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 **m**etre*	*Mass **K**ilo**g**ram*	*Time **s**econd*	*Temp kelvin(**K**)*	*Current ampere(**A**)*	*luminous intensity candela (**Cd**)*	*Amount of substance **mol**e*

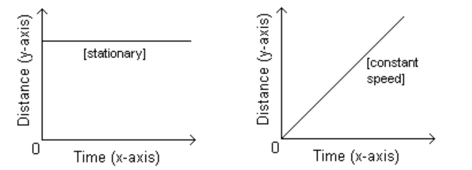
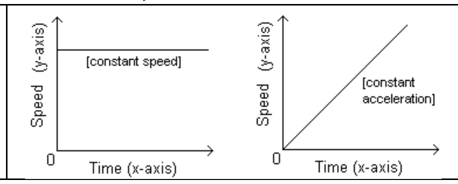
3	*Multiples of units*	*Tera* **T** 10^{12}	*Giga* **G** 10^{9}	*Mega* **M** 10^{6}	*Kilo* **K** 10^{3}	*Deci* **d** 10^{-1}	*centi* **c** 10^{-2}	*milli* **m** 10^{-3}	*micro* **µ** 10^{-6}	*nano* **n** 10^{-9}	*pico* **p** 10^{-12}	*femto* **f** 10^{-15}	*atto* **a** 10^{-18}

4	*Celsius to kelvin conversion*	$K = \theta^{o}C + 273.15$	*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×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 ∆value*	*the interval of confidence around the best measured value such that the measurement is certain not to lie outside this stated interval* $measurement = best\ measured\ value \pm uncertainty$	
12	*Percentage and relative uncertainty*	$percentage = \frac{uncertainty}{measured\ value} \times 100 = \frac{\Delta x}{x} \times 100$	$relative = \frac{uncertainty}{measured\ value} = \frac{\Delta x}{x}$
13	*Vector and scalar quantities*	*Vector → magnitude with unit and direction eg. velocity, force etc*	*Scalar→ 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* *⊥ to each other: apply Pythagoras theorem* $c = \sqrt{a^2 + b^2}$ *Not ⊥ 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* *⊥ to each other apply* $\theta = \tan^{-1}\frac{b}{a}$ *Not ⊥ to each other: use protractor*	
16	*Components of vector **F** making θ with x-axis*	*x- component* $\mathbf{F_x} = \mathbf{F} \times \cos\theta$	*y-component* $\mathbf{F_y} = \mathbf{F} \times \sin\theta$
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* $g=a=9.81ms^{-2}$ *- 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≫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* $v_y = v\sin\theta$ $y = v_y t - ½gt^2$	*horizontal range* $R = \frac{v^2}{g}\ sin2\theta$ *max range at* $\theta=45^o$
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* 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×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* $½m_a u_a^2 + ½m_b u_b^2 = ½m_a v_a^2 + ½m_b v_b^2$	
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* $½m_a u_a^2 + ½m_b u_b^2 > ½m_a v_a^2 + ½m_b v_b^2$	
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 ∝ acceleration* *- Mass of an object ∝ 1/acceleration* *-1 N is the amount of force require to create an acceleration of 1 ms^{-2} of mass of 1 kg; $k=1Nkg^{-1}m^{-1}s^2$*
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}*	$\rho = \frac{m}{V}$ *m is the mass and V is the volume*	*- ρ of Mercury is 13.6gcm^{-3}* *- ρ of water is 1gcm^{-3} at 4°C* *- ρ of air 0.001293gcm^{-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*	$p = \rho g h$	*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*	$upthrust = h\rho g A$ ** 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*	$\frac{density\ of\ liquid}{density\ of\ water} = \frac{upthrust\ in\ liquid}{upthrust\ in\ water}$	
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*	$\Delta W = ½kx^2 = ½Fx$ *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=gain or loss of E_k* $\Delta E_p = \Delta E_k$ $mgh = ½mv^2$	
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*	$Efficiency = \frac{useful\ energy\ output}{total\ energy\ input} \times 100$	*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 → electrolysis ..in liquids (eg mercury) or solids (metals) due to free electrons→ 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* $V = \frac{Energy}{Q}$	*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* *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 Ω.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→ the current stays the same and voltage divides In parallel circuit → the voltage stays the same and current divides*	
11	*Resistance in series*	$R = R_1 + R_2 + R_3 + \cdots$	*R,* R_1*,* R_2 *and* R_3 *are resistances of resistor in ohms*
12	*Resistance in parallel*	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$	
13	*Potential divider*	$\frac{V_1}{V_2} = \frac{R_1}{R_2}$	V_1 *voltage across* R_1 V_2 *voltage across* R_2
14	*Potential divider (V total voltage)*	$V_2 = (\frac{R_2}{R_1 + R_2}) \times V$	$V_1 = (\frac{R_1}{R_1 + R_2}) \times V$
15	*Power*	$P = I \times V$; $P = I^2 \times R$; $P = \frac{V^2}{R}$	*P is the power in watts (W)*
16	*Power*	$P = \frac{Energy}{time}$	*The unit of energy is joules (J)*
17	*I-V Characteristics*	*metals: I↑, V↑* ; *diode: I in one direction* ; *filament: V↑,T↑,R↑,I↓*	*thermistor: T↑, R↓, I↑* ; *LDR: L↑,R↓.I↑*
18	*Kirchhoff`s law*	$\sum I = 0$	$\sum EMF = \sum IR$
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}*	$\rho = \frac{m}{V}$	*ρ=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*	$p = \frac{force\ applied\ at\ right\ angle\ to\ an\ object}{area\ of\ contact}$	*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	$= \frac{1}{2} \times \frac{F}{A} \times \frac{x}{L}$ $= \frac{1}{2} \times stress \times strain$	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	Ductile: → drawn into wire without breaking → small elastic region and large ductile → eg copper wire	Brittle: → 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		${}_2^4He$ or ${}_2^4\alpha$
5	Beta-particles β-particles	Fast moving electrons Stopped by aluminum Less ionization potential		${}_{-1}^{0}e$ or ${}_{-1}^{0}\beta$
6	Gamma-particles γ-particles	Electromagnetic radiation Only stopped by thick a sheet of lead Least ionization potential		${}_0^0\gamma$
7	Alpha decay	${}_Z^AX \Rightarrow {}_{Z-2}^{A-4}Y + {}_2^4He + energy$		Parent nuclei X emit two protons and two neutrons to make alpha particle
8	Beta decay	${}_Z^AX \Rightarrow {}_{Z+1}^{A}Y + {}_{-1}^{0}\beta + energy$		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: ${}_1^1H$, ${}_6^{12}C$, ${}_8^{16}O$		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 ${}_6^{12}C$, ${}_6^{14}C$ or ${}_1^1H$, ${}_1^2H$, ${}_1^3H$ or ${}_{92}^{235}U$, ${}_{92}^{239}U$,

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 $'\lambda'$*	*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 nth 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,....*		
26	*Stationary wave in an air column one end open one end close*	*Fundamental mode or first harmonic:* $L = \frac{\lambda}{4}$ *or* $f_1 = \frac{v}{4L}$ *(½ loop)*	*First overtone or second harmonic:* $L = \frac{3}{4}\lambda$ *or* $f_2 = \frac{3v}{4L}$ *(1 ½ loops)*	*Second overtone or third harmonic:* $L = \frac{5\lambda}{4}$ *or* $f_3 = \frac{5v}{4L}$ *(1 ½ 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:→ this way the frequency decreases and wavelength increases* *Gamma rays ↔ X-rays ↔ UV ↔ Visible light ↔ IR ↔ Micro waves ↔ Radio waves*			

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