A Level Physics Formula Sheet

Cosmo

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Contents

1 Kinematics (AS) 5
- 1.1 Speed, Velocity and Acceleration . . . 5
- 1.2 Equations of Motion (SUVAT) . . . 5

2 Projectile Motion (AS) 5
- 2.1 Maximum Height . . . 5
- 2.2 Time of Flight . . . 5
- 2.3 Horizontal Range . . . 6

3 Dynamics (AS) 6
- 3.1 Newton's Laws . . . 6
- 3.2 Equilibrium . . . 6
- 3.3 Moments . . . 6
- 3.4 Principle of Conservation of Momentum . . . 6
- 3.5 Elastic Collision . . . 6
- 3.6 Kinetic Energy and Momentum . . . 7

4 Work, Power, Energy (AS) 7
- 4.1 Gravitational Potential Energy . . . 7
- 4.2 Kinetic Energy . . . 7
- 4.3 Work . . . 7
- 4.4 Power . . . 7
- 4.5 Efficiency . . . 7

5 Fluid Dynamics (AS) 7
- 5.1 Density . . . 7
- 5.2 Pressure . . . 8
- 5.3 Hydrostatic Pressure . . . 8
- 5.4 (*) Stoke's Law . . . 8

6 Deformation of Solids (AS) 8
6.1 Hooke's Law . . . 8
6.2 Combination of Springs (Series) . . . 8
6.3 Combination of Springs (Parallel) . . . 9
6.4 Elastic Potential Energy . . . 9
6.5 Stress . . . 9
6.6 Tensile Strain . . . 9
6.7 Young's Modulus . . . 9

7 Electricity (AS) 9
7.1 Electric Current . . . 9
7.2 Drift Velocity . . . 10
7.3 Potential Difference . . . 10
7.4 Electrical Resistance . . . 10
7.5 Electric Power . . . 10
7.6 Electric Energy . . . 10
7.7 Resistivity . . . 10
7.8 Internal Resistance . . . 10
7.9 Kirchhoff's Current Law (KCL) . . . 10
7.10 Kirchhoff's Voltage Law (KVL) . . . 11
7.11 Combined Resistance (Series) . . . 11
7.12 Combined Resistance (Parallel) . . . 11
7.13 Potential Dividers . . . 11

8 Waves (AS) 11
8.1 Wave Equation . . . 11
8.2 Doppler Effect of Sound Waves . . . 11
8.3 Malu's Law . . . 11
8.4 (*) Intensity of a Wave . . . 11
8.5 Relation of Phase and Path Difference . . . 12
8.6 Constructive Interference . . . 12
8.7 Destructive Interference . . . 12
8.8 Young's Double-Slit Experiment . . . 12
8.9 Diffraction at an angle . . . 12
8.10 Stationary Waves: Closed Pipe . . . 12
8.11 Stationary Waves: Open Pipe . . . 12

9 Particle Physics (AS) 12
9.1 α Decay . . . 12
9.2 β^- Decay . . . 13
9.3 β^+ Decay . . . 13
9.4 γ Decay . . . 13

10 Circular Motion (A2) **13**
10.1 Angular Speed $\vec{\boldsymbol{\omega}}$ . . . 13
10.2 Angular Acceleration $\vec{\boldsymbol{\alpha}}$ . . . 14
10.3 Centripetal Force $\vec{\boldsymbol{F_c}}$ . . . 14

11 Gravitational Fields (A2) **14**
11.1 Gravitational Force $\vec{\boldsymbol{F_g}}$ . . . 14
11.2 Gravitational Field Strength $\vec{\boldsymbol{g}}$ . . . 15
11.3 Orbital and Escape Velocity $\vec{\boldsymbol{v_o}}, \vec{\boldsymbol{v_e}}$ . . . 15
11.4 Gravitational Potential ϕ . . . 16
11.5 Gravitational Potential Energy E_p . . . 16
11.6 Why is Gravitational Potential negative? . . . 16

12 Electrostatics (A2) **17**
12.1 Electrostatic Force $\vec{\boldsymbol{F_e}}$ . . . 17
12.2 Electric Field Strength $\vec{\boldsymbol{E}}$ . . . 18
12.3 Electric Potential V . . . 18
12.4 Electric Potential Energy E_p . . . 18
12.5 Capacitance C . . . 19
12.6 Capacitance in Series C . . . 19
12.7 Capacitance in Parallel C . . . 19
12.8 Energy stored in a Capacitor . . . 20
12.9 Discharging a Capacitor . . . 20
12.10Dielectric Constant (Extra) . . . 21

13 Oscillations (A2) **21**
13.1 Velocity . . . 21
13.2 Acceleration in S.H.M . . . 22
13.3 Kinetic Energy E_k . . . 22
13.4 Potential Energy E_p . . . 22
13.5 Total Energy E_0 . . . 22
13.6 Point at which $E_k = E_p$ . . . 23
13.7 Derivations (Extra) . . . 23

14 Thermal Physics (A2) **24**
14.1 Ideal Gas Equation . . . 24
14.2 Mean Kinetic Energy $< E_k >$ . . . 24
14.3 First Law of Thermodynamics . . . 24
14.4 Derivation of $< E_k >$ . . . 25

15 Electromagnetism (A2) **25**
15.1 Force on current carrying conductor $\vec{\boldsymbol{F_B}}$ . . . 25
15.2 Force between two straight conductors . . . 26
15.3 Force on a moving charge $\vec{\boldsymbol{F_B}}$ . . . 26
15.4 Velocity Selector . . . 27
15.5 Hall Effect V_H . . . 27

15.6 Magnetic Flux ϕ . . . 28
15.7 Faraday's Law . . . 28
15.8 Lenz's Law . . . 28
15.9 Proof Light is an Electromagnetic Radiation . . . 29

16 Alternating Current (A2) 29
16.1 Circuit Equations . . . 29
16.2 Transformers . . . 30

17 Quantum Physics (A2) 30
17.1 Photon Energy . . . 30
17.2 Photon Momentum . . . 30
17.3 Photoelectric Equation . . . 31

18 Nuclear Physics (A2) 31
18.1 Energy Levels . . . 31
18.2 Mass-Energy Relation . . . 31
18.3 Mass Defect . . . 32
18.4 Example - α-decay . . . 32
18.5 Activity . . . 32
18.6 Decay Curves . . . 32
18.7 Mass and Number of Particles Relationship . . . 33

19 Medical Physics (A2) 33
19.1 Acoustic Impedance Z . . . 33
19.2 Ratio of Reflected Intensity . . . 33
19.3 Attenuation of Ultrasound . . . 34
19.4 Attenuation of X-Rays . . . 34
19.5 Half Thickness $x_{\frac{1}{2}}$ . . . 34
19.6 A-Scan . . . 34

20 Astronomy and Cosmology (A2) 35
20.1 Radiant Flux Intensity F . . . 35
20.2 Wien's Displacement Law . . . 35
20.3 Stefan-Boltzmann Law . . . 35
20.4 Redshift . . . 35
20.5 Hubble's Law . . . 36

21 Paper 5 (A2) 36
21.1 Algebraic Uncertainty . . . 36
21.2 Further Algebraic Uncertainty . . . 36
21.3 Logarithmic Uncertainty . . . 37
21.4 Line of Best Fit Uncertainity . . . 37
21.5 Y-Intercept Uncertainty . . . 37

1 Kinematics (AS)

1.1 Speed, Velocity and Acceleration

$$s = \frac{\Delta d}{\Delta t}$$

$$\vec{\boldsymbol{v}} = \frac{\Delta \vec{\boldsymbol{s}}}{\Delta t}$$

$$\vec{\boldsymbol{a}} = \frac{\Delta \vec{\boldsymbol{v}}}{\Delta t}$$

$$\vec{\boldsymbol{a}}_{avg} = \frac{\text{total displacement}}{\text{total time taken}}$$

1.2 Equations of Motion (SUVAT)

$$\vec{\boldsymbol{v}} = \vec{\boldsymbol{u}} + \vec{\boldsymbol{a}}t$$

$$\vec{\boldsymbol{s}} = \vec{\boldsymbol{u}}t + \frac{1}{2}\vec{\boldsymbol{a}}t^2$$

$$\vec{\boldsymbol{s}} = \vec{\boldsymbol{v}}t - \frac{1}{2}\vec{\boldsymbol{a}}t^2$$

$$\vec{\boldsymbol{v}}^2 = \vec{\boldsymbol{u}}^2 + 2\vec{\boldsymbol{a}}\vec{\boldsymbol{s}}$$

$$\vec{\boldsymbol{s}} = \left(\frac{\vec{\boldsymbol{u}} + \vec{\boldsymbol{v}}}{2}\right)t$$

2 Projectile Motion (AS)

2.1 Maximum Height

$$H_{max} = \frac{\vec{\boldsymbol{u}}^2 \sin^2\theta}{2g}$$

2.2 Time of Flight

$$T = \frac{2\vec{\boldsymbol{u}}\sin\theta}{g}$$

2.3 Horizontal Range

$$R = \frac{2\vec{\boldsymbol{u}}^2 \sin\theta\cos\theta}{g}$$

$$R = \frac{\vec{\boldsymbol{u}}^2 \sin(2\theta)}{g}$$

3 Dynamics (AS)

3.1 Newton's Laws

$$\vec{\boldsymbol{p}} = m\vec{\boldsymbol{v}}$$

$$\vec{\boldsymbol{F}} = \frac{\Delta\vec{\boldsymbol{p}}}{t}$$

$$\vec{\boldsymbol{F}} = \frac{m(\vec{\boldsymbol{v}} - \vec{\boldsymbol{u}})}{t}$$

$$\vec{\boldsymbol{F}} = m\vec{\boldsymbol{a}}$$

3.2 Equilibrium

$$\Sigma\vec{\boldsymbol{F}} = 0$$

$$\Sigma\tau = 0$$

3.3 Moments

$$\tau = \vec{\boldsymbol{F}} \cdot d$$

$$\Sigma M_{cw} = \Sigma M_{acw}$$

3.4 Principle of Conservation of Momentum

$$\vec{\boldsymbol{p}}_f = \vec{\boldsymbol{p}}_i$$

3.5 Elastic Collision

$$m_1\vec{\boldsymbol{u}}_1 + m_2\vec{\boldsymbol{u}}_2 = m_1\vec{\boldsymbol{v}}_1 + m_2\vec{\boldsymbol{v}}_2$$

$$\frac{1}{2}m_1\vec{\boldsymbol{u}}_1^2 + \frac{1}{2}m_2\vec{\boldsymbol{u}}_2^2 = \frac{1}{2}m_1\vec{\boldsymbol{v}}_1^2 + \frac{1}{2}m_2\vec{\boldsymbol{v}}_2^2$$

3.6 Kinetic Energy and Momentum

$$E_k = \frac{\vec{\boldsymbol{p}}}{2m}$$

$$\frac{1}{2}m\vec{\boldsymbol{v}}^2 = \frac{\vec{\boldsymbol{p}}}{2m}$$

4 Work, Power, Energy (AS)

4.1 Gravitational Potential Energy

$$E = mgh$$

$$\Delta E = mg\Delta h$$

4.2 Kinetic Energy

$$E = \frac{1}{2}m\vec{\boldsymbol{v}}^2$$

4.3 Work

Note: if the object is not moving at an angle, $\theta = 0$ and $\cos\theta = 1$

$$W = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{s}} \cos\theta$$

4.4 Power

$$P = \frac{W}{t} = \frac{E}{t}$$

$$P = \vec{\boldsymbol{F}} \cdot \vec{\boldsymbol{v}}$$

4.5 Efficiency

$$\eta = \frac{E_o}{E_i}$$

$$\eta = \frac{W_o}{W_i}$$

$$\eta = \frac{P_o}{P_i}$$

5 Fluid Dynamics (AS)

5.1 Density

$$\rho = \frac{m}{V}$$

5.2 Pressure

$$P = \frac{F}{A}$$

5.3 Hydrostatic Pressure

$$P = \rho g h$$

$$\Delta P = \rho g \Delta h$$

5.4 (*) Stoke's Law

Note: This is an extension of the CAIE 9702 Physics syllabus, we will only be using this equation to derive a relation.

$$\vec{\boldsymbol{F}}_v = 6\pi a \eta \vec{\boldsymbol{v}}$$

We can see that the force experienced due to the viscosity $\vec{\boldsymbol{F}}_v$, of the liquid is directly proportional to the speed $\vec{\boldsymbol{v}}$.

6 Deformation of Solids (AS)

6.1 Hooke's Law

$$\vec{\boldsymbol{F}} = kx$$

6.2 Combination of Springs (Series)

$$\Sigma x = x_1 + x_2 + ... + x_n$$

$$x_n = \frac{\vec{\boldsymbol{F}}}{k_n}$$

$$x_1 + x_2 + ... + x_n = \frac{\vec{\boldsymbol{F}}}{k_1} + \frac{\vec{\boldsymbol{F}}}{k_2} + ... + \frac{F}{k_n}$$

$$\vec{\boldsymbol{F}} = \left(\frac{1}{\Sigma K}\right) = \vec{\boldsymbol{F}}\left(\frac{1}{k_1} + \frac{1}{k_2} + ... + \frac{1}{k_n}\right)$$

$$\cancel{\vec{\boldsymbol{F}}}\left(\frac{1}{\Sigma K}\right) = \cancel{\vec{\boldsymbol{F}}}\left(\frac{1}{k_1} + \frac{1}{k_2} + ... + \frac{1}{k_n}\right)$$

$$\frac{1}{\Sigma K} = \frac{1}{k_1} + \frac{1}{k_2} + ... + \frac{1}{k_n}$$

6.3 Combination of Springs (Parallel)

$$\vec{\boldsymbol{F}} = kx$$
$$\Sigma\vec{\boldsymbol{F}} = \vec{\boldsymbol{F}}_1 + \vec{\boldsymbol{F}}_2 + ... + \vec{\boldsymbol{F}}_n$$
$$\Sigma\vec{\boldsymbol{F}} = k_1x + k_2x + ... + k_nx$$
$$\Sigma\vec{\boldsymbol{F}} = (k_1 + k_2 + ... + k_n)x$$

$$\Sigma k = k_1 + k_2 + ... + k_n$$

6.4 Elastic Potential Energy

$$E_p = \frac{1}{2}\vec{\boldsymbol{F}}x$$
$$E_p = \frac{1}{2}kx^2$$

6.5 Stress

Stress is essentially another word for pressure, however pressure is used when talking about fluids, and stress when talking about solids.

$$\sigma = \frac{F}{A}$$

6.6 Tensile Strain

Tensile Strain is the only type of strain in syllabus.

$$\text{strain} = \frac{\Delta l}{l}$$

6.7 Young's Modulus

$$E = \frac{\vec{\boldsymbol{F}}L}{Ax}$$

7 Electricity (AS)

7.1 Electric Current

$$I = \frac{Q}{t}$$
$$I = \frac{ne}{t}$$

7.2 Drift Velocity

$$I = nA\vec{\boldsymbol{v}}_d e$$

$$\vec{\boldsymbol{v}}_d = \frac{1}{nAe}$$

7.3 Potential Difference

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

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

7.4 Electrical Resistance

$$R = \frac{V}{I}$$

7.5 Electric Power

$$P = VI$$

$$P = I^2R$$

$$P = \frac{V^2}{R}$$

7.6 Electric Energy

$$E = I^2Rt$$

$$E = \frac{V^2t}{R}$$

7.7 Resistivity

$$\rho = \frac{RA}{L}$$

7.8 Internal Resistance

$$E = IR + Ir$$

$$E = I(R + r)$$

7.9 Kirchhoff's Current Law (KCL)

$$\Sigma I = 0$$

$$I_{in} = I_{out}$$

7.10 Kirchhoff's Voltage Law (KVL)

$$\Sigma E = \Sigma V$$

$$\Sigma E = \Sigma(IR)$$

7.11 Combined Resistance (Series)

$$\Sigma R = R_1 + R_2 + ... + R_n$$

7.12 Combined Resistance (Parallel)

$$\frac{1}{\Sigma R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$$

7.13 Potential Dividers

Note: Here V_1 is the voltage of the top resistor, and V_2 is the voltage of the bottom resistor.

$$V_1 = \left(\frac{V}{R_1 + R_2}\right) \cdot R_1$$

$$V_2 = \left(\frac{V}{R_1 + R_2}\right) \cdot R_2$$

8 Waves (AS)

8.1 Wave Equation

$$\vec{\boldsymbol{v}} = f\lambda$$

8.2 Doppler Effect of Sound Waves

$$f = f_o\left(\frac{v}{v \pm v_s}\right)$$

8.3 Malu's Law

$$I = I_o \cos^2\theta$$

8.4 (*) Intensity of a Wave

This is not a required formula to know, only the relation we can derive from it.

$$I = 2\pi^2 f^2 A^2 \rho \vec{\boldsymbol{v}}$$

We can see that intensity is directly proportional to amplitude squared (A^2) as well as a few other relations.

8.5 Relation of Phase and Path Difference

Here Δx is the path difference

$$\phi = \frac{2\pi}{\lambda} \cdot \Delta x$$

8.6 Constructive Interference

$$\phi = 2n\pi$$

8.7 Destructive Interference

$$\phi = (2n+1)\pi$$

8.8 Young's Double-Slit Experiment

$$\lambda = \frac{ax}{D}$$

8.9 Diffraction at an angle

$$\lambda = \frac{d\sin\theta}{n}$$

$$d = \frac{1}{c}$$

8.10 Stationary Waves: Closed Pipe

For n = 0, 1, 2, 3, ...

$$L = \frac{(2n+1)\lambda}{4}$$

8.11 Stationary Waves: Open Pipe

For n = 1, 2, 3, ...

$$L = \frac{n\lambda}{2}$$

9 Particle Physics (AS)

9.1 α Decay

Note: Here ${}^{0}_{0}\gamma$ is the energy released, you will learn about this in A2.

$${}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{4}_{2}\mathrm{He} + {}^{\mathrm{A}-4}_{\mathrm{Z}-2}\mathrm{Y} + {}^{0}_{0}\gamma$$

$${}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{4}_{2}\alpha + {}^{\mathrm{A}-4}_{\mathrm{Z}-2}\mathrm{Y} + {}^{0}_{0}\gamma$$

9.2 β^- Decay

$$
{}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{\;\,0}_{-1}\mathrm{e} + {}_{\mathrm{Z+1}}{}^{\mathrm{A}}\mathrm{Y} + {}^{0}_{0}\bar{\nu} + {}^{0}_{0}\gamma
$$

$$
{}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{\;\,0}_{-1}\beta^- + {}_{\mathrm{Z+1}}{}^{\mathrm{A}}\mathrm{Y} + {}^{0}_{0}\bar{\nu} + {}^{0}_{0}\gamma
$$

$$
{}^{1}_{0}\mathrm{n} \longrightarrow {}^{\;\,0}_{-1}\mathrm{e} + {}^{1}_{1}\mathrm{p}
$$

9.3 β^+ Decay

$$
{}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{0}_{1}\mathrm{e} + {}_{\mathrm{Z-1}}{}^{\mathrm{A}}\mathrm{Y} + {}^{0}_{0}\nu^+ {}^{0}_{0}\gamma
$$

$$
{}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{X} \longrightarrow {}^{0}_{1}\beta^+ + {}_{\mathrm{Z-1}}{}^{\mathrm{A}}\mathrm{Y} + {}^{0}_{0}\nu^+ {}^{0}_{0}\gamma
$$

$$
{}^{1}_{1}\mathrm{p} \longrightarrow {}^{0}_{1}\mathrm{e} + {}^{1}_{0}\mathrm{n}
$$

9.4 γ Decay

$$
{}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{Y}^* \longrightarrow {}^{\mathrm{A}}_{\mathrm{Z}}\mathrm{Y} + {}^{0}_{0}\gamma
$$

10 Circular Motion (A2)

10.1 Angular Speed $\vec{\boldsymbol{\omega}}$

$$
\vec{\boldsymbol{\omega}} = \frac{\Delta\theta}{\Delta t}
$$

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

$$
\vec{\boldsymbol{\omega}} = \frac{\vec{\boldsymbol{v}}}{r}
$$

$\theta \rightarrow$ angular displacement (rad)

$r \rightarrow$ radius (m)

$t \rightarrow$ time (s)

$\vec{\boldsymbol{v}} \rightarrow$ tangential velocity (ms^{-1})

$\vec{\boldsymbol{\omega}} \rightarrow$ angular speed $(rads^{-1})$

10.2 Angular Acceleration $\vec{a}$

$$\vec{a} = r\vec{\omega}^2$$

$$\vec{a} = \frac{\vec{v}^2}{r}$$

$$r \rightarrow \text{radius } (m)$$

$$\vec{v} \rightarrow \text{velocity } (ms^{-1})$$

$$\vec{\omega} \rightarrow \text{angular speed } (rads^{-1})$$

$$\vec{a} \rightarrow \text{acceleration } (ms^{-2})$$

10.3 Centripetal Force $\vec{F_c}$

$$\vec{F} = m\vec{a}$$

$$\vec{F_c} = mr\vec{\omega}^2$$

$$\vec{F_c} = \frac{m\vec{v}^2}{r}$$

$$m \rightarrow \text{mass } (kg)$$

$$r \rightarrow \text{radius } (m)$$

$$\vec{v} \rightarrow \text{velocity } (ms^{-1})$$

$$\vec{a} \rightarrow \text{acceleration } (ms^{-2})$$

$$\vec{\omega} \rightarrow \text{angular speed } (rads^{-1})$$

$$\vec{F} \rightarrow \text{centripetal force } (kgms^{-2} - N)$$

11 Gravitational Fields (A2)

11.1 Gravitational Force $\vec{F_g}$

$$\vec{F} = \frac{GMm}{r^2}$$

$$m \rightarrow \text{mass of planet/satellite } (kg)$$

$$M \rightarrow \text{mass of star/planet } (kg)$$

$$r \rightarrow \text{orbital radius } (m)$$

$$G \rightarrow \text{gravitational constant} \approx 6.67 \times 10^{-11} Nm^{-2}kg^{-2}$$

11.2 Gravitational Field Strength $\vec{g}$

$$\vec{g} = \frac{\vec{F}}{m}$$

$$\vec{g} = \frac{GM}{r^2}$$

$$M \rightarrow \text{mass of star/planet } (kg)$$

$$r \rightarrow \text{orbital radius } (m)$$

$$\vec{g} \rightarrow \text{gravitational field strength } (ms^{-2})$$

$$G \rightarrow \text{gravitational constant} \approx 6.67 \times 10^{-11} Nm^{-2}kg^{-2}$$

11.3 Orbital and Escape Velocity $\vec{v_o}, \vec{v_e}$

$$\vec{v_o} = \frac{2\pi r}{T}$$

$$\vec{v_o} = \sqrt{\vec{g}r}$$

$$\vec{v_o} = \sqrt{\frac{GM}{r}}$$

$$\vec{v_e} = \sqrt{2\vec{g}r}$$

$$\vec{v_e} = \sqrt{\frac{2GM}{r}}$$

$$\vec{v_e} = \vec{v_o}\sqrt{2}$$

$$M \rightarrow \text{mass of star/planet } (kg)$$

$$r \rightarrow \text{orbital radius } (m)$$

$$T \rightarrow \text{orbital time period } (s)$$

$$\vec{v_o} \rightarrow \text{orbital velocity } (ms^{-1})$$

$$\vec{v_e} \rightarrow \text{escape velocity } (ms^{-1})$$

$$G \rightarrow \text{gravitational constant} \approx 6.67 \times 10^{-11} Nm^{-2}kg^{-2}$$

11.4 Gravitational Potential ϕ

$$\phi = -\frac{GM}{r}$$

$$M \to \text{mass of star/planet } (kg)$$
$$r \to \text{orbital radius } (m)$$
$$G \to \text{gravitational constant} \approx 6.67 \times 10^{-11} Nm^{-2}kg^{-2}$$
$$\phi \to \text{gravitational potential}$$

11.5 Gravitational Potential Energy E_p

$$E_p = \phi m$$
$$E_p = \frac{GMm}{r}$$

$$m \to \text{mass of planet/satellite } (kg)$$
$$M \to \text{mass of star/planet } (kg)$$
$$r \to \text{orbital radius } (m)$$
$$G \to \text{gravitational constant} \approx 6.67 \times 10^{-11} Nm^{-2}kg^{-2}$$
$$\phi \to \text{gravitational potential}$$
$$E_p \to \text{gravitational potential energy } (kgm^2s^{-2} - J)$$

11.6 Why is Gravitational Potential negative?

Note: This derivation is **not required** for 9702 A Level Physics, it is just here to provide a more mathematical approach to the question at hand. Here we are going to be using a calculus approach to understand why the Gravitational Potential ϕ at a point is negative.

$$W = \vec{\mathbf{F}} \cdot r$$

Similarly:

$$W = \int \vec{\mathbf{F}}\, \vec{\mathbf{d}}r$$

Hence we can find a formula for Gravitational Potential Energy and use the relation $E = \phi m$ in order to obtain a result for ϕ.

$$\vec{\mathbf{F}} = \frac{GMm}{r^2}$$

$$E = \int \vec{\mathbf{F}}\, \vec{\mathbf{d}}r$$

$$E = \int \frac{GMm}{r^2}\,\vec{\mathbf{d}}r$$

Gravitational Potential is the work done in bringing a mass from **infinity** to **a point** r.

$$E = \int_{\infty}^{r} \frac{GMm}{r^2}\,\vec{\mathbf{d}}r$$

$$E = GMm \int_{\infty}^{r} \frac{1}{r^2}\,\vec{\mathbf{d}}r$$

$$E = \phi m$$

$$\frac{E}{m} = \phi$$

$$\frac{E}{m} = \frac{GM\cancel{m}}{\cancel{m}} \int_{\infty}^{r} \frac{1}{r^2}\,\vec{\mathbf{d}}r$$

$$\phi = GM \int_{\infty}^{r} \frac{1}{r^2}\,\vec{\mathbf{d}}r$$

$$\phi = GM \cdot -\frac{1}{r}\Big|_{\infty}^{r}$$

$$\phi = -\frac{GM}{r}\Big|_{\infty}^{r}$$

$$\phi = -\frac{GM}{r} - -\frac{GM}{\infty}$$

$$\phi = -\frac{GM}{r} + 0$$

$$\therefore \phi = -\frac{GM}{r}$$

12 Electrostatics (A2)

12.1 Electrostatic Force $\vec{F_e}$

$$\vec{F} = \frac{kQq}{r^2}$$

$$\vec{F} = \frac{Qq}{4\pi\epsilon_0 r^2}$$

$$k = \frac{1}{4\pi\epsilon_0} \approx 8.98 \times 10^9 Nm^2C^{-2}$$

$r \to$ distance between charges (m)

$q \to$ charge of point charge (C)

$Q \to$ charge of point charge (C)

$\epsilon_0 \to$ permitivity of air/vacuum $\approx 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$

12.2 Electric Field Strength $\vec{\boldsymbol{E}}$

$$\vec{\boldsymbol{E}} = \frac{\vec{\boldsymbol{F}}}{q}$$

$$\vec{\boldsymbol{E}} = \frac{kQ}{r^2}$$

$$\vec{\boldsymbol{E}} = \frac{Q}{4\pi\epsilon_0 r^2}$$

$$k = \frac{1}{4\pi\epsilon_0} \approx 8.98 \times 10^9 Nm^2C^{-2}$$

$$r \rightarrow \text{distance between charges } (m)$$

$$q \rightarrow \text{charge of point charge } (C)$$

$$Q \rightarrow \text{charge of point charge } (C)$$

$$\epsilon_0 \rightarrow \text{permitivity of air/vacuum} \approx 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$$

$$\vec{\boldsymbol{E}} \rightarrow \text{electric field strength } (NC^{-1}/Vm^{-1})$$

12.3 Electric Potential V

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

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

$$k = \frac{1}{4\pi\epsilon_0} \approx 8.98 \times 10^9 Nm^2C^{-2}$$

$$r \rightarrow \text{distance between charges } (m)$$

$$Q \rightarrow \text{charge of point charge } (C)$$

$$\epsilon_0 \rightarrow \text{permitivity of air/vacuum} \approx 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$$

12.4 Electric Potential Energy E_p

$$E_p = Vq$$

$$E_p = \frac{kQq}{r}$$

$$E_p = \frac{Qq}{4\pi\epsilon_0 r}$$

$$k = \frac{1}{4\pi\epsilon_0} \approx 8.98 \times 10^9 Nm^2C^{-2}$$

$$r \rightarrow \text{distance between charges } (m)$$

$$q \rightarrow \text{charge of point charge } (C)$$
$$Q \rightarrow \text{charge of point charge } (C)$$
$$\epsilon_0 \rightarrow \text{permitivity of air/vacuum} \approx 8.85 \times 10^{-12} C^2 N^{-1} m^{-2}$$
$$E_p \rightarrow \text{electric potential energy } (kgm^2 s^{-2} - J)$$

12.5 Capacitance C

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

$$C \rightarrow \text{capacitance } (F)$$
$$Q \rightarrow \text{charge } (C)$$
$$V \rightarrow \text{potential difference } (V)$$

12.6 Capacitance in Series C

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4} + ... + \frac{1}{C_n}$$
$$C_t = \frac{C_1 C_2}{C_1 + C_2}$$
$$C_i = \frac{C}{n}$$

$$C \rightarrow \text{capacitance } (F)$$
$$C_t \rightarrow \text{capacitance for two capacitors } (F)$$
$$C_i \rightarrow \text{capacitance for } n \text{ identical capacitors } (F)$$

12.7 Capacitance in Parallel C

$$C_p = C_1 + C_2 + C_3 + C_4 + ... + C_n$$
$$C_i = nC$$

$$C \rightarrow \text{capacitance } (F)$$
$$C_i \rightarrow \text{capacitance for } n \text{ identical capacitors } (F)$$

12.8 Energy stored in a Capacitor

$$E = \frac{1}{2}QV$$

$$E = \frac{1}{2}CV^2$$

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

$$C \rightarrow \text{capacitance } (F)$$

$$Q \rightarrow \text{charge } (C)$$

$$V \rightarrow \text{potential difference } (V)$$

$$E \rightarrow \text{energy } (kgm^2s^{-2} - J)$$

12.9 Discharging a Capacitor

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

$$t = -RC\,(lnQ - lnQ_0)$$

$$V = V_0 e^{(-t/RC)}$$

$$t = -RC\,(lnV - lnV_0)$$

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

$$t = -RC\,(lnI - lnI_0)$$

$$C \rightarrow \text{capacitance } (F)$$

$$R \rightarrow \text{resistance } (\Omega)$$

$$Q \rightarrow \text{charge } (C)$$

$$Q_0 \rightarrow \text{maximum charge } (C)$$

$$V \rightarrow \text{potential difference } (V)$$

$$V_0 \rightarrow \text{maximum potential difference } (V)$$

$$I \rightarrow \text{current } (A)$$

$$I_0 \rightarrow \text{maximum current } (A)$$

12.10 Dielectric Constant (Extra)

We are not required to know about the dielectric constant in A2, however this is useful for some questions with capacitance. The following is only applicable for **parallel plate capacitors**.

$$C = \frac{\epsilon A}{d}$$
$$\epsilon = \epsilon_r \cdot \epsilon_0$$

ϵ_r is the dielectric constant of the material and ϵ_0 is the permitivity of the medium. Through this we can deduce that capacitance is **directly proportional** to Surface Area of plates and **inversely proportional** to distance between plates.

$$C \propto A$$
$$C \propto \frac{1}{d}$$

$$C \rightarrow \text{capacitance } (F)$$
$$A \rightarrow \text{surface area of the plates } (m^2)$$
$$d \rightarrow \text{distance between the plates } (m)$$

13 Oscillations (A2)

13.1 Velocity

$$\vec{\boldsymbol{v_0}} = x_0 \vec{\boldsymbol{\omega}}$$
$$\vec{\boldsymbol{v}} = \pm \vec{\boldsymbol{\omega}} \sqrt{x_0^2 - \vec{\boldsymbol{x}}^2}$$

$$t \rightarrow \text{time } (s)$$
$$x_0 \rightarrow \text{maximum amplitude } (m)$$
$$\vec{\boldsymbol{x}} \rightarrow \text{displacement } (m)$$
$$\vec{\boldsymbol{\omega}} \rightarrow \text{angular speed } (rads^{-1})$$
$$\vec{\boldsymbol{v}} \rightarrow \text{velocity } (ms^{-1})$$
$$\vec{\boldsymbol{v_0}} \rightarrow \text{maximum velocity } (ms^{-1})$$

13.2 Acceleration in S.H.M

$$\vec{\boldsymbol{a}} = -\vec{\boldsymbol{\omega}}^2\vec{\boldsymbol{x}}$$

$$t \to \text{time } (s)$$
$$x_0 \to \text{maximum amplitude } (m)$$
$$\vec{\boldsymbol{x}} \to \text{displacement } (m)$$
$$\vec{\boldsymbol{\omega}} \to \text{angular speed } (rads^{-1})$$
$$\vec{\boldsymbol{a}} \to \text{acceleration } (ms^{-2})$$

13.3 Kinetic Energy E_k

$$E_k = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2(x_0^2 - \vec{\boldsymbol{x}}^2)$$
$$E_{max} = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2x_0^2$$

$$x_0 \to \text{maximum amplitude } (m)$$
$$\vec{\boldsymbol{x}} \to \text{displacement } (m)$$
$$\vec{\boldsymbol{\omega}} \to \text{angular speed } (rads^{-1})$$
$$E_k \to \text{ kinetic energy } (kgm^2s^{-2} - J)$$

13.4 Potential Energy E_p

$$E_p = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2\vec{\boldsymbol{x}}^2$$
$$E_{max} = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2x_0^2$$
$$E_p \to \text{potential energy } (kgm^2s^{-2} - J)$$

13.5 Total Energy E_0

Total energy in the system is equal to the total kinetic energy and the total potential energy in the system. This is proof of the principle of conservation of energy.

$$E_0 = E_p + E_k$$
$$E_0 = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2x_0^2$$
$$E_k \to \text{ kinetic energy } (kgm^2s^{-2} - J)$$
$$E_p \to \text{potential energy } (kgm^2s^{-2} - J)$$
$$E_0 \to \text{total energy } (kgm^2s^{-2} - J)$$

13.6 Point at which $E_k = E_p$

$$E_k = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2(x_0^2 - \vec{\boldsymbol{x}}^2)$$

$$E_p = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2\vec{\boldsymbol{x}}^2$$

$$\frac{1}{2}m\vec{\boldsymbol{\omega}}^2(x_0^2 - \vec{\boldsymbol{x}}^2) = \frac{1}{2}m\vec{\boldsymbol{\omega}}^2\vec{\boldsymbol{x}}^2$$

$$\cancel{\frac{1}{2}m\vec{\boldsymbol{\omega}}^2}(x_0^2 - \vec{\boldsymbol{x}}^2) = \cancel{\frac{1}{2}m\vec{\boldsymbol{\omega}}^2}\vec{\boldsymbol{x}}^2$$

$$x_0^2 - \vec{\boldsymbol{x}}^2 = \vec{\boldsymbol{x}}^2$$

$$2\vec{\boldsymbol{x}}^2 = x_0^2$$

$$\vec{\boldsymbol{x}}^2 = \frac{x_0^2}{2}$$

$$\vec{\boldsymbol{x}} = \frac{x_0}{\sqrt{2}}$$

13.7 Derivations (Extra)

Displacement-Time graphs of S.H.M are graphed using the fundamental equation:

$$\vec{\boldsymbol{x}} = \vec{\boldsymbol{x_0}}\sin\theta = x_0\sin\omega t$$

Using a bit of calculus, we can further derive some equations.

$$\vec{\boldsymbol{v}} = \frac{d\vec{\boldsymbol{x}}}{dt}$$

$$\vec{\boldsymbol{v}} = \vec{\boldsymbol{x_0}}\omega\cos\omega t$$

Since the maximum value for cosine is 1, we can derive the formula for the maximum velocity $\vec{\boldsymbol{v_0}}$ as follows:

$$\vec{\boldsymbol{v_0}} = \vec{\boldsymbol{x_0}}\omega \cdot 1$$

$$\vec{\boldsymbol{v_0}} = \vec{\boldsymbol{x_0}}\omega$$

Furthermore:

$$\vec{\boldsymbol{a}} = \frac{d\vec{\boldsymbol{v}}}{dt} = \frac{d^2\vec{\boldsymbol{x}}}{dt^2}$$

$$\vec{\boldsymbol{a}} = -\vec{\boldsymbol{x_0}}\omega^2\sin\omega t$$

Once again, as the maximum value for this sine is 1, we can derive the fundamental equation of S.H.M:

$$\vec{\boldsymbol{a}} = -\vec{\boldsymbol{x_0}}\omega^2 \cdot 1$$

$$\vec{\boldsymbol{a}} = -\vec{\boldsymbol{x_0}}\omega^2$$

14 Thermal Physics (A2)

14.1 Ideal Gas Equation

$$PV = nRT$$

$$PV = NkT$$

$$PV = \frac{1}{3}Nm < c^2 >$$

$$P = \frac{1}{3}\rho < c^2 >$$

$P \rightarrow$ pressure of gas (Pa)

$V \rightarrow$ volume of gas (m^3)

$T \rightarrow$ temperature in Kelvin (K)

$\rho \rightarrow$ density (kgm^{-3})

$n \rightarrow$ number of moles (mol)

$N \rightarrow$ number of molecules

$R \rightarrow$ universal gas constant

$k \rightarrow$ Boltzmann's constant

14.2 Mean Kinetic Energy $< E_k >$

$$< E_k >= \frac{3}{2}kT$$

$T \rightarrow$ temperature in Kelvin (K)

$k \rightarrow$ Boltzmann's constant

14.3 First Law of Thermodynamics

$$\Delta U = \Delta W + \Delta Q$$

$U \rightarrow$ total internal energy

$W \rightarrow$ work done

$Q \rightarrow$ thermal energy

14.4 Derivation of $< E_k >$

$$PV = \frac{1}{3}Nm < c^2 >$$
$$PV = nRT$$
$$nRT = \frac{1}{3}Nm < c^2 >$$
$$nRT = \frac{1}{2} \cdot \frac{2}{3}Nm < c^2 >$$

Here we convert $\frac{1}{3}$ to $\frac{1}{2} \cdot \frac{2}{3}$ in order to get a kinetic energy equation as:

$$\frac{1}{2}Nm < c^2 >$$

Since N is the number of molecules.

$$\frac{3}{2}nRT = \frac{1}{2}Nm < c^2 >$$
$$\frac{3}{2}\frac{nRT}{N} = \frac{1}{2}m < c^2 >$$
$$\frac{nR}{N} = k$$
$$\frac{3}{2}kT = \frac{1}{2}m < c^2 >$$
$$< E_k >= \frac{3}{2}kT$$

15 Electromagnetism (A2)

15.1 Force on current carrying conductor $\vec{\boldsymbol{F_B}}$

$$\vec{\boldsymbol{F_B}} = \vec{\boldsymbol{B}}IL\sin\theta$$

$$\vec{\boldsymbol{F_B}} \rightarrow \text{force (N)}$$
$$\vec{\boldsymbol{B}} \rightarrow \text{magnetic flux density (T)}$$
$$I \rightarrow \text{current through conductor(A)}$$
$$L \rightarrow \text{length of conductor (m)}$$
$$\theta \rightarrow \text{angle between magnetic field and conductor}$$

15.2 Force between two straight conductors

$$\vec{\boldsymbol{F_B}} = \frac{\mu_0 \cdot I_1 I_2}{2d}$$

$$\vec{\boldsymbol{F_B}} \rightarrow \text{force (N)}$$

$$I \rightarrow \text{current through conductor(A)}$$

$$d \rightarrow \text{distance between the two conductors (m)}$$

$$\mu_0 \rightarrow \text{permiability of free space}$$

15.3 Force on a moving charge $\vec{\boldsymbol{F_B}}$

$$\vec{\boldsymbol{F_B}} = \vec{\boldsymbol{B}}\vec{\boldsymbol{v}}q \sin\theta$$

$$\vec{\boldsymbol{B}}\vec{\boldsymbol{v}}q = \frac{m\vec{\boldsymbol{v}}^2}{r}$$

$$\vec{\boldsymbol{v}} = \frac{\vec{\boldsymbol{B}}qr}{m}$$

$$\frac{q}{m} \rightarrow \text{specific charge}$$

$$\vec{\boldsymbol{F_B}} \rightarrow \text{force (N)}$$

$$\vec{\boldsymbol{B}} \rightarrow \text{magnetic flux density (T)}$$

$$\vec{\boldsymbol{v}} \rightarrow \text{velocity of partical } (ms^{-1})$$

$$q \rightarrow \text{charge (C)}$$

$$m \rightarrow \text{mass of particle (kg)}$$

$$r \rightarrow \text{radius of circular motion (m)}$$

$$\theta \rightarrow \text{angle of entrance into magnetic field}$$

15.4 Velocity Selector

Note: my teacher recommended not to by-heart the third formula, instead, know how to derive it.

$$eV = \frac{1}{2}m\vec{\boldsymbol{v}}^2$$

$$\vec{\boldsymbol{v}} = \sqrt{\frac{2eV}{m}}$$

$$\frac{e}{m} = \frac{2V}{\vec{\boldsymbol{B}}^2 r^2}$$

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

$\vec{\boldsymbol{F_B}} \rightarrow$ force (N)

$\vec{\boldsymbol{B}} \rightarrow$ magnetic flux density (T)

$\vec{\boldsymbol{E}} \rightarrow$ electric field strength (Vm^{-1})

$\vec{\boldsymbol{v}} \rightarrow$ velocity of partical (ms^{-1})

$V \rightarrow$ potential difference (V)

$e \rightarrow$ elementary charge (C)

$m \rightarrow$ mass of particle (kg)

$r \rightarrow$ radius of circular motion (m)

15.5 Hall Effect V_H

$$V_H = \frac{\vec{\boldsymbol{B}}I}{ntq}$$

$V_H \rightarrow$ Hall voltage (V)

$\vec{\boldsymbol{B}} \rightarrow$ magnetic flux density (T)

$I \rightarrow$ current (A)

$q \rightarrow$ charge (C)

$t \rightarrow$ thickness

$n \rightarrow$ number density

15.6 Magnetic Flux ϕ

$$\phi = \vec{\boldsymbol{B}}A$$
$$\phi = \vec{\boldsymbol{B}}A\sin\theta$$
$$\phi = \vec{\boldsymbol{B}}A\cos\theta$$
$$\text{linkage} = N\phi$$

$\phi \rightarrow$ magnetic flux (Wb)

$\vec{\boldsymbol{B}} \rightarrow$ magnetic flux density (T)

$A \rightarrow$ area (m^2)

$\sin\theta \rightarrow$ if θ is angle between **area** and magnetic field

$\cos\theta \rightarrow$ if θ is angle between **normal** and magnetic field

15.7 Faraday's Law

$$e \propto \frac{\Delta N\phi}{\Delta t}$$
$$e = k \cdot \frac{\Delta N\phi}{\Delta t}$$

Experimental value of k is found to be 1.

$e \rightarrow$ induced emf (V)

$\phi \rightarrow$ magnetic flux (Wb)

$t \rightarrow$ time (s)

$N \rightarrow$ number of turns/rotations/etc (Wb)

15.8 Lenz's Law

$$e = -\frac{\Delta N\phi}{\Delta t}$$
$$e = -\frac{\mathrm{d}\phi}{\mathrm{d}t}$$

Using a bit of calculus, we can show Lenz's law. Direction of induced emf is so that to oppose the change in flux, which is $\frac{\mathrm{d}\phi}{\mathrm{d}t}$

$e \rightarrow$ induced emf (V)

$\phi \rightarrow$ magnetic flux (Wb)

$t \rightarrow$ time (s)

$N \rightarrow$ number of turns/rotations/etc (Wb)

15.9 Proof Light is an Electromagnetic Radiation

Using the two constants we learned in Electromagnetism and Electrostatics, those being:

$$\mu_0 \rightarrow \text{permiability of free space}$$

$$\epsilon_0 \rightarrow \text{permitivity of free space}$$

We can write the following equation:

$$\frac{1}{\sqrt{\mu_0 \cdot \epsilon_0}}$$

When evaluated, this gives the exact value for the speed of light c.

$$\frac{1}{\sqrt{\mu_0 \cdot \epsilon_0}} = 299,792,458ms^{-1}$$

16 Alternating Current (A2)

16.1 Circuit Equations

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

All circuit equations are essentially the same, however when working with A.C, we will use the R.M.S values for each equation, i.e:

$$P_{d.c} = VI$$

$$P_{a.c} = V_{rms} \cdot I_{rms}$$

$$V_{rms} \rightarrow \text{voltage AC (V)}$$

$$I_{rms} \rightarrow \text{current AC (A)}$$

$$V_0 \rightarrow \text{peak voltage (V)}$$

$$I_0 \rightarrow \text{peak current (A)}$$

16.2 Transformers

$$P_{in} = P_{out}$$
$$\frac{V_p}{V_s} = \frac{N_p}{N_s} = \frac{I_s}{I_p}$$

$P \rightarrow$ power (W)

$V \rightarrow$ voltage in primary (P) or secondary (S) (V)

$I \rightarrow$ current in primary (P) or secondary (S) (A)

$N \rightarrow$ number of turns in primary (P) or secondary (S)

17 Quantum Physics (A2)

17.1 Photon Energy

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

$E \rightarrow$ energy (J)

$f \rightarrow$ frequency (Hz)

$\lambda \rightarrow$ wavelength (m)

$h \rightarrow$ Planck's constant

$c \rightarrow$ speed of light

17.2 Photon Momentum

$$\vec{\boldsymbol{p}} = \frac{E}{c}$$
$$\vec{\boldsymbol{p}} = \frac{h}{\lambda}$$

$E \rightarrow$ energy (J)

$\lambda \rightarrow$ wavelength (m)

$h \rightarrow$ Planck's constant

$c \rightarrow$ speed of light

17.3 Photoelectric Equation

$$E = \Phi + \frac{1}{2} m \vec{\boldsymbol{v_m}}^2$$

$$hf = hf_0 + \frac{1}{2} m \vec{\boldsymbol{v_m}}^2$$

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2} m \vec{\boldsymbol{v_m}}^2$$

$\Phi \rightarrow$ photoelectric work function

$E \rightarrow$ energy (J)

$f \rightarrow$ frequency (Hz)

$\lambda \rightarrow$ wavelength (m)

$\lambda_0 \rightarrow$ threshold wavelength (m)

$f_0 \rightarrow$ threshold frequency (Hz)

$h \rightarrow$ Planck's constant

$c \rightarrow$ speed of light

18 Nuclear Physics (A2)

18.1 Energy Levels

$$hf = E_1 - E_2$$

18.2 Mass-Energy Relation

$$\Delta E = \Delta m c^2$$

$E \rightarrow$ energy

$\Delta m \rightarrow$ mass defect (if splitting nucleus)

$\Delta m \rightarrow$ mass difference (if nuclear decay)

$c \rightarrow$ speed of light

18.3 Mass Defect

Note: this formula is only used when calculating energy of splitting nucleii.

$$\Delta m = (Z \cdot m_p + (A - Z) \cdot m_n) - m_X$$

$$\Delta m \rightarrow \text{mass defect (if splitting nucleus)}$$

$$m_p \rightarrow \text{rest mass of proton}$$

$$m_n \rightarrow \text{rest mass of neutron}$$

$$m_X \rightarrow \text{mass of nuclide}$$

$$A \rightarrow \text{nucleon number}$$

$$Z \rightarrow \text{proton number}$$

18.4 Example - α-decay

$$^{235}_{92}\text{U} \longrightarrow {}^{231}_{90}\text{Th} + {}^{4}_{2}\text{He} + {}^{0}_{0}\gamma$$

The total mass of the Thorium-231 and Helium-4 nucleii is less than the mass of Uranium-235 (rest mass considered), the mass difference is then released as the energy ${}^{0}_{0}\gamma$, and may be calculated using the Mass-Energy relation.

18.5 Activity

The minus sign can be negated in calculations.

$$A = (-)\lambda N$$

$$A \rightarrow \text{activity}$$

$$\lambda \rightarrow \text{decay constant}$$

$$N \rightarrow \text{number of nucleii}$$

18.6 Decay Curves

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

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

$$R = R_o e^{-\lambda t}$$

$$t \rightarrow \text{time (s)}$$

$$\lambda \rightarrow \text{decay constant}$$

$$N \rightarrow \text{number of nucleii at t}$$

$$N_o \rightarrow \text{initial number of nucleii}$$

$$A \rightarrow \text{activity at t}$$

$$A_0 \rightarrow \text{initial activity}$$

$$R \rightarrow \text{count rate at t}$$

$$R_o \rightarrow \text{initial count rate}$$

18.7 Mass and Number of Particles Relationship

If you are given the mass of a sample of, for example, Strontium-90 ($^{90}_{38}\text{Sr}$), and you need to calculate the number of atoms, you can do so with the following formula:

$$N = \frac{m}{\text{nucleon number} \cdot u}$$

$$N \rightarrow \text{number of atoms}$$

$$m \rightarrow \text{mass}$$

$$u \rightarrow \text{unified atomic mass } (u = 1.66x10^{-27})$$

19 Medical Physics (A2)

19.1 Acoustic Impedance Z

$$Z = \rho c$$

$$Z \rightarrow \text{acoustic impedance of material } (kgm^{-2}s^{-1})$$

$$\rho \rightarrow \text{density of material } (kgm^{-3})$$

$$c \rightarrow \text{speed of ultrasound in material } (ms^{-1})$$

19.2 Ratio of Reflected Intensity

$$\alpha = \frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$

$$I_r \rightarrow \text{reflected intensity of ultrasound (W)}$$

$$I_i \rightarrow \text{incident intensity of ultrasound (W)}$$

$$Z_{1,2} \rightarrow \text{acoustic impedance of material } (kgm^{-2}s^{-1})$$

$$\alpha \rightarrow \text{absorption coefficient of material}$$

19.3 Attenuation of Ultrasound

$$I = I_o e^{-\alpha t}$$

$$\alpha = \frac{I_r}{I_i}$$

$I \rightarrow$ intensity of ultrasound at t (W)

$I_o \rightarrow$ initial intensity of ultrasound (W)

$\alpha \rightarrow$ absorption coefficient of material

$t \rightarrow$ time (s)

19.4 Attenuation of X-Rays

$$I = I_o e^{-\mu t}$$

$I \rightarrow$ intensity of X-Ray at t (W)

$I_o \rightarrow$ initial intensity of X-Ray (W)

$\mu \rightarrow$ attenuation coefficient of material

$t \rightarrow$ time (s)

19.5 Half Thickness $x_{\frac{1}{2}}$

$$x_{\frac{1}{2}} = \frac{\ln 2}{\mu}$$

$x_{\frac{1}{2}} \rightarrow$ half thickness

$\mu \rightarrow$ attenuation coefficient of material

19.6 A-Scan

$$\text{thickness of bone} = \frac{c\Delta t}{2}$$

$t \rightarrow$ time between two ultrasound pulses (t)

$c \rightarrow$ speed of ultrasound in material (ms^{-1})

20 Astronomy and Cosmology (A2)

20.1 Radiant Flux Intensity F

$$F = \frac{L}{4\pi d^2}$$

$F \rightarrow$ radiant flux intensity (Wm^{-2})

$L \rightarrow$ luminosity (W)

$d \rightarrow$ distance between star and imaginary surface (m)

20.2 Wien's Displacement Law

$$\lambda_{max} \propto \frac{1}{T}$$

$\lambda_{max} \rightarrow$ wavelength of maximum intensity black body radiation (m)

$T \rightarrow$ temperature (K)

20.3 Stefan-Boltzmann Law

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

$L \rightarrow$ luminosity (W)

$T \rightarrow$ temperature (K)

$r \rightarrow$ radius of star (m)

$\sigma \rightarrow$ Stefan-Boltzmann constant

20.4 Redshift

$$\frac{\Delta\lambda}{\lambda} \approx \frac{\Delta f}{f} \approx \frac{\vec{\boldsymbol{v}}}{c}$$

$\lambda \rightarrow$ wavelength (m)

$f \rightarrow$ frequency (Hz)

$\vec{\boldsymbol{v}} \rightarrow$ speed of galaxy (ms^{-1})

$c \rightarrow$ speed of light in vacuum (ms^{-1})

20.5 Hubble's Law

$$\vec{\boldsymbol{v}} = H_o d$$

$$H_o \rightarrow \text{Hubble constant}$$
$$\vec{\boldsymbol{v}} \rightarrow \text{receding speed } (ms^{-1})$$
$$d \rightarrow \text{distance (m)}$$

21 Paper 5 (A2)

21.1 Algebraic Uncertainty

If a reading of l is given as $l = (10 \pm 0.1)m$ and $A = l^2$, then:

$$l = 10m$$
$$\Delta l = 0.1m$$

$$\Delta l \rightarrow \text{absolute uncertainty in } l$$
$$\frac{\Delta l}{l} \rightarrow \text{fractional uncertainity in } l$$
$$\frac{\Delta l}{l} \cdot 100 \rightarrow \text{percentage uncertainty in } l$$
$$\frac{\Delta l}{l} \cdot 100 \rightarrow \text{percentage uncertainty in } l$$

$$\frac{\Delta A}{A} = \frac{\Delta l}{l} \cdot 2 \rightarrow \text{fractional uncertainty in } A$$

Note: Remember that we always **add** uncertainties, regardless to what order they are in, in the original equation, or what operation is being done (the only exceptions are elementary functions and powers.)

21.2 Further Algebraic Uncertainty

A small example: find the fractional uncertainity in f, assuming only $2, 3\pi$ are constants:

$$f = \frac{2M}{3\pi r^2 \sqrt{T}}$$

$$\frac{\Delta f}{f} = \left(\frac{\Delta M}{M} + \left(2 \cdot \frac{\Delta r}{r} \right) + \left(\frac{1}{2} \cdot \frac{\Delta T}{T} \right) \right)$$

We ignore the factors of 2 and 3π, as they are constants and are not related to the equation.

21.3 Logarithmic Uncertainty

If a reading of k is given as $k = (2 \pm 0.2)m$ and $L = \ln k$, we can get the uncertainty as follows:

$$\ln(2 \pm 0.2) = \ln(2 + 0.2) - \ln(2) \rightarrow \text{uncertainty in L}$$

Note: always **add** uncertainty in log, and **subtract** original value. Calculate all data in **3 s.f** or to **1 or more s.f** than the original data, this is because when working with elementary functions, we typically add 1 s.f

21.4 Line of Best Fit Uncertainity

$$\Delta m = m_b - m_w$$

$$\Delta m \rightarrow \text{absolute uncertainty in line of best fit}$$

$$m_b \rightarrow \text{gradient of line of best fit}$$

$$m_w \rightarrow \text{gradient of worst acceptable line}$$

21.5 Y-Intercept Uncertainty

$$\Delta c = c_b - c_w$$

$$\Delta c \rightarrow \text{absolute uncertainty in intercept of line of best fit}$$

$$c_b \rightarrow \text{intercept of line of best fit}$$

$$c_w \rightarrow \text{intercept of worst acceptable line}$$