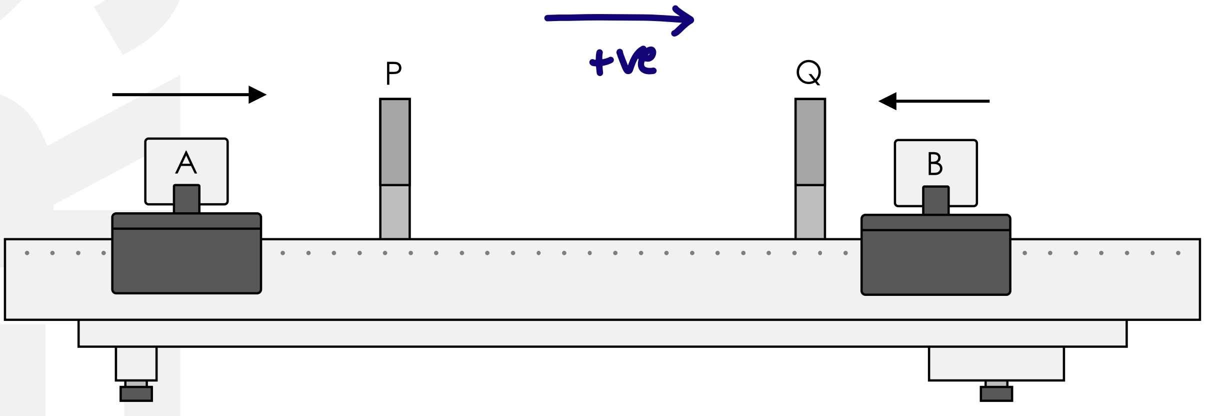
1st June

1. An air track is set up to investigate the conservation of linear momentum. Two gliders, A and B, are pushed towards each other. After the impact they separate and move back in opposite directions. The time it takes for the card to interrupt the light beam at two light gates P and Q is recorded.



Mass of glider A m_A	200 g
Mass of glider B m_B	200 g
Length of interrupt card A L_A	100 mm
Length of interrupt card B L_B	100 mm

1st time at gate P t_{P1}	0.102 s
2nd time at gate P t_{P2}	0.230 s
1st time at gate Q t_{Q1}	0.154 s
2nd time at gate Q t_{Q2}	0.131 s

Calculate:

a. The **initial** momentum of glider A $p = m_A u_A = m_A L_A / t_{P1} = 0.196\ kg\ m\ s^{-1}$

b. The **initial** momentum of glider B $p = m_B L_B / t_{Q1} = -0.130\ kg\ m\ s^{-1}$

c. The **total initial** momentum $0.196 - 0.130 = +0.066\ kg\ m\ s^{-1}$

d. The **final** momentum of glider A $p = m_A L_A / t_{P2} = -0.087\ kg\ m\ s^{-1}$

e. The **final** momentum of glider B $p = m_B L_B / t_{Q2} = +0.153\ kg\ m\ s^{-1}$

f. The **total final** momentum $-0.087 + 0.153 = +0.066\ kg\ m\ s^{-1}$

g. The **total initial kinetic energy** of both gliders

$\frac{1}{2} m_A u_A^2 + \frac{1}{2} m_B u_B^2 = 0.138\ J$

h. The **total final kinetic energy** of both gliders

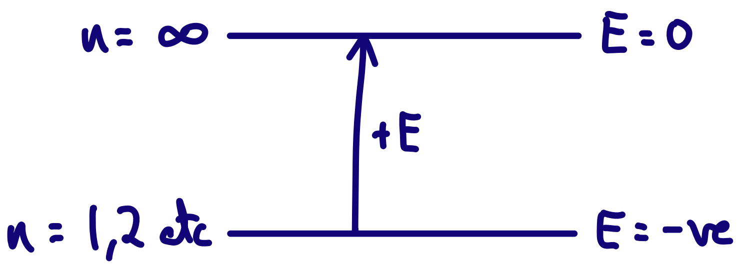
$\frac{1}{2} m_A v_A^2 + \frac{1}{2} m_B v_B^2 = 0.077\ J$

i. **Explain** if the collision is elastic or inelastic

Inelastic, as E_K is not conserved (but p is)

2nd June

1. Explain why energy levels for electrons in atoms have a **negative** value.



2. Two gliders on an air track move towards each other. After the collision they stick together and move off at the same final velocity.

Mass of glider A	208 g
Mass of glider B	231 g
Length of interrupt card A	103 mm
Length of interrupt card B	98.0 mm

1st time at gate P	0.102 s
2nd time at gate P	
1st time at gate Q	0.154 s
2nd time at gate Q	

a. Calculate their **final velocity**

$m_1u_1 + m_2u_2 = (m_1+m_2)v$

$v = \frac{m_1u_1 + m_2u_2}{m_1+m_2} = \frac{\left(0.208 \times \frac{0.103}{0.102}\right) - \left(0.231 \times \frac{0.0980}{0.154}\right)}{0.208 + 0.231} = +0.144\ ms^{-1}$

b. Fill in the table above, with the **time** it takes to pass through either light gate P or Q

v is +ve so they will pass through Q

$t = \frac{s}{v} = \frac{0.0980}{0.1436} = 0.682\ s$ as card B first passes through

(then $0.717\ s$ as card A goes through)

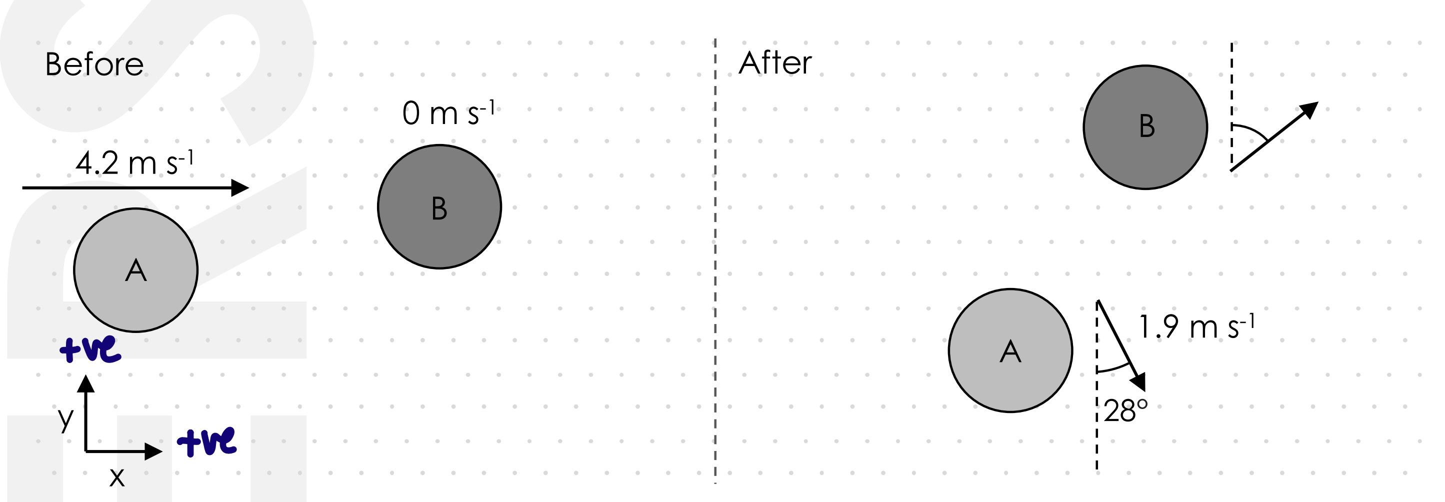
c. Calculate the **energy transferred** to the surroundings during the collision

$\Delta E = E_{K\,final} - E_{K\,initial}$

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1+m_2)v^2 = 0.148\ J$

3rd June

1. A 100 g puck on an air hockey table collides with a similar sized puck as shown below.



a. Calculate the **total initial** momentum of puck A and B in the:

i. x direction $m_A U_A + m_B U_B = (0.100 \times 4.2) + (0) = +\underline{0.42}\ kg\,m\,s^{-1}$

ii. y direction $= (0) + (0) = \underline{0}\ kg\,m\,s^{-1}$

b. State the **total final** momentum of puck A and B in the:

i. x direction $+\underline{0.42}\ kg\,m\,s^{-1}$ (P_x)

ii. y direction $\underline{0}\ kg\,m\,s^{-1}$ (P_y)

c. Calculate the **final momentum** of puck A in the:

i. x direction $0.100 \times 1.9 \sin 28 = +\underline{0.089}\ kg\,m\,s^{-1}$ (P_{Ax})

ii. y direction $0.100 \times 1.9 \cos 28 = -\underline{0.17}\ kg\,m\,s^{-1}$ (P_{Ay})

d. Calculate the final **speed** of puck B

$P_x = P_{Ax} + P_{Bx}$

$P_{Bx} = P_x - P_{Ax}$

$P_{Bx} = 0.42 - 0.0892 = 0.3308\ kg\,m\,s^{-1}$

$V_{Bx} = \frac{P_{Bx}}{m} = 3.308\ m\,s^{-1}$ (and $V_{By} = 1.6776$)

$V = \sqrt{V_x^2 + V_y^2}$

$V = \underline{3.7}\ m\,s^{-1}$

4th June

1 2 3

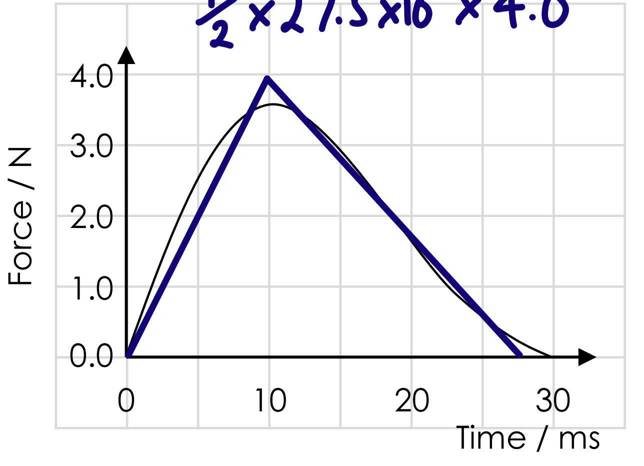
1. An electron drops from an energy level of -3.2 eV to -9.1 eV. Calculate the **frequency** of the photon that is released.

$E = hf$ $\quad f = \frac{E}{h} = \frac{(9.1 - 3.2) \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}} = 1.4 \times 10^{15}\ Hz$

2. A stationary 127 g glider on an air track is subjected to a variable force as shown in the graph.

   Calculate the velocity it accelerates to.

$\frac{1}{2} \times 27.5 \times 10^{-3} \times 4.0$

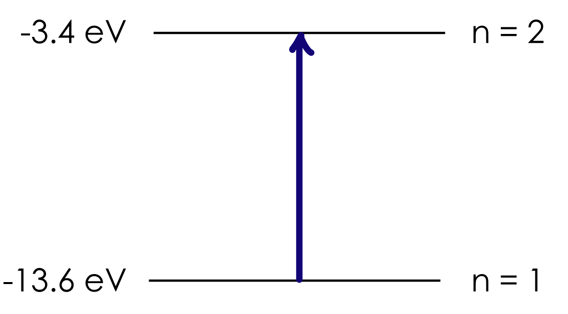


Area = 0.055 Ns

$I = m\Delta v$

$v = \frac{0.055}{0.127} = 0.43\ ms^{-1}$

3. a. Calculate the **frequency** and **wavelength** of a photon absorbed by a hydrogen electron in the ground state for it to move to the n = 2 energy state



$E = hf$ $\quad f = \frac{(13.6 - 3.4) \times 1.60 \times 10^{-19}}{6.63 \times 10^{-34}}$

$f = 2.5 \times 10^{15}\ Hz$ $\quad \lambda = \frac{c}{f} = 1.2 \times 10^{-7}\ m$

   b. State what **type** of electromagnetic wave this is

120 nm ∴ UV

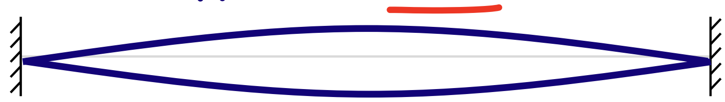
5th June

1 2

1. Sketch the **standing** wave formed on a 1.20 m **string** fixed at both ends, and state the **wavelength** in each case:

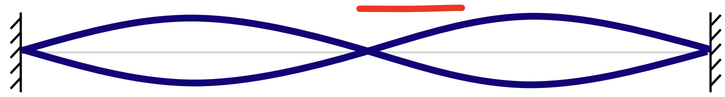
   a. First harmonic

   $\lambda = 2L = 2.40\,m$



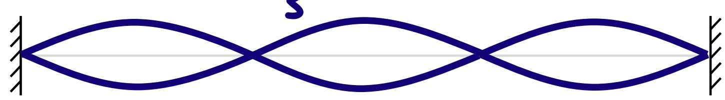
   b. Second harmonic

   $\lambda = L = 1.20\,m$

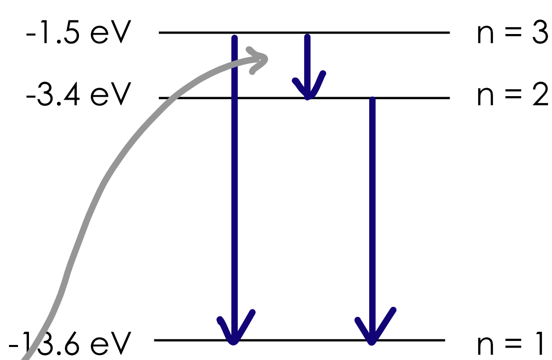


   c. Third harmonic

   $\lambda = \frac{2L}{3} = 0.80\,m$



2. a. State how **many** different photon energies can be emitted when electrons transfer between **three** energy levels



   3

   b. Calculate the **longest wavelength** emitted

   Long λ $\therefore$ Low f $\therefore$ Low E

   $E = \frac{hc}{\lambda}$ $\quad \lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{(3.4 - 1.5) \times 1.60 \times 10^{-19}} = 6.5 \times 10^{-7}\,m$

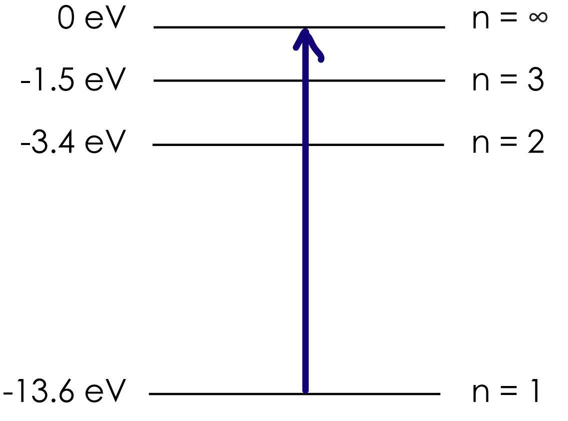
6[th] June

1 2 3

1. A diffraction grating has 300 lines mm^{-1}. A red laser of wavelength 660 nm is directed onto the grating. Calculate the **maximum** order that can be viewed on a screen.

$$d\sin\theta = n\lambda \qquad n = \frac{1}{300\times10^{3}} \times \frac{\sin 90}{660\times10^{-9}} = 5$$

2. Calculate the minimum frequency, and corresponding wavelength, of a photon needed to ionise a hydrogen atom that is in its ground state.



a. **Frequency**

$$f = \frac{13.6\times1.60\times10^{-19}}{6.63\times10^{-34}} = 3.28\times10^{15}\ \text{Hz}$$

b. **Wavelength**

$$\lambda = \frac{c}{f} = \frac{3.00\times10^{8}}{3.28\times10^{15}} = 9.14\times10^{-8}\ \text{m}$$

3. The work function for aluminium is 4.12 eV. Calculate the **maximum speed** of photoelectrons when the surface is illuminated by UV radiation of wavelength 120 nm.

$$\frac{hc}{\lambda} = \phi + \frac{1}{2} m V_{max}^{2}$$

$$V_{max} = \sqrt{\frac{2}{m}\left(\frac{hc}{\lambda} - \phi\right)}$$

$$V_{max} = \sqrt{\frac{2}{9.11\times10^{-31}}\left(\left(\frac{6.63\times10^{-34}\times3.00\times10^{8}}{120\times10^{-9}}\right) - 4.12\times1.60\times10^{-19}\right)}$$

$$V_{max} = 1.48\times10^{6}\ \text{ms}^{-1}$$

7th June

1 2 3

1. Explain how an **absorption spectrum** is produced.

See answers in the back of the book

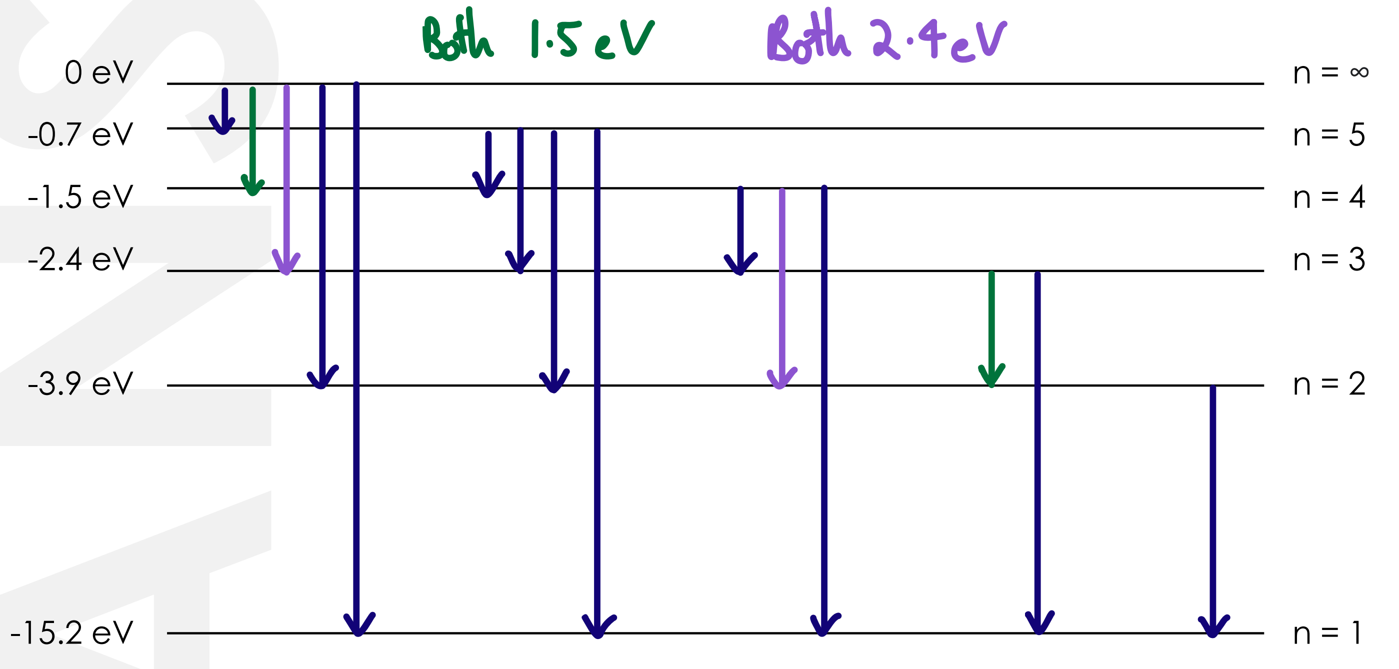
2. State:

   a. Kirchhoff's **first** law

   b. Kirchhoff's **second** law

3. Determine how **many** different energy photons could be emitted by an electron moving back to the ground state in this atom.

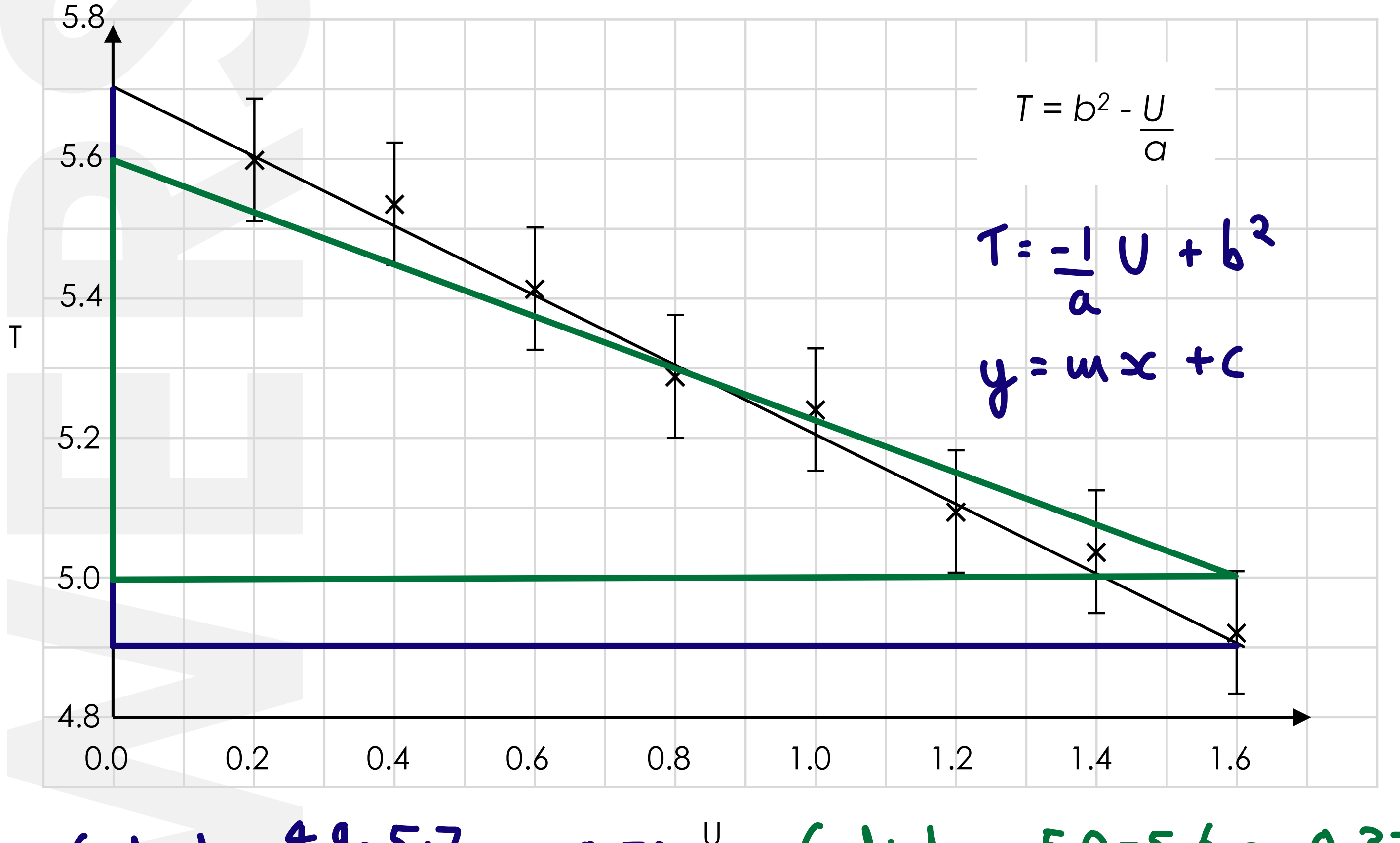
   (Add all the possible changes to the diagram to help you answer the question).



15 − 2 = 13

8th June

1. Determine the value of the constant **a** and the **percentage uncertainty** in this value.



$$\text{Gradient} = \frac{4.9 - 5.7}{1.6 - 0} = -0.50$$

$$\text{Gradient}_{worst} = \frac{5.0 - 5.6}{1.6 - 0} = -0.375$$

$$a = \frac{-1}{\text{Gradient}} = \frac{-1}{-0.50} = \underline{2.0}$$

$$\%U = \left| \frac{-0.50 - (-)0.375}{-0.50} \right| \times 100 = \underline{25\%}$$

2. Calculate the **wavelength** of laser light that produces a fringe spacing of 16 mm on a screen that is 2.0 m away, when it passes through two slits that are separated by 50 μm.

$$w = \frac{\lambda D}{s} \qquad \lambda = \frac{ws}{D} = \frac{0.016 \times 50 \times 10^{-6}}{2.0} = \underline{4.0 \times 10^{-7}}\ \text{m}$$

9th June

1 2 3

1. For sound waves of frequency 2.75 kHz and speed 330 m s^{-1}, calculate the **smallest distance** apart for two points which are:

   a. π/2 out of phase

   b. 4π/3 out of phase

$\lambda = \frac{v}{f} = \frac{330}{2750} = 0.120\ m$

$\frac{\pi}{2} \rightarrow \frac{\lambda}{4} = \frac{0.120}{4} = 0.030\ m$

$\frac{4\pi}{3} \rightarrow \frac{2\lambda}{3} = 0.080m$

$\therefore = 0.040m$ to the point on the next wave

2. A rock is falling directly towards the centre of Mars with a velocity of 35 m s^{-1}. After it has fallen 50 m lower the velocity has increased to 40 m s^{-1}. Use this information to calculate the **acceleration of free fall** on Mars.

$s = 50m$
$u = 35\ ms^{-1}$
$v = 40\ ms^{-1}$
$a = g_{Mars}$
t

$v^2 = u^2 + 2as$

$g_{Mars} = \frac{v^2 - u^2}{2s} = \frac{40^2 - 35^2}{2 \times 50} = 3.75$

$= 3.8\ ms^{-2}$

3. Some students are watching a floating buoy on the sea as water waves pass by. At time t = 0 s they observe the buoy at its maximum amplitude of 50 cm and record the time period as 4.0 s.

   Calculate the **displacement** of the buoy:

   a. 2.0 s later $= \frac{T}{2}$ $\therefore$ $x = -0.50m$

   b. 3.0 s later $= \frac{3T}{4}$ $\therefore$ $x = 0.00m$

   c. Explain if the water waves are **transverse** or **longitudinal**

A bit of both when you watch them in real life!

10^{th} June

1 2 3

1. Light travels from air into glass of refractive index 1.55, exiting with an angle of refraction of 30.0°. Calculate the:
   a. **Angle of incidence**

   $n = \sin i / \sin r \quad i = \sin^{-1}(n \sin r) = \sin^{-1}(1.55 \times \sin 30.0) = \underline{50.8^\circ}$

   b. **Speed** of light in the glass

   $v = \frac{c}{n} = 3.00\times10^8 / 1.55 = \underline{1.94\times10^8}\ ms^{-1}$

2. Light travels from water of refractive index 1.33 into oil with a refractive index 1.52. If the angle of incidence is 40.0°, calculate the **angle of refraction**.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$1.33 \sin 40.0 = 1.52 \sin r$$

$$r = \underline{34.2^\circ}$$

3. A beam of red and blue light travels from air into a crown glass triangular prism. The refractive index is 1.51 for red light and 1.54 for blue light.

   Calculate the **difference** in angles of **refraction** for an angle of incidence 50.0°.

$$r_{red} = \sin^{-1}\left(\frac{\sin i}{n}\right) = \sin^{-1}\left(\frac{\sin 50.0}{1.51}\right) = 30.5^\circ$$

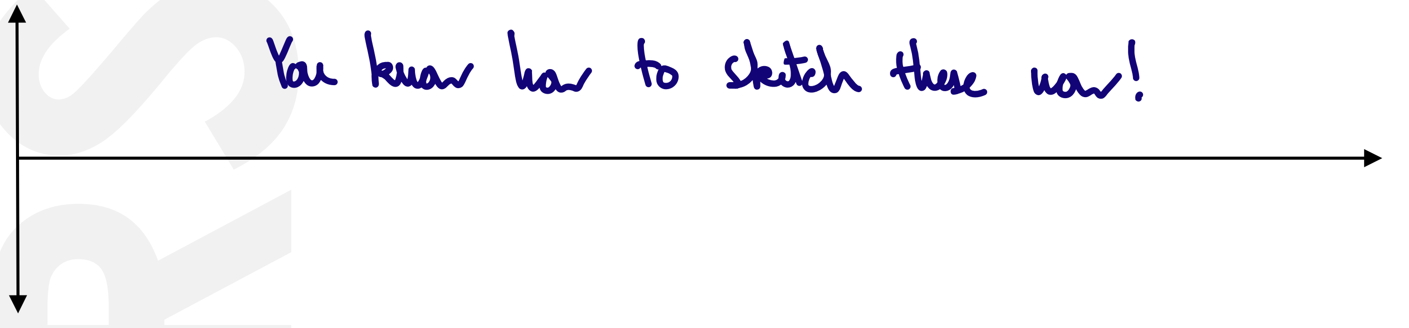
$$r_{blue} = \sin^{-1}\left(\frac{\sin i}{n}\right) = \sin^{-1}\left(\frac{\sin 50.0}{1.54}\right) = 29.8^\circ$$

$$\therefore \Delta\theta = \underline{0.7^\circ}$$

11th June

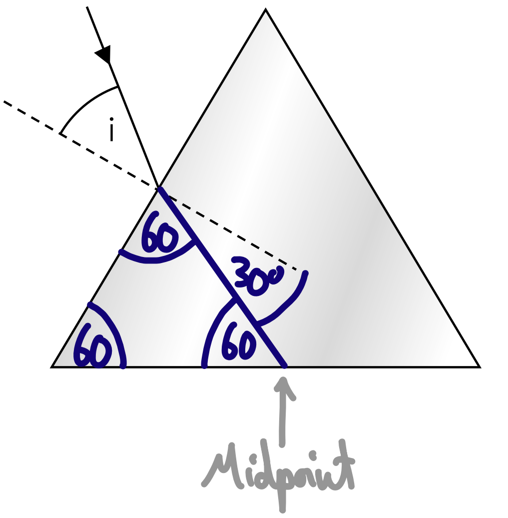
1 2 3

1. **Sketch** graphs of $y = \cos x$ and $y = \sin x$ on the same axis.



2. A ray of light hits the midpoint of the side of an equilateral glass prism with refractive index 1.51.

   Calculate the **angle of incidence** when the ray of light will pass out through the midpoint of the bottom edge of the prism.



$n = \frac{\sin i}{\sin r}$

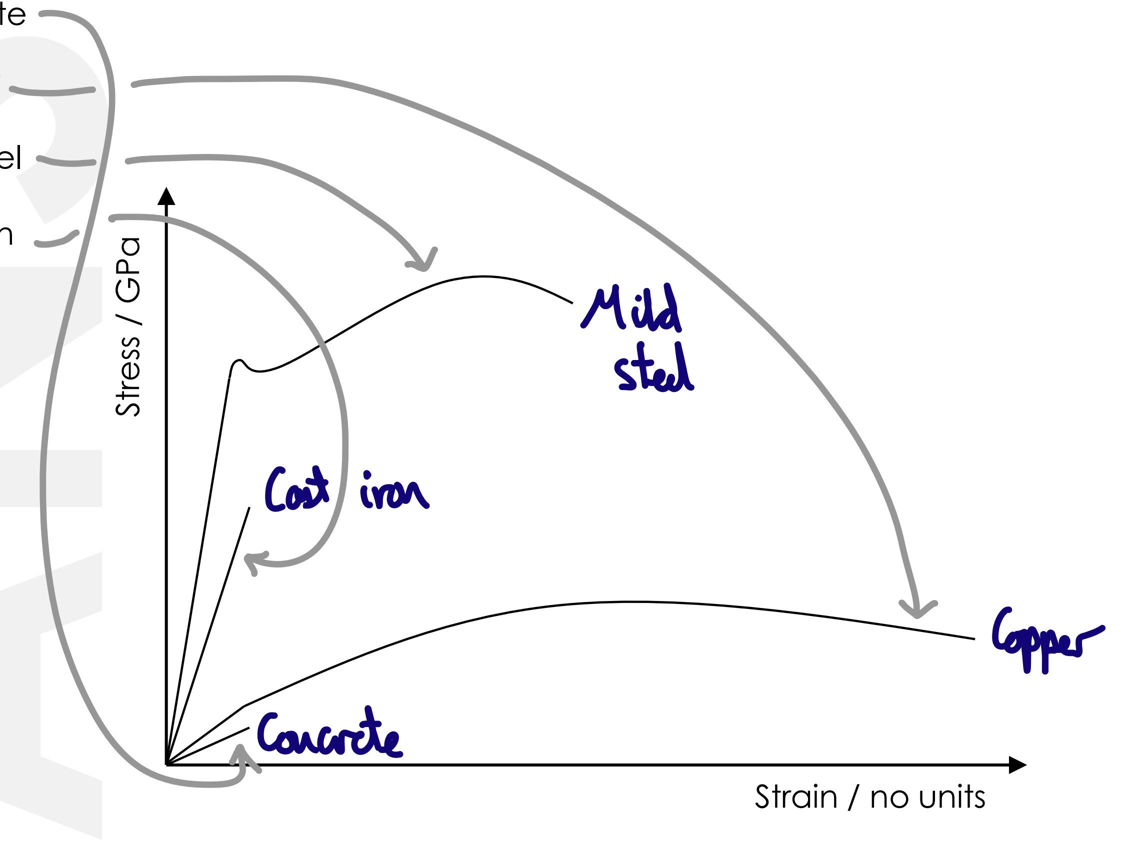
$i = \sin^{-1}(n \sin r)$

$i = \sin^{-1}(1.51 \times \sin 30.0)$

$i = 49.0°$

3. Label the following **stress-strain** graph with these materials:

   a. Concrete
   b. Copper
   c. Mild steel
   d. Cast iron



12th June

1 2 3

1. Calculate the **fringe spacing** of an interference pattern produced by a 650 nm laser shone through a pair of slits that are 0.600 mm apart and are 5.40 m from a screen.

$$w = \frac{\lambda D}{s} = \frac{650\times10^{-9} \times 5.40}{0.600\times10^{-3}} = 5.85\times10^{-3}\ \text{m}$$

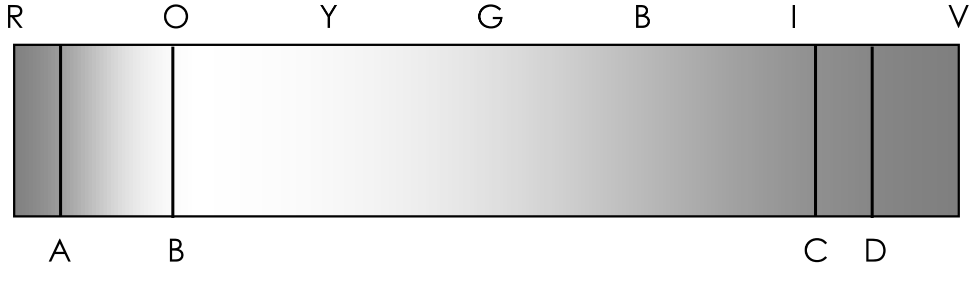
2. Define:

   a. **Internal resistance**

   b. The **volt**

3. The absorption spectrum of a cool gas is shown below. An electron in the cool gas gains 1.8 eV as they change energy levels.

   Determine which **line** (A, B, C or D) this energy difference corresponds to.



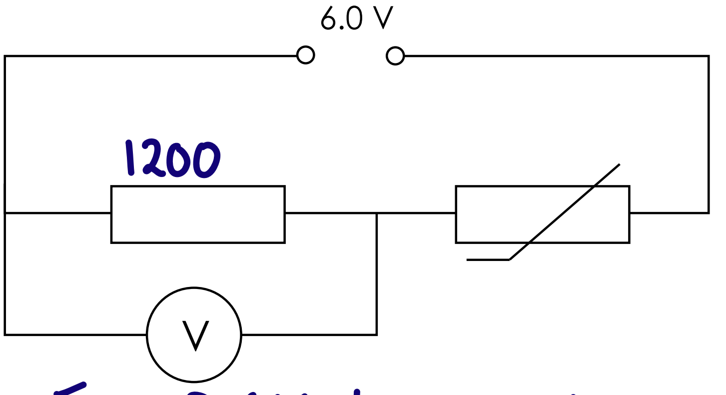
$$E = \frac{hc}{\lambda} \quad \lambda = \frac{hc}{E} = \frac{6.63\times10^{-34} \times 3.00\times10^{8}}{1.8 \times 1.60\times10^{-19}} = 6.9\times10^{-7}$$

690 nm ∴ Red ∴ A

13th June

1 2 3

1. Calculate the change in PD across the 1.2 kΩ resistor as the resistance of the thermistor changes from 800 Ω to 8.0 kΩ.



From $6.0 \times \left(\frac{1200}{1200+800}\right) = 3.6\text{V}$

To $6.0 \times \left(\frac{1200}{1200+8000}\right) = 0.78\text{V}$

From 3.6V to 0.78V

2. Two radio transmitters are 20.0 m apart, with one directly south of the other. They emit waves of frequency 2.00 GHz. A receiver is 500 m away to the east and moves along a line that is north-south.

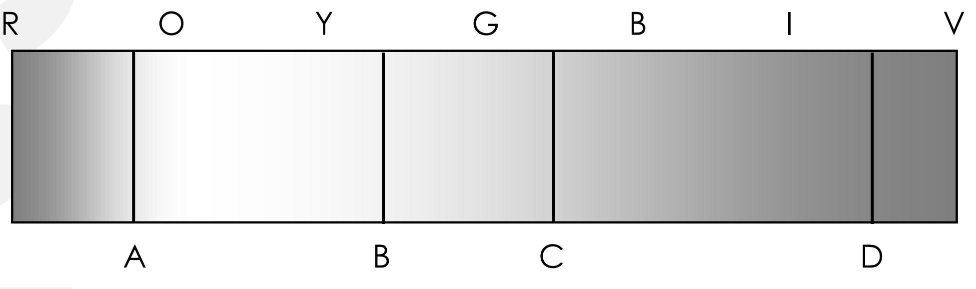
   Calculate how **far apart** the maximum strength signals will be detected.

$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8}{2.00 \times 10^9} = 0.150\text{m}$

$w = \frac{\lambda D}{s} = \frac{0.150 \times 500}{20.0} = 3.75\text{m}$

3. The absorption spectrum of a cool gas is shown below. The electrons change between the -7.2 eV and -10.1 eV energy levels.

   Determine which **line** (A, B, C or D) this corresponds to.



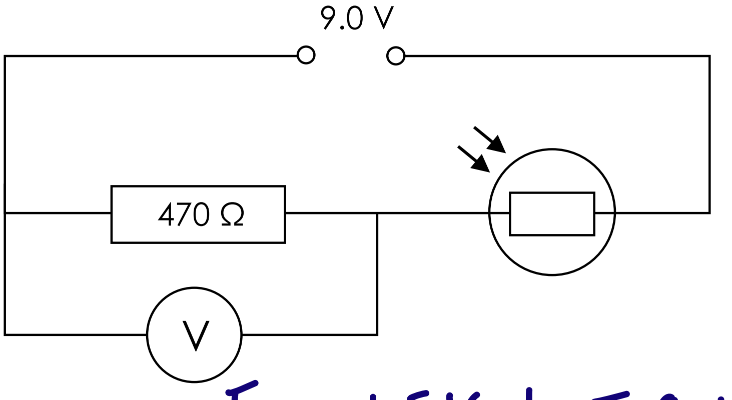
$E = \frac{hc}{\lambda}$ $\lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^8}{(10.1-7.2) \times 1.60 \times 10^{-19}} = 4.3 \times 10^{-7}$

430 nm ∴ Violet ∴ D

14th June

1 2 3

1. Calculate the change in PD across the fixed resistor as the resistance of the LDR decreases from 2.3 kΩ to 250 Ω.



From $9.0 \times \left(\frac{470}{470 + 2300}\right) = 1.5\,V$

To $9.0 \times \left(\frac{470}{470 + 250}\right) = 5.9\,V$

From 1.5 V to 5.9 V

2. Microwaves from a transmitter strike a metal plate normally and are reflected back towards the transmitter. A receiver detects a maximum signal every 5.0 cm along the path of the microwaves.

   Calculate the **frequency** of the microwaves.

$\lambda = 2 \times 0.050 = 0.10\,m$

$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{0.10} = 3.0 \times 10^9\,Hz$

3. A tuning fork is held over the end of a metre long glass pipe filled with water. The water slowly leaks out of the pipe so the length of an air column above the water gradually gets longer. A loud note is first heard for a length of 17.0 cm.

   If the speed of sound is 340 m s^{-1}, calculate the **frequency** of the tuning fork and at what **length** of air column another loud sound will be heard.

$L_1 = \frac{\lambda}{4} = 0.170\,m \quad \therefore \lambda = 0.680\,m$

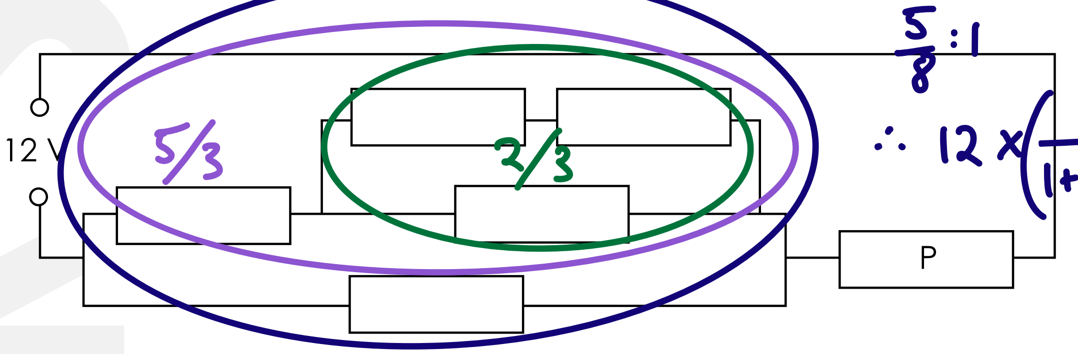
$f = \frac{c}{\lambda} = \frac{3.00 \times 10^8}{0.680} = 500\,Hz$

$L_2 = \frac{3\lambda}{4} = \frac{3 \times 0.680}{4} = 0.510\,m$

15^{th} June

$R_T = \frac{5/3}{5/3 + 1} = 5/8$

1. The following resistors are all identical, calculate the **PD** across the resistor labelled P.



$\frac{5}{8} : 1$

$\therefore 12 \times \left(\frac{1}{1 + 5/8}\right) = 7.4\,V$

2. A vertical metal wire of length 80.0 cm has a mass of 4.00 kg hanging on it. When plucked at its centre, it vibrates with a frequency of 60.0 Hz.

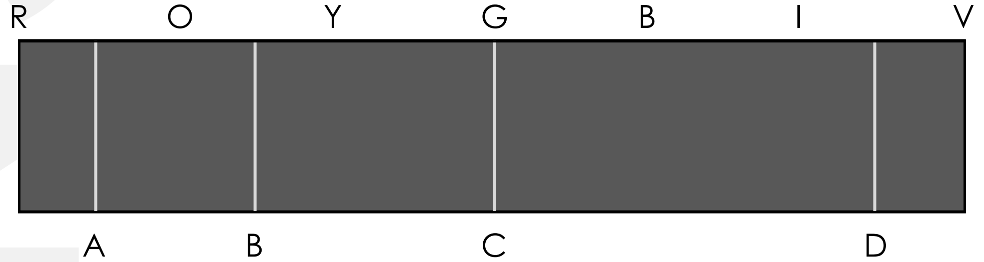
   Calculate the **mass per unit length** of the wire.

$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$ $\quad \mu = \frac{T}{4L^2 f^2} = \frac{4.00 \times 9.81}{4 \times 0.800^2 \times 60.0^2}$

$\mu = 4.26 \times 10^{-3}\ kg\,m^{-1}$

3. Below is the emission spectrum of an excited gas. The atom has energy levels at -0.85 eV and -3.1 eV.

   Determine which **line** (A, B, C or D) corresponds to the photon emitted as an electron drops between these two levels.



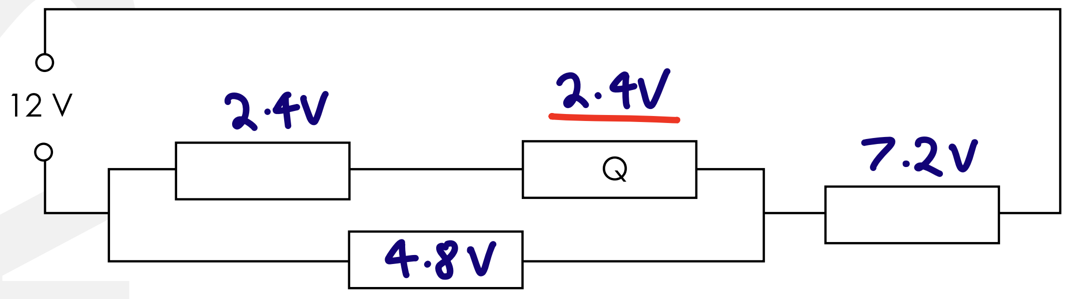
$E = \frac{hc}{\lambda}$ $\quad \lambda = \frac{hc}{E} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{(3.1 - 0.85) \times 1.60 \times 10^{-19}} = 5.5 \times 10^{-7}$

550 nm $\therefore$ Green $\therefore$ C

16th June

$R_T = \frac{2}{3}R + R = \frac{5}{3}R$

1. The following resistors are all identical, calculate the **PD** across the resistor labelled Q.



2. Two identical gliders (1 and 2) on an air track travel towards each other with speed u_1 twice that of u_2 (i.e. $u_1 = 2 \times u_2$). After the collision they stay connected.

   a. Give an expression for their **final velocity** in terms of u_1

   $m_1u_1 - m_2u_2 = (m_1 + m_2)v \quad mu_1 - m\frac{u_1}{2} = 2mv \quad 2v = \frac{u_1}{2} \quad v = \frac{u_1}{4}$

   b. Write an expression showing the **loss in E_k** during the collision in terms of m and u_1

   $\Delta E_K = \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 - \frac{1}{2}(m_1 + m_2)v^2$

   $\frac{1}{2}m\left(u_1^2 + \left(\frac{u_1}{2}\right)^2 - 2\left(\frac{u_1}{4}\right)^2\right) = mu_1^2\left(\frac{1}{2} + \frac{1}{8} - \frac{1}{16}\right) = \frac{9mu_1^2}{16}$

3. A diffraction grating has 250 lines mm^{-1}. White light is shone through the grating.

   Calculate:

   a. The **angle** for a 3rd order maximum for 700 nm red light

   $\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right) = \sin^{-1}\left(\frac{3 \times 700 \times 10^{-9}}{1/250 \times 10^{3}}\right) = 31.7^\circ$

   b. The **angle** for a 4th order maximum for 425 nm green light

   $\theta = \sin^{-1}\left(\frac{n\lambda}{d}\right) = \sin^{-1}\left(\frac{4 \times 425 \times 10^{-9}}{1/250 \times 10^{3}}\right) = 25.2^\circ$

   c. How **many orders** could potentially be observed for:

      i. The red light

      $n = \frac{d}{\lambda} \quad (\sin 90^\circ = 1) \quad n = 5 \quad \therefore \quad 11$

      ii. The green light

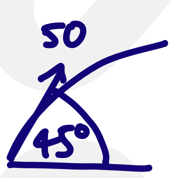
      $n = 9 \quad \therefore \quad 19$

17th June

1 2 3

1. An arrow is fired from ground level into the air at 45 degrees at a speed of 50 m s[-1].

   Calculate the **distance** it lands away from the archer.



$\uparrow$ s
$u = 50\sin 45$
$v = 0$
$a = -9.81$
$t = ?$

$v = u + at$

$t = \frac{v-u}{a}$

$t = \frac{0 - 50\sin 45}{-9.81} = 3.604$

$t_{total} = 7.208$

$\rightarrow s = vt$

$s = 50\cos 45 \times 7.208$

$s = 254.8$

$s = 250$ m

2. Calculate the **wavelength** of light used to produce a diffraction pattern through a diffraction grating with spacing of 2.09 μm, if the third order maxima is at an angle of 40°.

$$\lambda = \frac{d\sin\theta}{n} = \frac{2.09\times10^{-6}\times\sin 40}{3} = 4.5\times10^{-7}\text{ m}$$

3. Laser light is incident on a double slit and projected onto a screen. The total distance across eleven fringes of light is measured with a ruler as 3.6 cm, with an uncertainty of ± 1 mm.

(not to scale)

   a. Calculate the **percentage uncertainty** (to 2 s.f.) in the total distance measured

$$\frac{1}{36}\times100 = 2.8\%$$

   b. Calculate the **spacing** between each fringe

$$0.036 \div 10 = 3.6\times10^{-3}\text{ m}$$

   c. State the **percentage uncertainty** in spacing between individual fringes

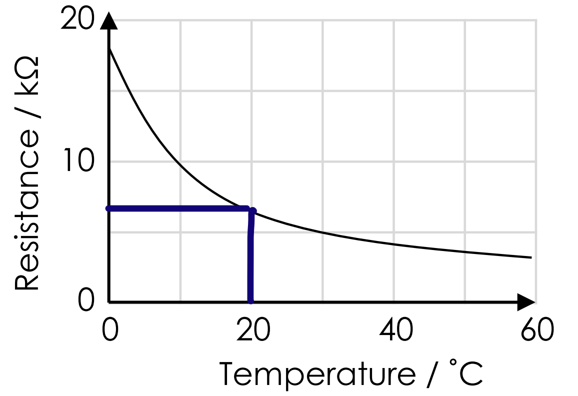
$$2.8\%$$

18th June

1 2 3

1. A potential divider consists of a 1.0 kΩ fixed resistor and a thermistor. The input potential difference to the potential divider is 12.0 V.

   Estimate the **potential difference** across the 1.0 kΩ resistor at room temperature.



7 kΩ at about 20°C

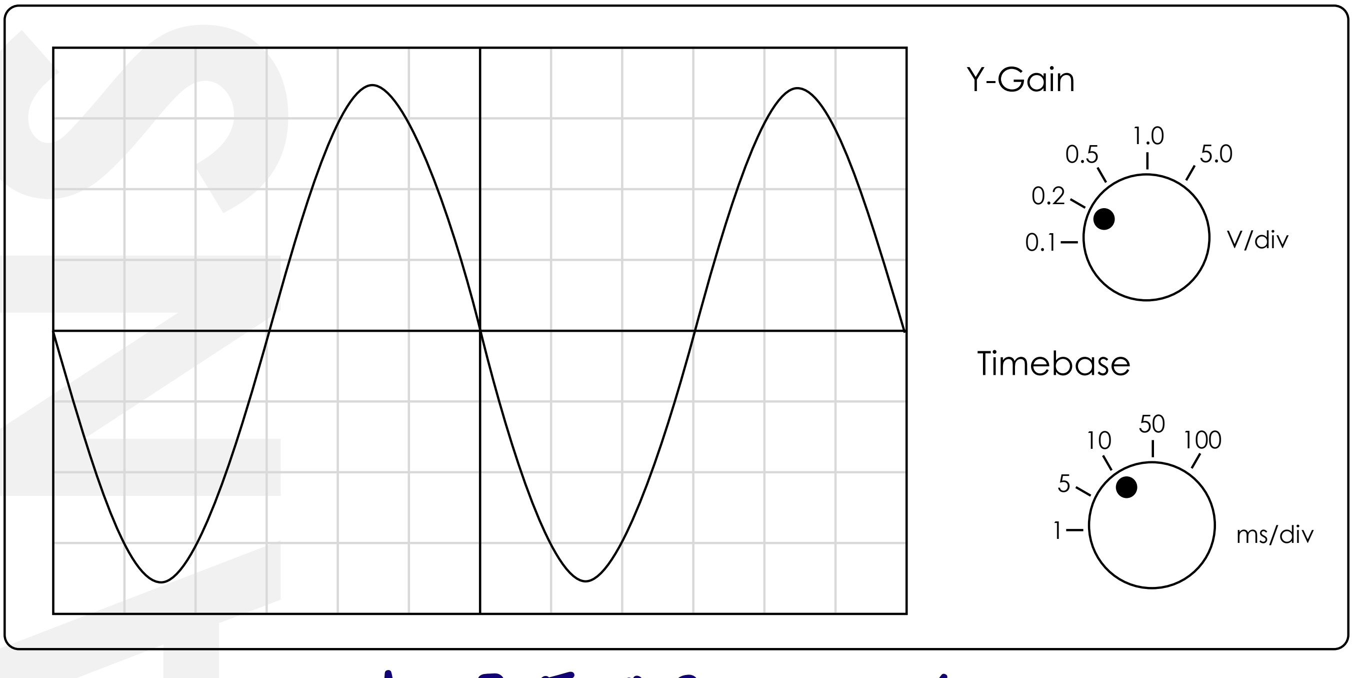
$V = \left(\frac{1.0}{1.0 + 7}\right) \times 12.0 \approx 1.5\,V$

2. Define:

   a. The **ohm**

   b. The **ampere**

3. Determine the **amplitude** (in V) and **frequency** of the signal on this oscilloscope trace.



$A = 3.5 \times 0.2 = 0.70\,V$

$f = \frac{1}{T} = \frac{1}{6 \times 10 \times 10^{-3}} = 17\,Hz$

19th June

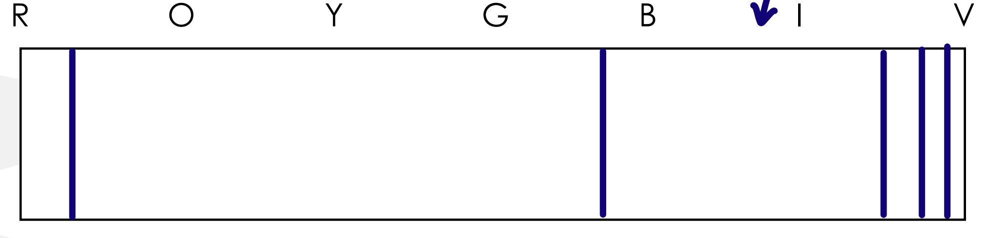
1 2 3

1. The power output of a laser pointer is stated as 5.0 mW. It the spot of the laser is a circle of diameter 1.0 mm, calculate the **intensity** of the laser light.

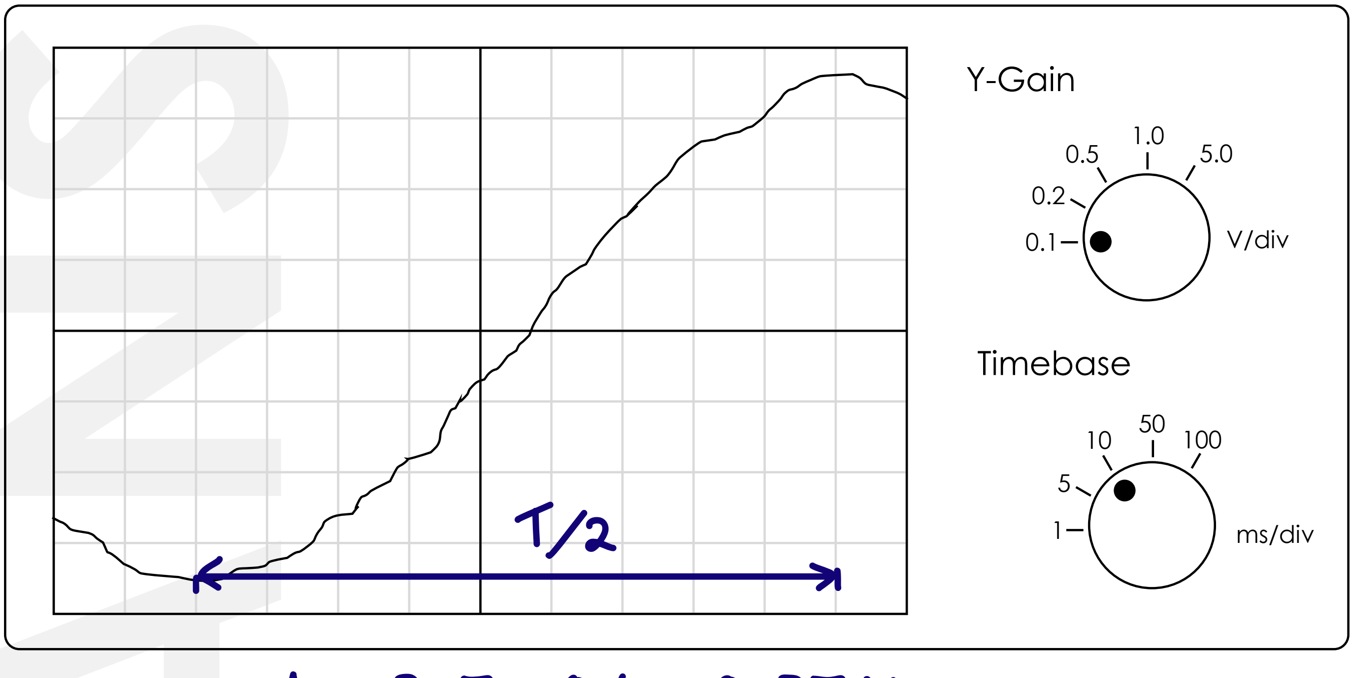
$$I = \frac{P}{A} = \frac{4P}{\pi d^2} = \frac{4 \times 5.0\times10^{-3}}{\pi \times (1.0\times10^{-3})^2} = 6.4\times10^{3}\ Wm^{-2}$$

2. Describe how we can **view** an emission spectrum for an excited gas in the lab, and sketch what this may look like for **hydrogen** below.

It looks a little bit like this



3. Determine the **amplitude** (in V) and **frequency** of the signal on this oscilloscope trace.



$$A \approx 3.7 \times 0.1 = 0.37\ V$$

$$f \approx \frac{1}{T} = \frac{1}{9 \times 2 \times 10\times10^{-3}} = 5.6\ Hz$$

20th June

1 2 3

1. Calculate the **de Broglie wavelength** of a proton travelling at 320 km s^{-1}.

$$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{1.673\times10^{-27}\times 320\times10^{3}} = 1.24\times10^{-12}\ \text{m}$$

2. An unknown particle has a de Broglie wavelength of 10 pm when travelling at 10.0 km s^{-1}.

   Calculate the **mass** of this particle and suggest what **type** of particle it is.

$$m = \frac{h}{\lambda v} = \frac{6.63\times10^{-34}}{10\times10^{-12}\times 10.0\times10^{3}} = 6.6\times10^{-27}$$

$\therefore$ Alpha particle

3. Calculate the **de Broglie wavelength** of an electron travelling at a speed of 4.0 × 10^{6} m s^{-1} and suggest what **material** could be used to produce a good diffraction pattern for a beam of these electrons.

$$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times 4.0\times10^{6}} = 1.8\times10^{-10}\ \text{m}$$

Graphite (spacing of atoms $\approx \lambda$)

21st June

1 2 3

1. A proton is accelerated across a potential difference of 2.0 kV. Calculate the **velocity** it reaches.

$QV = \frac{1}{2}mv^2 \quad v = \sqrt{\frac{2QV}{m}} = \sqrt{\frac{2 \times 1.60 \times 10^{-19} \times 2.0 \times 10^3}{1.673 \times 10^{-27}}}$

$v = 6.2 \times 10^5 \text{ ms}^{-1}$

2. An alpha particle is accelerated across the same potential difference as the proton in Q1. Calculate the **velocity** the alpha particle reaches.

$QV = \frac{1}{2}mv^2 \quad v = \sqrt{\frac{2QV}{m}} = \sqrt{\frac{2 \times 2 \times 1.60 \times 10^{-19} \times 2.0 \times 10^3}{6.646 \times 10^{-27}}}$

$v = 4.4 \times 10^5 \text{ ms}^{-1}$

3. Rewrite the **five** suvat equations for an object that starts at rest and accelerates downwards due to gravity, g.

$s = s$
$u = 0$
$v = v$
$a = g$
$t = t$

$s = ut + \frac{1}{2}at^2 \rightarrow s = \frac{1}{2}gt^2$

$v = u + at \rightarrow v = gt$

$v^2 = u^2 + 2as \rightarrow v^2 = 2gs$

$s = \left(\frac{u+v}{2}\right)t \rightarrow s = \frac{1}{2}vt$

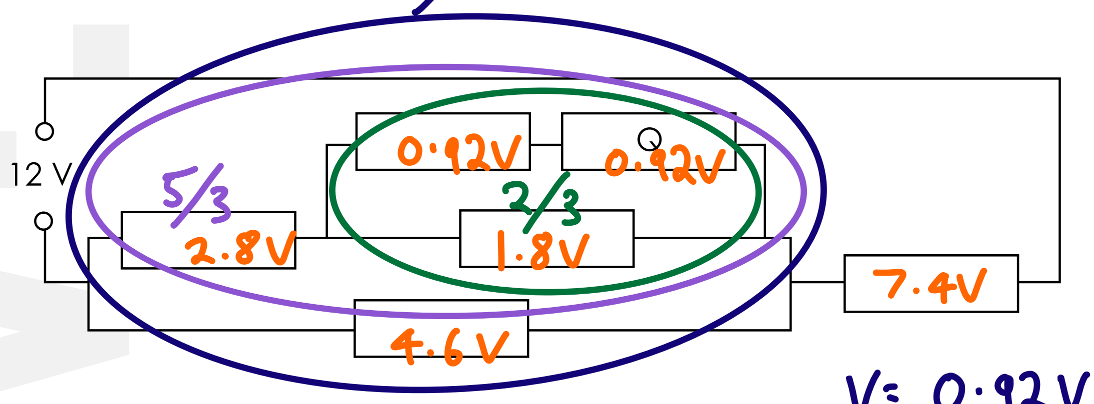
$s = vt - \frac{1}{2}at^2 \rightarrow s = vt - \frac{1}{2}gt^2$

22nd June

1. **Explain** why a diffraction grating produces a sharper diffraction pattern than a double slit.

$$R = \frac{5/3}{5/3 + 1} = 5/8$$

2. The following resistors are all identical, calculate the **PD** across the resistor labelled Q.



$V_Q = 0.92\text{V}$

3. An electron is accelerated through a potential difference of 2.50 kV in a cathode-ray tube.

   a. State the **kinetic energy** gained by the electron in **eV**

   2.50 keV

   b. Calculate the **kinetic energy** gained by the electron in **J**

   $$2.50\times10^{3} \times 1.60\times10^{-19} = 4.00\times10^{-16}\text{ J}$$

   c. Calculate the **speed** of the electron

   $$v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2\times4.00\times10^{-16}}{9.11\times10^{-31}}} = 2.96\times10^{7}\text{ ms}^{-1}$$

   d. Calculate its **wavelength**

   $$\lambda = \frac{h}{mv} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times2.96\times10^{7}} = 2.46\times10^{-11}\text{ m}$$

23rd June

1 2 3

1. Calculate the **velocity**, in m s^{-1}, an 80 kg person would have if they had the same magnitude momentum as a car with a mass of 2.0 tonnes moving at 30 km h^{-1}.

$$m_p v_p = m_c v_c$$

$$v_p = \frac{m_c v_c}{m_p} = \frac{2000 \times (30 \times 10^3 / 3600)}{80} = 210 \text{ m s}^{-1}$$

2. A current of 68 mA flows through a resistor for 8.0 minutes. Calculate the:

   a. **Charge** that has passed through the component in this time

$$Q = It = 68 \times 10^{-3} \times 8.0 \times 60 = 32.64 = 33 \text{ C}$$

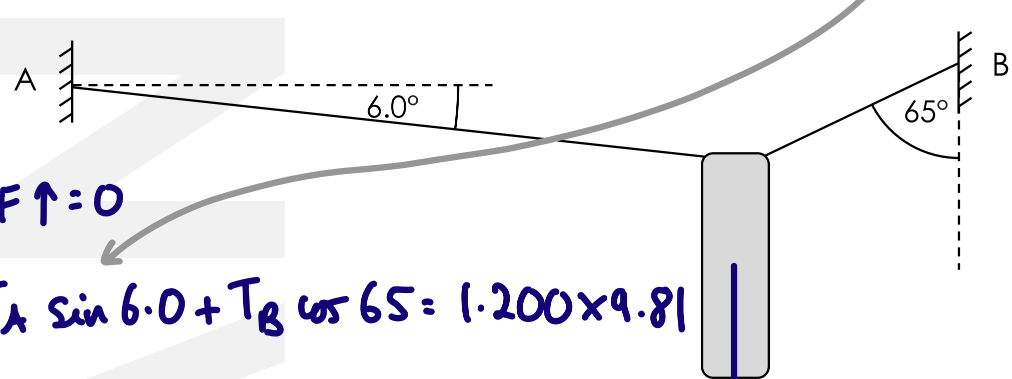
   b. **Number of electrons** that transfer this charge

$$Q = ne \qquad n = \frac{Q}{e} = \frac{32.64}{1.60 \times 10^{-19}} = 2.0 \times 10^{20} \text{ electrons}$$

3. A 1200 g mass is suspended from two fixed wires as shown below.

   Calculate the **tension** in each wire.

$$\Sigma F_{\rightarrow} = 0 \qquad T_A \cos 6.0 = T_B \sin 65 \qquad T_A = T_B \frac{\sin 65}{\cos 6.0}$$



$$\Sigma F_{\uparrow} = 0$$

$$T_A \sin 6.0 + T_B \cos 65 = 1.200 \times 9.81$$

$$T_B \left(\frac{\sin 65}{\cos 6.0} \cdot \sin 6.0 + \cos 65 \right) = 11.772$$

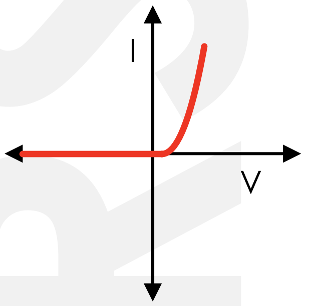
$$T_B = 22.73 = 23 \text{ N} \qquad T_A = 22.73 \cdot \frac{\sin 65}{\cos 6.0} = 21 \text{ N}$$

24^{th} June

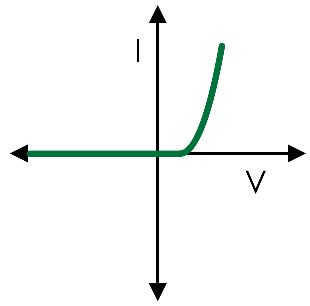
1 2 3

1. Sketch the **IV characteristics** of a:

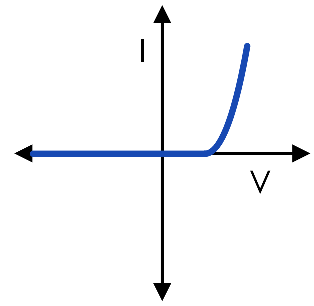
a. Red LED



b. Green LED



c. Blue LED

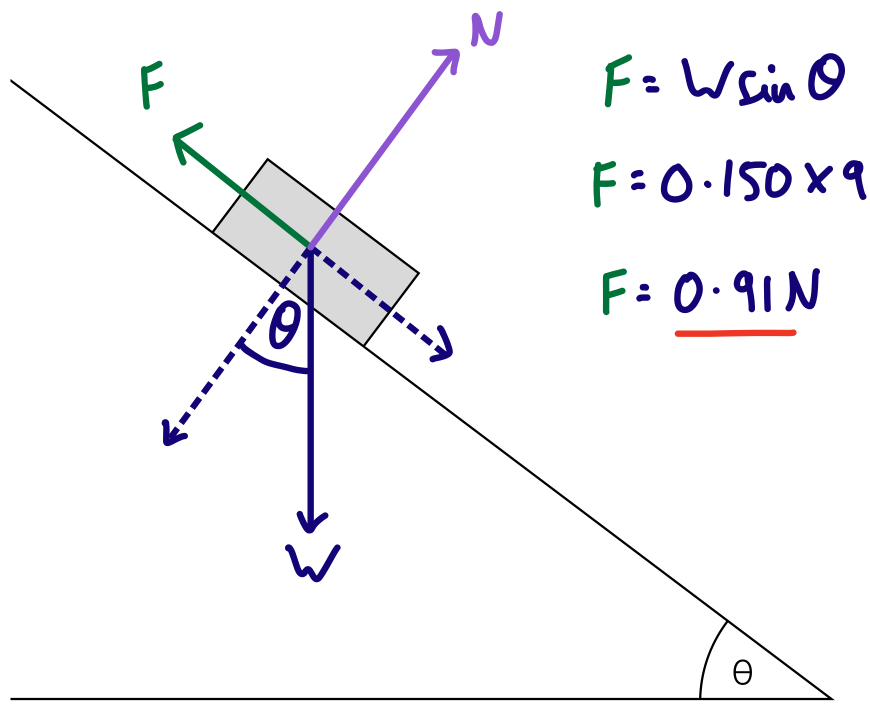


2. Define:

   a. The **joule**

   b. The **newton**

3. The block is **sliding** down the slope at a constant velocity of 12 cm s^{-1}. Calculate the size of the **friction** acting up the slope if the block's mass is 150 g and θ = 38˚.



$F = W \sin \theta$

$F = 0.150 \times 9.81 \times \sin 38$

$F = \underline{0.91\,N}$

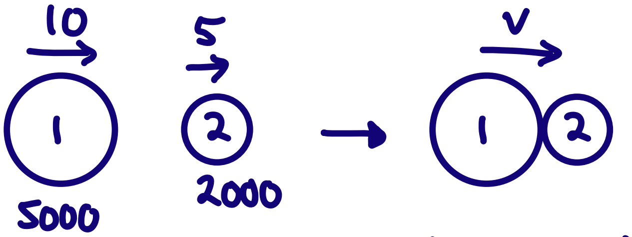
25^{th} June

1. Define:

   a. **Momentum**

   b. **Conservation of linear momentum**

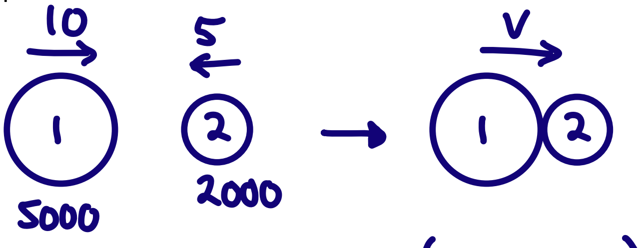
   c. A 5000 kg truck moving at 10 m s^{-1} collides with a car of mass 2000 kg travelling in the same direction at 5.0 m s^{-1}. If the vehicles stick together in the impact, calculate their combined **final velocity** (include a diagram in your answer)



$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

$$v = \frac{(5000 \times 10) + (2000 \times 5)}{7000} = +8.6 \text{ ms}^{-1}$$

   d. If the collision in part c. takes place with the same speeds, but the vehicles are travelling in opposite directions, calculate the **final velocity** of the vehicles as they move off together



$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

$$v = \frac{(5000 \times 10) - (2000 \times 5)}{7000} = +5.7 \text{ ms}^{-1}$$

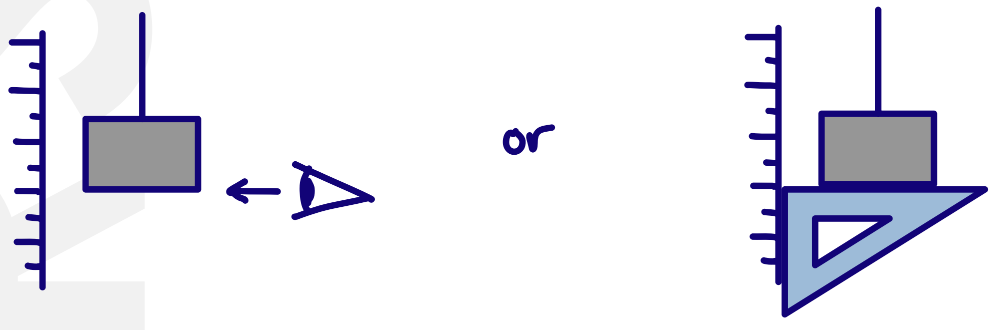
   e. Explain how vehicles are **designed** to reduce the forces that the occupants are subject to in collisions

$$F \propto \frac{\Delta p}{\Delta t} \qquad \Delta t \uparrow \therefore F \downarrow$$

26th June

1 2 3

1. When reading any scale in experimental physics, describe what can be done to minimise **parallax error**. Include a description of what parallax error is.

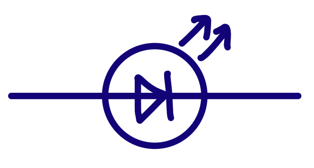


2. Define:
   a. The **independent** variable

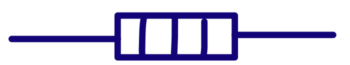
   b. The **dependent** variable

   c. **Control** variables

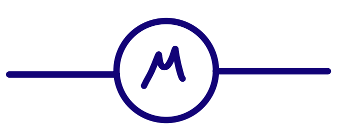
3. Draw the circuit symbol representing:
   a. An **LED**



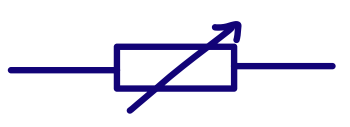
   b. A **heater**



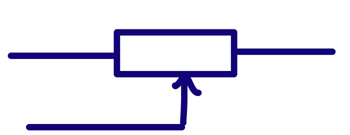
   c. A **motor**



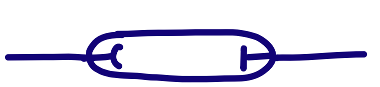
   d. A **variable resistor**



   e. A **potentiometer**



   f. A **vacuum photocell**



27th June

1 2 3

1. A resistor has 25 C of charge flow through it and a potential difference of 8.0 V across it. Calculate the **energy** transferred by the resistor.

$$E = QV = 25 \times 8.0 = 200\ J$$

2. Define:
   a. **Resistance**
   b. **Internal resistance**

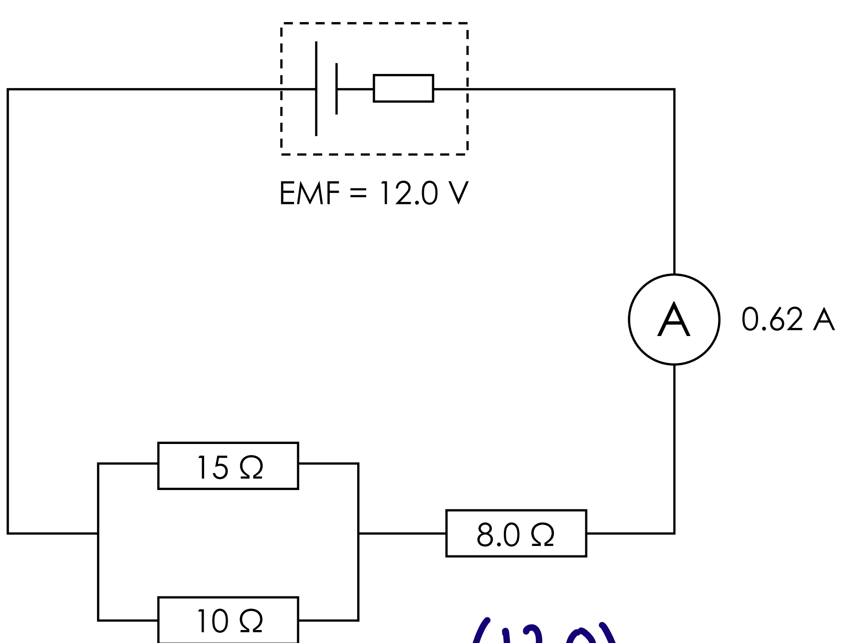
3. Calculate the **internal resistance** of the cell in the circuit below.

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

$$r = \frac{E}{I} - R_T$$

$$R_T = \left(\frac{150}{25}\right) + 8.0$$

$$R_T = 14\ \Omega$$

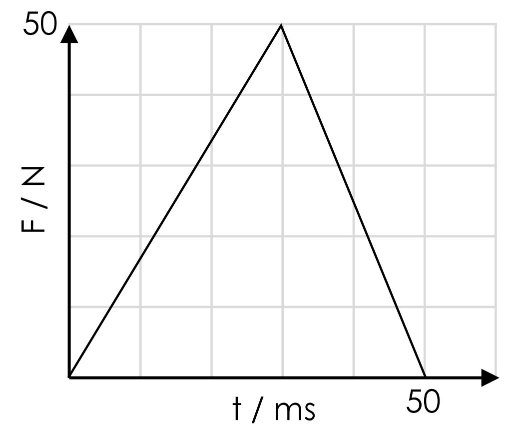


$$r = \left(\frac{12.0}{0.62}\right) - 14 = 5.4\ \Omega$$

28th June

1 2 3

1. A stationary tennis ball of mass 58 g is subjected to a force from a tennis racket as shown in the graph to the right. Calculate the **velocity** it would reach.



$I = \text{area} = \frac{1}{2} \times 50\times10^{-3} \times 50 = 1.25\ \text{Ns}$

$v = \frac{I}{m} = \frac{1.25}{0.058} = \underline{22}\ \text{ms}^{-1}$

2. A squash ball of mass 24 g travels normally towards a wall at 20 m s^{-1} and rebounds at 15 m s^{-1}. If the collision takes 20 ms, calculate the size of the **force** of the wall on the ball.

20 →

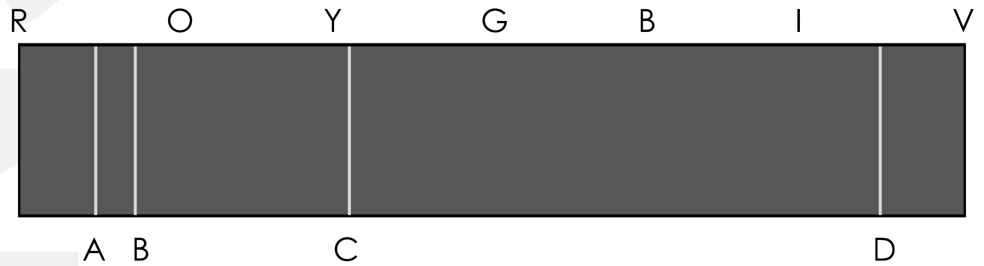
15 ←

$F = \frac{mv - mu}{t} = \frac{0.024\,(20 - (-)15)}{20\times10^{-3}}$

$F = \underline{42}\ \text{N}$

3. Below is the emission spectrum of an excited gas. The atom has electron energy levels at - 2.0 eV and - 4.2 eV.

Determine which **line** (A, B, C or D) corresponds to the photon emitted as the electron drops between these two levels.



$E = \frac{hc}{\lambda} \quad \lambda = \frac{hc}{E} = \frac{6.63\times10^{-34} \times 3.00\times10^{8}}{(4.2-2.0)\times1.60\times10^{-19}} = 5.7\times10^{-7}$

570 nm ∴ Yellow/Green ∴ $\underline{C}$

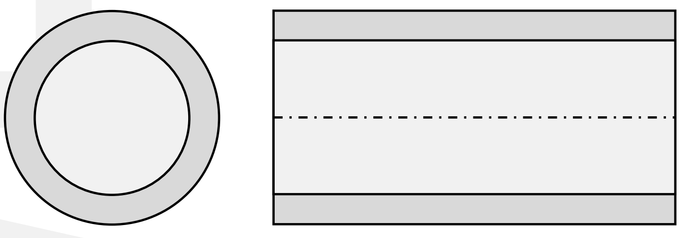
29th June

1. A spring in an arcade pinball machine has a spring constant of 25 N m^{-1}. It fires a 25 g pinball at 1.25 m s^{-1}. Calculate how **far** the spring was compressed before firing the ball.

$E_e = E_K$ $\quad \frac{1}{2}kx^2 = \frac{1}{2}mv^2$

$$x = \sqrt{\frac{mv^2}{k}} = \sqrt{\frac{0.025 \times 1.25^2}{25}} = \underline{0.040\,m}$$

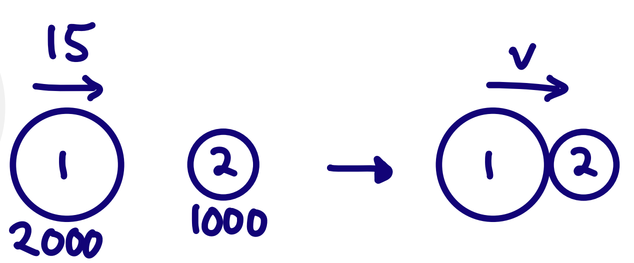
2. A step index optical fibre is made from two types of glass. Calculate the **critical angle** between the core and the outer layer.



Glass	n
Core	1.51
Outer	1.39

$n_1 \sin\theta_c = n_2 \sin\theta_2$ $\quad \theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{1.39}{1.51}\right) = \underline{67.0^\circ}$

3. A 2000 kg car moving at 15 m s^{-1} crashes into a stationary 1000 kg car. They stick together and move off at the same speed. Calculate the **change in KE** during the collision.



$$m_1u_1 + m_2u_2 = (m_1 + m_2)v$$

$$v = \frac{(2000 \times 15) + 0}{3000} = +10\,m s^{-1}$$

$$\Delta E_K = \frac{1}{2}m_1u_1^2 - \frac{1}{2}(m_1 + m_2)v^2$$

$$\Delta E_K = \left(\frac{1}{2} \times 2000 \times 15^2\right) - \left(\frac{1}{2} \times 3000 \times 10^2\right) = \underline{7.5 \times 10^4}\,J$$

30th June

1. Let's finish this month with some simple calculations:

   a. If a resultant force of 15 N acts on a mass of 3.0 kg, calculate the **acceleration**

   $F = ma \quad a = \frac{F}{m} = \frac{15}{3.0} = 5.0\ ms^{-2}$

   b. When a clockwise moment of 31 N m is due to a force of 6.0 N, calculate the **perpendicular distance** it is acting at

   $M = Fd \quad d = \frac{M}{F} = \frac{31}{6.0} = 5.2\ m$

   c. Calculate the **resistance** of a component that has a voltage of 2.0 V across it and a current of 0.15 A through it

   $V = IR \quad R = \frac{V}{I} = \frac{2.0}{0.15} = 13\ \Omega$

   d. Calculate the **spring constant** of a steel spring that extends by 6.8 cm when a 180 g mass is hung from it

   $F = ke$
   $F = mg \quad k = \frac{mg}{e} = \frac{0.180 \times 9.81}{0.068} = 26\ Nm^{-1}$

   e. Calculate the **final velocity** of an object that was initially travelling at 2.1 m s^{-1} before undergoing a uniform acceleration of 1.4 m s^{-2} for 3.8 s

   $v = u + at = 2.1 + (1.4 \times 3.8) = 7.4\ ms^{-1}$

   f. Calculate the **change in GPE** when a 152 g ball falls through a height of 2.4 m

   $E_p = mgh = 0.152 \times 9.81 \times 2.4 = 3.6\ J$

   g. Calculate the **time period** of a soundwave with a frequency of 1.8 kHz

   $T = \frac{1}{f} = \frac{1}{1800} = 5.6 \times 10^{-4}\ s$

   h. Calculate the **combined resistance** of 30 Ω, 40 Ω and 50 Ω resistors connected in parallel

   $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} = \frac{1}{30} + \frac{1}{40} + \frac{1}{50} \quad \therefore R_T = 13\ \Omega$

Compare how easy you found working through these answers to the ones you completed on the 1st March!

Hopefully they should seem easier now!