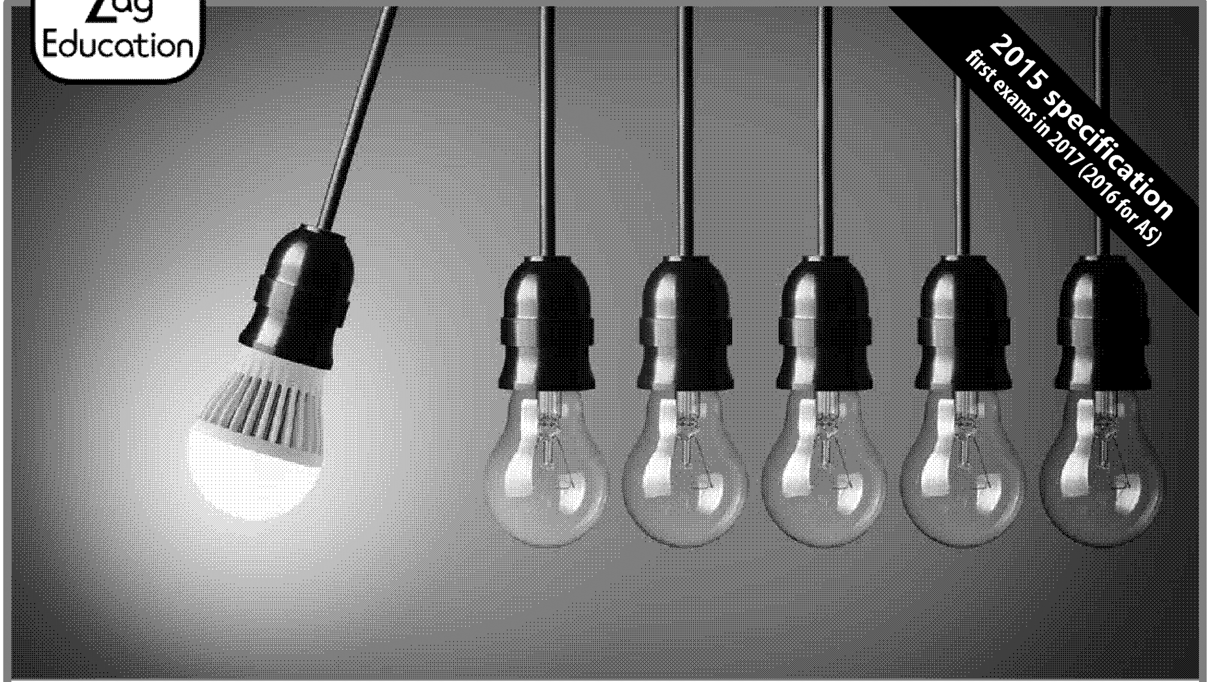
Physics AS / A Level Year 1 | Edexcel | 9PH0/8PH0



Differentiated Homeworks

for AS/A Level Year 1 Edexcel Physics

zigzageducation.co.uk

POD 9387

Contents

Teacher's Introduction

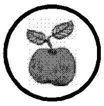
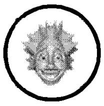
Recapping, revising and consolidating information is key to understandin
homework sheets with that specific aim. The homework worksheets have b
on topics 1–5 of the AS and A Level Year 1 Edexcel course:

- Working as a physicist
- Mechanics
- Electric circuits
- Materials
- Waves and particle nature of light

A range of activities has been used to ensure the worksheets are engaging and also to test a wide variety of skills. A number of the worksheets include comprehension and explanation tasks that cannot necessarily be covered in topic tests and practice papers, including experimental design, experimental recommendation and peer review activities. These activities can extend students' understanding and evaluate its depth. The resource's ability and flexibility to use these types of activity encourage further learning, and the activities introduce crucial skills necessary for a continued academic or professional career in science.

Ho

Structure:
The resource is split into 19 homeworks. Each homework is differentiated for lower and higher ability, denoted by the symbols Newton (apple) and Einstein (scientist) respectively. The terms 'higher' and 'lower' do not appear on the worksheets; only the symbols feature.

Key  = lower ability  = higher ability

Solutions are provided for each homework sheet towards the end of the resource.

L Burb

*A web page containing all the links listed in this resource is convenien Education's website at **zzed.uk/9387***

You may find this helpful for accessing the websites rather than typin

HOMEWORK ONE: MEASUREMENTS AND THE

Activity 1: Summary Questions

Aim: To consolidate the information presented during lessons with practic summarise the topic.

Task

1. Complete the table below.

Physical quantity	SI base uni
Mass	
	Metres
Time	
Amount of a substance	
	Kelvin
Electric current	

2. Complete the table

Prefix name	Prefix symbol	Order of m
Tera		
		×1
Giga		
Centi		
		×10
Mili		
Mega		
		×1
Pico		
		×1

3. From your knowledge of the SI base units, you can determine the deri physical quantities.

a) Which of the following statements are true?

A The derived SI units for velocity are $km\ s^{-1}$

B The derived SI units for energy are $kg\ cm^2\ s^{-2}$

C The derived SI units for charge are $s\ A$

D The derived SI units for force are $kg\ m\ s^{-1}$

b) For each false statement of question (a), write the physical quantit

4. Within the field of particle physics it is more convenient to determine t terms of electron volts rather than joules, considering the small-scale e with.

A sample of experimental data taken for a research project into the kin under various conditions is displayed below:

Particle	Kinetic Energy (J)	Kinetic
Alpha particle	8.1×10^{-13} J	
Electron	8×10^{-14} J	
Proton	5.6×10^{-11} J	

Complete the data analysis table to include the energies of the differen more convenient form of MeV.

Activity 2: Data Analysis Extended Question

Aim: To use unseen data and equations to analyse and solve physics probl

Task

As early as the 1600s, there were mathematical proposals being put forwar cosmos interacted. These physical laws of gravity are entrenched with accu stolen property.

The laws of gravitation are one of the biggest mathematical breakthroughs this the value for acceleration due to gravity can be determined using a sim the comfort of your own home.

It was first hypothesised by Galileo that the length of a pendulum was pro swing of the pendulum.

The equation relating period and length of a pendulum is as follows:

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

The pendulum can be set at different lengths, which are recorded using a m period of the swing at this length can then be measured using a stop clock.

Measurements:

Trial	Length (cm)	Period (s)
1	121 ± 1	2.2 ± 0.1
2	115 ± 1	2.0 ± 0.1
3	111 ± 1	2.1 ± 0.1
4	106 ± 1	2.1 ± 0.1
5	101 ± 1	2.1 ± 0.1
6	94 ± 1	2.1 ± 0.1

a) State what the systematic and random errors will be for this pendulum
b) Suggest methods the experimenter could use to reduce the errors discu
c) Determine the percentage uncertainty for both length and period for T
d) Determine the value for acceleration due to gravity for Trial 4.
e) Comment on the accuracy of the result determined in (d).
f) Comment on the precision of the results obtained in this experiment.
g) Determine the absolute uncertainty in the value for acceleration due to

Remember:
Accuracy is a term used to describe the **proximity of one measured value**
precision is a term used to describe the **proximity of a group of measure**

HOMEWORK ONE: MEASUREMENTS AND THE

Activity 1: Summary Questions

Aim: To consolidate the information presented during lessons with practi summarise the topic.

Task

1. **a)** From your knowledge of SI base units, determine whether the foll
   - A The derived SI units for velocity are $km\ s^{-1}$
   - B The derived SI units for energy are $kg\ cm^2\ s^{-2}$
   - C The derived SI units for charge are $s\ A$
   - D The derived SI units for force are $kg\ m\ s^{-1}$

   b) For each false statement of question (a), write the physical quantit

2. A janitor climbs 205 cm up a ladder to fix the broken roof of a school.

   a) Estimate the gravitational potential energy of the janitor at the top

   Note: The equation for gravitational potential energy is $E_p = mgh$

   b) Give your answer to (a) in kJ.

3. An experiment involving the consequences of the photoelectric effect w physics laboratory.

   A source of light was shone on a metal plate and as a result electrons w of the metal. The results are shown below:

Work Function (eV)	Frequency (Hz)
4.1	1.3×10^{16}

   The equation for calculating the maximum kinetic energy of the electr the frequency of light, ϕ is the work function and h is Planck's consta

   Calculate the maximum kinetic energy of the electrons in pJ.

4. The cost of using any electric appliance in your house can be determin

   The rate for electrical use in an average house in south Bristol is 1kwh

   Calculate the cost of using an average TV for 30 minutes, which uses 2.

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e) Explain the accuracy of the result determined in (d).
f) Comment on the precision of the results obtained in this experiment.
g) Determine the absolute uncertainty in the value for acceleration due to g

Extension Task

Imagine you are writing a scientific paper based on the results for this exp
Write the conclusion.

Hints and guidance:

A good conclusion *should*:

- simply summarise the main findings and the validity of the results ach conclusions does not need to be repeated
- explain the larger significance of your ideas and demonstrate the impo
- explain what further work needs to be undertaken to confirm/improve experiment

A good conclusion *should not*:

- include any new thoughts, findings or ideas that have not already bee results and findings

Please have a look at these websites for further help on how to write a succ

- **http://libguides.usc.edu/writingguide/conclusion**
- **https://www.colby.edu/biology/BI17x/writing_papers.html**
- **http://www.cfa-international.org/ONGSWmanu.html**

Purpose of task:

It is essential that science students are comfortable demonstrating results a their findings. If the pursuit of science is taken further, to a university level scientific reports and papers will become crucial.

Activity: Planning an attack

Aim: To determine the velocity and angle at which a trebuchet needs to lau
different parts of a medieval castle.

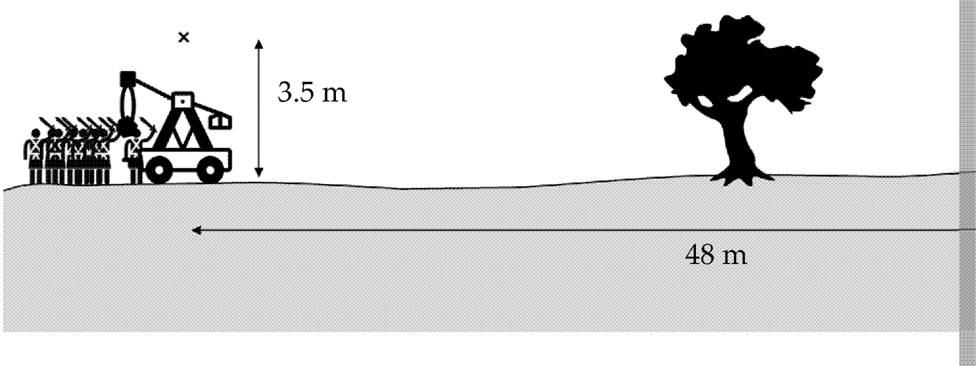
Below are the SUVAT equations that you will need for this homework.

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

s – Displacement; u – Initial velocity; v – Final velocity; a – Acc

Task

You are the operator of a trebuchet as part of an attack on a medieval cast has told you to launch a projectile, a 450 kg boulder, at one of the suppor with a white ×. The boulder is always released by the trebuchet at the poi The diagram below shows the distance and height of the target wall supp The target on the wall support and the point of release of the trebuchet a the ground.



As the operator of the trebuchet, you can change the velocity and angle at released by altering the weight of the boulder and trebuchet's counterwe

1. Your commanding chief tells you the boulder must hit the wall suppor velocity of 8.50 m s^{-1} as this should be fast enough the break the suppo the projectile to hit the wall support after release. Use an equation that velocity, gravitational acceleration (g_{earth} = 9.81 N/kg) and time.

   (Hint: calculate the time it takes the boulder to reach its maximum height and flight time.)

2. Use your answer from question 1 to calculate the horizontal velocity of flight. Then calculate the angle and magnitude of the boulder when lau Remember, the initial vertical velocity of the boulder is the same as the boulder when it hits the support because the start and end points are a

(Hint: you will need to use tan θ in this question.)

The boulder is launched and strikes the castle wall! The wall support is d The castle has not been breached.

Your commanding chief says that he must have miscalculated the speed a to be travelling when it hits the wall support. He tells you that the bould velocity of 35 m s⁻¹. He also tells you the boulder should hit the support a horizontal and vertical components of the boulder's velocity are equal.

3. Calculate the vertical component of this initial velocity using sine of th launched at. Then use this velocity to calculate the new time it takes th after release using the same method as in question 1.

Success! The boulder strikes the wall support with enough kinetic energy collapses and an opening forms. Your army's soldiers march on forward t commanding chief wants to launch one more boulder at the castle tower l castle. The new target is the same horizontal distance away from your tre above the ground. The boulder needs a kinetic energy of 90 kJ to knock d

4. Calculate the velocity the boulder should be launched at. Remember th than the launch point, so you will need to consider the change in gravi which is given by $\Delta E_p = m \times g \times \Delta h$. Below is a template to help you i

The increase in gravitational potential energy needed to get the b height is: Assuming no drag, the kinetic energy of the boulder when launch   The initial velocity of the boulder therefore needs to be:

It takes you and your assistant 25 s to reload the trebuchet and get it read the trebuchet an extra 2 s to launch the boulder, getting it to the point ma tower needs to be hit 15 s before the army reaches the castle edge, otherw injure one of your soldiers.

5. Assuming you and your assistant start loading the trebuchet at the sa march, calculate the maximum speed the army can march at so they re commanding chief informs you that the boulder must be launched at a template to help you in this derivation.

Using the previously found initial velocity of the boulder, the time reach its maximum height is:

The maximum height of this flight can be found using $s = ut + \frac{1}{2}at^2$:

The boulder then falls from this height to the tower height, a distance of:

Using $s = ut + \frac{1}{2}at^2$ for this second half of the flight, the time for this s

which means the total time of flight is:

Adding this time of flight to the loading time, launching time and safety time for the army to reach the castle after launch of:

Finally, the fastest the army should walk is, therefore:

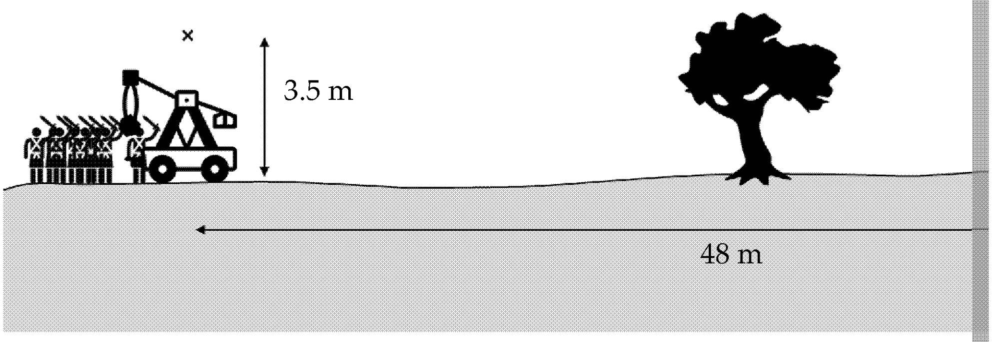
HOMEWORK TWO: MEDIEVAL ASSAU

Activity: Planning an attack

Aim: To determine the velocity and angle at which a trebuchet needs to lau
different parts of a medieval castle.

Task

You are the operator of a trebuchet as part of an attack on a medieval cast has told you to launch a projectile, a 450 kg boulder, at one of the suppor with a white ×. The boulder is always released by the trebuchet at the poi The diagram below shows the distance and height of the target wall supp The target on the wall support and the point of release of the trebuchet a the ground.



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The boulder is launched and strikes the castle wall! The wall support is c The castle has not been breached.

Your commanding chief says that he must have miscalculated the speed a to be travelling when it hits the wall support. He tells you that the bould energy of 2.76×10^5 J. He also tells you the boulder should hit the supp horizontal and vertical components of the boulder's velocity are equal.

2. Calculate the initial vertical velocity of the boulder, and, therefore, the to hit the castle wall after release.

Success! The boulder strikes the wall support with enough kinetic energ collapses and an opening forms. Your army's soldiers march on forward t commanding chief wants to launch one more boulder at the castle tower l castle. The new target is the same horizontal distance away from your tre above the ground. The boulder needs a kinetic energy of 90 kJ to knock d

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Extension Task

By using Excel or some other similar software, type in a variation of initial v 1 m s^{-1} to 100 m s^{-1}. Then, in a separate cell away from your table, enter an i

Then in each consecutive column, type the calculations for:

- vertical component of initial velocity
- horizontal component of initial velocity
- time to reach maximum height
- double the time to reach maximum height, i.e. time of full flight if start same level
- distance of maximum height
- horizontal distance of trajectory

When typing the angle into each Excel equation, use the $ symbol to keep th calculation. For example, if your angle is in G3 and your initial velocity is in the vertical velocities type = A1*sin(G3)

Then plot two graphs on the same axis (you can add more graphs using sel maximum height against initial velocity, and one graph for maximum hori velocity.

Then vary the initial angle between 0° and 90°. What do you notice? At wha height become larger than the maximum horizontal distance?

HOMEWORK THREE: PRACTICE QUESTI

Activity 1: Summary Questions

Aim: Complete summary questions to demonstrate an understanding of th

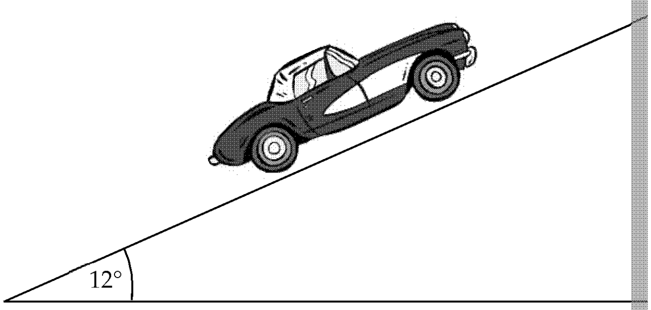
1. a) Complete the table by ticking the box that correctly identifies the n quantity. An example has been provided for you.

	Scalar
Velocity	
Distance	
Force	
Speed	
Acceleration	
Energy	
Mass	
Temperature	
Weight	

b) Comment on the difference in the nature of scalars and vectors.

2. A sailboat travels due east at a velocity of 5.6 m s^{-1}. After time t the b begins to travel at 4.2 m s^{-1} due north. Calculate the resultant velocity

3. A 680 kg car is travelling up a steep incline.



a) Calculate the weight force acting against the car (the weight force p

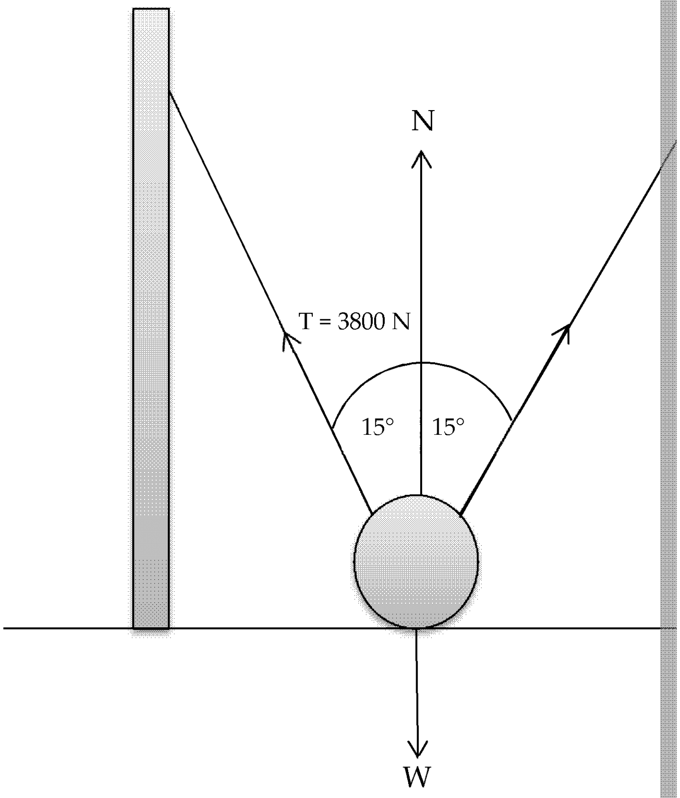
There is a net force of 150 N acting on the car.

b) Determine the magnitude and direction of the force of the engine.

Extension Question

4. At a theme park there is a ride in which visitors are strapped into a bal downwards to its maximum length and then released.

As the visitors are strapped into the ball, the ball is at rest. There is tens attached to the ball and each rope has the same magnitude of tension.



a) State whether tension is a scalar or a vector.
b) Resolve the tension vector T into its horizontal and vertical compo
c) Hence, determine the weight of the people and the ball.

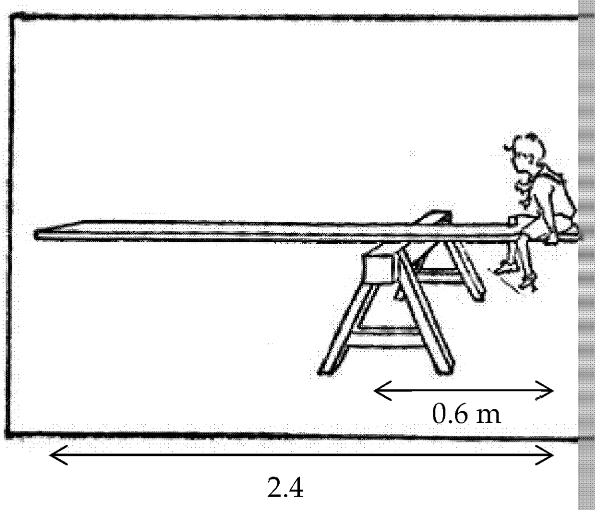
The ride is currently at rest, and the ball is in contact with the ground.

d) State the normal contact force.

Activity 2: Exam-style Questions

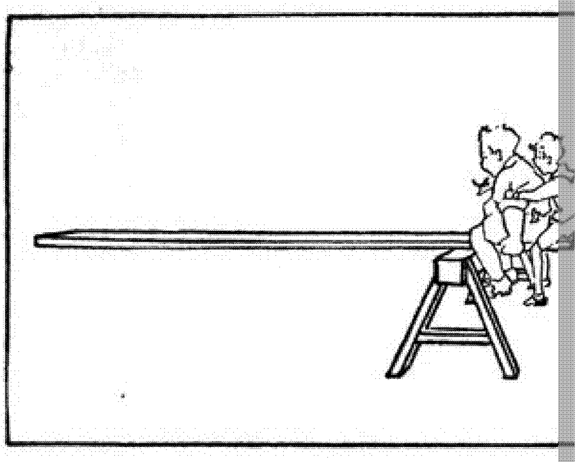
The local council is building a new playground and determining the best de
seesaws.

1. A 50 kg boy sits on the seesaw, initially by himself. He sits 0.6 metres fr
the seesaw manages to sit at rest in equilibrium. The full length of the v
and the seesaw has mass equally distributed throughout its length.



a) Calculate the clockwise moment about the pivot of the seesaw.
b) Comment on the position of the centre of mass of the seesaw.
c) Using your answer to (b) determine the weight of the seesaw.
d) Comment on what would happen if the boy had been 45 kg.

The boy's friend joins him on the seesaw. The friend has mass of 75 kg.
adjustable, and the friends move the pivot closer to the end of the sees
equilibrium again.



e) Determine the new ratio of distance of the two boys from the pivot
centre of mass of the seesaw from the pivot.

Extension Question

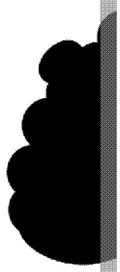
f) Using your answer to (e), calculate the distance of the two boys fro

Activity 1: Summary questions

Aim: To fill in the gaps of the listed scenarios using Newton's laws of moti energy and the conservation of momentum.

Task

1. An apple falls from a tree and hits a philosopher on the head.



$F_{head} = m_{apple} \times a_{apple}$

The philosopher estimates that the apple is falling at 5 m s^{-1} and bounces up at 1 m s^{-1} after being in contact with his head for half a second.

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

$a_{apple} =$ ☐ m s^{-2}

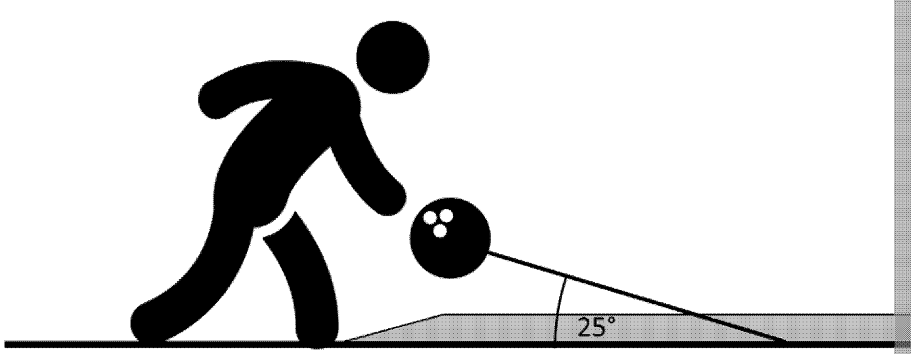
The philosopher estimates the force exerted by the apple, so

$F_{head} = 2.50$ N

$m_{apple} = \frac{F_{head}}{\square}$

$m_{apple} =$ ☐

2. A bowler bowls a bowling ball down a bowling alley. The bowler's ha 32.5 N at an angle of 25.0° from the bowling alley. The force acts for 1.2 bowling ball is 7.26 kg. The bowler releases the ball directly onto the al



a) Calculate the momentum of the ball as it hits the floor.

The change in momentum is given by

$\Delta p = Ft$

$\Delta p =$ ☐

$\Delta p =$ ☐ kg m s^{-1}

The bowling ball is accelerating from rest so $\Delta p = p$

b) Calculate the horizontal and vertical components of the ball's velo

The velocity of the bowling ball is

$v =$ ☐

$v =$ ☐

$v = 5.596$ m s^{-1}

Vertical:

$v_y = v$ ☐ θ

$v_y = 5.596 \times$ ☐

$v_y =$ ☐ m s^{-1}

Horizontal:

$v_x = v$ ☐ θ

$v_x = 5.596 \times$ ☐

$v_x =$ ☐ m s^{-1}

c) As the ball hits the floor, the floor exerts a total resultant force acti the bowling alley floor. This force acts for 155 ms and brings the ve zero, but the ball continues to roll down the alley.

Calculate the force exerted on the ball.

The change in momentum of the ball is equal to the impulse exerte

$F_y t = \Delta p_y$

Ft ☐ $\theta = m \times$ ☐

$F =$ ☐

$F =$ ☐

$F = 115.2$ N

d) Calculate the new horizontal velocity of the ball just after it lands.

$F_x t =$ ☐

Ft ☐ $\theta = m$ ☐

$v_x =$ ☐

$v_x =$ ☐

$v_x =$ ☐ m s^{-1}

e) The bowling ball experiences a constant frictional force of 0.140 N bowling alley.

Calculate the final velocity of the bowling ball as it reaches the end of the alley.

The frictional forces do work against the ball

Loss in kinetic energy = work done by frictional forces

$\frac{1}{2}m\Delta(v^2) = \boxed{}$

$v_{final} = \sqrt{v_{initial} - \boxed{}}$

$v_{final} = \boxed{}$

$v_{final} = 4.305$ m s^{-1}

f) The bowling ball strikes a single pin with a mass of 1.50 kg, which direction as the bowling ball. The bowling ball's velocity slows to Calculate the pin's velocity after being struck by the bowling ball.

The momentum of the ball before the collision is

$p_{initial} = m_{ball}v_{initial}$

$p_{initial} = \boxed{}$

$p_{initial} = 31.25$ kg m s^{-1}

Through conservation of momentum

$p_{initial} = p_{ball} + p_{pin}$

$v_{pin} = \boxed{}$

$v_{pin} = \boxed{}$ m s^{-1}

3. A rower pulls back on their oars, causing the oars to exert a force on th One complete stroke lasts 2.5 s, with the oar pushing against the water water displaced by each oar in one stroke is $m_{water} = 375$ kg.

The displaced water moves to the left at an average velocity of 0.38 m rower, boat and oars is $m_{boat} = 94$ kg.

During each stroke, when the oar is out of the water, the boat slows do

Other than the water displaced by the oars, the water is completely stil

The maximum speed of the boat once the oar is back in the water and c found using the conservation of momentum

$\Delta p_{left} = \Delta p_{right}$

$m_{water} \times \Delta v_{water} = \boxed{}$

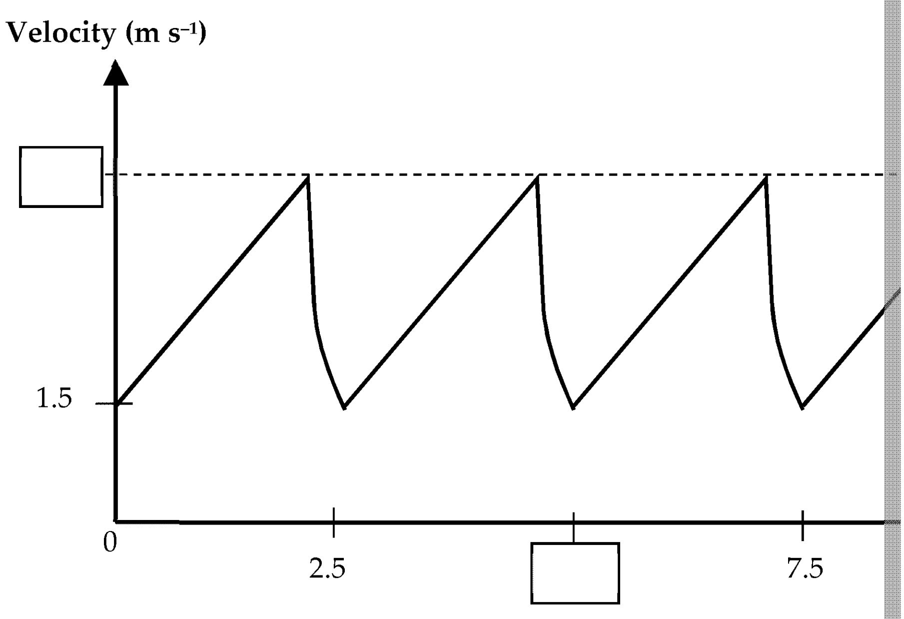
$\boxed{} \times 0.38 = 94 \times \Delta v_{boat}$

$\Delta v_{boat} = 3.0$ m s^{-1}

Adding this to the minimum speed of the boat gives

$v_{max} =$ [ ]

Below is a velocity–time graph describing the motion of the rowing bo



The water initially is stationary before being moved by each oar. There
momentum for the water moved by one oar is

$\Delta p_{water} =$ [ ] $= 143$ kg m s^{-1}

The water is moved while the oar moves through the water, so

$\Delta t = 1.5$ s

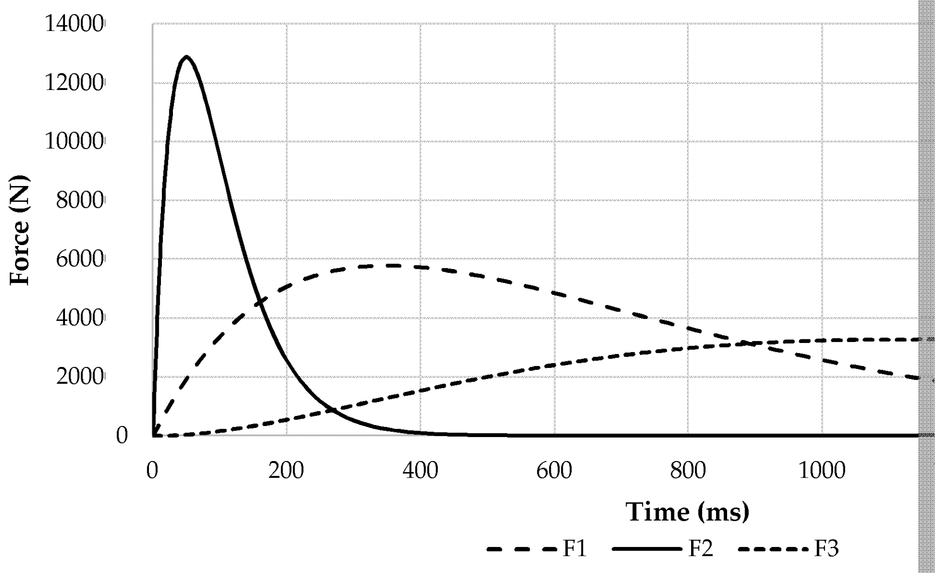
So the force exerted by each oar on the water is

$F =$ [ ] $= \frac{143}{1.5} =$ [ ]

Activity 2: Report writing

Aim: To write a scientific report on the results from a crash test experimen

You are part of a research team that is investigating the crumple zones o you are investigating three new designs. The car manufacturer has only a each design. Your team places five force detectors in the crumple zones o placed in the same position relative to the other two cars. The cars are th brick wall, travelling at 60 miles per hour before colliding head-on with t measured by the five detectors for each car design is plotted on the graph



Write a short scientific report that presents and analyses the data shown a report should have:

- a title
- an introduction describing the purpose of the investigation and the re and why they are used)
- the results from the investigation (you may cut out and paste the grap
- a discussion/analysis of the results (consider the impulse experienced this relates to the safety of each car)
- a conclusion/conclusions to draw from the discussion (you should en the most effective and why)

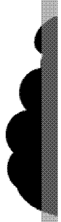
Use the template on the following page to write your report.

Activity 1: Summary questions

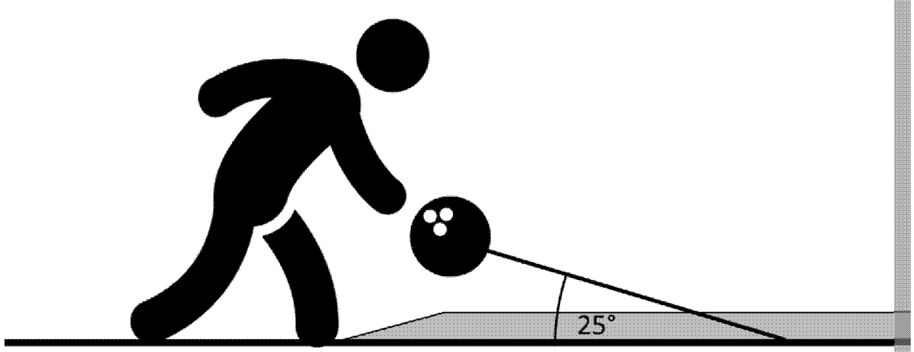
Aim: To work out/calculate what is missing in the derivations below. The s
laws of motion, the conservation of energy and the conservation of momen

Task

1. An apple falls from a tree and hits a philosopher on the head. If the force exerted on the philosphers head is 2.50 N, calculate the mass of the apple. The philosopher estimates that the apple is falling at 5 m s^{-1} and bounces up at 1 m s^{-1} after being in contact with his head for half a second.



2. A bowler bowls a bowling ball down a bowling alley. The bowler's hand exerts a force on the ball of 32.5 N at an angle of 25.0° from the bowling alley. The force acts for 1.25 s from rest. The mass of the bowling ball is 7.26 kg. The bowler releases the ball directly onto the alley floor.



a) Calculate the momentum of the ball as it hits the floor.

b) Calculate the horizontal and vertical components of the ball's velo

c) As the ball hits the floor, the floor exerts a total resultant force acti
the bowling alley floor. This force acts for 155 ms and brings the ve
zero, but the ball continues to roll down the alley.

Calculate the force exerted on the ball.

d) Calculate the new horizontal velocity of the ball just after it lands.

e) The bowling ball experiences a constant frictional force of 0.140 N
bowling alley.

Calculate the final velocity of the bowling ball as it reaches the end

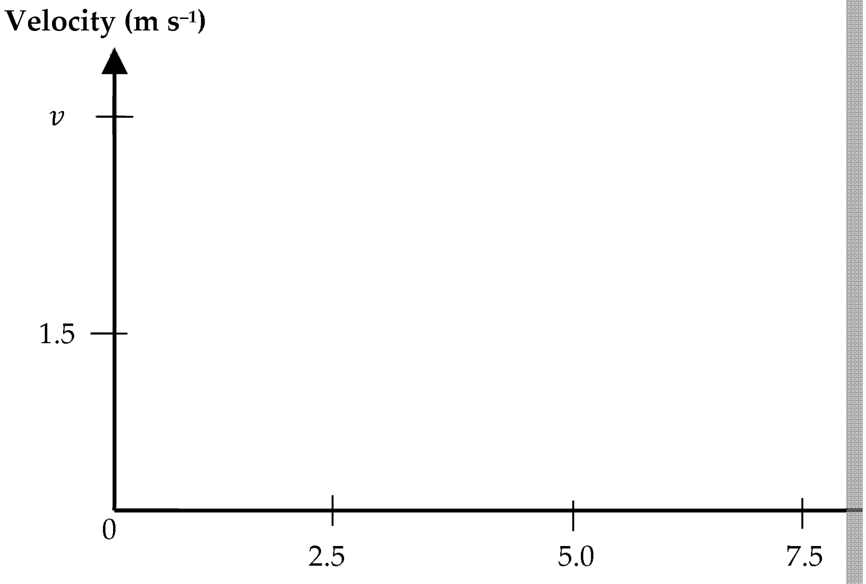
f) The bowling ball strikes a single pin with a mass of 1.50 kg, which
direction as the bowling ball. The bowling ball's velocity slows to 2

Calculate the pin's velocity after being struck by the bowling ball.

3. A rower pulls back on their oars, causing the oars to exert a force on the water in the left direction. One complete stroke lasts 2.5 s, with the oar pushing against the water for 1.5 s. The total mass of water displaced by each oar in one stroke is $m_{water} = 375$ kg. The displaced water moves to the left at an average velocity of 0.38 m/s. The total mass of the rower,
kg. During each stroke, when the oar is out of the water, the boat slow

a) What is the maximum speed reached by the boat after each strok

b) On the axes below, draw the shape of the graph that describes th
Complete the y-axis with your calculated maximum speed.



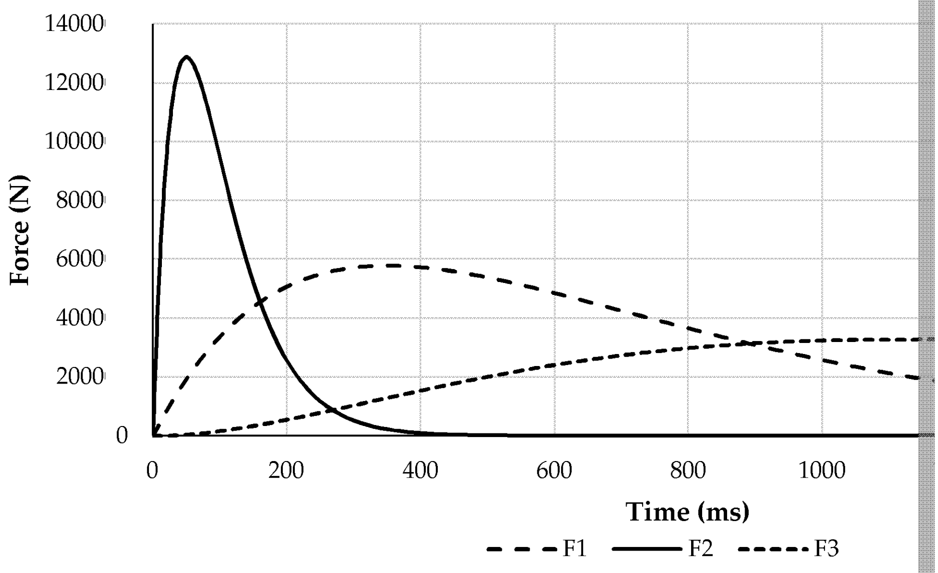
c) Assuming the water is stationary before being pushed by each oa
by each oar on the water.

d) In reality the maximum speed reached by the boat is not your ans
this is.

Activity 2: Report writing

Aim: To write a scientific report on the results from a crash test experimen

You are part of a research team that is investigating the crumple zones o
you are investigating three new designs. The car manufacturer has only a
each design. Your team places five force detectors in the crumple zones o
placed in the same position relative to the other two cars. The cars are th
brick wall, travelling at 60 miles per hour before colliding head-on with t
measured by the five detectors for each car design is plotted on the graph



Write a short scientific report that presents and analyses the data shown a
report should have:

- a title
- an introduction
- the results from the investigation
- a discussion/analysis of the results
- a conclusion

HOMEWORK FIVE: BE THE REVIEWE

Activity 1: Promotional Article

Aim: To demonstrate an ability to explain and apply physics concepts to re

Task

Cool Services Ltd is using a new model for its heat engine. The new model previous model from heat energy into work. However, the new model take energy from heat to work compared to the older model.

Write a brief specification review as if you were a journalist reviewing the r model with reference to the following properties:

- Energy transfer
- Rate of energy transfer
- Efficiency
- Percentage efficiency
- Conservation of energy
- Carbon footprint

A sample of a potential template review is given below:

Cool Services Ltd moves on up!	
How has its product improved?	
	H
How has the carbon footprint of the company improved?	

Additional Reading

The list below provides additional information on heat engines and will p to help you write your article on the new engine model:

- **https://www.bluffton.edu/~bergerd/NSC_111/thermo4.html**
- **http://physics.bu.edu/~duffy/py105/Heatengines.html**
- **http://aether.lbl.gov/www/classes/p10/heat-engine.html**

This list is only a suggestion, please proceed with your own research also.

HOMEWORK FIVE: BE THE REVIEWE

Activity 1: Promotional Article

Aim: To demonstrate an ability to explain and apply physics concepts to re

Task

A refrigeration company, Cool Services Ltd, is using a new heat engine for engine advertises to convert more of the input heat energy into output wor machine. The new model converts 100 J more than the previous model from However, the new model takes twice as long to convert energy from heat to model.

Write a brief specification review as if you were a journalist reviewing the r model with reference to the following properties:

- Energy transfer
- Rate of energy transfer
- Efficiency
- Percentage efficiency
- Conservation of energy
- Carbon footprint

You will need to do additional research into heat engines and how they wo review.

Additional Reading
The list below provides additional information on heat engines and will p to help you write your article on the new engine model:

- **https://www.bluffton.edu/~bergerd/NSC_111/thermo4.html**
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- **http://aether.lbl.gov/www/classes/p10/heat-engine.html**

This list is only a suggestion, please proceed with your own research also.

HOMEWORK SIX: EXAM-STYLE QUESTI

Activity 1: Exam-style Questions

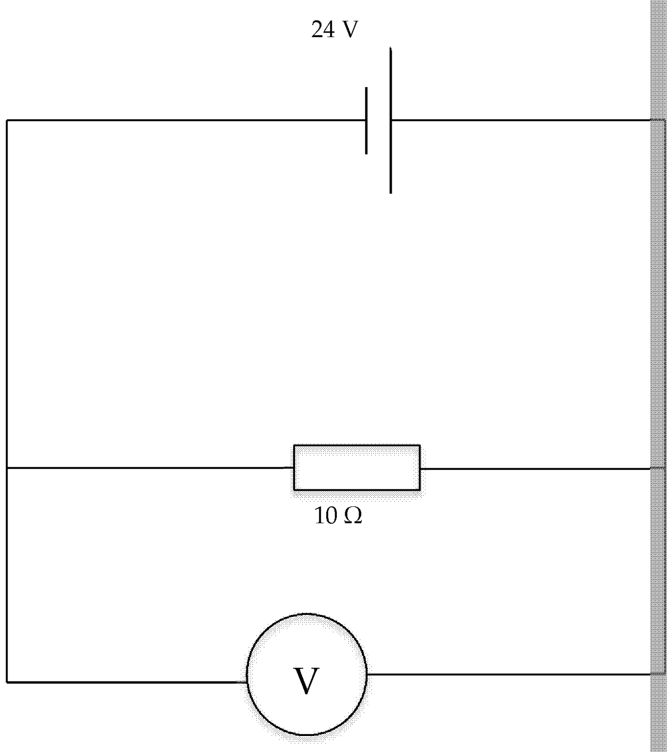
Aim: To practice and become comfortable with the level and style of exam

Task

1. A cell has electromotive force of 24 V; however, it can only provide 23.

Explain why the total possible emf is not supplied to the circuit.

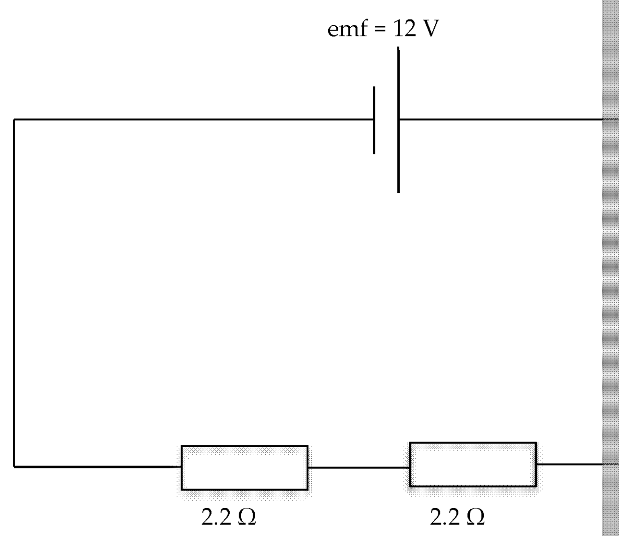
2. The circuit below was constructed to investigate the properties of inter electromotive force. The internal resistance of the 24 V emf source is 0.



a) Determine the reading on the voltmeter.

b) Explain what would happen to the reading on the voltmeter if the source increased.

3. A Year 10 physics student sets up the following circuit.



The internal resistance of the emf source is 0.2 Ω.

a) Calculate the current flowing through the circuit

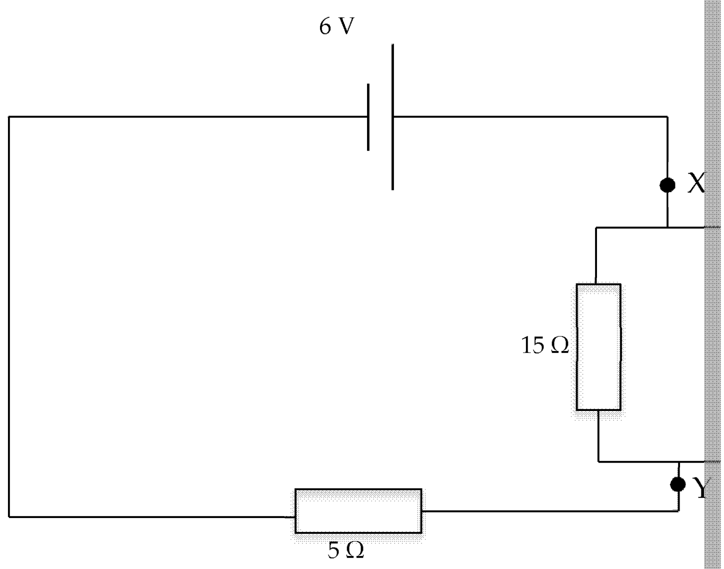
b) Calculate the potential difference across one of the 2.2 Ω resistors.

The current flows through the emf source for 500 seconds.

c) Determine the energy supplied per coulomb of charge flowing thr

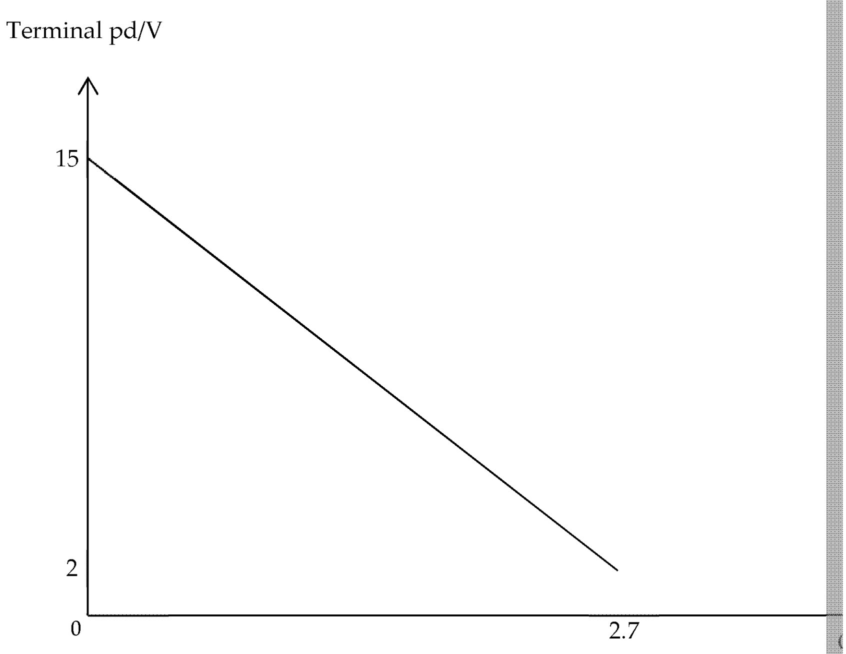
Extension Questions

4. The current flowing through the circuit below is 0.5 A.



a) Calculate the internal resistance of the battery.
b) Calculate the voltage between X and Y.
c) Determine the energy transferred from chemical to electrical energ
first 20 seconds.

5. A group of physicists is carrying out tests on the relationship between difference of a source and the current flowing through the source.



a) State the emf of the source used in the experiment.
b) Calculate the internal resistance of the source.
c) Calculate the terminal potential difference when the current was 1
d) Explain whether the terminal potential difference would have bee when 0.8 A of current was flowing through the circuit.

Activity 1: National Grid Recommendation

Aim: To develop your problem-solving skills, in the context of the physics

Task

Using the following brief, choose from the list of materials available to you
recommendation form provided by the National Grid.

Brief:
We are trying to reduce the power loss during transmission of electricity al
circuit section, and, therefore, are attempting to re-evaluate the dimensions
achieve this. We are, however, limited by certain parameters:

- Maximum length of cable needs to be 240 km
- Maximum cross-sectional area of the cable is 110 mm^2
- Maximum operating voltage is 400 kV
- Minimum power delivered of 1 MW
- Magnetic fields

In order to reduce the amount of power loss we need to ensure that we sup
current along cables with low resistivity. Please fill in our feedback form o
best we can achieve this.

Available materials:

- plastic cable, length 230 km, radius 5.6 mm
- aluminium cable, length 230 km, 5.6 mm
- plastic cable, 220 km, radius 5.5 mm
- aluminium cable, 220 km, radius 5.5 mm
- plastic cable, 220 km, radius 5.65 mm
- aluminium cable, 220 km, radius 5.6 mm

The National Grid Recommendati

	Recommendation
Material of Cable	
Length of Cable	
Radius of Cable	
Optimal Current	

Additional queries

1. What effect would a temperature increase in the cables have transmission?
2. Are there other methods of reducing the power loss in the c

HOMEWORK SEVEN: BE THE CONSULT

Activity 1: National Grid Recommendation

Aim: To develop your problem-solving skills, in the context of the physics

Task

Using the following brief, choose from the list of materials available to you recommendation form provided by the National Grid.

Brief:
We are trying to reduce the power loss during transmission of electricity al circuit section, and, therefore, are attempting to re-evaluate the dimensions achieve this. We are, however, limited by certain parameters:

- Maximum length of cable needs to be 240 km
- Maximum cross-sectional area of the cable is 110 mm^2
- Maximum operating voltage is 400 kV
- Minimum power delivered of 1 MW
- Magnetic fields

In order to reduce the amount of power loss we need to ensure that we sup current along cables with low resistivity. Please fill in our feedback form to achieve this.

Available materials:

- plastic cable, length 230 km, radius 5.7 mm
- aluminium cable, length 230 km, 5.7 mm
- copper cable, length 230 km, 5.7 mm
- plastic cable, length 245 km, radius 10.1 mm
- aluminium cable, length 245 km, radius 10.1 mm
- copper cable, length 245 km, radius 10.1 mm
- plastic cable, 220 km, radius 5.5 mm
- aluminium cable, 220 km, radius 5.5 mm
- copper cable, 220 km, radius 5.5 mm
- plastic cable, 210 km, radius 5.65 mm
- aluminium cable, 210 km, radius 5.65 mm
- copper cable, 210 km, radius 5.65 mm

You will need to complete some additional reading to complete your recom reading list is given below; however, you will need to do further reading.

Additional Reading:

- **http://www.cyberphysics.co.uk/topics/magnetsm/electro/nat_gri**
- **http://www.cyberphysics.co.uk/topics/magnetsm/electro/nat_gri**
- **http://www2.nationalgrid.com/uk/**
- **http://www.suptech.com/Cables_Oct_10.pdf**
- **http://large.stanford.edu/courses/2010/ph240/yankowitz1/**

The National Grid Recommendatio

	Recommendation
Material of Cable	
Length of Cable	
Radius of Cable	
Optimal Current	

Additional queries

1. What affect would a temperature increase in the cables have transmission?
2. Sketch a graph that would help to illustrate the effect tempe of our cables.
3. Are there other methods of reducing the power loss in the c
4. What temperature would we need to keep the cables at in o

HOMEWORK EIGHT: BE THE RESEARC

Activity 1: Research Investigation

Aim: To understand the properties and I-V characteristics of common elec

Task

Your task is to research the properties and I-V characteristics of a **metal wi** **resistor** and **filament lamp**.

From your own knowledge and from supplementary knowledge gained fr must report on the following points:

- Ohmic conductor
- I-V characteristic graph
- Explanation of I-V characteristic graph
- Conductivity of the component
- Applications of the component

You can present your research information in any appropriate format you formats are:

- Table
- PowerPoint slide
- Mind map

A table template is demonstrated below:

	Ohmic conductor	I-V graph
Semiconductor Diode		
Metal Wire		
Resistor		
Filament Lamp		

You will need to do additional research to complete the table. A few sugge however, you will need to read further.

Additional Reading:

- **http://www.electronics-tutorials.ws/blog/i-v-characteristic-curves.ht**
- **http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/curre**

HOMEWORK EIGHT: BE THE RESEARC

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Additional Reading:

- **http://www.electronics-tutorials.ws/blog/i-v-characteristic-curves.ht**
- **http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/cur**

HOMEWORK NINE: BE THE ELECTRICI

Activity 1: Designing Your Own Circuit

Aim: To design a working circuit.

Task

You will be presented with two design specifications and a list of the availa

Your task is to design circuits for two different companies which satisfy th specifications provided by each company. Along with each circuit design, t short report summary explaining your choices for the components used an

Design Specification1:
A refrigeration company is seeking a design for a circuit that can be implemented i purpose is to alert customers when the fridge door has been open too long. When th long the temperature in the fridge rises and the food can overheat.

Design Specification 2:
A camera manufacturer is seeking a design to improve the quality of the images on produces. The company wants a circuit which allows the shutter of the camera to r light level is low compared to when the light level is high. The camera shutter cont camera is exposed to light, and, therefore, when it is darker outside the sensor need in order to produce a quality image.

You have the following components:

- ×2 12V battery supplies
- thermistor
- bulb
- alarm
- LDR
- ×2 variable resistors
- ×2 switches
- ×2 transistors

You have to use the components for both design specifications.

Transistors
A transistor is a device that can be used as an electrical switch in circuits. A two separate circuits; it 'switches' the second half of the circuit on when it h voltage supply from the first half of the circuit. Usually a transistor will 'sw with 0.7 V, above which it allows current to flow into the second half of the

HOMEWORK TEN: BECOMING ONE OF THE B

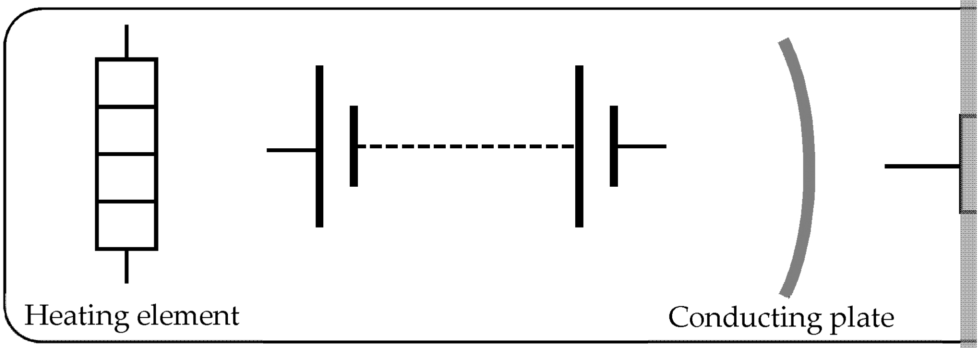
Activity: Designing the electron gun

Aim: You are an evil villain who is poised to take over the world. To ensur orders, you will design and build an electron gun – that way everyone wil design process below, answering any questions that are posed.

Task

When a conducting plate heats up, free electrons in the plate gain kineti when these electrons gain enough energy to escape the conducting plate. described as evaporating from the surface of the wire in a process known These emitted electrons aren't in a gaseous state but they do behave simi

1. Using the circuit symbols in the box below, draw a circuit that can var conducting plate and, therefore, vary the intensity of your electron gu



A typical firearm uses the rapidly expanding gas from an exothermic co (i.e. an explosion) to quickly accelerate a projectile. Electrons, however, a projectiles used in firearms, so instead are accelerated using electric field

2. Describe how an electric field accelerates electrons. Fill in the gaps bel answer.

An electron has charge, which means it ____________________

When in the presence of an __________, an electron will experience a f to the field.

By Newton's second law, _______, this force causes ____________

3. Draw a second circuit on your drawing from question 1 that accelerat the principles from your answer for question 2. (Hint: you need to set electrons are emitted from the conducting plate.)

You now have a circuit diagram for your electron gun, and you successfull

The wire connecting the heat element to a battery has a diameter of 1.25 copper, which has a free electron density of $n = 8.49 \times 10^{28}$ m⁻³. You pla around the wire and measure the current to be $I = 2.25$ A.

4. Calculate the mean drift velocity through the wire. You will need to us

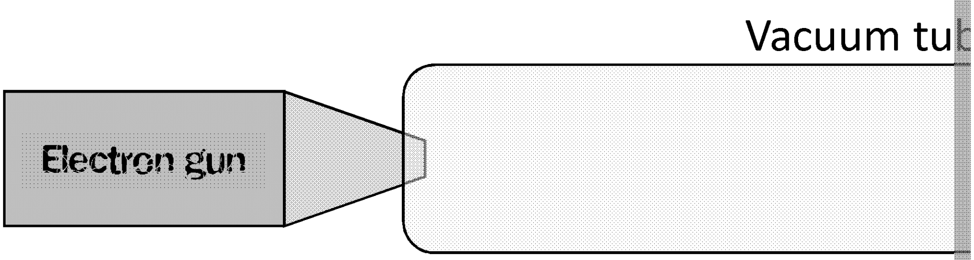
You fire your gun at a nearby fluorescent screen. The screen lights up wh find that the electrons are firing in random directions once they exit the g

5. Describe one improvement or addition to the gun that will focus the el beam. (Hint: think about how electrons can be accelerated.)

After making the improvements from question 5, you build your second working electron gun that fires electrons precisely where you want. Now world!

You show your friend your ray gun before instilling fear in the masses. H don't penetrate through air that well (as you may remember, beta radiati penetrates through a few metres of air). Not only that, but electrons aren' on their kinetic energy. Looks as though your plans for world dominatio hold.

Your friend does inform you that your work hasn't gone to waste, howev gun is used in fluorescent lights, among other uses. The electron gun is c as shown in the diagram below.



6. What effect does the vacuum have on the emitted electrons?

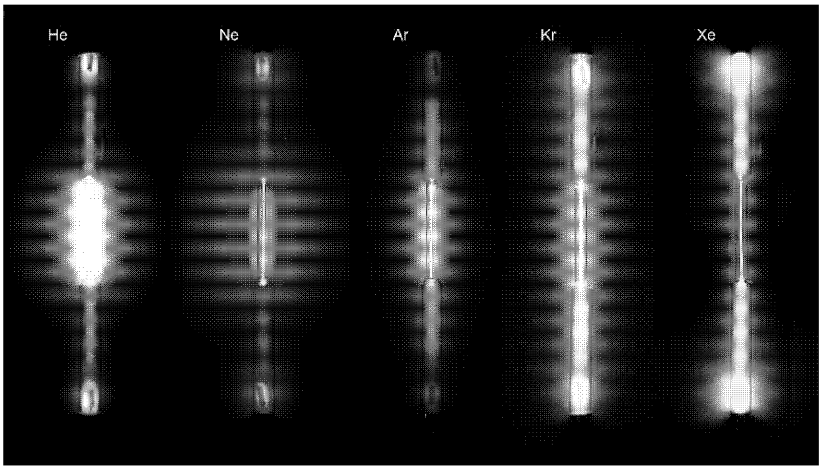
A little bit of elemental gas (a gas of one element, such as pure nitrogen) This gas is then ionised using a strong potential difference set up across Electrons are accelerated and emitted at high speeds from the electron gu ionised gas. These electrons excite the ionised gas atoms, which then emi back to their ground state. The wavelength of the emitted photons depen the ionised atoms and is, therefore, specific to the element used.

7. The electrons accelerated by your electron gun pass through a potentia

   a) Calculate the work done on an electron by the electron gun.

   b) Assuming the electrons were approximately stationary before bein velocity of the electrons as they leave the gun and travel through t

Many elements can be used as the gas in the discharge tube (a gas discha name for your contraption). The noble gases are the most common in ligh an image of the five noble gases showing the different colours (i.e. wavel



You decide to implement your electron gun in a neon sign that will sprea and rage! It's not quite what you had in mind, but a successful campaign start with good PR.

8. The noble gases are not the only gases that can be used in a gas dischar gases used. Two of them are nitrogen and oxygen – name two others.

The design of a gas discharge tube is used in fluorescent lighting (the lor large rooms such as classrooms). These use mercury which emits UV ligh incident electrons. This UV light is converted into white visible light usi inside of the tube.

9. Explain the energy transfer step by step, describing how the electric po converted into visible light using fluorescent lighting. Use the template answer.

The energy transferred as electrical power is…

The accelerated electrons now have kinetic energy and…

These atoms fall back to a lower…

The fluorescent coating then re-emits the light as…

HOMEWORK TEN: BECOMING ONE OF THE B

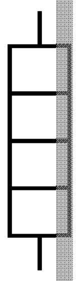
Activity: Designing the electron gun

Aim: You are an evil villain who is poised to take over the world. To ensu orders, you will design and build an electron gun that way – everyone wil design process below, answering any questions that are posed.

Task

When a conducting plate heats up, free electrons in the plate gain kineti when these electrons gain enough energy to escape the conducting plate. described as evaporating from the surface of the wire in a process known These emitted electrons aren't in a gaseous state but they do behave simi

1. Using the circuit symbols to the right, draw a circuit that can vary the heat supplied to the conducting plate and, therefore, vary the intensity of your electron gun.



Heating el

A typical firearm uses the rapidly expanding gas from an exothermic combustion of propellant (i.e. an explosion) to quickly accelerate a projectile. Electrons, however, are much smaller than the projectiles used in firearms, so instead are accelerated using electric fields.

2. Describe how an electric field accelerates electrons.

3. Draw a second circuit on your drawing from question 1 that accelerate the principles from your answer for question 2. Label the anode and ca

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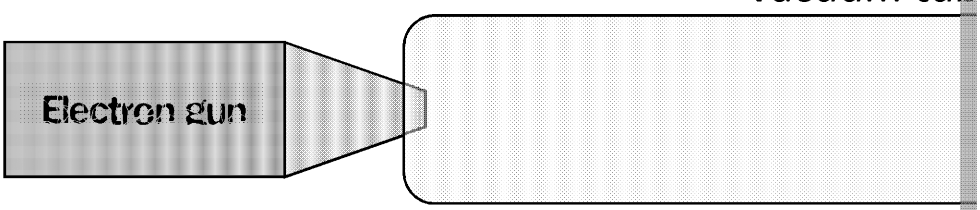
Your friend does inform you that your work hasn't gone to waste, howev electron gun is used in fluorescent lights, among other uses. The electron vacuum tube, as shown in the diagram below.

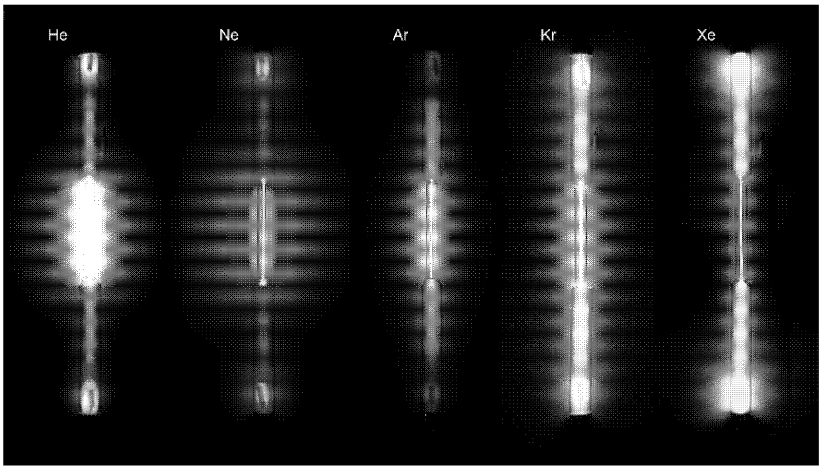


6. What effect does the vacuum have on the emitted electrons?

A little bit of gas is let into the vacuum tube. This gas is then ionised using set up across either end of the tube. Electrons are accelerated and emitted a electron gun, travelling through the ionised gas. These electrons excite the then emit photons when they fall back to their ground state. The waveleng depends on the energy levels of the ionised atoms and is, therefore, specifi

7. The electrons accelerated by your electron gun pass through a potentia Assuming the electrons were approximately stationary before being ac velocity of the electrons as they leave the gun and travel through the io

Many elements can be used as the gas in the discharge tube (a gas discha your contraption). The noble gases are the most common in lighting appl of the five noble gases showing the different colours (i.e. wavelengths) o



You decide to implement your electron gun in a neon sign that will sprea and rage! It's not quite what you had in mind, but a successful campaign start with good PR.

8. The noble gases are not the only gases that can be used in a gas dischar gases used and name at least four elements.

The design of a gas discharge tube is used in fluorescent lighting (the long t such as classrooms). These use mercury, which emits UV light after being ex This UV light is converted into white visible light using a filter painted on t

9. Explain the energy transfer step by step, describing how the electric po converted into visible light using fluorescent lighting.

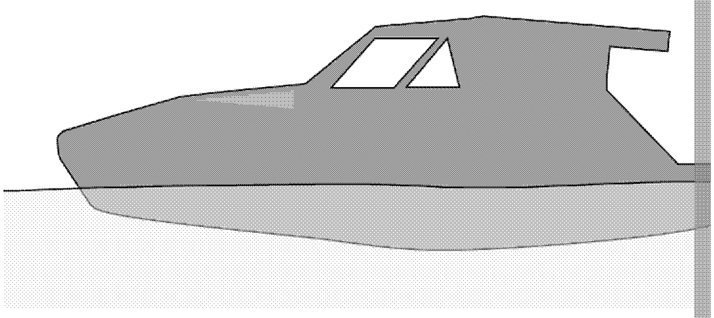
Activity 1: Questions

Aim: To help design engineers make a boat more effective at moving throu

Task

1. Design engineers are trying to design the shape of a private yacht to be diagram below, draw and label all the forces that act on the boat when below gives you all of the forces you need, plus some extra quantities.

WEIGHT	VELOCITY	UPTHRUST
MASS		ACCELERATION



The boat experiences drag from both the air and the water.

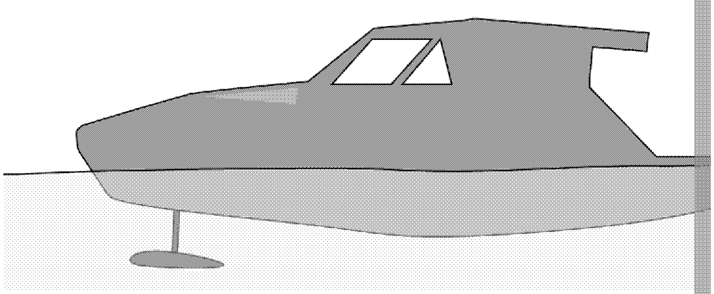
2. Name one factor that affects the magnitude of the drag force due to wa

The total mass of the yacht is 5500 kg. The density of water is 1000 kg m^{-3}

3. What upthrust must the water provide to keep the boat floating?

4. Calculate the volume of water displaced by the boat based on the upth

One engineer suggests to add a foil to the underneath of the boat, as seen that creates upthrust when a fluid such as water flows over it. A plane wi creates lift when the plane moves fast enough. The foil attached to the bo of the water on its front end.



5. How does this benefit the efficiency of the boat?

Activity 2: Questions

Aim: To help design engineers make a command module more effective at

Rocket engineers are designing the heat shield for the command module spacecraft. The heat shield is used during the re-entry into the atmosphe to slow down the module via a drag force. This creates immense amount heat, hence its name. It's placed on the bottom of the module, so the rest the module is protected by the shield.

1. Explain how drag creates immense amount of heat around fast moving objects. Hint: think about the friction of air.

2. Name one factor that affects how effective the heat shield is at slowing

3. Two of the engineers are in an argument over the design. Adam says
"The heat shield should be replaced with a cone because this sh

   Whereas Beth says
"The heat shield should stay as a flat disc as this shape has

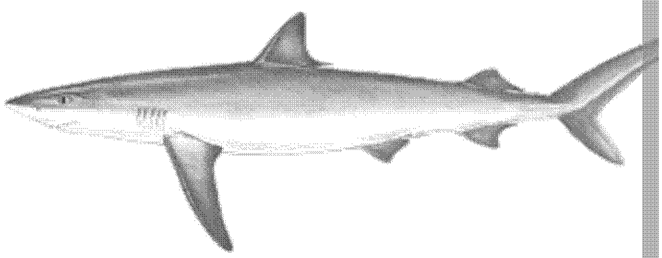
Which design do you think the engineers should go for and why?

Activity 3: Questions

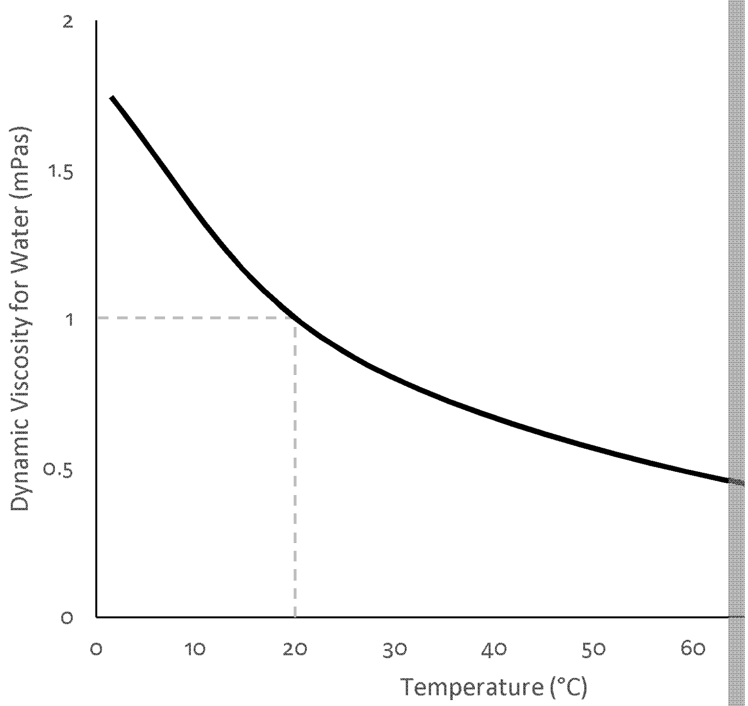
Aim: To help design engineers analyse the efficient shape of a shark.

Sharks have evolved over millions of years to efficiently swim through w naturally designed to cut through the water, allowing sharks to quickly c diagram of a blue shark. A typical blue shark will grow to over 2 m long. determining what makes a shark so efficient at moving through water, in grade submarines with similar features.

1. A blue shark will move through the water so the water flows from its r about the sharks shape reduces the drag force experienced by the shar



2. The graph below describes the relationship between viscosity and tem



a) What is the viscosity of water at 20 °C?

The shark swims in 20°C water at 2.5 m s^{-1}. Its radius (of cross-sectio is 20 cm.

b) Calculate the viscous drag force that acts on the shark as it swims law.

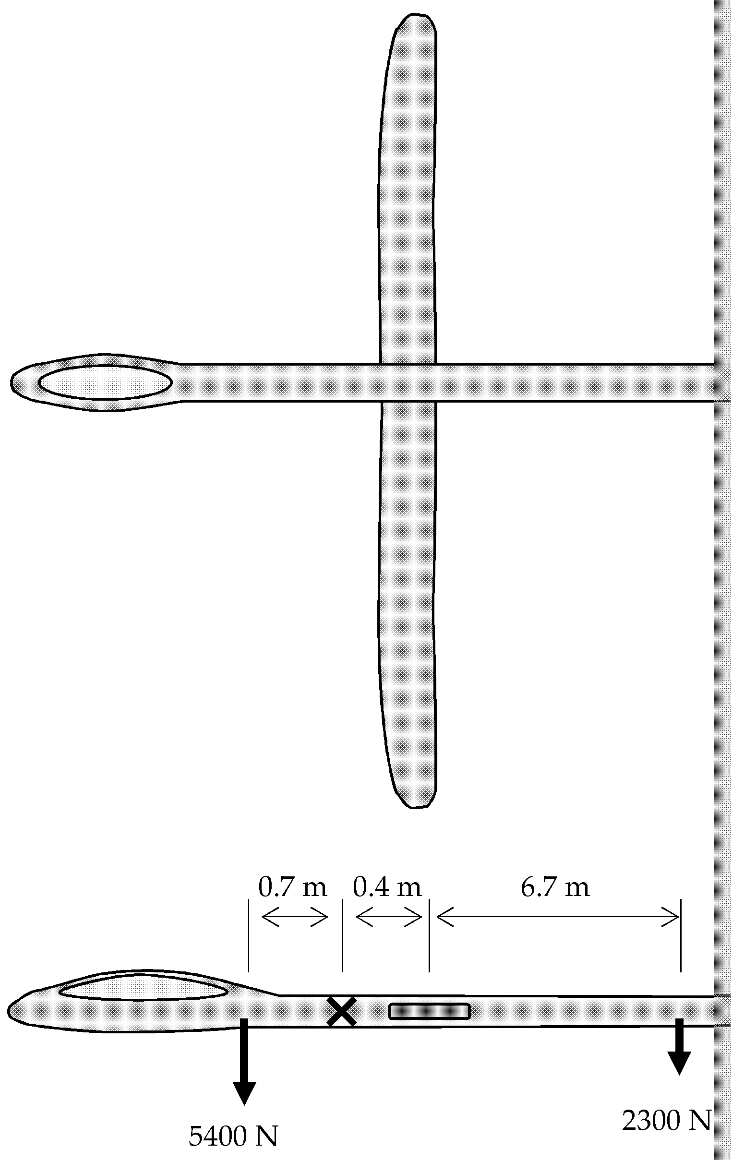
c) Comment on the realistic nature of your answer.

3. Sharks can swim to different depths using their fins. Man-made subm Instead they have tanks called ballasts that they fill with water if they Explain how filling water in the submarine allows it to dive to deeper initially have air in them which is less dense than water.

Activity 4: Questions

Aim: To help design engineers make their glider more effective at moving t

A glider is a single or dual passenger aircraft that has no means of propul up to a high altitude and glides down until it needs to land. An aeronauti prototype for a new glider to write a report on its design. The design of th



1. The glider can be split into two parts, in front of the wing and behind t its own weight that acts about the centre of mass of the whole aircraft, the upthrust needed by the main wings (ignore the tail wings) to ensur tip up or down during flight. Use the template below to help you in yo

Anticlockwise moments   Clockwise moments   For the glider to stay balanced, the clockwise and anticlockwise r therefore:

2. The wing has a height (from its bottom to its top) of 16 cm. Calculate th between the top and bottom of the wing when the glider is stationary c (ρ_{air} = 1.225 kg m^{-3})

3. The glider falls by 10 m in 10 s after reaching its maximum altitude. Us acceleration of the glider. Assume the initial velocity, u, is zero becaus to is maximum altitude.

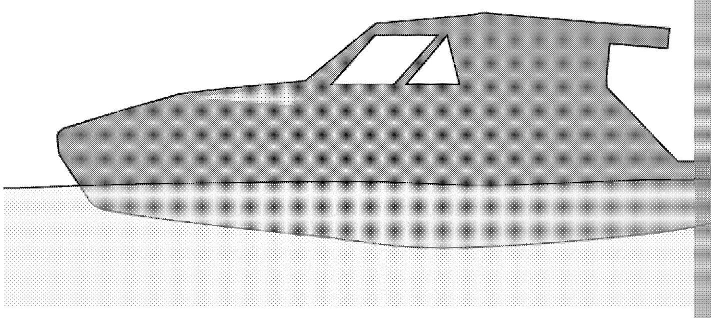
HOMEWORK ELEVEN: GIVING THE ENGINEER

Activity 1: Questions

Aim: To help design engineers make a boat more effective at moving throu

Task

1. Design engineers are trying to design the shape of a private yacht to be diagram below, draw and label all the forces that act on the boat when



The boat experiences drag from both the air and the water.

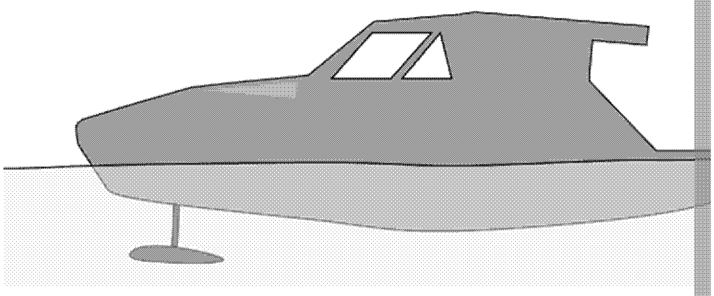
2. Name two factors that affect the magnitude of the drag force due to air the drag force.

The total mass of the yacht is 5500 kg. The density of water is 1000 kg m^{-3}

3. Calculate the volume of water displaced by the boat.

One engineer suggests to add a foil to the underneath of the boat, as seen that creates upthrust when a fluid such as water flows over it. When the b upthrust on the front end of the boat.

4. Explain what would happen to the boat due to this upthrust and how of the boat?



Activity 2: Questions

Aim: To help design engineers make a rocket more effective at moving thr

Roket engineers are designing the heat shield for the command module the next generation of spacecraft. The heat shield is used during the re-entry into the atmosphere to slow down the module via a drag force. This creates immense amount of heat, hence its name. It's placed on the botto of the module, so the rest of the module is protected by the shield.

1. Explain how this heat shield reduces the sped of the command modul

2. Two of the engineers are in an argument over the design. Adam says
   "The heat shield should be replaced with a cone because this sh

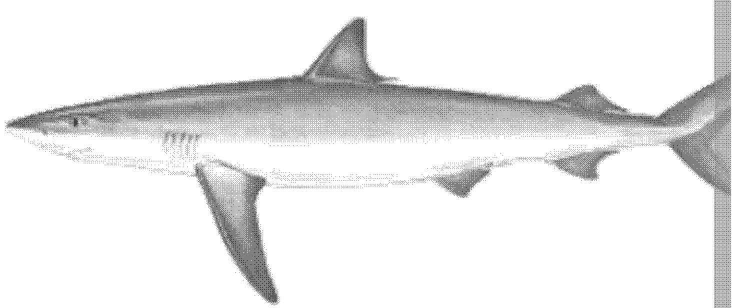
   Whereas Beth says
   "The heat shield should stay as a flat disc as this shape has

   Which design do you think the engineers should go for and why?

Activity 3: Questions

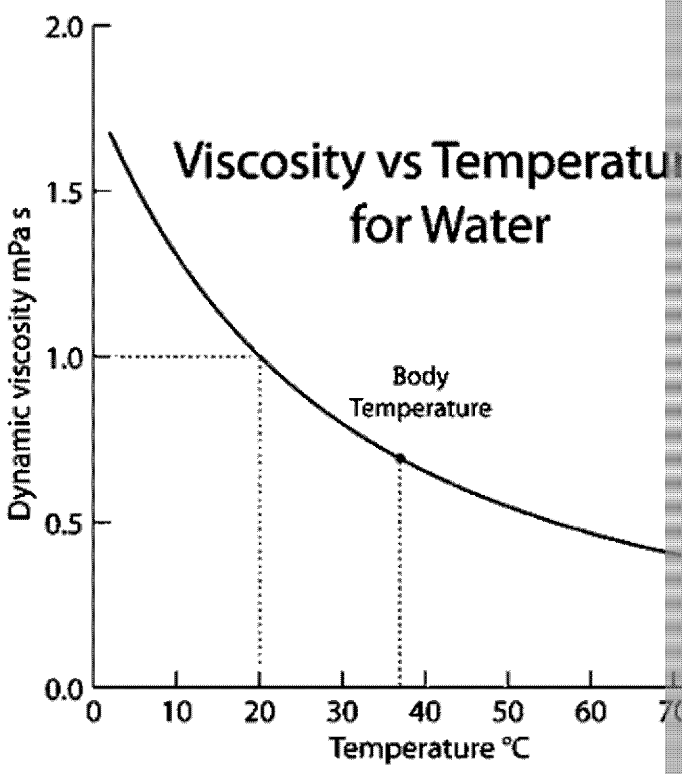
Aim: To help design engineers analyse the efficient shape of a shark.

Sharks have evolved over millions of years to efficiently swim through w been naturally designed to cut through the water, allowing sharks to qui Below is a diagram of a blue shark. A typical blue shark will grow to ove tasked with determining what makes a shark so efficient at moving thro design military grade submarines with similar features.



1. A blue shark will move through the water so the water flows from its r about the sharks shape reduces the drag force experienced by the shar

2. Using the graph below, determine the viscous drag force using Stokes
as it swims at 2.5 m s^{-1} and if its radius (of cross-sectional area relative
temperature of the sea water where blue sharks swim is 20 °C. Comme
your answer.



3. Sharks can swim to different depths using their fins. Man-made subm
Instead they have tanks called ballasts that they fill with water if they
Explain how filling water in the submarine allows it to dive to deeper

Activity 4: Questions

Aim: To help design engineers make their glider more effective at moving

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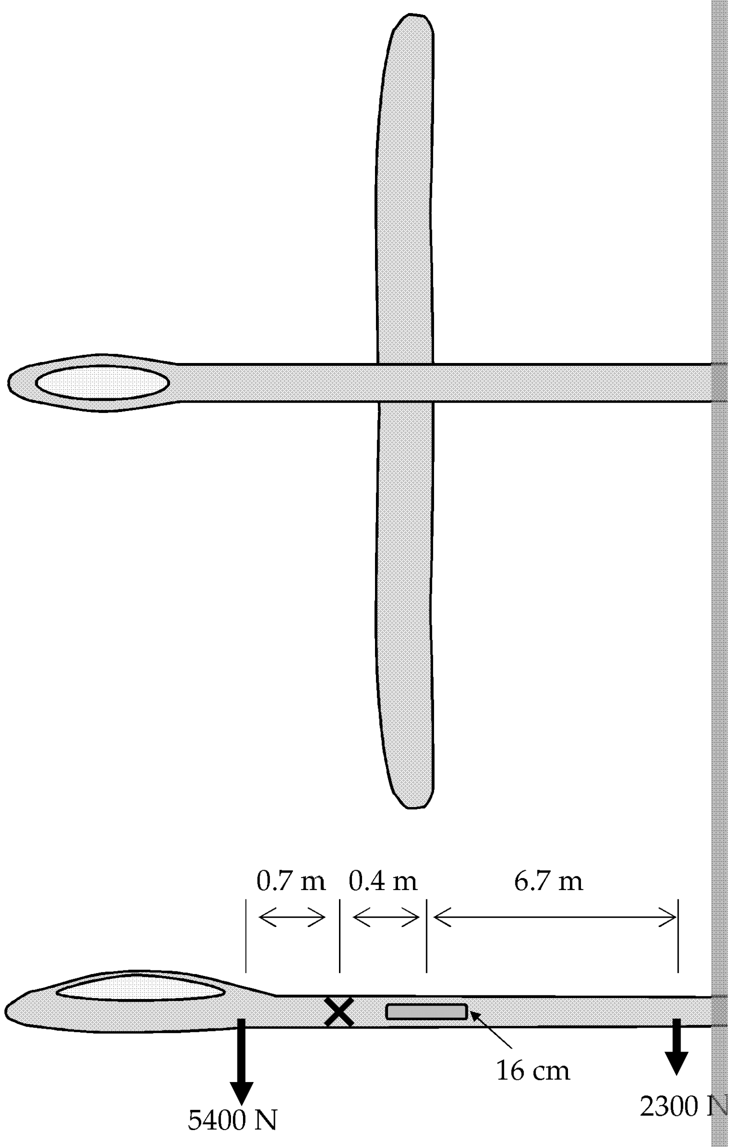


1. The glider can be split into two parts, in front of the wing and behind t own weight that acts about the centre of mass of the whole aircraft, ma upthrust needed by the wings (ignore the tail wings) to ensure the pla down during flight

2. The wing has a height (from its bottom to its top) of 16 cm. Calculate t between the top and bottom of the wing when the glider is stationary (ρ_{air} = 1.225 kg m^{-3})

3. The glider falls by 10 m in 10 s after reaching its maximum altitude. U acceleration of the glider. Assume the initial velocity, u, is zero becaus to is maximum altitude. What is the acceleration due to upthrust from

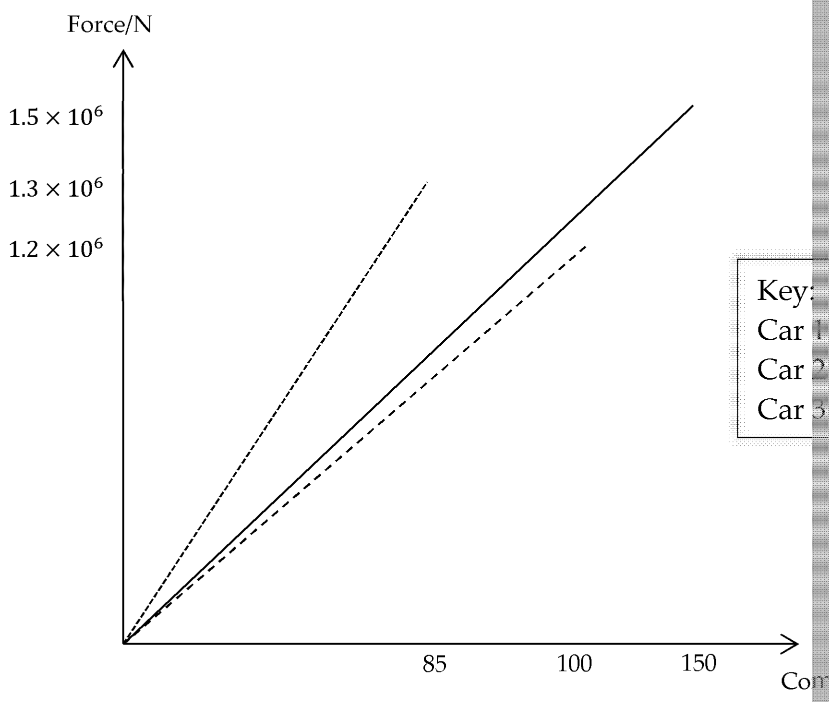
Activity 1: Graph Analysis Question

Aim: Interpret graphical data to form evidenced-based judgments.

Task

A group of engineers have produced a set of graphical data from a range of carried out on three cars' suspensions.

The cars' suspensions are made of springs that compress during the cars' m unwanted energy gained when travelling over bumps or holes in the road.



a) Explain the energy transformation that occurs during compression.
b) Which car has spring suspension with greatest spring constant?
c) What does your answer from (b) tell you about the properties of the sp suspension?
d) Explain which car's spring stores the greatest elastic potential energy.

The group of engineers have not completed all of the data analysis for their want to determine the Young's modulus of the different springs used in ea

Below is a list of raw data of the dimension of the springs in each car.

	Length of Spring/m	Radius of sp
Car 1	0.25	0.05
Car 2	0.30	0.1
Car 3	0.28	0.06

The cross-sectional area of a spring is a circle and, therefore, the equation fo

$$A = \pi r^2$$

e) Sketch the relationship between tensile stress and tensile strain for each
f) From the graph sketched in (f) determine the Young's modulus of each

HOMEWORK TWELVE: GRAPH SKILL

Activity 1: Graph Analysis Question

Aim: Interpret graphical data to form evidenced-based judgments.

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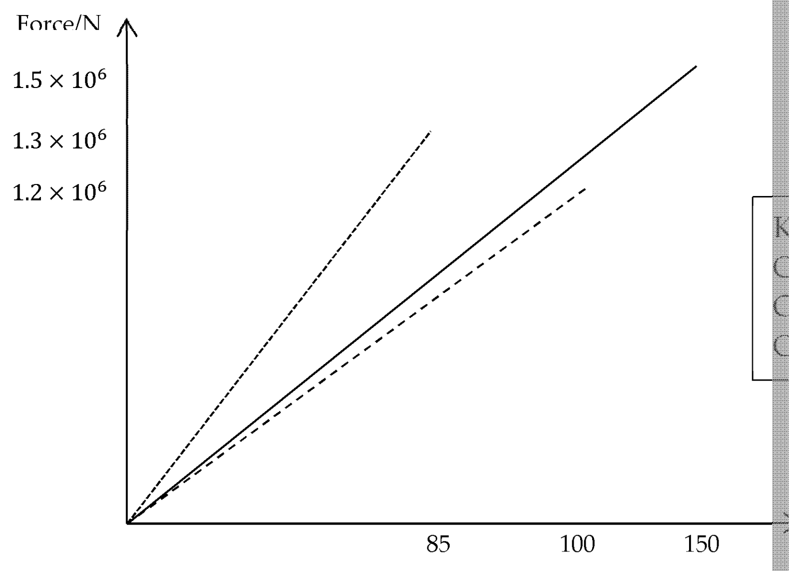
The cars' suspensions are made of springs that compress during the cars' m unwanted energy gained when travelling over bumps or holes in the road.



a) Explain the energy transformation that occurs during compression.
b) Which car has spring suspension with greatest spring constant?
c) What does your answer from (b) tell you about the properties of that c

The data was collected from three different cars, but for the purpose of com compression was collected when all three cars were travelling with the sam

d) Explain which car is the heaviest.

The group of engineers have not completed all of the data analysis for their want to determine the Young's modulus of the different springs used in ea

Below is a list of raw data of the dimension of the springs in each car.

	Length of Spring/m	Radius of sp
Car 1	0.25	0.05
Car 2	0.30	0.1
Car 3	0.28	0.06

The cross-sectional area of a spring can be estimated as the cross-sectional a

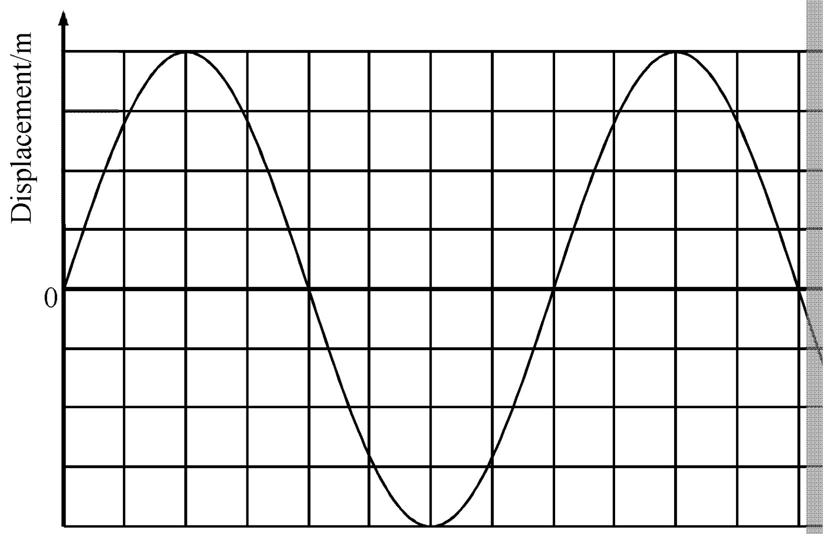
e) Sketch the relationship between tensile stress and tensile strain for each
f) From the graph sketched in (f) determine the Young's modulus of each

Activity 1: Summary Questions

Aim: Complete summary questions to demonstrate understanding of the to

1. On the following graph indicate the following wave properties:

- Amplitude
- Wavelength
- Displacement



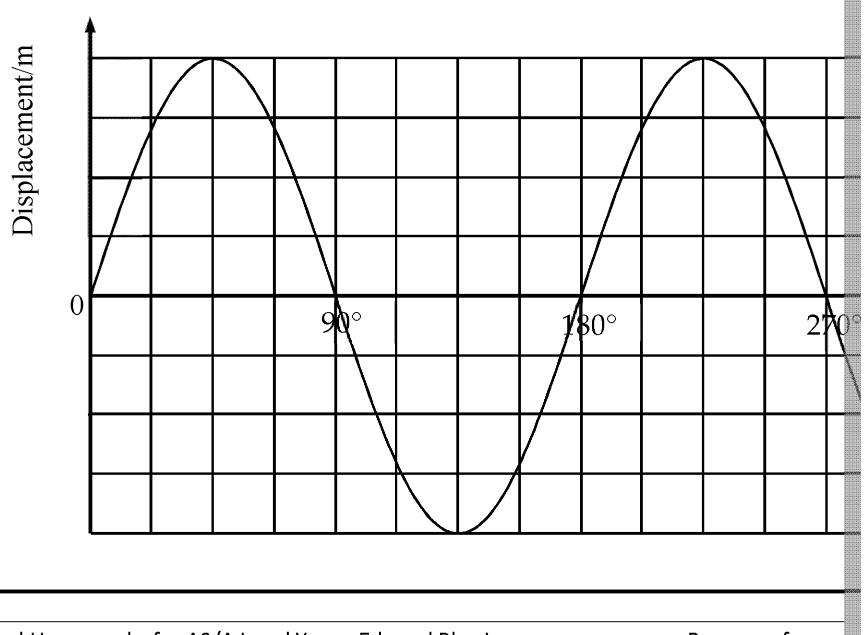
2. Sketch the snapshot of a sound wave.

On the sketch, indicate both the direction of oscillation of the particles of the wave itself.

3. On the following graph, mark two points that have a phase difference

a) 45°

b) $\frac{1}{2}$ of a fraction of a cycle



c) Explain whether the wave represented in the graph is transverse o

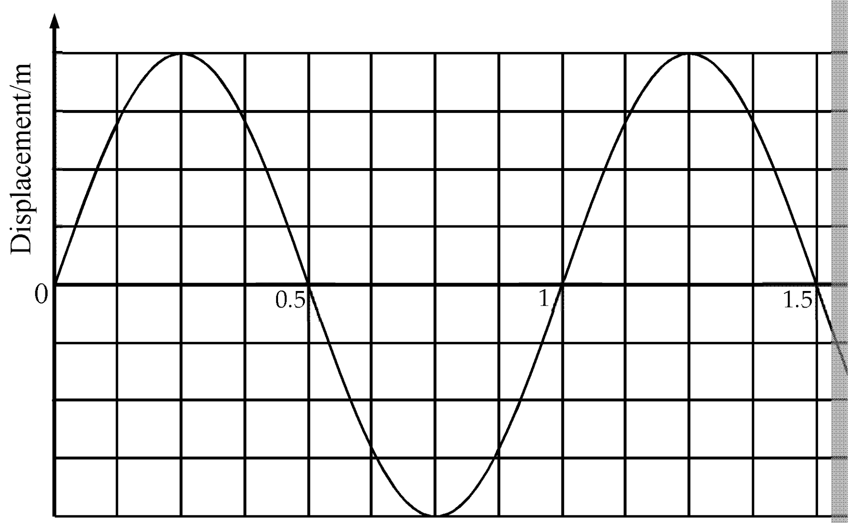
d) Give one example of a transverse wave and one example of a long

4. A radio wave can travel 50 km in one cycle.

It takes 1.7×10^{-4} seconds to complete one cycle.

Calculate the wave speed of the wave that travels 50 km in one cycle.

5. A wave, with frequency 0.5 kHz, is represented by the following graph



a) Calculate the wave speed of the wave represented in the graph.

b) Calculate the period of the wave.

c) Comment on what will happen to the wave speed if the period is i remains constant.

6. Polaroid filters are used in the manufacture of sunglasses in order to r

a) Comment on the speed of sunlight.

b) Explain what the effect **one** polaroid filter has on sunlight travelli

c) Explain what would happen to the sunlight received if a second p to the first polariser.

One of the wavelengths that comprise the range of wavelengths that m

d) Calculate the frequency of light with wavelength of 500 nm.

e) Comment on the effect on the frequency of light if the wavelength

f) State another application of polarisation.

Activity 1: Summary Questions

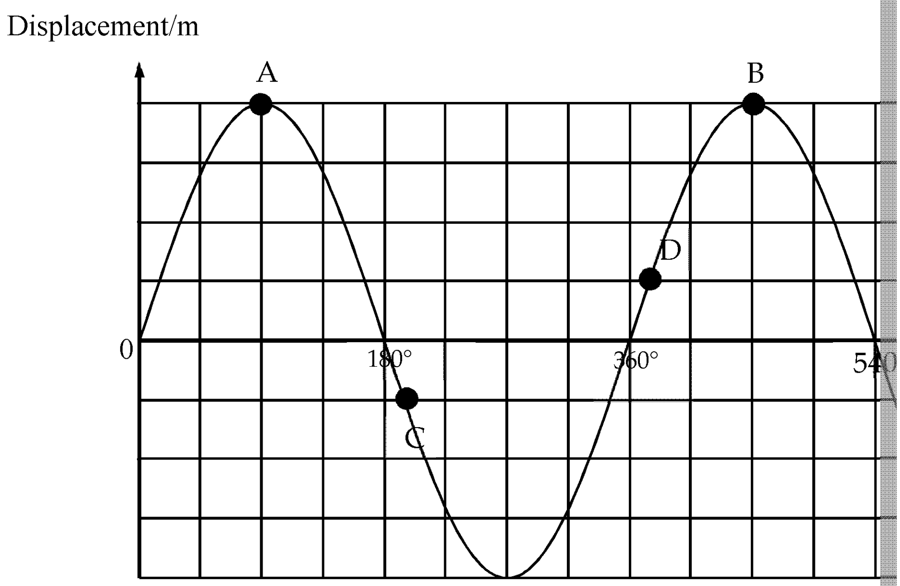
Aim: Complete summary questions to demonstrate understanding of the to

1. Sketch a snapshot of a sound wave.

On the sketch indicate both the direction of oscillation of the particles o of the wave itself.

2. On the following graph comment on the phase difference, both degrees

a) A and B
b) C and D



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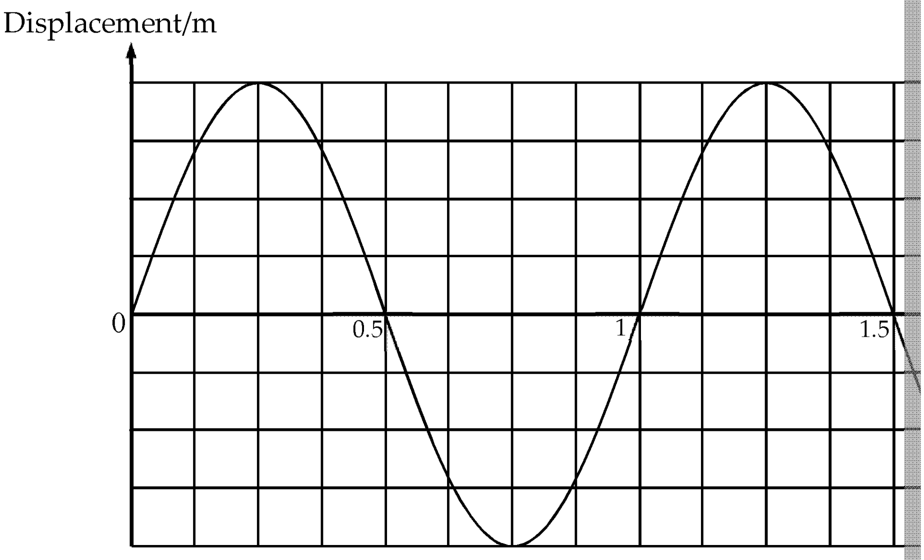

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b) Calculate the period of the wave.
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wavelength remained constant.

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a) Comment on the speed of sunlight.
b) Explain what the effect **one** polaroid filter has on sunlight travelli
c) Explain what would happen if a second polariser is introduced at 9

The wavelength of part of the light that comprises sunlight is 500 nm.

d) Calculate the frequency of light with wavelength of 500 nm.
e) Comment on the effect on the frequency of light if the wavelength
f) State another application of polarisation.

HOMEWORK FOURTEEN: BE THE ENGI

Activity 1: Letter of explanation

Aim: To use your knowledge of physics to recommend experimental set-u

Task

A recording company is attempting to set up a speaker in their new studio. engineer to obtain some advice on the best method to arrange the speakers email they suggest that, for one of the speakers, they are going to set it up room's walls.

You are the sound engineer and you are expected to write an email, illustr up one of the speakers directly facing the wall. Your professional opinion scientific evidence to give your advice credibility and for the studio to take

The email must include reference to:

- Stationary waves
- Nodes and antinodes
- Harmonics
- Frequency

The template below provides an idea of how to structure your letter.

Name of recipient
Address of the recipient

Dear [Name of recipient]

HOMEWORK FOURTEEN: BE THE ENGI

Activity 1: Letter of Explanation

Aim: To use your knowledge of physics to recommend experimental set-u

Task

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You are the sound engineer and you are to write an email, illustrating your speaker directly facing the wall. Your professional opinion must be backed give your advice credibility and for the studio to take it on board.

The email must include reference to:

- Stationary waves
- Nodes and antinodes
- Harmonics
- Frequency

HOMEWORK FIFTEEN: HOW TO SEE *AVAST*

Activity: A pirate's life for me

Aim: To develop a telescope by understanding and applying the principles

Task

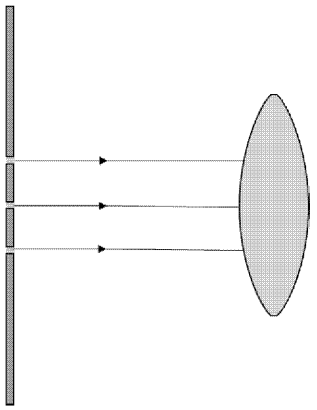
You are the captain of The Cruel Curse, a feared pirate ship that sails the seven seas. While at Tortuga you hear that the Royal Navy has develope a device that allows them to see the horizon in detail. You can't allow them to have such an advantage so must create a similar device for yourself. Your research tells you that you need to use a lens.

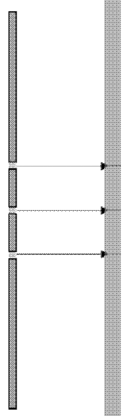
1. **a)** Name two types of lens that affect parallel rays of light differently

You get your hands on two lenses, one of each type named in question 1 slits in some wood, and align the wood and each lens with the sun.

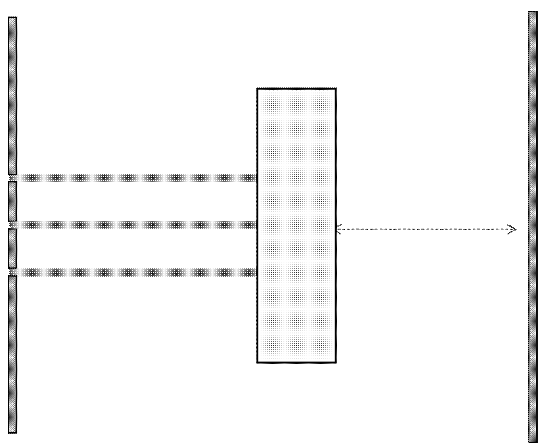
b) What is the purpose of adding slits in the wood and placing this w

c) Complete the ray diagrams below, which trace the path of the ligh each lens as one of the types stated in question 1.





You place another piece of wood behind one of the lenses and adjust the and the lens, as shown in the diagram on the next page. There is a point second piece of wood becomes a small, bright spot.

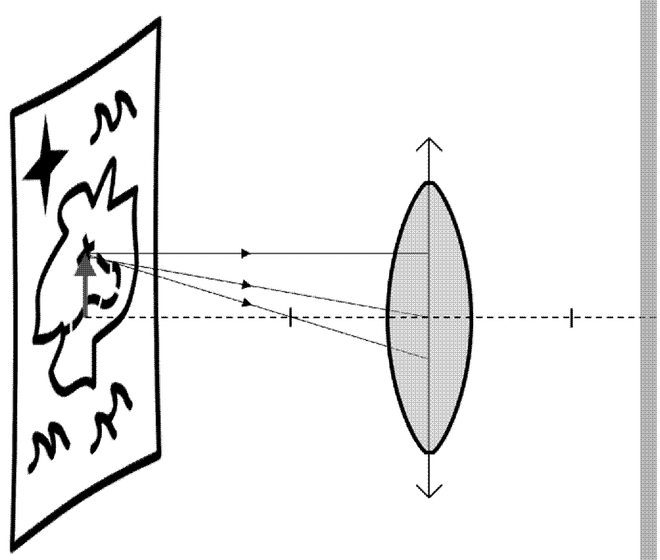


2. a) What type of lens was used?

b) What is the name given to the distance between the lens and the sc

After playing around with the converging lens some more, you find that when looking through the lens at which a clear image is seen. You look a your lens.

3. Complete the ray diagram below to show the formation of the image.



You notice that if you keep your eye a fixed distance away from the map, lens between you and the map, the image of the island changes size. You details on the map with great clarity – your fellow sea dog suggests that t applied to looking at the horizon.

The magnification of a lens is described by the ratio between the height the height of the object itself.

4. If a poppy seed has a height of 7.5 mm and is observed to have a heigh converging lens, what is the magnification of the lens?

5. a) The lens from question 4 is used to read a finely written letter. The from the letter. How far away from the lens is the image produced

b) What is the focal length in this case?

The smaller the focal length of a lens, the more the lens bends the light. T of a lens and is given by the inverse of the focal length.

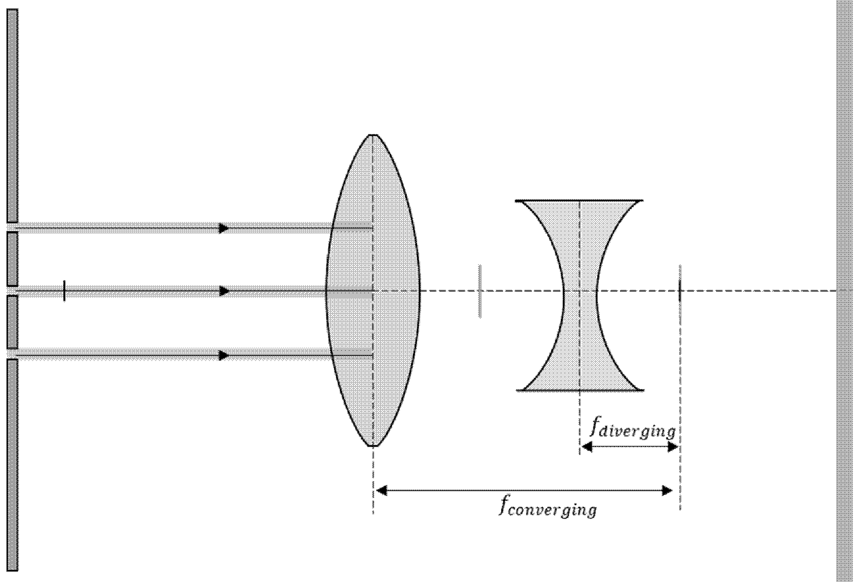
c) What is the power of the lens used to view the letter?

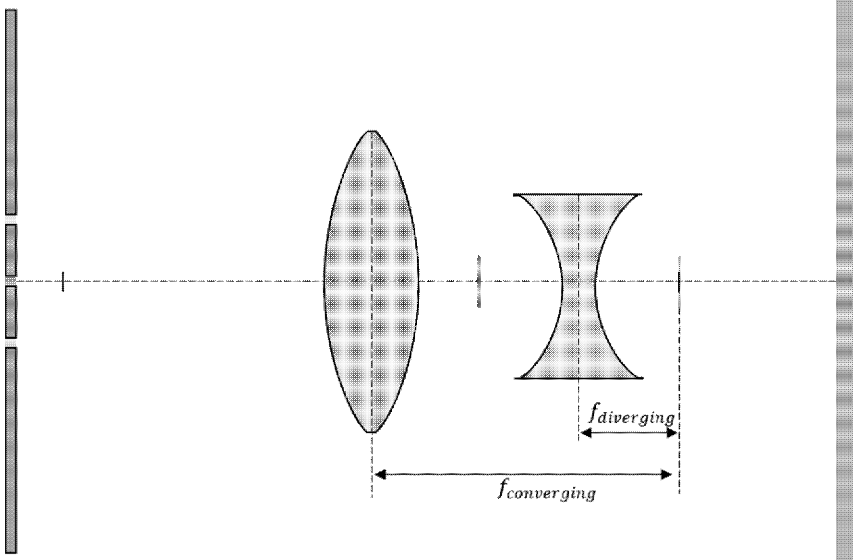
A single diverging lens is able to magnify an object; however, you have to distance away from the lens. Otherwise, the light rays diverge too much ar

You start to experiment with the diverging lens and find that any converg pass through the lens are refracted into parallel rays, if the lens is positio You position a diverging lens behind a converging lens so its focal length with the focal length of the converging lens, as shown below.

The three light rays pass through both lenses and hit the second piece of

6. Complete the ray diagram below showing the light passing though bo





The image produced on the wood is a magnified version of the object an we move the wood away from the lens. We can view this image at any di lens – hooray!

This device is known as a telescope, specifically a Galilean telescope. Th as the objective lens, and the diverging lens is known as the eyepiece.

You can now use your telescope to view your distant enemies out on the

Extension task

A Keplerian telescope uses two converging lenses instead of one convergin Research how Keplerian telescopes work and what their advantages are ov a ray diagram showing how a Keplerian telescope produces an image, and such a telescope.

HOMEWORK FIFTEEN: HOW TO SEE *AVAST* D

Activity: A pirates life for me

Aim: To develop a telescope by understanding and applying the principles

Task

You are the captain of The Cruel Curse, a feared pirate ship that sails the seven seas. While at Tortuga you hear that the Royal Navy has developed a device that allows them to see the horizon in detail. You can't allow them to have such an advantage so must create a similar device for yourself. Your research tells you that you need to use a lens.

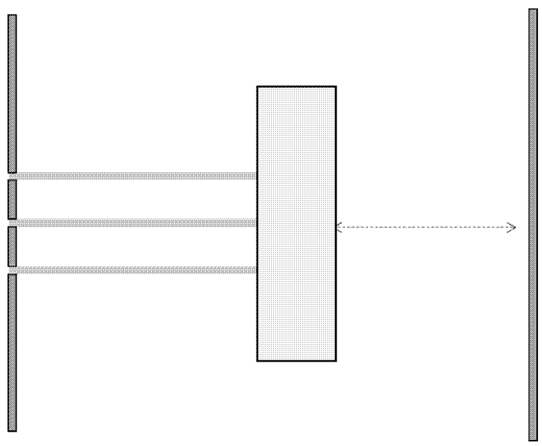
1. a) Name two types of lens that affect parallel rays of light differently.

You get your hands on two lenses, one of each type named in question 1. in some wood, and align the wood and each lens with the sun.

b) What is the purpose of adding slits in the wood and placing this w

c) Draw a ray diagram of each lens as it refracts incident parallel rays

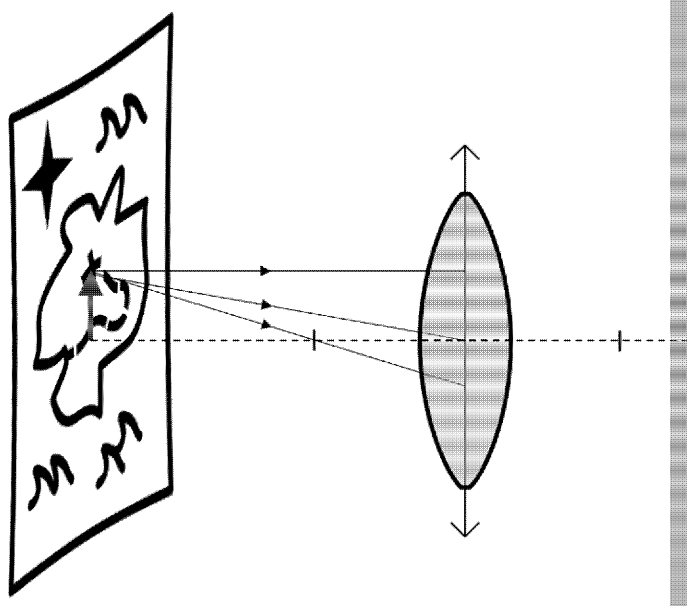
You place another piece of wood behind one of the lenses and adjust the and the lens, as shown in the diagram below. There is a point where the l wood becomes a small, bright spot.



2. What type of lens was used? Label the diagram above with any relevar

After playing around with the converging lens some more, you find that at which a clear image is seen when looking through the lens. You look a your lens.

3. Complete the ray diagram below to show the formation of the image.



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The magnification of a lens is described by the ratio between the height the height of the object itself.

4. a) If a poppy seed has a height of 7.5 mm and is observed to have a h converging lens, what is the magnification of the lens?

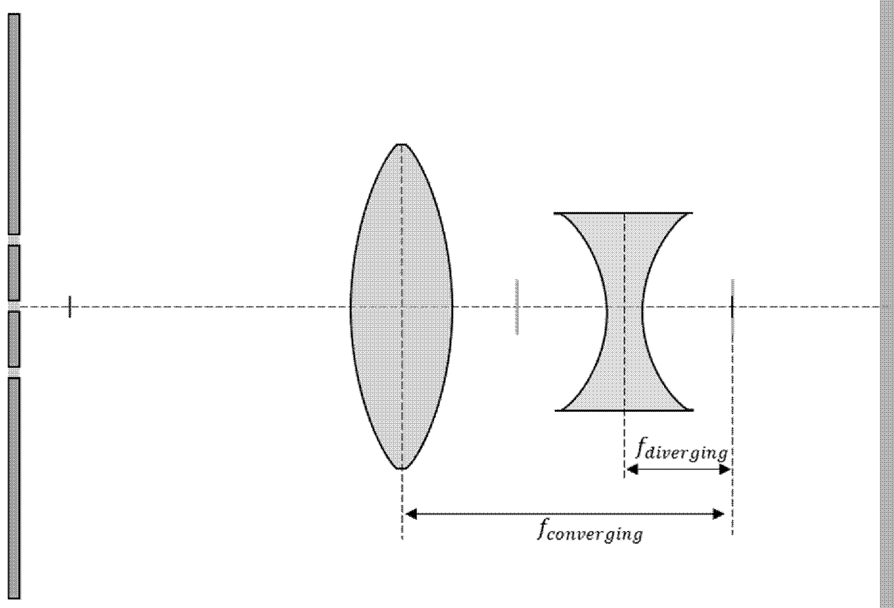
   b) A gold coin is viewed through a converging lens with a known ma image of the gold coin has a diameter of 11 cm, what is the actual

5. a) The lens from question 4 a) is used to read a finely written letter. T held 7.0 cm away from the letter. How far away from the lens is th produced, and what is the focal length of the lens in this case?

   b) What is the power of the lens used to view the letter?

A single diverging lens is able to magnify an object; however, you have t distance away from the lens. Otherwise, the light rays diverge too much blurry.

You start to experiment with the diverging lens and find that any conver the lens are refracted into parallel rays if the lens is positioned correctly lens behind a converging lens so its focal length coincides with the focal lens, as shown below.



The three light rays pass through both lenses and hit the second piece of

6. Draw a diagram showing the light rays as they pass through both lens the light rays as they pass through both lenses.

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This device is known as a telescope, specifically a Galilean telescope. Th as the objective lens, and the diverging lens is known as the eyepiece.

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HOMEWORK SIXTEEN: BE THE DESIGN

Activity 1: Design of an Experimental Set-up

Aim: Demonstrate your ability to apply your knowledge of physics to real-
designing an experiment set-up adhering to a brief.

Task

A theatre company is seeking advice on how to set up two speakers on stag
have large cylindrical pillars separating each row of seats.

The company wants to ensure that the maximum pitch is heard at the seats
minimum pitch is heard at the pillar positions as no audience members wil

Therefore, given your physics knowledge, your task is to provide the comp
plan/method demonstrating how best to place its speakers.

Information provided by the theatre company:

- The distance from the edge of the stage to the row of pillars and seats i
- The width of the seating in between each pillar is 1.2 metres.
- The speakers will be emitting sound waves of same wavelength which n

Sketch an experimental set-up that would achieve the theatre company's ne
heard at the rows of seats and minimum pitch to be heard at pillar position
dimensions so that the theatre company can accurately set up the plan then

In addition, the company is seeking scientifically backed-up answers to que
quality assurance assessment that would allow it to adjust the set-up if any
changed.

Quality Assurance Assessment
1. Will the set-up still work if the two speakers are transmitting sound w frequencies? 2. If the speakers are set back on the stage by a further 0.4 metres wha waves we transmit in order to achieve the same sound pattern reachi 3. What would happen to the sound pattern if only one speaker was use slits of width 14 cm? 4. Can the same set-up be applied to Room 2 that has a stage that is 4 distance from the stage to the audience's seats is the same?

Activity 2: Summary Questions

Aim: Complete summary questions to demonstrate an understanding of th

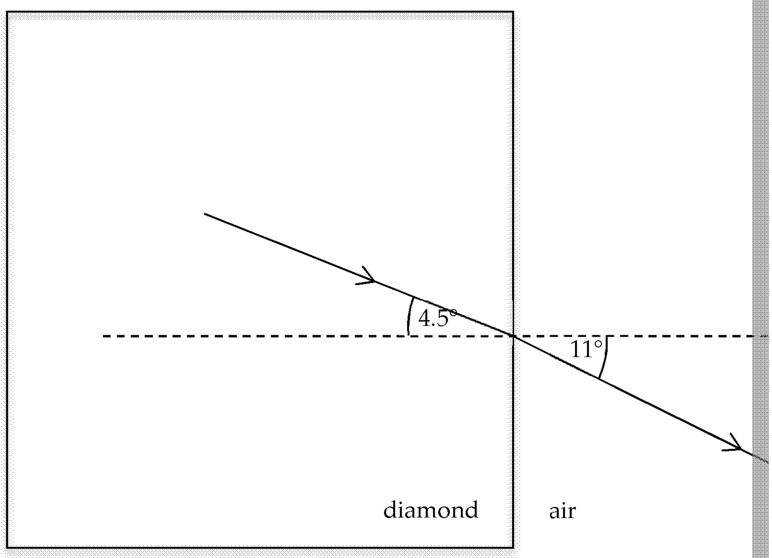
1. The sun emits light rays that can travel through air and eventually thr made of glass.

The speed of light in air is 3×10^8 ms^{-1} and the speed of light in glass is

Calculate the refractive index of glass.

2. Show that the refractive index of air is approximately 1.

3.



a) Determine the refractive index of diamond.
b) Determine the critical angle.

4. Optical fibres are used to transmit information over long distances.

a) Explain how optical fibres transmit information.
b) Explain how to reduce the amount of modal dispersion.

HOMEWORK SIXTEEN: BE THE DESIGN

Activity 1: Design of an Experimental Set-up

Aim: Demonstrate your ability to apply your knowledge of physics to real-
an experiment set-up from a provided brief.

Task

A theatre company is seeking advice on how to set up two speakers on sta
have large cylindrical pillars separating each row of seats.

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dimensions so that the theatre company can accurately set up the plan the

In addition, the company is seeking scientifically backed-up answers to qu
quality assurance assessment that would allow it to adjust the set-up if any
changed.

Quality Assurance Assessment
1. Will the set-up work if the two speakers are transmitting sound waves
2. For a few of the shows we push back the stage by 0.4 metres so that the stage for part of the performance. What would need to be altered achieve the same results as the proposed plan?
3. What would happen to the sound pattern if only one speaker was us slits of width 14 cm?
4. Can the same set-up be applied to Room 2 that has a stage width of from the stage to the audience's seats is the same?

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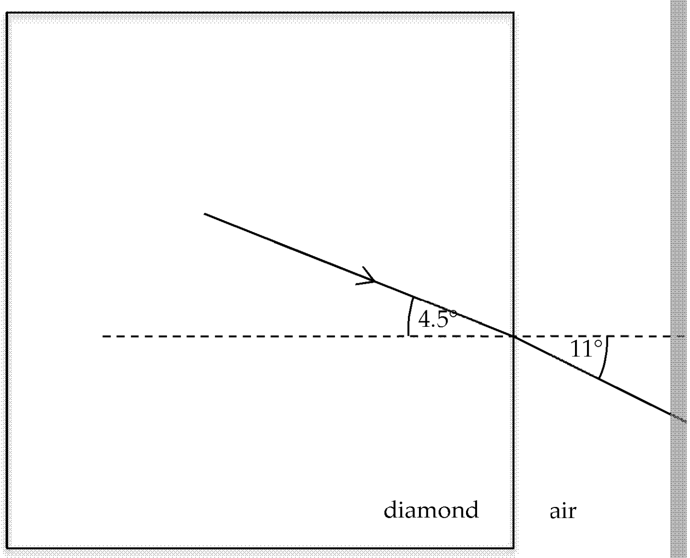
The speed of light in air is $3 \times 10^{8}\ \text{ms}^{-1}$ and the speed of light in glass is

Calculate the refractive index of glass.

2. Prove that the refractive index of air is approximately 1.

3.



a) Determine the refractive index of diamond.
b) Hence, determine the critical angle.

4. Optical fibres are used to transmit information over long distances.

a) Explain how optical fibres transmit information.
b) Explain how to reduce the amount of modal dispersion.

HOMEWORK SEVENTEEN: YOUNG'S DOUBLE SLI

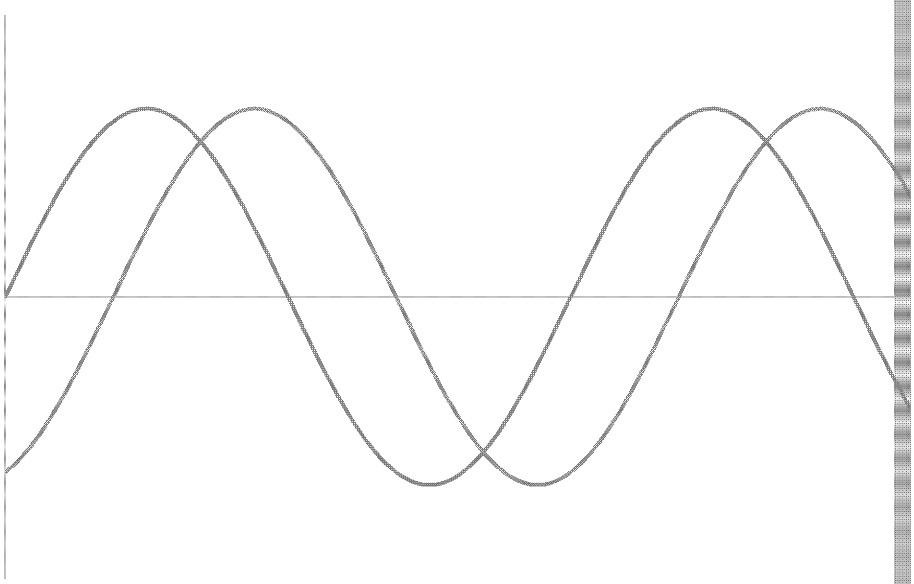
Activity 1: Refresher

Aim: A refresher on superposition and its terminology.

Task

1. What is meant by the superposition of two waves?

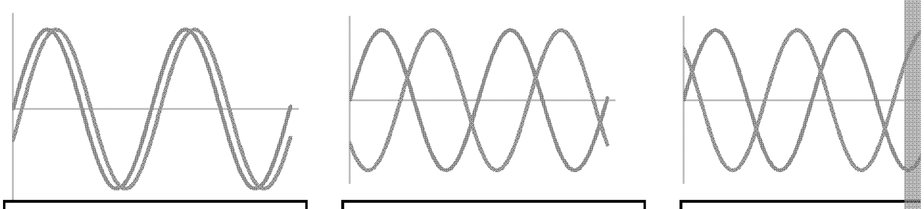
2. The two waves on the graph below superimpose. Draw the shape of th superposition of the two waves.



3. Connect the words to their correct definitions below.

Path difference	When the two waves same space superimp
Coherence	The difference in leng by a wave.
Interference	The angle or fraction two waves.
Phase difference	When two waves are

4. Interference can be described as constructive or destructive. Label the either constructive or destructive interference if the waves shown supe



Activity 2: Experimental analysis

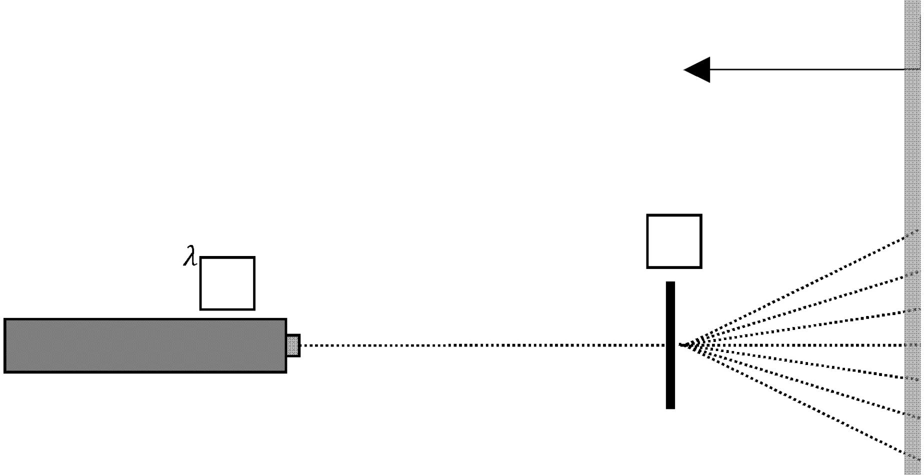
Aim: To develop understanding of Young's double slit experiment and its i

Task

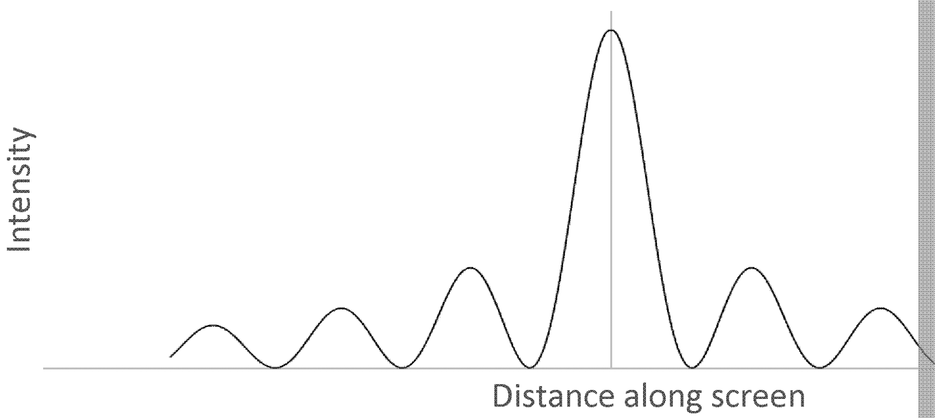
Young's double slit experiment projects visible light at two slits. The light c
interferes to produce an interference pattern on a screen. There are four va

- Wavelength of light, λ
- Spacing between slits, a
- Distance between maxima (bright spots) in interference pattern, x
- Distance between slits and screen, D

1. On the diagram of the experiment below, add the three missing variab



The interference pattern seen on the screen is a series of bright spots spa graph below shows the intensity of light on the screen.



2. Fill in the gaps in the paragraph below, which describes how the interf
emitted from each slit produces this interference pattern.

The waves originate from different points so they interfere by different
________________ away from each slit. This varies the ________________
their superposition creates a ________________ wave that varies with d
example, there are positions between the slit and screen that result in b
they maximally ________________ interfere, and other points where th
maximally ________________ interfere. This results in areas of construc
neighboured by areas of destructive ________________. The waves ther
the seen pattern of ________________ and ________________ spots.

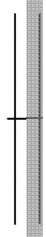
3. The interference pattern produced gives evidence that light is a wave. T
to measure the wavelength of light if it is unknown. What are the indep
variables in this experiment?

The equation that relates the four variables in Young's double slit experi when $a \ll D$.

4. A laser with an unknown frequency is shone at two slits with a spacing
screen is placed 3.40 ± 0.01 m away from the two slits. The distance be
and the neighbouring maximum is measured as 5.2 ± 0.1 mm. Calculat
with its associated error.

Remember, to calculate the error of a variable you must convert the absol variables into percentage uncertainties, then apply the following rules de and finally convert the new percentage uncertainty back to an absolute er

- $\%(\boldsymbol{a} \times \boldsymbol{b})$ ***or*** $\%\left(\frac{a}{b}\right) = \%(\boldsymbol{a}) + \%(\boldsymbol{b})$
- $\%(2 \times \boldsymbol{a}) = \%(\boldsymbol{a})$
- $\%(\boldsymbol{a}^2) = 2 \times \%(\boldsymbol{a})$



5. Huygens principle states that a wavefront can be considered as an infinite number of points sources of the wave, all arranged in a line perpendicular to the direction of propagation.

Explain how Huygens' Principle can be applied to Young's double slit experiment. Draw a diagram to aid your answer.

A wave that propagates through a gap of similar size to its wavelength will diffract. This diffraction is what leads to diffraction patt two diffraction patterns is what is seen in Young's double slit experimen electrons that pass through a certain gap size also show diffraction patter

6. What do the diffraction patterns observed by electrons tell us?

The wavelength associated with a particle is called its de Broglie waveler using the equation $\lambda = \frac{h}{p}$

7. a) What is the momentum of an electron travelling at 1.50×10^7 m s

b) What is the de Broglie wavelength of this electron?

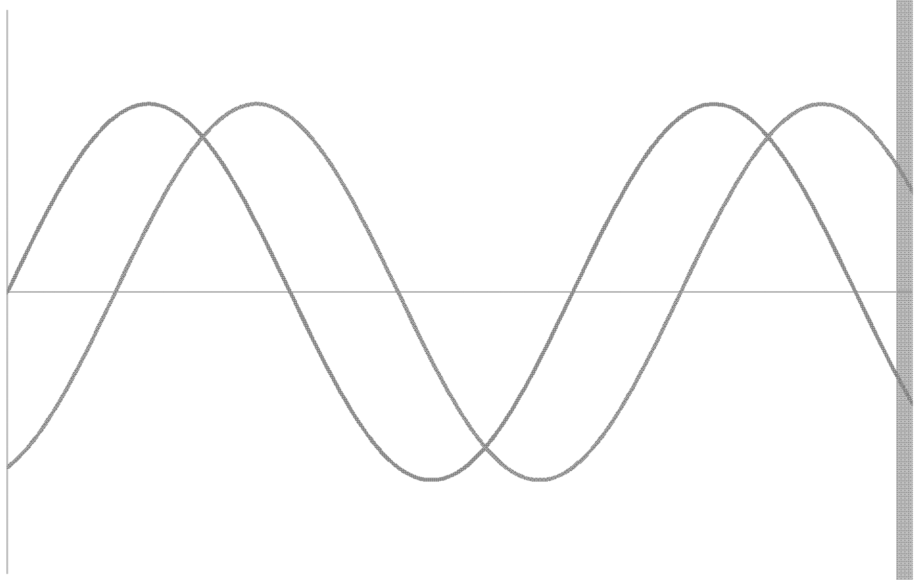
Homework Seventeen: Young's Double Sli

Activity 1: Refresher

Aim: A refresher on superposition and its terminology.

Task

1. What is meant by the superposition of two waves?

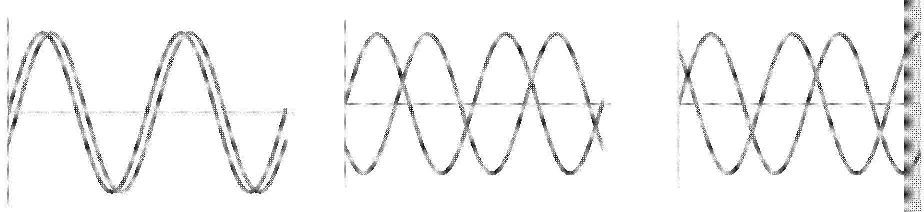


2. The two waves on the graph below superimpose. Draw the shape of th superposition of the two waves.

3. Define the following words relating to the superposition of waves:

Path difference	Coherence	Interferenc

4. Interference can be described as constructive or destructive. Label the g resulting in either constructive or destructive interference if the waves



The interference of two waves depends on what property? Explain you

Activity 2: Experimental analysis

Aim: To develop understanding of Young's double slit experiment and its i

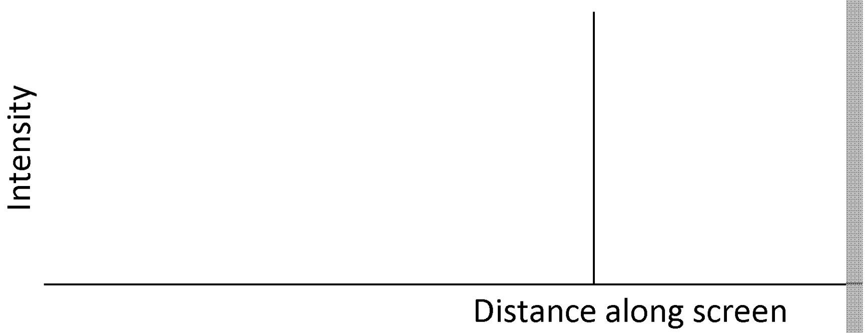
Task

Young's double slit experiment projects visible light at two slits. The light c
interferes to produce an interference pattern on a screen. There are four var

- Wavelength of light, λ
- Spacing between slits, a
- Distance between maxima (bright spots) in interference pattern, x
- Distance between slits and screen, D

1. Draw a diagram of Young's double slit experiment and label the four v

2. a) Copy the axes below and draw a graph that shows the intensity of observed on the screen.



2. b) Explain how the interference of the waves emitted from each slit p pattern.

3. The interference pattern produced gives evidence that light is a wave. T to measure the wavelength of light if it is unknown. What are the indep variables in this experiment?

The equation that relates the four variables in Young's double slit experi when $a \ll D$.

4. A laser with an unknown frequency is shone at two slits with a spacing screen is placed 3.40 ± 0.01 m away from the two slits. The distance be and the neighbouring maximum is measured as 5.2 ± 0.1 mm. Calculat with its associated error.

5. Huygens' principle states that a wavefront can be considered as an infi source of wavelets. Research Huygens principle and draw a diagram o wavelets to explain the principle. Then explain how Huygens principle double slit experiment. Draw another diagram to explain this answer.

A wave that propagates through a gap of similar size to its wavelength w diffraction is what leads to diffraction patterns, and the interference of tv what is seen in Young's double slit experiment. Weirdly, particles such a through a certain gap size also show diffraction patterns.

6. What do the diffraction patterns observed by electrons tell us?

The wavelength associated with a particle is called its de Broglie waveler using the equation $\lambda = \frac{h}{p}$

7. What is the de Broglie wavelength of an electron travelling at 5 % of th

HOMEWORK EIGHTEEN: BE THE SCIEN

Activity 1: Mock Scientific Report

Aim: To construct a scientific report using mock data.

This task is designed to provide you with the skills to produce a (professio
accurately and effectively displays the results, conclusions and considerati

Task

Write a scientific report on the famous gold leaf electroscope **photoelectri**

The aim of the experiment is to determine the value of Planck's constant h
equation, $KE_{\max} = hf - \phi$.

> **Remember:** It is essential that this aim forms the basis of your report and commentary throughout. It may be useful to ask yourself after writing ea whether your writing has relevance to / has addressed the aim of your ex

The experiment uses the following apparatus:

- (Thoroughly cleaned) Zinc plate
- Gold leaf electroscope
- Ultraviolet lamp
- Extra high tension supply

The experiment consequently obtained the following raw data:

	Frequency/Hz	Energy/J
1	0	0
2	0	0
3	1.1×10^{15}	7.3×10^{-19}
4	1.6×10^{15}	3.1×10^{-19}
5	2.8×10^{15}	1.4×10^{-18}
6	3.7×10^{15}	1.9×10^{-18}
7	4.5×10^{15}	2.3×10^{-18}

Your task is to write a mock scientific report on this experiment that follow
professional scientific report.

The next page contains a list of reading to help you structure your report.

Scientific report structure:
This may be a very new and unfamiliar way of writing for you, and somet been asked to complete before.

Below is a list of websites to help you understand what should be included structure it.

- **http://unilearning.uow.edu.au/report/2b.html**
- **http://www.monash.edu.au/lls/llonline/writing/science/7.xml**
- **https://writing.wisc.edu/Handbook/ScienceReport.html**
- **http://biology.kenyon.edu/Bio_InfoLit/how/page2.html**

***Additional reading for gold leaf experiment*:**
You will need to do additional reading on the gold leaf experiment to sup for the method and results sections if you have not covered this experime

- **http://www.st-ambrosecollege.org.uk/library/client/documents/Scie G482%20Mod%205%202.5.2%20The%20Photoelectric%20Effect.pdf**
- **https://www.stem.org.uk/elibrary/resource/28841/photoelectric-effe**
- **https://books.google.co.uk/books?id=TRIA5VgModIC&pg=PA570&l +leaf+electroscope+photoelectric+effect&source=bl&ots=imUOrfJnW OpHDruktZ9AG3k&hl=en&sa=X&ved=0ahUKEwizwfOMtbjLAhU QgkMAE#v=onepage&q=gold%20leaf%20electroscope%20photoelec**
- **http://astro.uchicago.edu/~randy/YSI05_pdfs/photoelec.july28.pdf**

Your report should follow this basic structure:

Abstract

- The abstract is a summary of the report and acts as a preview to illustr its results and, therefore, its conclusions.
- It can almost be seen as a rehash of the conclusion but with the purpos

Note: The abstract should be 100–150 words.

1. **Introduction**
   - The introduction should set your experiment in the wider context, and significance.
   - It should discuss any previous relevant research.
   - It should outline the aim being investigated and how you are goin

2. **Method**
   - Explain the procedures and equipment used to carry out the exper the particular procedures and equipment.

3. **Results**
   - Demonstrate the results obtained without explaining their signific
   - Format raw data into a useful and appropriate format to analyse r the reader, e.g. demonstrate results as a graph.

   Note: Do not simply repeat the raw results given in the results sectio appropriate format such as a graph as this will provide a clear analys

   In this case, a plot of kinetic energy against frequency will be a usefu constant and provide clear analysis of the results to the reader.

4. **Discussion**
   - Explain your findings indicating the significance of any trends de
   - State your final conclusion.
   - Explain the accuracy/precision of your results and suggest any lim that might have affected the validity of the results or created error

5. **Conclusion**
   - The conclusion should restate the outcome of your experiment, w
   - It should restate the limitations and considerations of the experim validity of your answer.

   Note: The conclusion should be 100–150 words and not introduce an already been discussed in the report.

Extension Task

As an extension task you are required to add an additional section to your r

How to reference:
In any pursuit of the sciences, you will most likely come across scientific jou that is you writing them or reading them for research. It is, therefore, usefu referencing.

For the task, it is highly encouraged that you do as much of your own readi the photoelectric effect as possible. When researching in this manner it is u recording the books/websites used for research in order to reference them i

The method:

- Make relevant notes of the facts, information, theories and concepts yo your investigation, making sure you note the book/website you are tak

- When including any of these facts, information, theories of concepts in you have to reference in the main text as well as the references section

  '… it can be said that this method is the most accurate method for this [1]'

- Your references section is then where you include the full reference. Th of text are linked to the references sections by the numbers appearing a e.g. [1]. It would appear in your references sections like so:

  '[1] Bloggs, J. (2005). Experiments of the photoelectric effect. Physics Re

Note: The Harvard referencing system is used in scientific reports. The fo books, journals and websites differs slightly depending on what source yo the rough format: *Surname, initial (of authors), Year published, Title, City pub*

Specific formats are given below:

- **For a scientific journal:** *Surname, Initial. (Year). Title of article. Title of j*
- **For a website:** *Surname, Initials*. *Title. Place of publication. Available from Day Month Year].*
- **For a book:** *Surname, Initial. (Year). Title of book, edition. Place of publica*

HOMEWORK NINETEEN: EXCITATION, IONISATION AND W

Activity 1: Exam-style Questions

Aim: To practice and become familiar with the level and style of exam que

1. **a)** Explain the differences between ionisation and excitation of an ato
b) Explain two situations when ionisation can occur.

2. Sketch a diagram to illustrate the process of ionisation and the process

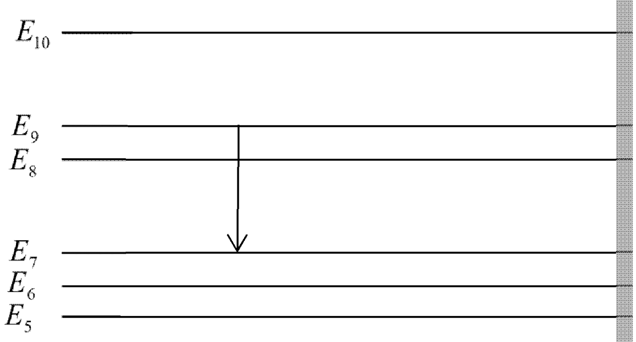
3. Comment on the kinetic energy of the collision electron and internal er
a collision that causes excitation.

4. During the excitation process an electron from an inner shell of an aton

An electron moves from energy level $E_2 = 4.9$ eV to energy level $E_3 = 5.$

a) State whether a photon has been emitted or absorbed during the p
b) Determine the energy of the photon from your answer to (a).
c) Explain the difference in the energy of the photon from (b) if the el
an energy level lower than E_2.

5. Some of the energy levels of the of mercury atom are displayed below:



a) State whether a photon is absorbed or emitted when an electron in
moves from E_9 to E_7.
b) Calculate the energy of the photon involved in the de-excitation fr
c) Calculate the frequency of the photon from (b).

The ionisation energy of a mercury atom is less than that of a hydrogen
electron from ground state.

d) Explain what that implies about the energy needs to remove an ele
ground state, from a hydrogen atom compared to a mercury atom.

6. A beam of electrons is fired at a thin metal foil comprised of rows of el

The thin beam of electrons is fired at the metal foil at a speed of $2.6 \times 1($

a) Sketch the pattern obtained on the screen of this experiment.
b) State the significance of this experiment.
c) Calculate the wavelength of the electrons used in this experiment.

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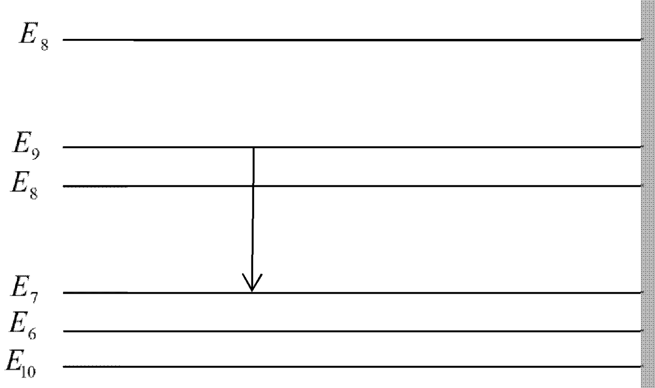

   a) State whether a photon is absorbed or emitted when an electron in from E_9 to E_7.
   b) Calculate the wavelength of the photon from (a).

   The atom then absorbs a photon with frequency of 3.8×10^{14} Hz.

   c) Sketch the possible energy transitions if the atom absorbs a photon 3.8×10^{14} Hz.
   d) Explain whether the photon from (c) could provide enough energy mercury atom.

The ionisation energy of a mercury atom is less than that of a hydroge
of electron from ground state.

e) Explain what that implies about the energy needs to remove an el
hydrogen atom compared with a mercury atom.

6. A beam of electrons is fired at a thin metal foil comprised of rows of el

The thin beam of electrons is fired at the metal foil at a speed of 2.6×1

a) Sketch the pattern obtained on the screen of this experiment.
b) State the significance of this experiment.
c) Calculate the wavelength of the electrons used in this experiment.
d) Explain the effect on the pattern and wavelength if the momentum o

Answers

Homework One: Measurements and Their Errors

Activity 1: Summary Questions

1.

Physical quantity	SI base unit
Mass	Kilograms
Length	Metres
Time	Seconds
Amount of a substance	Moles
Temperature	Kelvin
Electric current	Amperes

2.

Prefix name	Prefix symbol	Order of magni
Tera	T	$\times 10^{12}$
Micro	μ	$\times 10^{-6}$
Giga	G	$\times 10^{9}$
Centi	c	$\times 10^{-2}$
femto	f	$\times 10^{-15}$
Mili	m	$\times 10^{-3}$
Mega	M	$\times 10^{6}$
Nano	n	$\times 10^{-9}$
Pico	p	$\times 10^{-12}$
Kilo	K	$\times 10^{3}$

3. a) A False
B False
C True
D False

b) B: $kg\ m^2\ s^{-2}$
D: $kg\ m\ s^{-2}$

4.

Particle	Kinetic Energy (J)	Kinetic Energy (
Alpha particle	8.1×10^{-13}	5.1
Electron	8×10^{-14}	0.5
proton	5.6×10^{-11}	350

Activity 2: Data Analysis Extended Question

a) Possible systematic errors:
- Inaccurate use of stop clock and metre rule when taking measurem
- Uncalibrated/faulty stop clock
- Unclear/worn scale reading on metre stick resulting in length para

Possible random errors:
- Incorrect technique of measurement
- Human limitation in taking measurement (parallax error and hum
- Wind changes in surroundings
- Temperature changes in surroundings

b) Reduce systematic errors:
- Calibrate stop clock correctly
- Use alternative stop clock
- Use alternative metre stick

Reduce random errors:
- Repeat the experiment
- Take mean of measured values
- Carry out experiment in an isolated setting
- Take note of temperature changes to account for their presence

c) $$percentage\ uncertainity = \frac{absolute\ error}{measurement} \times 100\%$$

For length:

$$= \frac{1}{121} \times 100\%$$
$$= 0.8\%$$

For period:

$$= \frac{0.1}{2.2} \times 100\%$$
$$= 4.5\%$$

d)

Trial	Length (m)	Period (s)
1	1.21 ± 0.01	2.2 ± 0.1
2	1.15 ± 0.01	2.0 ± 0.1
3	1.11 ± 0.01	2.1 ± 0.1
4	1.06 ± 0.01	2.1 ± 0.1
5	1.01 ± 0.01	2.1 ± 0.1
6	0.94 ± 0.01	2.0 ± 0.1

e) The measurement for trial 4 has high accuracy due to its close proximit acceleration due to gravity.

f) The measurements 1, 3, 4, 5, 6 have high precision due to their close p the measurement for trial 2 is significantly out compared to the others precision is low.

g) $g = \frac{4\pi^2 L}{T^2}$

$g \propto \frac{L}{T^2}$

$\%\ uncertainty\ L = \frac{0.01}{1.21} \times 100 = 0.83\%$

$\%\ uncertainty\ in\ T = \frac{0.1}{2.2} \times 100 = 4.5\%$

$\%\ uncertainty\ in\ g = (\%L) + 2 \times (\%T)$

$\%\ uncertainty\ in\ g = (0.83 + (2 \times 4.5)) = 9.83\%$

$absolute\ uncertainty\ in\ g = \frac{\%g \times g}{100\%}$

$absolute\ uncertainty\ in\ g = \frac{9.83}{100} \times 9.86 = \pm 0.97$

Activity 1: Summary Questions

1. a) A False
   B False
   C True
   D False

   b) B: kgm^2s^{-2}
   D: $kgms^{-2}$

2. a) $E_p = mgh$

   $E_p = (70-80) \times 9.8 \times (205 \times 10^{-2})$

   $E_p = 1406.3 - 1607.2$ J

   b) $E_p = 1406.3 - 1607.2$ J

   $E_P = 1.4 - 1.6$ kJ

3. $E = hf - \phi$

   $E = (6.63 \times 10^{-34} \times 1.3 \times 10^{16}) - (4.1 \times 1.6 \times 10^{-19})$

   $E = 7.96 \times 10^{-18}$

   $E = 7.96 \times 10^{-6}$ pJ

4. $1\ kW = 1000\ J/s$

   $1\ kWh = 1000\ J/s \times 60 \times 60s$

   $1\ kWh = 3\ 600\ 000\ J$

   $\frac{2.28 \times 10^7}{3\,600\,000} = 6.3\ kWh$

   $\text{cost} = kWh \times 8p$

   $\text{cost} = 6.3 \times 8$

   $\text{cost} = 50.6\ p$

Activity 2: Data Analysis Extended Question

1. a) Possible systematic errors:
   - Inaccurate use of stop clock and metre rule when taking meas
   - Uncalibrated/faulty stop clock
   - Unclear/worn scale reading on metre stick resulting in length pa

   Possible random errors:
   - Incorrect technique of measurement
   - Human limitation in taking measurement (parallax error and
   - Wind changes in surroundings
   - Temperature changes in surroundings

   b) Reduce systematic errors:
   - Calibrate stop clock correctly
   - Use alternative stop clock
   - Use alternative metre stick

   Reduce random errors:
   - Repeat the experiment
   - Take mean of measured values
   - Carry out experiment in an isolated setting
   - Take note of temperature changes to account for their presenc

   c) $$percentage\ uncertainty = \frac{absolute\ error}{measurement} \times 100\%$$

   For length:

   $$= \frac{1}{121} \times 100\%$$
   $$= 0.8\%$$

   For period:

   $$= \frac{0.1}{2.2} \times 100\%$$
   $$= 4.5\%$$

   d)

Trial	Length (m)	Period (s)
1	1.21 ± 0.01	2.2 ± 0.1
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4	1.06 ± 0.01	2.1 ± 0.1
5	1.01 ± 0.01	2.1 ± 0.1
6	0.94 ± 0.01	2.0 ± 0.1

   e) The measurement for trial 4 has high accuracy due to its close pro acceleration due to gravity.

   f) The measurements 1, 3, 4, 5, 6 have high precision due to their clos but the measurement for trial 2 is significantly out compared to th overall the precision is low.

g) $g = \frac{4\pi^2 L}{T^2}$

$g \propto \frac{L}{T^2}$

$\%\,uncertainty\ L = \frac{0.01}{1.21} \times 100 = 0.83\%$

$\%\,uncertainty\ in\ T = \frac{0.1}{2.2} \times 100 = 4.5\%$

$\%\,uncertainty\ in\ g = (\%L) + 2 \times (\%T)$

$\%\,uncertainty\ in\ g = (0.83 + (2 \times 4.5)) = 9.83\%$

$absolute\ uncertainty\ in\ g = \frac{\%g \times g}{100\%}$

$absolute\ uncertainty\ in\ g = \frac{9.83}{100} \times 9.86 = \pm 0.97$

Extension Task:

An exact solution has not been included for task as answers will vary.

When marking, check the conclusion includes:

- A summary of the main findings and the validity of the results achieve
- Explanation of the larger significance of the ideas and demonstration o findings.
- Explanation of what further work needs to be undertaken to confirm/i experiment.

A good conclusion should not include:

- New thoughts, findings or ideas that have not already been demonstra findings.

Homework Two: Medieval Assault

Activity: Planning an attack

1. Initial vertical velocity, u_v, of projectile is equal to the final vertical vel Therefore, the time until projectile reaches maximum height is

   $v_v = u_v - g t_{\frac{1}{2}}$

   $t_{\frac{1}{2}} = \frac{(v_v - u_v)}{-g}$

   $t_{\frac{1}{2}} = \frac{0 - 8.50}{-9.81}$

   $t_{\frac{1}{2}} = 0.866\ \text{s}$

   This means the total flight time of the projectile is

   $t = 2 \times t_{\frac{1}{2}} = 1.73\ \text{s}$

2. Horizontal velocity, $v_h = u_h$, can be found using $s = vt$

$$v_h = \frac{s_h}{t}$$

$$v_h = \frac{48}{1.73}$$

$v_h = 27.7$ m s^{-1} $(= u_h)$

The angle between the horizontal and vertical components of the veloc
the tangent

$$tan\theta = \frac{u_v}{u_h}$$

$$\theta = \tan^{-1}\left(\frac{8.5}{27.7}\right)$$

$$\theta = 17.1°$$

The magnitude of the initial velocity can be found by using Pythagoras

$$v = \sqrt{u_v^2 + u_h^2}$$

$$v = \sqrt{8.5^2 + 27.7^2}$$

$v = 29.0$ m s^{-1}

3. To calculate the vertical component of this velocity

$$v_v = v \times \sin(45°)$$

$$v_v = 35 \times \sin(45°)$$

$v_v = 24.7$ m s^{-1}

Then for the new flight time, use the same procedure as in Q1

$$t = 2 \times t_{\frac{1}{2}} = 2 \times \left(\frac{0 - 24.7}{-9.81}\right)$$

$t = 5.04$ s

4. The increase in gravitational potential needed for the increase in height of

$$E_p = m \times g \times h$$

$$E_p = 450 \times 9.81 \times (12 - 3.5)$$

$E_p = 3.75 \times 10^4$ J

The initial kinetic energy of the boulder therefore needs to be this poten
efficient energy transfer) plus the kinetic energy it needs when it impac

$$E_k = (3.75 \times 10^4) + (9.00 \times 10^4)$$

$E_k = 1.275 \times 10^5$ J

The initial velocity of the boulder therefore needs to be

$$u = \sqrt{2 \times \frac{E_k}{m}}$$

$$u = \sqrt{2 \times \frac{1.275 \times 10^5}{450}}$$

$u = 23.8$ m s^{-1}

5. To answer this question let's find the total time it takes a boulder to be lo
the tower. First, we need to the time of flight of the boulder, given the ini

$u_v = u \times \sin(50°)$

$u_v = 23.8 \times \sin(50°)$

$u_v = 18.2$ m s^{-1}

The time of flight up to the boulders maximum height is

$t_1 = \frac{0 - 18.2}{-9.81}$

$t_1 = 1.86$ s

To find the time of flight for the second half we need the maximum height

$s_{max} = ut_1 - \frac{1}{2}gt_1^2$

$s_{max} = 18.2 \times 1.86 - \frac{1}{2} \times (9.81) \times 1.86^2$

$s_{max} = 16.9$ m

Therefore, the height the boulder must fall from the maximum point to

$s = 16.9 - 8.50 = 8.38$ m

From this we can find the time of flight for the second half of the trajec

$s = 8.38 = 0 \times t_2 + \frac{1}{2} \times 9.81 \times t_2^2$

$t_2 = \sqrt{\frac{2 \times 8.38}{9.81}}$

$t_2 = 1.31$ s

The total flight time of the boulder is, therefore

$t = t_1 + t_2 = 3.17$ s

Adding this flight time to the preparation, launch and safety buffer tim
time of the soldiers as

$t_{min} = 25 + 2 + 3.17 + 15 = 45.17$ s

$t_{min} \approx 45$ s

The maximum speed the soldiers should march at is, therefore

$v_{max} = \frac{s_h}{t_{min}}$

$v_{max} = \frac{48}{45} = 1.1$ m s^{-1}

Activity: Planning an attack

1. Initial vertical velocity, u_v, of projectile is equal to the final vertical vel
Therefore, the time until projectile reaches maximum height is

$$v_v = u_v - gt_{\frac{1}{2}}$$

$$t_{\frac{1}{2}} = \frac{(v_v - u_v)}{-g}$$

$$t_{\frac{1}{2}} = \frac{0 - 8.50}{-9.81}$$

$$t_{\frac{1}{2}} = 0.866 \text{ s}$$

This means the total flight time of the projectile is

$$t = 2 \times t_{\frac{1}{2}} = 1.73 \text{ s}$$

Horizontal velocity, $v_h = u_h$, can be found using $s = vt$

$$v_h = \frac{s_h}{t}$$

$$v_h = \frac{48}{1.73}$$

$$v_h = 27.7 \text{ m s}^{-1} \; (= u_h)$$

The angle between the horizontal and vertical components of the veloc
the tangent

$$tan\theta = \frac{u_v}{u_h}$$

$$\theta = \tan^{-1}\left(\frac{8.5}{27.7}\right)$$

$$\theta = 17.1°$$

The magnitude of the initial velocity can be found by using Pythagoras

$$v = \sqrt{u_v^2 + u_h^2}$$

$$v = \sqrt{8.5^2 + 27.7^2}$$

$$v = 29.0 \text{ m s}^{-1}$$

2. To calculate the vertical component of this velocity

$$v_v = v \times \sin(45°)$$

$$v_v = 35 \times \sin(45°)$$

$$v_v = 24.7 \text{ m s}^{-1}$$

Then for the new flight time, use the same procedure as in Q1

$$t = 2 \times t_{\frac{1}{2}} = 2 \times \left(\frac{0 - 24.7}{-9.81}\right)$$

$$t = 5.04 \text{ s}$$

3. The increase in gravitational potential needed for the increase in height of

$$E_p = m \times g \times h$$

$$E_p = 450 \times 9.81 \times (12 - 3.5)$$

$$E_p = 3.75 \times 10^4 \text{ J}$$

The initial kinetic energy of the boulder therefore needs to be this pote
efficient energy transfer) plus the kinetic energy it needs when it impa

$$E_k = (3.75 \times 10^4) + (9.00 \times 10^4)$$

$$E_k = 1.275 \times 10^5 \text{ J}$$

The initial velocity of the boulder therefore needs to be

$$u = \sqrt{2 \times \frac{E_k}{m}}$$

$$u = \sqrt{2 \times \frac{1.275 \times 10^5}{450}}$$

$u = 23.8$ m s^{-1}

4. To answer this question let's find the total time it takes a boulder to be lo
the tower. First, we need to the time of flight of the boulder, given the in

$$u_v = u \times \sin(50°)$$

$$u_v = 23.8 \times \sin(50°)$$

$u_v = 18.2$ m s^{-1}

The time of flight up to the boulders maximum height is

$$t_1 = \frac{0 - 18.2}{-9.81}$$

$t_1 = 1.86$ s

To find the time of flight for the second half we need the maximum height

$$s_{max} = ut_1 - \frac{1}{2}gt_1^2$$

$$s_{max} = 18.2 \times 1.86 - \frac{1}{2} \times (9.81) \times 1.86^2$$

$s_{max} = 16.9$ m

Therefore, the height the boulder must fall from the maximum point to

$s = 16.9 - 8.50 = 8.38$ m

From this we can find the time of flight for the second half of the traje

$$s = 8.38 = 0 \times t_2 + \frac{1}{2} \times 9.81 \times t_2^2$$

$$t_2 = \sqrt{\frac{2 \times 8.38}{9.81}}$$

$t_2 = 1.31$ s

The total flight time of the boulder is, therefore

$t = t_1 + t_2 = 3.17$ s

Adding this flight time to the preparation, launch and safety buffer tim
time of the soldiers as

$t_{min} = 25 + 2 + 3.17 + 15 = 45.17$ s

$t_{min} \approx 45$ s

The maximum speed the soldiers should march at is, therefore

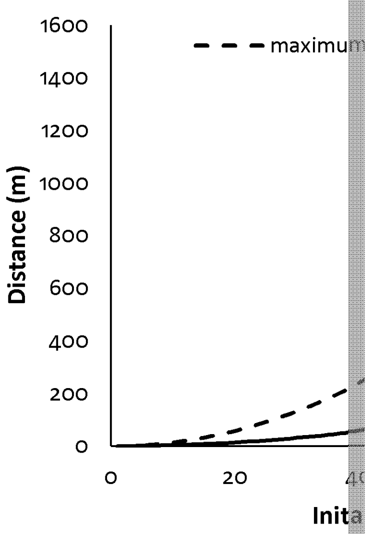
$v_{max} = \frac{s_h}{t_{min}}$

$v_{max} = \frac{48}{45} = 1.1$ m s^{-1}

Extension Task

Answers may vary. Below is an example answer.

Initial velocity	v_v	v_h	Time to max	2 × time to max	distance to max height	horizontal distance	
1	0.984807753	0.173648178	0.100490587	0.200981174	0.148445864	0.034900015	Initial angle
2	1.969615506	0.347296355	0.200981174	0.401962348	0.593783455	0.139600059	80
3	2.954423259	0.520944533	0.301471761	0.602943522	1.336012775	0.314100132	
4	3.939231012	0.694592711	0.401962348	0.803924696	2.375133821	0.558400234	
5	4.924038765	0.868240888	0.502452935	1.00490587	3.711146596	0.872500366	
6	5.908846518	1.041889066	0.602943522	1.205887045	5.344051098	1.256400527	
7	6.893654271	1.215537244	0.703434109	1.406868219	7.273847328	1.710100717	
8	7.878462024	1.389185421	0.803924696	1.607849393	9.500535285	2.233600936	
9	8.863269777	1.562833599	0.904415283	1.808830567	12.02411497	2.826901185	
10	9.84807753	1.736481777	1.00490587	2.009811741	14.84458638	3.490001463	
11	10.83288528	1.910129954	1.105396457	2.210792915	17.96194952	4.22290177	
12	11.81769304	2.083778132	1.205887045	2.411774089	21.37620439	5.025602106	
13	12.80250079	2.25742631	1.306377632	2.612755263	25.08735099	5.898102472	
14	13.78730854	2.431074487	1.406868219	2.813736437	29.09538931	6.840402867	
15	14.7721163	2.604722665	1.507358806	3.014717611	33.40031936	7.852503291	
16	15.75692405	2.778370843	1.607849393	3.215698785	38.00214114	8.934403744	
17	16.7417318	2.95201902	1.70833998	3.416679959	42.90085465	10.08610423	
18	17.72653955	3.125667198	1.808830567	3.617661134	48.09645988	11.30760474	
19	18.71134731	3.299315376	1.909321154	3.818642308	53.58895684	12.59890528	
20	19.69615506	3.472963553	2.009811741	4.019623482	59.37834553	13.96000585	
21	20.68096281	3.646611731	2.110302328	4.220604656	65.46462595	15.39090645	
22	21.66577057	3.820259909	2.210792915	4.42158583	71.8477981	16.89160708	
23	22.65057832	3.993908086	2.311283502	4.622567004	78.52786197	18.46210774	
24	23.63538607	4.167556264	2.411774089	4.823548178	85.50481757	20.10240842	
25	24.62019383	4.341204442	2.512264676	5.024529352	92.7786649	21.81250914	
26	25.60500158	4.514852619	2.612755263	5.225510526	100.349404	23.59240989	
27	26.58980933	4.688500797	2.71324585	5.4264917	108.2170347	25.44211066	
28	27.57461708	4.862148975	2.813736437	5.627472874	116.3815572	27.36161147	
29	28.55942484	5.035797152	2.914227024	5.828454048	124.8429715	29.3509123	
30	29.54423259	5.20944533	3.014717611	6.029435223	133.6012775	31.41001316	
31	30.52904034	5.383093508	3.115208198	6.230416397	142.6564751	33.53891405	
32	31.5138481	5.556741685	3.215698785	6.431397571	152.0085646	35.73761498	
33	32.49865585	5.730389863	3.316189372	6.632378745	161.6575457	38.00611593	
34	33.4834636	5.904038041	3.416679959	6.833359919	171.6034186	40.34441691	
35	34.46827136	6.077686218	3.517170546	7.034341093	181.8461832	42.75251792	
36	35.45307911	6.251334396	3.617661134	7.235322267	192.3858395	45.23041895	
37	36.43788686	6.424982574	3.718151721	7.436303441	203.2223876	47.77812002	
38	37.42269461	6.598630751	3.818642308	7.637284615	214.3558274	50.39562112	
39	38.40750237	6.772278929	3.919132895	7.838265789	225.7861589	53.08292224	
40	39.39231012	6.945927107	4.019623482	8.039246963	237.5133821	55.8400234	
41	40.37711787	7.119575284	4.120114069	8.240228137	249.5374971	58.66692458	
42	41.36192563	7.293223462	4.220604656	8.441209312	261.8585038	61.5636258	
43	42.34673338	7.46687164	4.321095243	8.642190486	274.4764022	64.53012704	
44	43.33154113	7.640519817	4.42158583	8.84317166	287.3911924	67.56642831	
45	44.31634889	7.814167995	4.522076417	9.044152834	300.6028743	70.67252962	
46	45.30115664	7.987816173	4.622567004	9.245134008	314.1114479	73.84843095	
47	46.28596439	8.16146435	4.723057591	9.446115182	327.9169132	77.09413231	
48	47.27077214	8.335112528	4.823548178	9.647096356	342.0192703	80.4096337	
49	48.2555799	8.508760706	4.924038765	9.84807753	356.4185191	83.79493511	
50	49.24038765	8.682408883	5.024529352	10.0490587	371.1146596	87.25003656	
51	50.2251954	8.856057061	5.125019939	10.25003988	386.1076918	90.77493804	
52	51.21000316	9.029705239	5.225510526	10.45102105	401.3976158	94.36963955	
53	52.19481091	9.203353416	5.326001113	10.65200223	416.9844315	98.03414108	
54	53.17961866	9.377001594	5.4264917	10.8529834	432.8681389	101.7684426	
55	54.16442642	9.550649772	5.526982287	11.05396457	449.0487381	105.5725442	
56	55.14923417	9.724297949	5.627472874	11.25494575	465.526229	109.4466459	
57	56.13404192	9.897946127	5.727963461	11.45592692	482.3006116	113.3901475	
58	57.11884967	10.07159431	5.828454048	11.6569081	499.3718859	117.4030492	
59	58.10365743	10.24524248	5.928944635	11.85788927	516.740052	121.4865509	
60	59.08846518	10.41889066	6.029435223	12.05887045	534.4051098	125.6400527	
61	60.07327293	10.59253884	6.12992581	12.25985162	552.3670593	129.8629544	
62	61.05808069	10.76618702	6.230416397	12.46083279	570.6259006	134.1556562	
63	62.04288844	10.93983519	6.330906984	12.66181397	589.1816336	138.518158	
64	63.02769619	11.11348337	6.431397571	12.86279514	608.0342583	142.9504599	
65	64.01250395	11.28713155	6.531888158	13.06377632	627.1837747	147.4525618	
66	64.9973117	11.46077973	6.632378745	13.26475749	646.6301829	152.0244637	
67	65.98211945	11.6344279	6.732869332	13.46573866	666.3734828	156.6661657	
68	66.9669272	11.80807608	6.833359919	13.66671984	686.4136744	161.3776676	
69	67.95173496	11.98172426	6.933850506	13.86770101	706.7507577	166.1589696	
70	68.93654271	12.15537244	7.034341093	14.06868219	727.3847328	171.0100717	
71	69.92135046	12.32902061	7.13483168	14.26966336	748.3155996	175.9309737	
72	70.90615822	12.50266879	7.235322267	14.47064453	769.5433581	180.9216758	
73	71.89096597	12.67631697	7.335812854	14.67162571	791.0680084	185.9821779	
74	72.87577372	12.84996515	7.436303441	14.87260688	812.8895504	191.1124801	
75	73.86058148	13.02361333	7.536794028	15.07358806	835.0079841	196.3125823	
76	74.84538923	13.1972615	7.637284615	15.27456923	857.4233095	201.5824845	
77	75.83019698	13.37090968	7.737775202	15.4755504	880.1355267	206.9221867	
78	76.81500473	13.54455786	7.838265789	15.67653158	903.1446356	212.331689	
79	77.79981249	13.71820604	7.938756376	15.87751275	926.4506362	217.8109913	
80	78.78462024	13.89185421	8.039246963	16.07849393	950.0535285	223.3600936	
81	79.76942799	14.06550239	8.13973755	16.2794751	973.9533126	228.978996	
82	80.75423575	14.23915057	8.240228137	16.48045627	998.1499884	234.6676983	
83	81.7390435	14.41279875	8.340718724	16.68143745	1022.643556	240.4262008	
84	82.72385125	14.58644692	8.441209312	16.88241862	1047.434015	246.2545032	
85	83.70865901	14.7600951	8.541699899	17.0833998	1072.521366	252.1526057	
86	84.69346676	14.93374328	8.642190486	17.28438097	1097.905609	258.1205082	
87	85.67827451	15.10739146	8.742681073	17.48536215	1123.586743	264.1582107	
88	86.66308227	15.28103963	8.84317166	17.68634332	1149.56477	270.2657133	
89	87.64789002	15.45468781	8.943662247	17.88732449	1175.839687	276.4430158	
90	88.63269777	15.62833599	9.044152834	18.08830567	1202.411497	282.6901185	
91	89.61750552	15.80198417	9.144643421	18.28928684	1229.280198	289.0070211	
92	90.60231328	15.97563235	9.245134008	18.49026802	1256.445792	295.3937238	
93	91.58712103	16.14928052	9.345624595	18.69124919	1283.908276	301.8502265	
94	92.57192878	16.3229287	9.446115182	18.89223036	1311.667653	308.3765292	
95	93.55673654	16.49657688	9.546605769	19.09321154	1339.723921	314.972632	
96	94.54154429	16.67022506	9.647096356	19.29419271	1368.077081	321.6385348	
97	95.52635204	16.84387323	9.747586943	19.49517389	1396.727133	328.3742376	
98	96.5111598	17.01752141	9.84807753	19.69615506	1425.674076	335.1797405	
99	97.49596755	17.19116959	9.948568117	19.89713623	1454.917911	342.0550433	
100	98.4807753	17.36481777	10.0490587	20.09811741	1484.458638	349.0001463	



The graphs show that a
distance reached in the
directions also increase

For low angles, the hori
much more than the ma
changes around 53°, wh
height and maximum h
roughly equal.

Homework Three: Practice Questions

Activity 1: Summary Questions

1. a)

	Scalar	Vector
Velocity		✓
Distance	✓	
Force		✓
Speed	✓	
Acceleration		✓
Energy	✓	
Mass	✓	
Temperature	✓	
Weight	✓	

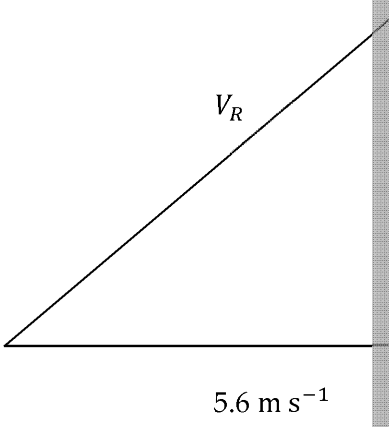
   b) Scalars are defined by magnitude, whereas vectors have to be defi direction.

2. $a^2 + b^2 = c^2$

   $v_R = \sqrt{a^2 + b^2}$

   $v_R = \sqrt{(5.6)^2 + (4.2)^2}$

   $v_R = 7 \text{ m s}^{-1}$



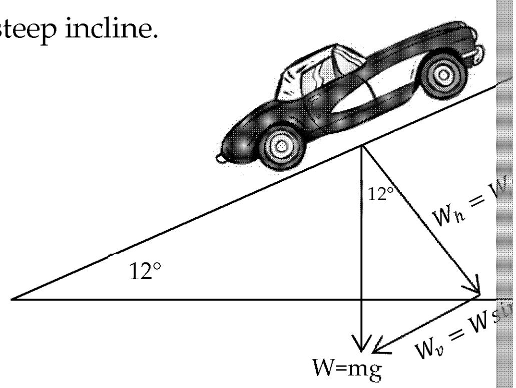
   $\tan\theta = \dfrac{o}{a}$

   $\theta = \tan^{-1}\left(\dfrac{4.2}{5.6}\right)$

   $\theta = 36.9°$

   Therefore, the resultant velocity of the boat is 7 ms^{-1} on a bearing of 37

3. A 680 kg car is travelling up a steep incline.



   a) $W_v = W \sin\theta$

   $W_v = (680 \times 9.8) \times \sin 12$

   $W_v = 1385.5 \text{ N}$

   b) $F_{net} = F_{engine} - W_v$

   $F_{engine} = W_v + F_{net}$

   $F_{engine} = 1385.5 + 150$

   $F_{engine} = 1535.5 \text{ N}$; parallel to the incline

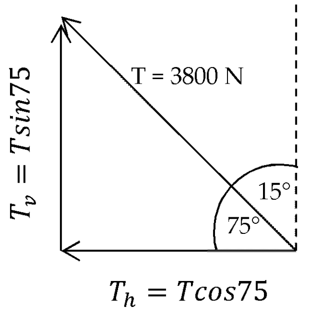
Extension Question

4. a) Vector

b) $T_h = T\cos\theta$

$T_h = 3800\cos 75$

$T_h = 983.5\text{ N}$



$T_v = T\sin\theta$

$T_v = 3800\sin 75$

$T_v = 3670.5\text{ N}$

Note: You could have also used $T_h = T\sin 15$ and $T_v = T\cos 15$.

c) $T_{1v} = Vertical\ tension\ in\ rope\ 1$

$T_{2c} = Vertical\ tension\ in\ rope\ 2$

$W = (T_{1v} + T_{2v})$

$W = 2T_v$

$W = 2 \times 3670.5$

$W = 7341\text{ N}$

d) $W = N$

$N = 7314\text{ N}$

Activity 2: Exam-style Questions

1. a) $clockwise\ moment = weight\ of\ boy \times distance\ from\ pivot$ (1)

$clockwise\ moment = (50 \times 9.81) \times 0.6$

$clockwise\ moment = 294\text{ Nm}$ (1)

b) In the middle of the length of the seesaw. (1)

c) Since the system is in equilibrium then the principle of moments h

$W_1 = weight\ of\ seesaw$

$d_1 = distance\ from\ centre\ of\ mass\ of\ seesaw\ to\ pivot$

$W_2 = weight\ of\ boy$

$d_2 = distance\ from\ boy\ to\ pivot$

$W_1 d_1 = W_2 d_2$ (1)

$W_1 = \dfrac{W_2 d_2}{d_1}$ (1)

$W_1 = \dfrac{(50 \times 9.81) \times 0.6}{(1.2 - 0.6)}$

$W_1 = 490.5\text{ N}$ (1)

d) The weight of the ball will, therefore, be less than the weight of th will no longer be in equilibrium and will tip in the anticlockwise d

e) $W_1 = weight\ of\ seesaw$

$d_1 = distance\ from\ centre\ of\ mass\ of\ seesaw\ to\ pivot$

$W_2 = weight\ of\ boy\ 1 + weight\ of\ boy\ 2$

$d_2 = distance\ from\ two\ boys\ to\ pivot$

$W_1 d_1 = W_2 d_2$ (1)

$\frac{d_1}{d_2} = \frac{W_2}{W_1}$ (1)

$\frac{d_1}{d_2} = \frac{(50 \times 9.81) + (75 \times 9.81)}{490}$

$\frac{d_1}{d_2} = \frac{1226.25}{490.5}$

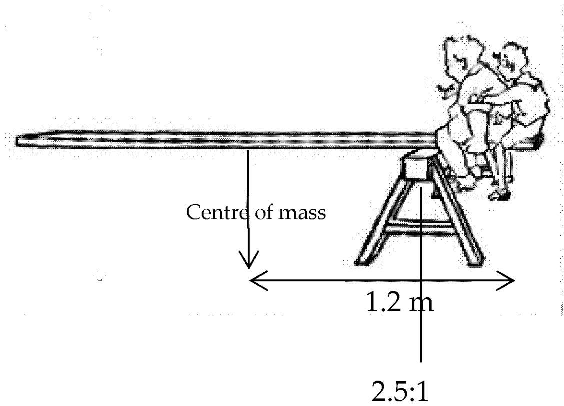
$\frac{d_1}{d_2} = \frac{2.5}{1}$ (1)

$d_1 : d_2 = 2.5 : 1$ (1)

Extension Question

f) If the centre of mass of the seesaw is in the middle then:

Distance from centre of mass to the two boys = 1.2 metres (1)



From (e) we then know that this distance is split into a ratio of 2.5:

$2.5 + 1 = 3.5$ (1)

$d_2 = \frac{1.2\ \text{metres}}{3.5} \times 1$

$d_2 = 0.34$ metres (1)

Homework Four: Laws of Motion

Activity 1: Summary Questions

1. $F_{head} = m_{apple} \times a_{apple}$

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

$$a = \frac{5+1}{0.5}$$

$a_{apple} = 14$ m s^{-2}

The philosopher estimates the force exerted by the apple, so

$F_{head} = 2.50$ N

$$m_{apple} = \frac{F_{head}}{a_{apple}}$$

$m_{apple} = 210$ g

2. a) The change in momentum is given by

$\Delta p = Ft$

$\Delta p = 32.5 \times 1.25$

$\Delta p = 40.63$ kg m s^{-1}

The bowling ball is accelerating from rest so $\Delta p = p$

b) The velocity of the bowling ball is

$$v = \frac{p}{m}$$

$$v = \frac{40.63}{7.26}$$

$v = 5.596$ m s^{-1}

Vertical:

$v_y = v \sin\theta$

$v_y = 5.596 \times \sin 25.0$

$v_y = 2.365$ m s^{-1}

Horizontal:

$v_x = v \cos\theta$

$v_x = 5.596 \times \cos 25.0$

$v_x = 5.072$ m s^{-1}

c) The change in momentum of the ball is equal to the impulse exerte

$F_y t = \Delta p_y$

$Ft \sin\theta = m \times \Delta v_y$

$F = \frac{m \times \Delta v}{t \sin\theta}$

$F = \frac{7.26 \times 2.365}{155 \times 10^{-3} \times \sin 74.1}$

$F = 115.2$ N

d) $F_x t = \Delta p_x$

$Ft \cos\theta = m(u_x - v_x)$

$v_x = u_x - \frac{Ft \cos\theta}{m}$

$v_x = 5.072 - \frac{115.2 \times 155 \times 10^{-3} \times \cos 74.1}{7.26}$

$v_x = 4.398$ m s^{-1}

e) The frictional forces do work against the ball

Loss in kinetic energy = work done by frictional forces

$\frac{1}{2} m\Delta(v^2) = Fs$

$v_{final} = \sqrt{v_{initial} - \frac{2Fs}{m}}$

$v_{final} = \sqrt{4.398^2 - \frac{2 \times 0.140 \times 21.0}{7.26}}$

$v_{final} = 4.305$ m s^{-1}

f) The momentum of the ball before the collision is

$p_{initial} = m_{ball} v_{initial}$

$p_{initial} = 7.26 \times 4.305$

$p_{initial} = 31.25$ kg m s^{-1}

Through conservation of momentum

$p_{initial} = p_{ball} + p_{pin}$

$v_{pin} = \frac{p_{initial} - m_{ball} v_{ball}}{m_{pin}}$

$v_{pin} = \frac{31.25 - 7.26 \times 2.90}{1.50}$

$v_{pin} = 6.80$ m s^{-1}

3. a) A rower pulls back on their oars, causing the oars to exert a force c
direction. One complete stroke lasts 2.5 s, with the oar pushing ag
total mass of water displaced by each oar in one stroke is m_{water} =

The displaced water moves to the left at an average velocity of 0.3
rower, boat and oars is $m_{boat} = 94$ kg.

During each stroke, when the oar is out of the water, the boat slow

The maximum speed of the boat once the oar is back in the water a
be found using the conservation of momentum

$\Delta p_{left} = \Delta p_{right}$

$m_{water} \times \Delta v_{water} = m_{boat} \times \Delta v_{boat}$

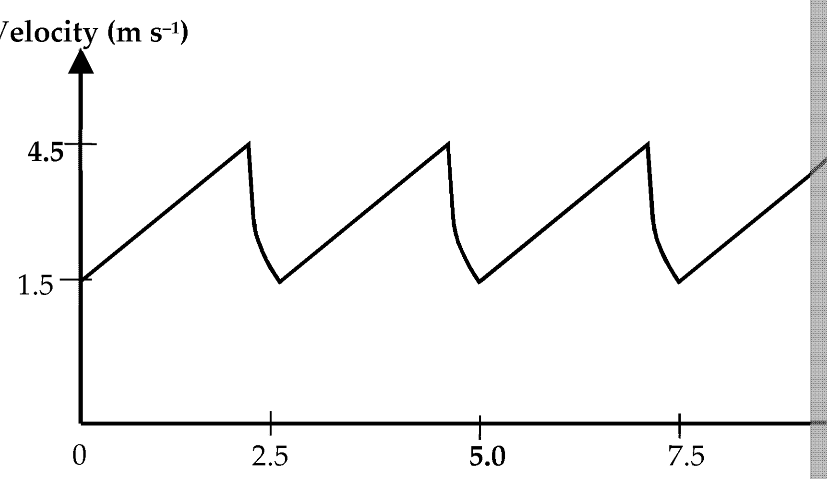
$2 \times 375 \times 0.38 = 94 \times \Delta v_{boat}$

$\Delta v_{boat} = 3.0$ m/s

Adding this to the minimum speed of the boat gives

$v_{max} = 4.5$ m/s

b) Below is a velocity–time graph describing the motion of the rowin



c) The water is initially stationary before being moved by each oar. T
momentum is

$\Delta p_{water} = \mathbf{375 \times 0.38} = 143$ kg m/s

The water is moved while the oar moves through the water, so

$\Delta t = 1.5$ s

So the force exerted by each oar on the water is

$F = \frac{\Delta p}{\Delta t} = \frac{\mathbf{143}}{\mathbf{1.5}} = \mathbf{95\ N}$

d) Friction between the oars and the water causes a slight temperature i energy reduces the useful kinetic energy of the water so the accelerati is a fluid so is turbulent around the edges of the oars, further decreasi transfer. Finally, the oar will not leave the water instantaneously, and after each stroke before its left the water, and before each stroke after

Activity 2: Report Writing

The report should include all listed features.

Results should include:

- F3 experiences lowest force over greatest time
- link between this and lower rate of change of momentum
- even lowest force experienced is around 3000 N

Discussion should include:

- lower force correlates with greater time
- identification of possible features that cause this lower force
- discussion of how lower force corresponds to greater degree of safety
- need for a wider data set
- need for discussion of placement of detectors, e.g. how are the placeme designs of cars?
- identification of an extension, such as how force changes with collision

Homework Five: Be the Reviewer

Activity 1: Promotional Article

Marking checklist

	Points that must be included by student
How does the product work?	☐ Explanation of cycle of a heat engine (heat en converted into work and the rest exhausted i ☐ Explanation of what is meant by the term 'w
How has their product improved?	☐ Statement about whether they believe the ne ☐ Difference in energy transfer between old an ☐ Difference in rate of energy transfer between the ☐ Difference in percentage ☐ Efficiency between old and new model
Comment on how the carbon footprint of the company might have changed as a result of the new model.	☐ Statement about whether they believe that th carbon footprint of the company ☐ Comment on the new efficiency of the model ☐ Comment on how the efficiency of the model of the company

Activity 1: Exam-style Questions

1. The source has its own internal resistance (1) and when current flows t source some of the possible volts are 'lost' in overcoming this resistanc supplied to the rest of the circuit is slightly lower than the emf of the sc

2. a) $\varepsilon = I(R+r)$ (1)

$I = \frac{\varepsilon}{(R+r)}$

$I = \frac{24}{(10+0.3)}$

$I = 2.3$ A (1)

$V = IR$ (1)

$V = 2.3 \times 10$

$V = 23$ V (1)

b) The voltage reading on the voltmeter would decrease (1) because v resistance there is an increase in energy required to overcome this the process. (1)

3. a) $\varepsilon = I(R+r)$ (1)

$I = \frac{\varepsilon}{(R+r)}$

$I = \frac{12}{((2.2+2.2)+0.2)}$ (1)

$I = 2.6$ A (1)

b) $V = IR$

$V = 2.6 \times 2.2$

$V = 5.7$ V

c) $E = \varepsilon Q$

$Q = It$ (1)

$Q = 2.6 \times 500$

$Q = 1300\ C$ (1)

$E = \varepsilon Q$ (1)

$E = 12 \times 1300$

$E = 15\,650$ J (1)

Extension Questions

4. a) $\varepsilon = I(R+r)$

$r = \frac{\varepsilon}{I} - R$ (1) #

In parallel:

$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2}$ (1)

$\frac{1}{R_t} = \frac{1}{10} + \frac{1}{15}$

$\frac{1}{R_t} = \frac{25}{150} = \frac{1}{6}$

$R_t = 6\Omega$ (1)

In series:

$R = R_3 + R_t$ (1)

$R = 5 + 6$

$R = 11\,\Omega$ (1)

$r = \frac{6}{0.5} - 11$

$r = 1\,\Omega$ (1)

b) $V = IR$ (1)

$V = 0.5 \times 6$

$V = 3$ V (1)

c) $E = \varepsilon Q$ (1)

$Q = It$ (1)

$Q = 0.5 \times 20$

$Q = 10\ C$ (1)

$E = 6 \times 10$

$E = 60$ J (1)

$Q = It$ (1)

$Q = 0.5 \times 20$

$Q = 10\ C$ (1)

$E = 6 \times 10$

$E = 60$ J (1)

5. a) $\varepsilon = 15$ V (1)

b) $gradient = -r$ (1)

$gradient = \frac{2-15}{2.7-0}$

$gradient = -4.8$ (1)

$r = 4.8$ V (1)

c) $V = \varepsilon - Ir$ (1)

$V = 15 - 1.2 \times 4.8$

$V = 9.2$ V (1)

d) Greater. (1) Either explanation through observation of the graph tr

$V = \varepsilon - Ir$. (1)

Homework Seven: Be the Consultant

Activity 1: National Grid Recommendation

The National Grid Recommendation Fee

	Recommendation	Supporting explanation/evidence
Material of Cable	Aluminium	Aluminium is a conductor and, therefore, c therefore, electricity. The other option was a insulator and would not be able to transmit
Length of Cable	210 km	To reduce power loss during transmission, minimum resistance. The equation for resistance is $R = \frac{\rho L}{A}$ and, cable whose ratio of length and cross-sectio This cable has the shortest length.
Radius of Cable	5.65 mm	To reduce power loss during transmission, minimum resistance. The equation for resistance is $R = \frac{\rho L}{A}$ and, cable whose ratio of length and cross-sectio Despite 5.7 mm giving a greater cross-secti 5.65 mm radius has a length of 210 km and, smallest area.
Optimal Current	2.5 A	The equation for current is $I = \frac{P}{V}$. This current would provide the maximum minimum value of power required. A higher power delivery would require a la induce further power loss due to heating.

Additional queries

1. **What effect would a temperature increase in the cables have on the transmission?**
   If there were any temperature increases then the resistance of the cab proportionally. When the resistance of the cables increases then more with the current trying to overcome this resistance and, therefore, the from heating in the cables.

2. **Are there other methods of reducing the power loss in the cables?**
   The use of superconducting wires can reduce the amount of power lo Superconducting materials have the property that, once cooled to bel the material displays zero resistivity and current can, therefore, flow source, therefore reducing the amount of power loss.

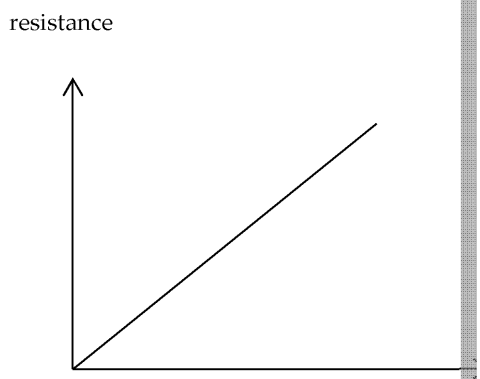
Activity 1: National Grid Recommendation

The National Grid Recommendation Fee		
	Recommendation	**Supporting explanation/evidence**
Material of Cable	Aluminium	• Aluminium and copper are both condu transmit current and, therefore, electrici plastic cable, which is an insulator and current. • Aluminium is then chosen over copper conductivity, this is compensated by its dense.
Length of Cable	210 km	• To reduce power loss during transmissi minimum resistance. • The equation for resistance is $R = \frac{\rho L}{A}$ a cable whose ratio of length and cross-se This cable has the shortest length.
Radius of Cable	5.65 mm	• To reduce power loss during transmissi minimum resistance. • The equation for resistance is $R = \frac{\rho L}{A}$ a cable whose ratio of length and cross-se • Despite 5.7 mm giving a greater cross-se 5.65 mm radius has a length of 210 km a smallest area.
Optimal Current	2.5 A	• The equation for current is $I = \frac{P}{V}$. • This current would provide the maximu the minimum value of power required. • A higher power delivery would require could induce further power loss due to l

Additional queries

1. **What effect would a temperature increase in the cables ha[v] transmission?**
   If there were any temperature increases then the resistance [o] proportionally. When the resistance of the cables increases t[h] with the current trying to overcome this resistance and, ther[e] from heating in the cables.

2. **Sketch a graph that would help to illustrate the effect tem[p] resistance of our cables.**



3. **Are there other methods of reducing the power loss in the**
   The use of superconducting wires can reduce the amount of Superconducting materials have the property that, once coo[l] the material displays zero resistivity and current can, theref[o] source, therefore reducing the amount of power loss.

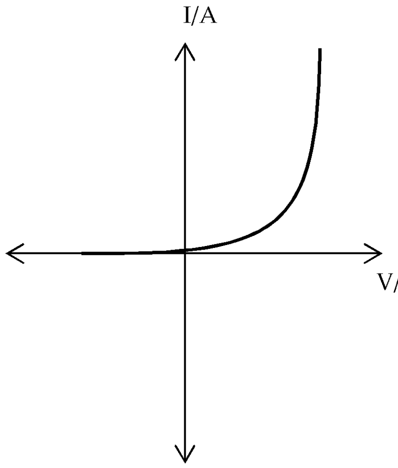
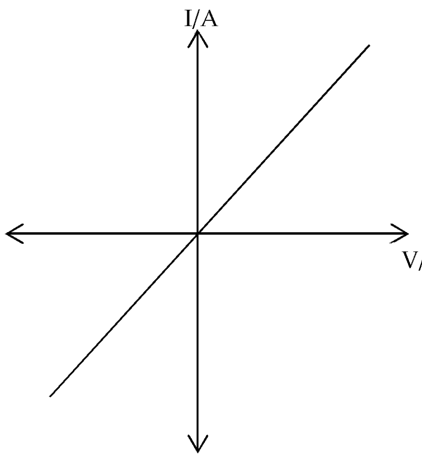
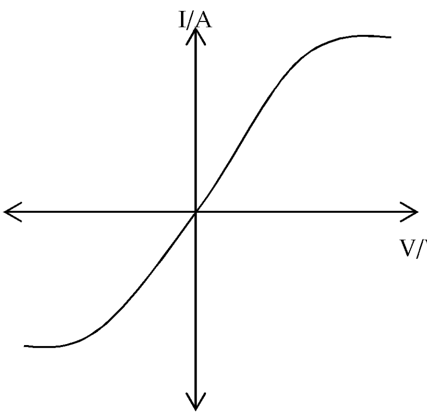
4. **What temperature would we need to keep the cables at in [o] loss?**
   The critical temperature for aluminium is 1.2 K; therefore, if superconductivity of aluminium to reduce power loss, the c[a] temperature of 1.2 K.

Homework Eight: Be the Researcher

Activity 1: Research Investigation

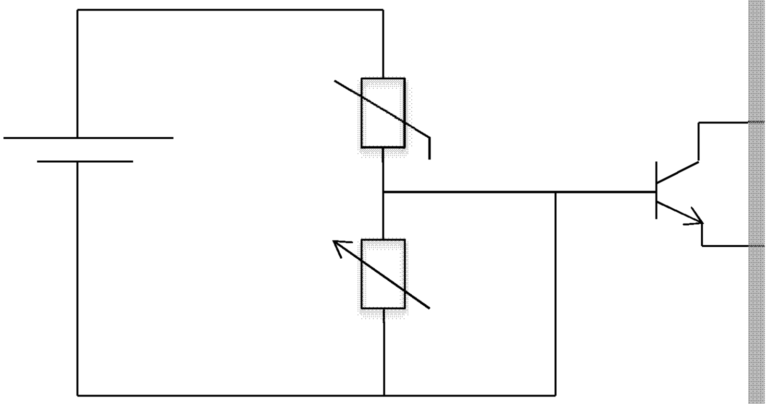
Any format for presenting information is acceptable as long as informatio bullet points mentioned in the task explanation.

An example of the information that should be included is displayed below:

	Ohmic conductor	I-V graph	Explanation of I-
Semiconductor Diode	Not an ohmic conductor		A semiconductor diod allows current to pass forward direction and current in the reverse. **that's why curve equa the negative current** The diode is a light an as current passes throu component the tempe therefore, resistance w and, therefore, there is exponential relationsh opposed to a linear re between I and V.
Metal Wire	An ohmic conductor		If the temperature can constant then so can th and, therefore, since V constant then V will b proportional to I and t will be a linear relatio straight line).
Filament Lamp	Not an ohmic conductor		As current passes the temperature increases therefore, is not a cons Therefore, since V = IR not constant, the I-V c non-linear.

Activity 1: Designing Your Own Circuit

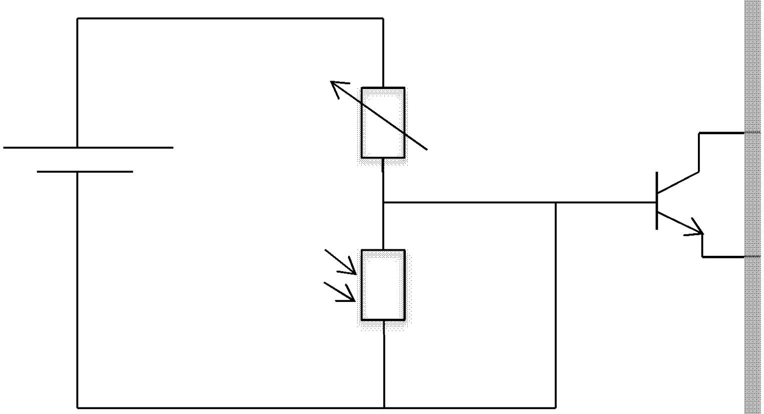
Design Specification 1:



The report should include the following points:

- The circuit design chosen is a series circuit to ensure the current flowin and the thermistor is the same, so that the voltage and resistance ratio l proportional to one another.
- A thermistor has been used as this device operates in the following wa increases the resistance decreases and, therefore, so does the voltage ac . Since the thermistor and resistor are connected in series, then the volt increase as the voltage across the thermistor decreases.
- Once the temperature increases above the 'acceptable' level and the vo reaches the 'switch on' voltage of the transistor, the transistor 'switche second circuit causing the buzzer to alarm.

Design Specification 2:

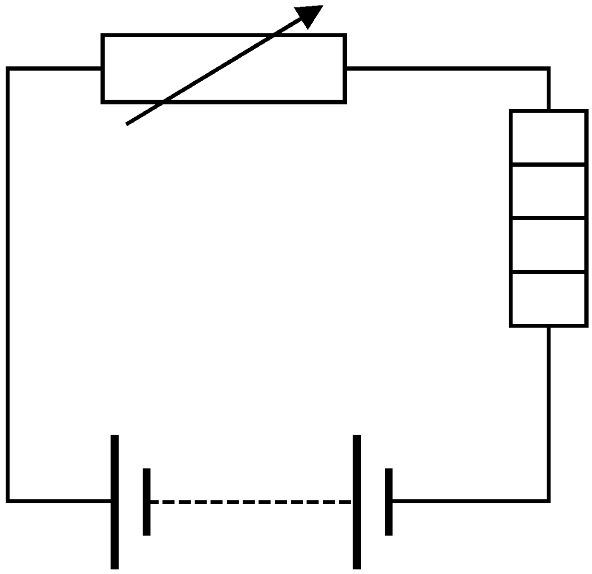


The report should include the following points:

- The circuit design chosen is a series circuit to ensure the current flowin and the LDR is the same so that the voltage and resistance ratio betwe proportional to one another.
- A LDR has been used as this device operates in the following way: as t the resistance increases, and, therefore, so does the voltage across LDR
- When the light intensity falls below an 'acceptable level' the resistance along with the voltage until it reaches 'switch on' voltage of the transis 'switches on' and current flows in the second circuit that controls the ti

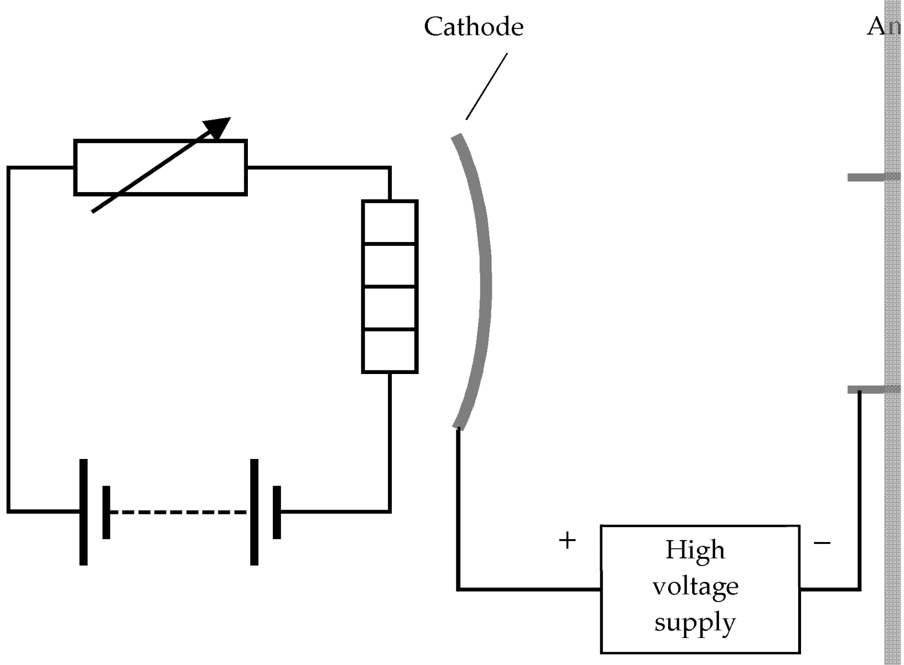
Activity: Designing the electron gun

1.



2. An electron has charge, which means it interacts with electric and mag
presence of an electric field, an electron will experience a force in the o
By Newton's second law, $F = ma$, this force causes the electron to acce

3.



4. First, calculate the cross-sectional area of the wire

$A = \pi r^2$

$A = \pi \left(\frac{1.25 \times 10^{-3}}{2}\right)^2$

$A = 1.23 \times 10^{-6}$ m²

The equation for mean drift velocity is

$I = Anev$

So the mean drift velocity of the electrons in this wire is

$v = \frac{I}{Ane}$

$v = \frac{2.25}{(1.23 \times 10^{-6})(8.49 \times 10^{28})(1.60 \times 10^{-19})}$

$v = 1.35 \times 10^{-4}$ m s^{-1}

5. Add a ring of capacitors or oppositely charged plates around a wide be plates/capacitors will generate an electric field perpendicular to the mo electrons experience a centripetal force. The deviating electrons are for trajectory, keeping the beam focused. By placing several of these rings and increasing the length of the gun, the electron beam emitted from th

6. The vacuum results in there being no particles along the trajectory of th therefore, travel much further than the few metres they penetrate in air in a vacuum, the range of the gun is increased.

7. a) $V = 400$ V so the work done on the electron is

   $W = QV$

   $W = (1.60 \times 10^{-19})(400)$

   $W = 6.40 \times 10^{-17}$ J

   b) The average speed of the electrons is, therefore

   $v = \sqrt{\frac{2E_k}{m}}$

   $v = \sqrt{\frac{2 \times (6.4 \times 10^{-17})}{9.11 \times 10^{-31}}}$

   $v = 1.19 \times 10^{7}$m/s

8. Any two from:
- Mercury
- Sodium
- Sulphur
- Nitrogen
- Hydrogen
- Oxygen

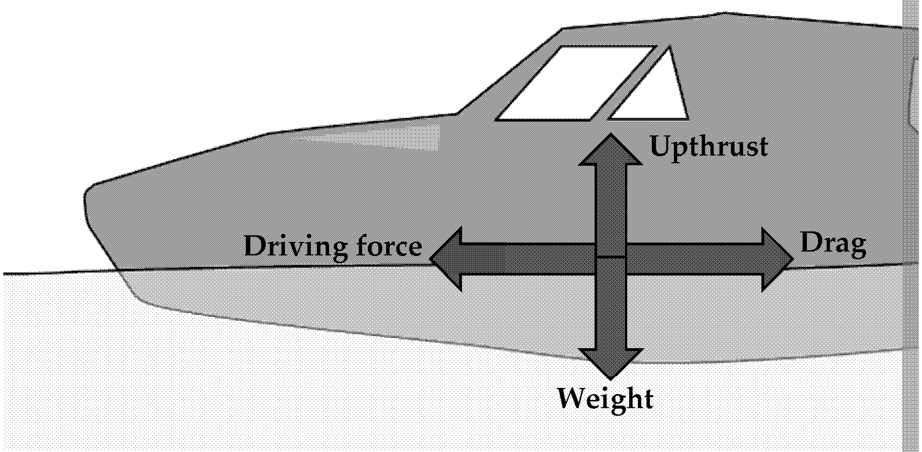
Others may also be used, although less commonly.

9. The energy transferred as electrical power is used to heat a cathode so
create an electric field that accelerates these free electrons. The electrica
initially create a high potential difference across the bulb's gas so the a
accelerated electrons now have kinetic energy and collide with the ioni
atoms and dissipating their kinetic energy. The atoms fall back to a low
UV photon. This energy is transferred as UV light until it hits the fluor
the bulb, where it is absorbed. It is then remitted and transferred as vis

Homework Eleven: Giving the engineers a hand

Activity 1

1.



2. Any one from:
   - Cross-sectional area of boat hitting air – This is the surface area tha the area, the more surface of the fluid to hit, therefore for a given a exerted is larger.
   - Speed of boat – The faster the boat, the more fluid particles that hit therefore a larger force is exerted.
   - Density/pressure of air – The denser (and higher pressure of) the a that hit the boat per second, therefore a larger force is exerted.
   - Temperature of air – The higher the temperature of the air, the larg volume (using the ideal gas law), therefore the larger the pressure

3. Weight of boat is

   $W = mg$

   $W = 5500 \times 9.81$

   $W = 54.0$ Kn

   So the upthrust acting on the boat to keep it floating is

   $F = 54.0$ kN

4. The boat is in equilibrium so this weight is equal to the upthrust cause

   $54.0\text{ kN} = \rho_{water} \times g \times V$

   $V = \dfrac{54000}{1000 \times 9.81}$

   $V = 5.5\text{ m}^3$

5. The generated upthrust would cause a greater upwards moment actin
the boat would rotate and lift out of the water. This means there is less
the water, resulting in less drag due to water. Less drag forces means t
effective and therefore the motion of the boat is more efficient.

Activity 2

1. Drag is the impact of fluid particles against an object as the fluid flows
friction between the fluid and the object. This friction acts over a distan
The result is this work heating the object up.

2. The cross-sectional area of the heat shield. A larger cross-sectional area
drag force to be exerted on the command module, slowing it down.

2./3. They should go with Beth's design because the purpose of the heat shiel
as much as possible. A cone is very aerodynamic, so any air the hits the
smaller amount compared to if it hit the flat shield. This results in less dr
decelerates much more slowly. Therefore a flat heat shield with a larger

Activity 3

1. The water flows from left to right. Therefore the shark has a small cross
flow of the water, shown in the diagram by a short height compared to
very smooth (ignoring the fins and tail) so water (a fluid) easily flows o
sharp nose to cut through the water, reducing drag and guiding the wa

2. a) From the graph, $\eta = 1.0$ mPa s.

   b) Viscous drag force is therefore

   $F = 6\pi\eta rv$

   $F = 6\pi \times (1.0 \times 10^{-3}) \times 0.2 \times 2.5$

   $F = 9.4$ mN

   c) This force is much too small to have an effect on the 110 kg shark.
   around the shark would be too turbulent to apply Stokes law.

3. The ballast tanks are initially filled with air. By allowing water to flow
air out into the sea, the mass of submarine increases. This is because th
air is much denser than the air. The tanks have a constant volume, ther
tank is higher than before. The increase in mass and therefore weight o
submarine experiences a net force downwards. The submarine then pu
reaches its required depth.

Activity 4

1. For the glider to not tip up or down, the moments about the centre of

   Anticlockwise
   $M_{clockwise} = 5400 \times 0.7 = 378$ Nm

   Clockwise
   $M_{anticlockwise} = (2300 \times (0.4 + 6.7)) + (0.4 \times F_{wing})$

   These moments are equal, therefore

   $3780 = 16330 + 0.4F_{wing}$

   $F_{wing} = 31.4$ kN

2. Pressure difference, p, between top and bottom of wing is

   $p = h\rho g$

   $p = 0.16 \times 1.225 \times 9.81$

   $p = 1.9$ Pa

3. By using SUVAT equations of motion

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

   $a_v = \frac{2s}{t^2}$

   $a_v = \frac{2 \times 10}{10^2}$

   $a_v = 0.2$ m s^{-2}

Activity 1

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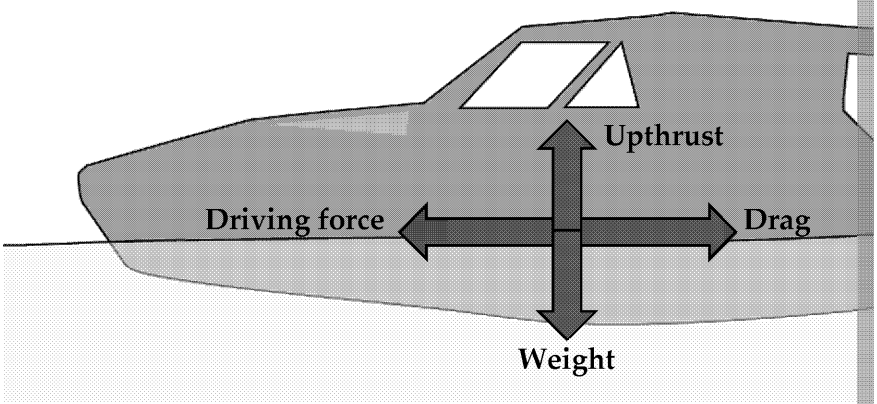

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   $a_v = \frac{2 \times 10}{10^2}$

   $a_v = 0.2$ m s^{-2}

   The acceleration due to upthrust from the wing is therefore

   $a_{wing} = g - a_v$

   $a_{wing} = 9.81 - 0.2$

   $a_{wing} = 9.61$ m s^{-2}

Homework Twelve: Graph Skills

Activity 1: Graph Analysis Question

a) The kinetic energy from the motion of the car is absorbed by the sprin the elastic potential energy of the car's springs.

b) The greatest spring constant will be the line with the greatest gradient either be determined by simple observation or through calculation:

Car 1	*Car 2*	
$gradient = \frac{1.5\times10^6}{0.15}$ $gradient = 1\times10^7$ $k = gradient$ $k = 1\times10^7\ \text{N m}^{-1}$	$gradient = \frac{1.2\times10^6}{0.1}$ $gradient = 1.2\times10^7$ $k = gradient$ $k = 1.2\times10^7\ \text{N m}^{-1}$	

Therefore, Car 3 has the greatest spring constant k.

c) The spring used for Car 3 is the stiffest of the three cars.

d) The elastic potential energy stored is equal to the area under a force–e greatest elastic potential can either be read off from the graph or deter

elastic potential energy=area under force-extension graph

Car 1:

$area\ under\ the\ graph = 0.5\times0.15\times(1.5\times10^6)$

$area\ under\ the\ graph = 1.1\times10^5$

$E = area\ under\ the\ graph$

$E = 1.1\times10^5\ \text{J}$

Car 2 :

$area\ under\ the\ graph = 0.5\times0.1\times(1.2\times10^6)$

$area\ under\ the\ graph = 6\times10^4$

$E = area\ under\ the\ graph$

$E = 6\times10^4\ \text{J}$

Car 3 :

$area\ under\ the\ graph = 0.5\times0.085\times(1.3\times10^6)$

$area\ under\ the\ graph = 5.5\times10^4$

$E = area\ under\ the\ graph$

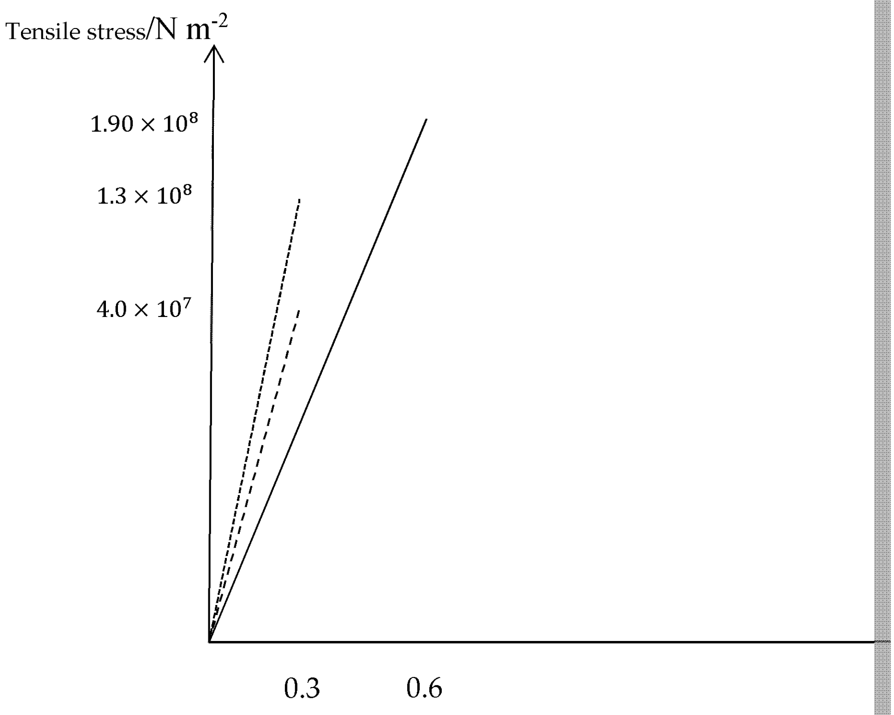
$E = 5.5\times10^4\ \text{J}$

e) The equations needed:

$$tensile\ stress = \frac{F}{A}$$

$$tensile\ strain = \frac{\Delta L}{L}$$

	Length of spring/m	**Radius of spring/m**	**Area/m²**
Car 1	0.25	0.05	7.9×10^{-3}
Car 2	0.30	0.1	0.03
Car 3	0.28	0.06	0.01



f) Young's modulus=gradient of stress strain graph :

Car 1	**Car 2**
$Young's\ modulus = \frac{1.90\times10^8}{0.6}$ $Young's\ modulus = 3.2\times10^8$	$Young's\ modulus = \frac{4.0\times10^7}{0.3}$ $Young's\ modulus = 1.3\times10^8$

Homework Twelve: Graph Skills

Activity 1: Graph Analysis Question

a) The kinetic energy from the motion of the car is absorbed by the spring the elastic potential energy of the car's springs.

b) The greatest spring constant will be the line with the greatest gradient. either be determined by simple observation or through calculation:

$$Car\ 1:$$
$$gradient = \frac{1.5\times10^{6}}{0.15}$$
$$gradient = 1\times10^{7}$$
$$k = gradient$$
$$k = 1\times10^{7}\ \text{N m}^{-1}$$

$$Car\ 2:$$
$$gradient = \frac{1.2\times10^{6}}{0.1}$$
$$gradient = 1.2\times10^{7}$$
$$k = gradient$$
$$k = 1.2\times10^{7}\ \text{N m}^{-1}$$

$$Car\ 3:$$
$$gradient = \frac{1.3\times10^{6}}{0.085}$$
$$gradient = 1.5\times10^{7}$$
$$k = gradient$$
$$k = 1.5\times10^{7}\ \text{N m}^{-1}$$

Therefore, Car 3 has the greatest spring constant k.

c) The spring used for Car 3 is the stiffest of the three cars.

d) The elastic potential energy stored is equal to the area under a force–ex greatest elastic potential can either be read off from the graph or deter

$elastic\ potential\ energy = area\ under\ force - extension\ graph$

Car 1:

$area\ under\ the\ graph = 0.5 \times 0.15 \times (1.5 \times 10^6)$

$area\ under\ the\ graph = 1.1 \times 10^5$

$E = area\ under\ the\ graph$

$E = 1.1 \times 10^5$ J

Car 2 :

$area\ under\ the\ graph = 0.5 \times 0.1 \times (1.2 \times 10^6)$

$area\ under\ the\ graph = 6 \times 10^4$

$E = area\ under\ the\ graph$

$E = 6 \times 10^4$ J

Car 3 :

$area\ under\ the\ graph = 0.5 \times 0.085 \times (1.3 \times 10^6)$

$area\ under\ the\ graph = 5.5 \times 10^4$

$E = area\ under\ the\ graph$

$E = 5.5 \times 10^4$ J

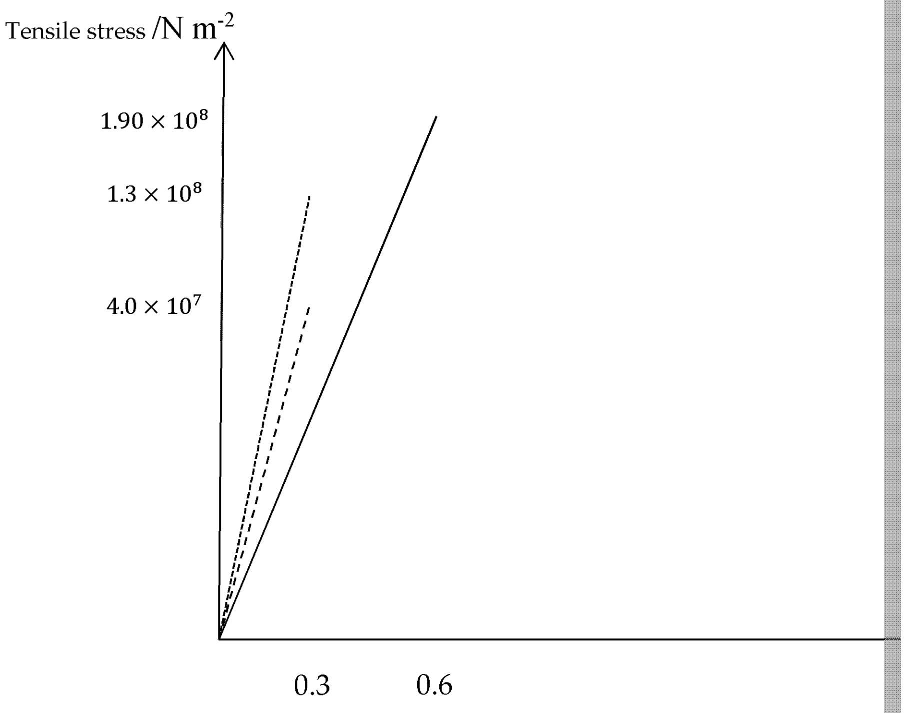
Therefore, considering the kinetic energy of the car has been converted by the spring, Car 1 will have held the greatest kinetic energy. Additio travelling at the same velocity v then Car 1 must also have the largest

e) The equations needed:

$tensile\ stress = \frac{F}{A}$

$tensile\ strain = \frac{\Delta L}{L}$

	Length of spring/m	Radius of spring/m	Area/m^2
Car 1	0.25	0.05	7.9×10^{-3}
Car 2	0.30	0.1	0.03
Car 3	0.28	0.06	0.01



f) $Car\ 1:$

$Young's\ modulus = gradient\ of\ stress\ strain\ graph$

$$Young's\ modulus = \frac{1.90 \times 10^8}{0.6}$$

$Young's\ modulus = 3.2 \times 10^8$

$Car\ 2:$

$Young's\ modulus = gradient\ of\ stress\ strain\ graph$

$$Young's\ modulus = \frac{4.0 \times 10^7}{0.3}$$

$Young's\ modulus = 1.3 \times 10^8$

$Car\ 3:$

$Young's\ modulus = gradient\ of\ stress\ strain\ graph$

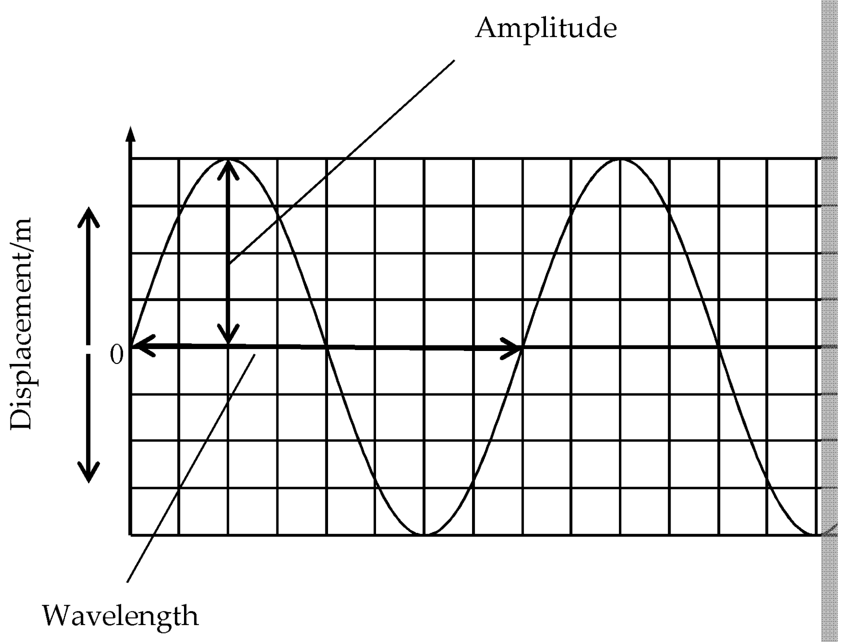
$$Young's\ modulus = \frac{1.3 \times 10^8}{0.3}$$

$Young's\ modulus = 4.3 \times 10^8$

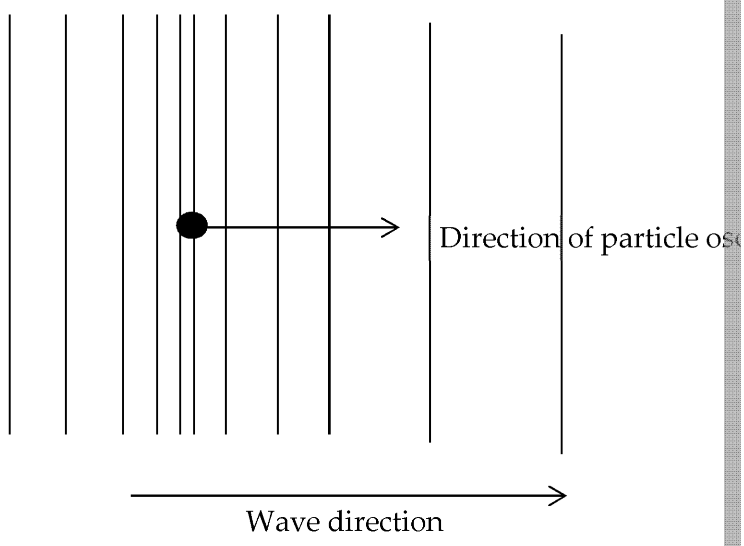
Homework Thirteen: Summary Questions

Activity 1: Summary Questions

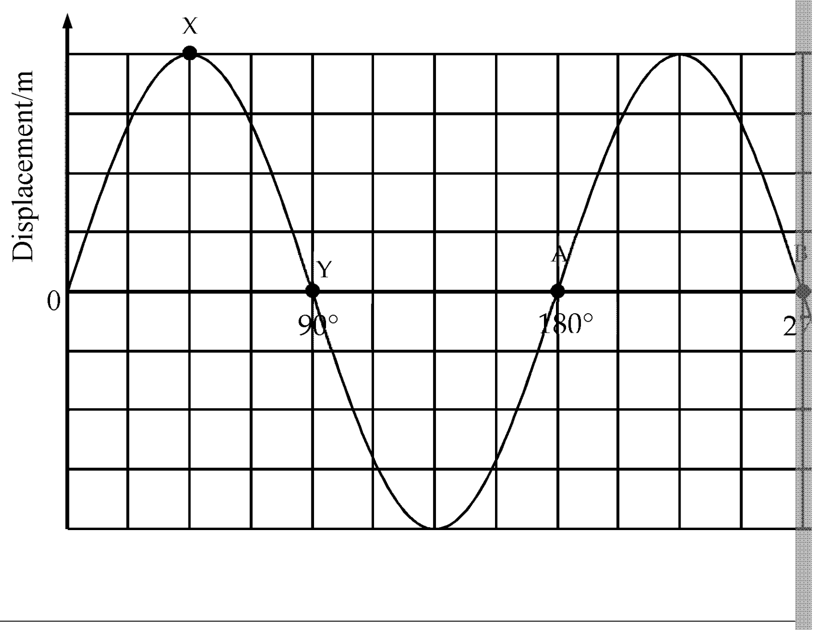
1.



2.



3.



a) X and Y represent an example of two points with phase differenc

b) A and B represent an example of two points with phase differenc

c) Transverse, because the particles on the graph oscillate perpendic of the wave.

d) Possible examples of transverse waves:
- Electromagnetic radiation
- Waves on a string

Possible example of longitudinal waves:
- Sound waves

4. $v = \frac{\textit{distance travelled in one cycle}}{\textit{time taken for one cycle}}$

$v = \frac{50 \times 10^3}{1.7 \times 10^{-4}}$

$v = 2.9 \times 10^8 \text{ m s}^{-1}$

5. a) $f = 0.5 \times 10^3 \text{ Hz}$

$\lambda = 1 \text{ m}$

$v = f\lambda$

$v = 0.5 \times 10^3 \times 1$

$v = 500 \text{ m s}^{-1}$

b) $T = \frac{1}{f}$

$T = \frac{1}{0.5 \times 10^3}$

$T = 2 \times 10^{-3} \text{ s}$

c) If period increases, then the frequency decreases and, therefore, th

6. a) Sunlight (visible light) is an electromagnetic wave and all electrom speed of light $3 \times 10^8 \text{ ms}^{-1}$.

b) A polaroid filter only allows light oscillating in a certain orientati through it. Therefore, the filter takes unpolarised light (light that o reduces it to a plane polarise wave (a wave that oscillates in only o intensity of light is reduced.

c) The plane polarised light would be further polarised and no light

d) $f = \frac{v}{\lambda}$

$f = \frac{3 \times 10^8}{500 \times 10^{-9}}$

$f = 6 \times 10^{14} \text{ Hz}$

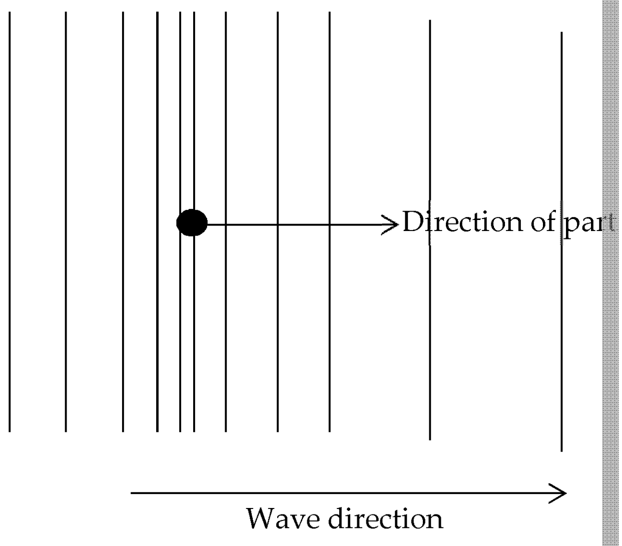
e) The frequency of light would be smaller.

f) Radio wave transmission.

Homework Thirteen: Summary Questions

Activity 1: Summary Questions

1.



2. a) 360°; 1 cycle

   b) 180°; 1/2 cycle

   c) Transverse, as the particles oscillate perpendicular to the wave dir

   d) Possible examples of transverse waves:
   - Electromagnetic radiation
   - Waves on a string

   Possible example of longitudinal waves:
   - Sound waves

3. $v = \dfrac{distance\ travelled\ in\ one\ cycle}{time\ taken\ for\ one\ cycle}$

$$v = \frac{50 \times 10^{3}}{1.7 \times 10^{-4}}$$

$$v = 2.9 \times 10^{8}\ \text{m s}^{-1}$$

4. a) $f = 0.5 \times 10^{3}$ Hz

$$\lambda = 1\ \text{m}$$

$$v = f\lambda$$

$$v = 0.5 \times 10^{3} \times 1$$

$$v = 500\ \text{m s}^{-1}$$

   b) $T = \dfrac{1}{f}$

$$T = \frac{1}{0.5 \times 10^{3}}$$

$$T = 2 \times 10^{-3}\ \text{s}$$

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c) The plane polarised light would be further polarised and no light

d) $f = \dfrac{v}{\lambda}$

$f = \dfrac{3 \times 10^{8}}{500 \times 10^{-9}}$

$f = 6 \times 10^{14}\text{Hz}$

e) The frequency of light would be smaller.

f) Radio wave transmission.

Homework Fourteen: Be the Engineer

Activity 1: Letter of Explanation

Note: This task is subjective and, therefore, there can be a number of varyin this task. A student is deemed to have a correct answer as long as they back in their letter with scientific fact that validates the reasoning.

A model answer is, however, demonstrated below:

- **Recommendation**: Do not set them up facing the wall
- The sound wave will be reflected off the wall and, therefore, since the t reflected wave will be travelling at the same frequency they will interfe wave (a set of harmonics)
- Despite the standing wave creating points of maximum pitch, it will al is complete sound cancellation (nodes and antinodes)
- The set-up will result in uneven frequency balance

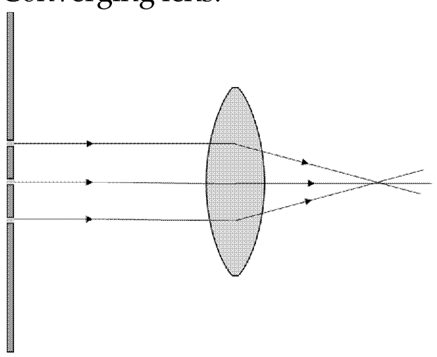
Homework Fifteen: How to see Avast distance

Activity

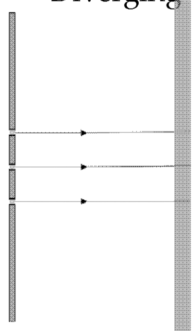
1. a) Converging lens and diverging lens

b) The slits only allow a small beam of light from the Sun to pass thro each slit are parallel to one another, so this creates several parallel investigate the properties of the lenses.

c) Converging lens:

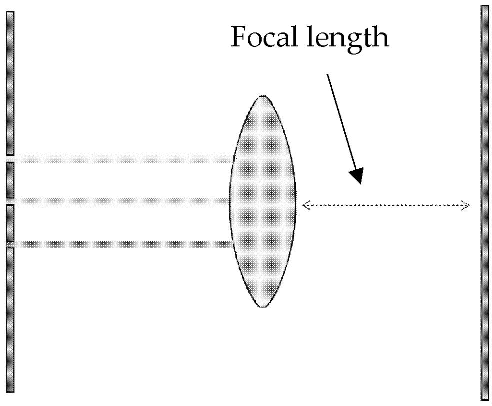


Diverging

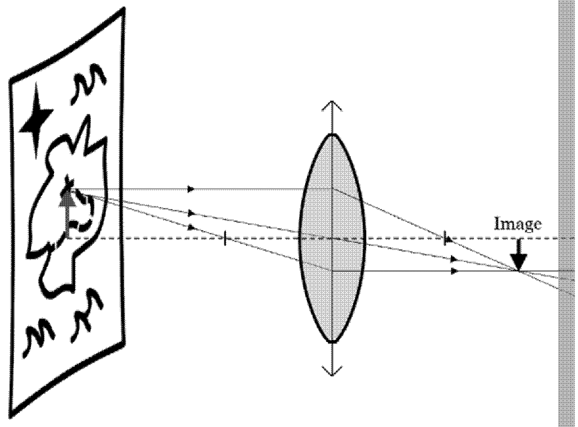


2. a) The rays converge to one spot, hence the lens used is a convergin

b)



3.



4. $magnification = \frac{image\ height}{object\ height}$

$magnification = \frac{24}{7.5}$

$magnification = 3.2$

5. a) Magnification, m, is given by

$m = \frac{v}{u}$

where u is the distance between the object and lens, and v is the di the lens. Therefore

$3.2 = \frac{v}{u}$

$v = 3.2u$

$v = 3.2 \times 7$ cm

$v = 22.4$ cm

b) The focal length, f, can be found using

$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$

$\frac{1}{f} = \frac{1}{7} + \frac{1}{22.4}$

$f = 5.3$ cm

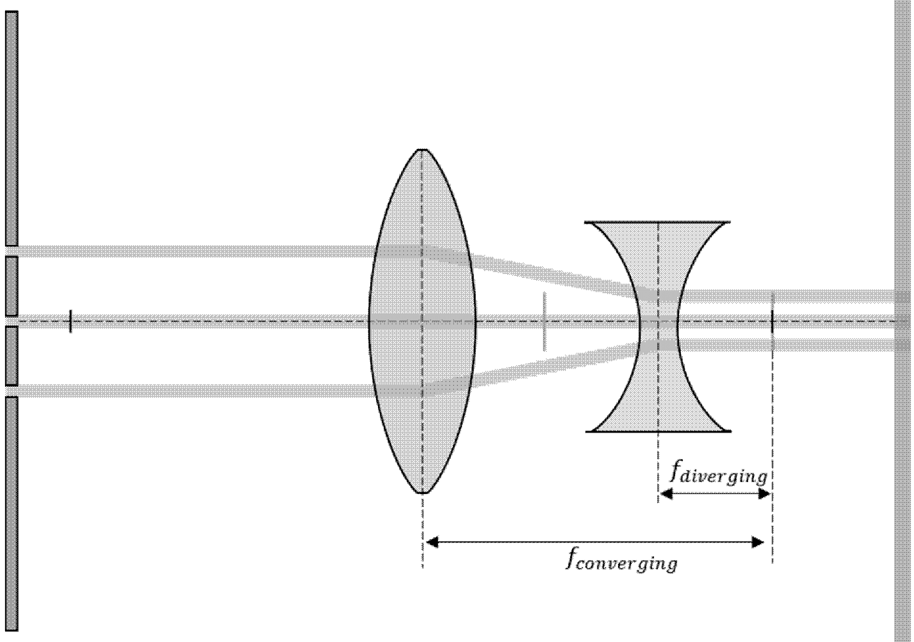
c) The power of the lens, P, is given by

$$P = \frac{1}{f}$$

$$P = \frac{1}{5.3}$$

$$P = 0.19\ \text{cm}^{-1}$$

6.

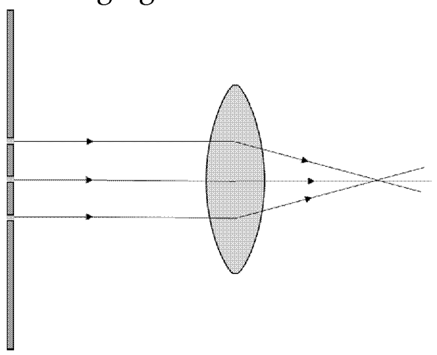


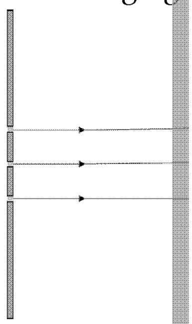
Activity

1. a) Converging lens and diverging lens

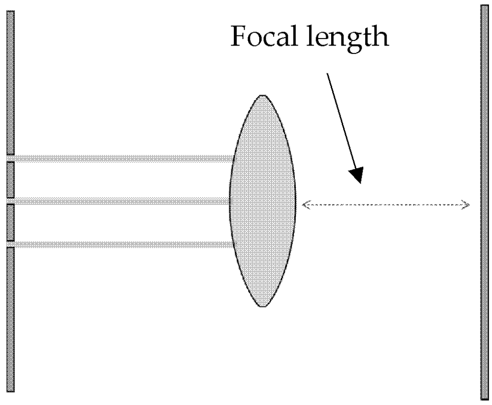
b) The slits only allow a small beam of light from the Sun to pass thr
each slit are parallel to one another, so this creates several parallel
investigate the properties of the lenses.

c) Converging lens: Diverging

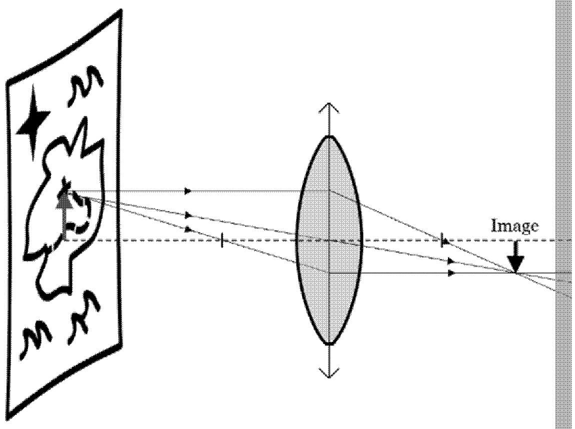




2. The rays converge to one spot, hence the lens used is a converging lens



3.



4. a) $magnification = \frac{image\ height}{object\ height}$

$magnification = \frac{24}{7.5}$

$magnification = 3.2$

b) $object\ diameter = \frac{image\ diameter}{magnification}$

$object\ diameter = \frac{11}{2.4}$

$object\ diameter = 4.6$ cm

5. a) Magnification, m, is given by

$m = \frac{v}{u}$

where u is the distance between the object and lens, and v is the di the lens. Therefore

$3.2 = \frac{v}{u}$

$v = 3.2u$

$v = 3.2 \times 7$ cm

$v = 22.4$ cm

The focal length, f, can be found using

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\frac{1}{f} = \frac{1}{7} + \frac{1}{22.4}$$

$$f = 5.3 \text{ cm}$$

b) The power of the lens, P, is given by

$$P = \frac{1}{f}$$

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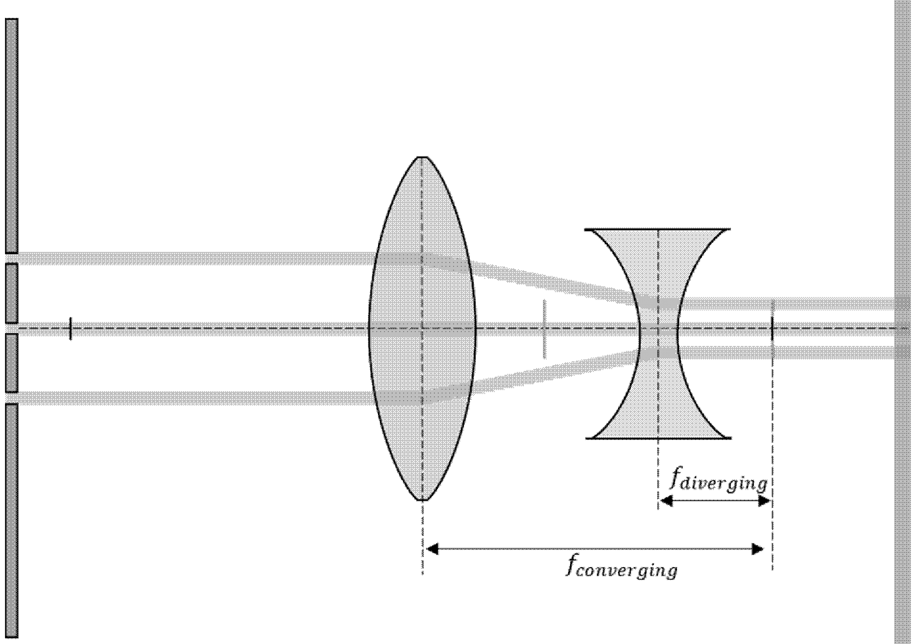
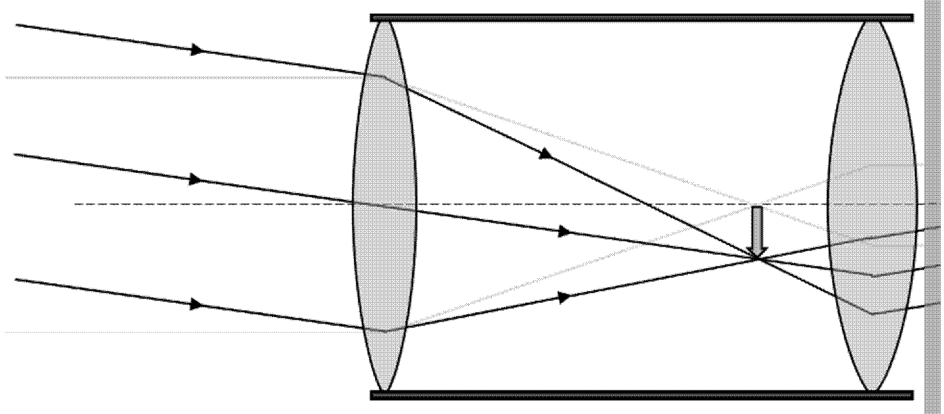
$$P = 0.19 \text{ cm}^{-1}$$

6.



Parallel rays incident on the converging lens will refract towards each o lens focal point. However, they instead hit the face of the diverging len each other. If this diverging lens is positioned so its focal point coincid converging lens, as described in the example above, these previously c be refracted just enough to leave the diverging lens as parallel rays. Th the converging lens is preserved but has now been magnified.

Extension task



Advantages over Galilean telescopes:

- Wider viewing angle
- The focal plane (the grey arrow above) can also have a micrometer fitt objects can be measured

Homework Sixteen: Be the Designer

Activity 1: Design of an Experimental Set-up

The criteria can be met by setting up an experiment that mimics Young's d with two speakers acting as coherent sources of sound waves. The equatio double slit experiment can, therefore, be used to determine how far apart t order to achieve the required interference pattern:

s = distance between speakers

D = distance between speakers and seats

w = width of sound fringe

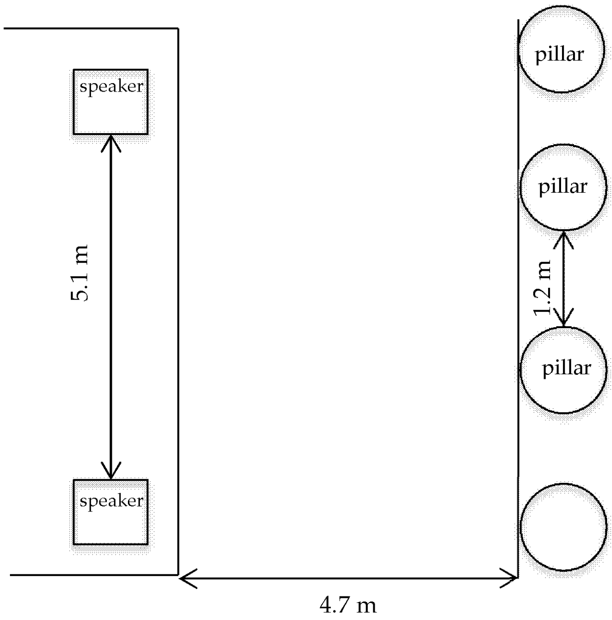
λ = wavelength of sound wave

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

$$s = \frac{(130 \times 10^{-2}) \times 4.7}{1.2}$$

$$s = 5.1\,\text{m}$$

Therefore, the two speakers have to be placed 5.1 metres apart on the stage interference pattern that meets the theatre company's specification.



1. **Will the set-up still work if the two speakers are transmitting sound frequencies?**
   No, as the two sources of sound waves will no longer be coherent, meaning th constant phase difference or frequency. Non-coherent sources will mean that t constructively or destructively.

2. **If the speakers are set back on the stage by a further 0.4 metres what waves we transmit in order to achieve the same sound pattern reachi**

   s = distance between speakers
   D = distance between speakers and seats
   w = width of sound fringe
   λ = wavelength of sound wave

   $$s = \frac{\lambda D}{w}$$
   $$s = \frac{(130 \times 10^{-2}) \times (4.7 + 0.4)}{1.2}$$
   $$s = 5.5\,\text{m}$$

   After a recalculation with the new parameters, I suggest that in order to achie will now have to be placed at a distance of 5.5 metres from one another.

3. **What would happen to the sound pattern if only one speaker was us slits of width 14 cm?**
   Using this method essentially significantly reduces the distance between the s therefore, significantly increases the separation between the fringes. Therefore, pillars might not receive maximum pitch as the distance between the fringes o (higher-pitched sound) will be greater and will not coincide with the spaces in

4. **Can the same set-up be applied to Room 2 that has a stage width of 4 from the stage to the audience's seats is the same?**

No. If the distance from the stage to the audience is the same then the same se speakers will be needed to ensure the same result. Therefore, since Room 2's st will be too small for the separation needed.

Activity 2: Summary Questions

1. $n = \frac{c}{v}$

$n = \frac{3\times10^8}{2\times10^8}$

$n = 1.5$

2. $n = \frac{c}{v}$

$n = \frac{3\times10^8}{3\times10^8}$

$n = 1$

3. a) $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 = \frac{n_2 \sin\theta_2}{\sin\theta_1}$

$n_2 = \frac{1\times\sin 11}{\sin 4.5}$

$n_2 = 2.4$

b) $\sin\theta_c = \frac{n_2}{n_1}$

$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

$\theta_c = \sin^{-1}\left(\frac{1}{2.4}\right)$

$\theta_c = 24°$

4. a) Light carrying information enters the optical fibre at an angle grea the material it is made of. Therefore, when the light ray hits the bo and the outer core cladding then it undergoes total internal reflecti and travels towards the opposing boundary. The process is then co the optical fibre until it reaches the end.

b) Reduce the width of the optical fibre as it will reduce the discrepa travelled by the light undergoing total internal reflection and the l of the optical fibre.

Homework Sixteen: Be the Designer

Activity 1: Design an Experimental Set-up

The criteria can be met by setting up an experiment that mimics Young's d with two speakers acting as coherent sources of sound waves. The equatio double slit experiment can, therefore, be used to determine how far apart t order to achieve the require interference pattern:

s = distance between speakers

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w = width of sound fringe

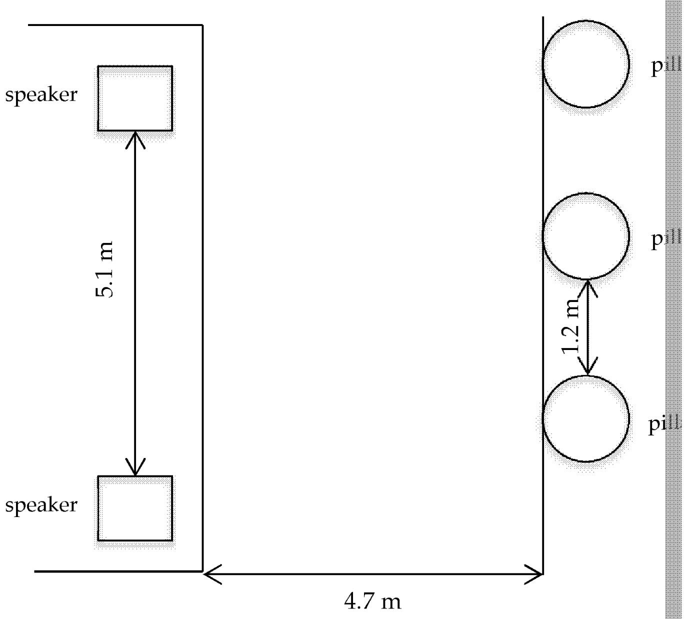
λ = wavelength of sound wave

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

$$s = \frac{(130 \times 10^{-2}) \times 4.7}{1.2}$$

$$s = 5.1\,\text{m}$$

Therefore, the two speakers have to be placed 5.1 metres apart on the stage interference pattern that meets the theatre company's specification.



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2. **If the speakers are set back on the stage by a further 0.4 metres what waves we transmit in order to achieve the same sound patter reachi**

s = distance between speakers

D = distance between speakers and seats

w = width of sound fringe

λ = wavelength of sound wave

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

$$s = \frac{(130\times10^{-2})\times(4.7+0.4)}{1.2}$$

$$s = 5.5\,\text{m}$$

After a recalculation with the new parameters, I suggest that in order to achi will now have to be placed at a distance of 5.5 metres from one another.

3. **What would happen to the sound pattern if only one speaker was us slits of width 14 cm?**
Using this method essentially significantly reduces the distance between the s therefore significantly increases the separation between the fringes. Therefore pillars might not receive maximum pitch as the distance between the fringes o (higher pitched sound) will be greater and will not coincide with the spaces in

4. **Can the same set up be applied to Room 2 that has a stage width of 4 from the stage to the audiences' seats is the same?**
No, since the speakers need to be at a distance of 5.1 metres from each other in interference pattern necessary. To achieve the pattern for Room 2 you would waves with smaller wavelength:

s = *distance between speakers*

D = *distance between speakers and seats*

w = *width of sound fringe*

λ = *wavelength of sound wave*

$$\lambda = \frac{wD}{s}$$

$$\lambda = \frac{4.7\times1.2}{(\le 4.5)}$$

$$\lambda \le 1.25\text{ m}$$

Therefore, if you use sound waves with wavelength of 1.25 metres or less the interference pattern necessary on the stage in Room 2.

Activity 2: Summary Questions

1. $n = \frac{c}{v}$

$n = \frac{3 \times 10^8}{2 \times 10^8}$

$n = 1.5$

2. $n = \frac{c}{v}$

$n = \frac{c}{v}$

$n = \frac{3 \times 10^8}{3 \times 10^8}$

$n = 1$

3. a) $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$n_1 = \frac{n_2 \sin\theta_2}{\sin\theta_1}$

$n_2 = \frac{1 \times \sin 11}{\sin 4.5}$

$n_2 = 2.4$

b) $\sin\theta_c = \frac{n_2}{n_1}$

$\theta_c = \sin^{-1}\left(\frac{n_2}{n_1}\right)$

$\theta_c = \sin^{-1}\left(\frac{1}{2.4}\right)$

$\theta_c = 24°$

4. a) Light carrying information enters the optical fibre at an angle grea the material it is made of. Therefore, when it hits the boundary bet outer core cladding, then it undergoes total internal reflection and towards the opposing boundary. The process is then continued do fibre until it reaches the end.

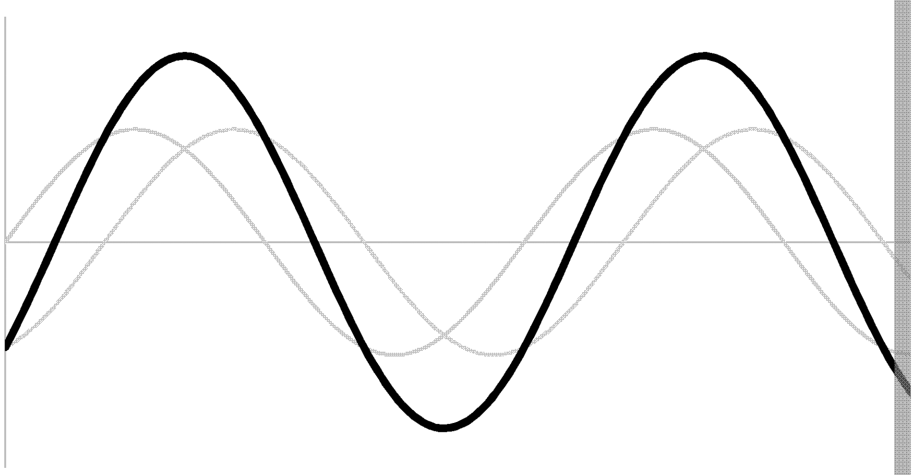
b) Reduce the width of the optical fibre as it will reduce the discrepar travelled by the light undergoing total internal reflection and the li of the optical fibre.

Homework Seventeen: Young's Double Slit Experiment

Activity 1: Summary questions

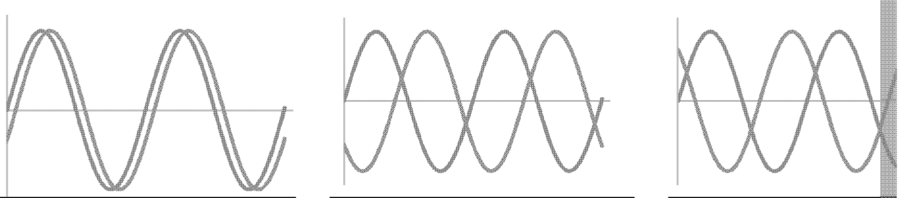
1. When two waves meet they add together to interfere either constructiv destructively. The resulting wave is known as the superposition of the

2. Accept a graph that looks similar to the one below.



3. Path difference → The difference in length between two paths taken by
Coherence → When two waves are in phase with one another.
Interference → When two waves propagate through the same space su wave.
Phase difference → The angle or fraction of one oscillation between tw

4.

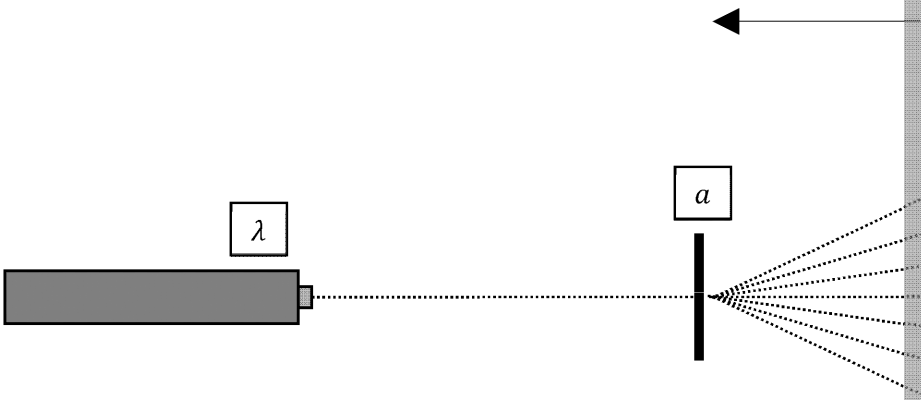


Constructive	Destructive	Destructive

The interference of two waves depends on the phase difference betwe in phase (a phase difference of $-\frac{\pi}{2} < \theta < \frac{\pi}{2}$), then the interference will b the waves are out of phase (a phase difference of $\frac{\pi}{2} < \theta < \frac{3\pi}{2}$), then the i destructive.

Activity 2: Experimental analysis

1.



2. The waves originate from different points so they interfere by differen the **distance** away from each slit. This varies the **phase** between the wa superposition creates a **resultant** wave that varies with distance from c there are positions between the slit and screen that result in both wave they maximally **constructively** interfere, and other points where the w maximally **destructively** interfere. This results in areas of constructive neighboured by areas of destructive **interference**. The waves then hit t the seen pattern of **bright** and **dark** spots.

3. **Independent variable:** Either the slit spacing, a, or the distance betwe
Dependent variable: The distance between maxima in the diffraction p

4. To calculate the frequency, we first need to calculate the wavelength o

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

$$\lambda = \frac{(3.5 \times 10^{-4}) \times (5.2 \times 10^{-3})}{3.40}$$

$$\lambda = 5.35 \times 10^{-7}\text{m}$$

which has an absolute error of

$$(5.35 \times 10^{-7}) \times \left(\frac{0.02}{0.35} + \frac{0.01}{3.40} + \frac{0.1}{5.2}\right)$$

$$= 4.24 \times 10^{-8}\text{ m}$$

So the wavelength of light is

$$\lambda = 535 \pm 42\text{ nm}$$

The corresponding frequency of light is

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

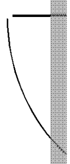
$$f = \frac{3.0 \times 10^{8}}{5.35 \times 10^{-7}}$$

$$f = 5.6 \times 10^{14}\ \text{Hz}$$

and with its error

$$(5.6 \pm 0.4) \times 10^{14}\ \text{Hz}$$

5. By considering each slit in Young's double slit experiment as the point source of a wavelet, the diffraction pattern observed can be explained by the interference of the wavelets, as seen to the right.



6. Electrons demonstrate wave-like behaviour under certain conditions. This observation combined with other experimental observ effect) results in waves-particle duality. This is the notion that waves a behaviour of one another, suggesting there is underlying physics that

7. The mass of an electron is $m_e = 9.11 \times 10^{-31}$ kg. If it travels at 5 % of th velocity is $v_e = 0.05 \times 3.00 \times 10^{8} = 1.50 \times 10^{7}$ m s⁻¹.

   a) Its momentum is, therefore, $p = (9.11 \times 10^{-31}) \times (1.50 \times 10^{7}) = 1.$

   b) Its de Broglie wavelength is, therefore

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

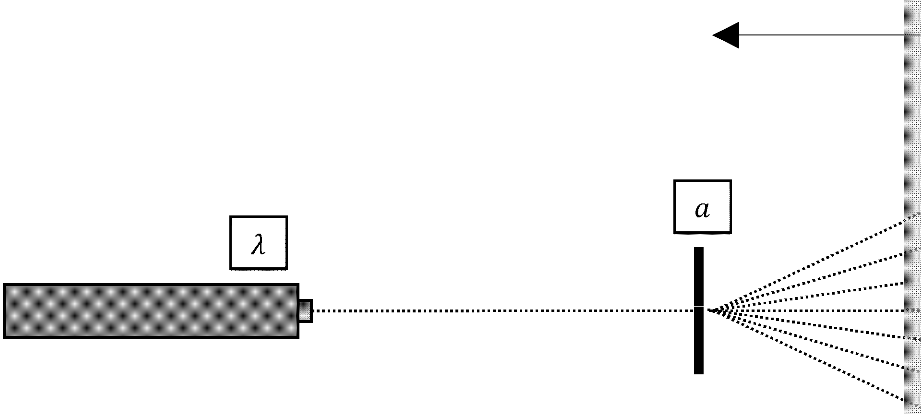
$$\lambda = \frac{6.63 \times 10^{-34}}{(1.50 \times 10^{7}) \times (9.11 \times 10^{-31})}$$

$$\lambda = 4.85 \times 10^{-11}\ \text{m}$$

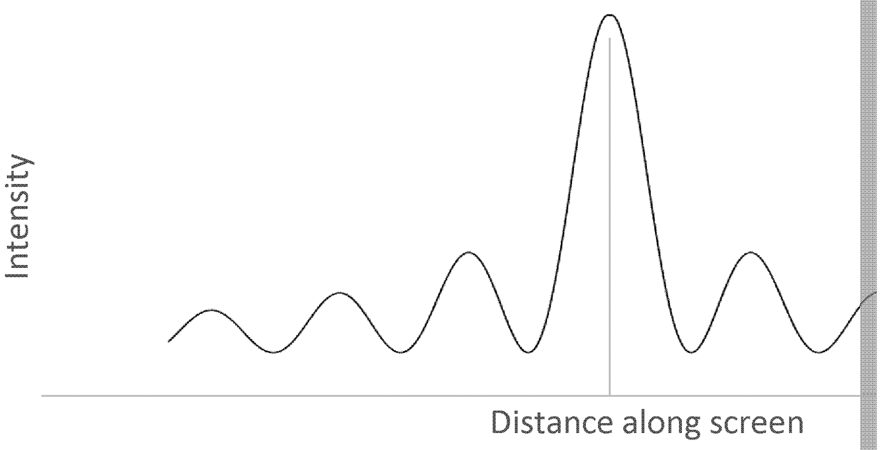
$$\lambda = 48.5\ \text{pm}$$

Activity 2: Experimental analysis

1.



2. a)



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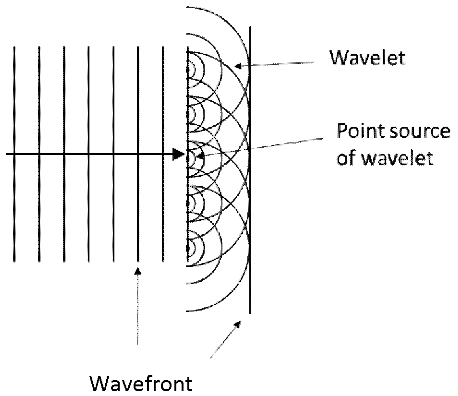

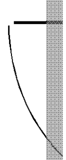

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Homework Eighteen: Be the Scientist

Activity 1: Mock Scientific Report

Peer-marking Grid

	Mark 1–5*	Comments an
Does the report include all five sections?		
Does the report follow a coherent line of argument/thought?		
Does the report cover each bullet point in task checklist in sufficient detail?		
Does the report use scientific terms and concepts accurately?		
Are the conclusions and findings of the report backed up by the evidence and data presented?		
Are the conclusions of the report valid and demonstrated by sound reasoning?		
Does the report's conclusion answer the initial aim of the report?		
Is the use of spelling and grammar correct?		
Total score	/40	

* Where 5 is 'does this very well' a

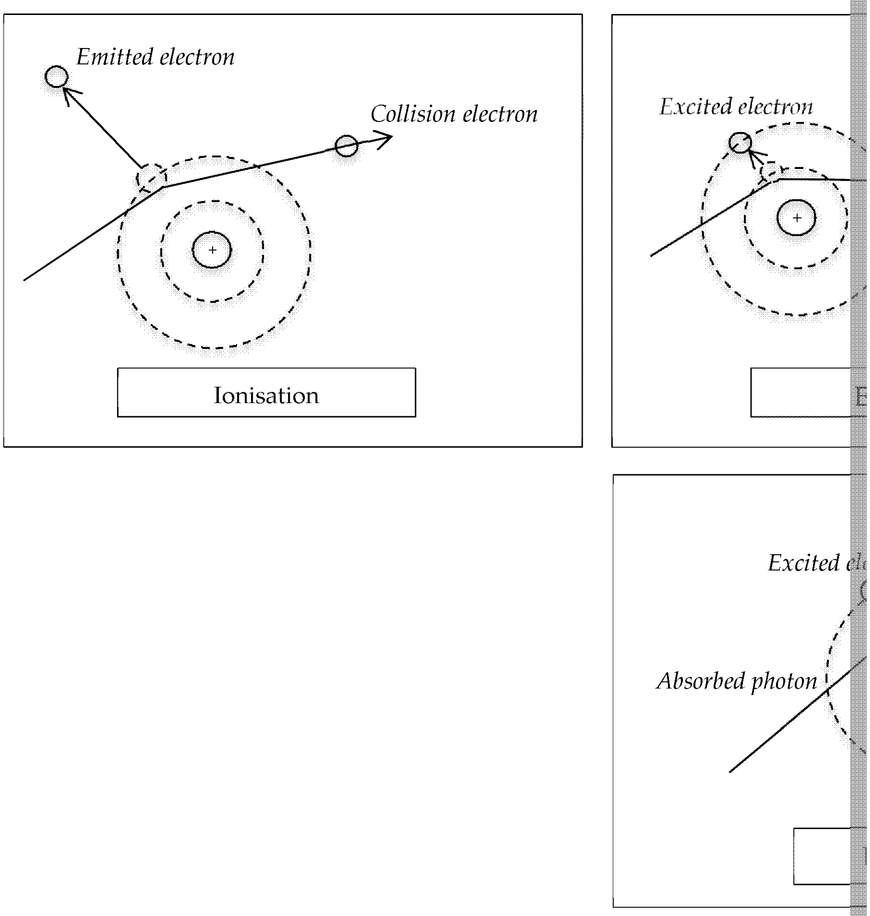
Homework Nineteen: Excitation, Ionisation and Wave-particle Duality

Activity 1: Exam-style Question

1. a) Ionisation is the process that creates ions (1), which are atoms tha result of gaining or losing an electron (1), whereas excitation refers atom absorbing energy without creating an ion. (1)

   b)
   - Alpha, beta and gamma radiation can collide with the atoms c ionisation of atoms. (1)
   - Electrons travelling in a fluorescent tube can collide with ator cause ionisation of the gas atoms. (1)

2.



3. The kinetic energy of the collision electron decreases after the collision energy is converted into increasing the internal energy of the atom (1) to an outer shell energy level.

4. a) Absorbed (1)

   b) $E = E_3 - E_2$ (1)

   $$E = (5.7 \times 1.6 \times 10^{-19}) - (4.9 \times 1.6 \times 10^{-19})$$

   $$E = 1.3 \times 10^{-19}\ \text{J}\ (1)$$

   c) The energy of the photon would have to be equal to the energy dif energy levels (1), and, therefore, the energy required to move the e

5. a) Emitted (1)

b) $E = E_9 - E_7$ (1)

$E = (-1.56 \times 1.6 \times 10^{-19}) - (-2.48 \times 1.6 \times 10^{-19})$

$E = 1.47 \times 10^{-19}$ J (1)

c) $E = hf$

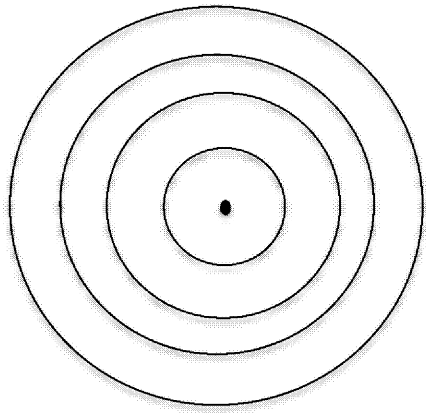
$f = \frac{E}{h}$ (1)

$f = \frac{1.47 \times 10^{-19}}{6.63 \times 10^{-34}}$

$f = 2.22 \times 10^{14}$ Hz (1)

d) The energy needed to remove an atom from its ground state and i
be greater than that of the mercury atom. (1)

6. a) (1) mark for sketch



b) The interference pattern of the experiment is caused by the diffrac
therefore, the experiment proves the wave-like nature of particles.

c) $\lambda = \frac{h}{p}$ (1)

$\lambda = \frac{h}{mv}$ (1)

$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.6 \times 10^{6}}$

$\lambda = 2.8 \times 10^{-10}$ m (1)

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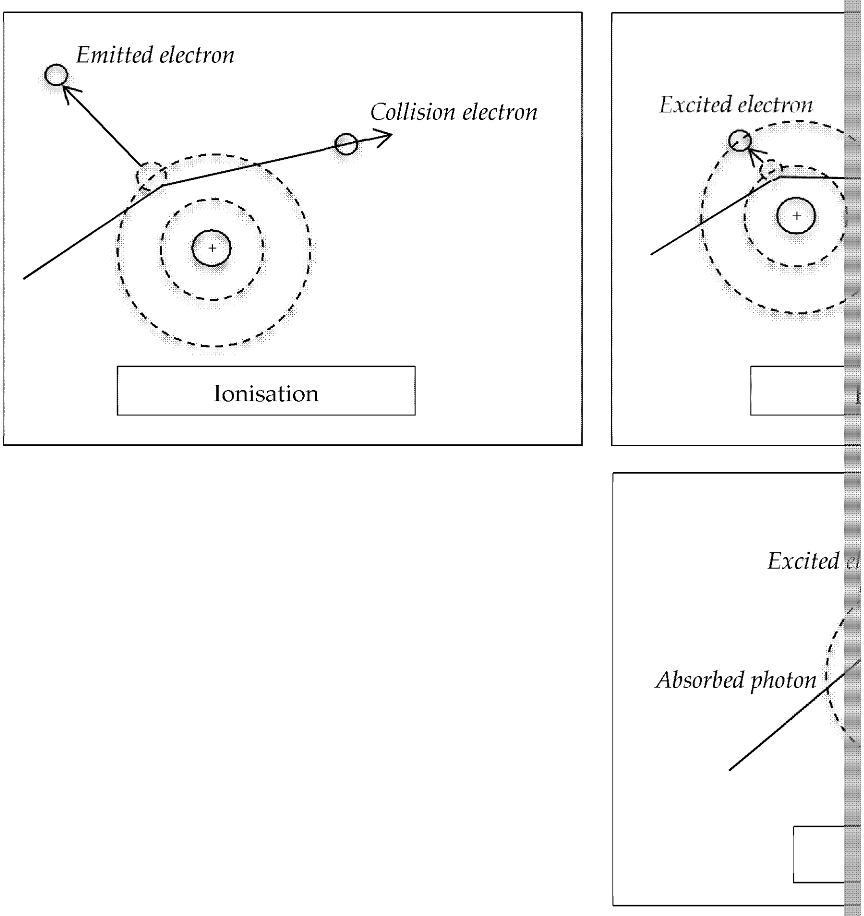

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$E = 1.47 \times 10^{-19}$ J (1)

$E = \dfrac{hc}{\lambda}$

$\lambda = \dfrac{hc}{E}$ (1)

$\lambda = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.47 \times 10^{-19}}$

$\lambda = 1.35 \times 10^{-6}$ m (1)

c) $E = hf$ (1)

$E = 6.63 \times 10^{-34} \times 3.8 \times 10^{14}$

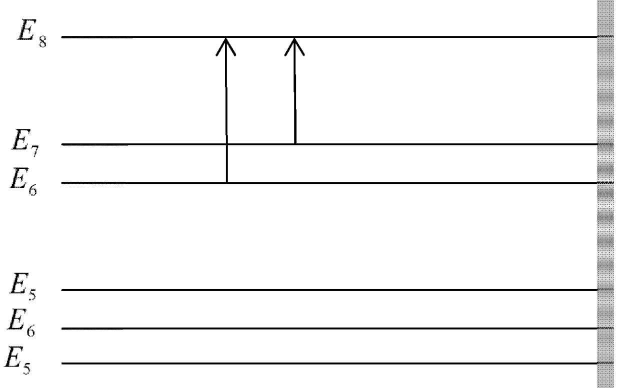
$E = 2.52 \times 10^{-19}$ J (1)

$E = \dfrac{2.52 \times 10^{-19}}{1.6 \times 10^{-19}}$

$E = 1.58$ eV (1)

$1.58 \text{ eV} = E_n - E_m$

Therefore, any transition between any two levels with an energy d possible. (1)

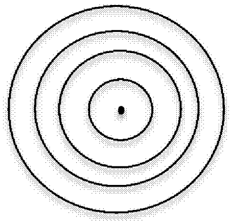


Only the transition from E_8 to E_{10} and E_9 to E_{10} is possible.

d) The photon energy $(E = 1.58 \text{ eV})$ is greater than the energy diffe E_9 *to* E_{10} (1) and, therefore, would provide enough energy to the from energy levels E_9 and E_8, ionising the mercury atom. (1)

e) The energy needed to remove an atom from its ground state and i be greater than that of the mercury atom. (1)

6. a) (1) mark for sketch



b) The interference pattern of the experiment is caused by the diffract
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c) $\lambda = \frac{h}{p}$ (1)

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$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.6 \times 10^{6}}$

$\lambda = 2.8 \times 10^{-10}$ m (1)

d) If the momentum decreases then the wavelength of the electron de
diffraction rings are larger. (1)