A2 Physics Formula Sheet

1. **Circular motion**
- **Angular displacement**
$$S = r\theta$$
- **Angular velocity**
$$\omega = \frac{d\theta}{dt}$$
- **Instantaneous velocity**
$$v = r\omega$$
- **Centripetal acceleration**
$$a_c = \frac{v^2}{r} \qquad a_c = r\omega^2$$
- **Centripetal force**
$$F_c = \frac{mv^2}{r} \qquad F_c = mr\omega^2$$
- **Lower bound for velocity at top most point of a loop**
$$v > \sqrt{gr}$$
- **Upper bound for velocity at top most point of a speedbreaker**
$$v < \sqrt{gr}$$

2. **Gravitation**
- **Gravitational field strength**
$$g = \frac{F_G}{m} \qquad g = \frac{GM}{r^2} \qquad g = \frac{-d\phi}{dr}$$
- **Newton's law of gravitation**
$$F_G = \frac{GMm}{r^2}$$
- **Gravitation potential**
$$\phi = \frac{-W}{m} \qquad \phi = \frac{-GM}{r}$$
- **Change in gravitational potential energy**
$$\Delta G.P.E = m \times \Delta\phi \qquad \Delta G.P.E = GMm(\frac{1}{r_i} - \frac{1}{r_f})$$
- **Escape velocity**
$$v = \sqrt{\frac{2GM}{R}} \qquad M = Mass\ of\ Planet \qquad R = Radius\ of\ Planet$$
- **Orbiting system**
  - $K.E = \frac{GMm}{2r}$
  - $G.P.E = \frac{-GMm}{r}$
  - $Total\ energy = K.E + G.P.E$

- $E_T = \frac{-GMm}{2r}$

- **Kepler's law**

$$T^2 \propto r^3$$

3. Simple Harmonic Motion
- **S.H.M equation**

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

- **Angular frequency in S.H.M**

$$\omega = \frac{2\pi}{T} \qquad \omega = 2\pi f$$

- **Period of oscillation**

$$T = \frac{2\pi}{\omega}$$

- **Displacement at time t**

$$x = x_o \sin(\omega t)$$

- **Velocity at time t**

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

- **Acceleration at time t**

$$a = -\omega^2 x_o \sin(\omega t)$$

Max acceleration: $a_o = -\omega^2 x_o$

- **Velocity in terms of displacement**

$$v^2 = \omega^2 (x_o^2 - x^2)$$

Max velocity: $v_o = w x_o$

- **Energy**

  - K.E $= \frac{1}{2} m\omega^2 (x - xo^2)$

  - P.E $= \frac{1}{2} m\omega^2 x^2$

  - Total energy $= \frac{1}{2} m\omega^2 x_o^2$

- **Time period of an oscillating spring**

$$T = 2\pi \sqrt{\frac{m}{k}}$$

- **Time period of a pendulum**

$$T = 2\pi \sqrt{\frac{l}{g}}$$

4. Electric field
- **Electric field strength**

$$E = \frac{F}{q} \qquad E = \frac{kQ}{r^2} \qquad E = \frac{-dV}{dr}$$

- **Coulomb's law**

$$F_q = \frac{Qq}{4\pi E_o r^2} \qquad F_q = \frac{kQq}{r^2}$$

- **Electric potential (V)**

$$V = \frac{KQ}{r}$$

- **Uniform electric Fields**

$$|E| = \frac{\Delta V}{d}$$

$$F = \frac{Vq}{d}$$

- **Acceleration**

$$a = \frac{Eq}{m}$$

- **Change in Electrical potential Energy**

$$\Delta E = \Delta Vq \qquad \Delta E = kQq(\frac{1}{r_f} - \frac{1}{r_i})$$

5. Capacitance
- **Capacitance**

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

- ***Capacitance of a charged metal sphere:***

$$C = 4\pi E_o r$$

- **Important relationships of a parallel plate capacitor**
  - Area varying : $C \propto A$
  - Distance varying : $C \propto \frac{1}{d}$
  - Both varying : $C \propto \frac{A}{d}$
- **Energy stored in a capacitor**
  - $E = \frac{1}{2}VQ$
  - $E = \frac{Q^2}{2C}$
  - $E = \frac{1}{2}CV^2$
- **Capacitors in series**

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$V = V_1 + V_2 + V_3$$

$$Q = Q_1 = Q_2 = Q_3$$

- **Capacitors in parallel**

$$C = C_1 + C_2 + C_3$$

$$V = V_1 = V_2 = V_3$$
$$Q = Q_1 + Q_2 + Q_3$$

- **Time constant**
$$T = R \times C$$

- **Charging capacitors**

• $V = V_o(1 - e^{\frac{-t}{RC}})$

• $Q = Q_o(1 - e^{\frac{-t}{RC}})$

• $I = I_o e^{\frac{-t}{RC}}$

- **Discharging capacitors**

• $V = V_o e^{\frac{-t}{RC}}$

• $Q = Q_o e^{\frac{-t}{RC}}$

• $I = I_o e^{\frac{-t}{RC}}$

- **Half life of capacitors**
$$t_{\frac{1}{2}} = R \times C \times ln2$$

6. Magnetism

- **Magnetic field strength (B)**
$$B = \frac{F}{I \times l} \quad Or \quad B = \frac{F}{q \times v}$$
$$F = BIl \quad Or \quad F = Bqv$$

- **Left hand fleming's rule**
  • Pointer: Direction of magnetic field
  • Middle finger: Direction of current
  • Thumb: Direction of the force

- **Right hand thumb rule:**
  • It is used for a single current carrying wire
  • Thumb: Direction of Current
  • Fingers: Magnetic fields

- **Single Current Carrying Wire:**

• $B = \frac{\mu_o I}{2\pi r} \qquad \rightarrow \quad \mu_o = 4\pi \times 10^{-4} Hm^{-1}$

- **Forces between 2 current carrying conductors**
$$F = \frac{\mu_o I_1}{2\pi r} \times I_2 \times l$$

- **Current balance**
$$F_{mag} = BIL$$

- **Right hand grip rule :**
  - It is used for a solenoid
  - Fingers : Direction of Current
  - Thumb : North pole
- **Solenoid**

  $B_{inside} = \mu_o \times n \times l \qquad \rightarrow \qquad n = \frac{no.\,of\,turns\,of\,solenoid}{length\,of\,solenoid}$

- **Single loop of the wire**

  $B = \frac{\mu_0 I}{2r}$

- **Charges in a magnetic fields**

  $r = \frac{mv}{Bq}$

- **Velocity selection**

  $v = \frac{E}{B}$

- **Max velocity of a particle when accelerated through a potential difference:**

  $v_{max} = \sqrt{\frac{2Vq}{m}} \qquad E_k = \Delta Vq$

- **Hall probe**

  $V_H = \frac{BI}{ntq}$

7. Electromagnetic Induction

- **Magnetic field strength**

  $\phi = B \times A \qquad \phi = BA\,\sin\theta$

- **Faraday's law of induction**

  $E = \frac{d\phi}{dt}$

- **Lenz's law**

  $E = -\frac{d\phi}{dt}$

- **Induced e.m.f across a single wire moving perpendicular to a magnetic field:**

  $E = Blv$

8. Ideal Gasses:

- $1\,mole = 6.023 \times 10^{23}\,particles\,(Avagadro's\,constant = N_A)$
- $N = nN_A \quad (n = moles)$
- $n = \frac{mass}{Mr/Ar}$
- $K = °C + 273.15$
- $PV = nRT \,/\, NkT \,/\, \frac{1}{3}Nm < c^2 >$
- $P = \frac{1}{3}\rho < c^2 > \; (\rho = density\,of\,gas)$

- **E$_k$ of one particle**

  $$K.E = \frac{3}{2}KT$$

- **E$_k$ of N particle**

  $$K.E = \frac{3}{2}NKT$$

- **Internal energy of an Ideal Gas (U)**

  $$U = \frac{3}{2}NKT$$

- **Root mean square speed (c.r.m.s)** = $\sqrt{<c^2>}$

  $$\frac{T_1}{<c^2>_1} = \frac{T_2}{<c^2>_2}$$

- **Charles's Law**
  - Pressure is constant
  - V $\propto$ T
- **Boyle's Law**
  - Temperature is constant
  - $p \propto \frac{1}{V}$
  - $Q = -W$
- **Pressure Law**
  - Volume is constant
  - P $\propto$ T
  - $\Delta U = Q$
- **Adiabatic process**

  $$\Delta U = W$$
  $$Q = 0$$

9. **Thermodynamics**
- **Work done**

  $$W = P \, X \, \Delta V$$

- **Specific heat capacity** (c)

  $$c = \frac{Q}{m\Delta\theta} \qquad Q = mc\Delta\theta$$

- **Heat capacity**

  $$C = m \times c \qquad c = \frac{C}{m}$$

- **Specific latent heat of fusion**

  $$l_f = \frac{Q \; same \; as \; Lf}{m}$$

- **Latent heat of fusion**

  $$L_f(Q) = l_f \times m$$

- **Specific latent heat of evaporation**

  $$l_v = \frac{Q \; same \; as \; Lv}{m}$$

- **Latent heat of vaporisation**

$$L_v(Q) = l_v \times m$$

- **First law of thermodynamics**

$$\Delta U = Q + W$$

- +ΔU :- increase in internal energy
- -ΔU :- decrease in internal energy
- +Q :- heat supplied to the system
- -Q :- heat lost from the system
- +W :- work done on the system (compression)
- -W :- work done by the system (expansion)

10. Quantum physics
- **Intensity**

$$I = \frac{P}{A} \qquad I = \frac{E}{A \times t} \qquad I = \frac{nhf}{At} \qquad I = \frac{nhc}{\lambda At}$$

$$\frac{n}{t} = number\ of\ photons\ incident\ per\ unit\ time$$

- **Photon Energy**

$$E = hf \qquad E = \frac{hc}{\lambda}$$

- **E of n photons**

$$E = nhf \qquad E = \frac{nhc}{\lambda}$$

- **Work function**

$$\phi = hfo \qquad \phi = \frac{hc}{\lambda_o}$$

- **De Broglie's wavelength**

$$p = \frac{h}{\lambda}$$

- **Momentum in terms of energy**

$$p = \frac{E}{c}$$

11. Medical physics
- **Specific acoustic impedance**

$$Z = \rho \times c$$

- **Absorption coefficient** (k or μ)

$$I = I_o e^{-kx} \quad or \quad I = I_o e^{-\mu x}$$

- **Intensity reflection coefficient**

$$\alpha = \frac{I_r}{I_i} = \left(\frac{\Delta Z}{\Sigma Z}\right)^2$$

- **Factor transmitted**

- $\frac{I_T}{I_i} = (1 - \alpha)$

- $I_i = I_R + I_T \rightarrow I_i$ = Incident Intensity $\quad I_R$ = Reflected Intensity $\quad I_T$ = Transmitted Intensity

- **Half value thickness**

$$X_{\frac{1}{2}} = \frac{ln2}{\mu} \quad \text{or} \quad X_{\frac{1}{2}} = \frac{ln2}{k}$$

12. Radioactivity

- **Mass defect for a nucleus**:

$\Delta m = m \text{ of individual components } - m \text{ of nucleus bounded atom}$

- **Mass defect for a nuclear reaction:**

$$\Delta m = m_{products} - m_{reactants}$$

- **Binding energy:**

$$E = \Delta mc^2 \qquad E = B.E_{Product} - B.E_{Reactant}$$

- **Binding energy per nucleon**

$$\frac{B.E \text{ of a nucleus bounded atom}}{Nucleon \text{ } Number}$$

- **Electron Volt**:

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

$$1 \, Mev = 1.6 \times 10^{-13} J$$

- **Activity**

$$A = \frac{-dN}{dt} \qquad A = \lambda N \qquad A_o = \lambda N_o$$

- **Decay constant**

$$\lambda = \frac{-\Delta N}{Nt}$$

- **Decay Equations**

$$\bullet \, N = N_o e^{-\lambda t}$$

$$\bullet \, A = A_o e^{-\lambda t}$$

- **Half life**

$$t_{\frac{1}{2}} = \frac{ln2}{\lambda} \quad or \quad \frac{0.693}{\lambda}$$

13. Alternating currents

- **Current at time t**

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

- **Voltage at time t**

$$V = V_o sin(\omega t) \qquad V = V_o cos(\omega t)$$

- **RMS Value**

$$I_{rms} = \frac{I_o}{\sqrt{2}} \qquad V_{rms} = \frac{V_o}{\sqrt{2}}$$

- **Charge:**

$$Q = I_{rms} \times t$$

- **Ohm's law:**

$$V_{rms} = I_{rms} \times R$$

- **Average Power:**

$$P = I_{rms} \times V_{rms} \qquad P = I_{rms}^2 \times R \qquad P = \frac{V_{rms}^2}{R}$$

- **Max Power:**

$$P_o = I_o \times V_o \qquad P_o = I_o^2 \times R \qquad P_o = \frac{V_o^2}{R}$$

14. Astronomy and Cosmology

- **Radiant flux density**

$$F = I = \frac{P}{A} = \frac{L}{4\pi d^2} \quad d = distance\ between\ Earth\ and\ Star$$

- **Wien's displacement law**

$$\lambda \propto \frac{1}{T} \quad T = Thermodynamic\ Surface\ temperature\ of\ star$$

- **Stefan Boltzman Law**

$$L = 4\pi\sigma r^2 T^4 \quad r = radius\ of\ star$$

- **Doppler's effect**

$$\frac{\Delta\lambda}{\lambda} = \frac{\Delta f}{f} = \frac{v}{c}$$

- **Hubbles's Law**

$$v = H_o \times d \quad \rightarrow \quad H_0(Hubble's\ constant) = 2.21 \times 10^{-18}$$

- **Age of universe**

$$T_o = \frac{1}{H_o}$$