

PHYSICS SPM 2019
Important Notes For Paper 1

- 1 Physical quantity is a quantity that can be measured.
Non-physical quantity is a quantity that cannot be measured, like inertia, attitude, beauty and so on
- 2 Base quantities are quantities that cannot be defined in terms of other physical quantities.
Remember.....Five base quantities are mass (kg), time (second), length (metre), temperature (Kelvin), electric current (Ampere)
Derived quantities are quantities that are derived from base quantities by either multiplication or division or both
- 3 Scalar quantity is a quantity which has only magnitude or size.
Remember!!Both the **power** and **work done** are scalar quantity (work isn't directional)
Vector quantity is a quantity which has both magnitude and direction.
- 4 Error is the difference between the measured value with the actual value due to the uncertainty during measurement.

All measurements are approximation only. There are two types of errors: systematic error and random error.

Systematic error is an error due to the condition of the measuring instrument or the state of error in calibration of instrument.

Examples: Zero error, incorrect calibration, and wrong assumption.

All the readings **may look consistent**. This error will lead to a **decrease in accuracy** and can be improved by choosing appropriate instrument or proper technique of measuring.

Random error is an error due to the carelessness of the observer when taking measurement or due to a sudden change of ambient factors such as temperature and humidity of air.

Example: Parallax error, environmental factor.

All the readings **may not look consistent**. This error will lead to a **decrease in consistency** and can be improved by taking the mean value of repeating measurements.

Types of errors that may occurs during measurement:

Zero error is an error that arises when the measuring instrument does not start from exactly zero. The actual value is always **subtracted** to the zero error.

Parallax error is an error due to the wrong eyes positioning which is not in a line perpendicular to the plane of scale. Parallax error can be reduced by **placing a plane mirror underneath the scale of device**.

5 Characteristics of data

Consistency / Precision is the degree of measurement to get the readings which are close to each others with very small relative deviation. Consistency of data can be improved by avoiding the parallax error or repeating the measurements.

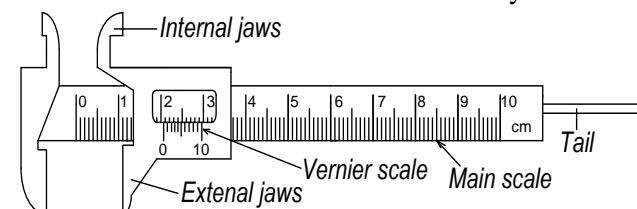
Accuracy is the degree of measurement to get the readings which are close to the actual value. Accuracy can be improved by using a more sensitive or smaller scale division or high accuracy instrument.

Sensitivity is the degree of measurement **to detect the small change in its reading**. Sensitivity can be improved by using instrument with smaller scale divisions. For example, use digital stopwatch rather than analogue stopwatch.

- 6 Metre rule is to measure the length between two points. Its smallest scale division/sensitivity/consistency is 0.1 cm.

Question: State the physical quantity shown by metre rule. Answer: length

Vernier callipers is a device used to measure the diameter or depth from 0cm to 10 cm. Its smallest scale division/sensitivity/consistency is 0.01 cm.

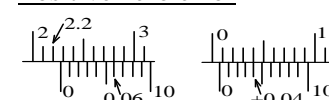


Internal jaws: To measure the internal diameter

External jaws: To measure the external diameter

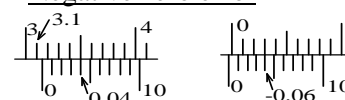
Tail: To measure the depth

Positive zero error



$$\begin{aligned}\text{Reading} &= 2.26 - (+0.04) \text{ cm} \\ &= 2.22 \text{ cm}\end{aligned}$$

Negative zero error



$$\begin{aligned}\text{Reading} &= 3.14 - (-0.06) \text{ cm} \\ &= 3.20 \text{ cm}\end{aligned}$$

The reading is always **deducted** to the zero error!!

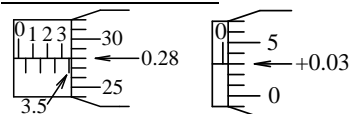
Example: the final reading is 3.50cm

If the zero error is +0.02cm: The actual reading is $= 3.50 \text{ cm} - (+0.02 \text{ cm})$
 $= 3.48 \text{ cm}$

If the zero error is $- 0.02 \text{ cm}$: The actual reading is $= 3.50 \text{ cm} - (- 0.02 \text{ cm})$
 $= 3.52 \text{ cm}$

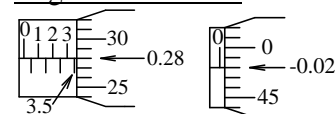
Micrometer screw gauge is a device used to measure the **diameter** of small object from 0 mm to 25 mm. Its smallest scale division/ sensitivity/ consistency is 0.01mm.

Positive zero error



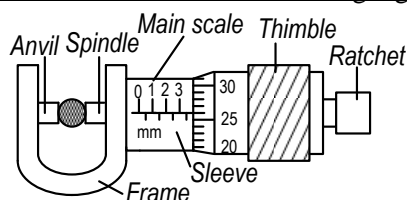
$$\text{Reading} = (3.5 + 0.28) - (+0.03) \text{ mm} = 3.75 \text{ mm}$$

Negative zero error



$$\text{Reading} = (3.5 + 0.28) - (-0.02) \text{ mm} = 3.80 \text{ mm}$$

Structure of micrometer screw gauge



Anvil+ spindle: To hold the object

Frame: To limit the size of object that can be measured by micrometer

Sleeve: The place to mark the main scale

Thimble: Can be turned to hold the object by jaws

Ratchet: To prevent the overtightening of object held by jaws by making a click sound when the micrometer is ready to be read

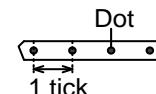
- 7 Prefixes are used to simplify the description of physical quantities that are either very big or very small value.

#Remember: $1 \text{ gcm}^{-3} = 1000 \text{ kgm}^{-3}$

Table of prefixes and values

Prefix	Value	Prefix	Value
deci, d	10^{-1}	Deca, D	10^1
centi, c	10^{-2}	Hecto, H	10^2
mili, m	10^{-3}	kilo, k	10^3
Micro, μ	10^{-6}	Mega, M	10^6
nano, n	10^{-9}	Giga, G	10^9
pico, p	10^{-12}	Tera, T	10^{12}
feto, f	10^{-15}	Peta, P	10^{15}
ato, a	10^{-18}	Esa, E	10^{18}

- 8 Distance is the length between two points.
 Displacement is the length between two points at certain direction.
 Speed is the rate of change of distance.
 Velocity is the rate of change of displacement.
 Acceleration is the rate of change of velocity
- Ticker timer is connected to an **alternating current** (a.c) power supply 12 V and vibrates at a frequency of 50 Hz.
- One tick is the time taken to make two adjacent dots.**



Time for one tick is 0.02 s

- 9 **Mass is the quantity of matter contained by an object.**
 Mass is measured in unit kilogram and the value is always constant at anywhere. Can be measured using inertia balance or weighing balance.

Weight is the amount of gravitational pull exerting on the object.

Weight, $W = \text{mass} \times \text{gravity}$

$$W = mg$$

Weight is measured in unit Newton and measured using spring balance. The value is always changing depends on place. $1 \text{ kg} = 10 \text{ N}$

- 10 **Inertia is the tendency of an object to resist any change in its motion or state of rest.**

#Inertia depends on the mass. Bigger mass of object has bigger inertia.

#Is either at rest or moves with constant velocity if there is no external force acting on the system (**also related to Newton's first law**)

Momentum is the product of mass and velocity.

Formula: Momentum = mass \times velocity = mv In unit kgms^{-1}

Force is the pull or push due to the product of mass and acceleration.

Formula Force, $F = \text{mass} \times \text{acceleration}$

$$F = ma \text{ or } F = m\left(\frac{v-u}{t}\right)$$

Example of force: pulling force, pushing force or weight.

#Bigger force \rightarrow shorter in impact time or time in contact

#Smaller force \rightarrow longer time of impact

Net force is the geometric sum of all forces acting on an object.

Net force means using the formula: $F_{\text{net}} = ma$

No net force means the object can be in rest, or moving at constant or uniform velocity. The object experiences no acceleration or is not falling under gravity.

Along a road with angle (pull/push)

$$F \cos \theta - R = ma \quad \# R = 0 \text{ N if the surface is smooth}$$

Impulse is the change of momentum.

$$\text{Impulsive force, } F = \frac{m(v-u)}{t}$$

In order to reduce the impulsive force, the time of impact/collision between two surfaces must be lengthened by using soft mattress or bending legs upon landing

When two objects are dropped from the same height,

a) **falling time and acceleration is always same**

b) **impulsive force is always different depending on the surface of landing**

Impulsive force is the rate of change of momentum.

$$\text{Impulse} = mv - mu$$

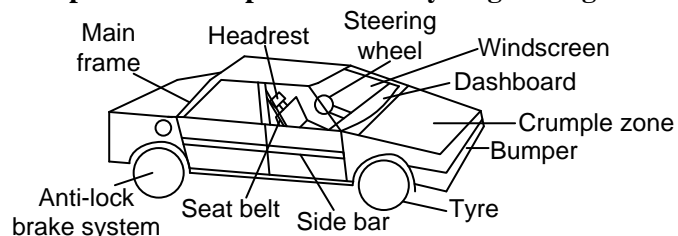
Impulse is also defined as the product of force with time.

Force in equilibrium is a state of equilibrium with no net force.

An object in equilibrium force **may be at rest / remains stationary, maybe moving at uniform velocity in straight line and the acceleration is zero**

11 Safety features in car

Concept: smaller impulsive force by lengthening the time of impact.



Safety feature	Reason
Front and rear bumper	to lengthen the impact time
Anti break windscreen	to protect passenger being cut
Air bags	inflate upon impact to cushion passengers from direct impact with the steering wheel or dashboard by lengthening the impact time
Safety belts	prevent passengers from being thrown forward due to their inertia
Anti-lock brake (ABS)	prevent the wheels from locking when the brake is applied and this can prevent the car from skidding

Headrest	to cushion the head or neck of drivers
Soft dashboard	to lengthen the collision time when the head of driver collides it
Tyre	should be broad and with friction grooves so as to control better the stability
Steering wheel	made of soft material as to lengthen the collision time with driver
Side-bar car	provide passengers with extra protection in the event of a side impact
Main frame of car	strong enough as to prevent the car being badly damage which may hurt the passengers
Crumple zone	lengthen the impact time so that the impulsive force can be reduced

12 Gravity is a force originated from centre of the Earth that pulls all objects towards the ground.

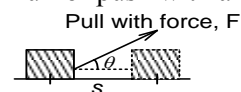
All the objects of different masses if is falling from the same height will have **same time of falling** and **same acceleration**.

Free fall is the falling of an object with acceleration due to the gravity only.

13 Work done is the product of force and displacement in parallel to the force.

Work done, $W = Fs$ #Work done is a scalar quantity!!

Pull or push with angle θ :



$$\text{Work done, } W = F \cos \theta \times s$$

Energy is the ability of doing work.

#Potential energy is the energy due to its location or position.

$$\text{The formula is } E_p = mgh$$

#Kinetic energy is the energy due to its state of motion.

$$\text{The formula is } E_k = \frac{1}{2}mv^2$$

	<p>Highest point: Maximum potential energy</p> <p>Lowest point: Maximum kinetic energy (fastest speed)</p>
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Power is the rate of work done.

$$\text{Power, } P = \frac{\text{Energy}}{\text{Time}} \text{ or } P = \frac{\text{Work done}}{\text{Time}}$$

Work done can be due to kinetic energy or potential energy or heat energy

- 14 Hooke's law states that the force applied to a spring is directly proportional to the spring's extension or compression such that the elastic limit is not exceeded.**

Elasticity is the ability of an object that can resume or return to its original shape after the applied force is removed.

More elastic → can extend longer and can withstand bigger force

Force constant is the force per unit length of extension.

From Hooke's law, $F = kx$ and so the force constant, $k = F/x$

Bigger force constant → spring is stiffer which can withstand bigger force
→ has bigger elastic limit

Work done to extend or compress a spring, $W = \frac{1}{2} kx^2$ or $W = \frac{1}{2} Fx$

Elastic limit is the maximum applied force that can be applied to an elastic material before it loses its elasticity and cannot return to its original state.

- 15 Principle of conservation of energy states that the energy cannot be created or destroyed, but it can be transformed from one type to another type with the total energy is conserved.**

Example: Launching of rocket, cuttlefish ejecting a liquid when moving

Efficiency is the ability of an electrical appliance to transform energy from one form to another without producing useless energy or wastage.

$$\text{Efficiency} = \frac{\text{output work}}{\text{input work}} \times 100\%$$

#100% efficient means there is no loss in the output power.

#The more powerful device will do more work in shorter time

- 16 Newton's first law of motion states that a body will either remain at rest or continue with constant velocity unless it is acted on by an external unbalanced force. ← Also related to the inertia**

Newton's second law of motion states that the acceleration is directly proportional to the net force acting on it and inversely proportional to its mass. Formula: $F = ma$ and always referred to the collision system.

Newton's third law of motion states that to every action, there is an equal but opposite reaction. Example: the hand is painful after hitting a ball

- 17 Pressure is the force acting normally per unit area.**

Pressure, $p = F/A$ (solid)

Pressure, $p = h\rho g$ (liquid/gas)

Pressure, $p = 76 + \text{unbalance arm}$

Device used to measure pressure

Bourdon gauge: measure the air pressure

Aneroid barometer: measure the atmospheric pressure due to change of altitude or height

Fortin barometer: measure the atmospheric pressure

Manometer: U-shape and to measure the pressure of mercury or air trapped

Gas pressure is due to the collision between molecules and with the walls of their container. Random means no definite direction of movement!

- 18 Buoyant force is the vertical upthrust acting onto the object.**

Buoyant force, $F = \rho Vg$ ρ : density of water, V : volume of block immersed,

Buoyant force, $F = \text{spring balance in air} - \text{spring balance in water}$

Pascal's Principle states that in enclosed system, the pressure applied to the fluid will be transmitted equally to all the directions throughout the fluid.

Application like hydraulic jack, car brake system

Car brake system

→ oil liquid (incompressible and thus transmitting pressure efficiently)

→ small pedal area (Small area produce big pressure, use less space)

→ thick brake line (withstand big pressure without cracking)

→ high specific heat capacity (slower getting hot which will not heat up the brake system)

→ big area of output slave piston to master piston (can multiply the input force)

Archimedes' principle states that when the object is partially or wholly immersed into the fluid, the weight of water displaced due buoyant force is equal to the weight of the object being immersed.

Design → streamline which can reduce water friction while moving

Plimsoll line → safety features marked on the ship to enable the maximum load limit that can be carried by the ship before it starts to sink.

Ship which is safely loaded in deep sea may sink when reaches to fresh water. Why?

Reason: Sea water has high density and thus supports more loads for the ship before it starts to sink. Fresh water has lower density and thus support lesser loads for the ships before it starts to sink.

Hot air balloon

- big balloon (can displace more air and thus creates more lifting force)
- synthetic nylon (strong material and long lasting)
- bigger burner/more burner (can heat up the air inside the balloon faster and cause the air become lighter which produces more lifting force)
- high temperature (air is lighter / more lifting force)

Bernoulli's principle states that in fluid system or air system, the region which experiences high pressure will have low speed and vice-versa.

Design of aeroplane → aerodynamics / streamline (cut air while moving)

Name of the shape of body → aerofoil (produce a lifting force due to the change of air speed above and below the body)

Water rocket

- air tight (to keep the pressure pumped into the bottle from leaking)
- 1/3 filled with water (to increase the momentum of launching)
- add wings (will not wobble and stable while flying)
- add cone (to reduce the air friction while flying)
- low density of material (will not cause the rocket becomes too heavy)
- angle 45° of launching (to get maximum distance travelled)

19 Density is the mass per unit volume

Low density → the object is lighter and easy to carry

High density → the object is heavier and stable

Hydrometer → to measure the density of liquid

The stability of the hydrometer

- The lead shots at the base lower the centre of gravity of the hydrometer.
- Cylinder with bigger diameter at the lower section
- To enable the hydrometer to float upright in a liquid and not overturn.

Ability to measure wide range of densities of liquids

- Longer stem so that the scale can be made more to cover a wide range of densities

The sensitivity of the hydrometer

- The cylinder must have a small diameter on the upper section
- A small reading scale can be incorporated and thus increases its sensitivity.

The calibration of the hydrometer

- The hydrometer is floated in a liquid with a known density like water. The liquid level at the stem is marked
- For every liquid with a known density, the level of the liquid on the hydrometer stem is marked.

20 **Temperature is the degree of hotness of an object.**

Thermometer is used to measure the temperature of object

- small bore (faster detecting heat and thus more sensitive)
- narrower stem (small heat can get big change of mercury expansion)
- thin glass wall (faster detecting and receiving heat)
- low specific heat capacity (faster getting hot even small heat)
- use mercury (does not stick to the wall and sensitive to heat)

Conviction: To prevent the mercury from flowing back to the bore before the reading is ready to be read.

Heat is a form of energy.

Specific heat capacity is the amount of heat required to change the temperature of 1 kg object by 1°C without change in its physical state.

Heat, $H = mc\theta$ (temperature change)

High specific heat capacity → slower getting hot

Low specific heat capacity → faster getting hot

Why using the lubricating oil? To improve the thermal contact between the thermometer with the block

Specific latent heat is the amount of heat required to change 1 kg of a substance physically without change in temperature. There is no change in the temperature as the heat supplied is used to break the bond between the molecules.

Heat, $H = mL$ (physical change)

Specific latent heat of fusion → solid to liquid

Specific latent heat of vapourisation → liquid to gaseous/steam

Thermal equilibrium is a state when heat transfer between the two objects are equal, the net rate of heat transfer between the two objects are zero, same final temperature, same heat but there is still a flow of heat between two object.

21 **Boyle's Law** states that the **pressure** of a fixed mass of gas is **inversely** proportional to its **volume** provided the temperature of the gas is kept constant. Formula is $P_1V_1 = P_2V_2$

Charles' law states that the **volume** of a fixed mass of gas is **directly** proportional to its **absolute temperature** (in Kelvin), provided the pressure of the gas is kept constant. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$, $T \rightarrow$ must Kelvin and $T = (0 + 273)$

Pressure law states that the **pressure** of a fixed mass of gas is **directly** proportional to its **absolute temperature** (in Kelvin), provided the volume of the gas is kept constant. $\frac{P_1}{T_1} = \frac{P_2}{T_2}$ $T \rightarrow$ must Kelvin and $T = (0 + 273)$

Absolute zero temperature is the lowest possible temperature of gas by where the pressure and volume are zero.

Absolute zero temperature = -273°C or 0 K

22 Wave or light phenomenon

Refraction → passes through/see through the medium

Refraction will cause → direction, speed and wavelength will change
→ speed is faster in less dense or deeper medium

Reflection → hits the obstacle and then rebounds back

Speed = $\frac{\text{distance}}{\text{time}}$

Time = $\frac{1}{2} \times (\text{echo})$

Reflection will cause → direction of wave moving change
→ speed and wavelength remain unchanged
→ wave pattern is symmetrical

Diffraction → passes through the gap or hole.

Diffraction will cause → speed and wavelength change

Small gap: diffraction effect is obvious but lesser energy of wave entering the gap!

Interference → superposition of waves in amplitude producing wave of maximum or minimum amplitude

Antinode: is a point where the superposition of same phase of waves occur producing a wave with maximum amplitude.

Constructive interference → crest + crest
→ trough + trough

Nodal point: Destructive interference → crest + trough

23 Apparent depth, d is the distance between the image with the surface of water. Refractive index, $n = \frac{\text{RealDepth}}{\text{ApparentDepth}}$

Real depth, D is the distance between the object with the surface of the water.

Total internal reflection is the total reflection of a beam of light at the boundary of two mediums when **the angle of incidence exceeds the critical angle**.

Critical angle, c is the greatest angle of incident when the refraction angle is 90° .

$i < c$ (will pass through the medium)

$i = c$ (will parallel to the surface of medium)

$i > c$ (will be totally reflected from the medium)

Refractive index, $n = \frac{1}{\sin c}$

Obey Snell's law

Snell's Law states that the value of $(\sin i / \sin r)$ is a constant. Snell's law

formula: $n = \frac{\sin i}{\sin r}$ i = incident angle r = refracted angle

24 Power of lens is the reciprocal of focal length.

Power of lens, $P = \frac{1}{f}$ F = focal length in unit metre

Unit of power of lens is in unit Dioptre or D

25 Wave is the vibration or oscillation of an particle which **transfer energy** without transferring matter and this vibration is repeated periodically.

There are two main types of waves: longitudinal wave and transverse wave

Transverse wave is a wave in which the vibration of particles in the medium is **perpendicular** to the direction of propagation of the wave

Example: Water wave, light wave, electromagnetic waves

Polarisation → **prove that the light is a transverse**

Longitudinal wave is a wave in which the vibration of particles in the medium is **parallel** to the direction of propagation of the wave

Example: sound waves, ultrasound only and cannot travel in vacuum

26 Same phase means waves with **same direction**, same frequency and **same displacement**.

Amplitude is the maximum displacement from its equilibrium position.

Period is the time taken to complete an oscillation.

Frequency is the number of complete oscillations performed by a vibrating system in one second. Frequency, $f = \frac{1}{T}$

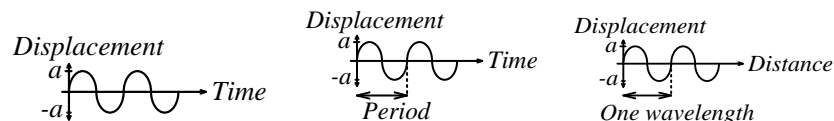
Wavelength is the distance between two adjacent crest or two adjacent trough.

Damping is the condition where there is a decrease in the **amplitude** of an oscillating system.

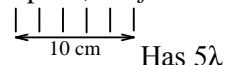
Resonance occurs when a system is made to oscillate at a frequency equivalent to its natural frequency by an external force.

The resonating system oscillates at its **maximum amplitude**.

Some useful information:



$$\text{Speed, } v = f\lambda$$



$$\text{So, } 5\lambda = 10 \text{ cm}$$

$$\lambda = 2 \text{ cm}$$

From Young's double-slit experiment: $\lambda = \frac{ax}{D}$

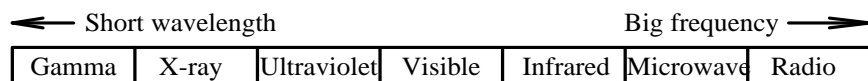
a = distance between two gaps or slits

x = distance between two adjacent crest or two adjacent trough

D = distance between the gap with the screen

- 27** Electromagnetic wave is the propagating waves in space with electric and magnetic components which are oscillating at right angles to each other and to the direction of propagation of wave.

Electromagnetic spectrum **is the arrangement of electromagnetic wave according to its wavelength or frequency.**



Gamma ray → kill cancer cell and for destruction purpose

X-ray → scanning or diagnosis in medical

Ultraviolet → vitamin D for skin / detect forge note

Visible → for sight

Infrared → short distance linking like remote control, hidden camera

Microwave → cause heating like micro oven, satellite communication

Radio wave → broadcasting

- 28** **Monochromatic light** means light with only one colour or one wavelength. Principle of superposition states that at any instant, the wave displacement of the combined is the sum of the displacements of all the components waves at that point.

- 29** Sound quality must possess loudness of sound and pitch of sound.

Loudness of sound depends on its amplitude. Stronger energy of sound wave will has higher amplitude.

Pitch of sound depends on its frequency. Frequency of sound is measured in unit decibel or db.

Infrasonic sound is the sound of frequency which is lower than 20 Hz and can be heard by some animal like bat or dog

Audible frequency is the range of sound which can be heard by human being. The range is from 20 Hz to 20 kHz.

Ultrasonic sound is the range of frequency which is higher than 20 KHz and may destroy the hearing system of human being.

Sonar is a way to detect the image of object by using the reflection of sound.

- 30** **Charge**, Q , is the number of electron. Charge, $Q = It$ or $Q = ne$
Conclusion: $It = ne$ where n = number of electron, $e = 1.6 \times 10^{-19} \text{ C}$

Current, I , is the rate flow of charge.

Potential difference, V , is the work done in moving one coulomb of charge from one point to another in an electric field.

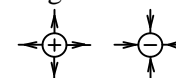
Electric field is a region where electric charge experiences an electric force.

Same charge or like charge → repel

Unlike charge → attract

Positive charges give out electric field lines

Negative charges receive the electric field lines



Resistance is a measure of ability of the conductor to resist the flow of an electric current through it. Resistance of wire, $\frac{\rho L}{A}$,

Resistance of wire decreases if → use low resistivity of wire

→ use shorter wire

→ use thicker wire/big area/ bigger diameter

Resistance → will cause system become more hot

→ good as heating element like nichrome

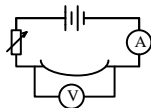
Resistance increases in order:

Copper < aluminium < tungsten < constantan < nichrome

Why choosing nichrome? Nichrome has high resistance which can convert electric current to heat faster.

Aluminium is widely used as conducting wire because it is lighter as low density, cheaper and less reactive with oxygen

Rheostat → adjustable resistance of resistor which is used to control the flow of current

- 31** Circuit is a closed loop through which charge can continuously flow.
Series circuit
 → same amount of current will flow in circuit
 → the rest of the bulbs will not light up once one of the bulb is burnt
 → save wiring during instalment/save cost
 → the brightness of the bulbs may vary depends on its internal resistance
Parallel circuit
 → same voltage across the circuit causing all bulbs to light at same brightness
 → the rest of the bulbs can still light on once one of the bulb is burnt
 → use lot of wiring during instalment
 → brightness of the bulbs are constant as they have same voltage value
- 32** Electromotive force (*e.m.f.*) is the total energy supplied by a cell to move a unit of electrical charge from one terminal to the other through the cell and the external circuit
 $e.m.f. = I(R + r)$ [*e.m.f.* is referred to the value of voltage of battery used]
 R = total resistance of resistor in circuit
 r = internal resistance of battery
- 33** **Ohm's law states that the electric current flowing through a conductor is directly proportional to the potential difference if temperature and other physical conditions remain constant.**
 Ohm's law: $V = IR$

 Voltmeter must be connected parallel to the device being measured
- 34** Electric energy is the amount of work done to move one coulomb of charge from one point to another point.
 Electric energy, $E = VIt$
 Electric energy, $E = \text{Power} \times \text{time}$
 Electric energy used in house, $E = \text{Power in kilowatt} \times \text{time}$
 Electric cost = $E \times \text{unit price}$
 Electric power is the rate of electric energy used.
 Power, $P = \frac{\text{Electric Energy}}{\text{Time}}$
 Power, $P = IV$ or I^2R or V^2/R
Transmission of energy is done at high voltage as to reduce the energy

loss in transmission cable.

Since the heat dissipation depends on the magnitude of the current, it is more efficient to transmit electrical energy at very low currents. To produce this low current, the voltage has to be increased.

The transmission of electricity in cable is done using alternating current
→ the voltage can be alternated easily or can be changed easily using transformer

Advantage of using National Grid Network

- uninterrupted other power supply even where there is a breakdown in one power station
- power is distributed by a series of substations to meet the requirement of consumers
- the voltage can be step-up or step-down easily depends on the demand of the consumers.
- repairs and maintenance can be carried out at any station at any time
- power station can be located outside the city area (not necessary in city)

35 Magnetic field is a region in where a magnetic material experiences a force.

Electromagnet is the production of magnetism by flow of electric current in coils wound around soft iron core will magnetise the soft iron core.

Electromagnetic induction is the production of an electric current by a changing magnetic field or cut of magnetic flux and there is no physical contact between them. The induced current can be produced by moving a magnet bar into a coil system. Cut of magnetic flux perpendicularly produces an induced current

36 Transformer is a equipment used to step up or step down the **potential difference of an alternating current supply.**

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Symbol of transformer



Must be connected to a.c voltage. **Why?** a.c voltage can be alternated easily

37 **Physics concept: Electromagnetic induction**

Faraday's Law states that the **magnitude** of the induced electromotive force is directly proportional to the rate of change of magnetic flux cut

Ways to increase the strength of magnet

- use stronger magnet (increase the magnetic flux strength)
- use soft magnet (can be magnetised and demagnetised easily)
- use laminated magnet (to reduce eddy current)

- use bigger current (increase the rotation energy)
- increase the number of turns of coil (increase the rate of magnet flux cut)
- use thicker diameter of wire (reduce the resistance)
- use cylinder/concave shape of magnet (to concentrate the magnetic flux/radial magnet)

Lenz's law states that the **direction** of induced electric current always flows in such a direction so as to oppose the change (or motion) producing it.

Fleming's right hand rule states that when the thumb, forefinger and the middle is extended at an right angle to each other, then the

Thumb – shows the direction of force/rotation

Forefinger – shows the direction of magnet (North point to south)

Middle finger – shows the direction of current flow

For dynamo generator, there is no battery used but with slip rings. Rotation of solenoid cutting the magnetic flux in magnetic field will induce an induced current.

38 Physics concept: Electromagnet

Fleming's left hand rule states that when the thumb, forefinger and the middle is extended at an right angle to each other, then the

Thumb – shows the direction of force/rotation

Forefinger – shows the direction of magnet (North point to south)

Middle finger – shows the direction of current flow

Motor electric is using a current from battery which is connected to the commutator. The function of commutator is to reverse the direction of current for every half cycle of rotation of solenoid.

39 Cathode Ray Oscilloscope

Name the process happens in CRO: Thermionic emission

Thermionic emission is the process of releasing of electrons from hot metal surface.

The metal surface must be the cathode which can release electrons.

Thermionic emission depends on

- type of material (cathode coated oxide can release electrons faster)
- surface area (bigger surface area exposed to heat: release more electrons)
- temperature (higher temperature heating cathode to release electrons)

What is cathode ray?

Cathode ray **is the fast moving electrons travel in a straight line in vacuum.**

Fast moving electron once striking a screen will be converted into light energy!

Functions of CRO:

- can measure voltage
- can measure short time interval
- can measure wavelength

Three main part of CRO

- electron gun (cathode, filament, grid, accelerating anode, focusing anode)
- deflection system (Y-plates, X-plates)
- fluorescent screen (screen)

##Magnitude of deflection of electron in CRO can be increased by increasing the potential difference

40 Conductor is a material which allows current to flow through them and the conductivity will decrease when the temperature increases.

Semiconductor is a material whose resistance is between good conductor and insulator. Conductivity increases when the temperature increases.

p-type – Silicon doped with boron. Majority charge carrier is hole.

n-type – Silicon doped with phosphorus. Majority charge carrier is electron.

Hole → lack of one electron called hole as majority charge carrier in *p*-type semiconductor


Electron → extra one mobile electron as majority charge carrier in *n*-type semiconductor

Insulator is a material which does not conduct any electric current.

41 What is function of **diode**?

Diode is a device used to change the a.c. current to d.c current. Diode also allows the flow of current in one direction.

Process in diode: Rectification is the process of changing a.c. voltage to d.c. voltage by diode.

Symbol of diode 

Type of rectification

Half wave rectification → using two diodes

Full wave rectification → using four diodes

Diode can be connected to a.c or d.c current but it allows the current to pass through it in one direction only

What is **capacitor**? Capacitor is a device used to store charge.

Process in capacitor when it is connected in diode circuit: Smoothing

What is transistor? Transistor is a device used to act as an automatic switch or current amplifier.

Symbol of transistor



n-type transistor



p-type transistor

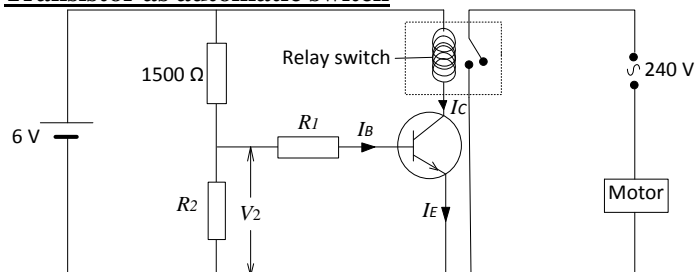
Function: as an automatic switch / or as current amplified

42 Light dependent resistor, *LDR* is a device which has very low resistance when exposed to sunlight but high resistance when nighttime.



Symbol of *LDR* is

Transistor as automatic switch



Which components need to be changed if the transistor circuit is changed to automatic switch along road? R_2 is changed to LDR. Motor is changed to lamp

Explain the working principle of transistor as automatic switch at nighttime.

1st: At nighttime, the LDR has very high resistance.

2nd: Most of the potential difference will cross down to the LDR causing a small current being driven to the base of transistor.

3rd: The transistor circuit is complete and magnetise the relay switch

4th: The relay switch is magnetised and pull the switch of secondary circuit which lights up the lamps

What is relay switch? Relay switch is a device used to switch open the secondary circuit depends on the operation of transistor in primary circuit

43 What are logic gates?

Logic gates are electronic switches with one or more inputs but only one output.

X-exclusive gate			AND gate		
Input 1	Input 2	Output	Input 1	Input 2	Output
0	0	0	0	0	0
0	1	1	0	1	0
1	0	1	1	0	0
1	1	0	1	1	1

OR gate			NOT gate	
Input 1	Input 2	Output	Input	Output
0	0	0	1	0
0	1	1	0	1
1	0	1		
1	1	1		

NAND gate (AND first then Not gate)			NOR gate (OR first then NOT gate)		
Input 1	Input 2	Output	Input 1	Input 2	Output
0	0	1	0	0	1
0	1	1	0	1	0
1	0	1	1	0	0
1	1	0	1	1	0

NOT gate is different from other logic gate as it has only **one input** with one output.

- 44** Radioisotope is an isotope that has unstable nucleus that tends to undergo radioactive decay.
 Handling radioactive source
 → use thick lead box (the ray cannot pass through)
 → packed into concrete drum and buried underground (prevent the radioactive waste discharged to the environment)
 → use forceps/robotic hand (avoid direct touching)
 → wearing photographic films (detect the exposure radiation)
- Remember: Photographic film is not a shield to protect human from radiation exposure!!**
- Radioactivity** is the spontaneous and random disintegration of unstable nucleus into a more stable nucleus with the emission of radiation and energy.
- Spontaneous** is a process which happens automatically without triggered by any external source like pressure, temperature or force.
- Random** is a process where there is no way to tell which nuclei will undergo the decay process and there is no way to tell when it will happen.
- Half-life** is the time taken for the half of the activity of atoms to decay.
 Short half life → less harmful because it decays faster and less radioactive remains
- Nuclear fission** is a process of **splitting** of a heavy nucleus into two nuclei of roughly equal mass and shooting out several **neutrons** at the same time.
- Nuclear fusion** is a process of **combining** two or more small and light nuclei together to form a heavier nucleus.
- Einstein's theory** is the change of energy linked to the change of mass by the equation of $E = mc^2$.
 m = mass defect
 = (Total mass before decay – Total mass after decay)
- Common explanation for:**
 Short half-life: Safe and will not give long term side effect.
 Long half-life: unsafe but can last for longer time and thus cost-saving
 Liquid: Easy to be put into the cell by just injection
 Solid: Easy to carry or handle as can overcome the material leaking
 Geiger Muller tube can detect all three radiations (alpha, beta, gamma) and the detection is read by the ratemeter.

45	COMPARE	Alpha	Beta	Gamma
	Nature / What is	Helium particle or ${}^4_2\text{He}$	Fast moving electron or ${}^0_{-1}\text{e}$	Electromagnetic wave
	Mass	4 or heavy	1/1827 or light	0 or no mass
	Charge	+2e	-e	0
	Speed	Slow	Fast	Speed of light
	Ionizing power	High and can change the structure of cell	Medium	Low
	Penetrating power	Weak as most energy is used to ionize the cell	Medium	High
	Stopping material	A few cm of air / a piece of paper	A few mm of aluminium foil	A few cm of lead
	Deflected by electric field	Yes to negative plate	Yes to positive plate	No deflection
	Deflected by magnetic field	Yes to south pole	Yes to north pole	No
	Magnitude of reflection	Small deflection as heavy particle	Big deflection as the particle is light	No deflection
	Common use	biotechnology or cloning as alpha is used to change the genetic of cells without killing (normally to change the genetic cell to more useful or to increase productivity)	Medical purpose because it has medium ionizing and penetrating power which does not ionise or kill the cell.	Kill cancer cell because it has strong penetrating power to kill the cancer cell directly. Widely used for nuclear industry making dangerous weapon.

END OF READING MODULE