

MOJZA

A2

Physics Cheat Sheet

Formulas + Definitions

9702

BY TEAM MOJZA

Visit mojza.org for more resources!

Circular Motion

Angular displacement: angle swept out by an arc at centre with radii

Radian: unit of angle subtended by an arc at centre with radii such that arc length is equal to the radius of circular path

Angular Speed: change of angle swept out by an arc at centre with radii per unit time

$$S=r\theta$$

$$\omega=2\pi/T$$

$$\omega = 2\pi f$$

$$v=r\omega$$

Angular Velocity: Change of angle in clockwise or in anticlockwise direction swept out by an arc at centre with radii per unit time

$$a = v\omega$$

$$a= r\omega^2$$

$$a= v^2/r$$

Centripetal force: rate of change of momentum which compel an object to move in a circular path

$$F = mv\omega = mr\omega^2 = mv^2/r$$

Gravitational Fields

Gravitational Field: A region of space where a mass experiences an attractive force

Newton's Law of Gravitation: The force of attraction between two point object is directly proportional to the product of their masses and inversely proportional to the square of the separation

Point Object: If size of an object is infinitely small as compared to separation between two objects.

$$F = GMm/r^2$$

Gravitational Field Strength: gravitational force per unit mass/attractive pull of a planet due to its mass per unit mass of an object in its field

$$g = GM/r^2$$

Gravitational Potential: Amount of work done per unit mass to bring it from infinity up to a point in the gravitational field

$$\Phi = -GM/r$$

$$\Delta\Phi = GM[1/r_1 - 1/r_2]$$

Gravitational Potential Energy: Ability of a mass to do work due to change of its position in an attractive field of a planet

$$E_p = -GMm/r$$

$$\Delta E_p = mgh$$

Orbiting Speed

$$F_G = F_c$$

$$GMm/r^2 = mv^2/r$$

$$v = \sqrt{GM/r}$$

$$v = \sqrt{gr}$$

Kinetic Energy

$$E_k = \frac{1}{2} m (\sqrt{GM/r})^2$$

Escape speed: The minimum speed with which a satellite is projected so that is no longer under gravitational pull of planet

$$\text{Initial } E_k = \text{Final } E_p$$

$$v = \sqrt{(2GM/R)} = \sqrt{(2gR)}$$

Geostationary Satellite: Satellite which revolves around Earth and looks stationary relative to a point at the surface of the Earth

- Time period and hence angular velocity of satellite and point on earth are same
- Tangential/linear velocity of satellite is greater than point due to greater radius
- Geostationary satellite is projected from equator in director of rotation of earth

Parking Orbit: Equatorial path at a fixed distance from centre of Earth along which a geo-stationary satellite revolves for 24hr live transmission

Binary Stars: Gravitational force between two satellites is providing centripetal force to each satellite since gravitational force on each satellite is same, so centripetal force on them is also same.

$$F_G = GMm/(r_1+r_2)^2$$

Capacitance

Capacitor: Component used to separate electric charge for storage of electrical energy

Capacitance: Amount of charge stored on a plate of capacitor per unit p.d across parallel plates

$$C = Q/V$$

Series Circuit

Total Capacitance = product of capacities/sum of capacities

Parallel

Total Capacitance = sum of capacities

For identical capacitors each of capacity c

Series: $C_T = c/n$

Parallel: $C_T = nc$

Common p.d across a combination of capacitors

$$V_c = C_1 V_1 / C_1 + C_2$$

Energy stored in a capacitor

$$E = \frac{1}{2} QV = \frac{1}{2} CV^2 = \frac{1}{2} Q^2/C$$

Energy delivered by an emf source

$$E = VQ$$

Variation of charge/current with time

$$Q = Q_0 e^{-t/RC}$$

$$I = I_0 e^{-t/RC}$$

Half life of a RC circuit: the half life ($T/2$) of a RC circuit is defined as; the time taken for the charge on the capacitor, p.d across or discharge current through it to decrease to half of its initial value

Time constant of RC circuit: It is the time taken for the charge on the capacitor or the p.d across it, or the discharge current through it to decrease to $1/e$ of its initial value

$$T = RC$$

Simple Harmonic Motion

Oscillation: The repeated motion of an object about its mean position and between two extreme positions

$$x = x_0 \cos(\omega t)$$

Angular frequency: change of angle subtended by a vibrating object with its mean position per unit time

Simple Harmonic Motion: The periodic motion in which magnitude of acceleration is directly proportional to displacement and is directed towards mean position

$$a = -\omega^2x$$

Damping: The decrease in amplitude of vibrating body due to loss of energy in doing work against friction/viscous forces is damping.

Resonance: The phenomena in which there is remarkable increase in the amplitude of vibrating body when driving/forced frequency of an external oscillator is equal to its natural frequency

Total Energy of Simple Harmonic System

$$E = \frac{1}{2} m\omega^2x_0^2$$

Speed of Oscillations

$$v = v_0\cos(\omega t)$$

Max speed

$$v_0 = \omega x_0$$

Temperature

Thermal Energy: Thermal energy is defined as the energy possessed by an object due to its temperature. Thermal energy is transferred from a region of higher temperature to a region of lower temperature

Thermal Equilibrium: When two substances in physical contact with each other no longer exchange any heat energy and both reach an equal temperature

Absolute Zero: The temperature at which the atoms and molecules in all substances have zero kinetic and potential energy. [The lowest temperature possible. 0K or -273.15°C]

Specific Heat Capacity: The amount of thermal energy required to raise the temperature of 1kg of a substance by 1°C

$$Q = mc\Delta\theta$$

Specific Latent Heat: The thermal energy required to change the state of 1kg of mass of a substance without any change of temperature

$$Q=Lm$$

Specific Latent Heat of Fusion: The thermal energy required to convert 1 kg of solid to liquid with no change in temperature

Specific Latent Heat of Vaporisation: The thermal energy required to convert 1 kg of liquid to gas with no change in temperature

Ideal Gases

Mole: It is the amount containing as many particles as there are atoms in 12 g of carbon-12

Avogadro's Constant (N_A): The number of atoms of carbon-12 in 12 g of carbon-12
 6.02×10^{23}

Mole = mass/molar mass

Ideal Gas Law

$$pV = nRT$$

$$pV = NkT$$

$$P_1V_1 = P_2V_2$$

Boltzmann Constant

$$k = R/N_A$$

Assumptions of Kinetic Theory of Gases

1. Molecules behave as identical, perfectly elastic spheres
2. The volume of the molecules is negligible compared to the volume of the container
3. The time of a collision is negligible compared to time between collisions
4. There are no forces of attraction or repulsion between molecules
5. The molecules are in continuous random motion

Root Mean Squared Speed ($\sqrt{\langle c^2 \rangle}$)

c is the average speed of particles in a gas

Kinetic Theory of Gases Equation

$$pV = \frac{1}{3} Nm\langle c^2 \rangle$$

$$p = \frac{1}{3} \rho \langle c^2 \rangle$$

Thermodynamics

Internal Energy (U): The sum of the random distribution of kinetic and potential energies within a system of molecules

$$\Delta U = \frac{3}{2} k\Delta T$$

Work done by a gas

$$W = p\Delta V$$

W= -ve when work is done by the gas

W= +ve when work is done on the gas

First law of thermodynamics

$$\Delta U = q + w$$

Electric Fields

Electric Field Strength: The electrostatic force per unit positive charge acting on a stationary point charge at that point

$$E = F/Q$$

$$E = \Delta V/\Delta d$$

Electric Field of a point charge:

$$E = Q/4\pi\epsilon_0 r^2$$

Coulomb's Law: The electrostatic force between two point charges is proportional to the product of the charges and inversely proportional to the square of their separation

$$F_E = Q_1Q_2/4\pi\epsilon_0r^2$$

Electric Potential: The work done per unit positive charge in bringing a small test charge from infinity to a defined point

$$V = Q/4\pi\epsilon_0r^2$$

Potential Gradient: The electric field at a particular point is equal to the negative gradient of a potential-distance graph at that point

$$E = -\Delta V/\Delta r$$

Electric Potential Energy

$$E_p = Q_1Q_2/4\pi\epsilon_0r$$

$$\Delta E_p = Q_1Q_2/4\pi\epsilon_0(1/r_1 - 1/r_2)$$

Work Done

$$W = VQ$$

Magnetic Fields

Magnetic Field: A region where a moving charge experiences a force

Force on a current carrying conductor

$$F = BIL \sin\theta$$

$$F = BQv \sin\theta$$

B = Magnetic Flux Density

Hall Voltage: The potential difference produced across an electrical conductor when an external magnetic field is applied perpendicular to the current through the conductor

$$E = V_H/d$$

$$V_H = BI/nqt$$

Magnetic Flux (Φ): The product of the magnetic flux density and the cross-sectional area perpendicular to the direction of the magnetic flux density

$$\Phi = BA$$

When not perpendicular: $\Phi = BA\cos\theta$

Faraday's Law: The magnitude of the induced e.m.f is directly proportional to the rate of change in magnetic flux linkage

Lenz's Law: The induced e.m.f acts in such a direction to produce effects which oppose the change causing it

$$\varepsilon = - N \Delta\Phi/\Delta t$$

Alternating Current

Alternating Current: A current which periodically varies from positive to negative and changes its magnitude continuously with time

Sinusoidal Representations

$$I = I_o\sin(\omega t)$$

$$v = v_o\sin(\omega t)$$

Root mean squared alternating current/voltage

The steady direct current, or voltage, that delivers the same average power in a resistor as the alternating current, or voltage

$$I_{r.m.s.} = I_o/\sqrt{2}$$

$$V_{r.m.s.} = V_o/\sqrt{2}$$

Mean Power: The mean power in a resistive load is half the maximum power for a sinusoidal alternating current or voltage

Rectification: The process of converting alternating current and voltage into direct current and voltage

Smoothing: The reduction in the variation of the output voltage or current

Quantum Physics

Photon: A photon is a massless “packet” or a “quantum” of electromagnetic energy

Photon Energy

$$E = hf$$

h: Planck’s constant

$$E = hc/\lambda$$

Photon Momentum

$$p = E/c$$

ElectronVolt: The energy gained by an electron travelling through a potential difference of one volt

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

When electron accelerates from rest, $eV = \frac{1}{2} mv^2$

Photoelectric Effect: The photoelectric effect is the phenomena in which electrons are emitted from the surface of a metal upon the absorption of electromagnetic radiation

Threshold Frequency: The minimum frequency of incident electromagnetic radiation required to remove a photoelectron from the surface of a metal

Threshold Wavelength: The longest wavelength of incident electromagnetic radiation that would remove a photoelectron from the surface of a metal

The longest wavelength of incident electromagnetic radiation that would make a photoelectron from the surface of a metal.

Photoelectric Equation:

$$E = hf = \Phi + \frac{1}{2}mv_{\text{max}}^2$$

Work Function (Φ): The minimum energy required to release a photoelectron from the surface of a material

Photoelectric Current: The photoelectric current is the number of photoelectrons emitted per second

De Broglie Wavelength: The wavelength associated with a moving particle

$$\lambda = h/p$$

$$\lambda = h/\sqrt{2mE}$$

Discrete Energies

$$\Delta E = hf = E_2 - E_1$$

Nuclear Physics

$$E = mc^2$$

Mass Defect: The difference between an atom's mass and the sum of the masses of its protons and neutrons

$\Delta m = \text{proton number} \times \text{proton mass} + (\text{nucleon number} - \text{proton number}) \times \text{neutron mass} - \text{total mass of nucleus}$

$$\Delta m = Zm_p + (A - Z)m_n - m_{\text{total}}$$

Binding Energy: The energy required to break a nucleus into its constituent protons and neutrons

Binding Energy per nucleon: The binding energy of a nucleus divided by the number of nucleons in the nucleus

Nuclear Fusion: The fusing together of two small nuclei to produce a larger nucleus

Nuclear Fission: The splitting of a large atomic nucleus into smaller nuclei

Radioactive Decay: The spontaneous disintegration of a nucleus to form a more stable nucleus, resulting in the emission of an alpha, beta or gamma particle

Decay Constant (λ): The probability that an individual nucleus will decay per unit of time

Activity: number of decays per unit time

$$A = \Delta N / \Delta t = -\lambda N$$

Exponential decay equations

$$N = N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}$$

Count rate

$$C = C_0 e^{-\lambda t}$$

Half Life: The time taken for the initial number of nuclei to reduce by half

Medical Physics

Piezoelectric effect: The ability of particular materials to generate a potential difference (p.d.) by transferring mechanical energy to electrical energy

Transducer: any device that converts energy from one form to another

Ultrasound: A high frequency sound above the range of human hearing

Acoustic Impedance: The product of the speed of the sound in a medium and the density of the medium

$$Z = \rho c$$

intensity reflection coefficient (α): The ratio of the intensity of the reflected wave relative to the incident (transmitted) wave

$$\alpha = I_r/I_o = (Z_2 - Z_1)^2 / (Z_2 + Z_1)^2$$

Attenuation: The reduction of energy due to the absorption of ultrasound as it travels through a material

$$I = I_0 e^{-\mu x}$$

Radioactive Tracer: A radioactive substance that can be absorbed by tissue in order to study the structure and function of organs in the body

Positron Emission Tomography (PET): A type of nuclear medical procedure that images tissues and organs by measuring the metabolic activity of the cells of body tissues

Annihilation: When a particle meets its equivalent antiparticle they are both destroyed and their mass is converted into energy

Momentum of Photon

$$p = E/c$$

Astronomy and Cosmology

Luminosity (L): The total power output of radiation emitted by a star

Radiant flux intensity (F): The observed amount of intensity, or the radiant power transmitted normally through a surface per unit of area, of radiation measured on Earth

$$F = L/4\pi d^2$$

Standard Candle: An astronomical object which has a known luminosity due to a characteristic quality possessed by that class of object

Wien's displacement law: The black body radiation curve for different temperatures peaks at a wavelength which is inversely proportional to the temperature

$$\lambda_{\max} T = 2.9 \times 10^{-3} \text{ mK}$$

Stefan-Boltzmann Law: The total energy emitted by a black body per unit area per second is proportional to the fourth power of the absolute temperature of the body

$$L = 4\pi r^2 \sigma T^4$$

Doppler Effect: The apparent change in wavelength or frequency of the radiation from a source due to its relative motion away from or toward the observer

Redshift: The fractional increase in wavelength (or decrease in frequency) due to the source and observer receding from each other

$$\Delta\lambda/\lambda = \Delta f/f = v/c$$

Hubble's Law: The recession speed of galaxies moving away from Earth is proportional to their distance from the Earth

$$v = H_0 d$$

Age of Universe

$$T = 1/H_0$$