

Important Equations in Physics (AS)

Unit 1: Quantities and their measurements (topics 1 and 2 from AS syllabus)

1	System of units			M.K.S system, C.G.S. system, F.P.S. system and SI system					meter, kilogram, second centimetre, gram, second foot, pound, second					
2	SI system Base units			Length metre	Mass Kilogram	Time second	Temp kelvin(K)	Current ampere(A)		luminous intensity candela (Cd)		Amount of substance mole		
3	Multiples of units	Tera T 10^{12}	Giga G 10^9	Mega M 10^6	Kilo K 10^3	Deci d 10^{-1}	centi c 10^{-2}	milli m 10^{-3}	micro μ 10^{-6}	nano n 10^{-9}	pico p 10^{-12}	femto f 10^{-15}	atto a 10^{-18}	
4	Celsius to kelvin conversion			$K = \theta^{\circ}C + 273.15$					Add to 273.15 to Celsius scale to convert to kelvin scale					
5	Accuracy			To find the accurate value, we need to know the true value of a physical quantity. Nothing can be measured absolutely accurate.										
6	Precision			...value close to the true value. Can be increase by sensitive instrument.										
7	Error			Systematic: due to faulty apparatus					Random: due to experimenter					
8	Calculation error			For sum $Q=a+b$ $\Delta Q=\Delta a+\Delta b$					For difference $Q=a-b$ $\Delta Q=\Delta a+\Delta b$					
9	Calculating error			For product $Q=a\times b$ $\Delta Q = \left(\frac{\Delta a}{a} + \frac{\Delta b}{b}\right) \times Q$					For division $Q=a/b$ $\Delta Q = \left(\frac{\Delta a}{a} + \frac{\Delta b}{b}\right) \times Q$					
10	Significant figures (sf) examples			1.234 four sf	1.2 two sf	1002 four sf	3.07 three sf	0.001 one sf	0.012 two sf	0.0230 three sf	0.20 two sf	190 2 or 3 sf		
11	Uncertainty Δ value			the interval of confidence around the best measured value such that the measurement is certain not to lie outside this stated interval $\text{measurement} = \text{best measured value} \pm \text{uncertainty}$										
12	Percentage and relative uncertainty			$\text{percentage} = \frac{\text{uncertainty}}{\text{measured value}} \times 100$ $= \frac{\Delta x}{x} \times 100$					$\text{relative} = \frac{\text{uncertainty}}{\text{measured value}}$ $= \frac{\Delta x}{x}$					
13	Vector and scalar quantities			Vector $\rightarrow$ magnitude with unit and direction eg. velocity, force etc					Scalar $\rightarrow$ only magnitude with units Eg. density, pressure, speed, distance etc					
14	Magnitude of resultant vector c of two vectors a and b			a and b same direction: apply simple addition a and b opposite direction: apply simple subtraction $\perp$ to each other: apply Pythagoras theorem $c = \sqrt{a^2 + b^2}$ Not $\perp$ to each other: apply cosine rule $c^2=a^2 + b^2 -2\times a \times b \times \cos \gamma$										
15	Direction of resultant vector c of two vectors a and b			a and b in same direction then c is also the in the same direction a and b opposite direction then c is in the direction of bigger vector $\perp$ to each other apply $\theta = \tan^{-1} \frac{b}{a}$ Not $\perp$ to each other: use protractor										
16	Components of vector F making θ with x-axis			x- component $F_x = F \times \cos \theta$					y-component $F_y = F \times \sin \theta$					
17	Measurement by cathode ray oscilloscope (cro)			Time base: horizontal scale or x-axis					Vertical gain: vertical scale or y-axis					

Unit 2: Motion, force and energy (topic 3, 4, 5 and 6 from AS syllabus)

1	Average velocity $\bar{v}$	$\bar{v} = \frac{s}{t}$	s is the displacement in meters and t is the time in seconds.
2	Instantaneous velocity	Velocity of an object at any particular instant of time.	
3	Average acceleration $\bar{a}$	$\bar{a} = \frac{\Delta v}{\Delta t}$	Δv is the change of speed and Δt is the change of time. Unit of acceleration is ms^{-2}
4	Acceleration and velocity	Same direction: acceleration is +ve (if velocity is in +ve direction) Opposite direction: acceleration is -ve, deceleration, retardation	
5	Graphical representation		
6	Speed-time graph	Area under the graph: distance covered by and object Gradient of the graph: acceleration	
7	Distance-time graph	Gradient of the graphs: speed of an object	
8	Equation for uniform motion, constant motion	$v = \frac{s}{t}$	only use when acceleration=0 and no net force is applied
9	Equations for uniformly accelerated motion - body start motion $u=0$ - body come to rest $v=0$ - free fall $g=a=9.81\text{ms}^{-2}$ - horizontal motion $s=x$ - vertical motion $s=h=y$	$v = u + at$ $s = \frac{(u + v)}{2}t$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$	v is the final velocity in ms^{-1} , u is the initial velocity in ms^{-1} , s is the distance/displacement in m , a is the acceleration in ms^{-2} and t is the time in s .
10	Friction → static and dynamic	Static $f_s = \mu_s \times N$ Dynamic $f_k = \mu_k \times N$ N is the reaction or normal force perpendicular to the surface	f_s is the static friction in newton, f_k is the dynamic friction in newton, μ_s is the coefficient of static friction μ_k is the coeff. of dynamic friction
11	Air resistance or viscous force or viscous drag	- Opposing force to the motion in presence of air or fluid - During free fall in the beginning: weight $\gg$ air resistance + upthrust - Later: weight $>$ air resistance + upthrust	
12	Terminal velocity	- at terminal velocity, weight = air resistance + upthrust	
13	Projectile: Motion in two dimensions, v and angle θ with horizontal, upward is +	x -component → no acceleration $v_x = v \cos \theta$ $x = v_x t = vt \cos \theta$	y -component → acceleration is g $v_y = v \sin \theta$ $y = v_y t - \frac{1}{2}gt^2$
14	Weight and mass: weight is force of gravity, mass is the amount of matter, it never changes	$w = m \times g$	w is the weight in newton (N), m is the mass in kg and g is acceleration due to gravity $= 9.81 \text{ ms}^{-2}$
15	Stability of an object	Lower the centre of gravity → more stable the object is Wider the base of an object → more stable the object is	
16	Momentum	Momentum = mass $\times$ velocity $p = m \times v$	unit is kg.m.s^{-1} or N.s
17	Conservation of linear momentum	Total momentum before collision = total momentum after collision $m_A u_A + m_B u_B = m_A v_A + m_B v_B$	
18	Elastic collision	Total kinetic energy before collision = total kinetic energy after collision $\frac{1}{2}m_a u_a^2 + \frac{1}{2}m_b u_b^2 = \frac{1}{2}m_a v_a^2 + \frac{1}{2}m_b v_b^2$	
19	Elastic collision	for two masses $m_a \neq m_b$ or $m_a = m_b$ the equation must satisfy $u_a + u_b = v_a + v_b$	

20	Inelastic collision	Total kinetic energy before collision > total kinetic energy after collision $\frac{1}{2}m_a u_a^2 + \frac{1}{2}m_b u_b^2 > \frac{1}{2}m_a v_a^2 + \frac{1}{2}m_b v_b^2$	
21	Newton's first law of motion	Object in motion → stay in motion forever object stationary → stay stationary forever } unless force applied	
22	Newton's second law of motion	$F_{net} \propto a$ $m \propto 1/a$ $F_{net} = kma$ $F_{net} = ma$	- Net force applied $\propto$ acceleration - Mass of an object $\propto 1/\text{acceleration}$ - 1 N is the amount of force required to create an acceleration of 1 ms^{-2} of mass of 1 kg; $k = 1 \text{ Nkg}^{-1} \text{ m}^{-1} \text{ s}^2$
23	Newton's third law of motion	Action and reaction forces applied by two objects on each other is always equal in magnitude and opposite in direction	
24	Momentum and 2nd law of motion	$F = \frac{mv - mu}{t} = ma$	Rate of change of momentum is equal to the net force applied
25	Impulse	$F\Delta t = mv - mu$	Constant force acting for short time
26	Density 'ρ' in kgm^{-3} or gcm^{-3}	$\rho = \frac{m}{V}$ <i>m is the mass and V is the volume</i>	- ρ of Mercury is 13.6 gcm^{-3} - ρ of water is 1 gcm^{-3} at 4°C - ρ of air $0.001293 \text{ gcm}^{-3}$
27	Pressure p in pascal (Pa)	$p = \frac{F}{A}$	F is the force in N and A is the area on which the force applied in m^2
28	Pressure in fluids due to depth h in meters	$p = \rho gh$	ρ is the density of the fluid, g is the acceleration due to gravity and h is the height or depth in metre
29	Upthrust: - upward force applied by fluid on an object	$\text{upthrust} = \rho g V$ * upthrust is equal to the weight of the liquid displaced	- Object floats if the density of object is less than or equal to the density of the fluid and object sinks if the density of object is more than the density of fluid
30	Measuring the density of liquid using (upthrust) - Archimedes principle	$\frac{\text{density of liquid}}{\text{density of water}} = \frac{\text{upthrust in liquid}}{\text{upthrust in water}}$	
31	Torque or moment of force	$\tau = Fd \times \sin \theta$	F applied perpendicular to d
32	Torque due to a couple or two equal forces	Couple = one force × perpendicular distance between the two forces $\tau = Fd$	
33	Conditions of equilibrium	$\Sigma F_{net} = 0$ $\Sigma \tau_{net} = 0$	- Total or net force applied is zero - Total torque applied is zero
34	Work : ΔW is the work in joules	$\Delta W = Fs \times \cos \theta$ work that causes motion → E_k work that store energy → E_p	F is the force, s is the displacement in the direction of the force applied and θ is the angle between F and s
35	External work done by an expanding gas	$\Delta W = p\Delta V$ In p-V graph the area under the graph is the work done	p is the pressure in Pa and ΔV is the expansion of gas in m^3
35	Work done in stretching a spring	$\Delta W = \frac{1}{2}kx^2 = \frac{1}{2}Fx$ Work = area under the F-x graph	F is the force applied and x is the extension
36	Principal of conservation of mechanical energy	Loss of gain or $E_p = \text{gain or loss of } E_k$ $\Delta E_p = \Delta E_k$ $mgh = \frac{1}{2}mv^2$	
37	Electrical potential energy: Work done in bring the unit positive charge from infinity to a point.	$E_{p,q} = qV$	q is the quantity of charge in coulomb and V is the potential difference between the points.

38	Internal energy: Sum of the E_k and E_p of the molecules of a system	$\Delta Q = \Delta U + \Delta W$	ΔQ heat applied, ΔU increase in the internal energy and ΔW is the work done by the system
39	Power	$P = \frac{W}{t} = Fv$	P is the power in watts, W is the work done, F is the force and t time
40	Efficiency of a machine	$\text{Efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$	Efficiency can be expressed as percentage

Unit 3: Electric charge (topic 17, 19 and 20 from the syllabus)

1	Electric field intensity E : force on a unit charge q at any point around another charge Q	..between the two parallel plates $E = \frac{V}{d}$.. uniform between the plates separation d , unit is Vm^{-1}	..due to point charge Q on charge q $E = \frac{F}{q}$.. decreases with distance increase, unit is NC^{-1}
2	Current: Rate of flow of charges in a conductor	$I = \frac{Q}{t}$	I is the current in amperes (A), Q is the charge in coulombs (C) t is the time in seconds (s)
3	Current path	In circuits the current always choose the easiest path	
4	Conduction of electric charge	..in electrolyte liquids due chemical reaction, ions $\rightarrow$ electrolysis ..in liquids (eg mercury) or solids (metals) due to free electrons $\rightarrow$ conduction	
5	Ohms law	Voltage across the resistor is directly proportional to current, $V \propto I$ or $\frac{V}{I} = R$	V is the voltage in volts (V), I is the current in amperes (A) and R is resistance in ohms (Ω)
6	Voltage	Energy per unit charge $V = \frac{\text{Energy}}{Q}$	Q is the charge in coulombs (C), V is the voltage in volts (V) Energy is in joules (J)
7	Electromotive force(emf)	e.m.f. = lost volts + terminal p.d. $\text{e.m.f.} = Ir + IR$ unit of emf is volts (V)	the energy transferred to electrical energy and when 1C charge passes through a circuit.
8	Max. Power dissipated by the cell	$P = \frac{E^2 R}{(R + r)^2}$	Max. power P when $R=r$, E is the emf
9	Resistance and resistivity	$R = \rho \frac{L}{A}$ ρ is the resistivity of resistor in $\Omega.m$	R is the resistance a resistor, L is the length of a resistor in meters A is the area of cross-section of a resistor in m^2
10	Circuit	In series circuit $\rightarrow$ the current stays the same and voltage divides In parallel circuit $\rightarrow$ the voltage stays the same and current divides	
11	Resistance in series	$R = R_1 + R_2 + R_3 + \dots$	
12	Resistance in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots$	
13	Potential divider	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$	
14	Potential divider (V total voltage)	$V_2 = \left(\frac{R_2}{R_1 + R_2} \right) \times V$	
15	Power	$P = I \times V$	$P = I^2 \times R$ $P = \frac{V^2}{R}$
16	Power	$P = \frac{\text{Energy}}{\text{time}}$	
17	I-V Characteristics	metals $I \uparrow, V \uparrow$	diode I in one direction
18	Kirchhoff's law	$\sum I = 0$	
19	Cathode rays	Stream of electrons emitted from heated metal (cathode) are called cathode rays and the process of emission is called thermionic emission.	

Unit 4: Matter (topic 9, and 10 from the syllabus)

1	Density: ratio of mass to volume, gcm^{-3} , kgm^{-3}	$\rho = \frac{m}{V}$	$\rho = m/V$ where m is the mass and V is the vol.
2	Kinetic molecular theory of matter	tiny particles, in constant collision, held by strong electric force, large empty space, temp increases the speed of particles,	
3	Kinetic molecular theory of matter - energies	Solids: vibrates at mean position called vibrational energy	Liquids: vibrational energy and translational (movement) energy Gases: Vibrational, translational and rotational energies
4	Brownian Motion	Random, zigzag motion of particles	
5	Pressure, p	$p = \frac{\text{force applied at right angle to an object}}{\text{area of contact}}$	Unit is pascal (Pa)
6	Pressure due to liquid	$p = \rho \times g \times h$	ρ is density, g is gravity and h is depth
7	Kinetic energy of the particles of a substance	proportional to the thermal energy of a substance	
8	Potential energy of the particles of a substance	Due to electrostatic force between particles of a substance	
9	Types of solids (based on the arrangement of atoms or molecules)	Crystalline solids: Atoms or molecules are arranged in regular three dimensional pattern	Non-crystalline or amorphous solids: Atoms or molecules are not arranged in regular pattern
		Polymer solids are either crystalline polymer if the molecules are arranged in some form of regular pattern or amorphous polymer if there is no particular systematic arrangement	
10	Hooke's Law	The extension of a spring Δx is directly proportional to the force applied F_{app} provide the elastic limit is not reached $F_{app} = kx$ or $F_s = -kx$ k is the spring constant and F_s is the restoring force of spring	
11	Elastic limit	Gradient or slope of the graph between force F (y-axis) and extension x (x-axis) is the elastic limit of a spring	
12	Stress σ (unit pascal)	$\sigma = \frac{F}{A}$	F is the force applied and A is the area of cross-section perpendicular to the force
13	Strain ε (no unit)	$\varepsilon = \frac{L}{x}$	x is the change in length and L is the original length
14	Young modulus E (unit is pascal)	$E = \frac{\sigma}{\varepsilon} = \frac{F/A}{x/L} = \frac{F \times L}{A \times x}$	ratio of stress over strain
15	Young modulus E	Gradient or slope of the graph between stress σ (y-axis) and strain ε (x-axis) is the Young modulus of a spring	
16	Elastic Hysteresis loop	The difference between the areas covered by force- extension during the expansion to when it is returning back to its original shape is called elastic hysteresis loop. The area under this loop is the energy dissipated by change in length for example rubber it is used as vibration absorber.	
17	Strain energy	$W = \frac{1}{2} kx^2 = \frac{1}{2} Fx$	It is the energy stored in an object due to change of shape or size. The area under force-extension graph is strain energy

18	Strain energy per unit volume	$= \frac{1}{2} \times \frac{F}{A} \times \frac{x}{L}$ $= \frac{1}{2} \times \text{stress} \times \text{strain}$	The area under the stress-strain graph is called strain energy per unit volume. The unit of energy is joules (J).
19	Ductile and brittle material	<u>Ductile:</u> → drawn into wire without breaking → small elastic region and large ductile → eg copper wire	<u>Brittle:</u> → cannot drawn into wire → small or large elastic region but small ductile region, eg glass

Unit 4: Nuclear physics (topic 27 from the syllabus)

1	Elementary particles of an atom	<u>Proton:</u> Positive charge, inside the nucleus, same mass as neutron	<u>Electron:</u> negative charge, revolve around the nucleus, mass is 1/1836 of proton	<u>Neutron:</u> no charge, inside the nucleus, same mass as proton
2	Nucleon no ‘A’	also called mass number or atomic weight, it is sum of protons and neutrons		
3	Proton no ‘Z’	also called atomic number, total number of protons		
4	Alpha particles α -particles	Helium nucleus Stopped by paper Highest ionization potential	or	${}^4_2\text{He}$ ${}^4_2\alpha$
5	Beta-particles β -particles	Fast moving electrons Stopped by aluminum Less ionization potential	or	${}^0_{-1}e$ ${}^0_{-1}\beta$
6	Gamma-particles γ -particles	Electromagnetic radiation Only stopped by thick a sheet of lead Least ionization potential		${}^0_0\gamma$
7	Alpha decay	${}_Z^AX \Rightarrow {}_{Z-2}^{A-4}Y + {}^4_2\text{He} + \text{energy}$	Parent nuclei X emit two protons and two neutrons to make alpha particle	
8	Beta decay	${}_Z^AX \Rightarrow {}_{Z+1}^AY + {}^0_{-1}\beta + \text{energy}$	In parent nuclei X one of the neutrons changes into neutron and electron. The electron emits as beta	
9	Gamma decay	${}_Z^AX \Rightarrow {}_Z^AY + {}^0_0\gamma$	Gamma decay is the simple loss of energy from the nucleus	
10	Radioactivity is a spontaneous process	Does not depend upon the environmental factors eg atm. Pressure, temperature, humidity, brightness etc		
11	Radioactivity is a random process	All the nuclei have equal probability of decay at any time, cannot predict which nucleus will emit radiation.		
12	Half-life	Time in which the activity or mass of a radioactive substance becomes half		
13	Atomic symbol	${}_Z^AX$ Examples: ${}_1^1\text{H}$, ${}_6^{12}\text{C}$, ${}_8^{16}\text{O}$	A is the total no of protons and neutrons Z is the total no of protons	
14	Isotopes	Elements having atoms of same number of protons but different number of neutrons	Eg ${}_6^{12}\text{C}$, ${}_6^{14}\text{C}$ or ${}_1^1\text{H}$, ${}_1^2\text{H}$, ${}_1^3\text{H}$ or ${}_{92}^{235}\text{U}$, ${}_{92}^{239}\text{U}$,	

Unit 5: Waves (topic 15 and 16 from the syllabus)

1	Wave equation 1	$v = f \times \lambda$	v is the speed of wave in ms^{-1} f is the frequency in Hz λ is the wavelength in metre
2	Wave equation 2	$f = \frac{1}{T}$	T is the time period of wave in second
3	Movement of the particles of the medium	Longitudinal waves=> back and forth same direction as waves Transverse waves=> perpendicular to the direction of waves	
4	Wavelength ' λ '	Distance between two crests or two troughs, unit metre (m)	
5	Frequency ' f '	Total number of waves in one second, unit hertz (Hz)	
6	Time period ' T '	Time taken for one complete wave, unit second (s)	
7	Speed of wave motion ' v '	Distance move by crest in direction of wave in 1second, unit ms^{-1}	
8	Displacement of particle ' s '	Distance move by a particle from its mean position in either direction, unit metre (m)	
9	Amplitude ' a '	The maximum distance move by the particle, unit metre (m)	
10	Wave fronts	Representation of crests of a wave by straight line perpendicular to the direction of wave. Distance between two wave fronts is wavelength.	
11	Progressive wave	Continuous waves created by a source	
12	Phase difference	When the crests and troughs of two waves do not overlap each other then two waves have phase difference	
13	Coherent waves	Two waves of same properties and originate from same source	
14	Intensity of a wave ' I '	$I = \frac{P}{A}$ Unit of intensity is Wm^{-2}	P the amount of wave energy per second at particular point falling on surface area A
15	Intensity of a wave ' I '	Intensity of wave is directly proportional to the amplitude square $I \propto a^2$	
16	Compression region	When particles of a medium come close to each other	
17	Rarefaction region	Where particles of a medium move further apart from each other	
18	Diffraction	When waves pass through a narrow gap, they spread out.	
19	Interference of light waves	Constructive interference: When the crests-crests and troughs-troughs of two waves overlap each other, amplitudes become added	Destructive interference: When crests-troughs of two waves overlap each other, amplitudes cancel each other
20	Young double slit experiment	For bright fringes: $x = \frac{n\lambda D}{a}$	For dark fringes: $x = \frac{(n+1)\lambda D}{a}$
		a is the distance between the two slits, D is the distance between slits and the screen, λ is the wavelength of light, n is the order of bright or dark fringe counting from the first bright fringe at the centre, x is the distance of n th fringe from the centre	
21	Diffraction grating	$d \sin \theta = n\lambda$	d is the gap between two grating lines, θ is the angle of the order of maxima, n is the order of a maxima and λ is the wavelength
22	Polarized light	When the electric and magnetic field of light waves oscillates only in one dimensions, this process of transforming un-polarized light into polarized light is called polarization.	
23	Standing or stationary waves	A wave results when two waves which are traveling in opposite direction, and which have the same speed and frequency and approx. equal amplitudes, are superimposed (overlapped)	

24	Stationary waves in a string of length 'L' and speed of wave is 'v'	Fundamental mode or first harmonic: $L = \frac{\lambda}{2}$ or $f_1 = \frac{v}{2L}$ (one loop)	First overtone or second harmonic: $L = \lambda$ or $f_2 = \frac{v}{L}$ (two loops)	Second overtone or third harmonic: $L = \frac{3\lambda}{2}$ or $f_3 = \frac{3v}{2L}$ (three loops)
25	Stationary waves in a string of length 'L'	For nth harmonic frequency: $f_n = \frac{nv}{2L}$ where $n = 1, 2, 3, \dots$		
26	Stationary wave in an air column one end open one end close	Fundamental mode or first harmonic: $L = \frac{\lambda}{4}$ or $f_1 = \frac{v}{4L}$ ($\frac{1}{2}$ loop)	First overtone or second harmonic: $L = \frac{3}{4}\lambda$ or $f_2 = \frac{3v}{4L}$ (1 $\frac{1}{2}$ loops)	Second overtone or third harmonic: $L = \frac{5\lambda}{4}$ or $f_3 = \frac{5v}{4L}$ (1 $\frac{1}{2}$ loops)
		For nth harmonic frequency: $f_n = \frac{(2n-1)v}{4L}$ where $n=1,2,3$.		
27	Speed of light	In air: 3×10^8 m/s	In glass: 2×10^8 m/s	In water: 2.25×10^8 m/s
28	Electromagnetic Spectrum: $\rightarrow$ this way the frequency decreases and wavelength increases Gamma rays $\leftrightarrow$ X-rays $\leftrightarrow$ UV $\leftrightarrow$ Visible light $\leftrightarrow$ IR $\leftrightarrow$ Micro waves $\leftrightarrow$ Radio waves			
29	The Electromagnetic Spectrum Chart by LRSP/University of Colorado, Boulder nm=nanometer, Å=angstrom, μm=micrometer, mm=millimeter, cm=centimeter, m=meter, km=kilometer, Mm=Megameter			