Super Physics Tuition O Level Summary

Chapter 1:

Measurements

- Scalar quantity is a quantity which has only magnitude but no direction.
- Vector quantity is a quantity that has both magnitude and direction.
- 7 Basic Quantities: Length, Mass, Time. Current. Temperature, Amount of Substance, Luminous Intensity.
- Derived Quantities: Volume, Velocity etc…
- Prefixes:

Prefix	Symbol	Multiplier	Exponential
giga	G	1,000,000,000	10^9
mega	M	1,000,000	10^6
kilo	k	1,000	10^3
deci	d	0.1	10^{-1}
centi	c	0.01	10^{-2}
milli	m	0.001	10^{-3}
micro	μ	0.000001	10^{-6}
nano	n	0.000000001	10^{-9}

Chapter 2:

Kinematics

- Displacement is the **distance** relative to a fixed point in a specified direction while distance is the length covered by a moving object.
- Displacement is the **position** of an object relative to a fixed point of reference.

Velocity and speed

- Velocity is the rate of change of displacement
- Speed is the distance moved per unit time
- Velocity is a vector that has direction and magnitude but speed is a scalar that has magnitude only.

Acceleration

- Average acceleration = rate of change of velocity
- **a =** $(v-u)/t$ where v = final velocity, u = initial velocity
- Object going round a circular track at constant speed has acceleration and a changing velocity
- This is because **direction** is changing constantly (tangent to the circular path)

Free fall in uniform gravitational field (no air resistance)

- A free falling object is falling under the influence of Earth's gravity (no air resistance, only weight)
- If there is no air resistance, all objects near Earth fall with the same acceleration (10 m/s^2)

Falling in a uniform gravitational field with air resistance

- When falling through air, **air resistance increases** as an object falls with **increasing velocity**.
- This opposes the weight and causes the net force downwards and hence acceleration to decrease.
- Terminal velocity is achieved when weight and air resistance are equal. (Newton's First Law)
- An object with a larger surface area/smaller mass will reach terminal velocity more quickly.

Chapter 3:

Dynamics

- **Newton's First Law**: Every object continues in its state of rest or uniform velocity, if no net force acts on it.
  - E.g. a car moving in one direction with constant speed: driving force and resistive forces are balanced
  - Hot air balloon descending with constant speed: weight and resistive forces are balanced

- **Newton's Second Law:** Acceleration of an object is directly proportional to the net force acting on it, and inversely proportional to its mass. The **direction** of the acceleration is in the direction of the net force acting on it.
  - **Net F = ma**

- **Newton's Third Law:** Newton's Third Law states that for every force exerted by one body on another body, there is an equal and opposite force exerted by the second body on the first body.

Examples of Newton's Third Law

- Fish swimming – fins push back on water with a certain force; water exerts an equal and opposite force to propel fish forward
- Earth exerts gravitational force on man and the man exerts an equal and opposite force on Earth. Contact force by man on earth = contact force by earth on man
- Rocket propulsion – solid fuel burns and produces gases that escape at high velocities. The escaping gases result in a force that act on the rocket to push (accelerate) it forward (thrust).
  - Take note that the thrust is not due to escaping gases pushing on the surrounding air and the air exerting a reaction force in turn to propel the rocket forward. This is because in outer space there is no atmosphere for this scenario to take place.

Chapter 4:

Mass, Weight and Density

- Mass of an object is a constant which is a measure of the amount of matter in an object but weight is the force of gravity acting on an object and it depends on the **gravitational field strength** of that location
- Density = Mass/Volume (SI unit: kg/m^3)
- Weight = mass × g where g = 10 N/kg on Earth

Chapter 5:

Moment of a Force & Stability

- Centre of gravity of a body is defined as the point through which the weight of the body appears to act (for any orientation of the body)
- Stability – For a body to remain in equilibrium, the line of action through its centre of gravity must fall within the base of support (when body is tilted, its c.g. produces a moment that returns the body to a stable position)
- Two factors that increase stability of an object – low c.g. and wide base
- Types of stability ○ Stable – when an object is displaced, its c.g. is raised resulting in a net moment that restores it to its original position
  - Unstable – when object is displaced, its c.g. is lowered resulting in a net moment that causes the object to topple.
  - Neutral – when object is displaced, its c.g. remains at the same height, the line of action of the weight of the object coincides with the pivot, hence no net moment is produced (no perpendicular distance) and it remains in the new position.

- Moment is defined as the product of a force and the perpendicular distance from the line of action of the force to the pivot
  - **Moment = F × perpendicular distance**
- **Principle of moments** states that for a body in equilibrium, the sum of clockwise moment about a pivot is equal to the sum of anticlockwise moments about the same pivot.
- The **resultant force** on a body in equilibrium is zero

Chapter 6:

Pressure

- Pressure is defined as the force acting normally per unit area
- $P = F/A$ (N/m^2 or Pa)
- $P = h\rho g$ (Pa)
- *Pressure can also be expressed in mmHg or cmHg or mHg*
- *Pressure can be measured using a barometer*
- *Gas pressure is measured using a manometer*
- Atmospheric pressure is caused by the weight of air above the surface of earth.
  - 1 atm = 1.0×10^5 Pa
  - Air pressure decreases with height because there are fewer air molecules per unit volume at a greater height as compared to at sea level

- PV = constant
- When pressure of a fixed mass of gas increases at constant temperature, its volume decreases.

Chapter 7:

Work, energy and power

- **Work done = Force × distance** (force and distance must be in the same direction; unit: J)
- Energy is defined as the capacity to do work.
- Mechanical energy = gravitational potential energy or kinetic energy
- $E_K = \frac{1}{2}mv^2$
- $E_P = mgh$
- Power is the rate at which work is done (J/s or W)
- Power × time = Work done (Unit of P is Watt, W)
- Weight = mass × gravitational field strength (unit: N)
- **Gravitational field strength** g is the force exerted by gravity on unit mass
- Other forms of energy: chemical PE, elastic PE, light, thermal (heat), sound energy
- **Principle of Conservation of Energy** states that energy cannot be created or destroyed; it can only be converted from one form to another. The total amount of energy in a closed system is constant.
- For a moving object coming to a stop, kinetic energy is converted to heat due to friction opposing its motion
- E_K = Frictional force × distance moved

Chapter 8:

Kinetic Model of matter

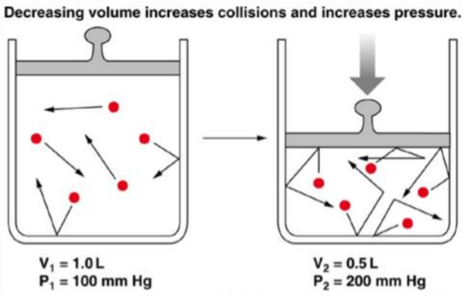
- Kinetic theory of matter states that all matter is made up of many particles that are in constant random motion.
- Kinetic model of matter is used to illustrate the arrangement and motion of molecules in solid, liquid and gas.
- Size of an atom is about 10^{-9} m (1 nm)
- Brownian motion provides the evidence for the Kinetic theory of matter
- Solid – particles are closely packed in a regular lattice arrangement; strong intermolecular forces; particles vibrate about fixed positions (fixed shape and volume)
- Liquid – particles are closely packed; particles are able to slide over one another; slightly weaker intermolecular forces (fixed volume but no fixed shape)
- Gas – particles are far apart moving randomly at high speeds; weak/negligible intermolecular forces (no fixed shape and volume)

- **Explanation for gas pressure in a container:**

When gas molecules in a container strike the walls of the container and rebound, a force is exerted on the walls. By Newton's Third law, there is an equal and opposite force exerted by the walls on the molecules. The gas pressure is the average force per unit area normal to the surface.

- **Pressure volume relationship (constant temperature)**

  When the **volume** of the container enclosing a gas **decreases**, the number of molecules per unit volume increases. This means that the **frequency** of collisions is **increased**, hence **average force exerted per unit area** or pressure i**ncreases**. (**Temperature is constant so kinetic energy, speed and force of collision is unchanged**)



- **Temperature volume relationship (constant pressure)** - When a gas is heated, molecules gain kinetic energy and move faster. They collide with the walls more frequently and forcefully. The gas pressure then increases to a value greater than the external pressure and the resultant force causes the volume to increase. This then decreases the number of molecules per unit volume, hence reducing the frequency of collision and gas pressure decreases until it is equal to external pressure and equilibrium is achieved again. (Temperature increases, volume increases in order for **pressure to stay constant**)

- **Temperature pressure relationship (constant volume)** - When a gas is heated, molecules gain kinetic energy and move faster. If the volume remains constant, the frequency of collisions and average force increases, resulting in an increase in pressure. (Temperature increases, pressure increases if **volume stays constant**)

Chapter 9:

Thermal Transfer

- **Conduction** – Transfer of thermal energy through molecular vibrations and collisions of particles
- **Conduction in metals** – mobile electrons at the heated end of the object gain energy and speed up. They collide with particles and other electrons to speed up the rate of energy transfer. This process is known as electron diffusion
- **Convection** – Transfer of heat energy due to density differences in a fluid. When heated, fluids will expand and become less dense. Less dense fluid tends to rise upwards while denser fluids sink. This sets up a convection current that heats up the fluid uniformly.
- **Radiation** – Continual emission of infrared radiation from the surface of all bodies; does not require any medium for transmission. Factors influencing rate of radiation include: surface area, surface temperature (the larger the temperature difference, the higher the rate of thermal radiation), colour of surface (dark or light) and type of surface. (rough or smooth)

Chapter 10:

Temperature

- Temperature is a measure of the degree of hotness or coldness of a body. (SI unit: K)
- Temperature is a measure of the **average kinetic energy** of the particles in a body
- Temperature in Kelvin (K) = Temperature in degree Celsius (°C) + 273

Chapter 11:

Thermal Properties of Matter

- Thermal energy = Internal energy = sum of internal kinetic and potential energy of the particles in the substance
- **Heat capacity** = Thermal energy needed to increase temperature of a substance by 1K or 1ºC (regardless of mass)
- **Specific heat capacity** = thermal energy needed to increase temperature of **unit mass** of a substance by 1K or 1ºC
- **Melting** – Latent heat supplied to a solid increase the potential energy of molecules, allowing them to overcome the molecular bonds, resulting in a change of state from solid to liquid. During melting, the average kinetic energy of the molecules remains constant.
- **Freezing** – Process where latent heat is released resulting in molecules losing internal potential energy. This results in the formation of strong intermolecular bonds and molecules become closely packed/arrange themselves in a regular pattern, changing state from liquid to solid.
- **Boiling** – Process where heat is supplied to increase internal potential energy of molecules in the liquid phase so that they can be separated and molecules can escape to the surroundings and move far apart.
- **Condensation** – Process where latent heat is released causing the internal potential energy of molecules in the gaseous phase to decrease so that they move closer together and form strong intermolecular bonds and turn into liquid.
- **Melting point** – Constant temperature at which a solid changes into its liquid state
- **Boiling point** – Constant temperature at which a liquid changes into its gaseous state

Chapter 12:

General Wave Properties

- A wave is the spreading of a disturbance/transfer of energy from one place to another through vibrations without net transfer of the medium
- The source of a wave is a vibration or oscillation.
- Longitudinal wave – vibration of the particles in the medium is parallel to the direction of the wave's motion
- Transverse wave – Particles in the medium vibrate in a direction perpendicular to the motion of the wave
- Quantities used to describe a periodic sinusoidal wave:
  - Amplitude A (m) – maximum displacement of a particle from its rest position
  - Wavelength λ (m) – distance between two successive crests or troughs
  - Or Wavelength is the distance between any two adjacent points on the wave which are in phase
  - Wavefront – Imaginary line in the path of a wave in which all the points on the line are in phase
  - Frequency f (Hz) – number of waves that pass a given point per second
  - Period T (s) – time between two successive crests passing by the same point in space ○ Wave velocity v (m/s) – velocity at which wave crests move
  - $v = f\lambda$
  - $f = 1/T$

- Frequency of waves entering a medium of different density or depth will not change if the source is the same ($v = f\lambda$)

	Velocity	Frequency	Wavelength
Deep to shallow	Decreases	Unchanged	Decreases
Optically denser to less dense	Increases	Unchanged	Increases

Chapter 13:

Reflection of light

- The incident ray, reflected ray and normal to the surface lie in the same plane
- The angle of incidence is equal to the angle of reflection at the point of incidence

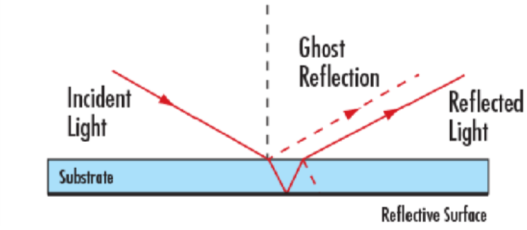
Refraction of light

- Refraction is the bending of light when it passes from one optical medium into another and undergoes a change in speed.
- A ray of light slows down and bends towards the normal when it passes from a less optically dense medium into an optically denser medium and vice versa.
- The **refractive index of a medium** is defined as the **ratio** of the speed of light travelling in **vacuum** to the speed of light travelling in the medium $n = \frac{c}{}$ $\frac{\text{speed of light in vacuum:}}{\text{speed of light in medium}}$
- Refractive index can also be found using: $n = \sin i / \sin r$, (i: air and r: denser medium) or $n =$ real depth/apparent depth
- When white light enters a prism, it disperses into its components: ROYGBIV
- Red light slows down by the least and has the longest wavelength and is bent the least • Violet light slows down the most and has the shortest wavelength and is bent the most

- **Total internal reflection** occurs when:
  - Light passes from an optically denser to less dense medium (e.g. water to air);
  - The angle of incidence in the optically denser medium is greater than the critical angle.
- The **critical angle** is defined as the angle of incidence in the optically denser medium for which the angle of refraction in the optically less dense medium is 90°.
- $n = \mathbf{1}/\sin c$, (c = critical angle)

Applications of Total internal reflection periscope

- Periscopes make use of glass prisms instead of mirrors as there is less scattering of light.

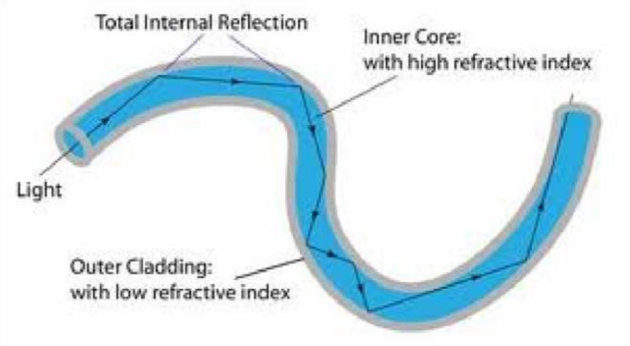


A mirror results in multiple images which causes the image to be unclear

- When light enters a glass prism and strike the inside surface of the glass prism at an angle greater than the critical angle, TIR occurs. This prevents the problem of the formation of multiple images.

Optical fibres

- Made up of thin glass core coated by a layer of glass of smaller refractive index.
- Light travelling in the optically denser core incident on the boundary between the optically denser and less dense medium will undergo total internal reflection if the angle of incidence is greater than the critical angle.



Losses in Optical Fibre

- When light travels along fibres by multiple reflections, some light is absorbed due to impurities in the glass.
- Some information could also be lost due to spreading of light signal. Light signals have a few frequencies therefore the different frequencies will reach the other end of the optical fibre at different times causing some distortion in the signal received.

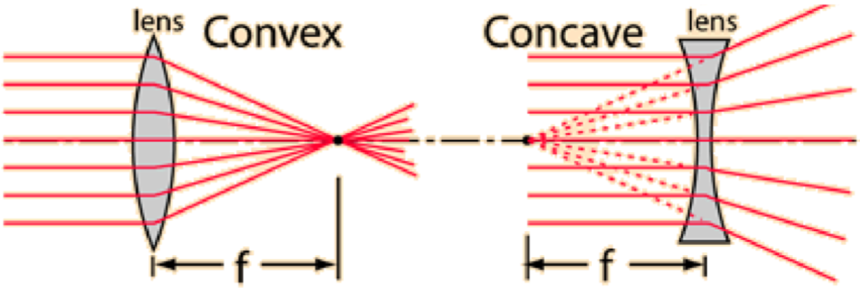
Advantages:

- Light in optical fibres travels faster than electrical signals in copper cable.
- Signals with different frequencies can be transmitted simultaneously so more information can be transmitted compared to copper cables.
- Less energy loss compared to electrical current as it does not have resistance
- They are not affected by electromagnetic interference.

Lenses

- Parallel rays of light passing through a converging lens converge at a point on its principal axis known as the focal point
- **Focal length** is defined as the distance from the optical centre of the lens to the focal point on the principal axis

- Focal point is the point on the principal axis where rays of light parallel to the principal axis converge after passing through the lens
- Parallel rays of light passing through a **diverging lens** appear to originate from a point on its principal axis known as the focal point (when extended backwards, they pass through the focal point)



- For converging lens:

Object	**Image**			
Location	**Size**	**Upright/inverted**	**Location**	**Nature**
At infinity	Diminished	inverted	At F	Real
Beyond 2F	Diminished	Inverted	Between F and 2F	Real
At 2F	Same size	Inverted	At 2F	Real
Between F and 2F	Magnified	Inverted	Beyond 2F	Real
At F	No clear image, ray s pass through optical centre and focal point and do not converge as they are parallel			
Less than F	Magnified	Upright	Same side as object behind lens	Virtual

Chapter 14:

Electromagnetic waves

- Transverse
- Travel at the speed of light
- Able to travel through a vacuum
- Do not have charge (positive or negative) hence unaffected by magnetic or electric fields

	EM wave	**Property**	**Use**
Non ionizing Molecules vibrate more quickly	Radio	Radio waves absorbed by metal aerials will produce a small current, which is converted to an audio signal. Radio waves can bend round (diffract) obstacles and be reflected from lower heights of the atmosphere which does not require receivers to be in the line of sight of transmitters	Radio telescopes Terrestrial transmission of TV and radio signals
	Microwave	Microwaves are used in satellite transmission and as they are **highly directional**, there needs to be a direct path between the transmitting and receiving satellite dish	Satellite transmission
	infrared	IR absorbed by an object causes a rise in temperature and a gain in internal energy.	Infrared thermometer Remote controller
	Visible light	Range of frequencies that the human eye can sense	Human vision
Ionizing Ionization of atoms and molecules when absorbed by matter. Exposure to ionising radiation may result in growth of tumours and cancer or cell damage	Ultraviolet	UV will cause fluorescence if absorbed by atoms UV is ionising	fluorescent lamp sunbeds sterilization killing bacteria
	X ray	Ionizing radiation	Used in X-rays of bones as the calcium in bones will absorb the X-rays and will show up on the film as shadows
	Gamma ray	Ionizing radiation	Gamma radiation is used in radiotherapy treatment for cancer.

Chapter 15:

Sound

- Sound is produced by vibrating sources placed in a medium.
- Sound is propagated when the vibrating source displaces particles in the medium causing the particles to vibrate and collide with neighbouring particles. The vibrating particles set up a series of compressions and rarefactions, transferring energy in the process.
- Sound is transmitted in the form of a longitudinal wave where particles in the medium vibrate parallel to the direction of wave motion, setting up regions of compressions and rarefactions
- Compressions – regions where pressure is higher than surrounding air pressure
- Rarefactions – regions where pressure is lower than surrounding air pressure
- Speed of sound in air is approximately 330 m/s
- Speed of sound is highest in solids, followed by liquids and gases. This is because particles in solids are closely packed, therefore particles will collide more frequently with neighbouring particles
- Human audible range – 20 Hz to 20 000 Hz
- Frequencies > 20000 Hz = ultrasound
- Frequencies < 20 Hz = infrasound

Direct method of finding speed of sound

1. 2 people to stand 100 m apart, one of them fires a gun, the other person sees the flash and start the stopwatch.
2. Stop the stopwatch when the sound from the shotgun is heard.
3. Find the speed of sound by dividing distance and time.
4. Exchange positions and repeat. (Eliminate effect of wind)
5. Find the average of the two speeds.

Applications of ultrasound (> 20 KHz):

- Sonar – Used to locate underwater objects by using reflection of sound pulses. Ultrasonic frequencies are used as they are inaudible and have high energy, hence the amount of energy reflected is still significant.
- Energy could be lost when the reflecting surface or obstacles absorb some of the energy.
- The reflected signal could also be weaker because when the pulse is reflected, it is reflected in different directions but the receiver is only able to pick up signals from one direction.
- Ultrasound medical imaging – A brief pulse of ultrasound is emitted. Part of the pulse is reflected as echoes at each interface in the body (between organs and other structures or lesions) and received by the receiver. The received pulse is used to form an image. Commonly used in pre-natal examinations
- Ultrasound in quality control. Check for flaws such as cracks, voids and frozen concrete in concrete slabs.
- Ultrasonic cleaning – dislodge/loosen small particles from surfaces

Pitch, Loudness and Quality of sound

- Waveforms of most notes are never harmonic or pure in practice, only a tuning fork can produce a pure note.
- This is why the same note played on the violin and piano will sound different
- **Pitch** is related to the **frequency** of a sound wave.
- **Loudness** is related to the **amplitude** of a sound wave.

Chapter 16:
Static Electricity

Charging by friction

- Transfer electrons from the surface of one insulator to another.
- When two different insulators are rubbed against each other, electrons will be **transferred** from the surface of one to the other. Usually the object that is a better insulator will gain electrons

Charging by induction

- When a charged object is brought near a conductor, unlike charges will be induced on the side of the conductor nearer the charged object while like charges are repelled. As the unlike charges on the 2 conductors are nearer each other, the force of attraction is stronger than the force of repulsion.
- This means that equal numbers of positive and negative charges will be induced on the conductor
- Take note that it is only the **negative charges** that are free to move.
- Charging by contact – conductors must start with different charge. Electrons will flow from one conductor to the other, resulting in a reduction of charge. The final charge on both conductors will be equal: (Q1 +Q2)/2
- Charging by earthing – the charge that is repelled will be neutralized by electrons from earth or if the charge repelled is negative, it will flow to earth.

Electric Field

- **An electric field is the region around a charge that will exert a force on another charge**
- Electric field lines are drawn such that they leave positive charges and end on negative charges. Direction of an electric field of a charged object is the direction of the force exerted on a positive test charge placed near the charged object
- Field lines should be drawn perpendicular to the charge and are closer when the field is stronger.

Electrostatic hazards and applications

- Static electrical charges accumulate on insulating surfaces due to friction causing a large potential difference to be produced. If there is a sudden discharge or spark, and flammable materials are around, this would cause ignition of the flammable material
- Applications and hazards
- Lightning
- Electrostatic precipitator
- Van de graaff generator
- Spray painting

Photocopier

- Image to be copied is projected onto a drum coated with positively charged selenium
- Selenium is a photoconductor, meaning it is a conductor when there is light
- The parts of the image that is dark remains positively charged on the drum but the parts exposed to light get neutralized
- A negatively charged toner is brushed onto the drum and they are attracted to the positively charged parts of the drum.
- The drum rotates and presses against a sheet of paper that is more positively charged than the selenium so the toner particles are transferred onto the paper.
- The paper is heated to fix the toner particles firmly on the paper

Chapter 17:
Electric Current (A or C/s)

- Current is the rate of flow of electric charge through a point in a circuit (C/s or A)
- $I=Q/t$

Chapter 18:
Electromotive force or Voltage or Potential difference (V or J/C)

- E.m.f. is defined as the work done (J) to move unit charge (C) around a complete circuit
- Potential difference across two points is defined as electrical energy converted to other forms of energy when unit charge moves across the two points
- $V=W/Q$

Resistance (Ω)

- Defined as ratio of voltage across the component to the current through it
- $R=V/I$
- Resistors in series:
  $R = R_1 + R_2 + \dots + R_n$

- Resistors in parallel:
- $1/R = 1/R_1 + 1/R_2 + 1/R_3 + \dots + 1/R_n$

Ohm's Law

- Current in a metallic conductor is proportional to the potential difference applied across the conductor provided physical conditions like temperature remain constant

Transducer – device that converts an analogue input signal into an output electrical signal or vice versa. (E.g. LDRs, thermistors)

Non ohmic resistors

- Ratio of voltage to current gives the resistance at that point for a non ohmic resistor that has a non linear graph
- NTC Thermistor – (negative temperature coefficient) component resistance increases as temperature decreases and vice versa
- Light dependent resistor (LDR) – resistance increases as brightness decreases and vice versa
- Diode – (semiconductor device) component that allows current to flow in one direction only when there is a minimum voltage across it. Resistance decreases when it is conducting (or forward biased)
- Light emitting diode (LED) – (semiconductor device) component that allows current to flow only in one direction and lights up when the voltage across it exceeds a minimum value. Resistance drops when the voltage exceeds the minimum value

Resistivity

- Resistance R of any wire is directly proportional to its length L and inversely proportional to its cross sectional area A. *The unit of resistance is Ω.*

- $R = \rho L/A$ where ρ is the constant of proportionality or **resistivity** and depends on the material used.
- Its unit is Ωm

Chapter 19:
Electrical Power

- $P = IV$
- $P = V^2/R$
- $P = I^2R$

Electrical energy

- Energy in joules = P (in Watt) × t (in seconds)
- Energy in kWh = P (in kW) × t (in hour)
- Cost of electrical energy = P (kW) x t (h) x cost per kWh

Safety features

- The fuse is placed in the live wire so that if there is a fault in the circuit, which causes the current to exceed the fuse rating, the fuse melts. Current stops flowing through the circuit and the appliance will be isolated from the high voltage live wire. This prevents the appliance from damage.
- Circuit breaker –When the operating current is not very high, the solenoid's magnetic field is not strong enough to magnetize and attract the iron latch. When there is a surge in current, the solenoid's magnetic field becomes strong enough to attract the iron latch and open the circuit. (refer to textbook diagram)
- Three-pin plug – has live (brown), neutral (blue) and earth wire (yellow and green) and a fuse connected to the live wire
- Earth wire – connected from the metal casing of an appliance to the ground, prevents user from getting an electric shock. Fuse and earth wire work in tandem, if the live wire comes into contact with the casing due to a fault, the current exceeds rated value of fuse. High current flows to ground through earth wire and at the same time, the high current causes the fuse will melt, preventing damage to the appliance.
- Double insulation – two layers of insulation that ensure the internal circuitry is insulated from the external casing which is also an insulator
- Switch – found on the live wire, if the switch is opened and there is a fault which causes a short circuit (live wire touch casing/neutral wire), the opened switch ensures that the high voltage mains is not connected to the appliance.

- Why are the electrical cables from the power supply of a heater **thicker** than the wires of the heating element in the heater?
  - The cables from the **supply** carry a high current from the supply to the heating element. Therefore they are designed to be **thick** so that they have less resistance. This ensures that very little electrical energy is lost as heat and the wires do not overheat. (Power loss = I^2R)

- In the heater, the wires of the heating element must be **thin** to increase the **resistance** of the heating element. This would ensure that all the electrical energy is converted to **thermal energy** to heat up the water in the heater.
- If a human touches a live wire, the current is **not** sufficient to melt a fuse because of the high resistance of human skin (especially when dry)

Chapter 20:

Magnetism

- Properties of magnets – magnetism is strongest at the poles, north pole of a freely hanging magnet will point to the Earth's north pole (north pole of a magnet is a north seeking pole)
- When a north pole of a magnetic is near the south pole of another magnet, attraction occurs as unlike poles attract. The force of attraction between the unlike poles is stronger than the repulsive force between the like poles as the unlike poles are nearer each other.

Attractive force between N and S is stronger than repulsive force between N and N or S and S

Magnetic field

- It is a region in which a magnetic object placed within the influence of a magnetic field, experiences a magnetic force.
- Magnetic materials like iron can be used to shield objects from surrounding magnetic fields

Magnetic Induction

- When a magnetic material is placed in a strong magnetic field, it becomes an induced magnet.

  This explains why if an iron nail touches a magnet or is near a permanent magnet, it will attract another iron nail. **Ways of making magnets**

- Stroking and electrical method
- Use the right hand grip rule (fingers represent current, thumb points to N pole) to determine polarity of electromagnet
- If a piece of iron is placed inside a solenoid connected to a voltage source, the magnetic field increases greatly. This is because the magnetic field now is the sum of the field due to the current in the solenoid and the field due to the iron core.

Ways of demagnetizing magnets

- Heating
- Hammering
- Place magnet in solenoid aligned in an east west direction; pass an alternating current through solenoid; remove magnet slowly

Magnetic effect of a current

- A current carrying wire produces a magnetic field around it
- The direction of the magnetic field around the wire can be determined using the Right-hand grip rule (thumb points in current direction; fingers show clockwise or anticlockwise magnetic field)

Chapter 21:

Electromagnetism (Motor effect)

- A force is induced on a current carrying conductor that is perpendicular to an external magnetic field. The direction of the force is determined by Fleming's left hand rule. Due to the interaction between the magnetic field of the current in the conductor and the external magnetic field, a force is induced on the wire acts due to a net magnetic field.

- This can be explained in terms of the magnetic field set up around the conductor due to the current and the magnet. One side of the conductor has a stronger magnetic field than the other side. A force will act on the conductor in the direction from the stronger field to the weaker field.
- Two current carrying wires placed parallel to each other exert a force on each other. This is also due to the interaction of magnetic fields ○ Currents in the same direction – attractive force ○ Currents in opposite direction – repulsive force

DC Motor

- A current carrying coil placed in a magnetic field such that the current direction is perpendicular to the magnetic field will experience a turning effect.
- A force is induced due to the interaction of the current's magnetic field and the external magnetic field. The resultant magnetic field determines the direction of the induced force
- Purpose of the split ring commutator is to reverse the direction of the current in the coil after half a revolution when it changes contact from one carbon brush to the other. This ensures that the coil will rotate continuously in the same direction.

Chapter 22:

Electromagnetic Induction (Generator)

- When the magnetic field lines linking a conductor changes, an e.m.f. is induced across the conductor. This is known as **electromagnetic induction**.
- **Faraday's Law** – The magnitude of the induced emf across a conductor is directly proportional to the rate of change of magnetic flux linkage.
- **Lenz's Law** – 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 in magnetic flux producing it.
- Lenz's law – conservation of energy (Mechanical work done in overcoming repulsion between the like poles is transformed into electrical energy as indicated by the induced current.)

When the north pole of P moves towards A, the magnetic flux is directed into A and magnetic flux linking A increases. By Lenz's law, the induced current produces a magnetic flux that is directed away from A opposite to the direction of the original flux. The current direction can be determined using the right hand grip rule. When the north pole of P moves away from A, the magnetic flux at A decreases. By Lenz's law, the current now reverses its direction producing a magnetic flux which opposes the decreasing magnetic flux linkage. A now becomes a south pole to attract the north pole that is moving away.

A.C. generator – uses principle of electromagnetic induction to transform mechanical energy to electrical energy.

- Slip rings allow the transfer of the alternating emf induced in the rotating coil to the external circuit.
- Fleming's **Right** hand rule is used to deduce the direction of the induced current. ○ When an induced current starts flowing in the circuit, the rotating coil will experience resistance. This is because the magnetic field of the induced current interacts with the external magnetic field resulting in a force on the coil. Applying Fleming's **Left** hand rule, it can be deduced that the force acts in the opposite direction to the rotation of the coil, causing the coil to slow down. This is known as back emf.

- The output emf of an ac generator is increased by
  - increasing the number of turns on the coil;
  - increasing the frequency of rotation;
  - increasing the strength of the magnetic field.

Fixed coil a.c. generator

- Coil is stationary and magnet is rotated around it
- Carbon brushes are not required resulting in less wear and tear.

Transformer – device that changes a high alternating voltage at low current to a low alternating voltage at high current or vice versa/device that varies an alternating voltage ○ Alternating current sets up an alternating magnetic field in the primary coil.

- Primary coil is wound on an iron core, so iron core also has an induced magnetic field.
- Function of the iron core is to maximize/concentrate flux linkage between primary and secondary coil.
- Secondary coil which is wound around the same iron core experiences a changing magnetic field causing an emf to be induced across the secondary coil
- Conservation of energy applies here: power input to the primary coil is equal to the power output at the secondary coil
- *For an ideal transformer:*
- $P_{in} = P_{out}$

  $I_P V_P = I_S V_S$

  $V_P N_S = V_S N_P$

  $I_P N_P = I_S N_S$

Power transmission

- Power loss in **transmission** lines (Joule heating) = I^2R
- To reduce power loss, minimize current I, and assuming constant power, voltage has to be increased or stepped up using transformers.