Important Equations in Physics (A2)

Unit 1: Non-uniform Acceleration (Topic 7 and 14)

1	*Base units*	*Length* ***m**eters*	*Mass* ***k**ilograms*	*Time* ***s**econds*	*Temp* *kelvin(**K**)*	*Current* *ampere (**A**)*	*luminous intensity* *candela (**Cd**)*	*Amount of substance* ***mol**e*

2	*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}

3	*Radian : Angle subtended by an arc equal to the length of radius*	$\theta = \frac{length\ of\ arc}{radius\ of\ circle} = \frac{circumference\ of\ the\ circle}{radius} = \frac{s}{r}$		
4	*Radian and degree*	$2\pi\ rad = 360^o$ $1\ rad = 57.3^o$	$radian = degree \times \frac{\pi}{180^o}$	$degree = rad \times \frac{180^o}{\pi}$
5	*Angular displacement, θ in radians*	$\theta = \frac{s}{r}$		*s is the arc length in meters* *r is the radius of a circle in meters*
6	*Angular speed, ω in radians/seconds*	$\omega = \frac{\Delta\theta}{\Delta t}$	$v = r\omega$	*ω is called omega, is a vector, direction clockwise or anticlockwise*
7	*Centripetal Force, F_c*	$F_c = \frac{mv^2}{r}$	$F_c = mr\omega^2$	*unit newtons, N, always directed towards the centre of the circle of radius r*
8	*Centripetal acceleration*	$a_c = \frac{v^2}{r}$	$a_c = r\omega^2$	*unit m/s^2 or rad/s^2 direction always towards the centre of the circle*

Oscillations

9	*Period **T***	*Time taken for one complete oscillation. Unit seconds*	
10	*Frequency **f***	*Number of oscillations per second. Unit oscillations per second or hertz or Hz*	
11	*Displacement **x***	*The distance from the equilibrium position at any time t. Unit meters, vector qty*	
12	*Amplitude x_o*	*The maximum displacement from the mean position. Unit meters, scalar qty*	
13	***S**imple **H**armonic **M**otion*	*a) motion about a fixed point,* *b) acceleration is proportional to displacement and directed towards a fixed point,* *c) direction of acceleration is opposite to displacement.*	
14	***S**imple **H**armonic **M**otion*	$a = -\omega^2 x$	*a, acceleration; ω, angular frequency; x, displacement*
15	*Angular frequency*	$\omega = 2\pi f$	*f is frequency of oscillations*
16	*Restoring force, F_{res}*	*The resultant force acting on an oscillating particle that cause acceleration a.* $F_{res} = -m\omega^2 x$	
17	*Simple harmonic motion Equations*	*at t=0 and x=0* $x = x_o \sin\omega t$ $v = x_o\omega \cos\omega t$ $v_o = x_o\omega$ $v = \pm\omega\sqrt{(x_o^2 - x^2)}$ $a = -x_o\omega^2 \sin\omega t$ $E_k = \frac{1}{2}m\omega^2(x_o^2 - x^2)$ $E_p = \frac{1}{2}m\omega^2 x^2$	*at t=0 and x=x_o* $x = x_o \cos\omega t$ $v = -x_o\omega \sin\omega t$ $v_o = x_o\omega$ $v = \pm\omega\sqrt{(x_o^2 - x^2)}$ $a = -x_o\omega^2 \cos\omega t$ $E_k = \frac{1}{2}m\omega^2(x_o^2 - x^2)$ $E_p = \frac{1}{2}m\omega^2 x^2$
18	*Total energy for SHM*	$E_{tot} = E_k + E_p = \frac{1}{2}m\omega^2 x_o^2$	
19	*Time period for Simple pendulum and mass on a helical spring*	$T = 2\pi\sqrt{\frac{l}{g}}$ *l is the length of the pendulum*	$T = 2\pi\sqrt{\frac{m}{k}}$ *m is the mass and k is the spring constant*
20	*Free oscillations*	*When the only force acting on a particle is external restoring force.*	
21	*Damped oscillations*	*When frictional and resistive force reduce the amplitude (energy) of the oscillation*	
22	*Resonance*	*When driving freq. of the osc. is equal to natural frequency gives max amplitude*	

Unit 2: Thermal Physics (Topic 11, 12, 13)

1	*Mole: amount of substance, n*	*eg 1 mole carbon=12g, 1 mole of oxygen=16g, 1 mole of water=18g*	
2	*Avogadro constant, N_A*	*Constant number of molecules or atoms in 1 mole=6.023×10^{23} particles*	
3	*Brownian motion*	*Random, jerky, haphazard, zigzag motion of molecules in liquid or gas*	
4	*Absolute Temperature, K*	*Temperature in kelvin scale*	*$T/K=\theta/^oC+273.15$*
5	*Ideal gas equation*	*pV=nRT*	*P=pressure, V=volume, T=temp in Kelvin, n number of moles, R=universal gas constant per mole=8.3$Jmole^{-1}K^{-1}$.*
6	*Ideal Gas*	*- gas that obeys ideal gas equation at all pressures, volumes, temperatures, - molecules do not exert forces on each other when collide, - the collision between the molecules is perfectly elastic*	
7	*Kinetic theory of ideal gas*	*- Matter is made of tiny particles called atoms or molecules, - These particles are in constant, random motion, - Particles collide with each other and collision is perfectly elastic, - Particles apply no force on each other when collide, - Motion of particles is greater in gas, less in liquid and least in solids, - Volume of particles in gas is negligible compare to the volume of gas.*	
8	*Kinetic theory of ideal gas*	$pV=\frac{1}{3}Nm\langle c^2\rangle$ *or* $p=\frac{1}{3}\rho\langle c^2\rangle$ *N is the total number of molecules, m is the mass of a molecule, p the pressure, V the volume of container, $\langle c^2\rangle$ the average of square of the velocities of molecules,* $\frac{Nm}{V}=\rho, the\ density\ of\ gas.$	
9	*Other gas equations*	$pV=NkT$ $R=\frac{N}{n}k$ $R=N_Ak$	*R=universal gas constant (per mole) =8.3$Jmole^{-1}K^{-1}$ k=Boltzmann constant (per molecule)=$1.38\times10^{-23}JK^{-1}$ $\frac{N}{n}=N_A$, Avogadro no. 6.023×10^{23}molecules/mole*
10	*Average of $\langle E_k\rangle$ molecules*	$\langle E_k\rangle=\frac{3}{2}kT$	*T, the temperature in kelvin, k, the Boltzmann constant*
11	*Heat and temperature*	*Heat is a form of energy measured in joules*	*Temperature is the degree of hotness of an object measure in ^oC or K*
12	*Internal energy ΔU*	*In ideal gas, it is the sum of kinetic energies of all molecules*	*In real gas, it is the sum of kinetic and potential energies of all molecules*
13	*Law of thermodynamics*	*The increase in internal energy (ΔU) of a system is equal to the sum of heat energy added to the system and the work done on it.* $\Delta U=Q+W$ *Q is the heat energy and W(=pΔV), is the work done on the system*	
14	*Thermal equilibrium*	*When all sections of a system are at same temperature*	
15	*Physical properties of matter when heated*	*- most materials expand upon heating, eg mercury in glass thermometer - resistance of metals increases when the temperature increases, eg thermocouple thermometer*	
16	*Thermocouple thermometer (junction between copper and iron wire)*	*a) wide range (-200^{o}C to 1500^{o}C) b) can store data electronically c) small size easy to manage d) record very rapid change of temperature e) can measure the temperature of small objects*	
17	*Specific heat capacity: ..amount of heat required to raised the temperature of unit mass of a substance to one degree*	$c=\frac{\Delta Q}{m\times\Delta\theta}$ $c=\frac{P\times t}{m\times\Delta\theta}$	*c, the specific heat capacity, $Jkg^{-1o}C^{-1}$ m, the mass of an object, kg $\Delta\theta$, the change in temperature, ^oC ΔQ, amount of heat energy, J P, the power of electrical heater, W t, ON time for electrical heater, s*
18	*Thermal capacity, C unit J/^{o}C*	$C=\frac{\Delta Q}{\Delta\theta}$ *or* $C=c\times m$	*..heat required to increase the temperature of a whole body*
19	*Specific latent heat: ..amount of heat require to change the state of unit mass of matter without increase of temperature*	*..of fusion → from solid to liquid* $l_f=\frac{Q}{m}=\frac{P\times t}{m}$ *unit J/kg*	*..of vaporization→ from liquid to gas* $l_v=\frac{Q}{m}=\frac{P\times t}{m}$ *unit J/kg*
		Always $I_v>I_f$ *for the same substance*	

Unit 3: Force fields (topic from syllabus 8, 17, 18, 21, 22)

Gravitational field			
1	*Newton's law of gravitation*	*Every two objects attract each other with force directly proportional to their masses and inversely proportional to the square of the distance between them*	
2	*Gravitational force between two masses*	$F_G = G\dfrac{m_1 \times m_2}{r^2}$	*F the force in newton, m_1 & m_2 masses, G universal force constant 6.67×10^{-11} Nm^2kg^{-2}*
3	*Earth's Gravitational force on mass m*	$mg = F = G\dfrac{M_e \times m}{R^2}$	*M_e the mass of earth, R the radius of earth*
4	*Gravitational field strength, g*	$g = G\dfrac{M_e}{R^2}$	*Force per unit mass placed at a point in a gravitational field=9.81Nkg^{-1}*
5	*Gravitational potential energy, E_p*	$E_p = -G\dfrac{M_e \times m}{r} = mgr$	*work done against the gravity on bringing the mass to distance r above the surface of the earth ($r=R+\Delta h$)*
6	*Gravitational potential ϕ*	$\phi = \dfrac{E_p}{m} = -G\dfrac{M_e}{r}$	*Potential energy per unit mass*
7	*Geostationary orbit*	$\dfrac{T^2}{r^3} = \dfrac{4\pi^2}{GM}$	*The square of the period is proportional to the cube of the radius of orbit*
Electric field			
8	*Coulomb's law of electrostatic*	$F_E = \dfrac{1}{4\pi\epsilon_o}\dfrac{q_1 \times q_2}{r^2}$ $1/4\pi\epsilon_o = 9\times10^9 C^{-2} Nm^2$	*q_1, q_2 charged objects in coulombs, r the distance between the charged objects, ϵ_o the permittivity of free space=$8.85\times10^{-12}C^2N^{-1}m^{-2}$*
9	*Electric field intensity, E, due to charge Q*	$E = \dfrac{F}{q} = \dfrac{1}{4\pi\epsilon_o}\dfrac{Q}{r^2}$	*- force on a unit charge q at any point around another charge Q* *- out from positive end to negative charge*
10	*Electric field intensity, E, between the two charged plates*	$E = \dfrac{V}{d}$	*V the potential difference between the plates* *d the distance between the plates* *E is uniform between the plates, unit is Vm^{-1}*
11	*Electric potential, V*	$V = \dfrac{Q}{4\pi\epsilon_o r}$	*.. work done in bringing the point charge from infinity to a point r in an electric field*
Capacitance			
12	*Capacitance, C*	$C = \dfrac{Q}{V}$	*ratio of charge (Q) stored to potential diff.(V) between conductor, unit Farad, mF and μF*
13	*Electric pot. energy stored in a capacitor*	$E_p = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$	*- Capacitor is use to store charges or energy,* *- has two plates and insulator in between*
14	*Factors affecting capacitance*	$C = \epsilon_r\epsilon_o\dfrac{A}{d}$	*A the area of parallel plates, d the distance between them, ϵ_o permittivity of free space, ϵ_r relative permittivity of dielectric*
15	*Relative permittivity ϵ_r*	*Capacitance with dielectric divided by capacitance with vacuum, no units*	
16	*Capacitors connected in...*	*.. parallel* $C = C_1 + C_2$	*.. series* $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$
Magnetic fields			
17	*Magnetic field*	*Force of field around magnets or current carrying conductor*	
18	*Magnetic flux density B*	*the magnetic field strength or force per unit length of conductor, unit tesla (T)*	
19	*Magnetic flux ϕ*	*Product of magnetic flux density (B) and area (A) normal to the magnetic field lines, unit weber (Wb) or tesla meter square (T m^2)* $\phi = BAsin\theta$	
20	*Force (F) in magnetic field*	*..on current carrying conductor* $F = BILsin\theta$	*..on moving charge q with speed v* $F = Bqvsin\theta$
21	*Specific charge of electron e/m*	$e/m = \dfrac{v}{Br}$	*The ratio of charge to mass of an electron*
22	*Faraday`s law of EM induction*	*Emf produce is directly proportional to rate of change of magnetic flux linkage*	
23	*Hall probe*	*Use to find amount of magnetic field by creating hall voltage V_H in a conductor*	

Unit 4: Electromagnetic Induction and alternating current (Topics from syllabus 23 and 24)

Electromagnetic Induction			
1.	Magnetic field, **B**	Field around a magnet or current carrying conductor where other magnetic materials experience force, direction $N \rightarrow S$	
2.	Law of Magnets	Like poles repel each other	Unlike poles attract each other
3.	Right hand rule	magnetic field around a current carrying conductor, thumb pointing in the direction of conventional current, curved fingers direction of mag. Field	
4.	Helmholtz coils	Two identical flat coils, placed side by side, having same current in them, separated by distance equal to the radius produce mag. field in between them	
5.	Motor effect Fleming's LH rule	A current carrying conductor placed in a magnetic field at right angle, experience motor force at right angle to both. Use Fleming's left hand rule	
6.	Motor force	$F = BIL\sin\theta$ $\theta = 90^o \rightarrow$ max. motor force $\theta = 0 \rightarrow$ zero motor force	B – magnetic field strength in tesla (T) I – current in the conductor in ampere(A) L – length of conductor in mag. field (m) θ – angle between I and B
7.	Magnetic flux density	It is the magnetic field strength, represented by symbol B. Its unit is tesla (T)	
8.	Magnetic flux , Φ units weber (Wb) or tesla meter sq (Tm^2)	$\Phi = BA\sin\theta$ θ is the angle between B and normal to A	It is the product of magnetic flux density B and area A normal to the magnetic field lines
9.	Define weber	The SI unit of magnetic flux, equal to a flux that produces a electromotive force of one volt in a single turn of wire when the flux is uniformly reduced to zero in a period of one second	
10.	Change in magnetic flux linkage	product of change in magnetic flux $\Delta\Phi$ and number of turns N in a conductor	$change\ in\ magnetic\ flux\ linkage = N\Delta\Phi$
11.	Faraday's law of electromagnetic induction	The emf produced in proportional to the rate of change of magnetic flux linkage	$emf = -N\frac{\Delta\Phi}{\Delta t}$ or $-N\frac{d\Phi}{dt}$ use fleming's RH rule to find the direction of induce current or induce emf.
12.	Lenz's law	The direction of induced emf is such as that it opposes the motion that causing it.	
13.	Mutual Induction	Changing mag. field in one coil induces changing emf in the other coil. Eg transformer.	
14.	Transformer step up $N_p<N_s$ step down $N_p>N_s$	$P_p = P_s$ $\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$	V_p and V_s are voltages in primar and sec. N_p and N_s are turns in primary and sec. I_p and I_s are current in primary and sec. P_p and P_s are power of primary and sec.
Alternating Current			
15.	a.c.	Alternating current – the mains supply of house electricity - 240V in UAE	
16.	a.c. equations – sinusoidal waves	$I = I_o \sin\omega t$ $V = V_o \sin\omega t$	I_o max current, ω angular speed, I and V are the instantaneous current and voltage at time t
17.	Peak values I_o and V_o	The max. values of the voltage or current in alternating current cycle	
18.	rms values V_{rms} or I_{rms}	effective values of voltage or current which will have same heating effect in a resistor that is produced by same value of direct current	
19.	rms values	$I_{rms} = \frac{I_o}{\sqrt{2}} = 0.7071 I_o$	$V_{rms} = \frac{V_o}{\sqrt{2}} = 0.7071 V_o$
20.	Why a.c. supply?	… so that the voltage can be increased before placing on power line to reduce the loss of energy due to high current	
21.	Diode	Electronic component that allows the current to pass only in one direction	
22.	Rectification	Process of changing a.c. to d.c. by using diodes. Full wave and half wave	
23.	Bridge rectifier	circuit that changes a.c. to d.c. using four diodes, capacitor and resistor	

Unit 5 Modern Physics (Topics from syllabus 25, 26 and 27)

Charges Particles			
1.	Millikan oil drop experiment	exp. to determine the charge of elementary particle – electron and proton = $1.6\times10^{-19}C$	weight of charged oil drop is equal to the force due to electric field $qE = \pi r^3(\rho - \rho_a)g$
2.	Charged particle in electric and mag. field	$\frac{mv^2}{r} = Eq$ and $\frac{mv^2}{r} = Bqv$	$F_c=F_E$ and $F_c=F_B$
3.	Velocity of charged particle in electric (E) and magnetic (B) field	$v = \frac{E}{B}$	Fc = centripetal force FB = force due to magnetic field FE = force due to electric field
4.	Specific charge	Charge to mass ratio e/m of electron or proton	
Photoelectric Effect			
5.	Photoelectric effect	Emission of electrons from metals when e.m. radiations fall on it. Proof of light as particles that is particle strikes particle emits	
6.	Photoelectric effect: Properties	a) instantaneous b) only happen if the freq is above minimum level c) each metal have its own freq d) rate of electrons emits is proportional to intensity	
7.	Threshold freq f_o	The minimum freq of wave required to emit the electrons from the metals, each metal have its own threshold frequency.	
8.	Max Plank Equation	$E = hf$	E the energy, f the freq and h the Planks constant= $6.63\times10^{-34}Js$
9.	Photon	Light as packets and energy of these packets are quantized, only on certain fixed levels.	
10.	Work function energy ϕ	The minimum amount of energy require for electron to escape, $\phi = hf_o$	ϕ work function energy in J, f_o the threshold freq, h planks constant
11.	Photoelectric equation	$E = hf = \phi + \frac{1}{2}m_e v_{max}^2$ $E = hf = hf_o + \frac{1}{2}m_e v_{max}^2$	
12.	de Broglie wavelength, λ Equation of wave particle duality	$\lambda = \frac{h}{p}$	p is momentum of the particle
13.	Electromagnetic spectra	Continuous spectra: spectrum of all colours and wavelengths	Line spectra: spectrum of only few colours and wavelengths shown as lines
14.	Quantization of energy levels in atomic orbits	$\Delta E = E_1 - E_2 = hf$	When electron jump from: lower to higher energy state → absorb energy higher to lower energy state → emit energy
Nuclear Physics			
15.	Atomic mass unit,1u	$1u=1.66\times10^{-27}kg$	Equal to one-twelfth of the mass of carbon-12 atom
16.	Mass deficit (or defect)	Difference between the total mass of separate nucleons and combine nucleus	
17.	Mass – Energy Equation	$E = mc^2$	E is the energy, m the mass and c the speed of light $1u = 931MeV$
18.	eV the unit of energy	$1eV=1.6\times10^{-19}J$	$1MeV=1.6\times10^{-13}J$
19.	Binding energy	Energy equivalence of mass deficit, energy require to separate the nucleons	
20.	Binding energy per nucleon	Total energy require to separate the nucleons divided by the number of nucleons (study the graph on page no 369 of AS Physics by Chris Mee.....)	
21.	Nuclear fusion	Smaller nuclei combine together to form larger nuclei, require high temperature and pressure	
22.	Nuclear fission	Heavy nuclei bombarded with neutrons, split into smaller nuclei, release energy	
23.	Isotopes	Same number of protons but different number of neutrons of an element	
24.	Nucleon number	Number of neutrons and protons in a nucleus.	
25.	nuclide	A particular type of nucleus, isotopes of same element have different nuclide	
26.	nuclei	It is the plural of nucleus	
27.	ion	An atom that loses one or more electrons and are not equal no of protons	

Radioactivity			
28.	*Radioactive emission*	*emission of radiation by certain unstable radioactive nuclei to become stable*	
29.	*Types of radiation*	*alpha particles (α), beta particles (β) and gamma rays (γ)*	
30.	*Alpha particles (α) emission*	*helium nucleus, +2 charge, stopped by paper, very short range in air, high ionization effect, deflected by electric and magnetic field, proton number decrease by 2, neutron number decrease by 2 and nucleon number decrease by 4 in parent nuclei*	
31.	*Beta particles (β) emission*	*high energy electrons, -1 charge, stopped by few mm thick aluminium sheet, weak ionization effect, deflected by electric and magnetic field, proton number increase by one, neutron number decrease by 1 and nucleon number stays the same in parent nuclei*	
32.	*Gamma rays (γ) emission*	*electromagnetic radiation, no charge, can only be reduced by thick lead sheet, weakest ionization effect, not deflected by electric or magnetic fields, no change in nucleon number*	
33.	*Spontaneous decay*	*radioactivity cannot be affected by external environmental factors for example temperature, pressure etc*	
34.	*Random decay*	*it is not possible to predict which nucleus in a sample will emit radiation but the probability that a nucleus will decay at any fixed time is constant*	
35.	*Decay curve*	*the graph of undecayed nuclei (y-axis) in a sample against time (x-axis)*	
36.	*Half life* $t_{1/2}$	$A = -\frac{dN}{dt} = \lambda N$ *N the number of undecayed nuclei, λ decay constant in* s^{-1}, yr^{-1}, *the activity (A) of an element*	*tt is the time taken for the number of undecayed nuclei (N) to be reduced to half its original number* (N_o)*. This is also called the activity (A) of the material.*
37.	*Activity (A)*	*number of decays produced per unit time measured in becquerels (Bq) means one decay per second*	
38.	*Decay constant (λ)*	*Probability per unit time that a nucleus undergo decay*	
39.	*Radioactive decay equations*	$N = N_o e^{-\lambda t}$	$A = A_o e^{-\lambda t}$
40.	*Decay constant and half life*	$t_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$	