1st May

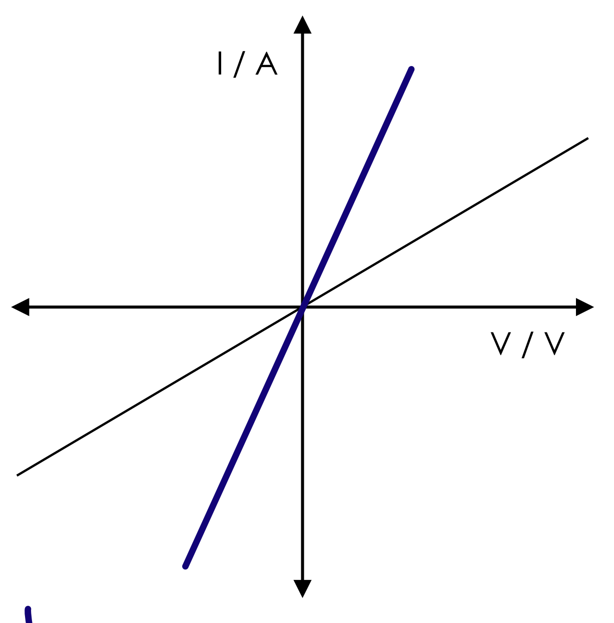
1. a. Name **three factors** that affect the **resistance** of a wire

L, A, ρ

b. A student has a long piece of metal wire, a battery, leads, a variable resistor, an ammeter and a voltmeter. **Draw** the **test circuit** needed to investigate the IV characteristics of the wire

See the diagram between 26th and 27th April

The student achieves the following results.



c. Explain the **significance** of the straight line

It has a constant resistance

d. Add a **second line** showing the expected results for a wire with twice the diameter

$2 \times d \therefore 4 \times A \therefore \frac{R}{4}$

e. Explain why the value for **current** should be kept **low** in this investigation

To reduce heating effects, which could change the resistance of the wire

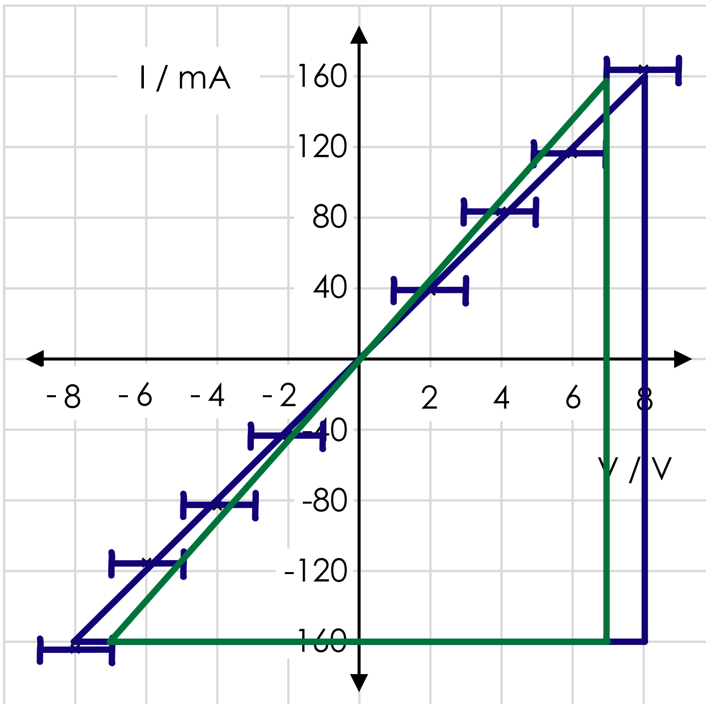
The resistance of a 75 cm length of wire with a diameter of 0.234 mm was measured as 19.2 Ω.

f. Calculate the **resistivity** of the metal used

$$\rho = \frac{RA}{L} = \frac{R\pi d^2}{4L} = \frac{19.2 \times \pi \times (0.234 \times 10^{-3})^2}{4 \times 0.75} = 1.1 \times 10^{-6}\ \Omega m$$

2nd May

1. Using a suitable test circuit, results are obtained for the current through, and potential difference across, an electrical component. These are shown on the axes below.



a. Add a **line of best fit** to the points and calculate the **gradient** of the line

$$\text{Gradient} = \frac{160\times10^{-3} - (-)160\times10^{-3}}{8.0-(-)8.0} = 2.0\times10^{-2}\ AV^{-1}$$

The current was measured to the nearest mA with an ammeter, but the voltmeter they used measured the voltage to the nearest volt.

b. Add **error bars** for the potential difference readings to your graph and use these to plot a **worst acceptable** line

c. Use this to calculate the **percentage uncertainty** in the gradient value

$$\text{Gradient}_{worst} = \frac{160\times10^{-3} - (-)160\times10^{-3}}{7.0-(-)7.0} = 2.3\times10^{-2}\ AV^{-1}$$

$$\%U = \left|\frac{2.0-2.3}{2.0}\right| \times 100 = 15\%$$

d. Without using the value for your gradient, calculate the **resistance** of the component and estimate the **uncertainty** in this value

$$R = \frac{V}{I} = \frac{8.0}{0.160} = 50\ \Omega \qquad 15\% \text{ of } 50\ \Omega = \pm 7.5\ \Omega$$

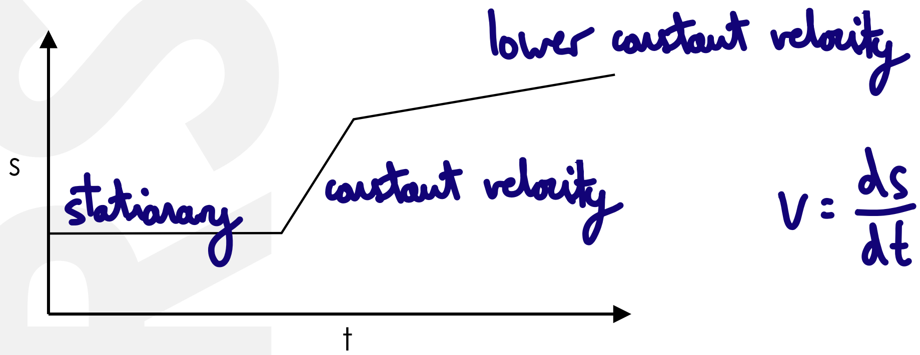
e. Explain how the data shown on the graph is related to **Ohm's law**

$V \propto I$ ∴ ohmic conductor

3rd May

1 2 3

1. Describe the **motion** of the object in the graph below:



2. A 1.2 tonne car accelerates from 0 to 60 mph (96.6 km h^{-1}) in 4.5 seconds. Calculate the minimum **energy** required to do this.

$$E_k = \frac{1}{2}mv^2 = 0.5 \times 1200 \times \left(\frac{96.6 \times 1000}{3600}\right)^2$$

Ignore the time

$$E_k = 4.3 \times 10^5 \text{ J}$$

3. The following values were recorded for a wire with a uniform cross-sectional area:

Quantity	Percentage Uncertainty / %
Diameter	2.8
Length	0.4
Potential Difference	0.9
Current	2.2

Calculate the **percentage uncertainty** in the calculated value of **resistivity**.

$$\rho = \frac{RA}{L} = \frac{V \pi d^2}{I \; 4L}$$

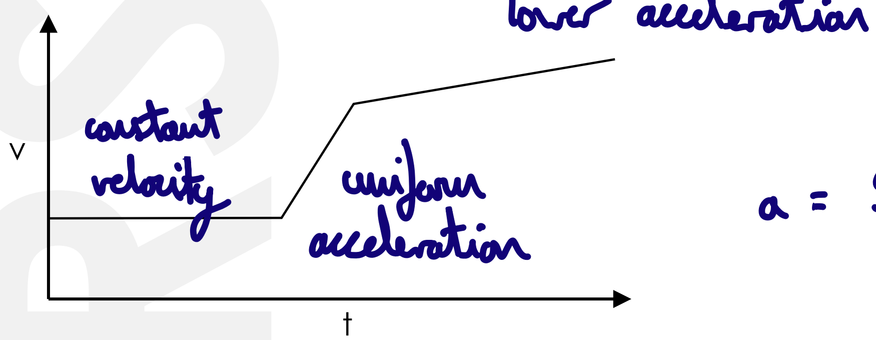
$$\%\rho = \%V + (2 \times \%d) + \%I + \%L$$

$$= 0.9 + (2 \times 2.8) + 2.2 + 0.4 = 9.1\%$$

4th May

1 2 3

1. Describe the **motion** of the object in the graph below.



$a = \frac{dv}{dt}$

2. Define:

   a. Electric **current**

   b. **Potential difference**

3. A 2000 kg rocket starts at rest and accelerates from the ground at 0.400 m s^{-2} for the first 5.00 s of its launch.

   Calculate its **height** after 5.00 s and the **thrust** of the rocket required for this acceleration:

   Values of g: Earth 9.81 N kg^{-1} and Moon 1.60 N kg^{-1}

   a. On the **Earth**

      i. Height 5.00 m

      ii. Force 2.04×10^4 N

   b. On the **Moon**

      i. Height 5.00 m

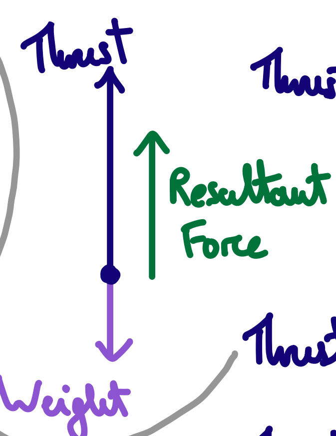
      ii. Force 4.00×10^3 N

$s = h$
$u = 0\ ms^{-1}$
v
$a = 0.400\ ms^{-2}$
$t = 5.00$

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

$h = \frac{1}{2} \times 0.400 \times 5.00^2$

$h = 5.00$ m



Thrust − Weight = Resultant Force

Thrust − $mg = ma$

Thrust = $m(g + a)$

Thrust = $2000 \times (9.81 + 0.400)$

Thrust = $2000 \times (1.60 + 0.400)$

5th May

1 2 3

1. A car accelerates to a final velocity of 70 mph in half a minute. It accelerates at a rate of 0.78 m s^{-2}. Calculate its **initial velocity** in m s^{-1}.

1 mile = 1609 m

s
u = ?
v = 70 mph
a = 0.78 m s^{-2}
t = 30 s

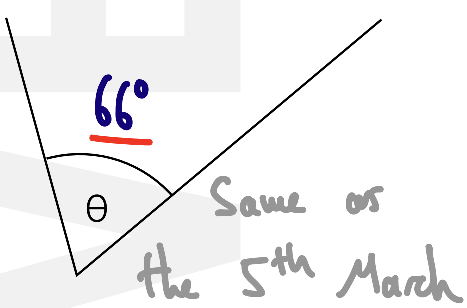
$v = u + at$

$u = v - at$

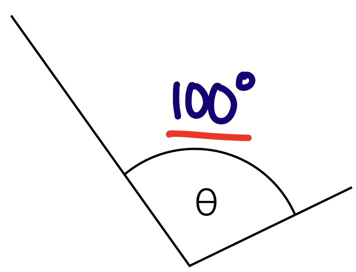
$u = \left(\frac{70 \times 1609}{3600}\right) - 0.78 \times 30 = 7.9 \text{ m s}^{-1}$

2. Measure these angles:

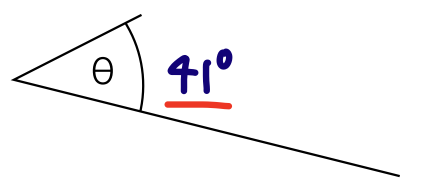
a.



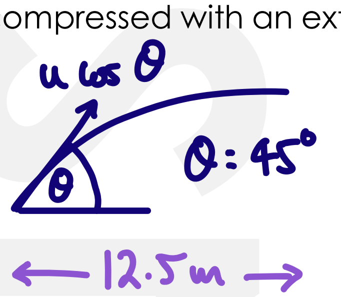
b.



c.



3. A human cannon ball, who has a mass of 75 kg, uses a spring powered cannon to launch themselves at an angle of 45° so that they travel a horizontal distance of 25 m. Assuming the launch is 100 % efficient, calculate the **spring constant** needed if the spring is fully compressed with an extension of 0.80 m.



→ $s_h = u \cos\theta . t$

$t = \frac{12.5}{u \cos 45}$

↑ s
u = u cos 45
v = 0
a = −9.81
t = t

$v = u + at$

$0 = u \cos 45 - 9.81 \times \frac{12.5}{u \cos 45}$

$u \cos 45 = \sqrt{9.81 \times 12.5}$

$u = 15.660 \text{ m s}^{-1}$

$E_K = E_e$

$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$

$k = \frac{mv^2}{x^2} = \frac{75 \times 15.660^2}{0.80^2} = 28\,740$

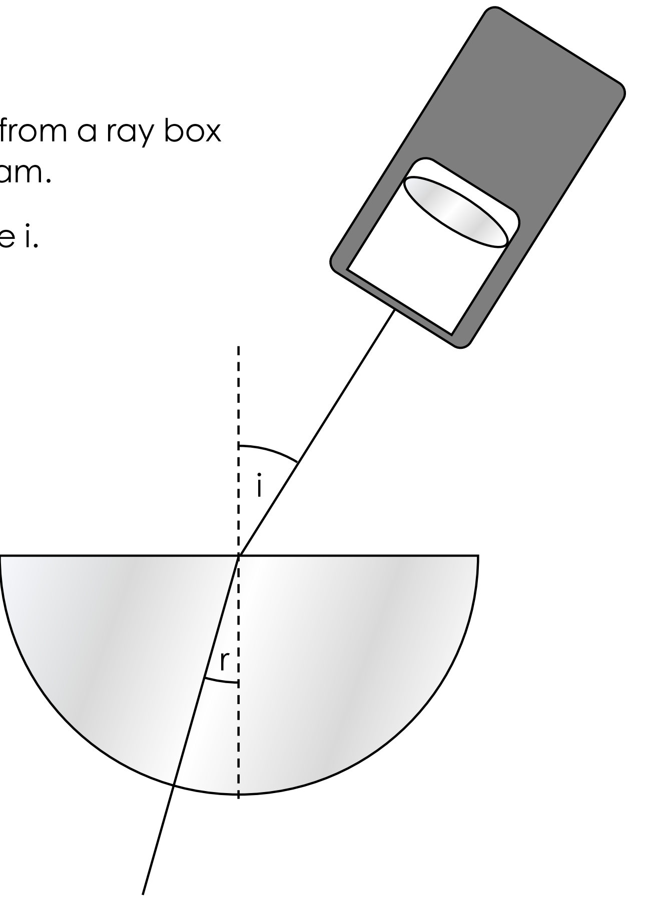
$= 2.9 \times 10^4 \text{ N m}^{-1}$

6th May

1. A transparent semicircular Perspex® block has light from a ray box directed towards the centre, as shown in the diagram.

   Values of angle r are recorded for a range of angle i.

i / °	r / °	sin i / sin r
15	10	1.49
30	19	1.54
45	29	1.46
60	35	1.51
75	40	1.50



a. Complete the last **column** of the table to 3 s.f.

b. Calculate a mean value, to 3 s.f., for the **refractive index** of Perspex® and the **absolute uncertainty** in this value

1.50 $\quad \left(\frac{1.54-1.46}{2}\right) = \pm 0.04$

The Perspex® block is replaced by a crown glass block with a refractive index of 1.52.

c. Calculate the **difference** in the angles of refraction for an angle of incidence of 75°

$n = \frac{\sin i}{\sin r} \quad r = \sin^{-1}\left(\frac{\sin i}{n}\right) = \sin^{-1}\left(\frac{\sin 75}{1.52}\right) = 39.5°$

$40 - 39.5 = 0.5°$

d. Explain whether this difference could be **measured** using a standard school protractor

No, this is less than the resolution of a protractor (1°)

7th May

1 2

1. Write the following purely in their **base units** and their more commonly used **unit**:

a. $N\,m^{-2}$ — $kg\,m^{-1}\,s^{-2}$ — Pa

b. $J\,s^{-1}$ — $kg\,m^{2}\,s^{-3}$ — W

c. $J\,C^{-1}$ — $kg\,m^{2}\,s^{-3}\,A^{-1}$ — V

d. $V\,A^{-1}$ — $kg\,m^{2}\,s^{-3}\,A^{-2}$ — Ω

2. **Complete** the following table:

	Constant	Symbol	Value	Unit
a.	Speed of light	c	3.00×10^{8}	$m\,s^{-1}$
b.	Planck constant	h	6.63×10^{-34}	$J\,s$
c.	Gravitational field strength*	g	9.81	$N\,kg^{-1}$
d.	Mass† of an electron	m_e	9.11×10^{-31}	kg
e.	Mass† of a proton	m_p	1.673×10^{-27}	kg
f.	Mass† of a neutron	m_n	1.675×10^{-27}	kg
g.	Elementary charge	e	1.60×10^{-19}	C
h.	Charge on an electron	e	-1.60×10^{-19}	C

* On the surface of the Earth

† Rest mass

8th May

1 2 3

1. On the 8th May at 5.00 pm, the intensity of light from the Sun at ground level is measured as 900 W m^{-2}. If the sunlight is incident on solar panels that are 20 % efficient, calculate the **area** of solar panels needed to power a 2.0 kW kettle.

$$\frac{2000}{900} = 2.22 \text{ m}^2 \qquad \frac{2.22}{0.20} = 11.11 = 11 \text{ m}^2$$

2. Define:

   a. **Work function**

   b. **Threshold frequency**

3. The work function for zinc is 3.74 eV. Calculate the:

   a. **Work function** in **joules**

$$3.74 \times 1.60 \times 10^{-19} = 5.98 \times 10^{-19} \text{ J}$$

   b. The **threshold frequency**

$$\phi = h f_0 \qquad f_0 = \frac{\phi}{h} = \frac{5.984 \times 10^{-19}}{6.63 \times 10^{-34}} = 9.03 \times 10^{14} \text{ Hz}$$

   c. The **maximum wavelength** of incident photons for which photoelectrons can be emitted

$$\lambda = \frac{c}{f_0} = \frac{3.00 \times 10^{8}}{9.03 \times 10^{14}} = 3.32 \times 10^{-7} \text{ m}$$

9th May

1 2

1. A student has a gold leaf electroscope which they plan to charge by induction using a positively charged Perspex® rod.

   a. Briefly describe how this process can produce a **charged electroscope**

   See the back of the book for the answers today, or watch the video where I explain this.

   b. A negatively charged electroscope with a clean zinc top plate can be discharged with ultraviolet light of wavelength 0.25 μm, if they increase the intensity of the UV arriving explain how will this affect the **energy** and **number** of photoelectrons emitted each second

2. The threshold frequency for a negatively charged electroscope corresponds to green light. A student initially shines red light at the electroscope.

   a. Explain if it will **discharge**

   The student then shines a variable light source at the electroscope, starting with blue light then increasing the frequency.

   b. Describe how will this **affect** the photoelectrons emitted

10th May

1 2 3

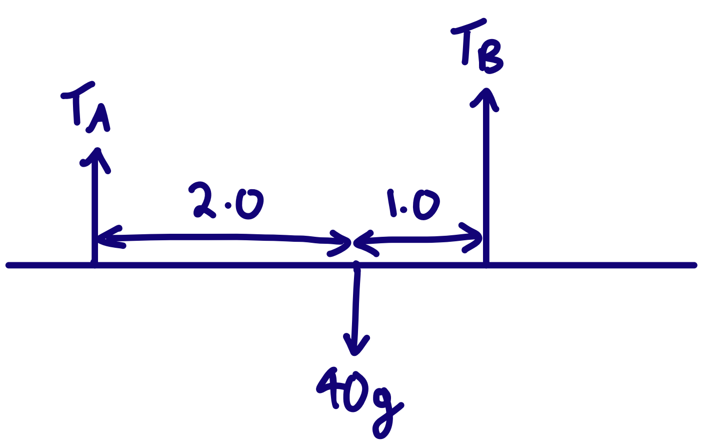
1. Write the **unit** more commonly used for these quantities expressed in their base units:
   a. kg m s^{-2} N
   b. kg m^2 s^{-2} J
   c. kg m^2 s^{-3} W

2. Define:
   a. **Potential difference**

   b. **Electromotive force**

3. A uniform beam of length 5.0 m and mass 40 kg hangs on two wires A and B. Wire A is 2.0 m from the centre and wire B is 1.0 m from the centre of the beam.

   Calculate the **tension** in each wire.



$\overset{\curvearrowright}{M} = \overset{\curvearrowleft}{M}$

About A. $(40 \times 9.81 \times 2.0) = T_B \times 3.0$ $T_B = 261.6 = 260\ N$

$F\uparrow = F\downarrow$ $T_A + T_B = 40g$ $T_A = (40 \times 9.81) - 261.6$

$T_A = 130.8 = 130\ N$

11th May

1. A student is investigating the current-voltage characteristic of a filament bulb.

PD / V	0.0	2.0	4.0	6.0	8.0	10.0
Current / A	0.00	0.60	1.05	1.40	1.65	1.85

a. Use the data in the table to calculate the **resistance** when the PD is:

i. 4.0 V

ii. 8.0 V

iii. 10.0 V

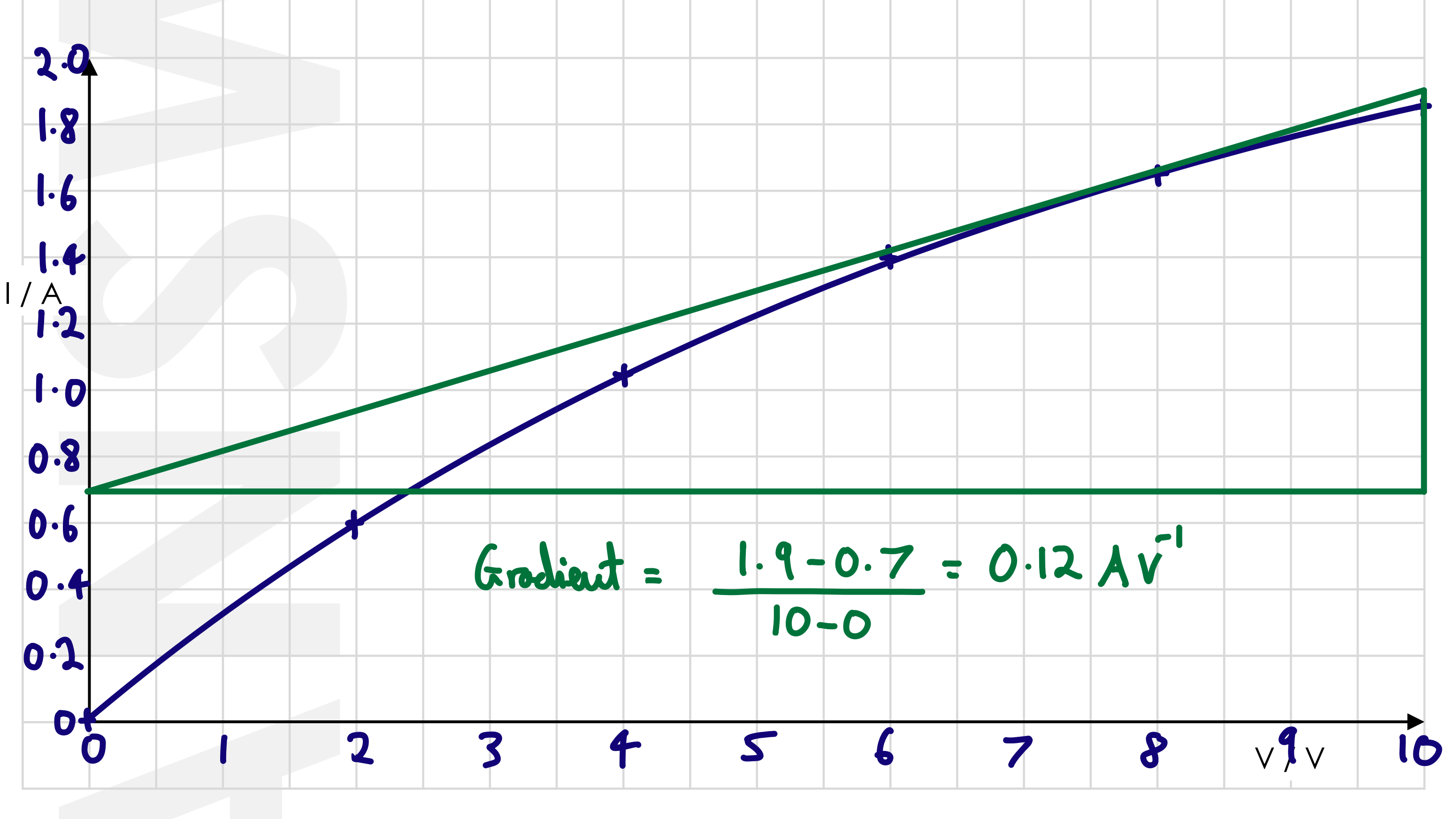
$R = \frac{V}{I}$

i. $= 4.0/1.05 = 3.8\ \Omega$

ii. $= 6.0/1.40 = 4.8\ \Omega$

iii. $= 10.0/1.85 = 5.4\ \Omega$

b. **Plot** the results in the table on the axes provided.



c. Calculate **1/gradient** of the line at 8.0 V and **compare** this to the value of a. part ii.

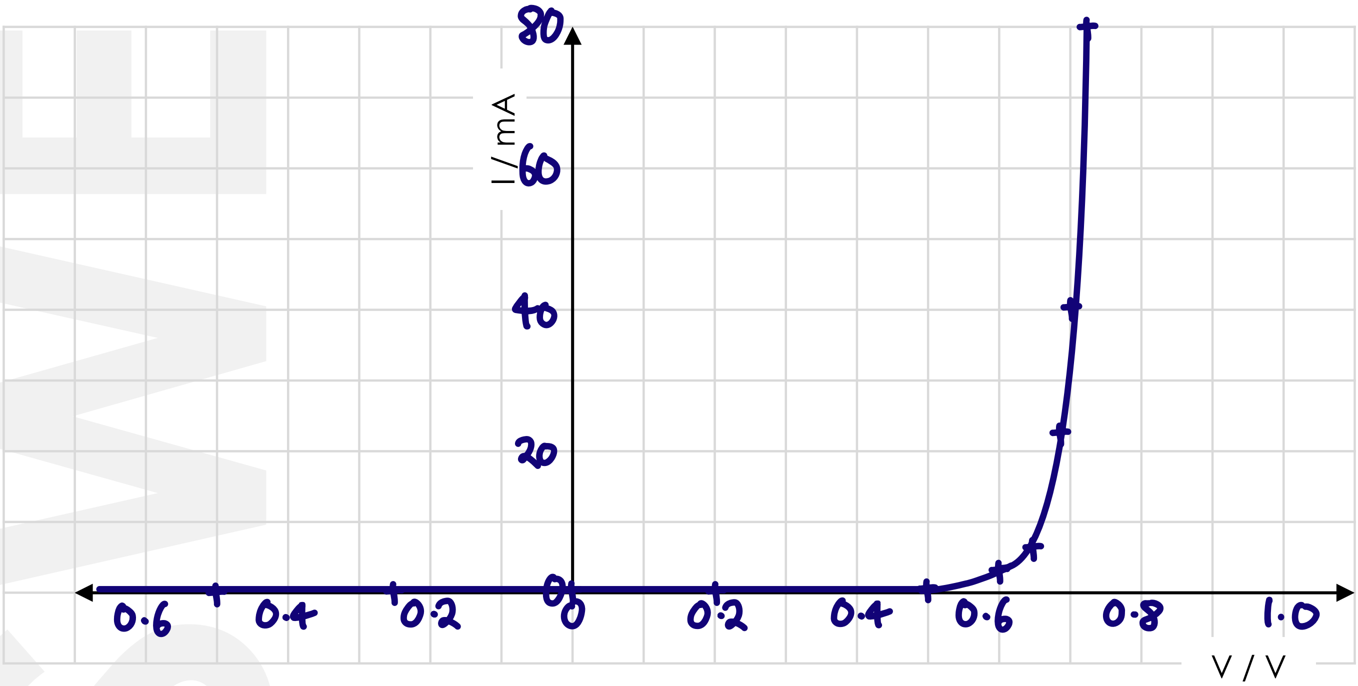
$\frac{1}{\text{Gradient}} = \frac{1}{0.12} = 8.3\ VA^{-1}$ (compared to 4.8) $\therefore \frac{1}{\text{Gradient}} \neq R$

12th May

1. A diode is connected in series with an ammeter, a resistor, and a variable power supply. A voltmeter is connected in parallel with the diode. The PD across the diode, V, is varied, including changing the polarity, and the current, I, is recorded for each value.

PD / V	-0.50	-0.25	0.00	0.20	0.50	0.60	0.64	0.68	0.70	0.72
Current / mA	0.0	0.0	0.0	0.0	1.0	3.0	6.0	22	40	80.0

a. **Plot** the data

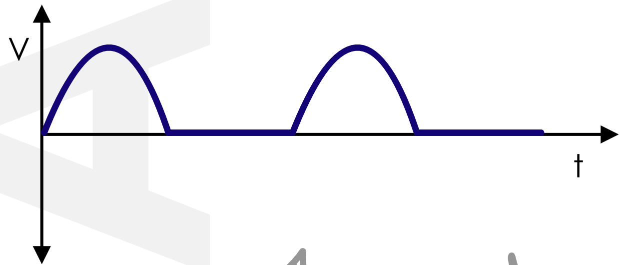


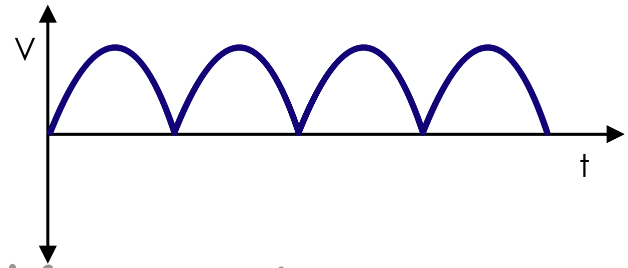
b. Calculate the **resistance** of the diode at:

i. 0.60 V $R = V/I = 0.60/3.0\times10^{-3} = 200\ \Omega$

ii. 0.70 V $R = V/I = 0.70/40\times10^{-3} = 18\ \Omega$

c. Research how a diode can be used in **half-wave** and **full-wave** rectification for an AC supply and sketch a graph of PD against time for these two uses





These convert an AC supply to DC

13th May

1 2 3

1. The power output from a wind turbine is proportional to the wind speed cubed. If the power output is 2.0 MW when the wind speed is 8.0 m s^{-1}, calculate the **wind speed** needed for a power output of 5.2 MW.

$P \propto v^3 \quad \frac{P_1}{v_1^3} = \frac{P_2}{v_2^3} \quad v_2 = \sqrt[3]{\frac{P_2}{P_1} \cdot v_1^3} = \sqrt[3]{\frac{5.2}{2.0} \cdot 8.0^3} = 11 \text{ ms}^{-1}$

2. The following values were recorded:

Quantity	Value	Uncertainty	% U
Potential Difference / V	1.5	± 0.1	6.7%
Current / A	0.79	± 0.01	1.3%

Calculate the **resistance**, including its **uncertainty**.

$R = V/I = 1.5/0.79 = 1.9\ \Omega$ $\quad \%R = \%V + \%I = 6.7 + 1.3 = 8.0\%$

8.0% of $1.9 = \pm 0.15\ \Omega$

3. The following values were recorded in a double slit experiment:

Quantity	Percentage Uncertainty / %
Distance to screen	0.2
Fringe spacing	4.7
Slit separation	2.6

Calculate the **percentage uncertainty** in the calculated value of **wavelength**.

$w = \frac{\lambda D}{s} \quad \lambda = \frac{ws}{D}$

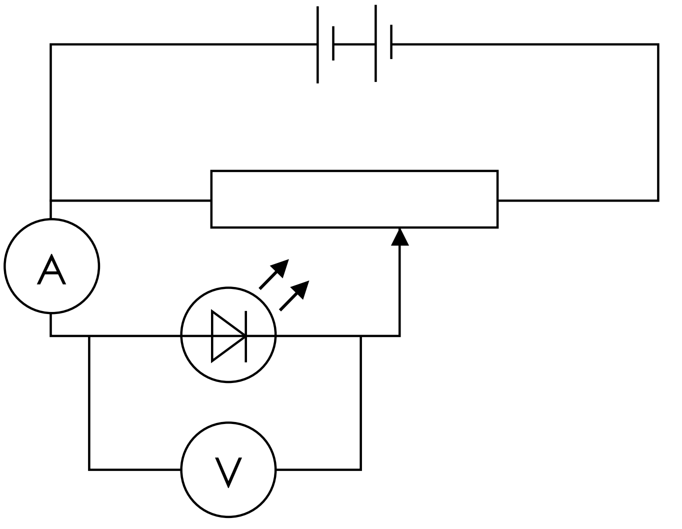
$\%\lambda = \%D + \%w + \%s$

$= 0.2 + 4.7 + 2.6$

$= 7.5\%$

14th May

1. A circuit is constructed where a variable potential difference is applied across a light emitting diode (LED). When the PD equals the activation voltage, V_A , the LED lights up. As each electron moves through the diode, a photon is emitted, and the work done on each electron by the PD determines the photon energy $E = hf = hc/\lambda$.



a. Calculate how much **energy**, in eV and J, an electron would gain passing through a PD of $V_A = 2.30$ V

i. eV $2.30 eV$

ii. J $2.30 \times 1.60 \times 10^{-19} = 3.68 \times 10^{-19}$ J

Different colour LEDs of known wavelength are used in the circuit and the activation PD measured.

Colour	λ / nm	V_A / V	Planck constant / x 10^{-34} J s
Violet	415	3.00	6.64
Blue	465	2.60	6.45
Green	550	2.26	6.63
Yellow	600	2.33	7.46 *
Red	650	1.92	6.66

*Anomaly

b. Using the equation $eV_A = hc/\lambda$, calculate a value for **Planck constant**, h, for each colour

c. Ignoring the anomaly, calculate a **mean** value for h, including its **uncertainty**

Mean $= 6.60 \times 10^{-34}$ Js

$\frac{6.66 - 6.45}{2} = \pm 0.11$

$= \pm 0.11 \times 10^{-34}$ Js

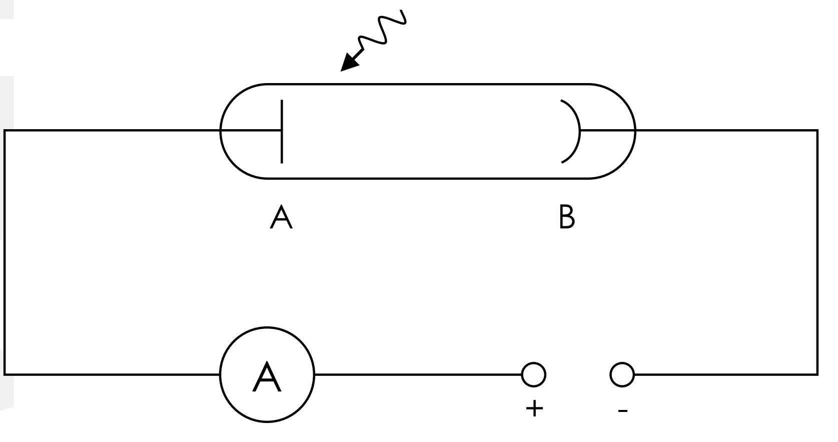
d. Using the accepted value for 'h', calculate the expected **activation PD** you would expect for the yellow LED

$V_A = \frac{hc}{e\lambda} = \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{1.60 \times 10^{-19} \times 600 \times 10^{-9}} = 2.07$ V

15th May – Part 1

1. A vacuum photocell can be used to investigate the photoelectric effect. EM waves above the threshold frequency are shone onto a metal surface at A and photoelectrons are emitted. These travel across to a collector plate at B.

   A PD is applied across A and B, with B negative with respect to A. As this PD is gradually increased from zero, then at a value V_s (called the stopping voltage) the current recorded on the ammeter decreases to zero. This happens when the PD is large enough that the electrical work done in stopping an electron is equal to KE_{max}. This is equal to the charge on an electron multiplied by V_s between A and B ($KE_{max} = eV_s$).



   The frequency, f, of the EM waves is changed and the stopping voltage, V_s, recorded.

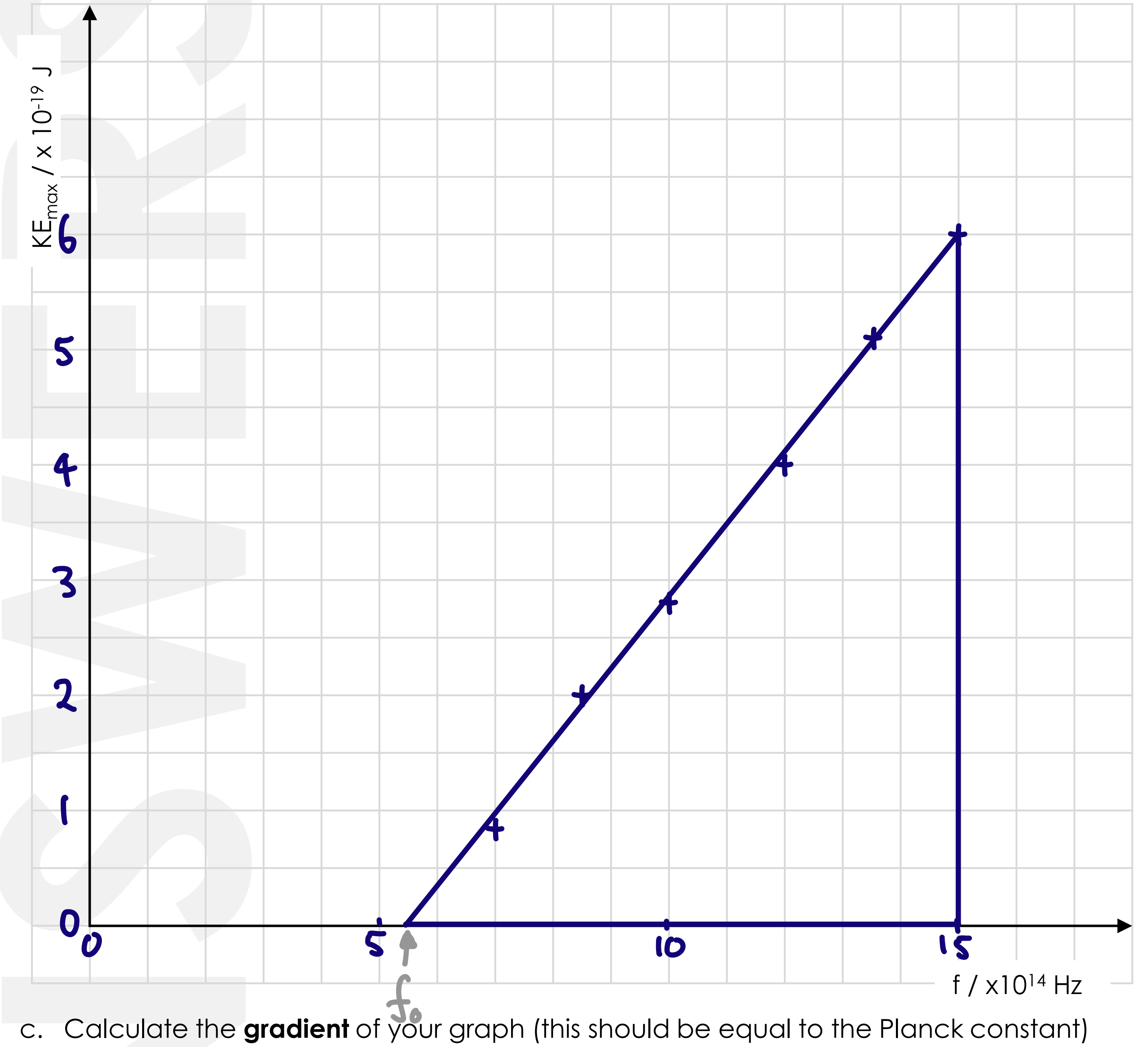
   a. Complete values for the **maximum kinetic energy** KE_{max} in the table below

f / x 10^{14} Hz	V_s / V	KE_{max} / x 10^{-19} J
7.0	0.53	0.85
8.5	1.25	2.00
10.0	1.75	2.80
12.0	2.50	4.00
13.5	3.19	5.10
15.0	3.75	6.00

15th May – Part 2

1

1. b. Use values from your table to **plot** a graph showing maximum kinetic energy, KE_{max}, against frequency, f



c. Calculate the **gradient** of your graph (this should be equal to the Planck constant)

$$\text{Gradient} = \frac{6.0\times10^{-19}}{(15-5.5)\times10^{14}} = 6.3\times10^{-34}\ \text{Js}$$

d. Use the intercept on the frequency axis (x-axis) to calculate the **work function** for the metal used for plate A in **electronvolts**

$f_0 = 5.5\times10^{14}$ Hz

$\phi = hf_0$

$\phi = 6.63\times10^{-34}\times 5.5\times10^{14}$

$\phi = 3.6465\times10^{-19}$ J

$\therefore\ \phi = 2.3$ eV

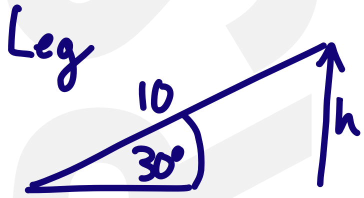
16th May

1 2 3

1. A student with mass 60 kg runs up a ramp 10 m long at 30° to the horizontal in 6.0 s. They then do 4 pull-ups, raising their body 0.50 m each time, in a total time of 10 seconds.

   Calculate the **ratio** of their leg power to arm power.

Leg



$h = 10 \times \sin 30 = 5.0\,m$

$P_{Leg} = \frac{mgh}{t} = \frac{60 \times 9.81 \times 5.0}{6.0}$

$P_{Leg} = 490.5\,W$

Arm

$P_{Arm} = \frac{4 \times 60 \times 9.81 \times 0.50}{10}$

$P_{Arm} = 117.72$

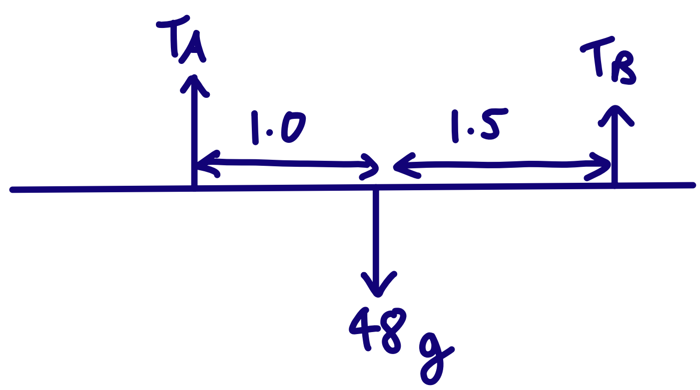
$\therefore$ 4.2 x

2. The EMF of a battery is 6.0 V. When the battery provides a current of 1.4 A, its terminal PD drops to 4.1 V. Calculate the **internal resistance** of the battery.

$E = V + Ir \qquad r = \frac{E - V}{I} = \frac{6.0 - 4.1}{1.4} = 1.4\,\Omega$

3. A uniform beam of length 4.0 m and mass 48 kg hangs on two wires A and B. Wire A is 1.0 m from the centre and wire B is 1.5 m from the centre.

   Calculate the **tension** in each wire.



$\overset{\curvearrowright}{M} = \overset{\curvearrowleft}{M}$

About A $\qquad 48 \times 9.81 \times 1.0 = T_B \times 2.5 \qquad T_B = 188.352$

$T_B = 190\,N$

$F\uparrow = F\downarrow \qquad T_A + T_B = 48g \qquad T_A = (48 \times 9.81) - 188.352$

$T_A = 280\,N$

17th May

1 2 3

1. A magnesium atom has 12 protons, 12 electrons and 12 neutrons. Assuming the mass of the nucleus is equal to the sum of the masses of the individual protons and neutrons, calculate the specific charge for:

    a. The **atom**

    $Q = 0 \quad \therefore \quad 0 \ C\,kg^{-1}$

    b. The **nucleus**

    $$\frac{12 \times 1.60 \times 10^{-19}}{(12 \times 1.673 \times 10^{-27}) + (12 \times 1.675 \times 10^{-27})} = 4.78 \times 10^{7} \ C\,kg^{-1}$$

    c. An **Mg^{2+} ion**

    $$\frac{2 \times 1.60 \times 10^{-19}}{(10 \times 9.11 \times 10^{-31}) + (12 \times 1.673 \times 10^{-27}) + (12 \times 1.675 \times 10^{-27})} = 7.96 \times 10^{6} \ C\,kg^{-1}$$

2. Define:

    a. A **photoelectron**

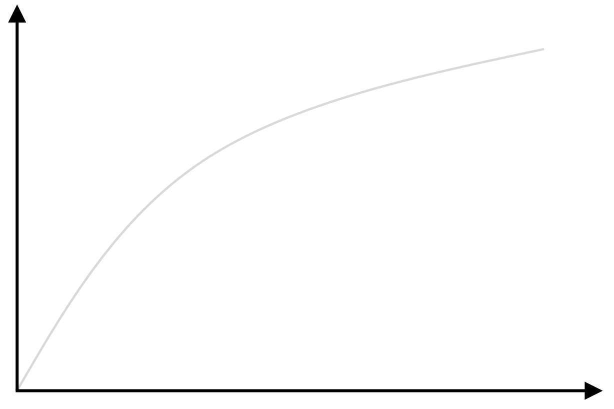
    b. A **photon**

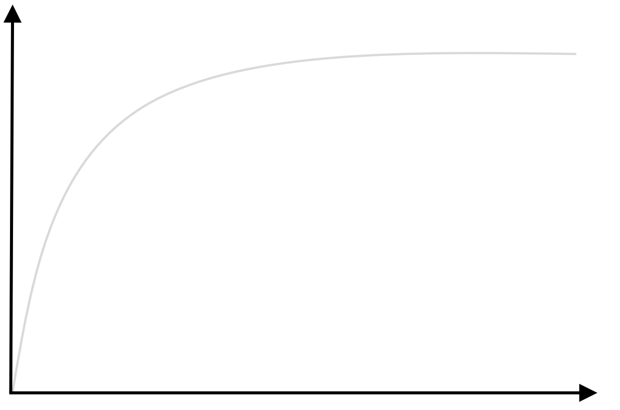
3. Explain why the **resistance** of a filament lamp **increases** with **current**.

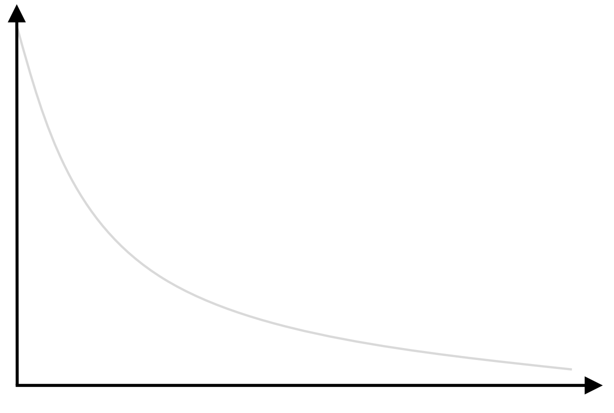
18th May – Part 1

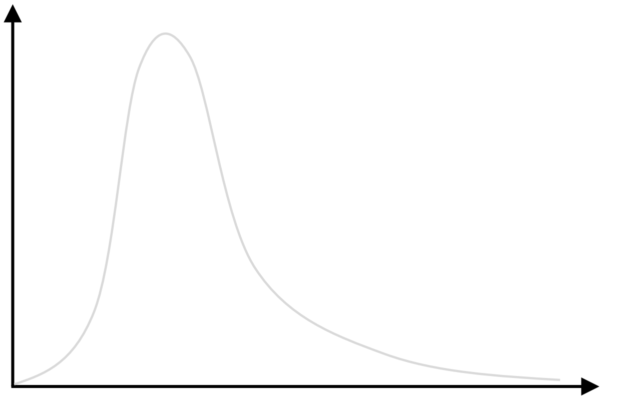
1

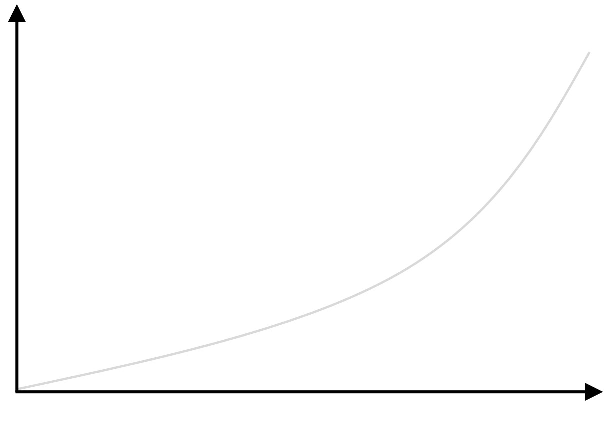
1. Trace the following **curves**.

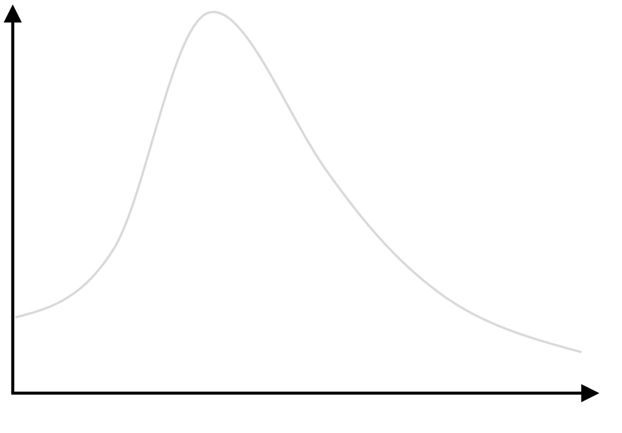






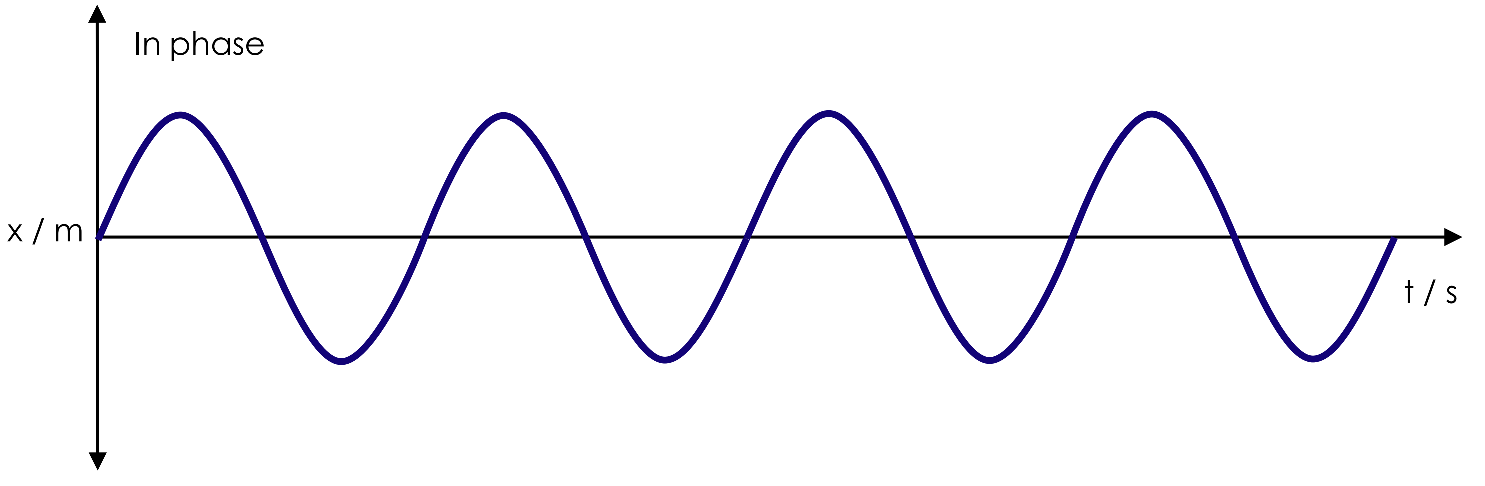


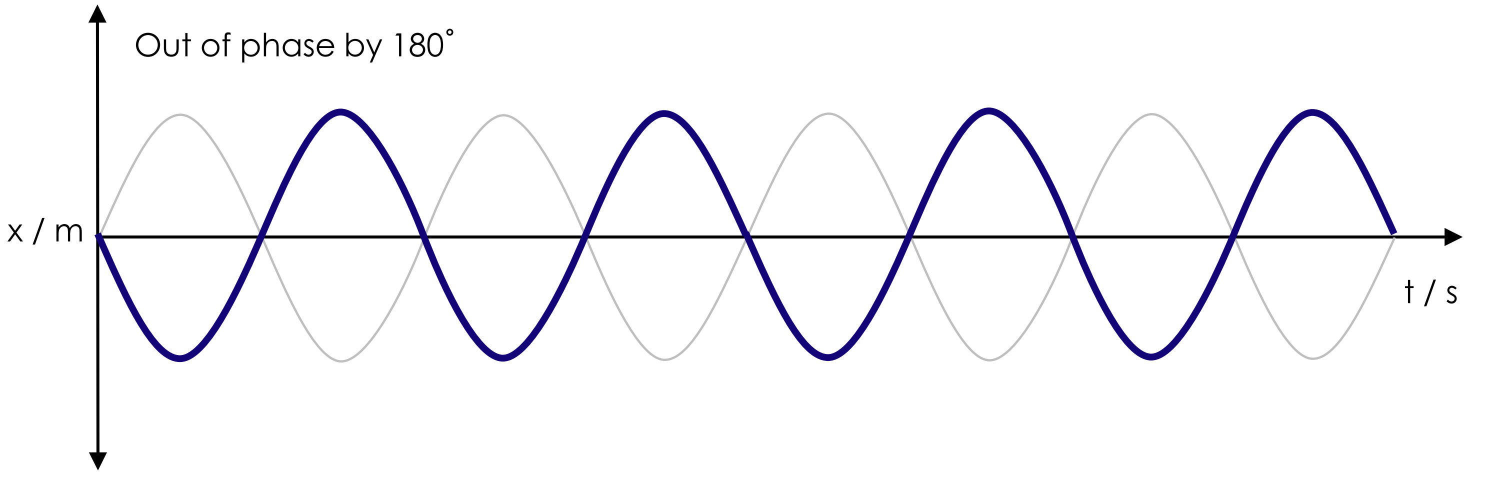


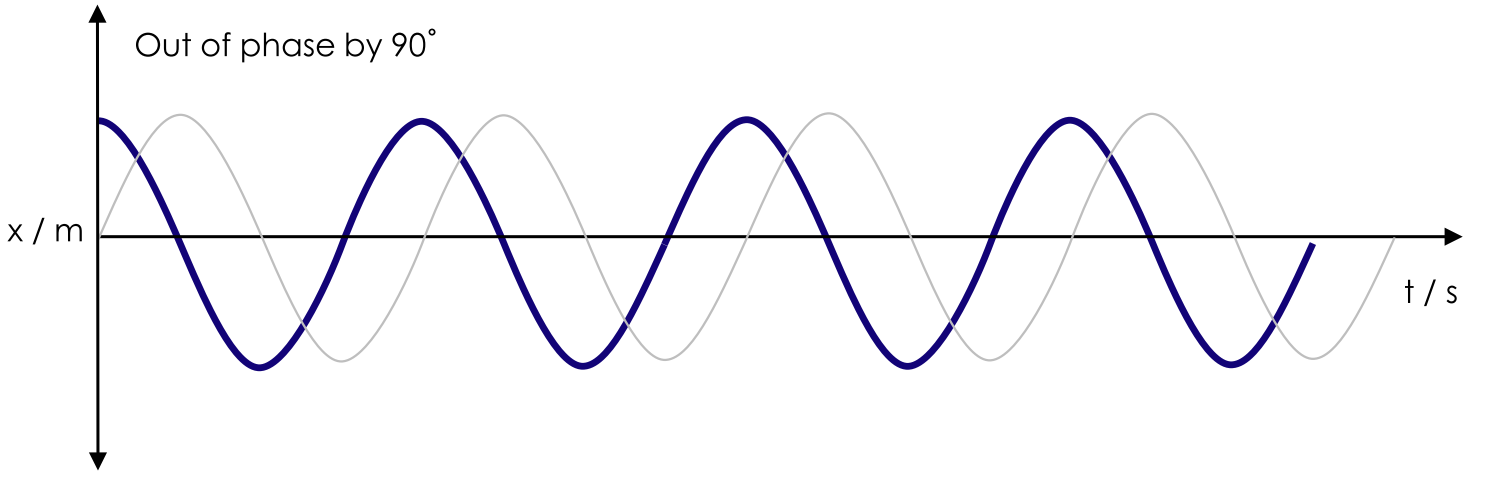


18th May – Part 2

2. Add a second **sinusoidal** curve for the following displacement-time graphs for a wave:







19th May

1 2 3

1. Calculate the **energy** of a gamma ray photon with wavelength 2.00 pm in:

   a. J

   $E = hf = \frac{hc}{\lambda} = \frac{6.63\times10^{-34} \times 3.00\times10^{8}}{2.00\times10^{-12}} = 9.95\times10^{-14}\ J$

   b. eV

   $9.95\times10^{-14} \div 1.60\times10^{-19} = 6.22\times10^{5}\ eV$

2. An alpha particle has a mass of 6.65 x 10^{-27} kg and kinetic energy of 5.0 MeV. Calculate:

   a. Its **speed** in m s^{-1}

   $E_k = \frac{1}{2}mv^2 \quad v = \sqrt{\frac{2E_k}{m}} = \sqrt{\frac{2\times5.0\times10^{6}\times1.60\times10^{-19}}{6.65\times10^{-27}}} = 1.6\times10^{7}\ ms^{-1}$

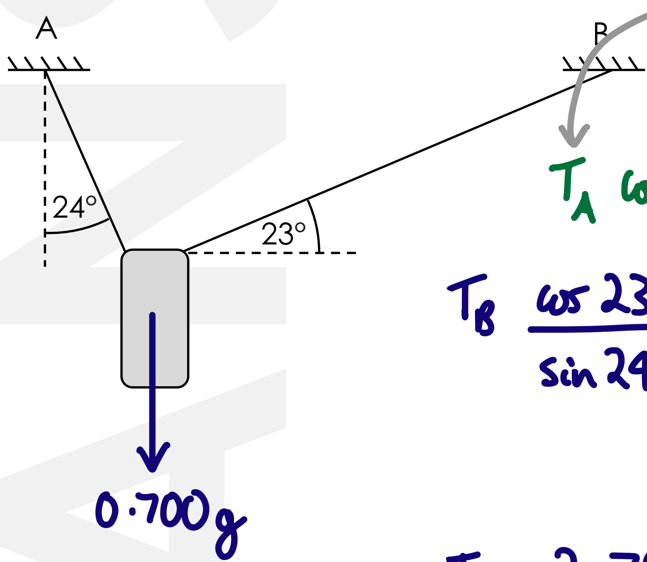
   b. Its speed as a **percentage** of light speed

   $\frac{v}{c}\times100 = \frac{1.55\times10^{7}}{3.00\times10^{8}}\times100 = 5.2\%$

3. A 700 g mass is suspended from two fixed wires as shown below.

   Calculate the **tension** in each wire.

$\Sigma F_{\rightarrow} = 0 \qquad T_A \sin 24 = T_B \cos 23 \qquad T_A = T_B \frac{\cos 23}{\sin 24}$



$\Sigma F_{\uparrow} = 0$

$T_A \cos 24 + T_B \sin 23 = 0.700\times9.81$

$T_B \frac{\cos 23}{\sin 24}.\cos 24 + T_B \sin 23 = 0.700\times9.81$

$T_B = 2.8N$

$T_A = 2.7935.\frac{\cos 23}{\sin 24} = 6.3\ N$

20th May

1 2 3

1. Calculate the **wavelength** of a photon with an energy of 780 meV and state the **type** of EM wave this is.

$E = \frac{hc}{\lambda}$ $\lambda = \frac{hc}{E} = \frac{6.63\times10^{-34} \times 3.00\times10^{8}}{780\times10^{-3}\times1.60\times10^{-19}} = 1.59\times10^{-6}$

Infrared

2. Define:

   a. **Interference**

   b. The principle of **superposition**

3. a. State the **mass** of an electron

   9.11×10^{-31} kg

   b. Using $E = mc^2$, calculate the **minimum energy** needed to produce an electron-positron pair

   $E = mc^2 = 2\times9.11\times10^{-31}\times(3.00\times10^{8})^2 = 1.64\times10^{-13}$ J

   c. Calculate the **minimum frequency** of the photon required for this

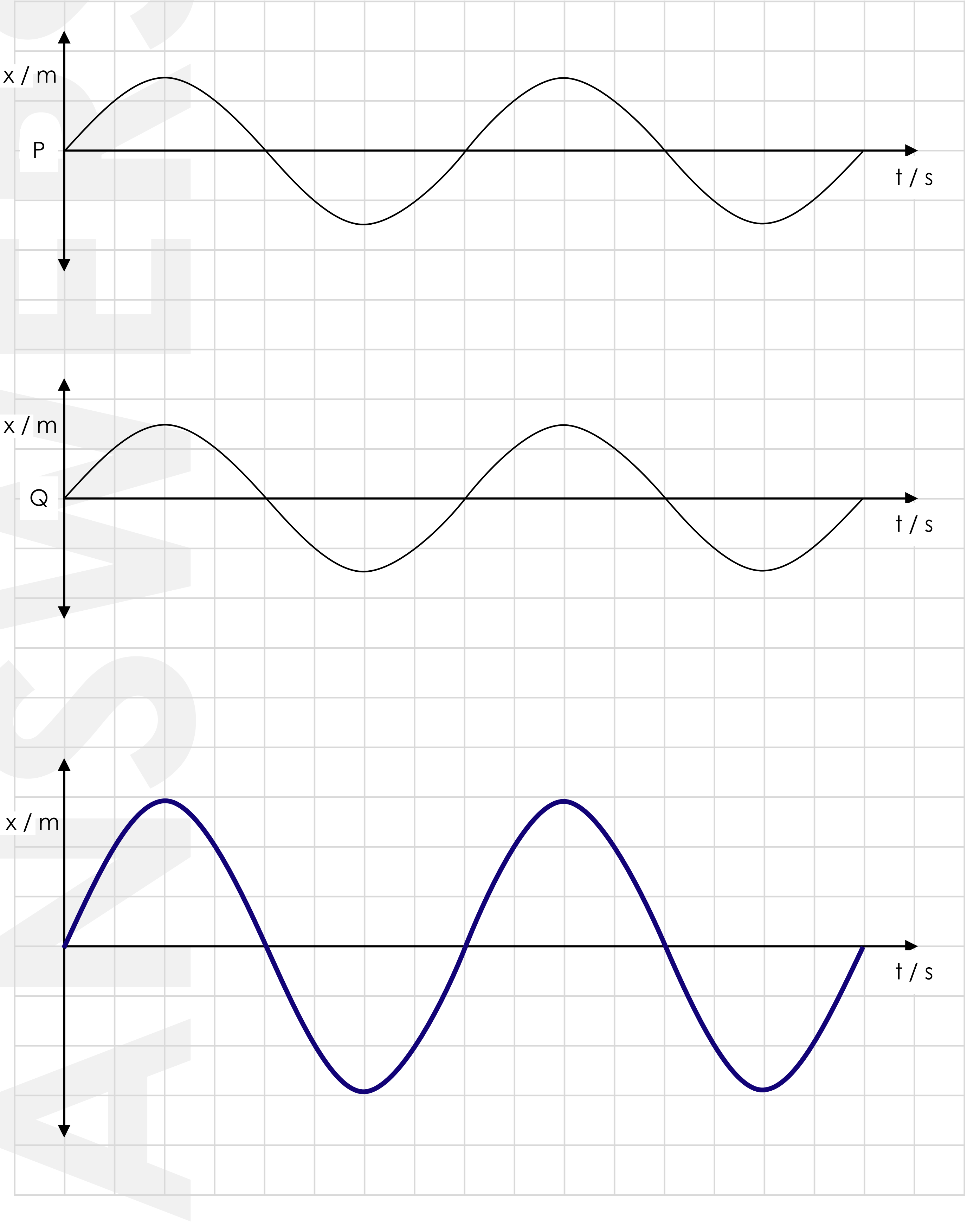
   $E = hf$ $f = \frac{E}{h} = \frac{1.6398\times10^{-13}}{6.63\times10^{-34}} = 2.47\times10^{20}$ Hz

   d. Explain why electron-positron pairs are the most **commonly produced** particles in pair production

   Electrons are the lowest mass fundamental particles so require the least energy to create.

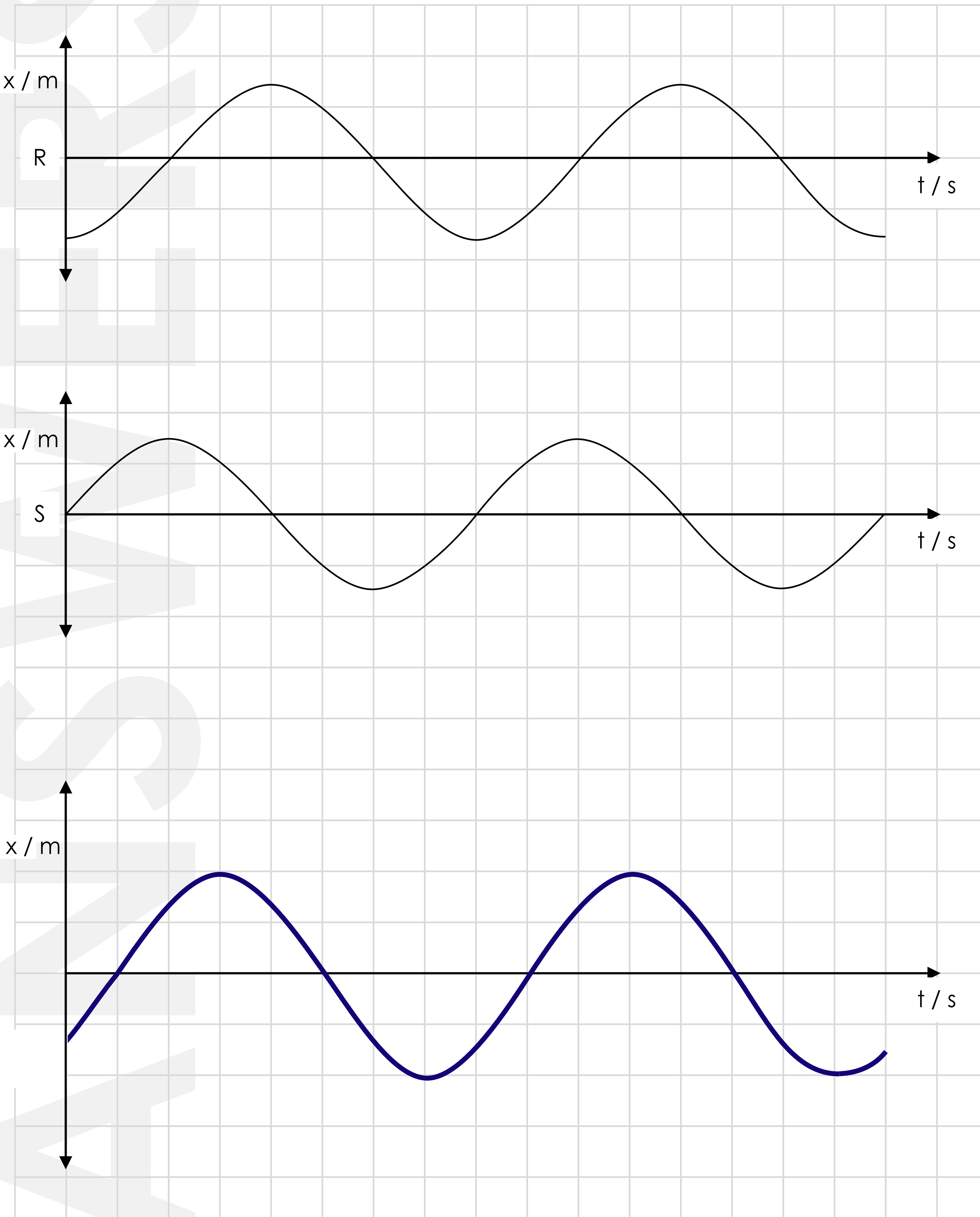
21st May – Part 1

1. Two coherent waves P and Q are in phase. They interfere and superpose. Sketch the **resultant wave**.



21st May – Part 2

2. Two coherent waves R and S are out of phase by π/2 radians. They interfere and superpose. Sketch the **resultant wave**.

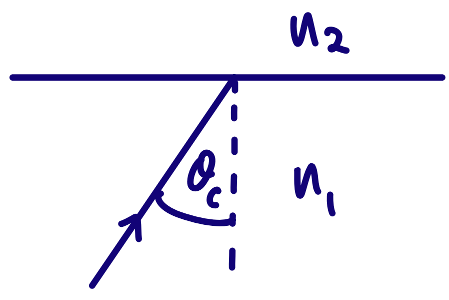


22nd May

1 2 3

1. Describe the **conditions** under which **total internal reflection**, TIR, occurs.

$\theta > \theta_c$



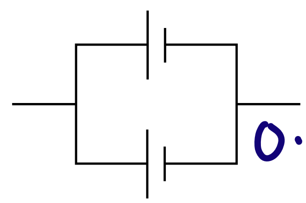
$n_1 > n_2$

2. Each cell has an EMF of 1.2 V and internal resistance of 0.10 Ω. Calculate the **total EMF** and total **internal resistance** for the batteries below:

a. $1.2 + 1.2 = 2.4\,V$

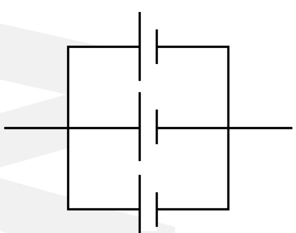
$0.10 + 0.10 = 0.20\,\Omega$

b. $1.2\,V$



$0.10 \div 2 = 0.050\,\Omega$

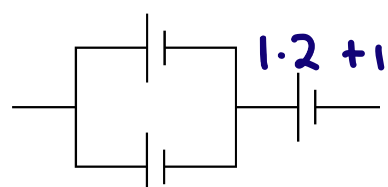
c.



$1.2\,V$

$0.10 \div 3 = 0.033\,\Omega$

d.



$1.2 + 1.2 = 2.4\,V$

$0.050 + 0.10 = 0.15\,\Omega$

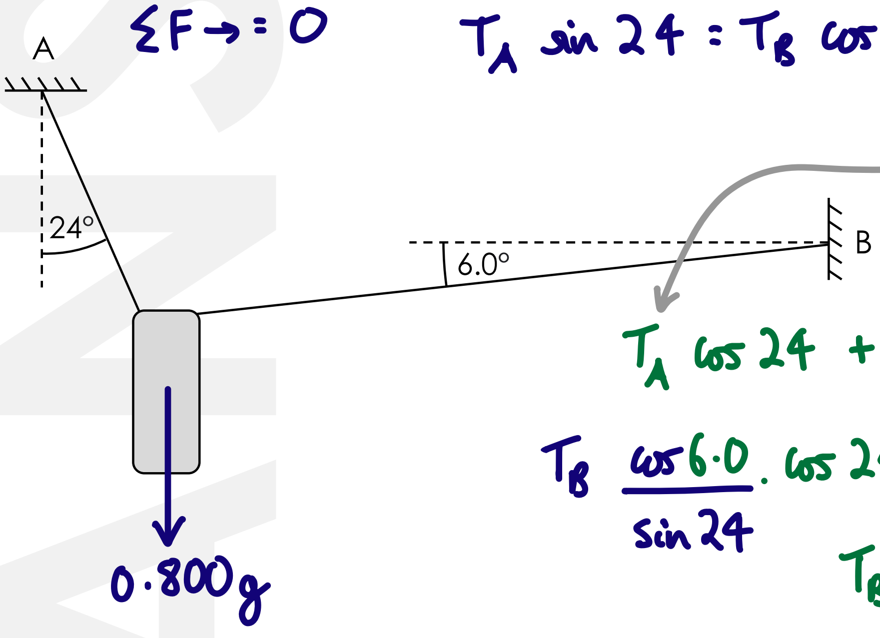
3. An 800 g mass is suspended from two fixed wires as shown below.

Calculate the **tension** in each wire.

$\Sigma F_{\rightarrow} = 0$

$T_A \sin 24 = T_B \cos 6.0$

$T_A = T_B \dfrac{\cos 6.0}{\sin 24}$



$\Sigma F_{\uparrow} = 0$

$T_A \cos 24 + T_B \sin 6.0 = 0.800 \times 9.81$

$T_B \dfrac{\cos 6.0}{\sin 24} . \cos 24 + T_B \sin 6.0 = 0.800 \times 9.81$

$T_B = 3.4\,N$

$T_A = 3.356 . \dfrac{\cos 6.0}{\sin 24} = 8.2\,N$

23rd May

1 2 3

1. a. Calculate the **critical angle** for a semicircular glass block made of crown glass with a refractive index, n, of 1.52

$\theta_c = \sin^{-1}\left(\frac{1}{n}\right) = \sin^{-1}\left(\frac{1}{1.52}\right) = 41.1^\circ$

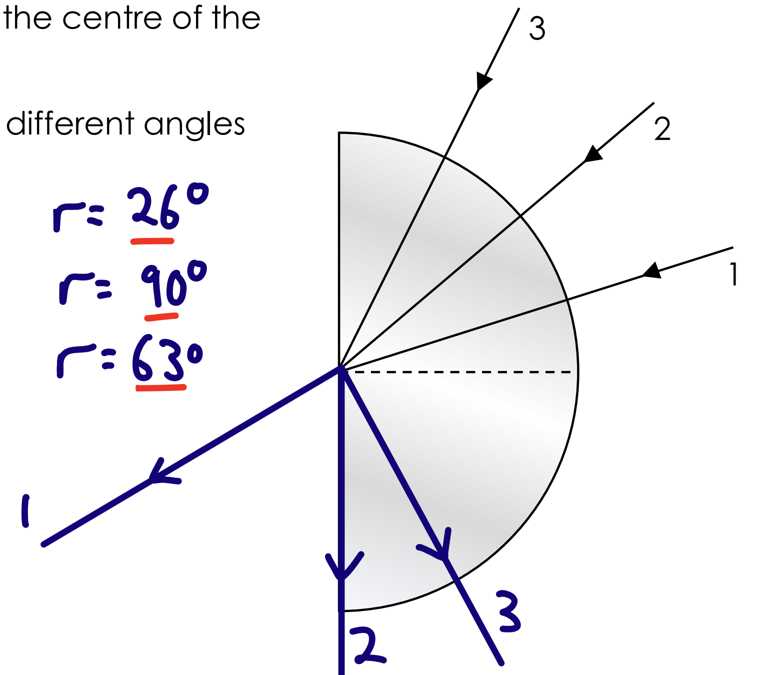
Three rays of light are directed towards the centre of the block as shown.

b. Complete the **paths** of the rays with different angles of incidence

i. Ray 1 $i_1 = 17^\circ$ $r = 26^\circ$

ii. Ray 2 $i_2 = 41^\circ = \theta_c$ $r = 90^\circ$

iii. Ray 3 $i_3 = 63^\circ$ ∴ TIR $r = 63^\circ$



2. Calculate the **critical angles** for diamond-air and diamond-water boundaries.

$n_{diamond} = 2.42$ $n_{water} = 1.34$

Diamond - Air

$\theta_c = \sin^{-1}\left(\frac{1}{2.42}\right) = 24.4^\circ$

Diamond - Water

$\theta_c = \sin^{-1}\left(\frac{1.34}{2.42}\right) = 33.6^\circ$

3. A step-index optical fibre is made of flint glass where n = 1.61 and crown glass as in Q1 above.

a. State which of these would be the **core** and which would be the **cladding**

Flint core, crown cladding $(n_1 > n_2)$

b. Calculate the **critical angle** at the core-cladding boundary in this optical fibre

$\theta_c = \sin^{-1}\left(\frac{1.52}{1.61}\right) = 70.8^\circ$

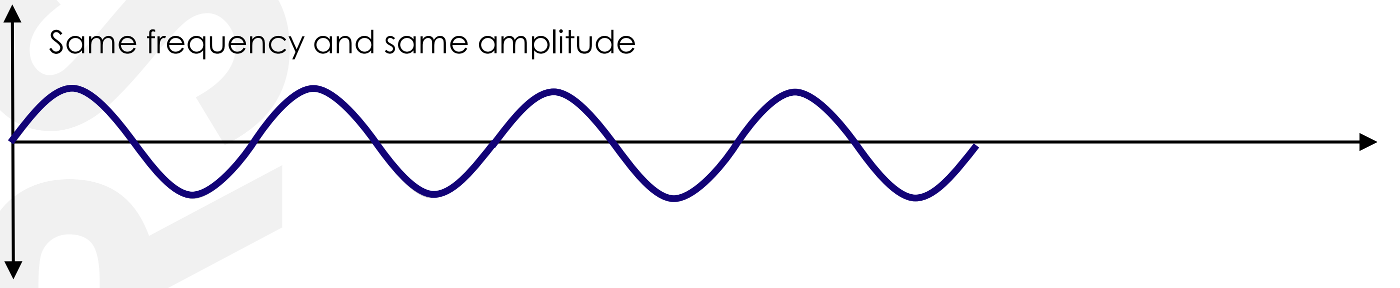
c. Explain the **advantage** of a large critical angle for an optical fibre

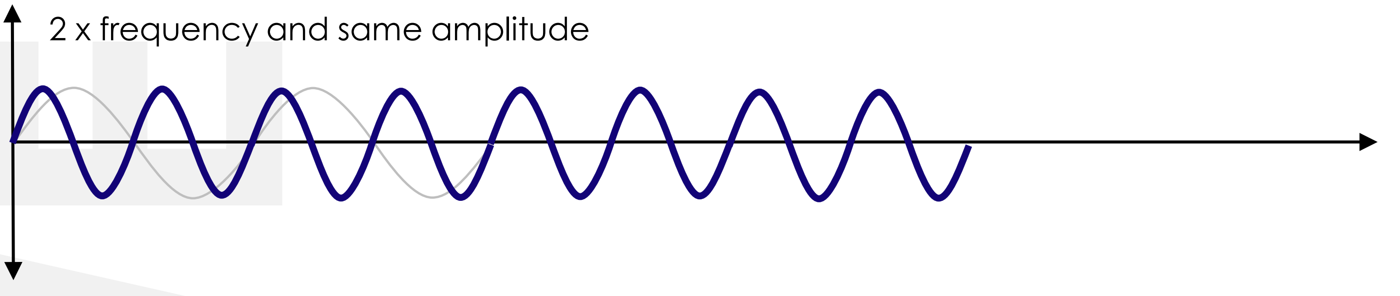
Minimises modal dispersion

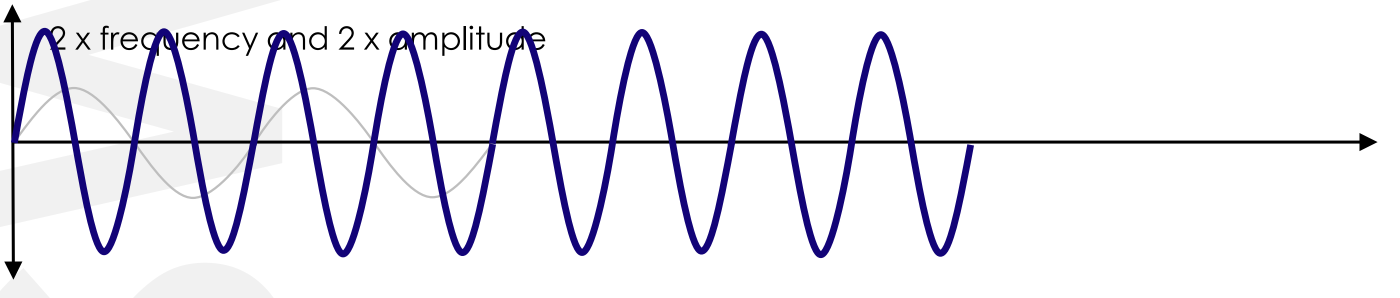
24th May

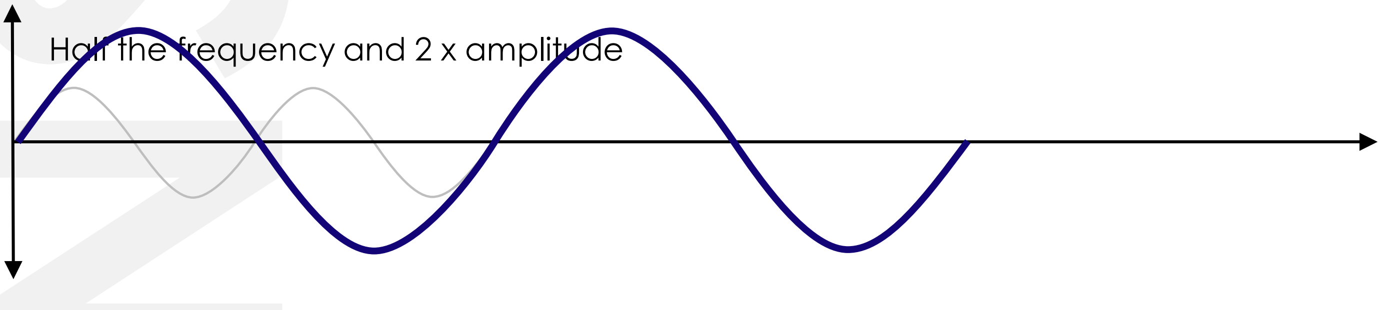
1

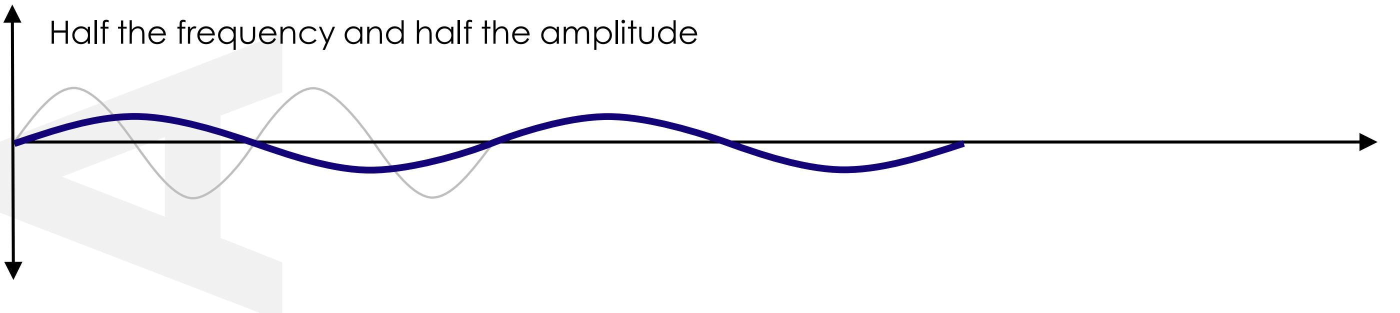
1. Sketch a **sinusoidal** curve for the following graphs:











25th May

1 2 3

1. Write the following purely in their **base units** and their more commonly used **unit**:

   a. $J\ s^{-1}$ $\quad kg\ m^2 s^{-2} . s^{-1} = kg\ m^2 s^{-3}$ $\quad$ W

   b. $N\ m^{-2}$ $\quad kg\ m\ s^{-2} . m^{-2} = kg\ m^{-1} s^{-2}$ $\quad$ Pa

   c. $J\ C^{-1}$ $\quad kg\ m^2 s^{-2} . A^{-1} s^{-1} = kg\ m^2 s^{-3} A^{-1}$ $\quad$ V

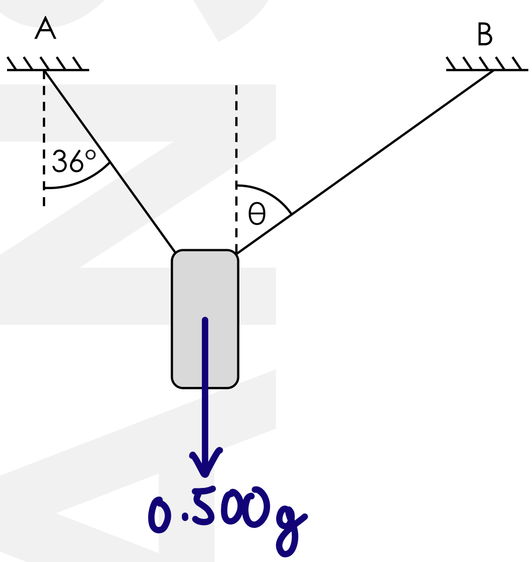
2. Define:

   a. **Refraction**

   b. **Diffraction**

3. A 500 g mass is suspended from two fixed wires as shown below.

   Calculate the **angle θ** when the tension in wire B is twice the tension in wire A.



$\Sigma F_{\rightarrow} = 0$

$T \sin 36 = 2T \sin \theta$

$\sin \theta = \frac{\sin 36}{2}$

$\theta = 17°$

26th May

1 2 3

1. An electron absorbs a photon such that it changes from an energy level of -11.0 eV to an energy level of -5.0 eV. Calculate the **energy** of the photon that is absorbed in joules.

$$\Delta E = 6.0\,eV = 6.0 \times 1.60 \times 10^{-19} = 9.6 \times 10^{-19}\ J$$

2. Define:

   a. An **ion**

   b. The **ground state** for an atom

3. A photon of wavelength 700 nm is incident on a stationary hydrogen atom (we can assume the mass of the hydrogen atom is solely due to a proton).

   By considering the conservation of momentum, calculate the **velocity** of the atom after this event.

$$\lambda = \frac{h}{m_\gamma u}$$

$$P_{before} = P_{after}$$

$$m_\gamma u = m_p V$$

$$\lambda = \frac{h}{m_p V} \qquad V = \frac{h}{\lambda m_p} = \frac{6.63 \times 10^{-34}}{700 \times 10^{-9} \times 1.673 \times 10^{-27}}$$

$$V = 0.566\ ms^{-1}$$

27th May

1 2 3

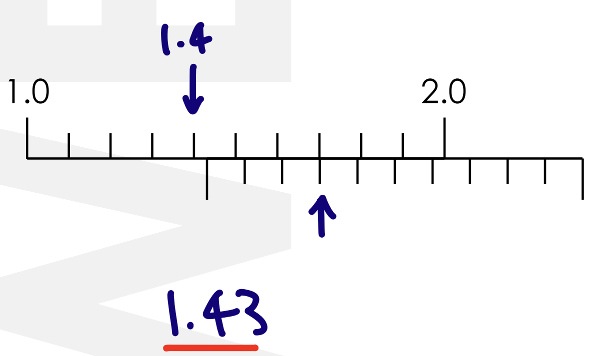
1. A datalogger was used to measure the velocity of a glider on an air track. Determine the **result** that should be recorded for 'v' and calculate the **percentage uncertainty** in the data:

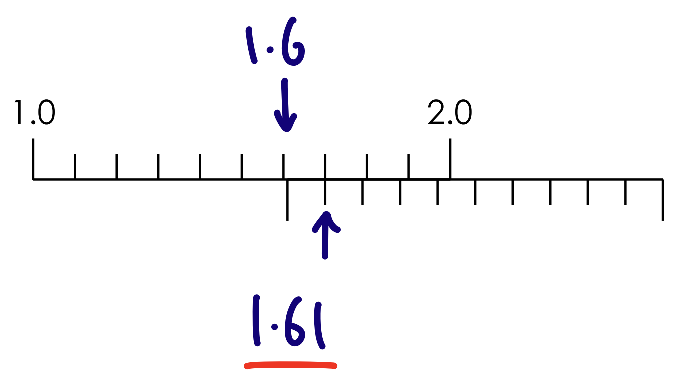
v / m s^{-1}	3.28	3.14	3.14	3.39	3.21

Mean = 3.23 ms^{-1}

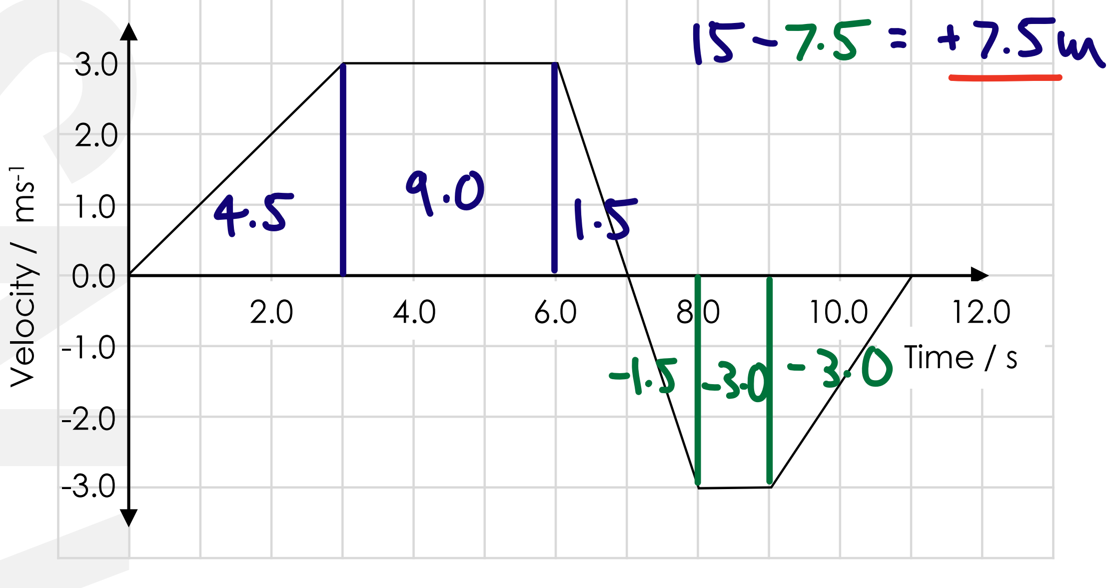
$$\%U = \frac{(3.39-3.14)\div 2}{3.23} \times 100 = 3.9\%$$

2. Read the **quantity** measured in the following diagrams of vernier scales.





3. Calculate the total **displacement** of the object in the v-t graph below.



28th May

1 2 3

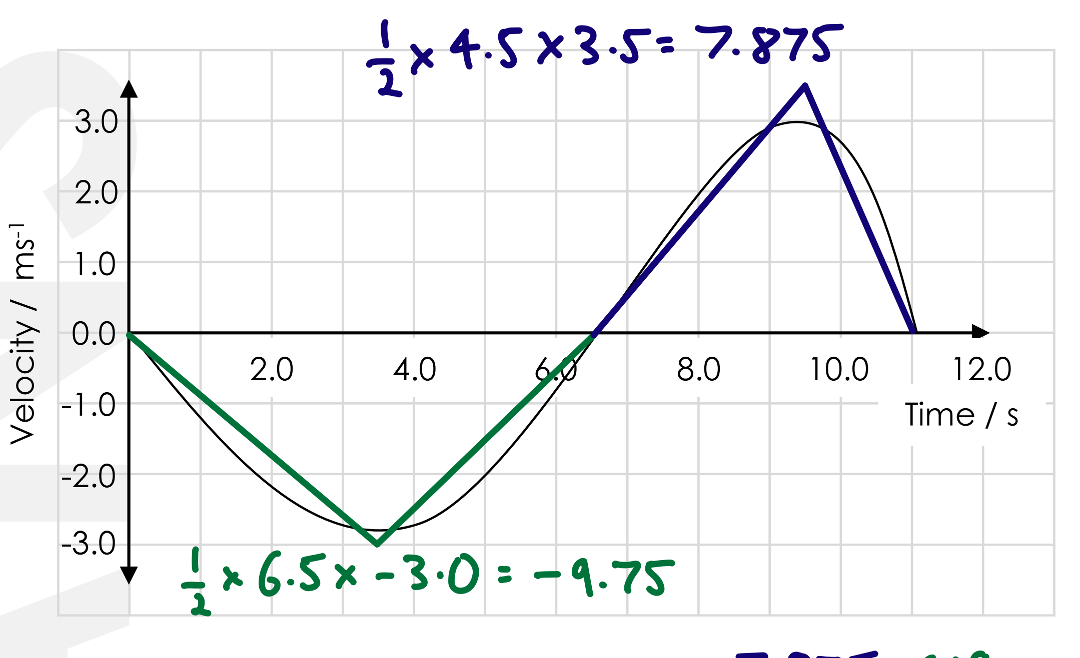
1. Write down the **units** for:
   a. Momentum — $kg\,m\,s^{-1}$
   b. Resistivity — $\Omega\,m$
   c. Work function — J or eV
   d. Impulse — Ns

2. Microwaves of wavelength 2.7 cm pass through two gaps in a metal screen that have their centres 15 cm apart. A microwave receiver is moved perpendicular to the direction of the beam at a distance of 1.5 m.

   Calculate the **distance** between adjacent points of maximum intensity.

$$w = \frac{\lambda D}{s} = \frac{2.7\times10^{-2} \times 1.5}{0.15} = 0.27\,m$$

3. Estimate the total **displacement** of the object in the v-t graph below.



$7.875 + (-)9.75$

$\approx -1.9\,m$

29th May

1 2 3

1. Describe why **wave theory** cannot explain the **photoelectric** effect.

See the back of the book for the answers today, or watch the video where I explain this.

2. Explain how **experiments** on the photoelectric effect **disagree** with wave theory.

3. Explain how Einstein's model of **photons** explains the photoelectric effect.

30th May

1 2 3

1. Underline the **vector** quantities:

Resistivity	Acceleration	Upthrust
Momentum	Young modulus	Strain
Current	Resistance	Displacement

2. Calculate the **maximum kinetic energy**, in J and eV, of a photoelectron that has been emitted from a metal with a work function of 3.5 eV which has absorbed a photon of frequency 9.2 x 10^{15} Hz.

   a. J

   $hf = \phi + KE_{max}$

   $KE_{max} = (6.63\times10^{-34} \times 9.2\times10^{15}) - (3.5 \times 1.60\times10^{-19})$

   $= 5.5\times10^{-18}$ J

   b. eV

   $5.540 \div 1.60\times10^{-19} = 35\,eV$

3. a. Calculate the **minimum frequency** of a photon that can free an electron from a metal surface which has a work function of 4.00 eV

   $hf_0 = \phi$ $\quad f_0 = \frac{\phi}{h} = \frac{4.00\times 1.60\times10^{-19}}{6.63\times10^{-34}} = 9.65\times10^{14}$ Hz

   b. Calculate the **wavelength** for this frequency

   $\lambda = \frac{c}{f_0} = \frac{3.00\times10^{8}}{9.65\times10^{14}} = 3.11\times10^{-7}$ m

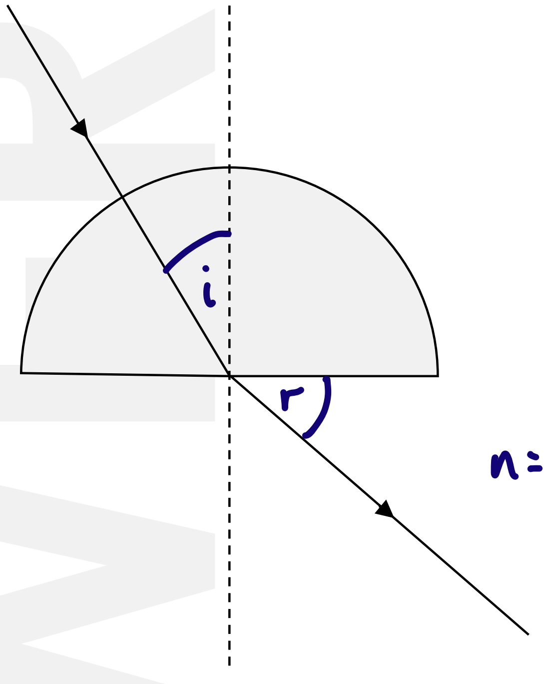
   c. State what **band** of EM radiation this is

   311 nm ∴ UV

31st May

1. A ray of light passes through a semicircular block and refracts, as shown in the diagram below.

   Identify which **material** the block is made from.



Material	Refractive index
Ice	1.31
Crown glass	1.51
Flint glass	1.69
Diamond	2.42

$n = \frac{\sin i}{\sin r} = \frac{\sin 30}{\sin 49} = 1.51$

$\therefore$ Crown glass

2. a. Calculate the **maximum velocity** of a photoelectron that has been emitted from a metal with a work function of 1.90 eV after it has absorbed a photon of frequency 6.00×10^{15} Hz

$hf = \phi + \frac{1}{2}mv^2$

$v = \sqrt{\frac{2(hf - \phi)}{m}} = \sqrt{\frac{2 \times ((6.63 \times 10^{-34} \times 6.00 \times 10^{15}) - 1.90 \times 1.60 \times 10^{-19})}{9.11 \times 10^{-31}}}$

$v = 2.84 \times 10^{6}\ ms^{-1}$

b. Determine the **stopping potential** for this frequency and metal (remember the 15th May)

$KE_{max} = eV_s$ (from 15th May)

$V_s = \frac{\frac{1}{2} \times 9.11 \times 10^{-31} \times (2.84 \times 10^{6})^2}{1.60 \times 10^{-19}} = 22.96$

$V_s = 23.0\ V$