Physics Derivations |

A list of all the necessary Physics Derivations, topic by topic and explained.

Linear motion

- $\boldsymbol{v = u + at}$
  $\Rightarrow\ a = \frac{v-u}{t}$: *Formula for acceleration.*
  $\Rightarrow\ at = v - u$: *Multiply both sides by* t.
  $\Rightarrow\ v = u + at$: *Add* u *to both sides.*

- $\boldsymbol{s = ut + \frac{1}{2}at^2}$
  $\Rightarrow$ V-ave = $\frac{u+v}{2}$: *From definition.*
  $\Rightarrow$ V-ave = $\frac{s}{t}$: *From definition.*
  $\Rightarrow\ \frac{u+v}{2} = \frac{s}{t}$
  $\Rightarrow\ \frac{(u+v)t}{2} = s$
  $\Rightarrow\ \frac{(u+(u+at))t}{2} = s$: *Substitute* v *for* $u + at$.
  $\Rightarrow\ \frac{(2u+at)t}{2} = s$
  $\Rightarrow\ \frac{2ut+at^2}{2} = s$
  $\Rightarrow\ s = ut + \frac{1}{2}at^2$

- $\boldsymbol{v^2 = u^2 + 2as}$
  $\Rightarrow\ v = u + at$: *First equation.*
  $\Rightarrow\ v^2 = (u + at)^2$: *Square both sides.*
  $\Rightarrow\ v^2 = u^2 + 2uat + a^2t^2$
  $\Rightarrow\ v^2 = u^2 + 2a\left(ut + \frac{1}{2}at^2\right)$: *Factorise* 2a.
  $\Rightarrow\ v^2 = u^2 + 2a(s)$: *Replace brackets with equation 2 for* s.
  $\Rightarrow\ v^2 = u^2 + 2as$

Force and momentum

- $\boldsymbol{F = ma}$
  $\Rightarrow F \propto \frac{\Delta P}{t}$
  $\Rightarrow F \propto \frac{mv-mu}{t}$
  $\Rightarrow F \propto m\left(\frac{v-u}{t}\right)$
  $\Rightarrow F \propto ma$: *Substitute equation for acceleration.*
  $\Rightarrow F = kma$
  $\Rightarrow 1 = k(1)(1)$: *1N can accelerate 1kg by* $1m/s^2$
  $\Rightarrow F = 1ma$: k=1
  $\Rightarrow F = ma$

Circular motion

- $\boldsymbol{v = r\omega}$
  $\Rightarrow v = \frac{s}{t}$: *By definition*.
  $\Rightarrow$ From $\theta = \frac{s}{r}$ we get $s = r\theta$.
  $\Rightarrow v = \frac{r\theta}{t}$: *Replacing* s.
  $\Rightarrow v = r\left(\frac{\theta}{t}\right) : \omega = \frac{\theta}{t}$
  $\Rightarrow v = r\omega$

- $\boldsymbol{a = r\omega^2}$
  $\Rightarrow a = \frac{v^2}{r}$: *Definition of centripetal acceleration*.
  $\Rightarrow a = \frac{(r\omega)^2}{r}$: $v = r\omega$
  $\Rightarrow a = \frac{r^2\omega^2}{r}$
  $\Rightarrow a = r\omega^2$

- $\boldsymbol{F = \frac{mv^2}{r}}$
  $\Rightarrow F = ma$: *Definition.*
  $\Rightarrow F = m\left(\frac{v^2}{r}\right)$: $a = \frac{v^2}{r}$ *Definition of centripetal acceleration.*
  $\Rightarrow F = \frac{mv^2}{r}$

- $\boldsymbol{F = mr\omega^2}$
  $\Rightarrow F = ma$: *By definition*.
  $\Rightarrow F = mr\omega^2$: $a = r\omega^2$ *From previous derivation.*
  $\Rightarrow F = mr\omega^2$

- $\boldsymbol{T^2 = \frac{4\pi^2(r+h)^3}{GM}}$

  $\Rightarrow mr\omega^2 = \frac{GMm}{r^2}$: *Centripetal force = Gravitational force.*

  $\Rightarrow \omega^2 = \frac{GM}{r^3}$: *Divide both sides by* (mr).

  $\Rightarrow \left(\frac{2\pi}{T}\right)^2 = \frac{GM}{r^3}$: $\omega = \frac{2\pi}{T}$

  $\Rightarrow \frac{4\pi^2}{T^2} = \frac{GM}{r^3}$

  $\Rightarrow \frac{T^2}{4\pi^2} = \frac{r^3}{GM}$: *Invert the equation*.

  $\Rightarrow T^2 = \frac{4\pi^2 r^3}{GM}$: *Multiply over the* $4\pi^2$.

  $\Rightarrow T^2 = \frac{4\pi^2(r+h)^3}{GM}$

Simple Harmonic motion (SMH)

- $\boldsymbol{a = -\omega^2 s}$

  $\Rightarrow F = -ks$

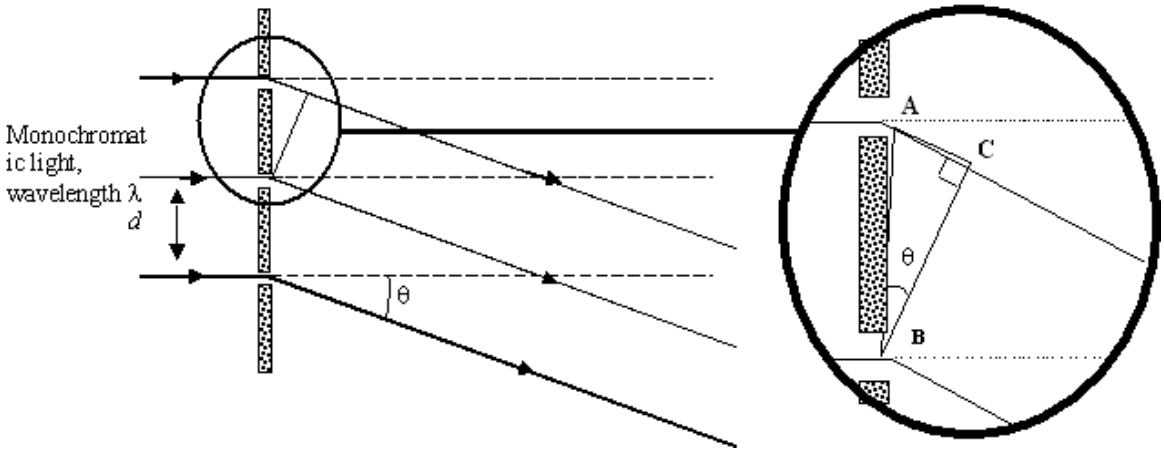
  $\Rightarrow ma = -ks$: *F=ma*

  $\Rightarrow a = -\frac{k}{m}s$

  $\Rightarrow a = -\omega^2 s$: *Let* $\omega^2 = \frac{k}{m}$

  $\Rightarrow a = -\omega^2 s$

Waves



$d = \frac{1}{N}, N = lines/mm$

$|AC| = n\lambda, n\epsilon N$

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

$n\lambda = dsin\theta$

Electricity

- **P=VI**

  $\Rightarrow W = VQ$: $V = \frac{W}{Q}$

  $\Rightarrow \frac{W}{t} = \frac{VQ}{t}$: *Divide both sides by* t

  $\Rightarrow P = VI$: $P = \frac{W}{t}$ *and* $I = \frac{Q}{t}$

- $\boldsymbol{R = R_1 + R_2}$ **(series)**

  $\Rightarrow V = V_1 + V_2$

  $\Rightarrow IR = IR_1 + IR_2$: $V = IR$

  $\Rightarrow R = R_1 + R_2$: *Divide by* I

  $\Rightarrow R = R_1 + R_2$

- $\boldsymbol{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}}$ **(parallel)**

  $\Rightarrow I = I_1 + I_2$

  $\Rightarrow \frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$: $I = \frac{V}{R}$

  $\Rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$: *Divide by* V

  $\Rightarrow \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$

- $\boldsymbol{Bev = \frac{mv^2}{r}}$

  $\Rightarrow F = BIl$: *Force felt by a current carrying conductor in a magnetic field.*

  $\Rightarrow F = B\frac{Q}{t}l$: $I = \frac{Q}{t}$

  $\Rightarrow F = B\frac{ne}{t}l$: *n = Number of electrons*, e= *charge on electron*

  $\Rightarrow \frac{F}{n} = Be\frac{l}{t}$: $\frac{F}{n}$ *= The force experienced by a single electron*

  $\Rightarrow \frac{F}{n} = Bev$: $\frac{l}{t}$ *= Speed of an electron*

  $\Rightarrow F = Bev$

  $\Rightarrow Bev = \frac{mv^2}{r}$: $F = \frac{mv^2}{r}$

- $\boldsymbol{E = -\frac{d\varphi}{dt}}$

  $\Rightarrow E\alpha\frac{\varphi_2 - \varphi_1}{t}$

  $\Rightarrow E = k\frac{\varphi_2 - \varphi_1}{t}$

  $\Rightarrow E = \frac{\varphi_2 - \varphi_1}{t}$: $k = 1$

  $\Rightarrow E = -\frac{d\varphi}{dt}$