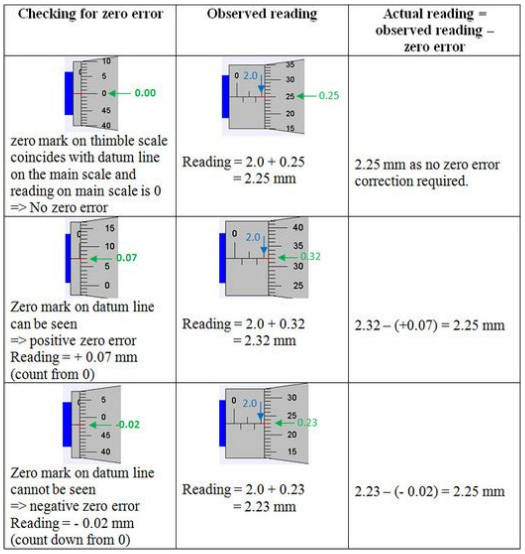
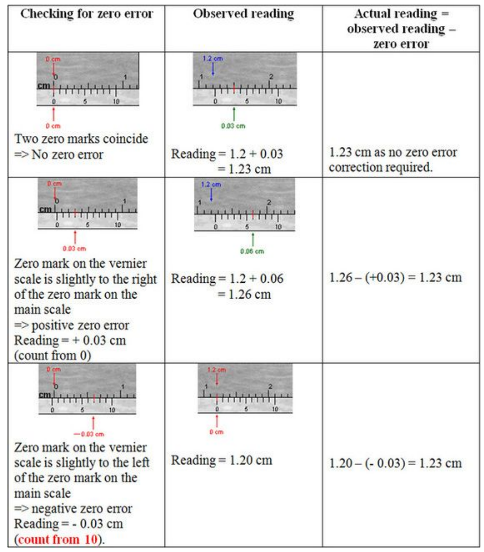
2017 Physics EOY

1. Measurement

Actual reading = observed reading - zero error



Checking for zero error	Observed reading	Actual reading = observed reading – zero error
zero mark on thimble scale coincides with datum line on the main scale and reading on main scale is 0 => No zero error	Reading = 2.0 + 0.25 = 2.25 mm	2.25 mm as no zero error correction required.
Zero mark on datum line can be seen => positive zero error Reading = + 0.07 mm (count from 0)	Reading = 2.0 + 0.32 = 2.32 mm	2.32 – (+0.07) = 2.25 mm
Zero mark on datum line cannot be seen => negative zero error Reading = - 0.02 mm (count down from 0)	Reading = 2.0 + 0.23 = 2.23 mm	2.23 – (- 0.02) = 2.25 mm



Checking for zero error	Observed reading	Actual reading = observed reading – zero error
Two zero marks coincide => No zero error	Reading = 1.2 + 0.03 = 1.23 cm	1.23 cm as no zero error correction required.
Zero mark on the vernier scale is slightly to the right of the zero mark on the main scale => positive zero error Reading = + 0.03 cm (count from 0)	Reading = 1.2 + 0.06 = 1.26 cm	1.26 – (+0.03) = 1.23 cm
Zero mark on the vernier scale is slightly to the left of the zero mark on the main scale => negative zero error Reading = - 0.03 cm (**count from 10**).	Reading = 1.20 cm	1.20 – (- 0.03) = 1.23 cm

Procedures to make readings more accurate

1. Obtain three or more readings at different positions and take the average.
2. Check and correct for any zero errors

Ratchet - Prevent over tightening of the micrometer screw gauge

PREFIXES

Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	k	10^{3}
Hecta	h	10^{2}
Deka	da	10^{1}
Deci	d	10^{-1}
Centi	c	10^{-2}
Milli	m	10^{-3}
Micro	µ	10^{-6}

Nano	n	10^{-9}
Pico	p	10^{-12}

SI UNITS

Length	Metre	m
Mass	Kilogram	kg
Time	Second	s
Electric Current	Ampere	A
Temperature	Kelvin	K (0K = -273°C)
Amount of Substance	Mole	mol
Luminous Intensity	Candela	cd
Speed	Meter per Second	m/s
Acceleration	$Meter\ per\ Second^2$	m/s^2
Weight	Newton	N or kgm/s^2
Volume	Cubic Centimeter	cm^3
Moments	Newton Meter	Nm
Work Done / Energy	Joules	J or kgm^2/s^2
Gravitational force	Newton per Kilogram	N / Kg
Frequency	Hertz	Hz
Wavelength	Metre (lambda)	m (symbol: 人)
E.M.F / Voltage / P.D	Voltage	V
Resistance	Ohm	Ω
Resistivity	Ohm • Meter	Ω m
Area	$Metre^2$	m^2
Pressure	Pascal	Pa

Scalar Quantity	Vector Quantity
Distance	Displacement
Speed	Velocity
Temperature	Acceleration
Mass	Weight
Density	Force
Energy	Turning Moments
Power	
Time	

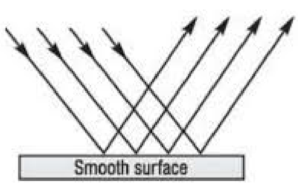
2. Mass, Weight & Density

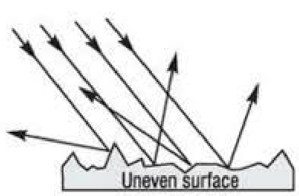
w = mg (weight = mass x gravitational pull)
p = $\frac{m}{V}$ (density = mass / volume)
Inertia - The property of a mass which resists change from its state of rest or motion of body
Weight - The amount of gravitational field acting on a mass

3. Reflection

Luminous objects - objects that give off light on its own (eg: Sun, Lamps)
Non-Luminous objects - objects that are seen when they reflect light from a source (the moon is a non-luminous object!!!!!!!)

Two laws of Reflection (true for ALL REFLECTING surfaces, including curved mirrors, and uneven / rough surfaces)
The first law states that the angle of incidence, i, is equal to the angle of reflection, r. (i=r)
The second law states that the incident ray, the reflected ray, and the normal to the surface of the mirror all lie in the same plane.
*Normal - perpendicular line to the reflecting surface
- When a light falls on an uneven surface, **individual** light rays still obey the laws of reflection. It is the overall image that is diffused.





Characteristics of a plane mirror image
1. The image is the same size as the object
2. It is laterally inverted
3. It is upright
4. It is virtual
5. Its distance from the mirror is equal to the distance of the object from the mirror

Applications of Reflection
1. Periscope
- Used to look over high obstacles
- Consists of 2 plane mirrors inclined at an angle of 45°
- Second mirror reverses the lateral inversion caused by the first mirror, causing the final image to appear without lateral inversion

Mirror in a Meter (Voltmeter, Ammeter)
- Adjust the position of your eye until the image of the pointer cannot be seen / the image is directly below the pointer, then read the reading to avoid parallax error.

Other Uses of Reflection in Our Daily Lives:
- Dentist mirror
- Rear view mirror
- Security mirror in shop
- Torchlight
- Cosmetic mirror
- Decorative mirror

4. Refraction
- Occurs when light travels from one medium to another
$n = \frac{\sin i}{\sin r}$ (air to glass)
$n = \frac{\sin r}{\sin i}$ (glass to air)
$n = \frac{1}{\sin c}$ (C = critical angle)
$n_1 \sin\theta_1 = n_2 \sin\theta_2$
$n = \frac{c}{v}$ (where c is the **speed of light in vacuum 3.0×10^8 ms^{-1}** and v is the speed of light in medium)
$n = \frac{\text{Real depth}}{\text{Apparent depth}}$ (with respect to air)
Note: Refractive index *n* will always be bigger than or equal to 1

Two laws of Refraction
The first law states that the incidence ray, the normal and the refracted ray all lie in the same plane.
The second law states that for two given media, the ratio of the sine of angle of incidence *i* to the sine of angle of refraction is a constant, ie $\frac{\sin i}{\sin r}$ = constant. This is also known as Snell's Law.

When the angle of incidence is 0^o, refraction does not occur

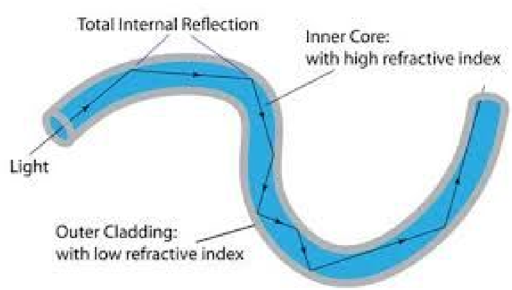
Critical angle *c* is defined as the angle of incidence in an optically denser medium for which the angle of refraction is the optically less dense medium is 90^o
$n = \frac{1}{\sin c}$

Total internal reflection is the complete reflection of a light ray inside an optically denser medium at its boundary with an optically less dense medium.
The two conditions for total internal reflection are

1. The light ray in an optically denser medium strikes its boundary with an optically less dense medium.
2. The angle of incidence is greater than the critical anger of the optically denser medium.

Why are refracted rays not as bright as incidence rays?
When light strikes the air glass boundary, part of the incident ray is reflected away at an angle of reflection equal to the angle of incidence. Hence only part of the ray is refracted, hence it is not as bright

Summary:
I < C - refraction
I = C - ray is refracted along the surface of object
I > C - total internal reflection occurs
Fiber Optics (Application of TIR)
- 'light pipes' used to transmit light from one place to another
- light entering the pipe comes out from the pipe because of total internal reflection from the sides
- images can be transferred from one point to another



Why does light not escape from the sides of the optical fibre?
The optical fibre has high optical density, thus from the equation n = $\frac{1}{sin\ c}$, it will have a small critical angle. When the angle of incidence is larger than the critical angle and travelling from an optically denser medium to an optically less dense medium, light undergoes total internal reflection.
Light Bending
1. From air to glass, angle of incidence is bigger than angle of refraction (refracted ray bends towards the normal)
2. From glass to air, angle of incidence is smaller than angle of refraction (refracted ray bends away from the normal)

5. General Wave Properties
v = fλ (speed = frequency x wavelength)
$T = \frac{1}{f}$
$f = \frac{1}{T}$

Transverse waves propagates in a direction / movement of each particle is perpendicular to the direction of vibration
Longitudinal waves propagates in a direction / movement of each particle is parallel to the direction of vibration
Note: If displacement is negative, include the negative sign

Displacement Distance graph - shows displacement of all particles at a particular point in time
Displacement time graph - shows displacement of one particle at a particular point in time
6. Electromagnetic Waves

No.	Property
1.	Electromagnetic waves are transverse waves. They comprise electric and magnetic fields that oscillate at 90^o to each other.
2.	They can travel through vacuum and do not require any medium to travel from one point to another
3.	They transfer energy from one place to another. E.g transferring heat energy from sun to Earth
4.	They travel at the same speed of light (3.0×10^8 ms^{-1}) in vacuum with their respective frequencies and wavelengths
5.	The wave speed equation v = fλ is applicable to all electromagnetic waves
6.	When an electromagnetic wave travels from one medium to another, it's: 1. Speed and wavelength changes 2. Frequency does not change Frequency only dependent on source of the wave E.g when light travels from vacuum to water, it's speed decreases from 3.0×10^8 ms^{-1} to 2.25×10^8 ms^{-1}. Its wavelength also decreases, while its frequency remains the same.
7.	They obey the laws of reflection and refraction
8.	They carry no electric charge

USES OF EM WAVES
*across the group frequency increases, wavelength decreases
Radio Waves (λ: 10^{-1} to 10^5)
- Radio and television communication to transmit sound and pictures
- Radio telescope

Microwaves (λ: 10^{-3} to 10^{-1})
- Communication with satellites
- Carry signals in mobile networks
- Microwave oven

Infrared Waves (λ: 10^{-7} to 10^{-3})

- Intruder alarms
- Night vision
- Ear thermometers
- Remote controls of electrical appliances
- Radiant heater

Visible Light (λ: 10^{-7})

- Lasers for medical, industrial and surveying uses
- Optical fibres for medical use and telecommunications
- Photosynthesis

Ultraviolet (λ: 10^{-8} to 10^{-7})

- Forensics
- Overexposure can lead to skin cancer
- Germicidal Lamps
- Sterilise medical equipment and laboratory equipment
- Sunbed
- Forgery detection
- Sterilisation
- Fluorescence Effect

X-ray (λ: 10^{-13} to 10^{8})

- Healthcare, kill cancer cells in radiation therapy
- Airport security scans
- Analysis of crystal structure
- Check for flaws in heavy metal equipment

Gamma Rays (λ: 10^{-14} to 10^{-10})

- Curing cancer -chemotherapy (Treatment of cancer) / Gamma Knife Radio Surgery
- Sterilising equipment
- Checking welds

IONISING - Ultraviolet Ray, X-Ray, Gamma Ray
NON-IONISING - Radio Waves, Microwaves, Infra-Red Ray, Visible Light

7. Sound
$v = f\lambda$ (speed = frequency x wavelength)
$T = \frac{1}{f}$
$f = \frac{1}{T}$

*For questions about echo
Speed of sound = distance apart from wall x2/time taken to hear echo
Note: Amplitude is linked to loudness whereas frequency is linked to pitch

Electromagnetic Spectrum

The Electromagnetic Spectrum refers to the entire range of electromagnetic radiation and their frequencies. Each frequency has a purpose in everyday life, as well as space related technologies.

RADIO WAVES

Radio waves are electromagnetic radiation with frequencies from about 3 kHz to about 1 GHz. These include:

Very Low Frequency [3-30 kHz]: Submarine communication
Low Frequency [30-300 kHz]: AM Radio Broadcasting
Medium Frequency [0.3-3 MHz]: Avalanche Beacons
High Frequency [3-30 MHz]: Amateur Radio
Very High Frequency [30-300 MHz]: Air Traffic Control Communications

MICROWAVES

Microwaves have frequencies ranging from 1 GHz to 300 GHz, including:

L Band [1-2 GHz]: GPS, Hydrogen Line [1.45 GHz]
S Band [2-4 GHz]: Bluetooth, WiFi
C Band [4-8 GHz]: Satellite Communication
X Band [8-12 GHz]: Wireless Computer Networks
K_u Band [12-18 GHz]: ISS Communications
K Band [18-27 GHz]: Water Absorption Line [22 GHz]
K_a Band [27-40 GHz]: CMB experiments
V Band [40-75 GHz]: Satellite Crosslink Communication
W Band [75-110 GHz]: Radar, Milimeter-Wave Observations

INFRARED

Consists of 300 GHz - 430 THz frequencies, such as:

Far Infrared [0.3-20 THz]: Observation of Interstellar Gases
Medium Infrared [20-214 THz]: Thermal Imaging
Near Infrared [214-430 THz]: Fiber Optic Telecommunications

VISIBLE LIGHT

From frequencies of 430-750 THz, this includes all the light we can see with our naked eyes. Applications include observations in Optical Astronomy, Lighting, etc.

ULTRAVIOLET

This category of radiation consists of frequencies from 750 THz - 30 PHz, with applications such as:

Ultraviolet A [750-952 THz]: Black lights
Ultraviolet B & C [0.952-3 PHz]: Germicidal Lamps
Lyman-alpha line [2.47 PHz]: Spectral Observation
Extreme Ultraviolet [2.47-30 PHz]: photoelectron spectroscopy, solar imaging, lithography

X-RAYS

X-radiation are a type of ionising radiation, with frequencies from 30 PHz - 30 EHz. Applications of X-rays include:

General [30 PHz-30 EHz]: X-ray Observations, X-ray spectroscopy
Soft X-rays [30 PHz-2.42 EHz]: X-Ray Microscope
Hard X-rays [2.42-30 EHz]: X-ray Crystallography, Medical Radiography, Airport Security Scanners

GAMMA RAYS

Gamma Rays have the highest amount of energy among all the radiation types, with frequencies above 30 HZ. Being extremely ionising radiation, gamma radiation are biologically hazardous. Gamma rays have different uses, including:

General [>30 EHZ]: Gamma Ray Astronomy (Pulsars/ Magnetars, Interstellar Cosmic Rays, Short Gamma Ray Bursts from Black Holes, Long Gamma Ray Bursts from Supernovae), Radioactive Decay Observations of Atomic Nuclei

SSTA
Singapore Space and Technology Association

Contact us at:
Website: www.space.org.sg Tel: (+65) 6735 7995 Email: ssta@space.org.sg

8. Kinetic Theory of Matter

Kinetic theory of matter states that all matter is made up of large number of tiny particles which are always in continuous and random motion.

Brownian motion is the random or irregular motion of smoke particles in air or pollen grains in water. When temperature increases, the smoke particles or pollen grains are observed to move faster and more vigorously

1. Brownian motion is caused by the bombardment of air molecules on smoke particles in air
2. Water molecules on pollen grains in water

Pressure in Gas
Key variables:

1. Number of particles per unit volume
2. Volume
3. Pressure
4. Temperature

Factors affecting pressure

1. Frequency of collision between particles and wall - increase if
    a. Number of particles increased and hence number of particles per unit volume increases
    b. Volume decreased and hence number of particles per unit volume increases
    c. Temperature increased and hence average speed of particles increases
2. Average force of collision between particles and wall - increase if
    a. Temperature increased and hence average speed of particles increases

Types of questions

1. Change in volume, but number of particles remain constant.
    a. Volume ↓ and number of particles per unit volume ↑
    b. Frequency of collision between particles and wall ↑
    c. Pressure inside ↑
2. Change in number of particles, volume remains constant
    a. Number of particles inside fixed volume ↑
    b. Number of particles per unit volume ↑
    c. Frequency of collision between particles and wall ↑
    d. Pressure inside ↑
3. Change in temperature, number of particles remain constant
    a. As temperature ↑, average KE of particles ↑
    b. Average speed of particles ↑
    c. Frequency of collision and force of collision between particles and wall ↑
    d. Pressure inside ↑
    e. External pressure smaller than internal pressure, container explodes
4. Temperature and volume increase, pressure remains constant
    a. Average speed of molecules ↑ (due to ↑ temperature)
    b. Average frequency of collision between particles and walls ↓ (due to ↑ in volume)
    c. Volume expand > increase in speed of particles

9. Temperature
°C = K - 273.15°
Ice point - The temperature of pure melting ice at one atmosphere (0°C)
Steam point - The temperature of steam from water boiling at one atmosphere (100°C)
Fixed points are temperatures which are chosen for the purpose of standardisation which are always easily attainable and reproducible under standard conditions.

Describe the steps in calibrating the mercury-in-glass thermometer with the celsius scale
The highest point reached by the mercury thread at each point is marked out on the thermometer. Divide the interval between the marked points on the thermometer by 100 equal divisions

10. Thermal Properties of Matter (Heat Capacity + Change of State)
$Q = mc\Delta\theta$
$Q = C\Delta\theta$
$Q = mL$ (change of state)
Latent heat of vapourisation is larger than latent heat of fusion because all the bonds have to be broken and the volume of gas is larger than volume of liquid. Furthermore, there is work done against atmospheric pressure.

Internal Kinetic Energy - Dependent on temperature
1. Due to motion of particles
2. Directly related to temperature - the higher the temperature, the more vigourous the motion of the particles.

Internal Potential Energy - Dependent on the state of matter
1. Due to stretching and compression of the interatomic or intermolecular bonds as particles move
2. Amount of potential energy stored in the bond depends on
    a. the forces between the particles
    b. how far apart they are

11. Transfer of Thermal Energy
Heat loss by object(s) A = heat gained by other objects
Conduction - mostly solids
Convections - substances (liquids and gas)
Radiation - Does not require medium, can be transferred through vacuum
Note: Good emitter = Good absorber

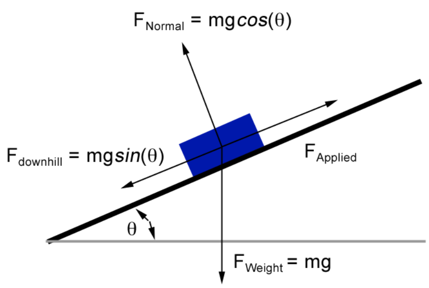
When we talk about material (metal, air, non-metal, insulator) of an object, heat is typically transferred through conduction but if it's about the surface (area, colour, texture) , it is typically through radiation.

12. Kinematics

$s = ½ (u+v) t$
$s = ut + ½ at^2$
$s = vt - ½ at^2$
$a = (v-u)/t$
$v^2 = u^2 + 2as$
$v= u+at$

Area under graphs/ gradient of graph	
Scalar Graphs	**Vector Graphs**
Area under speed-time graph = distance	Area under velocity-time graph = displacement
NIL	Area under acceleration-time graph = (change in) velocity
Gradient of speed-time graph = acceleration	Gradient of velocity-time graph = acceleration
Gradient of distance-time graph = speed	Gradient of displacement-time graph = velocity

13. Scalars & Vectors
Let 1.0cm : 5.0 N
Concluding statement: Resultant force is x N, y^o clockwise/anticlockwise from F = z N
Vector resolution



14. Forces
F_{net} = ma
Newton's First Law: An object at rest remains at rest, and an object in motion continues in motion at a constant speed
Newton's Second Law: When a resultant force acts on an object of constant mass, an acceleration will result with the product of its mass and acceleration equal to the resultant force. The direction of the acceleration being in the same direction as that of the resultant force
Newton's Third Law: For every action, there is an equal and opposite reaction
*Conditions: 1. Forces must be of the same type
2. Forces must be equal and opposite direction
3. Forces must be acting on different bodies

15. Turning Effects of Forces

Moment = Force x Perpendicular Distance (from line of action to pivot)

Principle of Moments states for an object to be in equilibrium, the sum of clockwise moments about any point equals to the sum of anticlockwise moments acting about the same point.

Explain why an object does not produce a turning effect about the pivot

The line of action of forces passes through the pivot hence the perpendicular distance from the line of action to the pivot is 0m, therefore turning moments due to force is 0Nm

Conditions for equilibrium

1. Net force on the body is 0 (Translational equilibrium)
2. Net moment about any point is 0 (Rotational equilibrium)

16. Work, Energy & Power

Work Done = Force x Distance

Power = Work done/time OR energy used/time

Efficiency = $\frac{Useful\ energy\ output}{Total\ energy\ input}$ x 100%

K.E. = ½ mv^2

G.P.E. = mgh

*Initial K.E. + Initial G.P.E. + work done = Final K.E. + Final G.P.E. + Work done by friction (conservation of energy)

Principle of conservation of energy states that energy cannot be created or destroyed, only be converted from one form to another or transferred from one body to another but the total amount remains constant

17. Pressure

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

P = hpg (where h is the height of liquid column in meters, p is the density of liquid in kg m^{-3} and g is gravitational field strength in N kg^{-1}. This formula is only for liquids)

$P_1V_1 = P_2V_2$

$\frac{P_1}{Surface\ Area_1} = \frac{P_2}{Surface\ Area_2}$

1 atm = 76 cmHg = 760mmHg

Density of water = $1g/cm^3$ or $1000kg/m^3$

$\frac{F_1}{A_1} = \frac{F_2}{A_2}$

Atmospheric pressure

Force due to bombardment by energetic air molecules on us in all directions.

Has a mass of about 5.0×10^{18}kg

18. Static Electricity

Law of Static electricity states that like charges repel and unlike charges attract

Normally, electrons will be transferred to the more "fuzzy" object

Electric force increases when:

1. Magnitude of charges increase and/or;
2. Distance between charges decrease

Charging by Rubbing (Friction) - Insulators only

1. Before rubbing, both rod and fur are electrically neutral
2. During rubbing, some of the electrons from the fur are removed from their atoms and are transferred to the rod
3. Rod now has an excess of electrons and is negatively charged (electrons that are transferred remain at the surface where the rod has been rubbed)
4. Fur has a deficit of electrons and is now positively charged

Charging by Contact - Conductors only

1. Positively charged metal object X touches a neutral metal object Y
2. Free electrons from Y flow towards X as opposite charges attract
3. Y acquires a net positive charge

If X starts with a net charge of +4, the resultant charge will be +2

Charging by Induction - Conductors only

Method 1

1. P and Q are two neutral metal spheres touching each other and placed on insulating stands (*never say negatively charged rod attracts positive charges)*
2. A negatively charged rod is brought close to P. This causes the free electrons in P to be repelled to the far end of Q as like charges repel, leaving the positive charges at the surface closest to the rod.
3. With the negatively charged rod still in place, separate Q from P using the insulating stand
4. Remove the charged rod, P and Q now have an excess number of excess opposite charges. The charges on each sphere redistribute themselves equally apart on the surface.

Method 2

1. Bring a positively charged rod P near Q which is placed on an insulted stand. The free electrons in Q will be attracted to the side closest to P as unlike charges attract, leaving the positive charges behind (*never say positively charged rod repels positive charges*)
2. Without removing P, earth by touching it with a finger or a wire connected to the ground. The flow of electron from the Earth neutralises the positive charges on Q
3. With P still in place, remove the finger from Q to stop the earthing process
4. Remove P. The negative charges on Q redistribute themselves equally apart on the surface. Q is now negatively charged.

Discharging through heating (Insulators)

1. Charged rod is brought near a flame
2. Heat from flame ionises nearby air particles
3. Ions neutralise excess charges on rod and is discharged

Discharging through humid conditions (Insulators)
1. Normally charged objects hold their charge for a limited time and will eventually return to their neutral state
2. Usually, there is a transfer of electrons between object and the water molecules in the air
3. As such, static electricity is more noticeable on dry days and it is more difficult for an object to hold a net charge in humid surroundings.

Discharging by earthing (Conductors(
1. The earth easily accepts or gives up electrons; hence it acts like a reservoir for charge
2. When a charged conductor is earthed, a path is provided for excess electrons to flow away from the conductor or electrons to flow towards the conductor to neutralise the excess positive charges
Sketching electric field lines
1. Lines must begin on the positive charge and end on negative charge
2. Number of lines drawn leaving the positive charge or ending on negative charge is proportional to magnitude
3. No two field lines can cross each other

Others to note
- Electric charges may build up on trucks due to friction between the road and rotating tires, and sudden discharge may cause spark and can ignite flammable items the truck is carrying. Thus older fuel tanks have a metal chain at the rear of the vehicle which hangs close to the ground and provides an earthing parth for excess charges
- Electrostatic discharge can also damage electronic equipment such as circuit boards and hard drives. Hence these items are packed in antistatic packaging. Antistatic materials have a thin layer of metallised film which acts as an electrostatic shield for the item enclosed.
- Spray painting, as spray paint leaves the nozzle of the spray paint gun, paint particles become charged by friction. Since paint particles contain like charges, they repel one another and spread out when they leave the nozzle. Charged paint particles are attracted to the metallic car body which is earthed. This produces a uniform coat of paint.

19. Current Electricity
$I = \frac{Q}{t}$
$\varepsilon = \frac{W}{Q}$
$V = \frac{W}{Q}$
$V = RI$
$R = \rho \frac{l}{A}$
$I \ \alpha \ V$
Factors affecting resistance of wire include length, cross sectional area, material and temperature

Ohm’s law states that the current passing through a metallic conductor is directly proportional to the potential difference across its end, provided the physical conditions and temperature are constant.

20. DC Circuits

$R = \rho \frac{l}{A}$

$R_{eff} = (1/R_1 + 1/R_2 \ldots)^{-1}$ *For parallel circuits

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

$= IV$

$= I^2R$

$= \frac{V^2}{R}$

$E = VIT$

To calculate power dissipation, use I^2R for bulbs in series and $\frac{V^2}{R}$ for bulbs in parallel

21. Circuit Components

Thermistor - temperature increase, resistance decrease (the one we learn normally, but can work the other way)

Light dependent resistor - light decreases, resistance increase

22. Magnetism

Magnetic field is a region in which a magnetic object, placed within the influence of the field, experiences a magnetic force.

Why is an iron nail attracted to the magnet

The end of the nail nearest to the magnet undergoes magnetic induction to have an opposite polarity to that of the end of the magnet nearest to the nail. Since unlike poles attract, the nail becomes attracted to the magnet.

How to distinguish if one or two metal bars are magnets

Invert one of the bars. If the two bars remain attracted, one is an iron bar and another is a magnet. If repulsion occurs, both are magnets

How to identify which piece is a magnet

Use one end of the first bar to move along the longer edge of the other bar from one end to the other. If the first bar experiences a stronger attraction at the two ends and weaker attraction in the middle, the first bar is an iron bar. If constant attraction is experienced, first bar is a magnet.

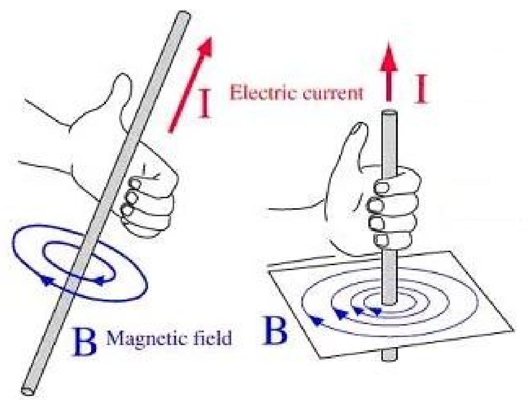
To demagnetize nails by an electrical method

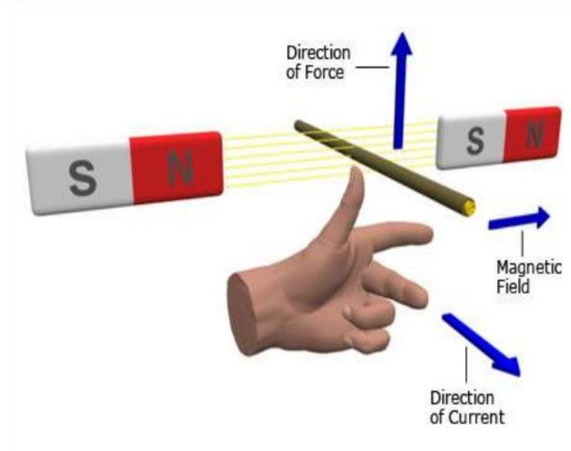
Place a nail in a solenoid in the east west direction then connect the solenoid to an alternating current supply. Withdraw the nails with the alternating current still flowing in the solenoid, until it is some distance away.

Soft Iron / Iron - more easily magnetised and demagnetised, suitable for electromagnets

Steel - Stays magnetised once magnetised, harder to demagnetise, suitable for permanent magnets

23. Electromagnetism





*For DC

DC Motor
Magnetic field due to current in sides of coil combine with magnetic field strength around the coil produces a downward force on one side an an upward force on another. Anticlockwise moment about pivot causes the coil to rotate.
When coil is at the vertical position, the current is cut off because the split ring commutator is not in contact tieh the carbon brushes. The inertia of the coil, however, carries it past the vertical position
Once the coil has rotate past its vertical position, current in the coil reverses its direction. This ensures that the force on the side of the coil next to the N pole continues to be in the same direction. Coil continues to rotate anticlockwise about the pivot

Soft Iron Core: To concentrate magnetic field lines
Split ring commutators: To reverse the direction of current every half a revolution in order for the coil to continue spinning in the same direction
Carbon brush: Maintain electrical contact between coil and external circuit

24. Electromagnetic Induction
If north pole enters, a north pole is induced at the end of the coil to oppose change created by the approaching north pole (same for south pole)
If a north pole leaves, a south pole is induced at the end of the coil to oppose change created by the leaving north pole

Faraday's law of electromagnetic induction states that the magnitude of the induced emf in a circuit is direction proportional to the rate of change of magnetic flux linking the circuit.
Lenz's law of electromagnetic induction states that the direction of the induced emf and hence the induced current in a closed circuit is always such that its magnetic effect opposes the motion or change producing it.

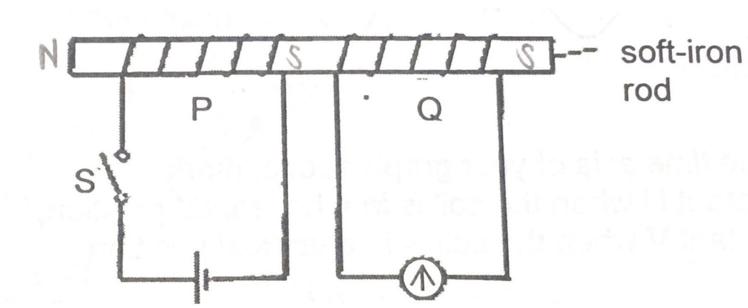
Slip Ring: Ensures that the induced current in coil is transferred to the external circuit
When coil is horizontal, rate of magnetic flux linking the coil is the greatest

Magnitude can be increased by
- Increasing number of turns of wire in coil
- Using stronger magnets
- Increasing frequency of rotation of coils
- Winding coil around a soft iron core to increase the magnetic flux linking the coil

For step up transformers, the current is bigger in the secondary coil but for step down transformers, the current is smaller in the secondary coil

Turns ratio = N_p / N_s (p is primary coil, s is secondary coil)
*Assuming 100% efficiency of transformer (aka. No power is lost)

Turns ratio = V_p / V_s
$= I_s / I_p$
Power loss = I^2R
Why does transmission voltage have to be higher than distribution?
This is to reduce current in transmission lines to minimise power loss due to heat
Changing magnetic flux induces emf which induces current which induces magnetic field
If speed is faster, the changing magnetic flux increases as more magnetic field lines are cut, which induces a higher emf
When coil is in horizontal position, the rate of cutting of magnetic lines is the greatest



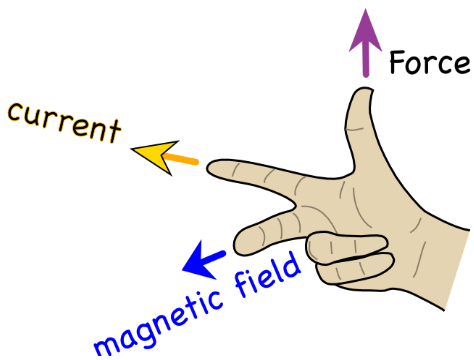
Why is a deflection seen in the galvanometer when switch is closed?
When the switch is closed, current starts to flow through P and creates a magnetic field in the soft iron rod that is increasing in magnitude. The iron rod links the increased magnetic flux to Q and the change in magnetic flux linking coil Q induces a current in Q, deflecting the needle.

When the switch is open, what would be observed in
i) the galvanometer
The needle will deflect in the opposite direction it deflected towards when the switch was open. When the switch is closed, the current in coil P decreases, decreasing the magnitude of the magnetic field generated by coil P, in the iron rod. There is a change in magnetic flux linking coil Q, inducing an emf in coil Q, inducing a current in the opposite direction.

ii) coils P and Q
Coils P and Q slide towards each other slightly as unlike poles induced at the ends of the coils facing each other attract.

What difference would there be if the rod was made of a non-magnetic material?
Deflection will be of a lower magnitude as the rod blocks most magnetic field lines from passing through it. This decreases the magnetic field strength of coil p, decreasing the magnetic flux linking coil Q which decreasing the induced emf and current in Q

Purpose of core in transformer - ensure magnetic flux linkage between coil
Purpose of laminated core - to reduce flow of eddy currents



*For AC