Chpt 1 – Measurement in 2 Pages

CONCEPT FIRST Your Physics Tuition Specialist

Focus 1 – Physical Quantities

Central Idea / Skill: Units and Prefixes

- A physical quantity cnsists of a numerical magnitude and **unit** (e.g. 25 **ms^{-1}**).
- Physical quantities are classified into

(a) Base Quantities

Base Quantity	Name of SI Unit	SI Unit
Length	metre	m
Mass	kilogram	kg
Time	second	s
Temperature	kelvin	K
Current	ampere	A
Amount of Substance	mole	mol

(b) Derived Quantities

Derived Quantity	Relation with Base Quantity	Symbol for Unit
area	length x width	m^2
speed	distance / time	m/s or m s^{-1}
density	mass / volume	kg/m^3 or kg m^{-3}

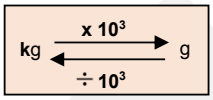
Prefixes for SI Units

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

E.g. 3215 **k**g = 3125 x **10^3** g = 3125000 g or 3.125 x **10^6** g
700 **n**m = 700 x **10^{-9}** m = 0.000000700 m or 7.00 x **10^7** m
0.000032 s = 32 x **10^{-6}** s = 32 μs

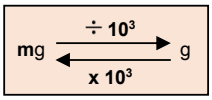
Conversion of Units

(a) kg and g



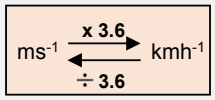
E.g. 2.1 kg = 2100 g

(b) mg and g



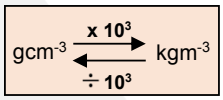
E.g. 25 g = 25000 mg

(c) ms^{-1} and kmh^{-1}



E.g. 20 ms^{-1} = 72 kmh^{-1}

(d) gcm^{-3} and kgm^{-3}



E.g. 7900 kgm^{-3} = 7.9 gcm^{-3}

- The follow tables show the orders of magnitude (approximation expressed in powers of ten) of some masses and lengths.

Mass / kg	Order of Magnitude
Electron	10^{-30}
Proton	10^{-27}
Ant	10^{-3}
Human	10^1
Earth	10^{24}
Sun	10^{30}

Length / m	Order of Magnitude
Radius of a proton	10^{-15}
Radius of an atom	10^{-10} m = 0.1 nm
Height of an ant	10^{-3}
Height of a human	10^0 = 1
Radius of the Earth	10^7 m = 10 Mm
Radius of the Sun	10^9

Scalars and Vectors

- DefN: A scalar quantity has magnitude but no direction. E.g. mass, time, distance, speed, work, energy, power, pressure.
- DefN: A vector quantity has magnitude and direction. E.g. displacement, velocity, acceleration, force.
- The resultant of adding 2 vectors can be determined using 3 methods (see Unit 3 – Forces for further elaboration)

1. Tip-to-tail
2. Parallelogram
3. Trigonometric (in some IP schools only)

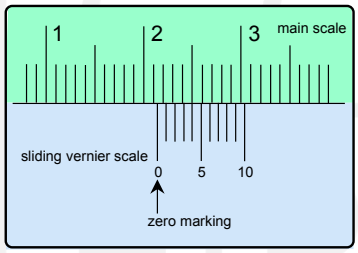
Focus 2 – Measurement of Length

Central Idea / Skill: Precision of Instruments

- SI unit : metre (m)
- Precision is the smallest unit an instrument can measure.
- To measure the length of an object, the instrument with the highest precision in which the object can fit within its range is chosen.

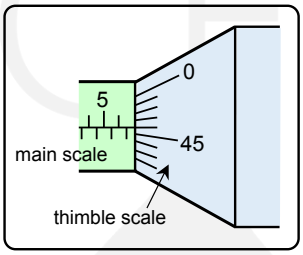
Instrument	Measuring range	Example	Precision (in cm)	Precision (in mm)
Measuring Tape	Several metres	Vehicles	0.1 cm	1 mm
Metre Rule	Several cm to 1 m	Length of a Book	0.1 cm	1 mm
Vernier Calipers	Between 1 cm to 10 cm	Diameter of test tubes	0.01 cm	0.1 mm
Micrometer Screw Gauge	Less than 2 cm	Thickness of wires	0.001 cm	0.01 mm

Vernier Calipers



How to Read
Main scale reading is **2.1** cm. The **4**th marking on the sliding vernier scale is aligned with the marking on the main scale. Therefore, reading is **2.1 + 0.04 = 2.14** cm

Micrometer Screw Gauge

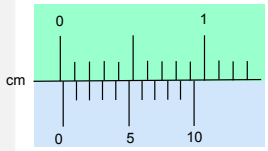


How to Read
Reading on the main scale is **6.5** mm.
Reading on the thimble scale is **0.46** mm.

Therefore, reading is **6.5** + **0.46** = **6.96** mm

Zero Error Correction

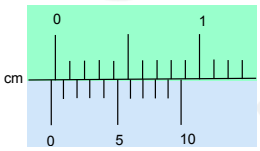
Positive Zero Error:



Zero error = +0.02 cm

Corrected Reading
= L - (+0.02)

Negative Zero Error:

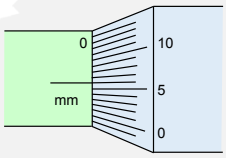


Zero error = -0.03 cm
(read from the 10, leftward)

Corrected Reading
= L - (-0.02)

Zero Error Correction

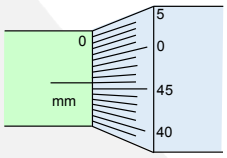
Positive Zero Error:



Zero error = +0.06 mm

Corrected Reading
= L - (+0.06)

Negative Zero Error:



Zero error = -0.04 mm

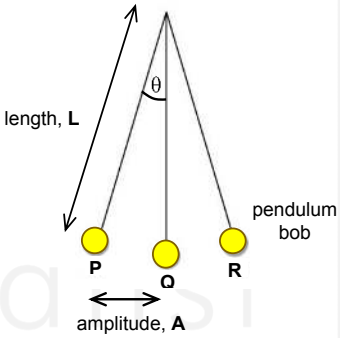
Corrected Reading
= L - (-0.04)

Focus 3 – Measurement of Time

Central Idea / Skill: Regular Time Intervals (Periodicity)

- SI unit : seconds (s)

Pendulum



- A complete to and fro motion is one oscillation. *(e.g. P– Q – R– Q – P)*
- The distance from P to Q is called the amplitude of the oscillation, **A**.
- The pendulum will complete every oscillation at regular time intervals called the period.
- DefN: The period, **T** is the time taken for one complete oscillation.
- The frequency, **f** refers to the number of complete oscillations in one second.
  SI Unit: Hertz (Hz)
- The frequency **f** of a pendulum is related to its period **T** by the following equation

$$f = \frac{1}{T}$$

Determining the Period of a Pendulum

1. Set the pendulum to oscillate. This is done by displacing the pendulum bob at a small angle of θ less than 10° and release.
2. When the motion is steady, start the stopwatch when the swing is at one end of its motion (e.g. at P)
3. Stop the stopwatch after 20 oscillations. Record the time t_1.
4. Repeat steps 2-3 for another set of reading t_2.
5. Take average $\langle t \rangle = \frac{t_1 + t_2}{2}$.
6. The period T is given by $T = \frac{\langle t \rangle}{20}$.

Chpt 2 - Kinematics in 2 Pages

Focus 1 – Kinematics Terms and Equations

Central Idea / Skill: Rate

Distance and Speed

- Scalar quantities
- Distance is the total length covered between two points.
- DefN: Speed is the change in distance per unit time.
  For objects moving at constant speed, its value it given by:

$$\text{speed} = \frac{\text{distance covered}}{\text{time taken}}$$

For objects moving at non-constant speed, the average speed is given by:

$$\text{average speed} = \frac{\text{total distance covered}}{\text{total time taken}}$$

- SI Unit: m/s or m s^{-1}

Displacement, Velocity and Acceleration

- Vector quantities
- Displacement is distance moved in a specified direction
- DefN: Velocity is the change in distance in a specified direction (displacement) per unit time.

$$\text{average velocity} = \frac{\text{displacement}}{\text{total time taken}}$$

- DefN: Acceleration is the change in velocity per unit time.

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}} \quad \text{i.e.} \quad a = \frac{v - u}{t}$$

- SI Unit: m/s^2 or m s^{-2}
- Acceleration occurs when a body is

  (a) changing magnitude of its speed

  (b) changing direction

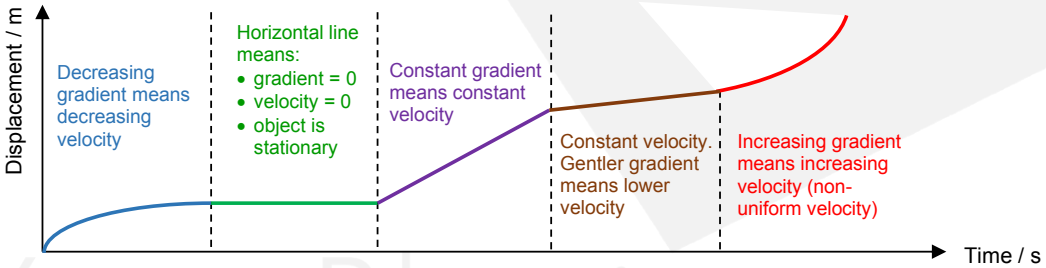
- A body moving with uniform acceleration experiences a constant rate of change of velocity.

Focus 2 – Motion Graphs

Central Idea / Skill: Gradient and Area

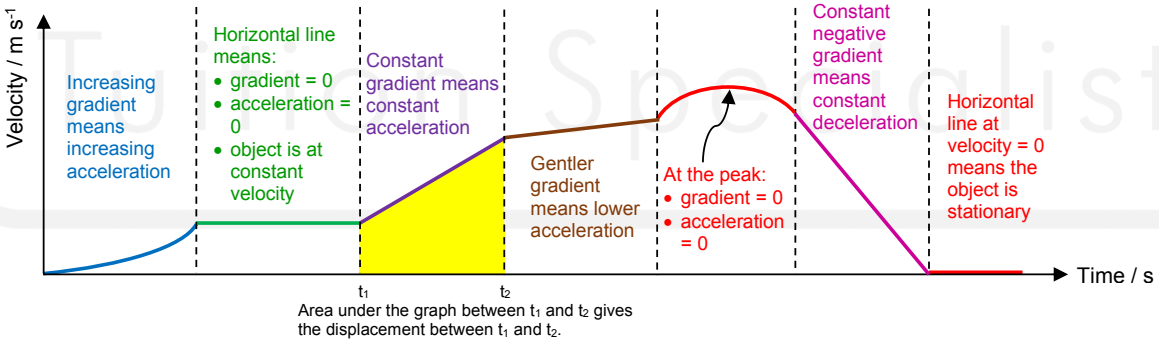
Displacement-Time Graph

- The average velocity can be calculated using average velocity = $\frac{\text{change in displacment}}{\text{time taken}}$.

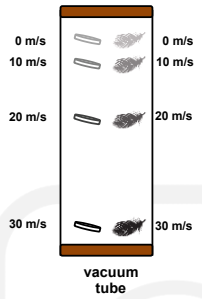


Velocity-Time Graph

- The gradient of velocity-time graph gives the acceleration.
- Area under the velocity-time is equivalent to the displacement of the object.



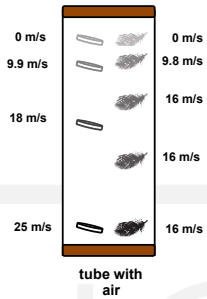
Objects falling without Air Resistance



- In the absence of air resistance, all falling objects fall with the same constant acceleration.
- This acceleration is known as acceleration of freefall and is determined to be 10 m/s^2.

Despite having different masses, both coin and feather will fall with the same acceleration.

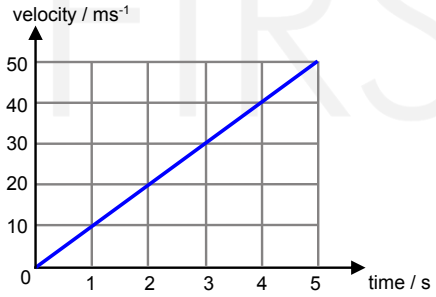
Objects falling with Air Resistance



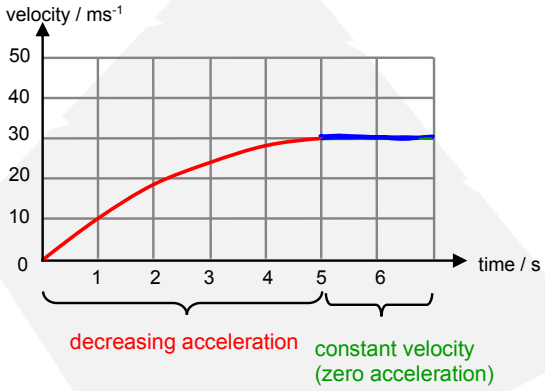
- When the feather is released, it accelerates under the influence of gravity.
- As it speeds up, the air resistance increases.
- This causes the resultant downward force acting on the feather to decrease. As a result, the acceleration decreases.
- Eventually, the magnitude of the upward air resistance equals the magnitude of the downward weight.
- This leads to the resultant force acting on the feather to be zero. The acceleration also becomes zero and the feather reaches it maximum velocity called the terminal velocity.

The feather has less weight is subjected to greater air resistance due to its larger cross-sectional area. As a result, it reaches a lower terminal velocity is a shorter time.

Velocity-time graph of a free-falling object



Velocity-time graph of a falling object through air



- Free fall is defined as the motion of an object under the influence of gravity only i.e. the only force acting on the object is its own weight.
- Air resistance tends to slow down a moving object. It has the following properties.

  (a) It always opposes the motion of objects.
  (b) It increases with the speed of the object.
  (c) It increases with cross-sectional area of the object.