SIMPLY TUITION

GCE O-Level

Pure Physics

Volume I.

Definitions & Formulas

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Physical quantity is a quantity that can be measured. It consists of a magnitude and a unit.

Base quantity is a physical quantity that is defined and measured independently of other quantities.

Derived quantity is a physical quantity that is defined in terms of the base quantities.

Parallax error is the error that occurs due to incorrect positioning of the eyes while taking a reading on the measuring scale.

Zero error is a type of systematic error that occurs in measuring instruments when they do not start from exactly zero.

Random error refers to unpredictable variations in measurements caused by uncontrollable factors, leading to scattered data around the true value.

Scalar quantities are physical quantities that have only magnitude.

Vector quantities are physical quantities that have both magnitude and direction.

Distance, d is the total length covered by a moving object regardless of its direction of motion.

Displacement, s is the distance measured in a straight line from a fixed reference point.

$$s = ut + \frac{1}{2}at^2$$

Speed, $|v|$ is the distance moved per unit time.

$$(speed)\ \mathrm{|v|} = |u| + at$$
$$Average\ Speed = \frac{Total\ Distance}{Total\ Time}$$

Velocity, v is the rate of change of displacement.

$$(velocity)\ v = u + at$$
$$Average\ Velocity = \frac{Total\ Displacement}{Total\ Time}$$

Acceleration, a is the rate of change of velocity.

$$Average\ Acceleration = \frac{\Delta v}{\Delta t} = \frac{v - u}{t}$$

Uniform acceleration is a constant rate of change of velocity.

Force is a push or pull.

Gravitational force, F_G is the pull exerted by Earth's gravity on any object.

Electrostatic force, F_E is the attractive or repulsive forces between electric charges.

Magnetic force, F_M is the attractive or repulsive forces between magnets.

Friction, f is the force that opposes or tends to oppose motion between surfaces in contact.

Air resistance is the frictional force exerted by air that opposes the motion of moving objects.

Normal force, N is the push exerted by a surface on an object pressing on it. This push is always perpendicular to the surface.

Tension, T is the pull exerted by a stretched spring, string, or rope on an object attached to it.

Mass, m is a measure of the amount of matter in a body.

Weight, W is the gravitational force acting on an object that has mass.

$$W = mg$$

Gravitational field is a region in which a mass experiences a force due to gravitational attraction.

Gravitational field strength, g is defined as the gravitational force per unit mass placed at that point.

$$g = \frac{W}{m}$$

Newton's first law of motion states that every object will continue in its state of rest or uniform motion in a straight line unless a resultant force acts on it.

Inertia of an object refers to the reluctance of the object to change its state of rest or motion, due to its mass.

Newton's second law of motion states that when a resultant force, $\sum F$ acts on an object of a constant mass, the object will accelerate in the direction of the resultant force.

$$\sum F = ma$$

Newton's third law of motion states that if a body A exerts a force, F_{AB} on body B, then body B will exert an equal and opposite force, F_{BA} on body A.

Terminal velocity is the velocity at which a falling object experiences zero acceleration and travels at a constant speed. It occurs when the air resistance acting against the object equals its weight.

Moment of a force, M or torque, τ about a pivot, is the product of the force, F and the perpendicular distance, $d_{\perp}$ from the pivot to the line of action of the force.

$$M = Fd_{\perp}$$

Principle of moments states that that when a body is in equilibrium, the sum of clockwise moments about a pivot is equal to the sum of anticlockwise moments about the same pivot.

Taking moments about X,

CW = ACW

$$F_1 * d_{1,\perp} = F_2 * d_{2,\perp}$$

Centre of gravity is an imaginary point where the entire weight of the object seems to act.

Stability of an object refers to its ability object to return to its equilibrium position after being displaced.

Pressure, P is the force acting per unit area.

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

$$P = h\rho g$$

Pascal's law states that if a pressure is applied to an enclosed liquid, the pressure is transmitted to all other parts of the liquid undiminished.

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

Density, ρ is defined as mass per unit volume.

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

Energy is defined as the ability to do work.

Principle of conservation of energy states that energy cannot be created or destroyed. Energy can only be transferred from one store to another. The total energy of an isolated system is constant.

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

$$E_p = mgh$$

Work done, W by a constant force on an object is the product of the force and the displacement moved by the object in the direction of the force.

$$W = Fs$$

Power, P is defined as the work done or energy transferred per unit time.

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

Efficiency, η is the ratio of useful output energy (or power) to the total input energy (or power).

$$Efficiency, \eta = \frac{output\ power}{input\ power} \times 100\%$$

Kinetic particle model of matter is made up of tiny particles that are in continuous motion.

Temperature rises with average kinetic energy of the particles in a body and vice versa.

Thermal equilibrium describes a state in which two or more objects have the same temperature and there is no net transfer of energy between them.

Conduction is a process of energy transfer where energy is transferred through the passing on of vibrational motion from one particle to another.

Convection is a process of energy transfer by means of convection currents of a fluid (liquid or gas), due to a difference in density.

Radiation is the process of energy transfer by electromagnetic waves. It does not require a medium.

Internal energy is an energy store that is made up of the total kinetic energy associated with the random motion of the particles and the total potential energy between the particles in the system.

Heat capacity, C of an object is the change in its internal energy per unit change in its temperature.

$$Q = C\Delta\theta$$

Specific heat capacity, c of a material is the change of its internal energy per unit mass for each unit change in its temperature.

$$Q = mc\Delta\theta$$

Latent heat, L is the energy released or absorbed to change the state of a substance, at constant temperature.

Latent heat of fusion, L_f is the amount of energy transferred to change a substance between the solid and liquid states, at constant temperature.

Specific latent heat of fusion, l_f is the amount of energy transferred per unit mass of a substance to change between the solid and liquid states, at constant temperature.

$$L_f = l_f m$$

Latent heat of vaporisation, L_v is the amount of energy transferred to change a substance between the liquid and gaseous states, at constant temperature.

Specific latent heat of vaporisation, l_v is the amount of energy transferred per unit mass of a substance to change it between the liquid and gaseous states, at constant temperature.

$$L_v = l_v m$$

Wave is a disturbance that propagates through space, transferring energy with it but not matter.

Transverse waves have a direction of vibration that is perpendicular to the direction of wave travel.

Longitudinal waves have a direction of vibration that is parallel to the direction of wave travel.

Amplitude, x_0 of a wave is its maximum displacement from its equilibrium position.

Period, T is the time taken by each point on the wave to complete one oscillation.

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

Frequency, f is the number of oscillations each point completes per second.

Wavelength, λ is the shortest distance between two successive crests or troughs.

Wave speed, v is the distance travelled by a wave per second.

$$v = f\lambda$$

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

Wavefront is an imaginary line joining all adjacent points that are in phase.

Soundwave is a longitudinal wave that propagates through a medium. The vibration of particles within the medium causes a series of compressions and rarefactions, resulting in the transmission of energy from one point to another.

Ultrasound is sound with frequencies above the upper limit of the human audible range ($\geq 20kHz$).

Electromagnetic waves are transverse waves made up of oscillating electric and magnetic field which travel at $3.0 \times 10^8\ m/s$ in a vacuum, without the need for a medium.

First law of reflection states that the incident ray, reflected ray, and the normal at the point of incidence lie in the same plane.

Second law of reflection states that the angle of incidence θ_i. is equal to the angle of reflection θ_r.

Refraction is the bending of light as it passes from one optical medium to another.

First law of refraction states that the incident ray, refracted ray, and the normal at the point of incidence all lie in the same plane.

Second law of refraction states that for two given media, the ratio of the sine of angle of incidence to the sine of the angle of refraction is a constant, that is $\frac{\sin i}{\sin r} = constant$.

Refractive index, n of a medium is defined as the ratio of the speed of light in a vacuum to the speed of light in that medium.

$$n = \frac{c}{v}$$

$$n = \frac{\sin i}{\sin r}$$

$$n \approx \frac{real\ depth}{apparent\ depth}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

Principle of reversibility of light rays states that regardless of how many times a light ray has been reflected or refracted, it will follow the same path when its direction is reversed.

Critical angle, c is defined as the angle of incidence in an optically denser medium for which the angle of refraction in the less dense medium is 90°.

Total internal reflection is the complete reflection of a light ray in an optically denser medium at the boundary with an optically less dense medium.

$$n = \frac{1}{\sin c}$$

$$c = sin^{-1}(\frac{1}{n})$$

Principal axis is the line which passes through the centre of the lens and is perpendicular to the plane of the lens.

Focal point / principal focal point, F is the point on the principal axis where all the rays parallel to the principal axis meet after passing through the lens.

Focal length, f is the distance between the optical centre and the principal focus point, the point where all parallel rays of light converge to after passing through the lens.

Optical centre is the point on the principal axis that is the midpoint between the surfaces of the lens.

Electric field is a region in which an electric charge experiences an electric force.

Electric current, I is the rate of flow of electric charge.

$$I = \frac{Q}{t}$$

Electromotive force, ε (e.m.f.) of an electrical source is the work done by the source in driving a unit charge around a complete circuit.

$$\varepsilon = \frac{W}{Q}$$

Potential difference, V (p.d.) across a component in a circuit is the work done per unit charge in driving charges through the component

$V = \frac{W}{Q}$

Resistance, R of a component is the ratio of the potential difference V across it to the current I flowing through it.

$R = \frac{V}{I}$	$V = IR$	$I = \frac{V}{R}$
$R = \frac{\rho l}{A}$		

Ohm's law states that electric current through a conductor between two points is directly proportional to the potential difference across the two points.

Potential divider is a voltage divider, which makes use of the voltage drop across resistors in series to divide voltage.

$V_1 = \frac{R_1}{R_1 + R_2} V_T$

Power, P of an electrical component is the rate at which it consumes or generate energy.

$P = IV$	$P = \frac{V^2}{R}$	$P = I^2R$

kilowatt-hour, kWh is a unit of energy equal to the amount of work done by a power of one kilowatt operating for one hour. It is commonly used to measure electrical energy consumption.

$1\ kWh = 3.6\ MJ = 3{,}600{,}000\ J = 3.6 \times 10^6\ J$

Induction, or induced magnetism, can take place when a magnetic material is placed close to a strong magnet or within a current-carrying solenoid.

Magnetic field is a region in which the force of magnetism acts.

Temporary magnets are magnets that retain their magnetism in the presence of an electric current or a permanent magnetic field.

Permanent magnets do not require the presence of an electric current or a permanent magnetic field to retain their magnetism.

Electromagnetic induction is the process through which an induced e.m.f. is produced in a conductor due to a changing magnetic field.

Faraday's law of electromagnetic induction states that the magnitude of the induced e.m.f. in a circuit is directly proportional to the rate of change of magnetic flux in the circuit. Magnetic flux is the magnetic field in a given area.

Lenz's law states that the direction of the induced e.m.f., and hence the induced current in a closed circuit, is always such that its magnetic effect opposes the motion or change producing it.

Alternating current is an electric current that reverses its direction many times a second at regular intervals.

Eddy currents are loops of electrical current induced within conductors by a changing magnetic field in the conductor.

Transformer is a device that can change a high alternating voltage to a low alternating voltage, or vice versa.

$$(for\ ideal)\ \frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$$(for\ non-ideal)\ \eta V_p\, I_p = V_s\, I_s$$

Proton number (atomic number) is the number of protons in an atom.

Nucleon number is the total number of neutrons and protons in the nucleus of an atom.

$$Neutrons = Nucleons - Protons$$

Isotopes are atoms of the same element that have the same number of protons but different numbers of neutrons.

Nuclear decay is a random process by which an unstable atomic nucleus loses its energy by emission of electromagnetic radiation and/or particle(s).

Spontaneous decay describes a nuclear decay process that occurs naturally without any external influence.

Random decay describes a nuclear decay process which happens unpredictably.

Ionising power of electromagnetic radiation or particle refers its ability to eject electrons from atoms to form ions.

Ionisation radiation is radiation with high energies that can knock off electrons from atoms to form ions.

Background radiation refers to nuclear radiation in an environment where no radioactive source has been deliberately introduced.

Half-life of a radioactive nuclide is the time taken for half the nuclei of that nuclide in any sample to decay.

Nuclear fission is a process in which the nucleus of an atom splits (usually into two parts) and releases a huge amount of energy.

Nuclear fusion is a process in which two light atomic nuclei combine to form one heavier atomic nucleus and releases a huge amount of energy.