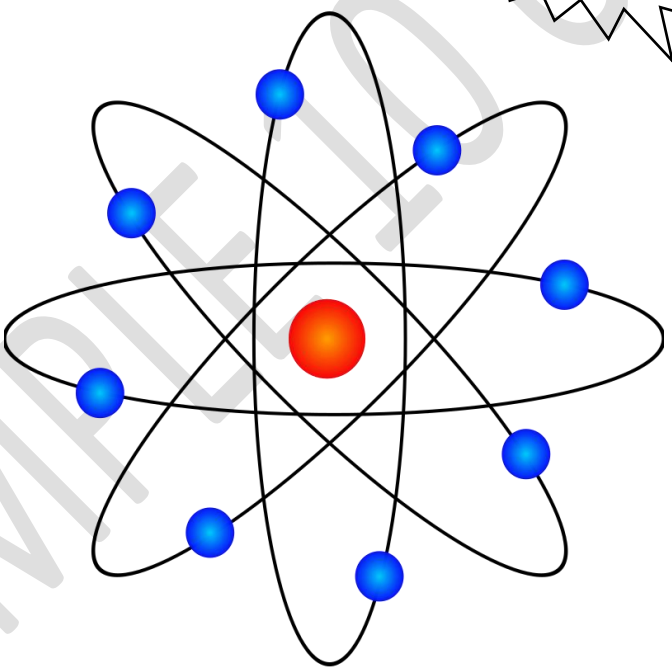
Marks Oriented Notes

O Level Physics (5054)

IGCSE Physics (0625)

Second Edition



Authored by

Sir Abdul Ahad Irfan Poshni

Scholastic (Boys Section) / TaughtWare Academy

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PREFACE

I am truly grateful to my Creator, who has given me some wonderful mentors at certain Islamic schools, thus enabling me to achieve feats such as this. I am also thankful to those of my students, whose feedback helped me improve these notes.

You will find these notes pretty mark-oriented. These notes can be a replacement for a textbook if you have a teacher.

My advice to students is that once you have covered some topics in class, then adopt this workflow:

- use these notes to revise
- practice related past paper questions
- discuss difficulties with your teacher

Abdul Ahad
Teacher

EXCLUDED TOPICS

Physics syllabus is revised by CAIE from time to time. Therefore, you may come across questions related to certain topics in past-papers that are no longer relevant. Here is a list of topics that have been excluded:

- Use of vernier scale
  (However, students still need to know other details related to vernier calipers, e.g., their ability to measure accurately to one-tenth of a millimeter, their ability to measure internal diameter, etc.)
- Transmission of pressure in hydraulic systems
- Use of manometer
- Principles of thermometry
- Practical thermometers
- Specific latent heat
  (However, latent heat has not been excluded.)
- Experiments related to refraction of sound waves
- Internal structure of a cathode-ray oscilloscope (CRO)
  (However, use of CRO has not been excluded.)
- Capacitors
- Applications of electrostatic charging
- Wiring a mains plug
- Methods of magnetization and demagnetization
- Magnetic screening
- Truth tables, transistors, logic gates, bistable and astable circuits
- Thermionic emission
- Power rating of resistors and other components
- Use of the formula: $E = mc^2$

UNIT 1: MEASUREMENT

- Physical quantities are either scalars or vectors.
- Scalars don't have a direction, e.g., distance, speed or time.
- Vectors have a direction, e.g., displacement, velocity or force.
- SI base units include:
    - m
    - kg
    - s
    - A
    - K
- Derived units are based on base units, e.g.,
    - Speed: m/s
    - Density: kg/m^3
- Prefixes can be used if a unit is too big or too small for a purpose:
    - mega (M) means 1,000,000
    - kilo (k) means 1,000
    - centi (c) means $\frac{1}{100}$
    - milli (m) means $\frac{1}{1000}$
    - micro (μ) means $\frac{1}{1000000}$
- Measurement of Length:

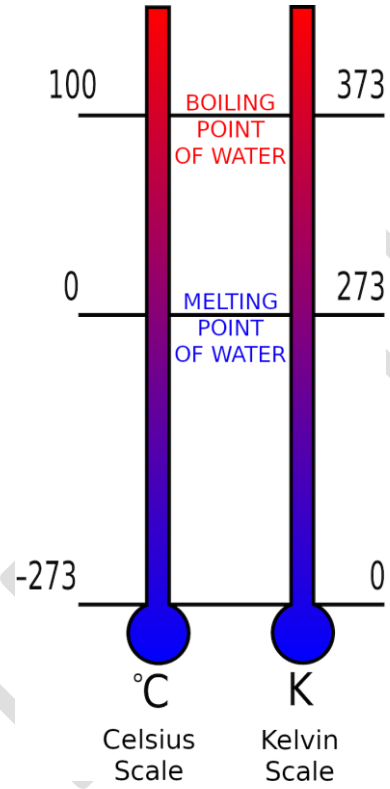
NAME	LEAST COUNT	SUITABILITY	RANGE
Ruler	1 mm or 0.1 cm		1 m
Measuring tape	1 mm or 0.1 cm	can measure curved distance	10 m
Vernier calipers	0.1 mm or 0.01 cm	can also measure internal diameter	15 cm
Micrometer	0.01 mm or 0.001 cm	most accurate	2 cm

- Measurement using micrometer screwgauge:
  $\text{Length} = \text{FixedScaleReading} + \text{RotatingScaleReading} \times \text{LeastCount} \pm \text{ZeroError}$
- Zero error is the non-zero measurement (when vernier calipers or micrometer is) closed.
    - Zero error needs to be added or subtracted from the measurement for correction.

- Measurement of time:

NAME	LEAST COUNT	REMARK
Watch / Clock	1 s	
Stopwatch	0.01 s	
Ticker-tape timer	$\frac{1}{50}s \; or \frac{1}{60}s$	It has a vibrating arm which puts dots on a paper strip. Each gap (not dot) represents an interval.

- Measurement of temperature



- Conversion between Kelvin temperature (T) and Celsius temperature (θ):

$$T = \theta + 273$$

- Temperature of a substance depends on average speed of its molecules.
- **Absolute zero temperature:** It is the lowest possible temperature of 0 K or -273 °C, because molecules have least speed (or kinetic energy).

UNIT 2: MOTION

- **Displacement:** It is distance in a particular direction.
- **Speed:** It is distance covered per unit time.

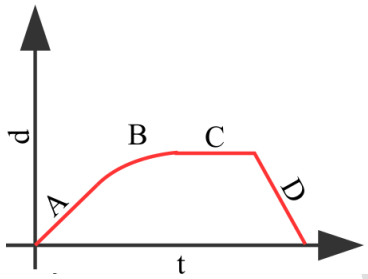
$$s = \frac{d}{t}$$

Use this formula for velocity too

- **Velocity:** It is displacement covered per unit time.
- **Acceleration:** It is change in velocity per unit time.

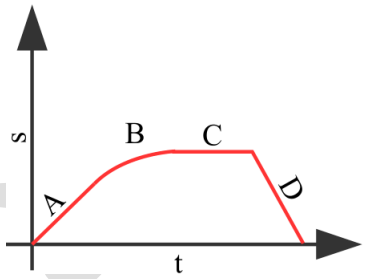
$$a = \frac{v - u}{t}$$

- Acceleration happens when
  - speed changes
  - or direction changes
- d-t graph
  - Gradient represents speed
  - Example:



A - Constant speed
B – Speed decreases (non-uniform speed)
C – Speed zero (object at rest)
D – Speeding back home (negative speed)

- s-t graph
  - Gradient represents acceleration
  - Area under graph represents distance
  - Example:



A - Constant acceleration
B – Acceleration decreases (non-uniform acceleration)
C – Acceleration zero (terminal velocity)
D – Decelerating (or negative acceleration or accelerating in opposite direction)

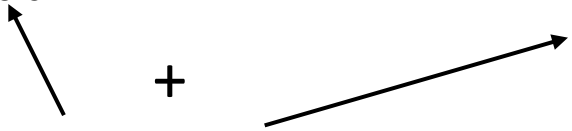
- **Uniform acceleration:** It is when there are equal increases in velocity per unit time.
- **Non-uniform acceleration:** It is when there are unequal increases in velocity per unit time.
- **Uniform deceleration:** It is when there are equal decreases in velocity per unit time.
- **Non-uniform deceleration:** It is when there are unequal decreases in velocity per unit time.
- **Uniform speed:** It is when equal distances are covered per unit time.
- **Non-uniform speed:** It is when unequal distances are covered per unit time.
- While driving,

$$stopping\ distance = thinking\ distance + braking\ distance$$

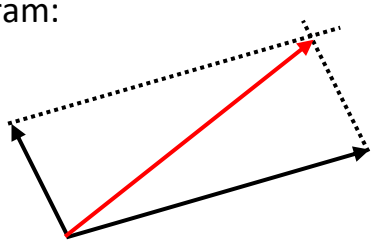
  - Thinking distance is affected by tiredness and alcohol
  - Braking distance is affected by load, tyre surface, etc.

UNIT 3: FORCES

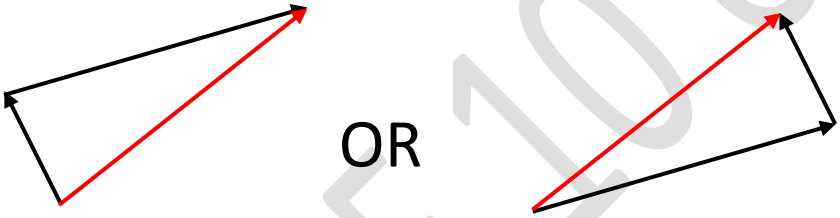
- **Force**: It is a push or pull.
    - Unit: N
- These are also forces: weight; tension; friction; magnetic force; electric force; air resistance; thrust; upthrust;
- Addition of vectors



    - Law of Parallelogram:



    - Head-to-tail Rule:



- Laws of Motion
    - **First Law:** An object either <u>remains</u> at rest, or continues to move in a straight line at constant speed unless acted on by a resultant force.
    - **Second Law:** Acceleration of a mass is directly proportional to the resultant force.

$$F \propto a$$

$$F = m\,a$$

        - Acceleration has the same direction as the resultant force.
        - For an object going in a circle at constant speed, the resultant force (and hence acceleration) is towards the center of the circle.
    - **Third Law:** When object A exerts a force on object B, then object B exerts an <u>equal</u> and <u>opposite</u> force on object A.
- When forces are balanced
    - resultant force is zero
    - acceleration is zero
    - velocity is uniform

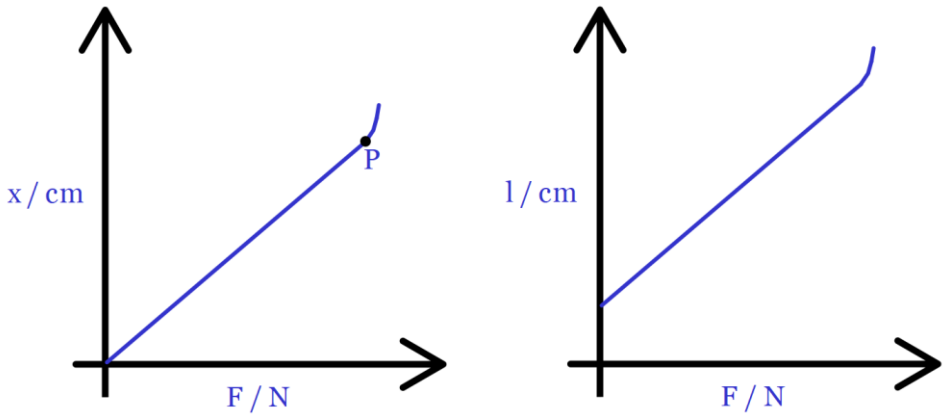
- With forces are unbalanced
    - resultant force is non-zero
    - acceleration is not zero
    - velocity is not uniform
- **Friction:** It is a force that opposes motion.
    - It produces heat.
- Free-fall
    - Without air
        - Constant acceleration (like that on moon).
        - Objects of different weights fall together.
    - With air
        - Acceleration decreases (from initial 9.8 m/s^2 on Earth).
        - Resultant force is weight minus air-resistance.
        - When the resultant force becomes zero, there is no acceleration and the body is said to be falling with terminal velocity.

UNIT 4: DEFORMATION

- Force produces extension (or compression).
- **Extension:** It is the difference between new length and original length.
- **Hooke's Law:** Force is directly proportional to extension up to limit of proportionality.

$$F \propto x$$
$$F = kx$$

  - where k is spring's constant
- **Spring's constant:** It is force per unit extension.
  - Unit: N/m
  - spring's constant k reflects stiffness of a spring
- Two possible graphs:



  - Point P is called limit of proportionality.
  - Beyond limit of proportionality, spring becomes easier to extend.
    - This means that same increase in force will now produce a greater extension than before.

UNIT 5: MASS, WEIGHT AND DENSITY

- **Mass:** It is the amount of matter (substance) in a body.
- **Weight:** It is force on a mass in a gravitational field.
    - It is equal to product of mass and gravitational field strength.

$$W = mg$$

- Comparison:

WEIGHT	MASS
It is a force	It is amount of matter
Unit is newton	Unit is kilogram
Vector	Scalar
Different on earth and moon	Same on earth and moon
Measured using newton meter	Measured using balance

- **Inertia:** The inertia of an object is its resistance to changes in motion.
    - Mass is a measure of an object's inertia.
    - For example, a truck has more mass and hence more inertia than a car. So a truck is harder to move and harder to stop.
- Gravitational field strength of Earth is 9.8 N/kg.
- Acceleration due to gravity on Earth is 9.8 m/s^2.
- Measuring instruments:
    - Newton-meter: More the weight, more the spring stretches.
        - Using the formula W=mg, it can have a scale for mass too. The value of 'g' is assumed in such a case.
    - Beam balance: Measures mass by comparing the weight of an unknown mass with the weight of known mass (e.g., disc).
- **Density:** It is the mass per unit volume.

$$\rho = \frac{m}{V}$$

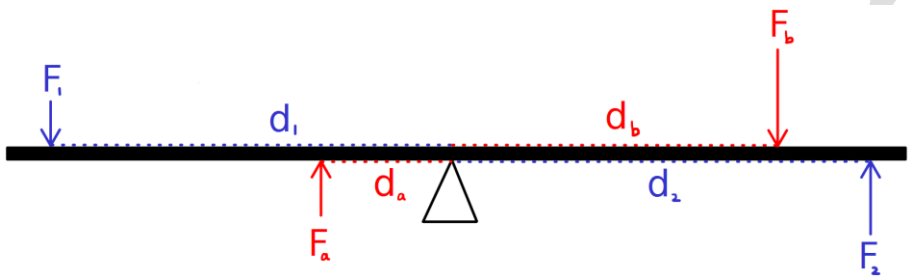
    - Unit: $\frac{kg}{m^3}$
- Measurement of volume: Volume can be found by
    - Displacing a liquid
    - For regular shaped objects a formula may be used, for example:
        - Block: $V = l \times w \times h$
        - Cylinder: $V = \pi r^2 \times l$
- Less dense liquids and gases rise above more dense liquids and gases respectively.

UNIT 6: TURNING EFFECT OF FORCES

- **Moment of a force:** It is product of force and perpendicular distance (between pivot and line of force).

$$Moment\ of\ force = F \times d$$

  - Moments can be clockwise or anticlockwise.
- **The Principle of Moments:** For a body in equilibrium, the sum of clockwise moments is equal to the sum of anticlockwise moments.
  - Example:



$$sum\ of\ anticlockwise\ moments = sum\ of\ clockwise\ moments$$

$$(F_1 \times d_1) + (F_2 \times d_2) + \cdots = (F_a \times d_a) + (F_b \times d_b) + \cdots$$

- **Centre of mass:** It is the point through which the whole weight of an object seems to act for any orientation of the object.
  - Centre of mass of an object (such as ring) can lie outside the object.
- Experiment to determine centre of mass of a plane lamina:
  - set lamina swinging (to ensure minimal friction at pivot)
  - allow to come to rest
  - use of plumb line from hole
  - mark line along plumb line (on lamina)
  - hang from another hole and repeat
  - hang from 3rd hole and repeat
  - point of intersection of lines is centre of mass
- **Stability:** It is the ability of an object to regain its original position after it has been tilted slightly.
- Stable objects have
  - low centre of mass
  - broad base

UNIT 7: WORK, ENERGY AND POWER

- **Energy:** It is the ability to do work.

$$E = W$$

- **Work:** It is the product of force and the distance moved parallel to the direction of force.

$$W = F \times s$$

  - Unit: J — Joule actually means Nm

- Forms of energy:
  - nuclear
  - radiant (e.g., light, X-rays, etc.)
  - electrical
  - thermal
  - chemical (potential) energy
  - **Elastic (potential) energy:** It is the energy due to condition of being stretched or compressed.
  - **Gravitational potential energy:** It is the energy due to position (in a gravitational field).

$$E = Wh$$
$$E = (mg)h$$

  - **Kinetic energy:** It is the energy due to motion of a mass.

$$E = \frac{1}{2}mv^2$$

- **Principle of conservation of energy:** Energy can be converted from one form to another but the total amount remains constant.
- **Power**: It is work done per unit time.

$$P = \frac{W}{t}$$

(OR) It is energy converted per unit time.

$$P = \frac{E}{t}$$

  - Unit: W — Watt actually means joules (converted) per second

- A relationship:

$$input\ energy = useful\ output\ energy + wasted\ energy$$

- Efficiency

$$efficiency = \frac{useful\ output\ energy}{input\ energy}$$
$$efficiency = \frac{useful\ power\ output}{power\ input}$$

Multiply by 100 to get a percentage

Renewable energy: Energy source that will not run out.

- Examples: solar, wind, hydroelectric, geothermal, etc.

- **Nonrenewable energy:** Energy source that will run out.
  - Examples: coal, oil, natural gas, nuclear,etc.

UNIT 8: PRESSURE

- Pressure: It is **the** force per unit area.

$$p = \frac{F}{A}$$

  - Unit: Pa — Pascal actually means N/m^2
  - Examples
    - Swords exert high pressure because they concentrate the force on a small area.
    - Skis exert low pressure on the snow because the weight is spread over a large area.
- Pressure of gases
  - Pressure of gases is due to molecular collisions.
  - Pressure of a gas can be increased by
    - decreasing volume
      - ❖ molecules closer → more frequent collisions
    - increasing mass
      - ❖ molecules closer → more frequent collisions
    - increasing temperature
      - ❖ molecules faster → more forceful and more frequent collisions
  - Atmospheric pressure
    - At sea level it is:

$$1\ atmosphere\ =\ 1.0\times10^{5}\ Pa\ =\ 76cm\ of\ Hg\ =\ 760mm\ of\ Hg$$

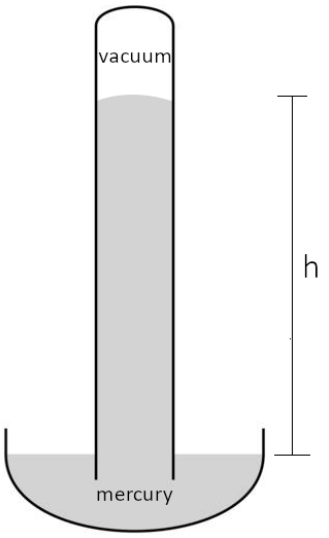
    - On a mountain top it is less.
    - In a deep mine it is more.
- Pressure of liquids

$$p = \rho g h$$

h is height of liquid <u>above</u>

  - Pressure of a liquid is due to weight of the liquid.
  - <u>Total</u> pressure beneath the surface of a liquid is the sum of atmospheric pressure and the liquid's pressure.
  - When something is immersed in a liquid, the liquid pushes it up. This <u>upthrust</u> is because the pressure near the top of the object is less and the pressure near the bottom of the object is more.

- Simple Mercury Barometer



  - Purpose: To measure atmospheric pressure.
  - Working: Pressure of atmosphere is equal to the pressure of liquid marked h.

$$p_a = p_l$$
$$p_a = \rho g h$$

- Boyle's Law:

$$p \propto \frac{1}{V}$$
$$p_1 V_1 = p_2 V_2$$

  - This formula assumes that
    - temperature remains same
    - mass remains same

UNIT 9: SIMPLE KINETIC THEORY OF MATTER

- **Kinetic theory of matter:** According to this theory, molecules of solids, liquids and gases are in continuous motion. This helps us understand and explain a range of phenomenon including:
    - diffusion
    - evaporation and other changes of state
    - pressure of a gas
    - why solids have a fixed shape
    - expansion
- Comparison of states of matter:

SOLID	LIQUID	GAS
Fixed shape	No fixed shape	No fixed shape
Fixed volume	Fixed volume	Fills all of available space
Most dense	Intermediately dense	Least dense
Incompressible	Incompressible	Compressible
Molecules vibrate about fixed positions	Molecules vibrate inside clusters, and can change position	Molecules move freely
Strong intermolecular forces	Fairly strong intermolecular forces	Weak intermolecular forces
Least speed (or kinetic energy)	Intermediate speed (or kinetic energy)	Most speed (or kinetic energy)
Least average separation between molecules	Intermediate average separation between molecules	Most average separation between molecules

- Evidence of molecular motion
    - Diffusion
    - Reflections from smoke particles in a glass cell are observed using a microscope. The smoke particles show random motion because of the air molecules hitting them.
    - Observing pollen on the surface of water

UNIT 10: MOMENTUM

- **Momentum:** It is product of mass and velocity.

$$p = m\,v$$

  - It is a vector quantity.
  - Unit: $\frac{kg\ m}{s}$
- **Impulse:** It is the change in momentum when force F acts on an object for time t.

$$impulse = F \times t$$

$$F \times t = p_2 - p_1$$

- **Resultant force:** It is change in momentum per unit time.

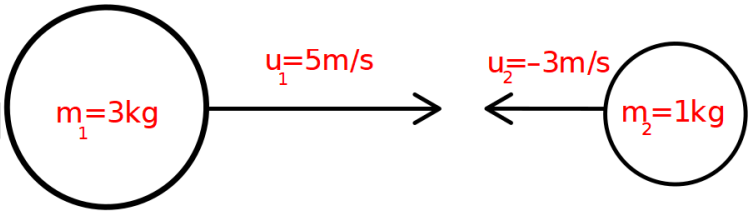
$$F = \frac{p_2 - p_1}{t}$$

- **Principle of conservation of momentum:** In absence of external forces, total momentum before collision equals total momentum after collision.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

When substituting values for velocities, signs are important. Therefore, assume one direction to be positive, and the opposite direction to be negative.

  - Example:



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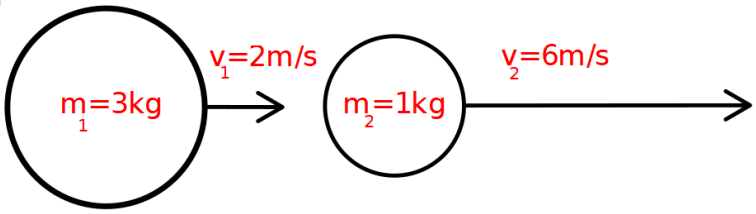

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