hence one can use the vernier calliper to measure 10.3 mm as it is between \_\_\_\_\_ cm and \_\_\_\_\_ cm

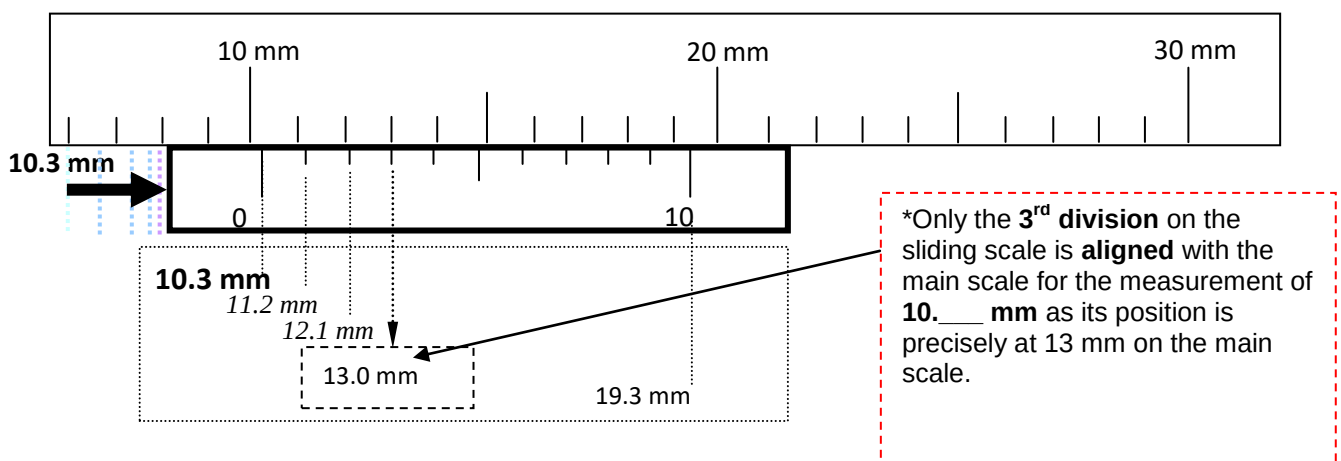
Example:

a) When measuring 10.0 mm, the scales would look like the following:



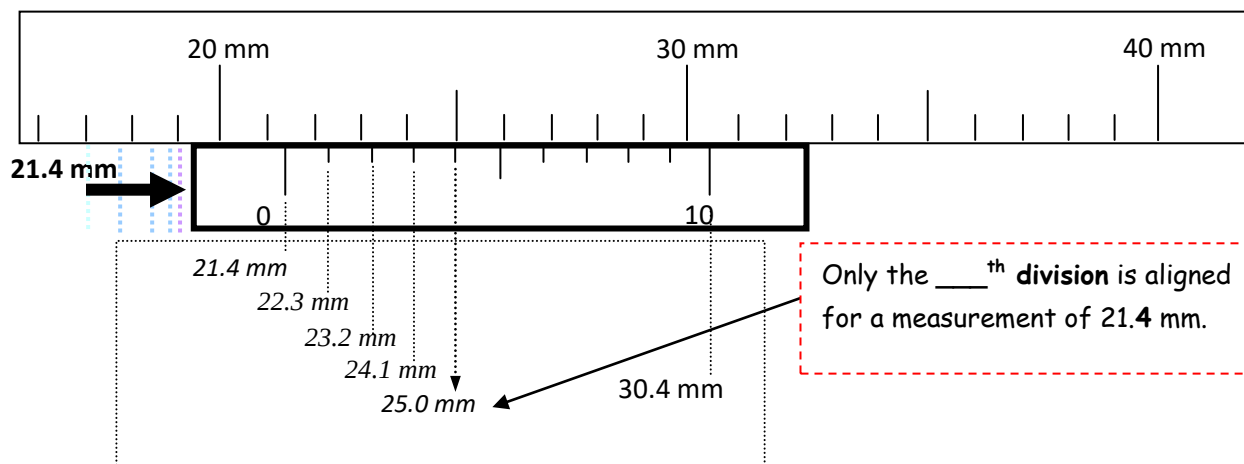
(The 1<sup>st</sup> to the 9<sup>th</sup> division on the sliding scale are not aligned with any of the divisions of the main scale because they have a decimal value associated with their positions)

b) When measuring 10.3 mm, the scales would look like the following:



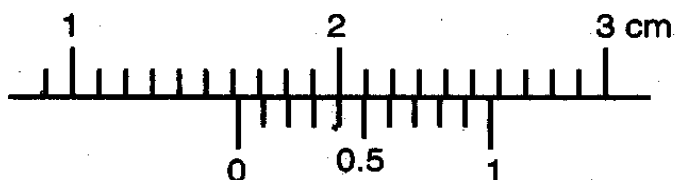
(Other divisions on the sliding scale are not aligned with any of the divisions on the main scale because they have a decimal value associated with their positions)

c) If you were **measuring 21.4 mm**, the scales would look like:



G.2) Please read the following measurements:

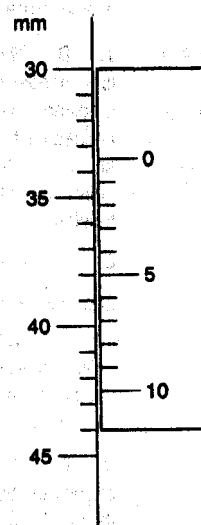
a) The diagram shows the scale of a vernier calliper.



The measurement of the calliper is \_\_\_\_\_ cm If there is no zero error on this vernier calliper.

b) The diagram shows the scale of a vernier calliper.

The measurement of the calliper is \_\_\_\_\_ mm if there is no zero error on this vernier calliper.

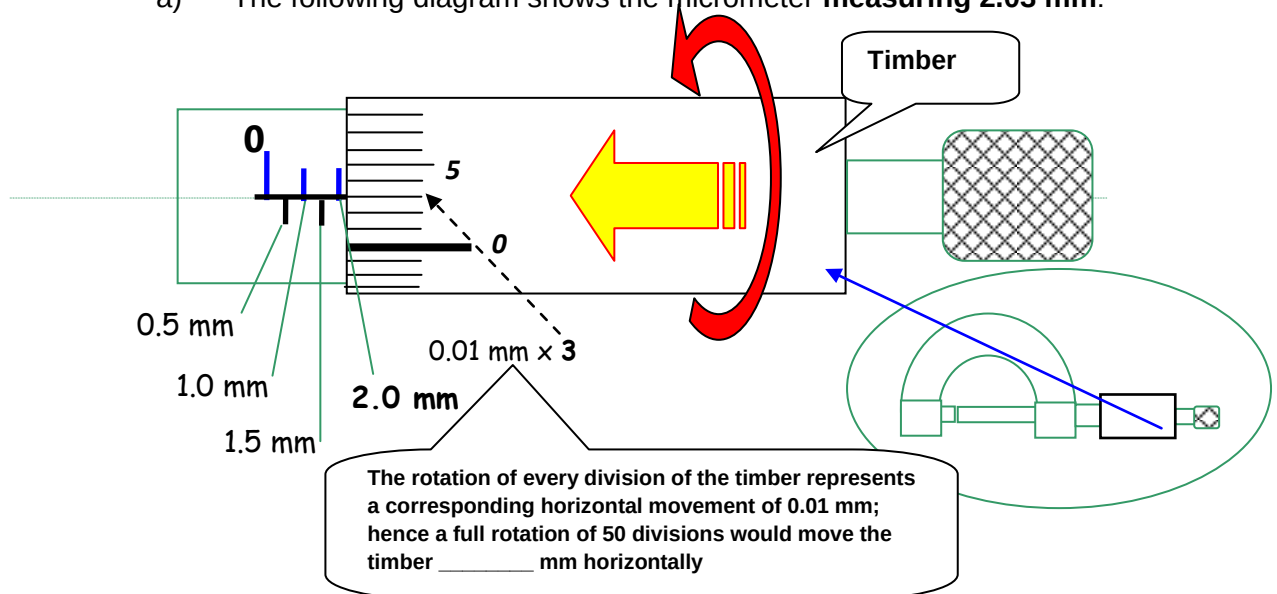




- G.3) The micrometer has a precision of 0.01 mm and is appropriate to measure length smaller than 5 cm. Hence one can use the micrometer to measure the thickness of a coin as it is smaller than \_\_\_\_\_ mm

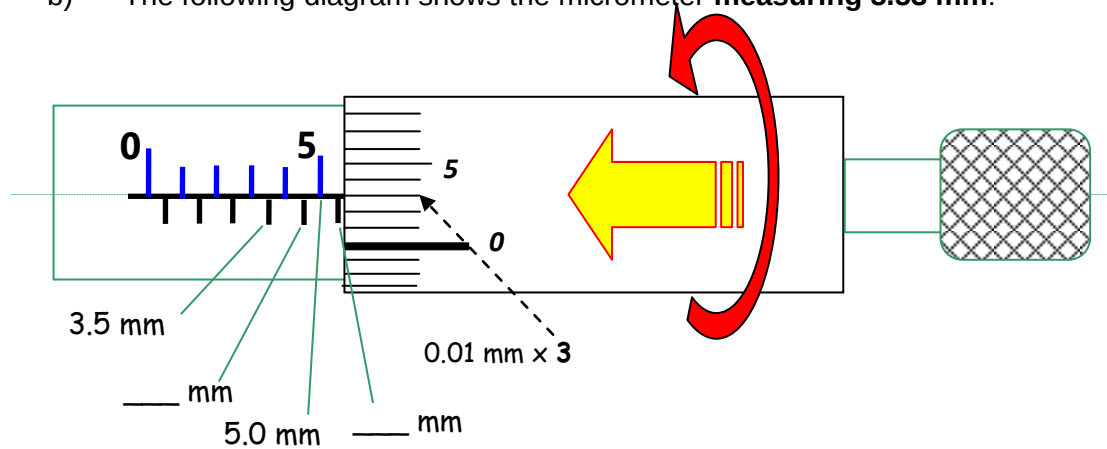
Example:

- a) The following diagram shows the micrometer **measuring 2.03 mm**:

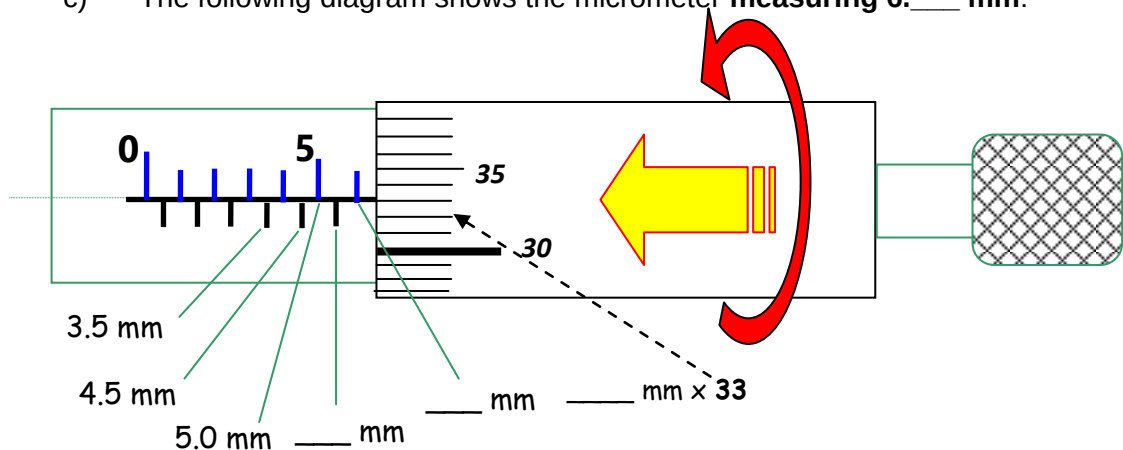


$$\text{Measurement} = 2.0 \text{ mm} + 0.01 \text{ mm} \times 3 = 2.03 \text{ mm}$$

- b) The following diagram shows the micrometer **measuring 5.53 mm**:

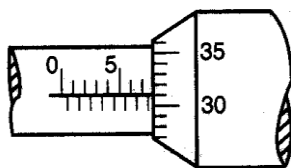


- c) The following diagram shows the micrometer **measuring 6.\_\_\_\_ mm**:



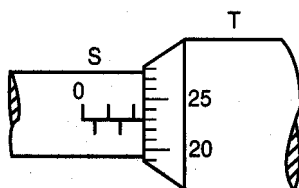
G.4) Please read the following measurements:

- a). A student used a micrometer screw gauge to measure the thickness of a metal sheet. The diagram below shows part of the micrometer. What is the thickness of the metal sheet?



\_\_\_\_\_ mm

- b) The diagram shows the barrel (S) and the rotating thimble (T) of a micrometer screw gauge.

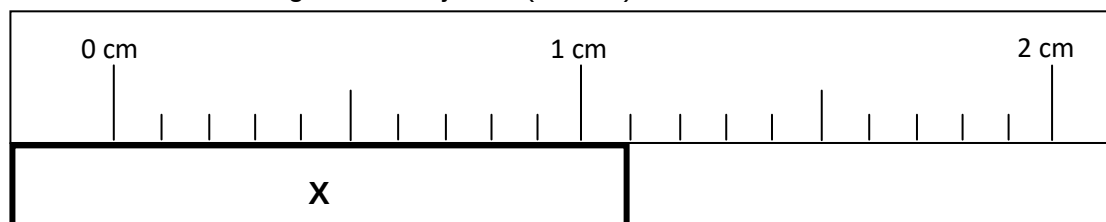


The divisions shown above the horizontal line on the barrel are millimetres and those below the line on the barrel are the half-millimetres. There are 50 divisions around the rim of the thimble of which some are shown. The correct reading of the instrument, as shown is

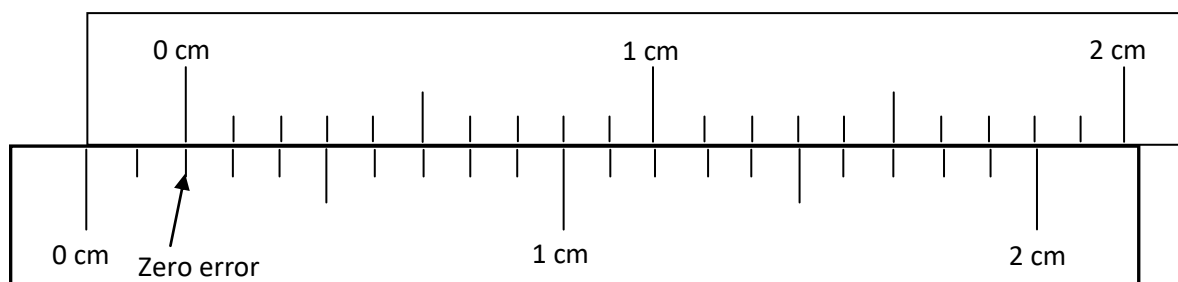
\_\_\_\_\_ mm

G.5) Compensating the Zero errors:

- a) There would be a zero error associated with the measurement taken by the rule if the length of an object X (11 mm) is measured as follows:

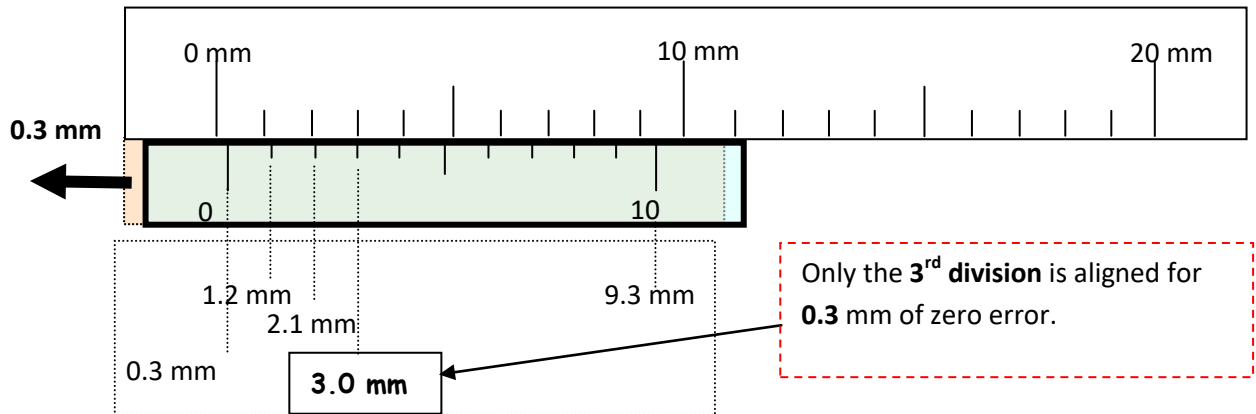


The zero error (of 2mm) can be determined by the measurement below:



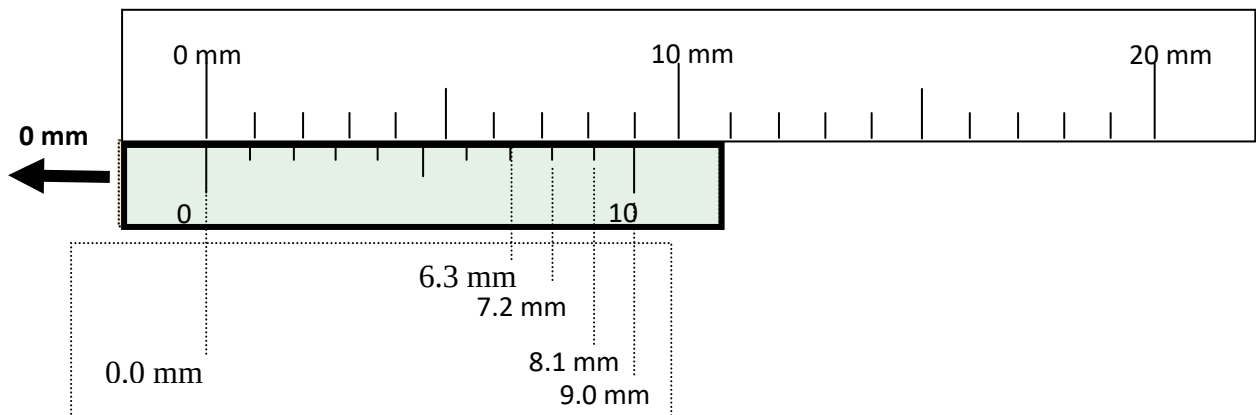
The actual measurement of the length of object X is therefore \_\_\_\_\_ mm instead of 11 mm after subtracting the negative zero error of 2 mm.

- b) The following shows a caliper with a **positive zero error of 0.3 mm** when it is fully closed:



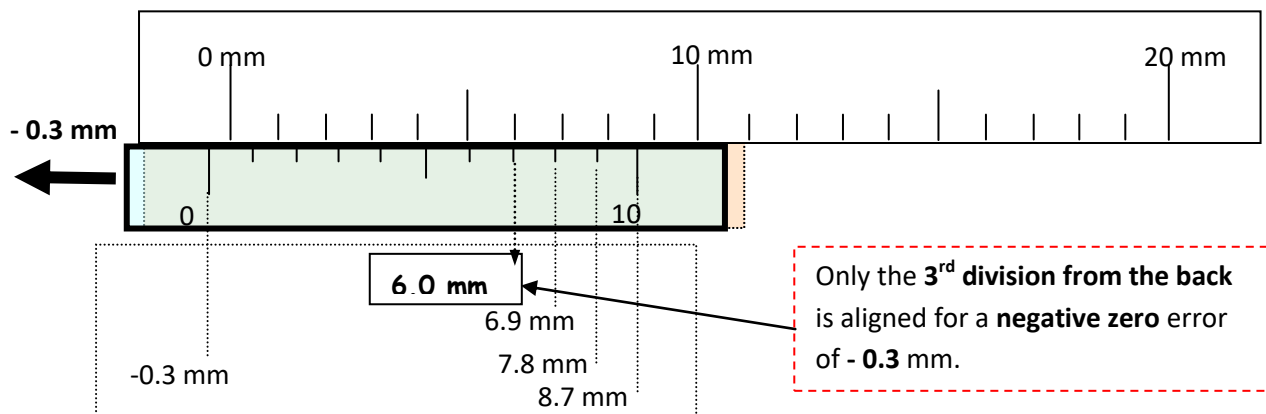
The measurement taken using this caliper would always be in excess \_\_\_\_\_ mm. Subtracting 0.3 mm to the measurement taken would compensate for the \_\_\_\_\_ zero error

The following shows a caliper with **no zero error** when it is fully closed:



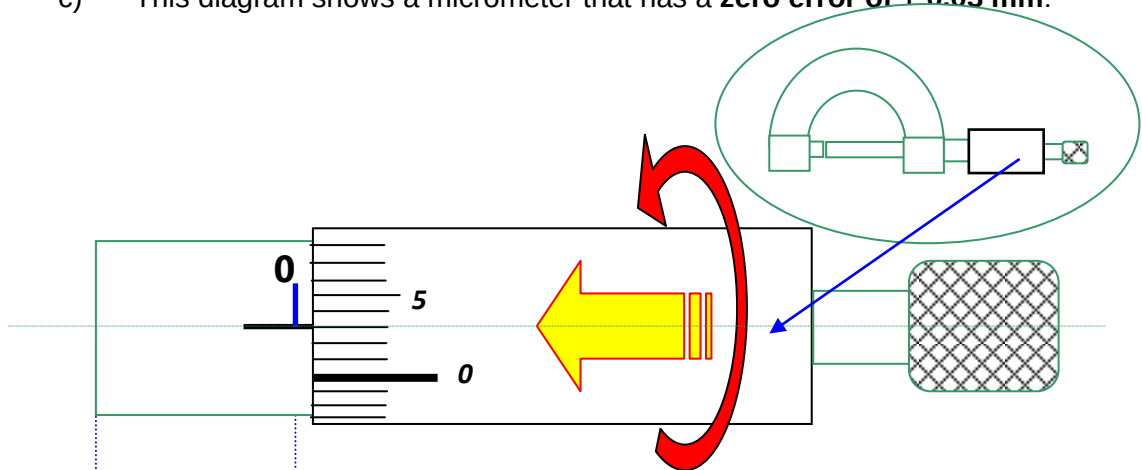
**No adjustment needed** for the measurement taken using this caliper

The following shows a caliper with a **zero error of - 0.3 mm**:



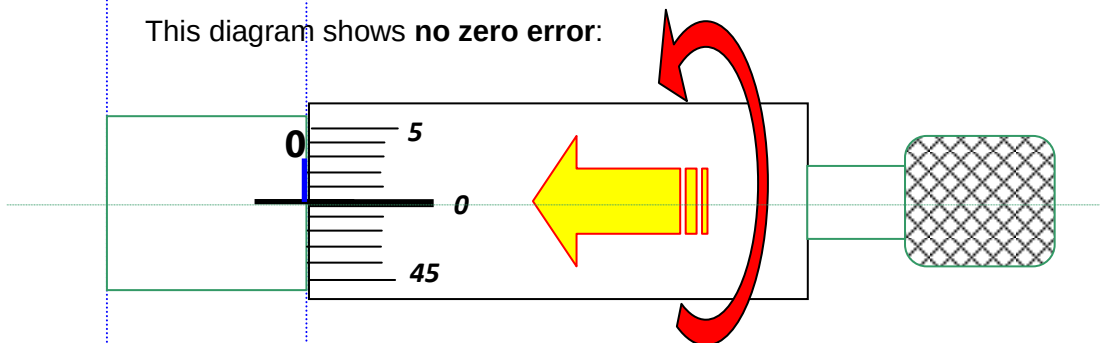
Adding \_\_\_\_\_ mm (or subtracting - 0.\_\_\_\_ mm) to the measurement taken would compensate for the \_\_\_\_\_ zero error

- c) This diagram shows a micrometer that has a **zero error of + 0.03 mm**:



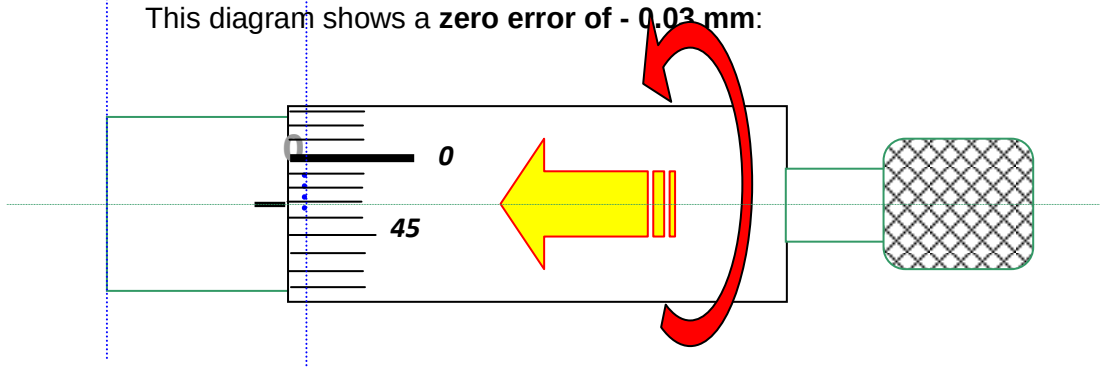
(Subtracting 0.03 mm to the measurement compensates the +zero error)

This diagram shows **no zero error**:



(No adjustment needed for the measurement taken)

This diagram shows a **zero error of - 0.03 mm**:



(Adding 0.03 mm or Subtracting - 0.03 mm to the measurement would compensate for the zero error)

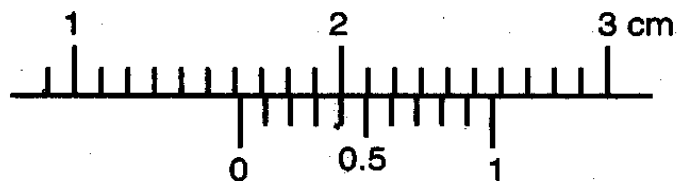
Example: Instrument Measures = 5.23mm  
 Zero Error of the instrument = -0.03 mm  
 Actual Measurement = 5.23 - (- 0.03) = 5.26 mm

### Conclusion

**Actual Measurement = Instrument Reading - positive or negative Zero Error**

G.6) Please read the following measurements:

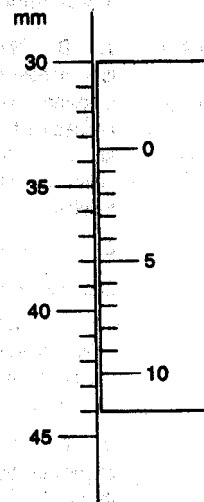
- a) The diagram shows the scale of a vernier calliper.



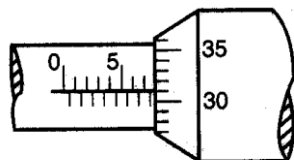
The measurement of the calliper is \_\_\_\_\_ cm If there is a zero error of +0.2 mm on this vernier calliper.

- b) The diagram on the right shows the scale of a vernier calliper.

The measurement of the calliper is \_\_\_\_\_ mm if there is a negative zero error of  $-0.1$  mm on this vernier calliper.

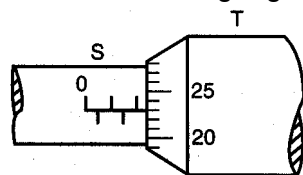


- c). A student used a micrometer screw gauge to measure the thickness of a metal sheet. The diagram below shows part of the micrometer. What is the thickness of the metal sheet if there is a positive zero error of  $0.02$  mm?



\_\_\_\_\_ mm

- d) The diagram shows the barrel (S) and the rotating thimble (T) of a micrometer screw gauge.



The divisions shown above the horizontal line on the barrel are millimetres and those below the line on the barrel are the half-millimetres. There are 50 divisions around the rim of the thimble of which some are shown. There is a negative zero error of  $0.01$  mm. The correct reading of the instrument, as shown is

\_\_\_\_\_ mm

**Why and How to deal with Significant Figures (S.F.) and Decimal Places (D.P.)**

The reason we need to determine the correct number of S.F. or D.P for a calculated number is because the calculated number may have been obtained from a combination of measurements that have different degree of precisions.

For example, the volume of a rectangular container of which the length, width, and height are all measured using different instruments and hence could have different precisions.

$$\begin{aligned}\text{Volume} &= \text{Length} \times \text{Width} \times \text{Height} \\ &= 8.1 \text{ cm} \times 15.7 \text{ mm} \times 15 \text{ mm}\end{aligned}$$

**The precision of the volume can only be as good as the precision of the least precise number used in obtaining the answer.** Therefore we should use the \_\_\_\_\_ significant figure (of the product or division) as the S.F. needed for the answer.

$$\begin{aligned}\text{Volume} &= 8.1 \text{ cm} \times 1.57 \text{ cm} \times 1.5 \text{ cm} && (2 \text{ s.f. is the least}) \\ &= 19.0755 && (\text{cut off at 3 s.f and round off to 2 s.f.}) \\ &= 19 \text{ cm}^3 && (2 \text{ s.f.})\end{aligned}$$

For example, the total length of two smaller lengths that having different number of decimal places:

$$\begin{aligned}\text{Total length} &= \text{Length 1} + \text{Length 2} \\ &= 18.7259 \text{ cm} + 6.2 \text{ cm}\end{aligned}$$

**The precision of the total length (or the sum of two lengths) would depend on the precision of the less precise of the two lengths.** We should use the \_\_\_\_\_ decimal place(s) of the addition or subtraction to determine the number of decimal place(s) needed for the answer.

$$\begin{aligned}\text{Total length} &= 18.7259 \text{ cm} + 6.2 \text{ cm} && (1 \text{ d.p is the least}) \\ &= 24.9259 && (\text{cut off at 2 d.p and round off to 1 d.p.}) \\ &= 24.9 \text{ cm} && (1 \text{ d.p.})\end{aligned}$$

**In short:**

Use **least decimal place (LDP)** for \_\_\_\_\_ and **subtraction** of measured quantities.  
(e.g.  $12.452 \text{ m} - 10.4 \text{ m} = 2.05 \text{ m} \rightarrow \underline{1dp}$ )

Use **least significant figure (LSF)** for \_\_\_\_\_ and **division** of measured quantities  
(e.g.  $4.5 \text{ m} \times 12.325 \text{ m} = 55.4xx \text{ m}^2 \rightarrow \underline{2sf}$ )

It is important to differentiate between a measurement (that has uncertainty) and a non-measurement (that has no uncertainty) because a non-measurement would usually be precise and has \_\_\_\_\_ uncertainty.

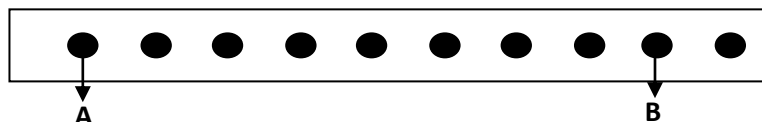
For example, the conversion factor of 10 that is used to convert 2.65 cm to 26.5 mm is not a measurement and should not be the least S.F. in the following calculation because it is not the least precise number in the calculation.

$$\begin{aligned}2.65 \text{ cm} &= 2.65 \times 10 && (3 \text{ s.f. is the least because "10" is not a measurement}) \\ &= 26.5 \text{ mm} && (3 \text{ s.f.})\end{aligned}$$

- H) Describe how to measure a short interval of time including the period of a simple pendulum with appropriate accuracy using stopwatches or appropriate instruments.

- H.1) A Ticker Tape timer creates dots at regular intervals (50 to 60 dots per second) on a strip of paper

Given that the dots are created at 50 dots per second, determine the time taken from A to B



The time interval between the dots would be \_\_\_\_\_ s.

There are altogether \_\_\_\_\_ time intervals between A and B.

Time taken = time interval x number of intervals between A and B = \_\_\_\_\_ s

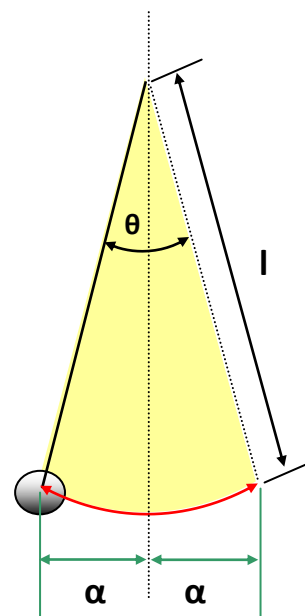
- H.2) **Time can also be measured in terms of the constant interval of the periodic oscillation provided by a swinging mass on a string kept in motion by gravity** (Like the grandfather clock.)

The square of the Period ***T*** (time of each oscillation) is directly proportional to **the length *l* of the string** and inversely proportional to **gravity *g***

$$T = 2\pi \sqrt{\frac{l}{g}}$$

Not required by the syllabus

This can be verified via experiments and mathematics. Note that the **period does not depend on the mass, volume, or angle  $\theta$**  of the swinging object.



- Given  $T$  is the period of a pendulum on earth as shown in the formula above, Show that the period of the same pendulum  $T_2$  on the moon is:  $T \times \sqrt{6}$  knowing that the gravity of moon is  $1/6^{\text{th}}$  that on earth.
- What is the new period ( $T_2$ ) if the length and mass of the pendulum is doubled? (Answer in terms of  $T$ )
- What is the period ( $T_2$ ) if a)  $\theta$  (angle of swing) is doubled? (Answer in terms of  $T$ )
- What is the period ( $T_2$ ) if  $\alpha$  (amplitude of oscillation) is halved? (Answer in terms of  $T$ )

**Answer Key**

- A) All **physical quantities** (like height, weight, volume and etc.) **consist of a numerical magnitude and a unit**

(fill in the blanks and circle the correct term within the brackets)

- A.1) the **height** of a boy is **1.62 metres**

The **height** would be the physical quantity

"**1.62**" would be the numerical magnitude

"**metres**" would be the unit

- A.2) The colour of the car is RED :

The colour (~~is~~ / **is not**) a physical quantity because RED (**is** / ~~is not~~) a numerical magnitude and there should (~~be~~ / **not be**) a unit.

- B) There are two types of physical quantities namely the **Base Quantities** and the **Derived Quantities**.

- B.1) The **base quantities** and their respective units are

| Base Quantity              | Name of S.I unit | Symbol      |
|----------------------------|------------------|-------------|
| <u>Mass</u>                | Kilogram         | kg          |
| <u>Length</u>              | Metre            | <u>m</u>    |
| <u>Time</u>                | Second           | s           |
| <u>Temperature</u>         | <u>Kelvin</u>    | °K          |
| <u>Current</u>             | Ampere           | A           |
| <u>Amount of Substance</u> | Molar mass       | <u>Mole</u> |

- B.2) Derived (non-base) Quantities are derived from base quantities.

Some examples of derived quantities are:

| Derived Quantity    | Name of S.I. unit              | Symbol                      |
|---------------------|--------------------------------|-----------------------------|
| <b>Area</b>         | <b>Square metre</b>            | <u><math>m^2</math></u>     |
| <b>Volume</b>       | <u><b>Cubic metre</b></u>      | $m^3$                       |
| <u><b>Speed</b></u> | <u>Metre per second</u>        | m/s                         |
| <b>Density</b>      | <u>Kilogram per metre cube</u> | <u><math>Kg/ m^3</math></u> |
| <b>Energy</b>       | <u>Joules</u>                  | <u>J</u>                    |
| <b>Force</b>        | <u>Newton</u>                  | <u>N</u>                    |
| <b>Voltage</b>      | <u>Volts</u>                   | V                           |
| And many more...    | ....                           | ...                         |

- B.3) Identify the base units in the following by underlying them:

Mass, Temperature, Force, Volume, length, Voltage, Time, Area, Colour, Heat, Energy, current, amount of substance, Density, Weight, speed

**Mass: kg, Temperature: degree Kelvin, Length: metre, Time: second, current: ampere, amount of substance: mole.**

- B.4) Is the size (small, medium or large) of a milk shake a physical quantity? Why?

**Size is not a physical quantity; because it does not have a numerical magnitude and a unit**



C) Prefixes are symbols to indicate decimal and multiples of S.I. units

C.1) ( Please fill in the blanks )

|       | Prefix          | Example                                                                                            |                                                                                                                                   |
|-------|-----------------|----------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| Nano  | $n = 10^{-9}$   | $1\text{nm} = 1 \times 10^{-9} \text{ m}$<br>$1\text{m} = 1 \times 10^9 \text{ nm}$                | (virus, molecule, atom)<br>The diameter of an atom is about 0.1 <u>n</u> m                                                        |
| Micro | $\mu = 10^{-6}$ | $1\mu\text{m} = 1 \times 10^{-6} \text{ m}$<br>$1\text{m} = \underline{1 \times 10^9} \mu\text{m}$ | (hair, bacteria, wave length of micro-waves)<br>The thickness of a hair is about 150 <u>μ</u> m                                   |
| Milli | $m = 10^{-3}$   | $1\text{mm} = 1 \times 10^{-3} \text{ m}$<br>$1\text{m} = 1 \times 10^3 \text{ mm}$                | (termites, pencil lead)                                                                                                           |
| Centi | $c = 10^{-2}$   | $1\text{cm} = \underline{1 \times 10^{-2}} \text{ m}$<br>$1\text{m} = 1 \times 10^2 \text{ cm}$    | (Coin, size of paper)                                                                                                             |
| Deci  | $d = 10^{-1}$   | $1\text{dm} = 1 \times 10^{-1} \text{ m}$<br>$1\text{m} = \underline{1 \times 10^1} \text{ dm}$    | (bottle container)<br>$1 \text{ litre} = 1 \text{ dm}^3 = 1 \times (\underline{10} \text{ cm})^3 = \underline{1000} \text{ cm}^3$ |
| Kilo  | $K = 10^3$      | $1 \text{ Km} = 1 \times 10^3 \text{ m}$<br>$1\text{m} = 1 \times 10^{-3} \text{ Km}$              | (distance between towns and cities)                                                                                               |
| Mega  | $M = 10^6$      | $1\text{Mm} = 1 \times 10^6 \text{ m}$<br>$1\text{m} = 1 \times 10^{-6} \text{ Mm}$                | (diameter of earth, speed of PC in Hz)<br>The radius of earth is about 6.38 <u>M</u> m                                            |
| Giga  | $G = 10^9$      | $1 \text{ Gm} = 1 \times 10^9 \text{ m}$<br>$1\text{m} = \underline{1 \times 10^{-9}} \text{ Gm}$  | (distance between earth and moon)<br>The sun is 149 <u>G</u> m away from earth                                                    |

C.2) Unit Conversion

Example)

a) 1234 **M** byte= ? **G** byte

$$\begin{aligned}
 1234 \text{ M byte} &= 1234 \times 1 \times 10^6 \text{ byte} \\
 &= 1.234 \times 10^9 \text{ byte} \\
 &= 1.234 \text{ G byte}
 \end{aligned}$$

c) 7,6 **g/cm<sup>3</sup>** = ? **Kg/m<sup>3</sup>**

$$\begin{aligned}
 7.6 \text{ g/cm}^3 &= 7.6 \times \frac{1 \text{ g}}{(1 \text{ cm})^3} \\
 &= 7.6 \times \frac{1}{\left(\frac{1}{100} \text{ m}\right)^3} \text{ kg} \\
 &= 7.6 \times \frac{1000}{\left(\frac{1}{100} \text{ m}\right)^3} \\
 &= 7.6 \times 1000 \text{ Kg/m}^3 \\
 &= 7,600 \text{ Kg/m}^3 \\
 &= 7.6 \times \underline{10^3} \text{ Kg/m}^3
 \end{aligned}$$

C.3) Unit Conversion II

|                                                                                 |                                                                                           |
|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| a) 40 cm = <u><math>4.0 \times 10^{-4}</math></u> km                            | l) 40 Mg = <u><math>4.0 \times 10^4</math></u> kg                                         |
| b) 200 m <sup>3</sup> = <u><math>2.00 \times 10^8</math></u> cm <sup>3</sup>    | m) 0.05 Km <sup>2</sup> = <u>50</u> m <sup>2</sup>                                        |
| c) 200 days = <u>4800</u> hrs                                                   | n) 3200 s = <u>0.8889</u> hrs                                                             |
| d) 0.002km <sup>2</sup> = <u><math>2.0 \times 10^7</math></u> cm <sup>2</sup>   | o) 40 l = 40 x (1 dm <sup>3</sup> ) = <u><math>4.0 \times 10^3</math></u> cm <sup>3</sup> |
| e) 4 tons = 4 x 1000 Kg = <u><math>4.0 \times 10^6</math></u> g                 | p) 400 cm = <u><math>4.0 \times 10^{-3}</math></u> km                                     |
| f) 420 K = 420 - (273) = <u>147</u> °C                                          | q) 200 Kg = <u>0.2</u> tons                                                               |
| g) 90 km/h = <u>25</u> m/s                                                      | r) 430 cm <sup>2</sup> = <u><math>4.0 \times 10^4</math></u> mm <sup>2</sup>              |
| h) 40 °C = <u>313</u> °K                                                        | s) 40 Gs = <u>462,962.96</u> days                                                         |
| i) 20 m/s = <u>72</u> km/h                                                      | t) 20,000 ns = <u>0.02</u> ms                                                             |
| j) 1000 mm <sup>3</sup> = <u><math>1 \times 10^{-15}</math></u> km <sup>3</sup> | u) -200 °C = <u>73</u> °K                                                                 |
| k) 4 g/cm <sup>3</sup> = <u><math>4.0 \times 10^3</math></u> Kg/m <sup>3</sup>  | v) 140 km = <u><math>1.4 \times 10^4</math></u> Gm                                        |

D) The orders of magnitude of the sizes of common objects ranging from a typical atom to the Earth:

- D.1) i) The size/diameter of an atom is about 0.1 nm  
 ii) The thickness of a hair is about 150  $\mu\text{m}$   
 iii) The diameter of earth is about  $2 \times 6.38 \text{ Mm}$   
 iv) The sun is 149 Gm away from Earth

E) State what is meant by scalar and vector quantities and give common examples of each:

E.1) **Scalar** quantities are quantities that **have size but no direction** whereas **Vector** quantities are quantities that **have both size and direction**.

i) Mass is a physical quantity that has a size but no direction, and therefore it is a scalar. On the other hand, weight is a physical quantity that has both size and direction (downward) and hence it is a vector.

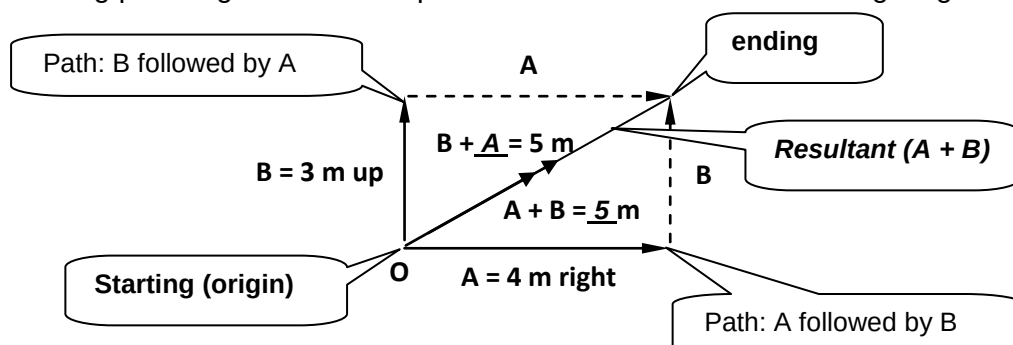
ii) Please determine if each of the following quantities is vector or scalar.

|                    |               |
|--------------------|---------------|
| Mass               | <b>Scalar</b> |
| Weight             | <b>Vector</b> |
| Distance           | <u>scalar</u> |
| Velocity           | <u>vector</u> |
| Displacement       | <u>vector</u> |
| Speed              | <u>scalar</u> |
| Acceleration       | <u>vector</u> |
| Force (All kinds)  | <u>vector</u> |
| Energy (All kinds) | <u>scalar</u> |
| Time               | <u>scalar</u> |
| Gravity            | <u>vector</u> |

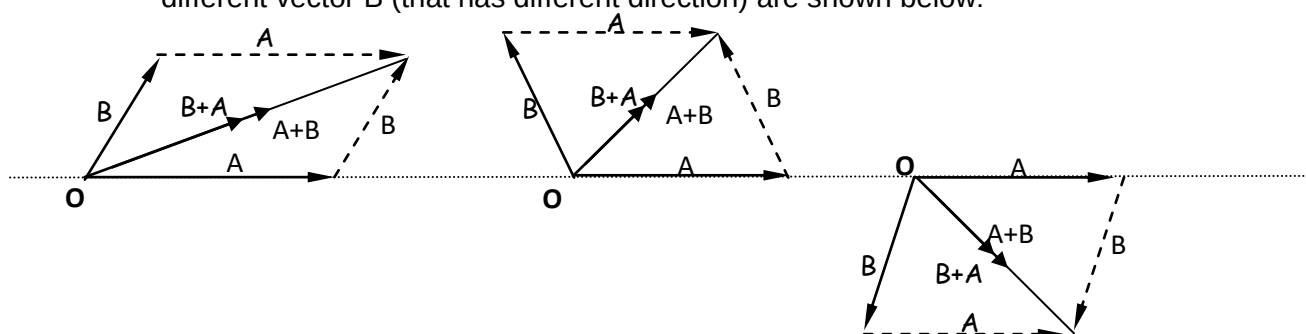
## F) Adding two scalars versus adding two vectors:

F.1) **The sum of two scalar quantities ( $A + B$  or  $B + A$ ) can be found by just adding the two quantities** without considering their directions. Hence the sum of two distances travelled by a person when he walks 3 metres in one direction (A) and another 4 metres in any direction (B) is always 7 metres (i.e.  $A + B$  or  $B + A$ )

F.2) **The sum of two vector quantities ( $A + B$  or  $B + A$ ) is found by drawing a scaled diagram** that represents the result of the two possible paths taken (i.e. A followed B or B followed A.) If A represents a displacement of 3 metres to the right and B represents another displacement of 4 metres upwards, then the vector sum of  $A + B = B + A$  (or the resultant vector) is measured from the starting point to the ending point regardless of the path taken as shown in the following diagram.

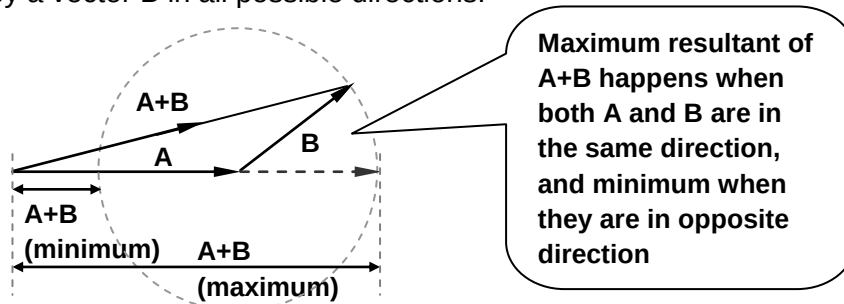


Three other possible examples of the vector sum  $A + B$  with a fixed A and three different vector B (that has different direction) are shown below:



(it is important to note that the Vector sum or the resultant =  $A + B = B + A$ )

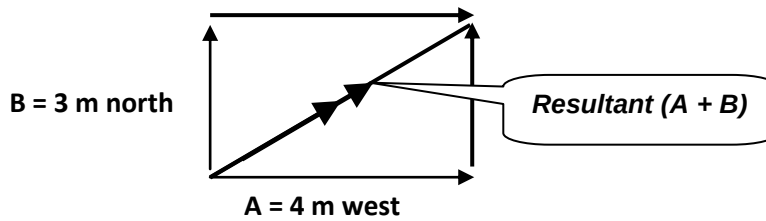
The following shows all possibilities of the resultant ( $A+B$ ) of a fixed vector A followed by a vector B in all possible directions.



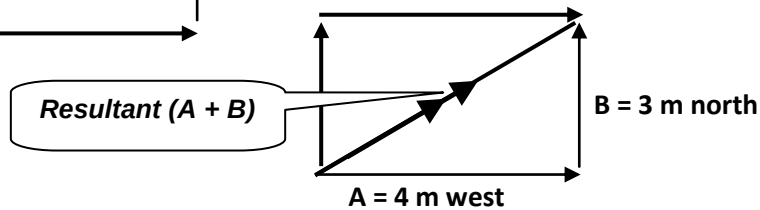
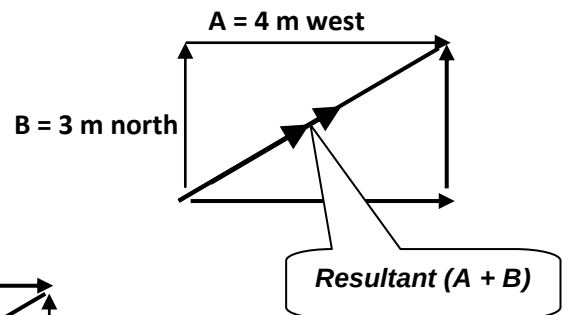
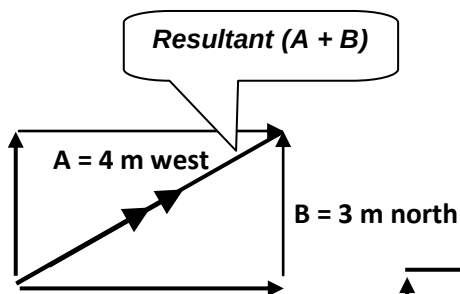
So if the size of vector A is 4 and the size of vector B is 3, then the maximum size of the resultant  $A+B$  would be 7 and the minimum size of the resultant  $A+B$  would be 1 in the direction of A.

F.3) The sum of two displacements (i.e. the vector sum or resultant) travelled by a person when he walks 3 metres north and 4 metres west is 5 metres in the direction shown in the following vector diagram.

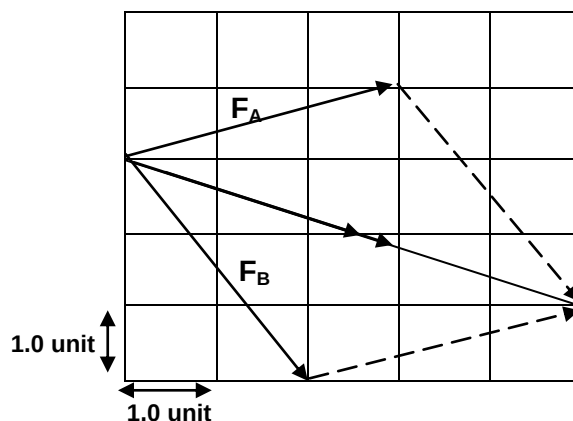
(please complete the following vector diagrams: by showing the resultant A+B)



(The following are equivalent to the vector diagram above: Please complete the following by showing the resultant A+B or B+A)

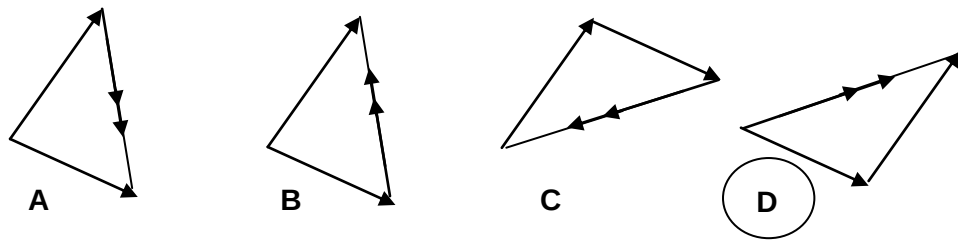


F.Q.4) Find the resultant of the following two forces acting on a body by drawing the resultant vector on the following scaled diagram:

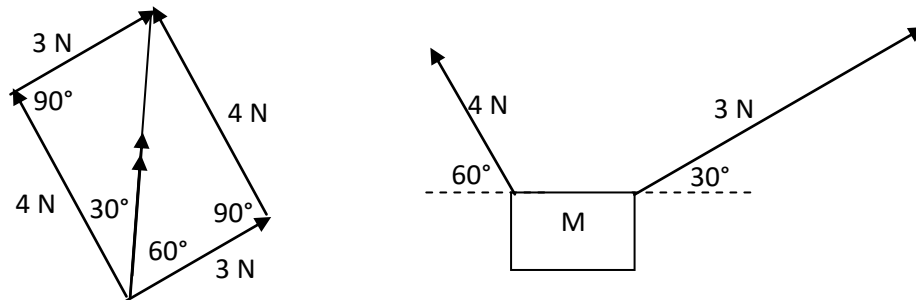


$$\text{Resultant} = (2.0^2 + 5.0^2)^{\frac{1}{2}} = 5.3 \text{ units}$$

F.Q.5) Which of the following shows a proper vector diagram of two forces and the resultant?

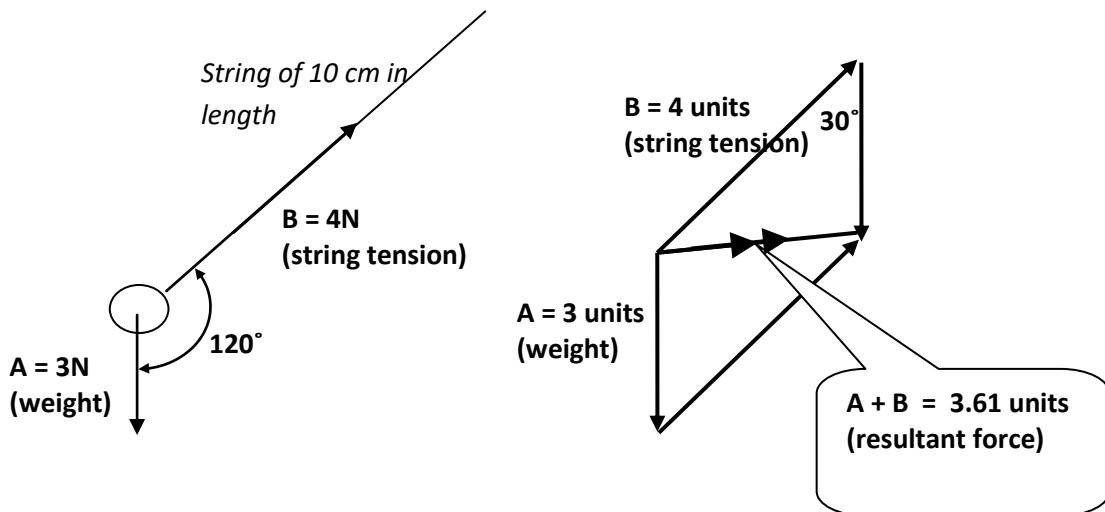


F.Q.6) Find the resultant force produced by the tension forces of the following two cables on the object M:



**Resultant force =  $(3^2 + 4^2)^{1/2} = 5$**

F.Q.7) Please find the resultant of following two forces acting on the following swinging object in this particular instant by drawing a vector diagram to scale..

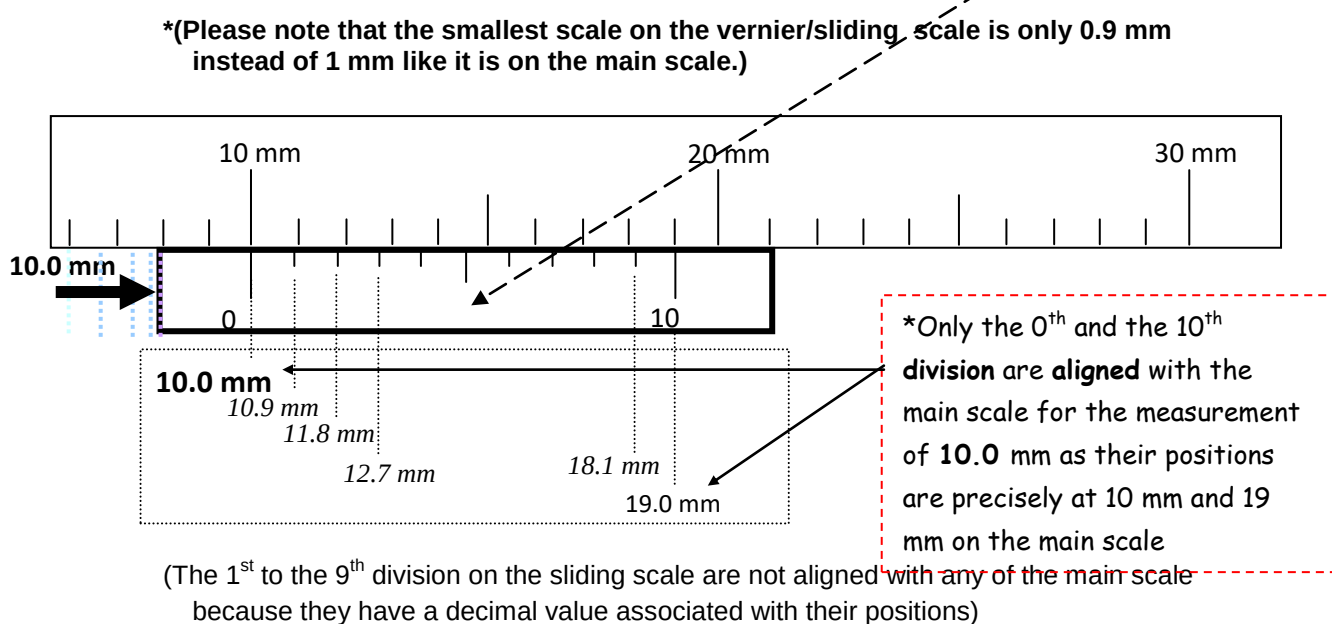


G) describe how to measure a variety of lengths with appropriate accuracy by means of tapes, rules, micrometers and callipers, using a vernier scale as necessary.

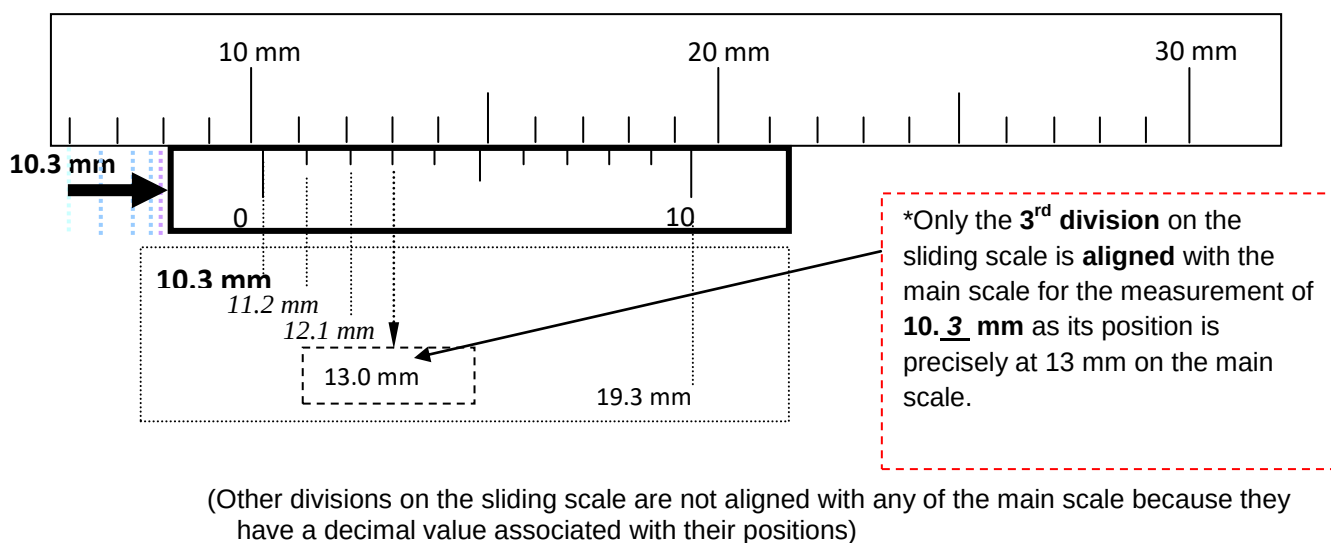
G.1) The vernier calliper has a precision of 0.1 mm and is appropriate to measure length between 1cm and 10 cm. Hence one can use the vernier calliper to measure 10.3 mm as it is between 1 cm and 10 cm

Example:

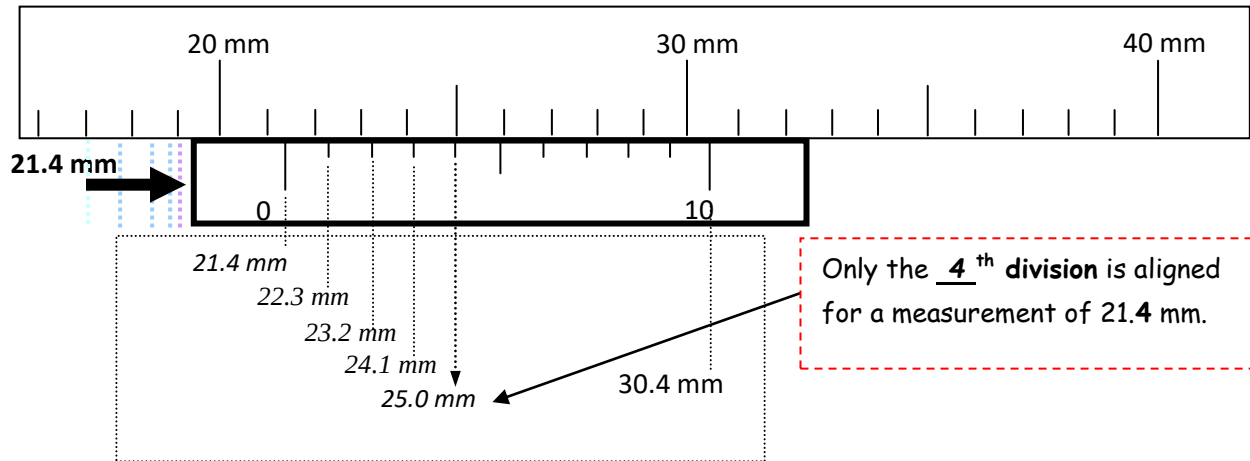
a) When measuring 10.0 mm, the scales would look like the following:



b) When measuring 10.3 mm, the scales would look like the following:

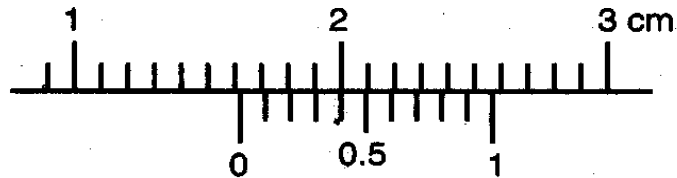


c) If you were measuring 21.4 mm, the scales would look like:



G.2) Please read the following measurements:

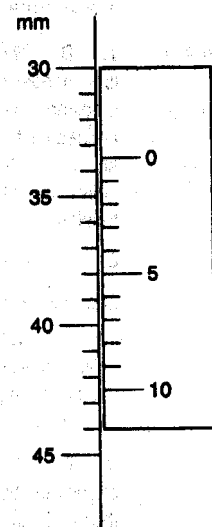
a) The diagram shows the scale of a vernier calliper.



The measurement of the calliper is 1.64 cm If there is no zero error on this vernier calliper.

b) The diagram shows the scale of a vernier calliper.

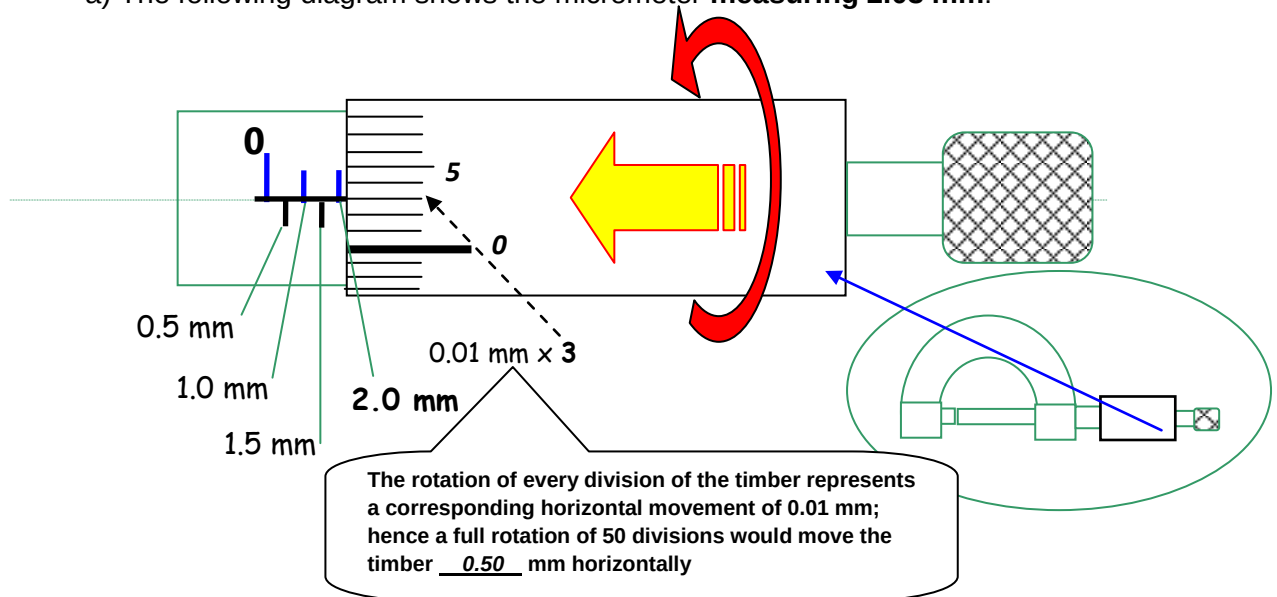
The measurement of the calliper is 33.5 mm if there is no zero error on this vernier calliper.



G.3) The micrometer has a precision of 0.01 mm and is appropriate to measure length smaller than 5 cm. Hence one can use the micrometer to measure the thickness of a coin as it is smaller than 50 mm

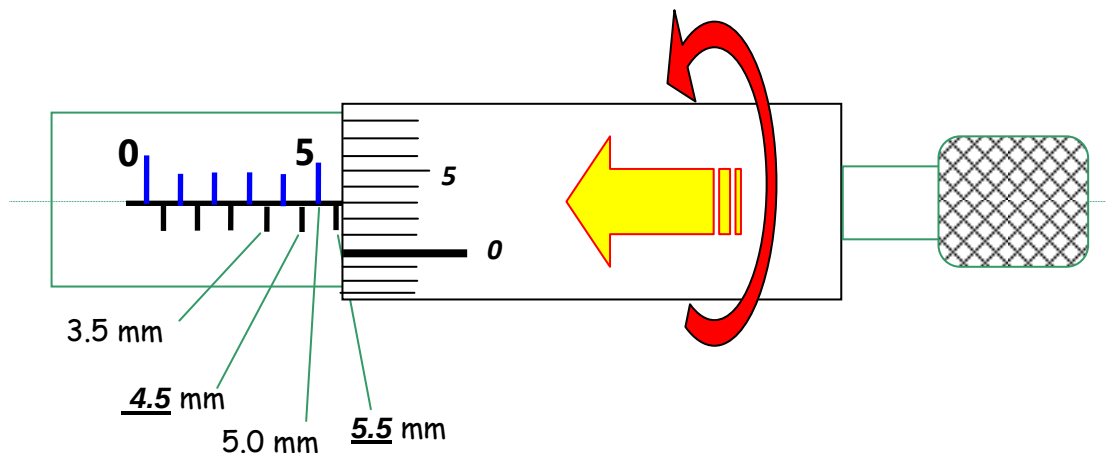
Example:

a) The following diagram shows the micrometer **measuring 2.03 mm**:

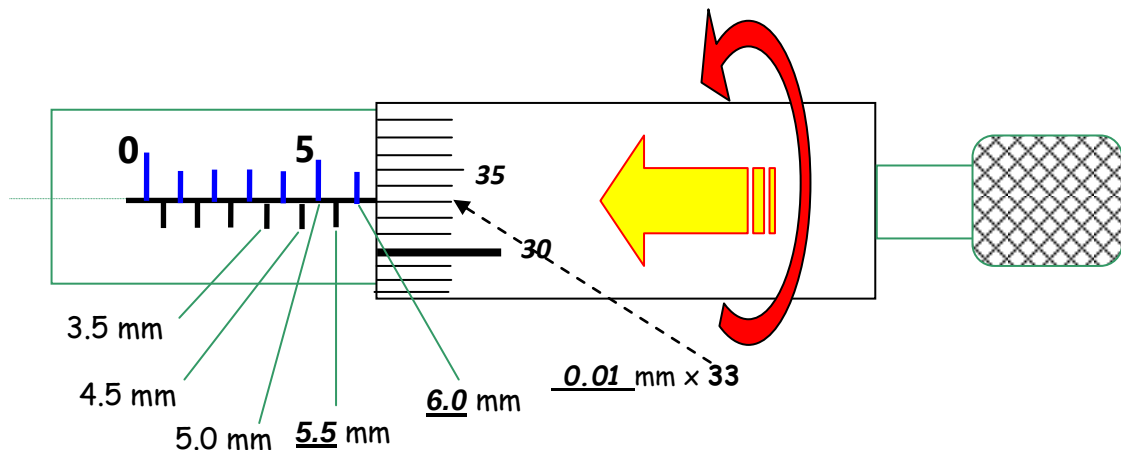


$$\text{Measurement} = 2.0 \text{ mm} + 0.01 \text{ mm} \times 3 = 2.03 \text{ mm}$$

b) The following diagram shows the micrometer **measuring 5.53 mm**:



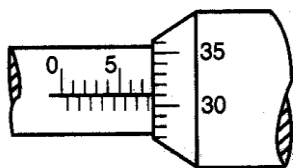
c) The following diagram shows the micrometer **measuring 6.33 mm**:





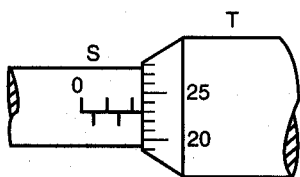
G.4) Please read the following measurements:

- a). A student used a micrometer screw gauge to measure the thickness of a metal sheet. The diagram below shows part of the micrometer. What is the thickness of the metal sheet?



7.81 mm

- b) The diagram shows the barrel (S) and the rotating thimble (T) of a micrometer screw gauge.

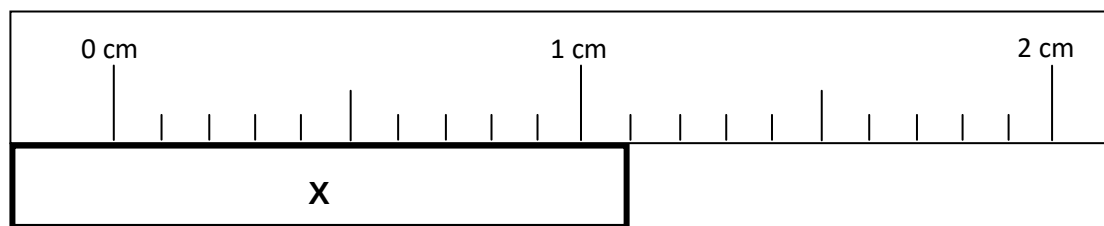


The divisions shown above the horizontal line on the barrel are millimetres and those below the line on the barrel are the half-millimetres. There are 50 divisions around the rim of the thimble of which some are shown. The correct reading of the instrument, as shown is

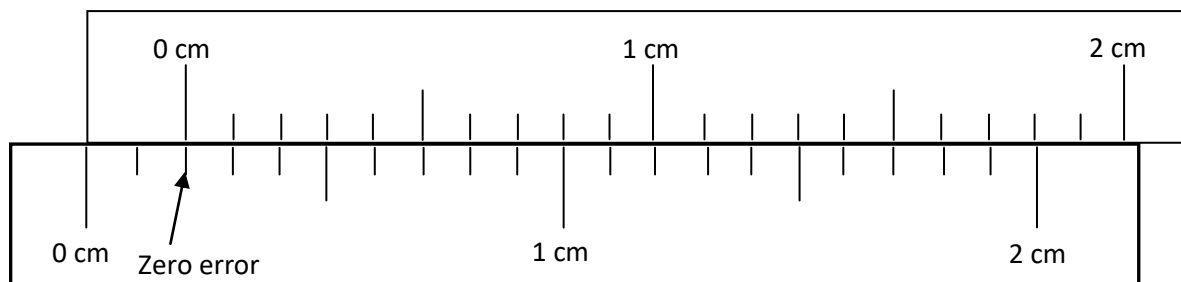
2.23 mm

G.5) Compensating the Zero errors:

- a) There would be a zero error associated with the measurement taken by the rule if the length of an object X (11 mm) is measured as follows:

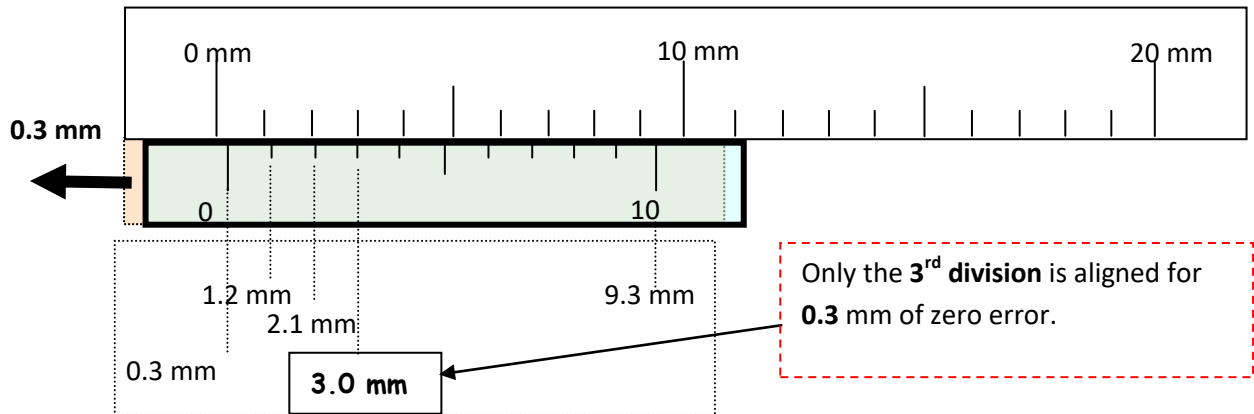


The zero error (of 2mm) can be determined by the measurement below:



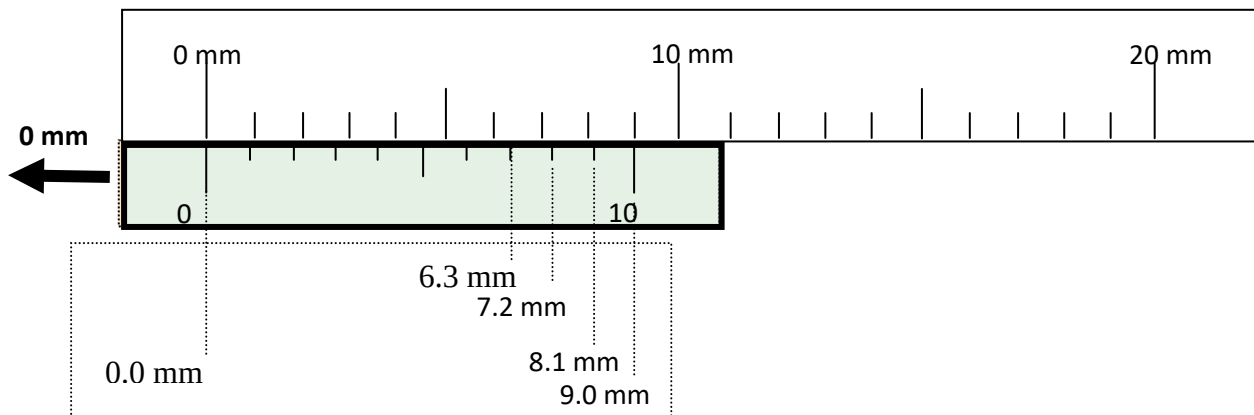
The actual measurement of the length of object X is therefore 13 mm instead of 11 mm after subtracting the negative zero error of 2 mm.

b) The following shows a caliper with a **positive zero error of 0.3 mm** when it is fully closed:



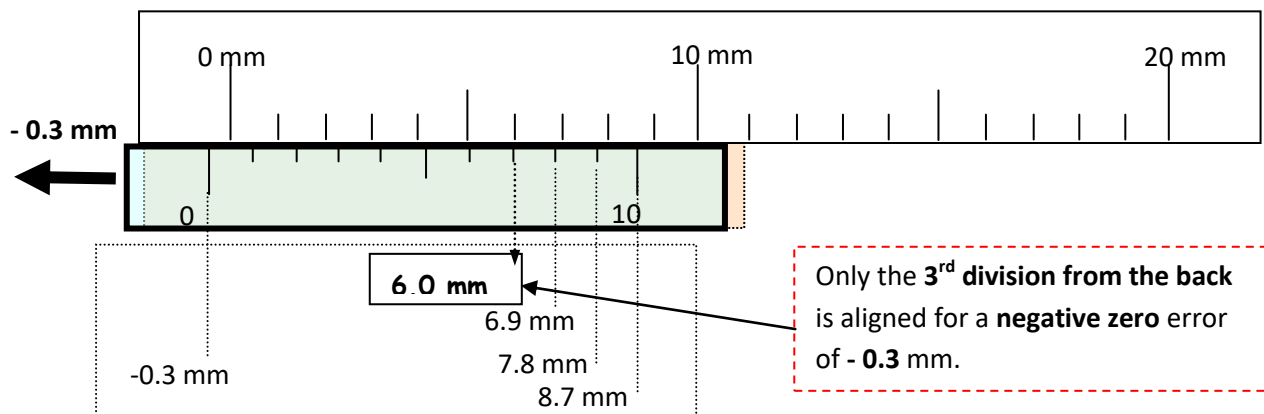
The measurement taken using this caliper would always be in excess 0.3 mm. Subtracting 0.3 mm to the measurement taken would compensate for the positive zero error

The following shows a caliper with **no zero error** when it is fully closed:



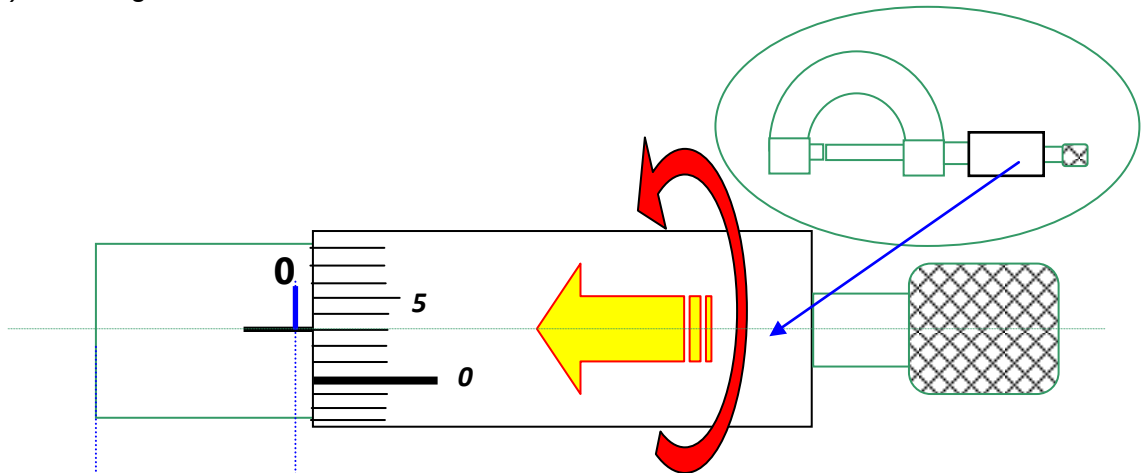
**No adjustment needed** for the measurement taken using this caliper

The following shows a caliper with a **zero error of - 0.3 mm**:



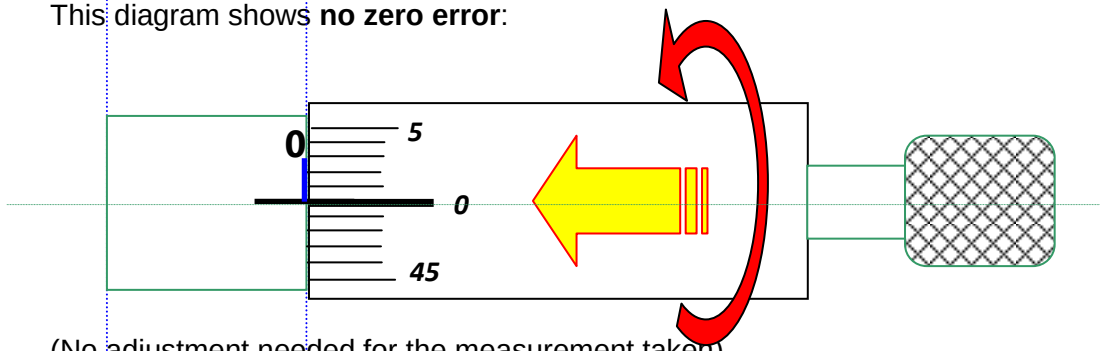
Adding 0.3 mm (or subtracting - 0.3 mm) to the measurement taken would compensate for the negative zero error

c) This diagram shows a micrometer that has a **zero error of + 0.03 mm**:



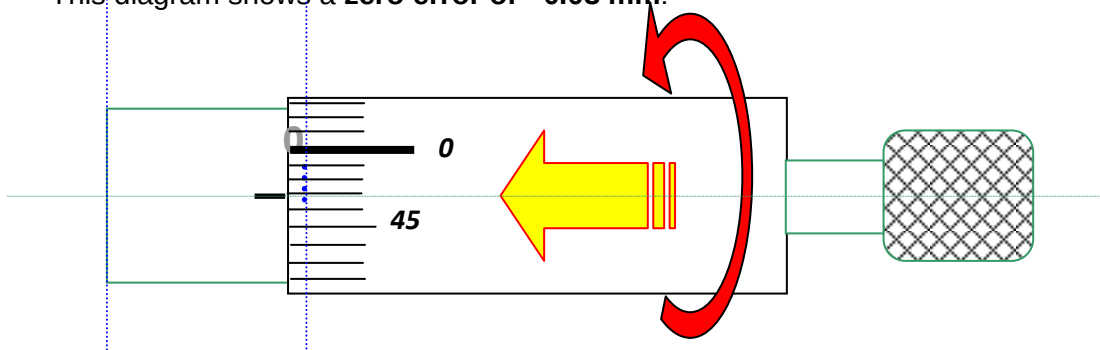
(Subtracting 0.03 mm to the measurement compensates the +zero error)

This diagram shows **no zero error**:



(No adjustment needed for the measurement taken)

This diagram shows a **zero error of - 0.03 mm**:



(Adding 0.03 mm or Subtracting - 0.03 mm to the measurement would compensate for the negative zero error)

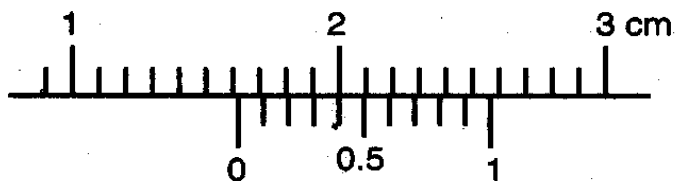
Example: Instrument Measures = 5.23mm  
 Zero Error of the instrument = -0.03 mm  
 Actual Measurement =  $5.23 - (-0.03) = 5.26$  mm

### Conclusion

**Actual Measurement = Instrument Reading - Zero Error**

G.6) Please read the following measurements:

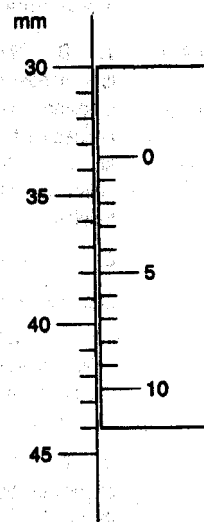
a) The diagram shows the scale of a vernier calliper.



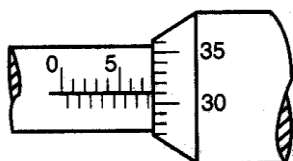
The measurement of the calliper is 1.62 cm. If there is a zero error of +0.2 mm on this vernier calliper.

b) The diagram shows the scale of a vernier calliper.

The measurement of the calliper is 33.6 mm if there is a negative zero error of -0.1 mm on this vernier calliper.

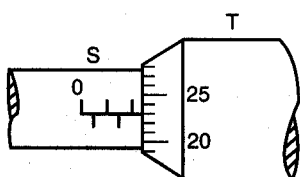


c) A student used a micrometer screw gauge to measure the thickness of a metal sheet. The diagram below shows part of the micrometer. What is the thickness of the metal sheet if there is a positive zero error of 0.02 mm?



7.79 mm

d) The diagram shows the barrel (S) and the rotating thimble (T) of a micrometer screw gauge.



The divisions shown above the horizontal line on the barrel are millimetres and those below the line on the barrel are the half-millimetres. There are 50 divisions around the rim of the thimble of which some are shown. There is a negative zero error of 0.01 mm. The correct reading of the instrument, as shown is

2.24 mm

### Why and How to deal with Significant Figures (S.F.) and Decimal Places (D.P.)

The reason we need to determine the correct number of S.F. or D.P for a calculated number is because the calculated number may have been obtained from a combination of measurements that have different degree of precisions.

For example, the volume of a rectangular container of which the length, width, and height are all measured using different instruments and hence could have different precisions.

$$\begin{aligned}\text{Volume} &= \text{Length} \times \text{Width} \times \text{Height} \\ &= 8.1 \text{ cm} \times 15.7 \text{ mm} \times 15 \text{ mm}\end{aligned}$$

**The precision of the volume can only be as good as the precision of the least precise number used in obtaining the answer.** Therefore we should use the least significant figure (of the product or division) as the S.F. required for the answer.

$$\begin{aligned}\text{Volume} &= 8.1 \text{ cm} \times 1.57 \text{ cm} \times 1.5 \text{ cm} && (2 \text{ s.f. is the least}) \\ &= 19.0755 && (\text{cut off at 3 s.f and round off to 2 s.f.}) \\ &= 19 \text{ cm}^3 && (2 \text{ s.f.})\end{aligned}$$

For example, the total length of two smaller lengths that having different number of decimal places:

$$\begin{aligned}\text{Total length} &= \text{Length 1} + \text{Length 2} \\ &= 18.7259 \text{ cm} + 6.2 \text{ cm}\end{aligned}$$

The precision of the total length (or the sum of two lengths) would depend on the less precise of the two lengths. We should use the least decimal place of the addition or subtraction to determine the number of decimal place(s) required for the answer.

$$\begin{aligned}\text{Total length} &= 18.7259 \text{ cm} + 6.2 \text{ cm} && (1 \text{ d.p is the least}) \\ &= 24.9259 && (\text{cut off at 2 d.p and round off to 1 d.p.}) \\ &= 24.9 \text{ cm} && (1 \text{ d.p.})\end{aligned}$$

#### **In short:**

Use **least decimal place (LDP)** for addition and subtraction of measured quantities.  
(e.g.  $12.452 \text{ m} - 10.4 \text{ m} = 2.05 \text{ m} \rightarrow \underline{2.1 \text{ m}}$ )

Use **least significant figure (LSF)** for multiplication and division of measured quantities

(e.g.  $4.5 \text{ m} \times 12.325 \text{ m} = 55.4xxx \text{ m}^2 \rightarrow \underline{55 \text{ m}^2}$ )

It is important to differentiate between a measurement (that has uncertainty) and a non-measurement (that has no uncertainty) because a non-measurement would usually be precise and has no uncertainty.

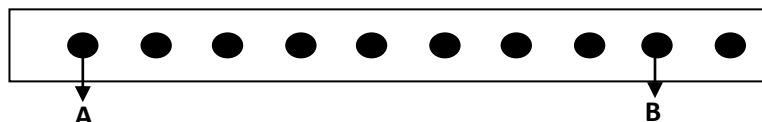
For example, the conversion factor of 10 that is used to convert 2.65 cm to 26.5 mm is not a measurement and should not be the least S.F. in the following calculation because it is precise.

$$\begin{aligned}2.65 \text{ cm} &= 2.65 \times 10 && (3 \text{ s.f. is the least because "10" is } \underline{\text{precise}}) \\ &= 26.5 \text{ mm} && (3 \text{ s.f.})\end{aligned}$$

H) describe how to measure a short interval of time including the period of a simple pendulum with appropriate accuracy using stopwatches or appropriate instruments.

H.1) A Ticker Tape timer creates dots at regular intervals (50 to 60 dots per second) on a strip of paper

Given that the dots are created at 50 dots per second, determine the time taken from A to B



The time interval between the dots would be  $\frac{1}{50} = 0.02$  s.

There are altogether 8 time intervals between A and B.

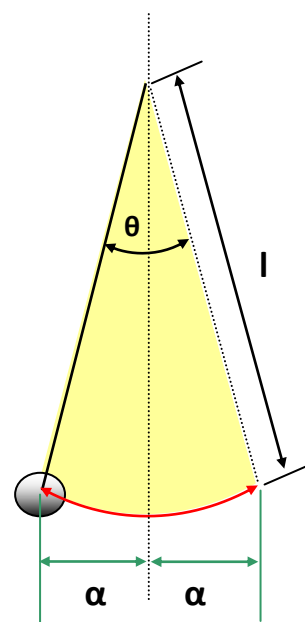
Time taken = time interval x number of intervals between A and B = 0.16 s

H.2) **Time can also be measured in terms of the constant interval of the periodic oscillation provided by a swinging mass on a string kept in motion by gravity** (Like the grandfather clock.)

The square of the Period  **$T$  (time of each oscillation)** is directly proportional to **the length  $l$  of the string** and inversely proportional to **gravity  $g$**

$$T = 2\pi \sqrt{\frac{l}{g}}$$

This can be verified via experiments and mathematics. Note that the **period does not depend on the mass, volume, or angle  $\theta$**  of the swinging object.



a) What is the new period ( $T_2$ ) if the pendulum is on the moon where the gravity is  $1/6$  that of earths'? (Answer in terms of  $T$ )

$$\underline{T_2 = 2\pi \sqrt{\frac{l}{g/6}} = 2\pi \sqrt{\frac{l}{g}} \times \sqrt{6} = T \times \sqrt{6}}$$

b) What is the new period ( $T_2$ ) if the length and mass of the pendulum is doubled? (Answer in terms of  $T$ )

$$\underline{T_2 = T}$$

c) What is the period ( $T_2$ ) if a)  $\theta$  (angle of swing) is doubled? (Answer in terms of  $T$ )

$$\underline{T_2 = T}$$

d) What is the period ( $T_2$ ) if  $\alpha$  (amplitude of oscillation) is halved? (Answer in terms of  $T$ )

$$\underline{T_2 = T}$$