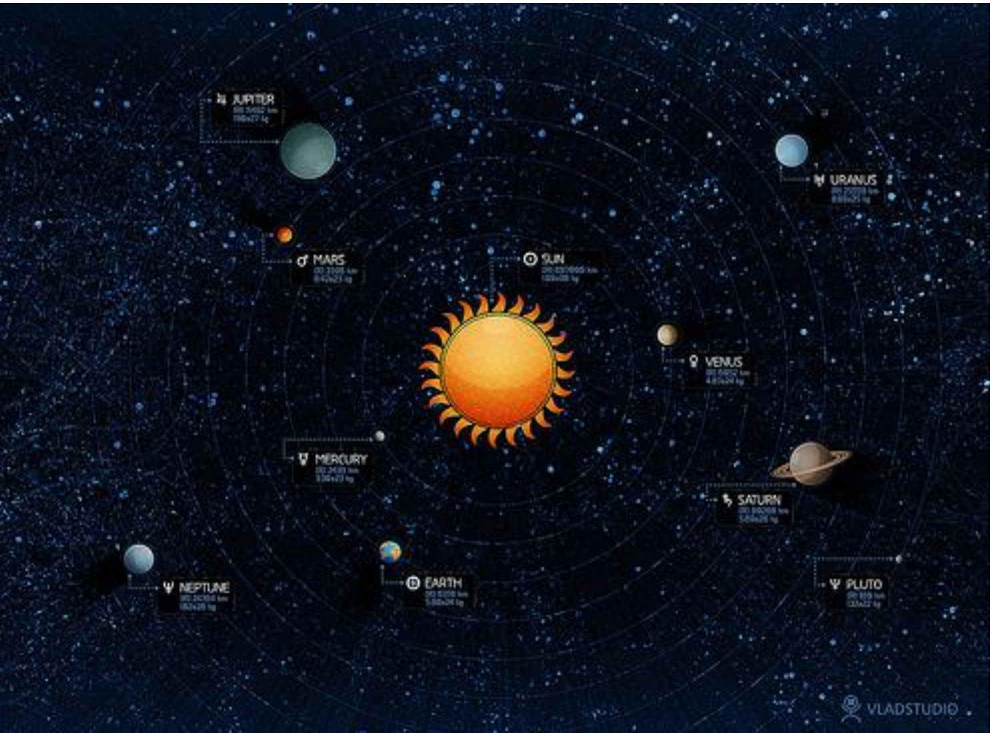
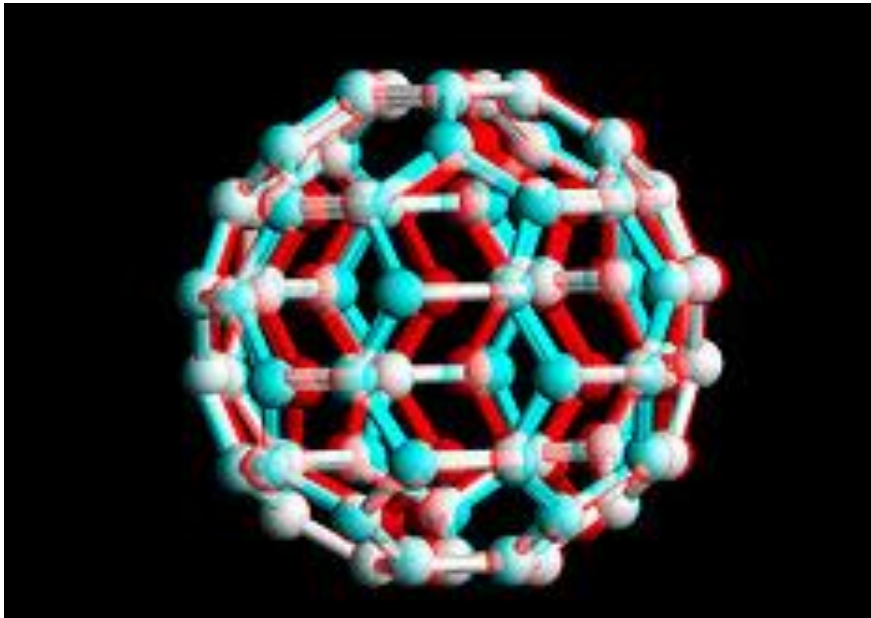
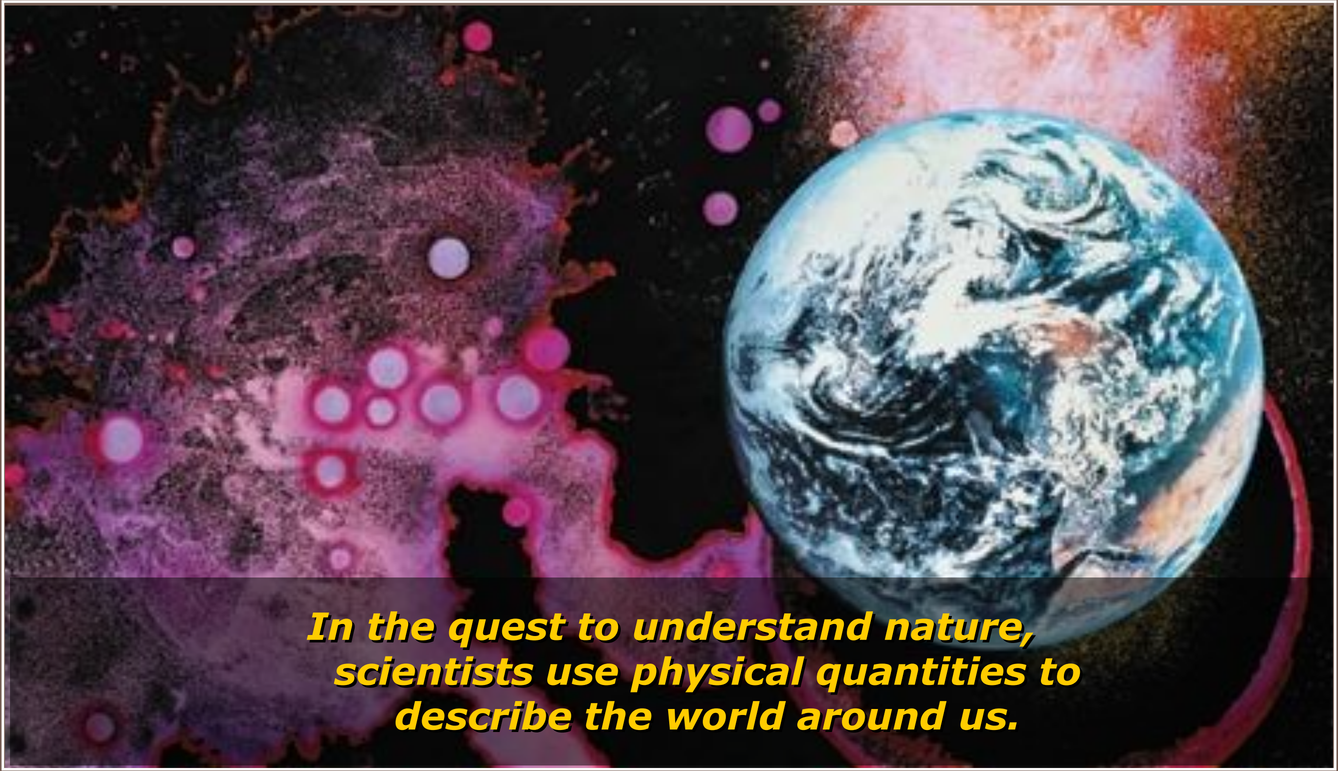
What is Physics?

- Physics is the study of the natural world around us – from the very large, such as the solar system, to the very small, such as the atom.







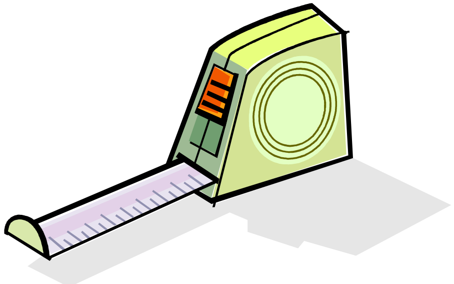
PHYSICAL QUANTITIES, SI UNITS AND MEASUREMENT

Chapter 1

At the end of this chapter…

You should be able to:

- show understanding that all physical quantities consist of a numerical magnitude and a unit
- recall the following base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K)
- use the following prefixes and their symbols to indicate decimal sub-multiples and multiples of the SI units: nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M)



At the end of this chapter…

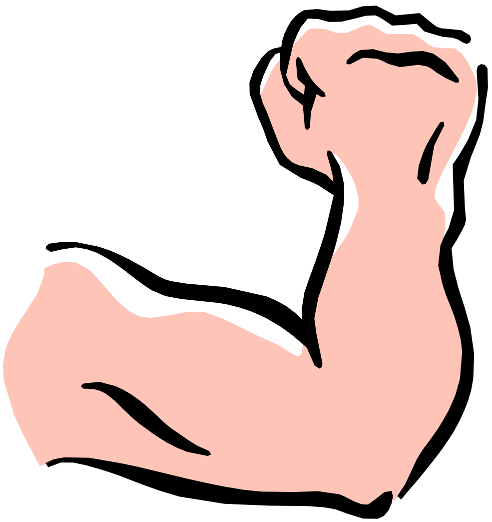
You should be able to:

- show an understanding of the orders of magnitude of the sizes of common objects ranging from a typical atom to the Earth
- describe how to measure a variety of lengths with appropriate accuracy by means of tapes, rules, micrometers and calipers, using a vernier scale as necessary
- describe how to measure a short interval of time including the period of a simple pendulum with appropriate accuracy using stopwatches or appropriate instruments

Why do We Need to Measure Things?

- Let's do this as a class…

1. Work in groups of two
2. Compare the length between the elbow to the first finger tip.



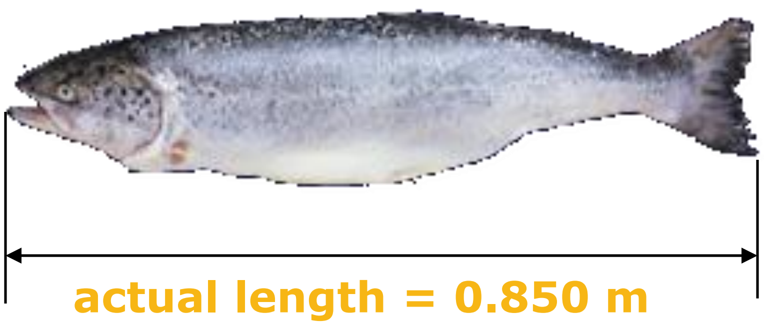
Physical Quantities and SI Units

Base Quantity	Name of SI unit	Symbol for SI Unit
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric Current	ampere	A
Temperature	kelvin	K
Intensity	candela	cd
Amount of Substance	mole	mol

Physical Quantities

- A physical quantity when measured may be described in terms of

1. <u>A number</u>
2. <u>Its unit of measurement</u>



Physical Quantities

- What is your height?

- 1.65 m

quantity

unit

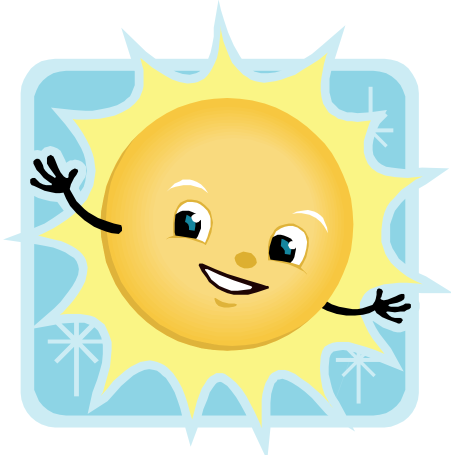
Physical Quantities

- **Mass** – unit of measurement, kilogram (kg)

Physical Quantities

- **Time** – unit of measurement, second (s)

Do You Know???



Diameter of the Sun

~~1 400 000 000 m~~

1.4 Gm (gigametre)

Thickness of a strand of hair

~~0.0002 m~~

0.2 mm (millimetre)

Prefixes for SI units

Factor	Prefix	Symbol
10^9	giga-	G
10^6	mega-	M
10^3	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	µ
10^{-9}	nano-	n

Prefixes Exercise 1

Express the following quantities in their respective SI unit.

a. One kilometer = 1000m or 10^3m

b. One microsecond = 0.000001s or 10^{-6}s

c. One centimeter = 0.01m or 10^{-2}m

d. One gram = 0.001kg or 10^{-3}kg

Factor	Prefix	Symbol
10^9	giga-	G
10^6	mega-	M
10^3	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	µ
10^{-9}	nano-	n

Prefixes Exercise 1

e. One miligram =

0.001g or 10^{-3}g =10^{-6} kg

f. One millisecond =

0.001s or 10^{-3}s

g. One minute =

60s

h. One hour =

3600s

Factor	Prefix	Symbol
10^9	giga-	G
10^6	mega-	M
10^3	kilo-	k
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	µ
10^{-9}	nano-	n

What does SI units mean?

- Système International
- *International System of Units*

Measurement of Length

- The SI unit for length is

  metre ( ) m

- Other units for length:

  millimetre (mm), centimetre (cm), kilometre (km)

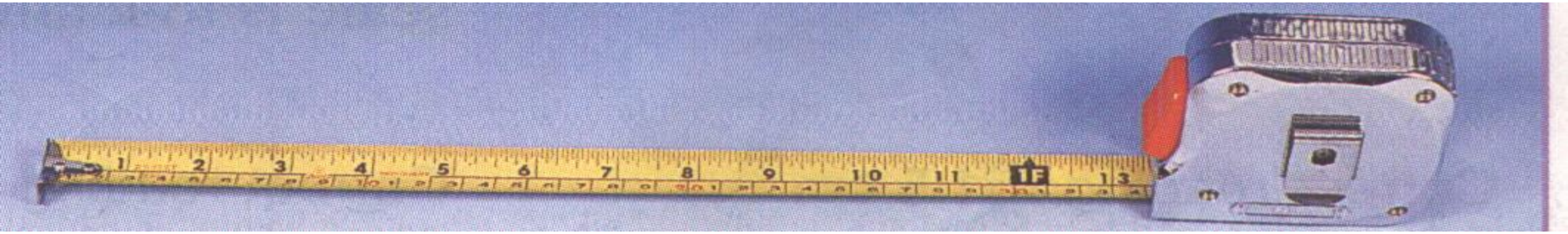
Measurement of Length

Range	Suitable Instruments	Accuracy of Instruments
Several metres (m)	Measuring Tape	0.1 cm (or 1 mm)
Several centimetres (cm)	Metre/Half-metre Rule	0.1 cm (or 1 mm)
Between 1cm to 10cm	Vernier Calipers	0.01 cm (or 0.1 mm)
Less than 2 cm	Micrometer Screw Gauge	0.001 cm (or 0.01 mm)

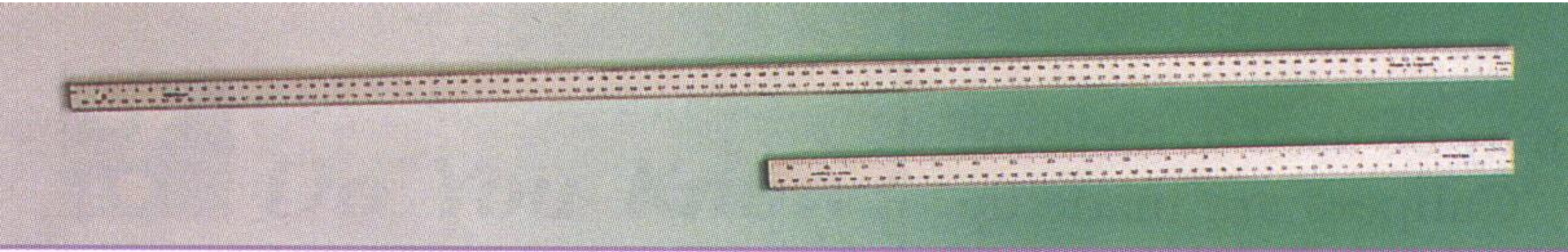
Measurement of Length

Measuring Tape

- Length of classroom, car, corridor



- **Metre rule:**
  - Length of desk, book

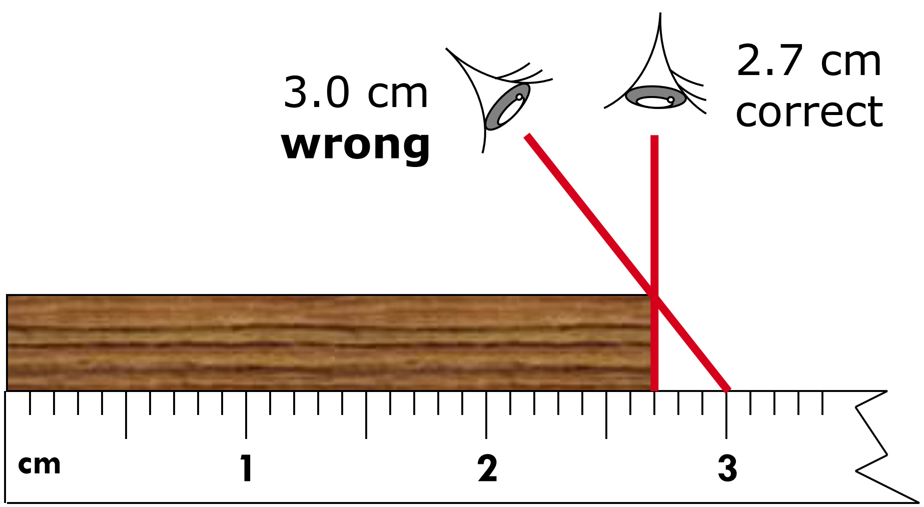


Measurement of Length

- **Parallax Error**

  What is Parallax Error?

  It is the error which arises due to incorrect positioning of the eye.

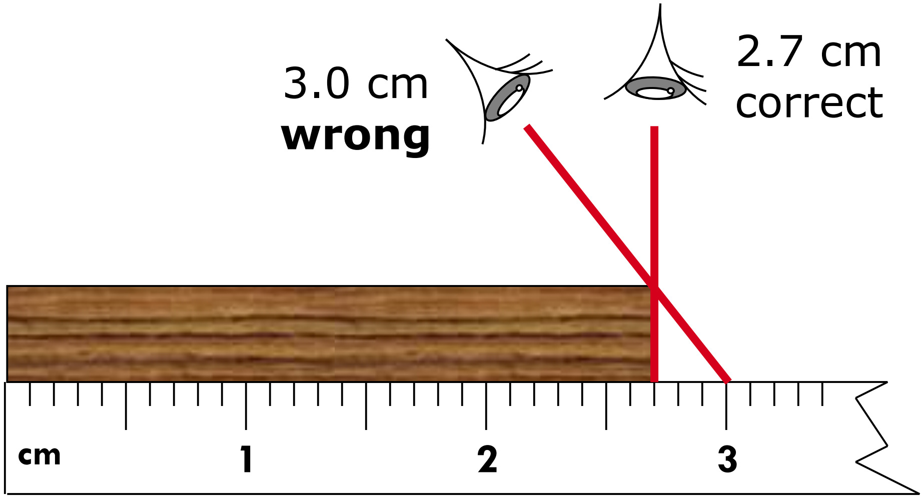


Measurement of Length

- **Parallax Error**

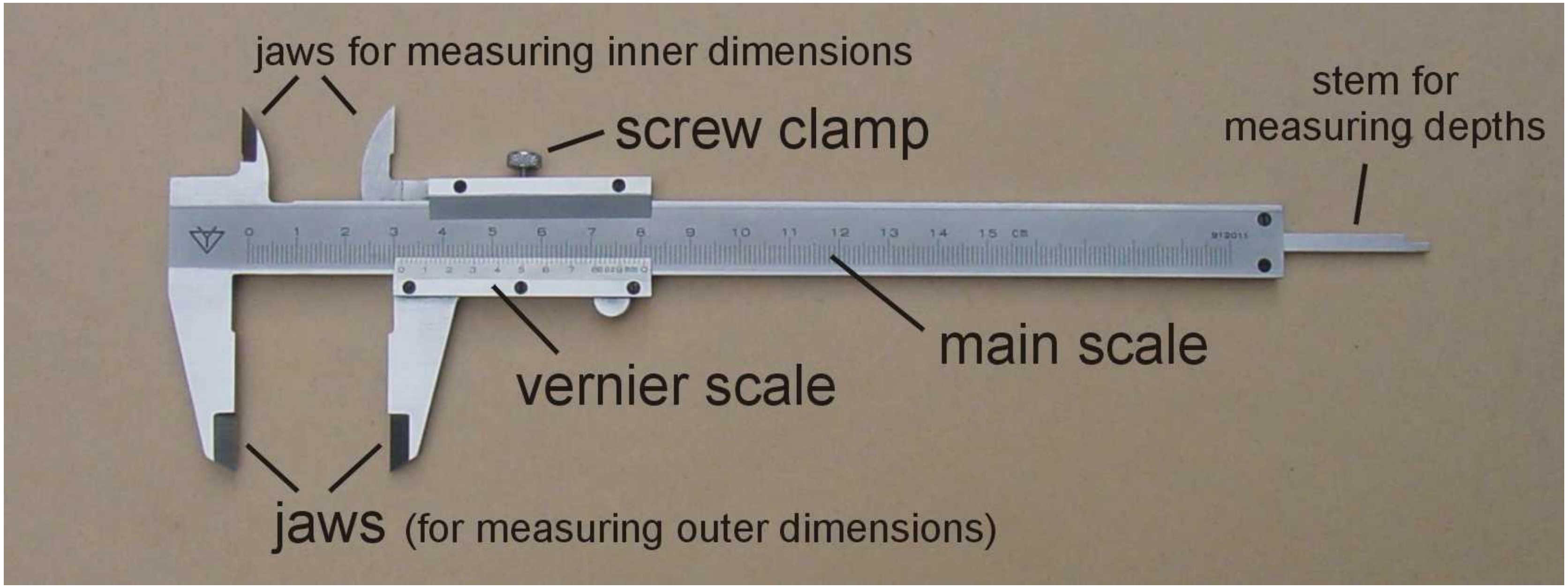
  How do we avoid Parallax Error?

  - Always place the eye vertically above the mark being read. **OR**
  - Place the eye in level with the mark being read.



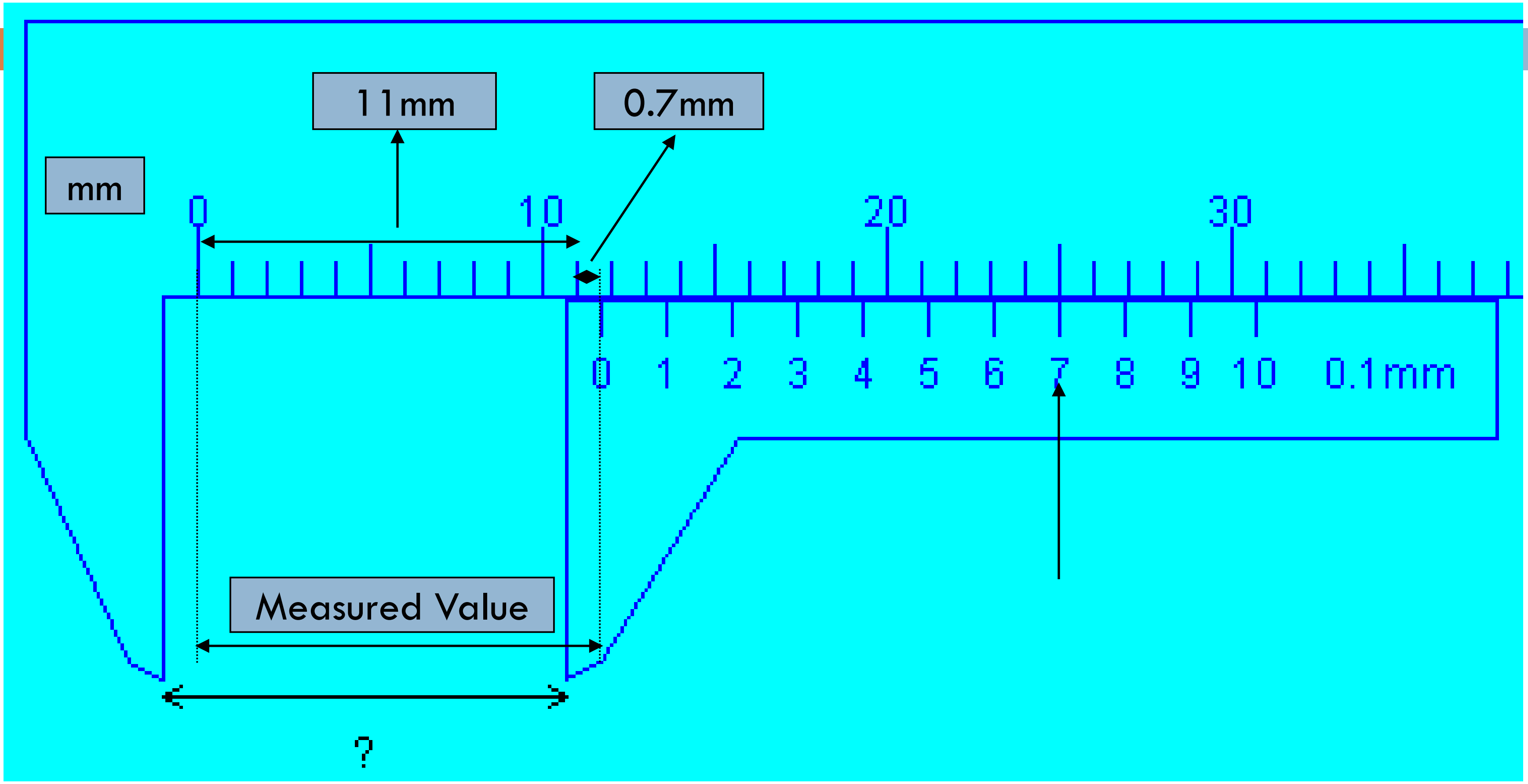
Vernier Calipers

- French scientist Pierre Vernier(1580-1637)



Accuracy: 0.01 cm (or 0.1 mm)

How to read off the Vernier Caliper?

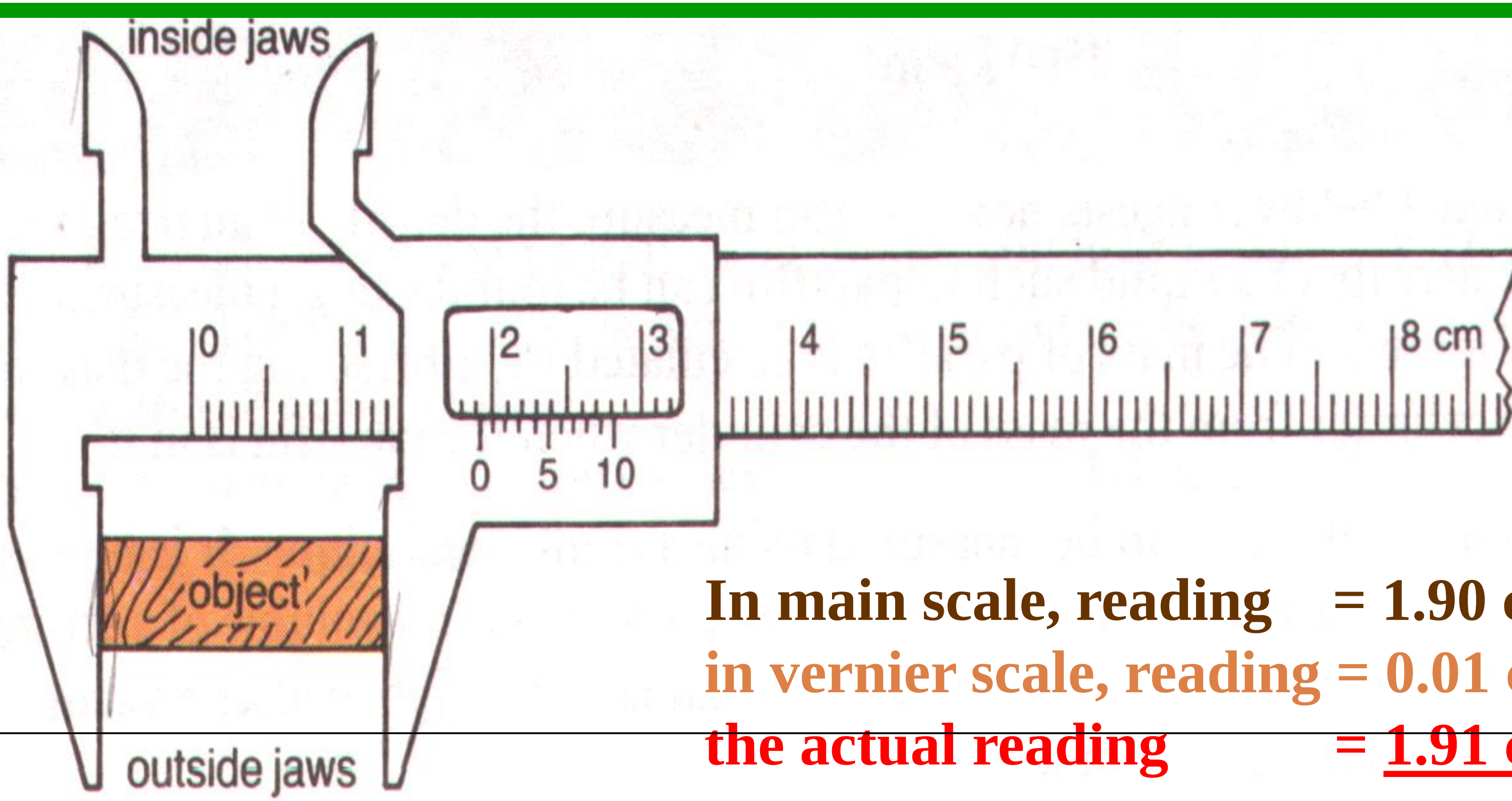


Reading = 11 mm + 0.7 mm = 11.7 mm

Vernier Calipers

Its structure and its application

- The inside jaws is used to measure internal diameter of test-tube, ring etc.



In main scale, reading = 1.90 cm

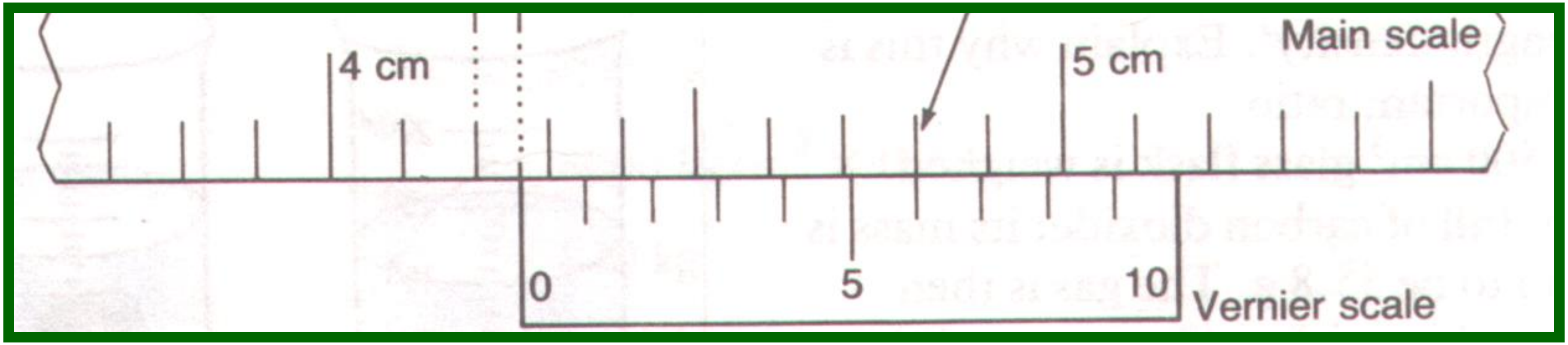
in vernier scale, reading = 0.01 cm

the actual reading = <u>1.91 cm</u>

Vernier Calipers

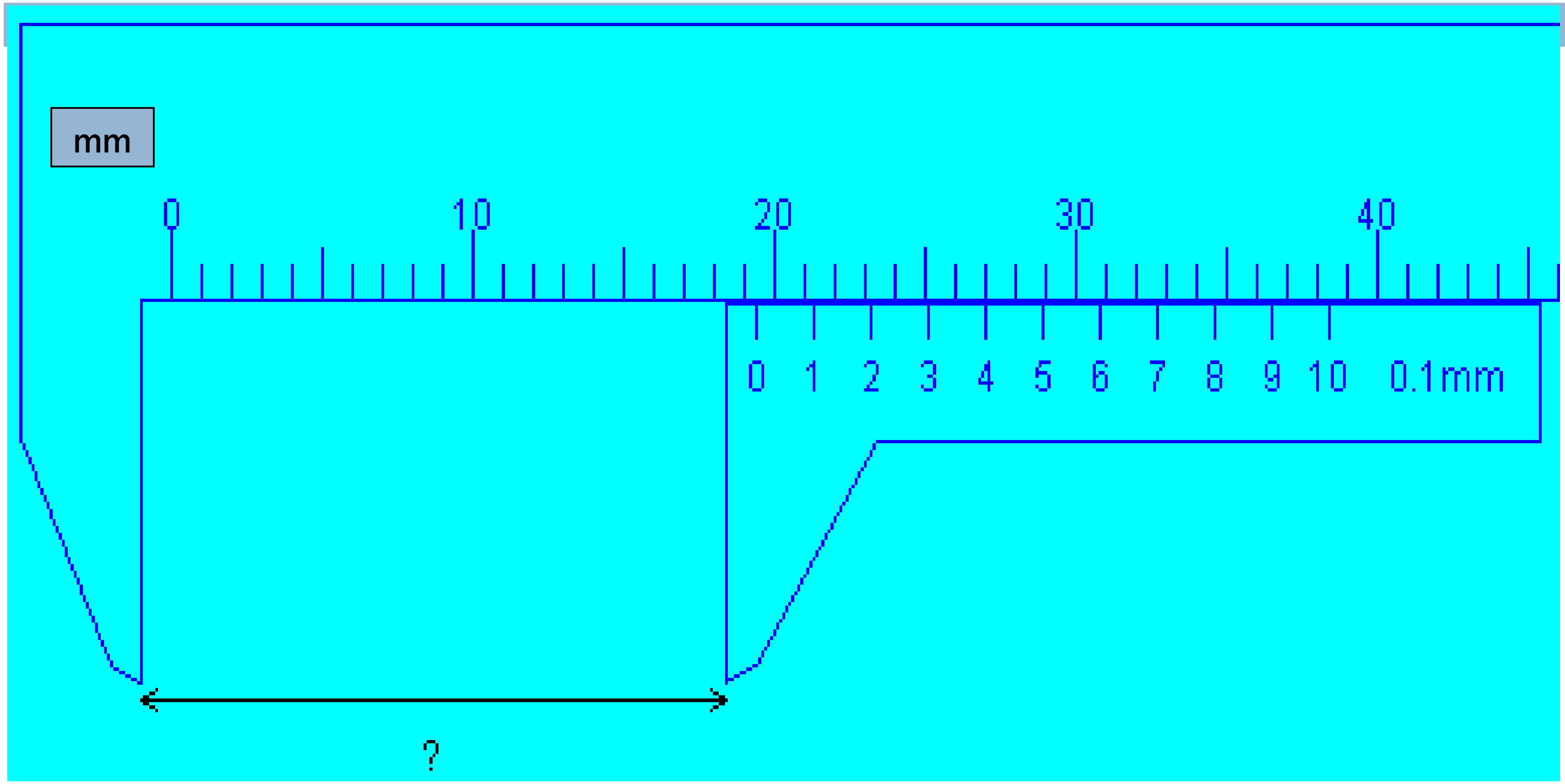
Its structure and its application

- The outside jaws is used to measure small length, diameter of test-tube etc.



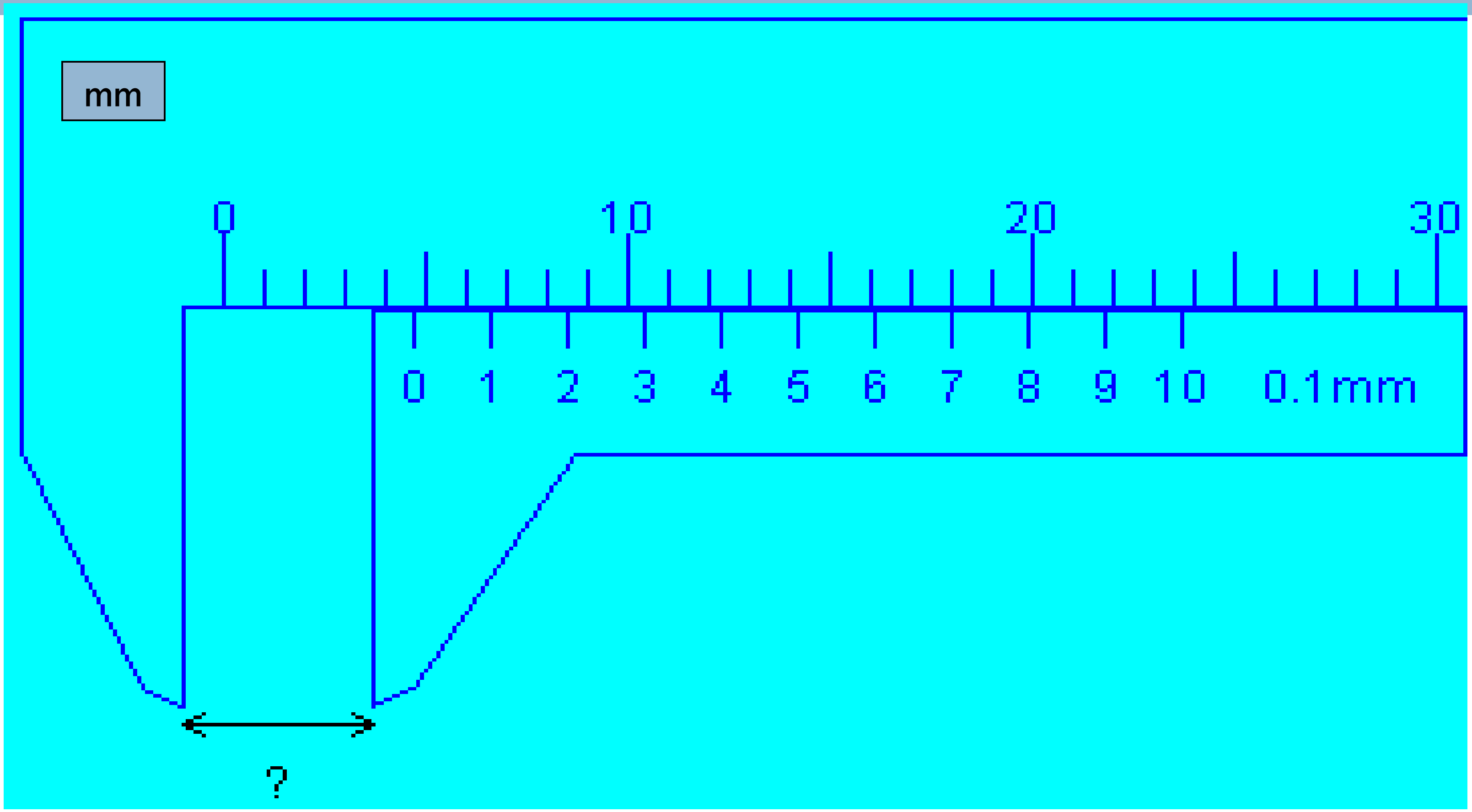
main scale reading = 4.20 cm
vernier scale reading = 0.06 cm
Actual reading = <u>4.26 cm</u>

Exercise 1



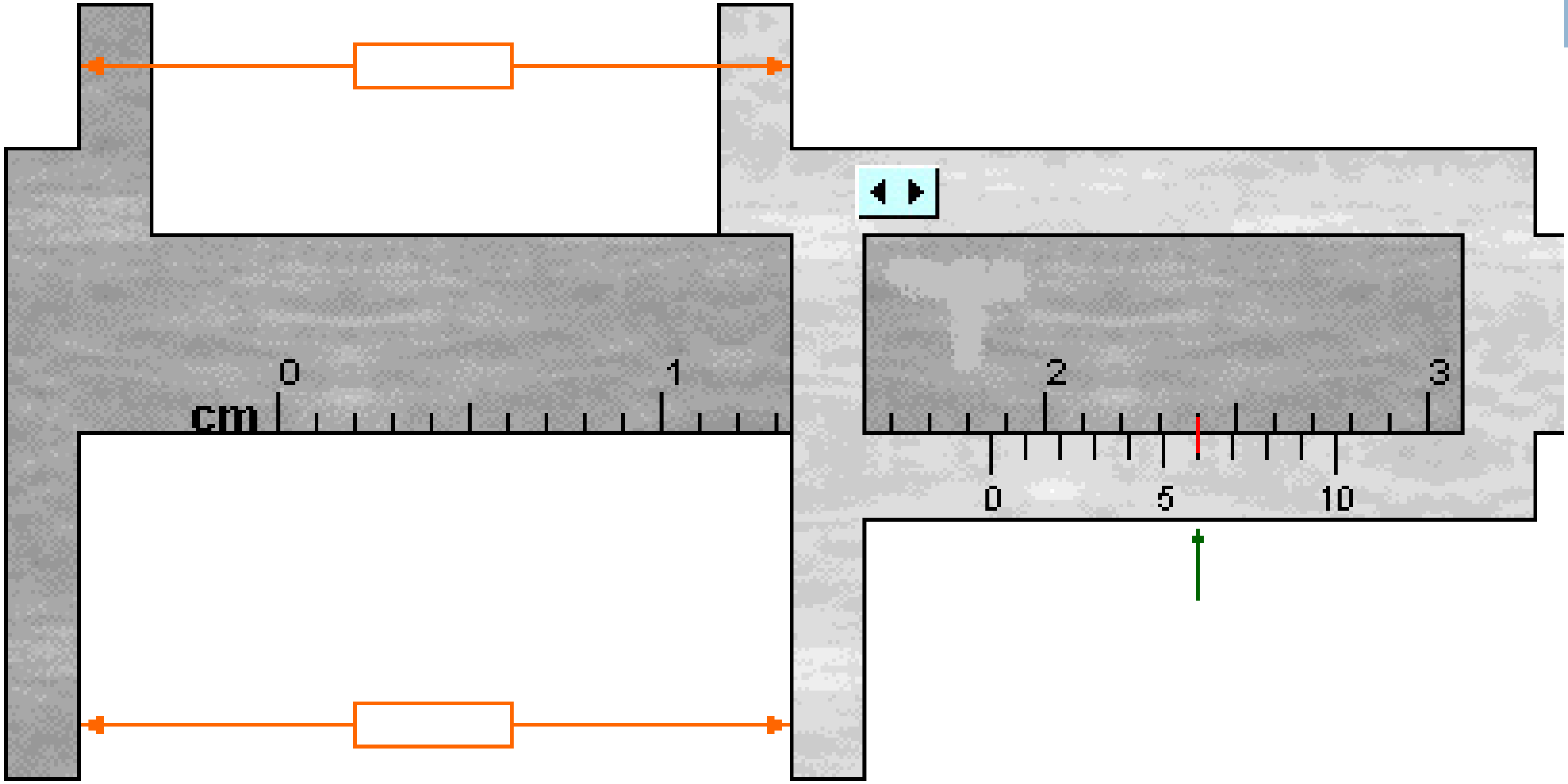
Reading = 19 mm + 0.4 mm = 19.4 mm

Exercise 2



Reading = 4 mm + 0.7 mm = 4.7 mm

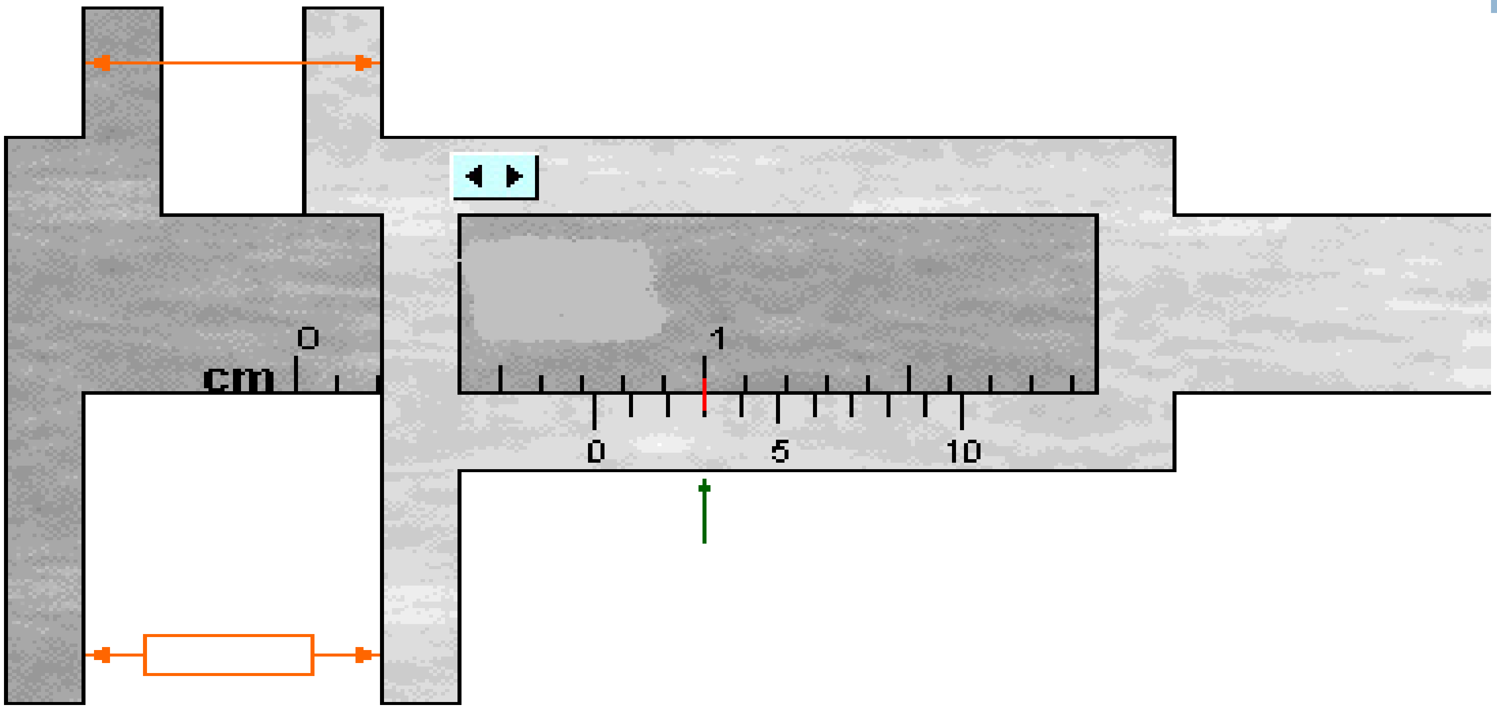
Exercise 3



MEASURE = 1.8 cm + 0.06 cm

MEASURE = 1.86 cm

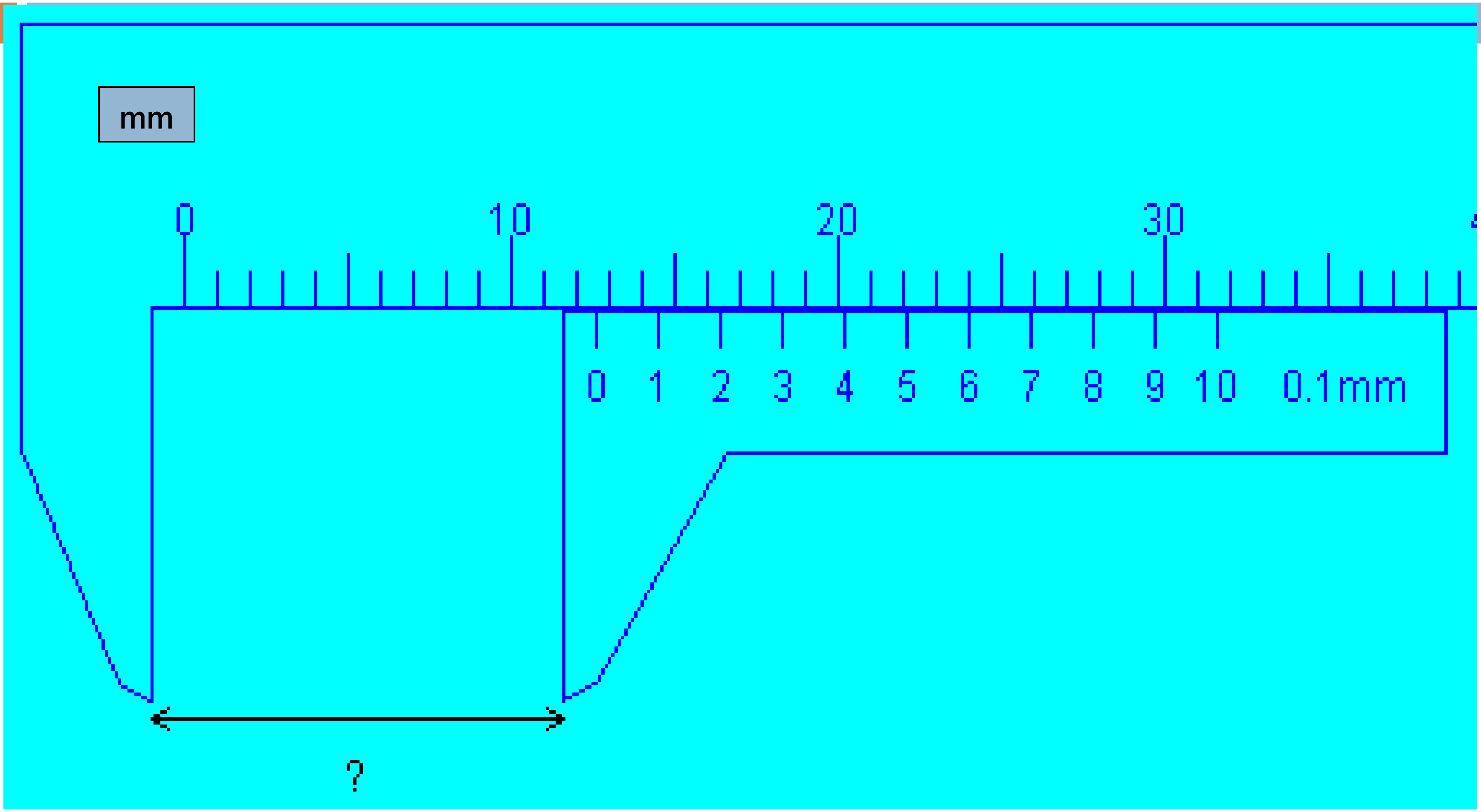
Exercise 4



MEASURE = 0.7 cm + 0.03 cm

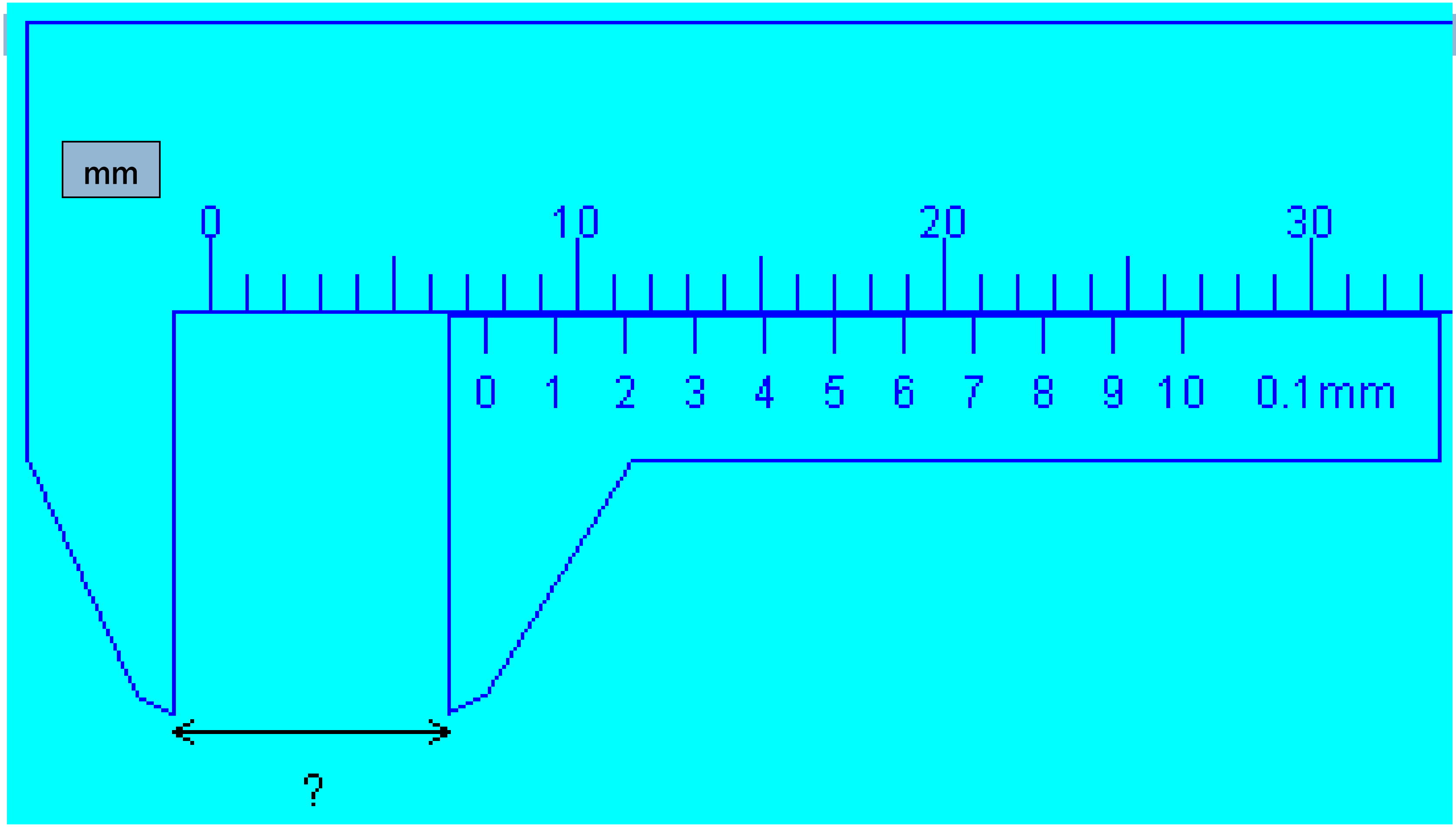
MEASURE = 0.73 cm

Exercise 5



Reading = 12 mm + 0.6 mm = 12.6 mm

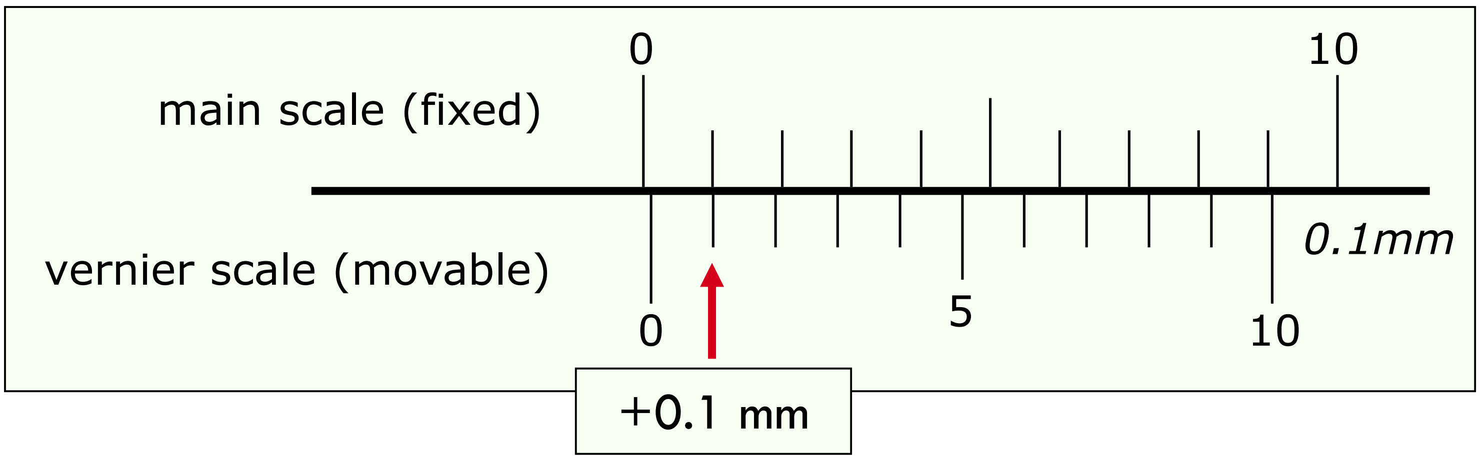
Exercise 6



Reading = 7 mm + 0.5 mm = 7.5 mm

Vernier Calipers

- **Zero Error (Vernier Calipers)**
  - Positive Zero Error



Zero Error = +0.1 mm

If the observed reading = 32.4mm, then

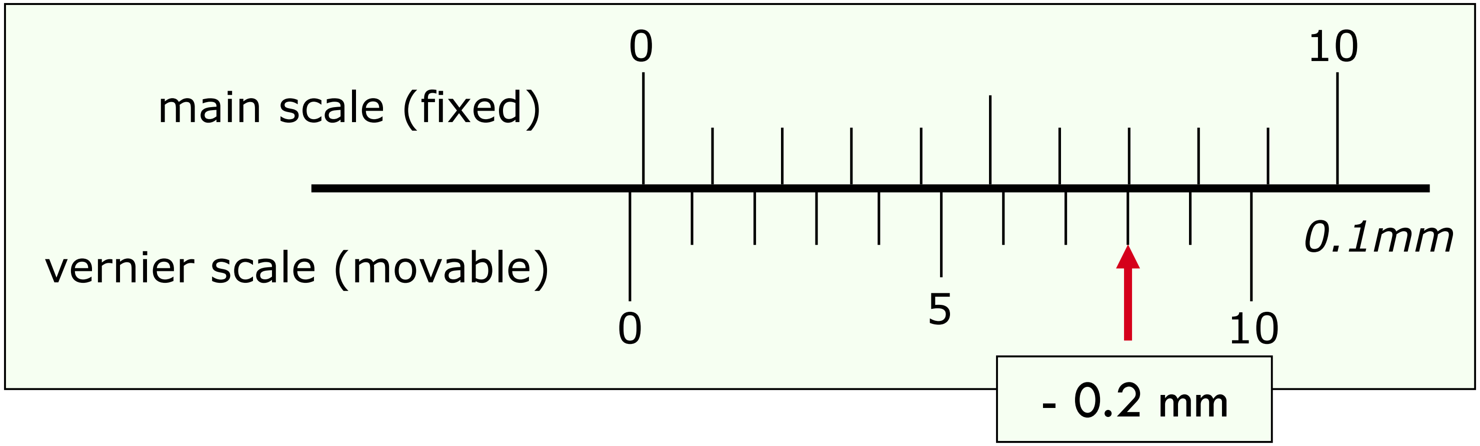
Actual measurement = Observed reading – Zero error

= 32.4 - (+0.1) mm

= 32.3 cm

Vernier Calipers

- **Zero Error (Vernier Calipers)**
  - Negative Zero Error



Zero Error = - 0.2 mm

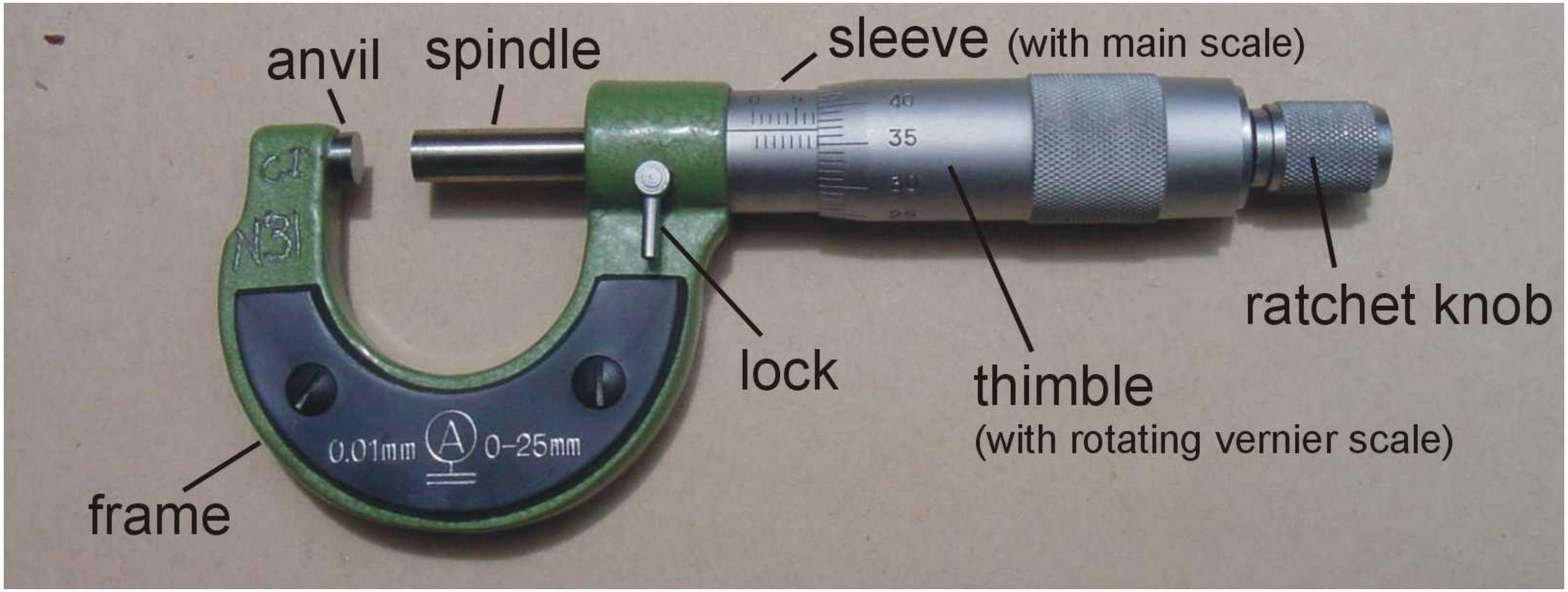
If the observed reading = 32.4 mm, then

Actual measurement = Observed reading – Zero error

= 32.4 - (-0.2) mm

= 32.6 mm

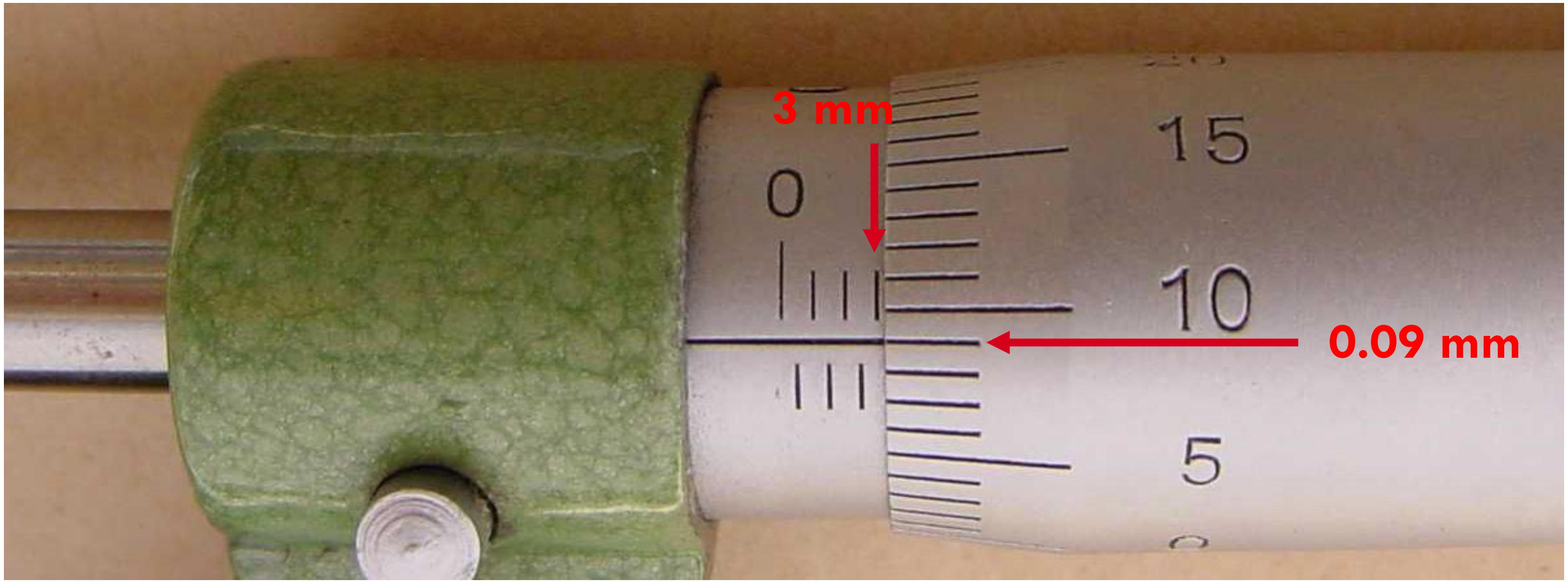
Micrometer Screw Gauge



Accuracy: 0.001 cm (or 0.01 mm)

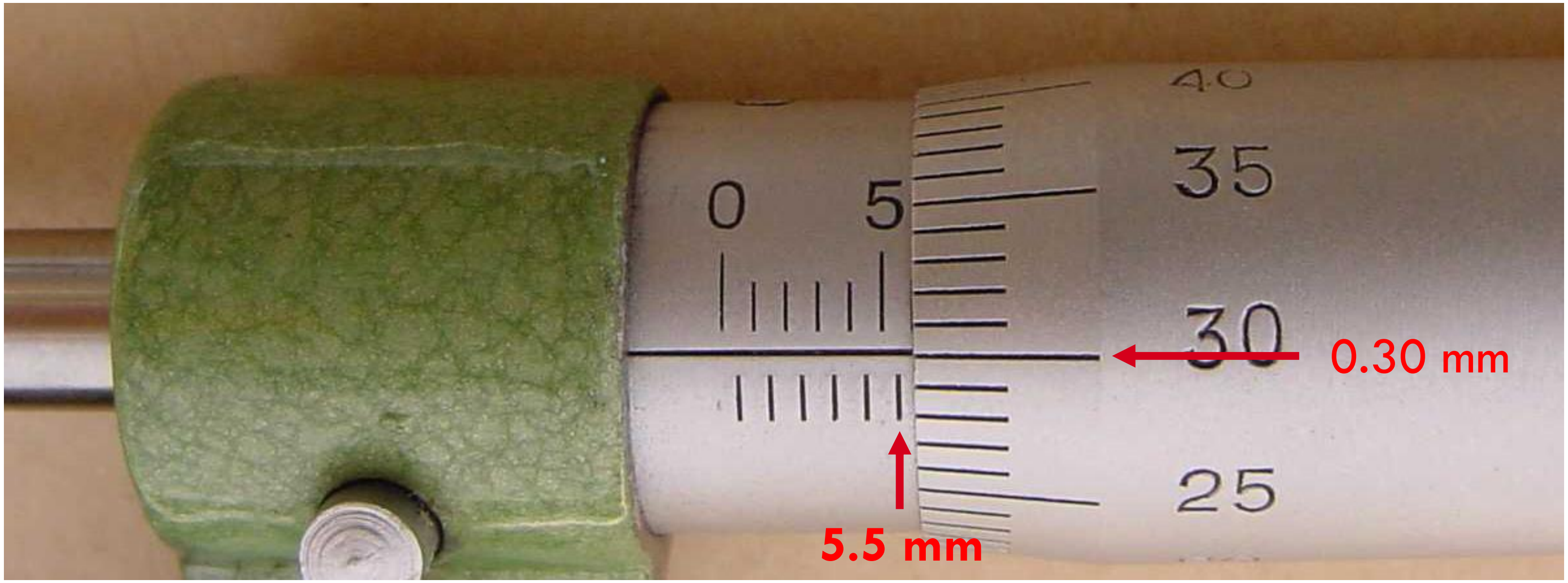
- Smaller length, such as diameter of thin wire, thickness of a piece of paper etc can be measured by **micrometer screw gauge.**

Micrometer Screw Gauge



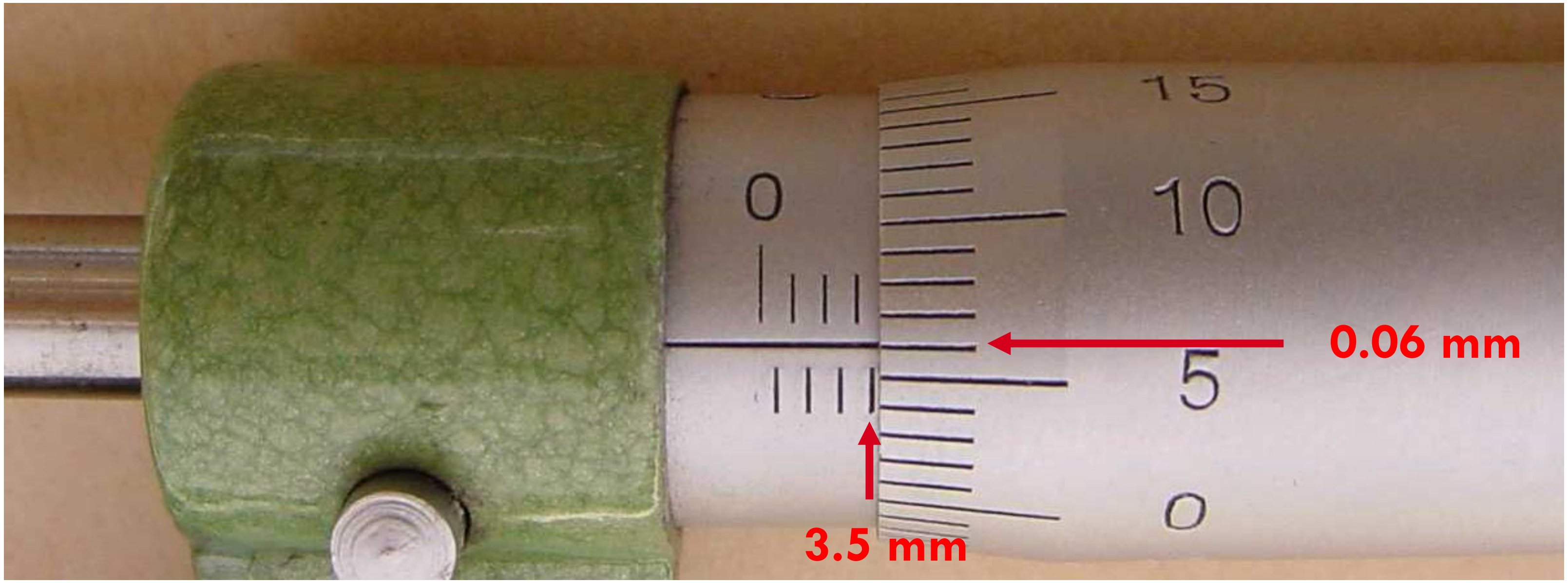
Sleeve reading	=	3.0	mm
Thimble reading	=	0.09	mm
Reading	=	3.09	mm
Reading	=	0.309	cm

Micrometer Screw Gauge



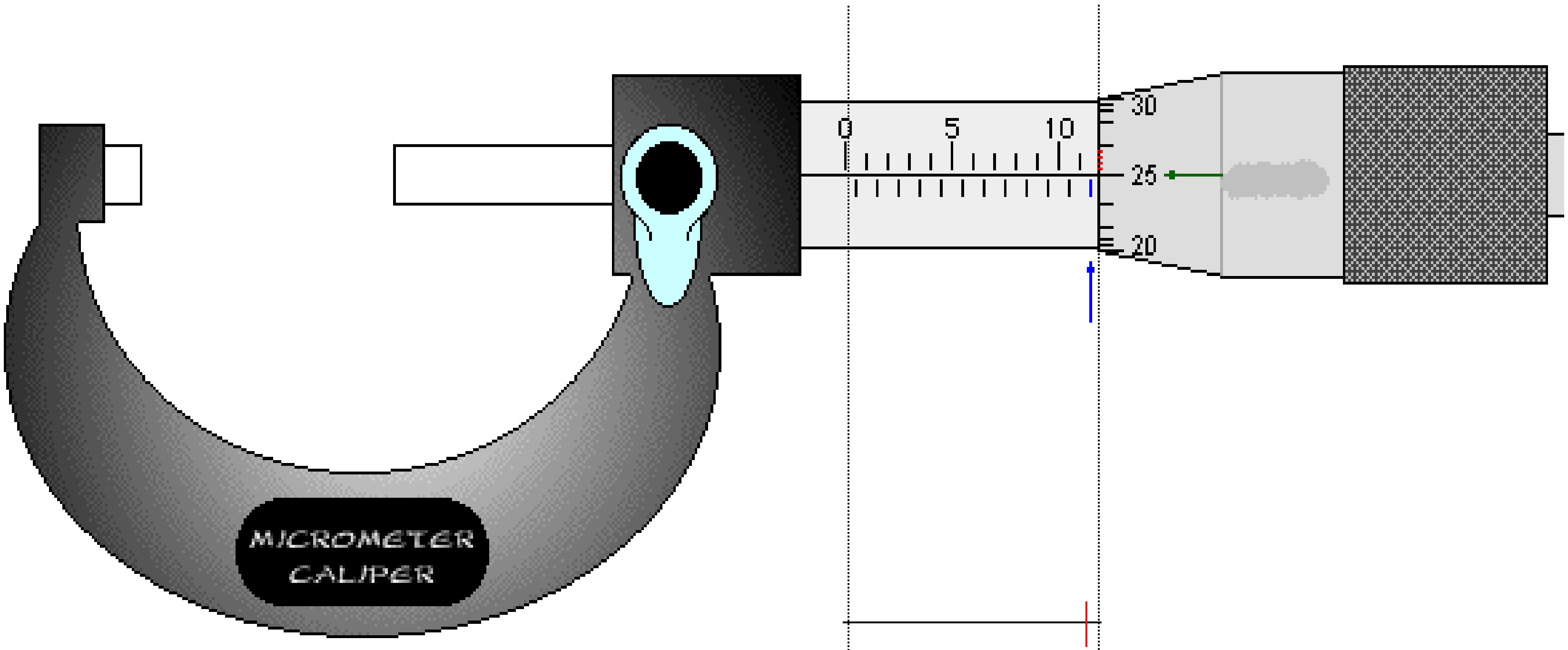
Sleeve reading	=	5.5	mm
Thimble reading	=	0.30	mm
Reading	=	5.80	mm
Reading	=	0.580	cm

Micrometer Screw Gauge



Sleeve reading	=	3.5	mm
Thimble reading	=	0.06	mm
Reading	=	3.56	mm
Reading	=	0.356	cm

Exercise 1

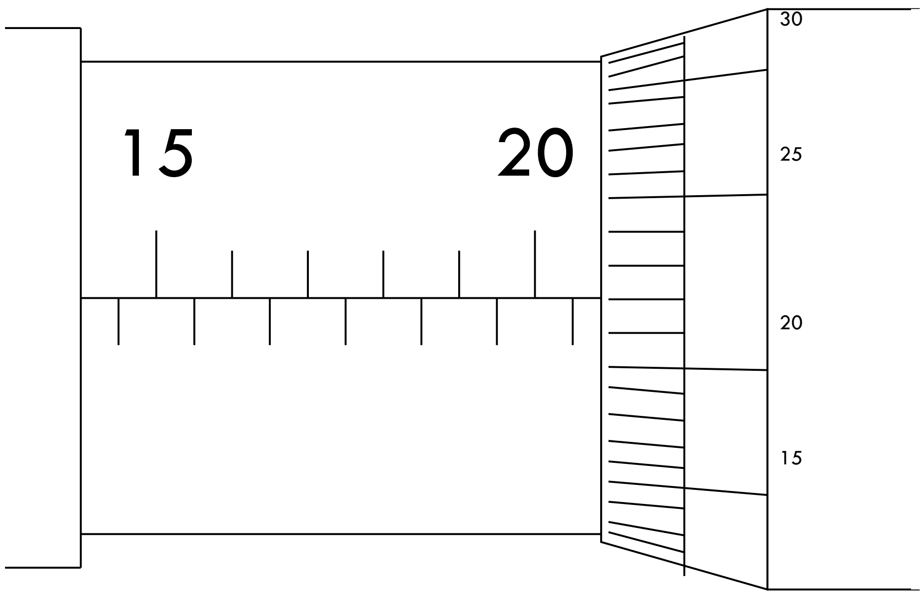


11.5mm

0.25mm

Reading = 11.5 mm + 0.25 mm = 11.75 mm

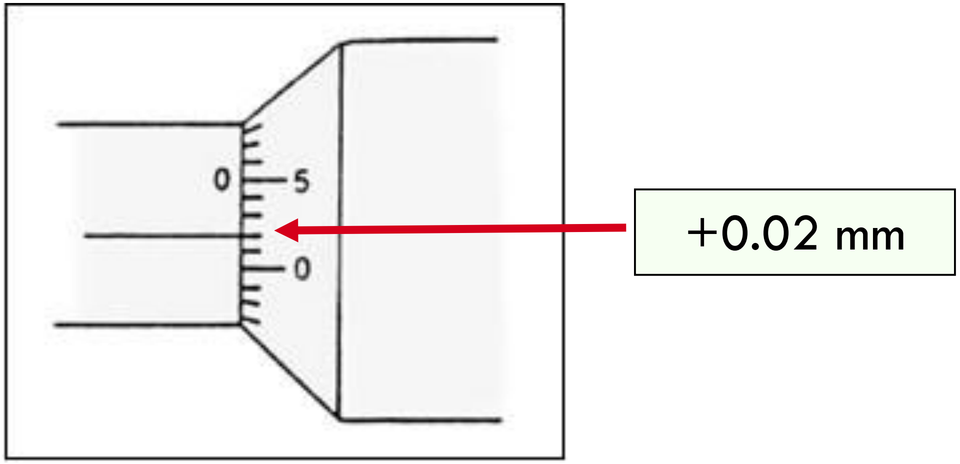
Exercise 2



Reading = 20.5 mm + 0.22 mm = 20.72 mm

Micrometer Screw Gauge

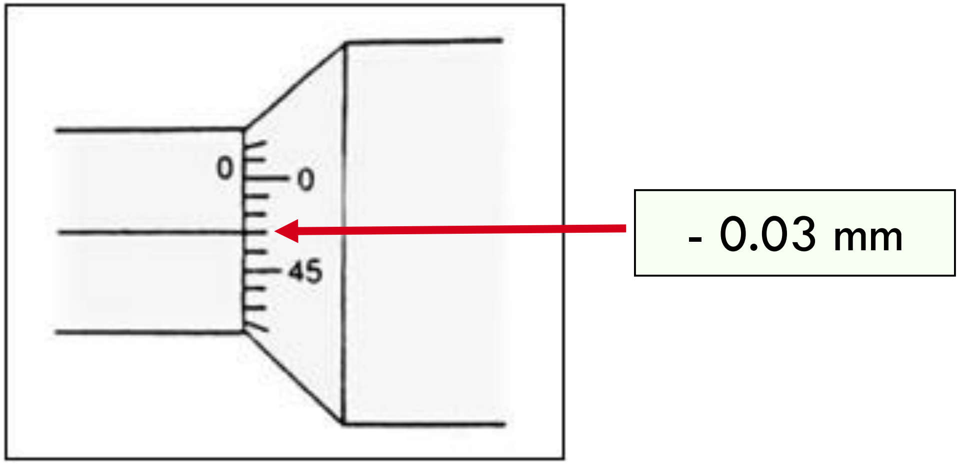
- **Zero Error (Micrometer Screw Gauge)**
  - Positive Zero Error



Zero Error = +0.02 mm
If the observed reading = 2.37mm, then
Actual measurement = Observed reading – Zero error
= 2.37 - (+0.02) mm
= 2.35 mm

Micrometer Screw Gauge

- **Zero Error (Micrometer Screw Gauge)**
  - Negative Zero Error



Zero Error = - 0.03 mm

If the observed reading = 2.37mm, then

Actual measurement = Observed reading – Zero error

= 2.37 - (- 0.03) mm

= 2.40 mm

Measurement of Time

- Stopwatches are used to measure short intervals of time.
- **Two types:**
  - **Digital stopwatch**
  - **Analogue stopwatch**

- **SI unit of time: second, s**

Measurement of Time

Instruments	Usage	Accuracy of Instruments
Watch/Clock	hrs, mins, sec	1 s
Analogue Stopwatch	mins, sec	0.1 s
Digital Stopwatch	mins, sec	0.01 s
Atomic Clock	about 10^{-10} s	-
Pendulum Clock	hrs, mins, sec	-
Radioactive decay clock	thousand of years	-

Measurement of Time

- Watch/Clock
  - used for measuring long intervals of time
  - most modern watches depend on the vibration of quartz crystals to keep time accurately
  - the energy that keeps these crystals vibrating comes from a small battery
  - many watches still make use of coiled springs to supply the needed energy

Measurement of Time

- Stopwatch (Analogue/Digital)
  - A stopwatch is used to measure short intervals of time.
  - stopwatches (analogue and digital)

Analogue Stopwatch
accuracy = 0.1 s

Digital Stopwatch
accuracy = 0.01 s

Measurement of Time

- Atomic Clock
  - Atomic clock also work on oscillation.
  - The big difference between a standard clock in your home and an atomic clock is that the oscillation in an atomic clock is between the nucleus of an atom and the surrounding electrons.

Measurement of Time

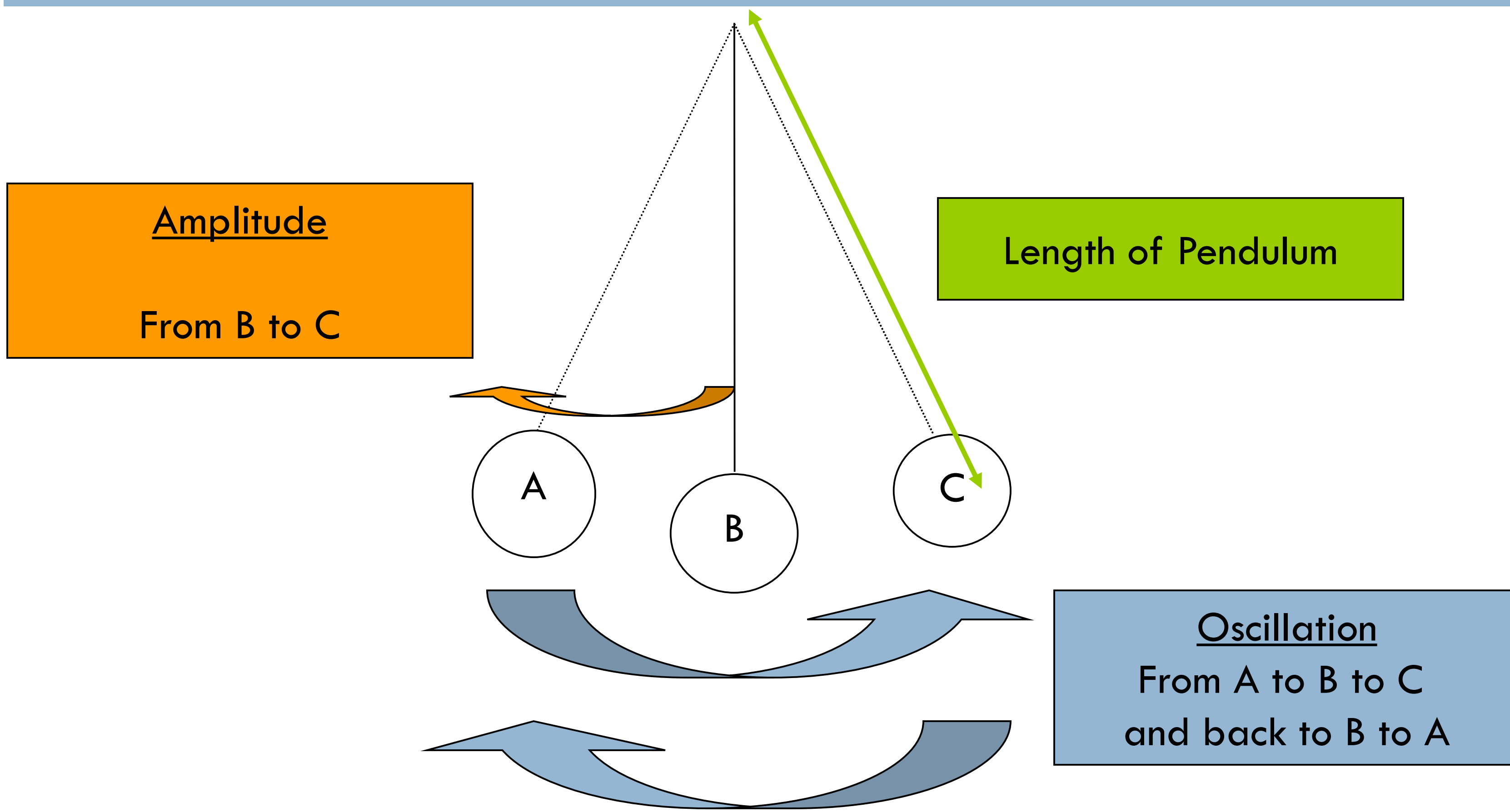
Pendulum Clock

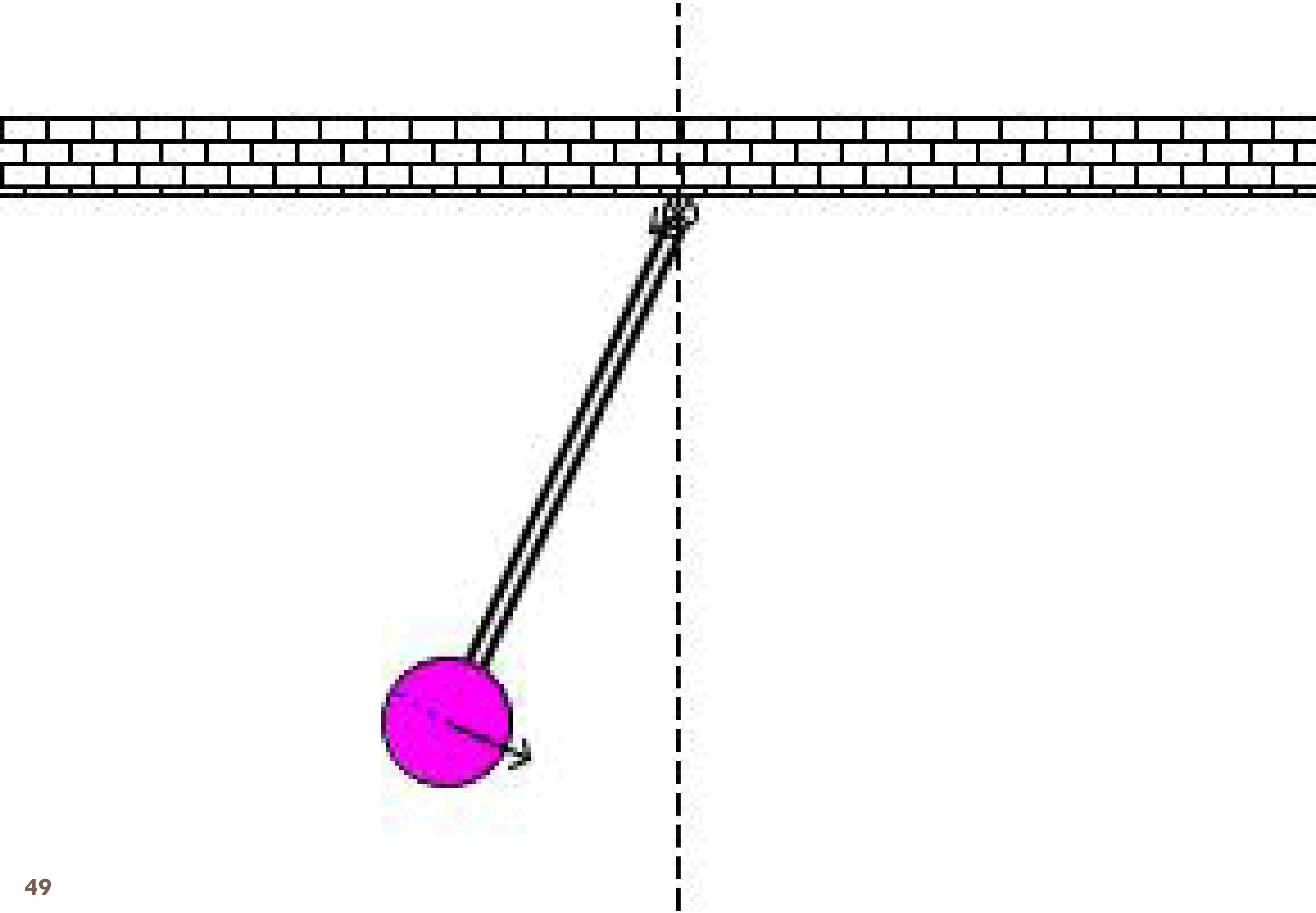
- clocks make use of a process which is a regularly repeating motion (oscillations), such as the swing of a pendulum
- such oscillations are very regular so period is regular
- most modern clocks depend on the vibration of quartz crystals to keep time accurately
- in clocks that are wound up, elastic potential energy is stored in coiled springs

What is a pendulum?

- A small object suspended by a piece of string or tread is called a simple pendulum.
- The distance from the centre of the pendulum bob to the point of suspension is called the **length of the pendulum**.
- One complete to and fro movement of the pendulum is called an **oscillation**.
- The time taken for one complete oscillation is called the **period**.
- The distance between the rest position of the pendulum and the extreme point of its oscillation is called the **amplitude**.

Diagram of a Pendulum





Finding the Period of a Pendulum

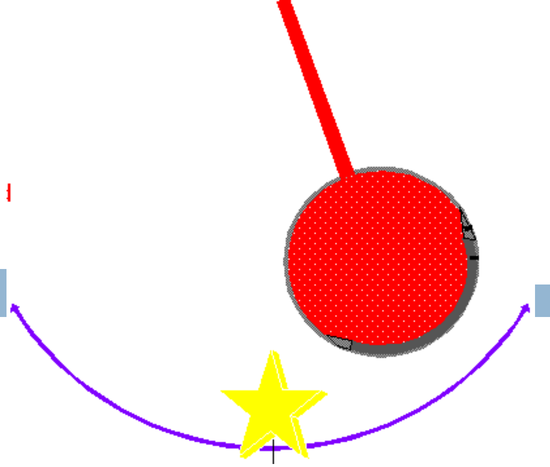
- To find the period:
- 1. Take the total time for 20 oscillations.

  Why 20?
- 2. Repeat 2 more times.
- 3. Calculate the average time for 20 oscillations.
- 4. Divide by 20 to obtain the period.

What Affects the Period of a Pendulum?

- Mass? ✗
- Amplitude? ✗
- Length? ✓

Simple Pendulum



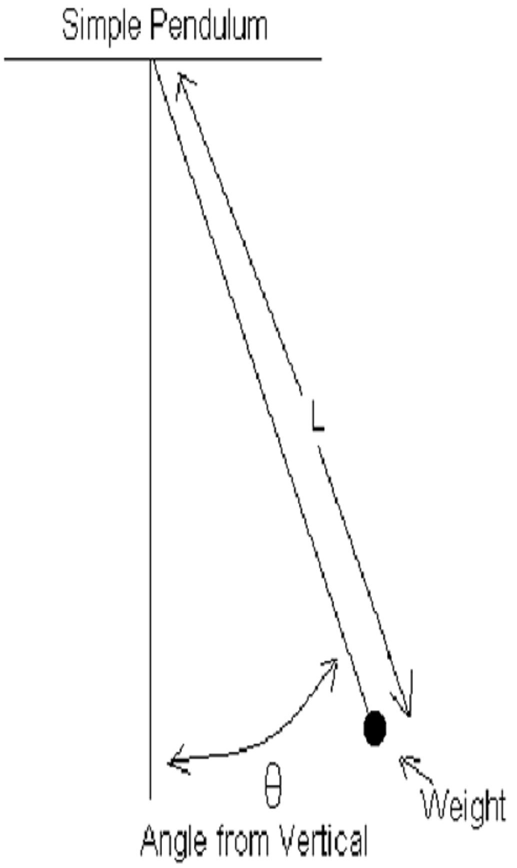
- When the <u>length increases</u>, the <u>period increases.</u>
- When the <u>length decreases</u>, the <u>period decreases.</u>

- When the <u>mass</u> of the bob <u>increases/decreases</u>, there is <u>no effect</u> on the period.

Simple Pendulum

- **When the <u>amplitude</u> of the bob <u>increases/decreases</u>, there is <u>no effect</u> on the period.**

- **When the same experiment is done on the <u>moon</u>, the period <u>increases</u>.**



Pendulum Exercise

The time taken for a pendulum to swing from rest position A to B is 0.8s. What is the time taken for the pendulum to make 20 oscillations?