



Differentiated Homeworks

for AS/A Level Year 1 AQA Physics

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Teacher's Introduction

Recapping, revising and consolidating information is key to understanding. This resource is a pack of homework sheets with that specific aim. The homework worksheets have been designed to test students on all of the first five sections of the AS and A Level Year 1 AQA course:

- Measurements and Their Errors
- Particles and Radiation
- Waves
- Mechanics and Materials
- Electricity

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 activities encourages further learning and introduces crucial skills necessary for a continued academic or professional career in science.

Structure:

The resource is split into 18 homeworks. Each homework is differentiated for lower and higher ability, which is denoted by Newton (apple) and Einstein (scientist) text boxes respectively. The names have been removed from the worksheets so only the symbols remain.

Key  = lower ability  = higher ability

Homework	Spec Coverage
1	3.1.1/3.1.2/3.1.3
2	3.2.1.1/3.2.1.2
3	3.2.1.3
4	3.2.1.4
5	3.1.2.5/3.1.2.6/3.2.1.7
6	3.2.2.1
7	3.2.2.2/3.2.2.3/3.2.2.4
8	3.3.1.1/3.3.1.2
9	3.3.1.3
10	3.3.2.1/3.3.2.2/3.3.2.3
11	3.4.1.1/3.4.1.2
12	3.4.1.3/3.4.1.5/3.4.1.6
13	3.4.1.7/3.4.1.8
14	3.4.2
15	3.5.1.1/3.5.1.2
16	3.5.1.3
17	3.5.1.4/3.5.1.5
18	3.5.1.6

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



A web page containing all the links listed in this resource is conveniently provided on ZigZag Education's website at zzed.uk/6889

You may find this helpful for accessing the websites rather than typing in each URL.

Free Updates!

Register your email address to receive any future free updates* made to this resource or other Physics resources your school has purchased, and details of any promotions for your subject.

* resulting from minor specification changes, suggestions from teachers and peer reviews, or occasional errors reported by customers

Go to zzed.uk/freeupdates

Remember!

Always check the exam board website for new information, including changes to the specification and sample assessment material.

Homework One: Measurements and The

Activity 1: Summary Questions

Aim: To consolidate the information presented during lessons with practice questions and to summarise the topic.

Task

1. Complete the table below.

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

2. Complete the table

Prefix name	Prefix symbol	Order of magnitude
Tera		
		$\times 10^3$
Giga		
Centi		
		$\times 10^{-2}$
Mili		
Mega		
		$\times 10^6$
Pico		
		$\times 10^{-12}$

3. From your knowledge of the SI base units you can determine the derived units for the following 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 $\text{kg cm}^2 \text{s}^{-2}$
 - 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 quantity it represents.

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

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

Particle	Kinetic Energy (J)	Kinetic Energy (eV)
Alpha particle	8.1×10^{-13} J	
Electron	8×10^{-14} J	
Proton	5×10^{-11} J	

Complete the data table to include the energies of the different particles in units of MeV.



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Activity 2: Data Analysis Extended Question

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

Task

As early as the 1600s, there were mathematical proposals being put forward as to how the cosmos interacted. These physical laws of gravity are entrenched with accumulated wisdom and stolen property.

The laws of gravitation are one of the biggest mathematical breakthroughs in science. This is how the value for acceleration due to gravity can be determined using a simple pendulum in the comfort of your own home.

It was first hypothesised in 1602 that the length of a pendulum was proportional to the square of the period of its swing.

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

T = 2π√(L/g)

The pendulum can be set at different lengths, which are recorded using a ruler. The 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 discussed in (a).
- c) Determine the percentage uncertainty for both length and period for Trial 1.
- 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 gravity.

Remember:

Accuracy is a term used to describe the proximity of one measured value to the true value.
Precision is a term used to describe the proximity of a group of measurements to each other.

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HOMWORK ONE: MEASUREMENTS AND THE

Activity 1: Summary Questions

Aim: To consolidate the information presented during lessons with practical work and to summarise the topic.

Task

1. a) From your knowledge of SI base units, determine whether the following statements are true or false.
 - A The derived SI units for velocity are $km\ s^{-1}$
 - B The derived SI units for energy are $kg\ m^2\ s^{-2}$
 - C The derived SI units for charge are sA
 - D The derived SI units for force are $kgms^{-1}$

- b) For the false statement of question (a), write the physical quantity that the units represent.

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 of the ladder.

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 was carried out in a physics laboratory.

A source of light was shone on a metal plate and as a result electrons were emitted from 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 electrons is $E_k = hf - \phi$, where f is the frequency of light, ϕ is the work function and h is Planck's constant.

Calculate the maximum kinetic energy of the electrons in pJ.

4. The cost of using any electric appliance in your house can be determined by knowing the rate for electricity and the power of the appliance.

The rate for electricity is £0.15 per kWh for an average house in south Bristol is 1kwh

Calculate the cost of using an average TV for 30 minutes, which uses 200W

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Activity 2: Data Analysis Extended Question

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

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

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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 discussed in (a).
- c) Determine the percentage uncertainty for both length and period for Trial 1.
- d) Determine the value for acceleration due to gravity for Trial 4.
- 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 gravity.

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Extension Task

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

Hints and guidance:

A good conclusion *should*:

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

A good conclusion *should not*:

- include any new ideas, findings or ideas that have not already been discussed in the results or conclusions

Please have a look at these websites for further help on how to write a successful conclusion:

- 🔗 <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 and their findings. If the pursuit of science is taken further, to a university level, scientific reports and papers will become crucial.

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HOMEWORK TWO: CONSTITUENTS OF THE ATOM AND STABLE AND UNSTABLE NUCLEI

Activity 1: Twitter Board

Aim: To demonstrate sound understanding of physics concepts by summarising information.

Task

Please read the following four extracts that summarise the information that you have learned about the constituents of the atom and about stable and unstable nuclei.

Extract 1:

The simple atom model is made up of a nucleus and shells of electrons that surround it.

We know that the majority of an atom's mass can be found in the nucleus and neutrons and protons both have the same mass 1.67×10^{-27} kg. A proton has a charge of $+1.6 \times 10^{-19}$ C whereas the neutron is neutral with no charge.

The electrons sit outside the nucleus in a set of shells that surround the nucleus. They have a significantly smaller mass than that of the proton and neutron, 9.11×10^{-31} kg, and are negatively charged but equal in magnitude to the charge of the proton, -1.6×10^{-19} C.

An ion is a specific name for an atom that has an overall net charge and is formed by the number of electrons and protons it has.

Sometimes it is more useful within a particular experiment to know the specific charge of an ion, which can be found by the ratio between overall charge and overall mass.

Extract 2:

Nuclide notation :



where A is the nucleon number (the number of protons and neutrons), Z is the atomic number (number of protons) and X is the element abbreviation.

This format is extremely useful for identifying isotopes. Isotopes are two or more forms of an element that has the same number of protons but a different number of neutrons. They have the same proton number (Z) but a different nucleon number (A).

For example, ${}^7\text{Li}$ and ${}^6\text{Li}$ are examples of lithium isotopes.

Extract 3:

We know that two point charges that have the same charge will repel each other. Why does this not happen inside the nucleus with protons?

It was hypothesised and later proven that there must be a stronger attractive force between nucleons that overcomes the electrostatic repulsion force pushing them apart. This is known as the strong nuclear force which acts on all protons and neutrons. However, it has a very short-range attraction, approximately only up to 3 fm, and a strong repulsion when nucleons are in proximity of less than 0.5 fm.

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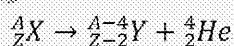
Extract 4:

Strong nuclear force plays a large part in whether a nucleus is referred to as a sufficient amount of strong nuclear force to bind the nucleus it will remain stable, if not, the nucleus would be referred to as unstable and would either be 'neutron rich', with too many neutrons to be stable, or 'proton rich', with too many protons to be stable and would be referred to as 'radioactive'.

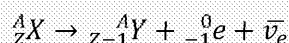
Unstable nuclei will always favour a more stable state. To achieve this, they undergo radioactive decay.

Examples of two forms of radioactive decay process are 'alpha decay' and 'beta-minus decay'.

In alpha decay, a parent nucleus (the unstable nucleus) decays into its daughter nucleus by emitting an alpha particle (an α particle). In other words, alpha radiation:



In beta-minus decay, a parent nucleus (the unstable nucleus) decays into its daughter nucleus by emitting a beta-minus particle (an electron) and a neutrino.



In all radioactive decays, the energy must be conserved. For beta-minus decay, the inclusion of the neutrino was hypothesised and later proven; it allowed for energy to be conserved during the decay.

For each extract, write a tweet summarising the key information, recalling the key information for class discussion that you also value to be important. You're writing for an audience that has no background knowledge or experience in the subject. Use simple language and knowledge of terminology.

Remember that your tweet is restricted to 140 characters.

Your tweet for Extract 1 should include reference to:

- The structure of the atom
- The relationship between the masses of the electron, proton and neutron
- The relationship between the charges of the electron, proton and neutron
- Specific charge and ions

Your tweet for Extract 2 should include reference to:

- Nuclide notation
- Isotopes
- Use of isotopic data

Your tweet for Extract 3 should include reference to:

- Strong nuclear force
- Strong nuclear force range properties

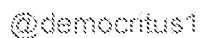
Your tweet for Extract 4 should include reference to:

- Unstable nuclei
- Alpha decay
- Beta decay

Note: The extracts are lengthy and you have limited space within your tweet. Choose the information you feel is vital in informing someone about the structure of the atom.

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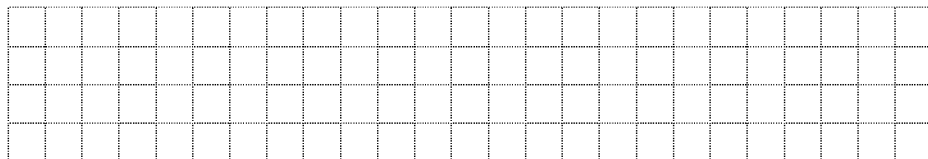




All matter is composed of indivisible particles called #a

16:18pm - 03 March 3988C

876 RETWEETS



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HOMWORK TWO: CONSTITUENTS OF THE ATOM AND STABLE NUCLEI

Activity 1: Twitter Board

Aim: To demonstrate sound understanding of physics concepts by summarising information.

Task

Below are four extracts that summarise the information that you have discovered about the constituents of the atom and about stable and unstable nuclei.

Extract 1:

The notion of the atom, the smallest particle making up everything we see, feel and touch and a smaller entity, the nucleus, was hypothesised in early ancient cultures. In fact, it was provided with the name we still use today, the 'atom'. By 1913, however, leaps in cementing these ideas through experiments that provided us with the atom and its properties; the same model we still use today.

The simple atom model demonstrates that the atom is made up of a nucleus outside the nucleus. We know that the majority of an atom's mass can be made up of protons and neutrons. Protons and neutrons both have the same different charge; the proton has a charge of $+1.6 \times 10^{-19}$ C whereas the neutron has no charge.

There are, then, electrons that sit outside the nucleus in a set of shells that an electron has a significantly smaller mass than that of the proton and neutron. An electron is negatively charged but equal in magnitude to the charge of the proton.

An ion is a specific name for an atom that has an overall net charge and, therefore, a different number of electrons and protons it has.

Sometimes it is more useful within a particular experiment to know the specific ion, which can be found by the ratio between overall charge and overall mass.

Extract 2:

There is a set notation that is followed within all scientific fields to denote the element.

This notation is called 'nuclide notation' and can be written as follows:



where A is the nucleon number (the number of protons and neutrons), Z is the atomic number (number of protons) and X is the element abbreviation.

This format is extremely useful for identifying isotopes. Isotopes are two or more atoms of the same element that have the same number of protons but a different number of neutrons; they have the same proton number (Z) but a different nucleon number (A).

For example, ${}^7\text{Li}$ and ${}^6\text{Li}$ are examples of lithium isotopes.

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Extract 3:

Despite knowing of the atom as early as the late 1800s, a question that physicists well into the 1970s was, how does the nucleus remain bound together of particles with the same charge?

We know that any two point charges that have the same charge will repel. How can this not happen inside the nucleus with protons?

It was hypothesised and then proven that there must be a stronger attractive force together which overcomes the electrostatic repulsion force that pushes them apart. This is the strong nuclear force that acts on all protons and neutrons. The force has a very short-range attraction, approximately only up to 3 fm, and is only effective at a very short-range proximity of less than 0.5 fm.

It was later discovered that protons and neutrons were not fundamental particles but were made up of even smaller particles. These particles are called 'quarks' and the strong nuclear force was discovered to be a by-product of the fundamental force, the quark

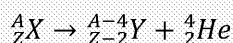
Extract 4:

Strong nuclear force plays a large part in whether a nucleus is referred to as stable or unstable. If there is a sufficient amount of strong nuclear force to bind the nucleus it will remain stable. If not, the nucleus would be referred to as unstable and would either be 'neutron rich' or 'proton rich', with too many neutrons to be stable, or too many protons to be stable. Nuclei that are unstable are referred to as 'radioactive'.

Unstable nuclei will always favour a more stable state. To achieve this, they undergo radioactive decay.

Examples of two forms of radioactive decay process are 'alpha decay' and 'beta-minus decay'.

In alpha decay, a parent nucleus (the unstable nucleus) decays into its daughter nucleus (the stable nucleus) by emitting an alpha particle or, in other words, alpha radiation:



In beta-minus decay, a parent nucleus (the unstable nucleus) decays into its daughter nucleus (the stable nucleus) by emitting a beta-minus particle (an electron) and a neutrino:



In all radioactive decays, the energy must be conserved. For beta-minus decay, the neutrino was initially hypothesised and later proven to exist, it allowed for the conservation of energy during the decay.

For each extract, write a tweet summarising the key information. Include the key points of information from each extract. Imagine that you are a physicist and you are writing a tweet to a friend who has no background understanding of physics, and they can obtain a basic understanding of the nuclear atom.

Assume some basic knowledge of terminology.

Remember that your tweet is restricted to 140 characters, so your task is to write a tweet that includes the information you feel is vital for accurately and succinctly describing the atom.

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HOMWORK THREE: BE THE JOURNALIST

Activity 1: Newspaper Article

Aim: Construct a newspaper, using your own knowledge, to inform others of our understanding of quantum particles.

It was in the 1930s that the existence of the antiparticle of the electron was eventually proven. Discoveries continued into the 1950s with the discovery of the antineutron. The concept of antiparticles was a significant leap forward which was a step towards understanding the antimatter that makes up so much of the universe.

Recently, man-made antiatoms have been constructed from antiprotons and positrons.

Task

This task requires you to be the journalist. Write a piece for a scientific magazine about the hypothesis and discovery of antiparticles. The piece should include:

- ☐ An explanation of why antiparticles were hypothesised
- ☐ An accessible explanation of what antiparticles are and their properties
- ☐ Introduction to annihilation and pair production, and the energies involved
- ☐ The importance and consequences of the study; applications of annihilation

Additional Reading

This task will require you to do additional research into the format and content of scientific magazines. Additionally, your class studies may not have covered in detail the background of the discoveries.

Below is a list of additional sources to help supplement your knowledge:

-  <http://press.web.cern.ch/backgrounders/matterantimatter-asymmetry>
-  <http://home.cern/topics/antimatter>
-  <https://www.newscientist.com/round-up/antimatter-mysteries/>
-  <http://www.iop.org/resources/topic/archive/antimatter/>
-  <http://www.scientificamerican.com/article/what-is-antimatter-2013/>

A template of the piece is given overleaf.

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The mystery of antimatter

The pre-buzz anticipation

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Sketch of general antiparticle

The nuts and bolts of the discovery

What are antiparticles?

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Properties

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Examples

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Evidence for other phenomena

Annihilation

Pair Production

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What is all this about?

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HOMWORK THREE: BE THE JOURNALIST

Activity 1: Newspaper Article

Aim: Construct a newspaper, using your own knowledge, to inform others of our understanding of quantum particles.

It was in the 1930s that the antiparticle of the electron was first hypothesised. Discoveries continued into the 1950s with the discovery of the antiproton. The concept of antiparticles was a significant leap forward within quantum mechanics towards understanding the antimatter that makes up so much of our universe.

Recently, man-made antiatoms have been constructed from antiprotons and

Task

This task requires you to be the journalist. Write a piece for a scientific magazine about the hypothesis and discovery of antiparticles. The piece should include:

- ☐ An explanation of why antiparticles were hypothesised
- ☐ An accessible explanation of what antiparticles are and their properties
- ☐ Introduction to photon model of electromagnetic radiation, annihilation and the energies involved
- ☐ The importance and consequences of the study; applications of annihilation

You are given flexibility in how you format this task. It is recommended that you research prominent scientific magazines to gain an understanding of how information is traditionally presented.

Additional Reading

This task will require you to do additional research into the format and content of scientific magazines. Additionally, your class studies may not have covered in detail the background of the discoveries.

Below is a list of additional sources to help supplement your knowledge:

-  <http://press.web.cern.ch/backgrounders/matterantimatter-asymmetry>
-  <http://home.cern/topics/antimatter>
-  <https://www.newscientist.com/roundup/story/antimatter-mysteries/>
-  <http://www.iop.org/resources/teachers/archive/antimatter/>
-  <http://www.scientificamerican.com/article/what-is-antimatter-2013-01>

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HOMWORK FOUR: BE THE PEER REVIEWER

Activity 1: Peer Review

Aim: To accurately assess the knowledge of your peers via a peer review to test the strength of your own understanding.

Being able to assess the errors and missteps in the methodology of your peers truly understand a topic, especially if you can then provide constructive feedback on what went wrong.

Task

Below is a set of questions with answers. Your task is to work through them, identify the incorrect answers and provide feedback to suggest where the 'student' has gone wrong. Your feedback should include:

- identify where the errors are in the answers
- provide a correct solution
- provide an explanation as to where the 'student' has gone wrong to help them work

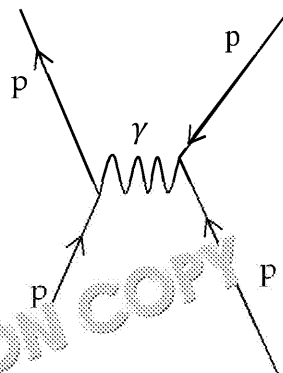
1. State the four fundamental interactions.

Answer: electromagnetic, gravity, radioactive and strong

2. The electromagnetic force is constantly effective around us. There are interactions between the particles that comprise all the matter we see around us.

- a) Sketch the Feynman diagram for the electromagnetic force between two protons.

Answer:



- b) Comment on why the exchange particle is described as 'virtual'.

Answer: Since the photon exchange particle cannot be detected directly, it consequently stops the force from acting.

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3. a) Name the force that causes a neutron to change into a proton or a neutron in the nucleus.

Answer: Strong nuclear force.

- b) State the two decays that the weak interaction is limited to:

Answer:

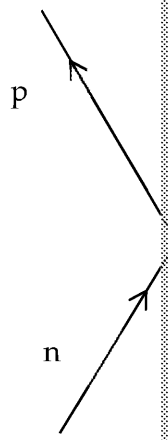
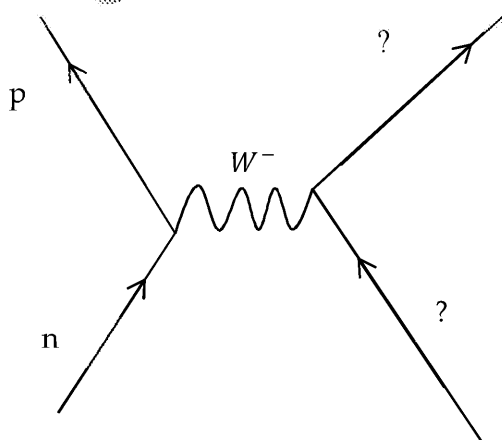
1. Beta-plus decay
2. Beta-minus decay

- c) Comment on the properties of the exchange particle of weak interaction.

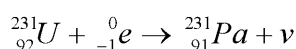
Answer: They have zero rest mass and can be positively or negatively charged. Additionally, they have significantly short ranges / they have a very short range.

4. Complete the following neutron-neutrino interaction diagram:

Answer:



5. 'Proton rich' nuclei can result in a proton turning into a neutron through the following process:



- a) State the interaction represented by the above equation.

Answer: Weak interaction

- b) Explain what is happening in this interaction.

Answer: A proton interacts through the weak interaction with an electron and changes into a neutron. In the process, the force carrier of the interaction, a W- boson, decays into an electron and an anti-neutrino.

- c) State the term given to this exchange.

Answer: Electron capture

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HOMWORK FOUR: BE THE PEER REVIEWER

Activity 1: Peer Review

Aim: To accurately assess the knowledge of your peers via a peer review to test the strength of your own understanding.

Being able to assess the errors and missteps in the methodology of your peers can help you truly understand a topic, especially if you can then provide constructive examples of what went wrong.

Task

Below is a set of questions with answers. Your task is to work through the questions, identify incorrect answers and provide feedback to suggest where the 'student' has gone wrong. You should:

- ☐ identify where the errors are in the answers
- ☐ provide a correct solution
- ☐ provide an explanation as to where the 'student' has gone wrong

1. State the four fundamental interactions relating to the following exchange particles:

- a) γ
- b) $W^{+/-}$
- c) Graviton
- d) Gluon

Answer:

- a) Strong
- b) Weak
- c) Gravity
- d) Electromagnetic

2. Explain the differences between two exchange particles, the W boson and the photon.

Answer:

- W boson has non-zero mass whereas virtual photon has zero mass
- W boson can either be positively charged (W^{+}) or negatively charged (W^{-}), whereas the photon is electrically neutral
- W boson and photon both have very short ranges

3. Explain the interaction between two charged particles using the analogy of throwing a ball from one person to another.

Answer:

If Student 1 was standing on a skateboard and threw a ball to Student 2, Student 1 would recoil when throwing the ball and Student 2 would recoil when catching the ball. There has been a transfer of momentum between Student 1 and Student 2. This illustrates the electromagnetic interaction between two charged particles. If two like charges repel each other as a result, the virtual photon transferring momentum between them is like the ball in the analogy.

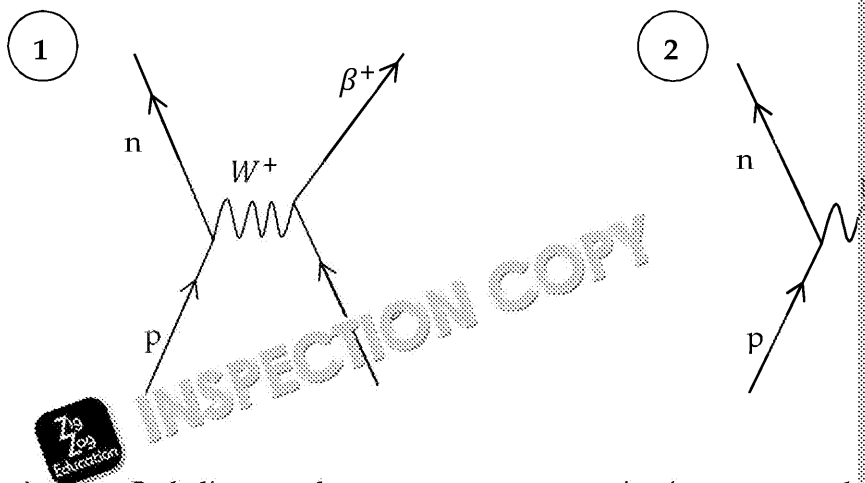
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4. Feynman diagrams are used as illustrative models to demonstrate the subatomic particles.

- a) Explain the differences between the following two Feynman diagrams



Answer: Both diagrams demonstrate a proton turning into a neutron but differently for each. Diagram 1 shows proton-neutrino interaction where a proton to change it into a neutron. In the process, a positron has been change. However, in diagram 2, a proton has interacted with an electron to a neutron. In the process the electron changes into a neutrino.

- b) Which interaction is most likely to occur?

Answer: Interaction 1

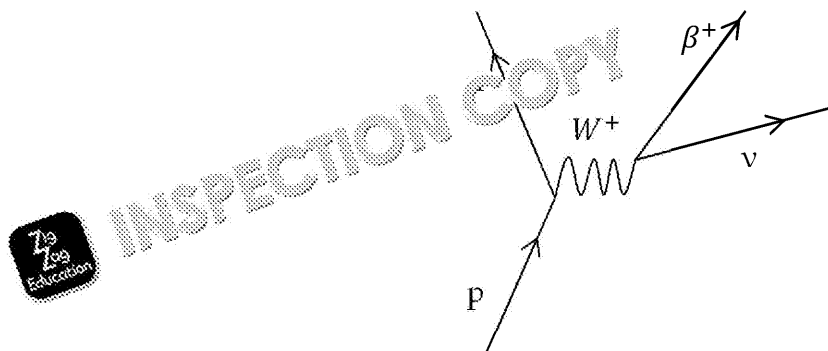
- c) What would the effect be on the exchange particle if diagram 1 is interaction?

Answer: W^+ boson

5. A common decay among subatomic particles is β^+ decay.

- a) Sketch the Feynman diagram for β^+ decay.

Answer:



- b) State the fundamental force responsible for this interaction.

Answer: Strong

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- c) Give another example of an exchange particle other than the W

Answer: virtual photon

- d) Explain the role of exchange particles in interactions.

Answer: To carry the force in action in the interaction between the subatomic particles interacting/decaying.

6. A neutron may act with a neutrino in the following way:

$$n + \nu \rightarrow p + e^-$$

- a) State the interaction represented by the equation.

Answer: Weak interaction

- b) State the exchange particle involved with the interaction represented by the equation.

Answer: W^- Boson

- c) Explain the role of the exchange particle for this interaction.

Answer: Turns neutrino into electron.

Other interactions can also cause neutrons to change into protons.

$$n \rightarrow p + \beta^- + \bar{\nu}$$

- d) Comment on whether the above equation correctly identifies the interaction.

Answer: Yes, this demonstrates β^- decay, which involves a neutron decaying into a proton, an electron, and an anti-neutrino.

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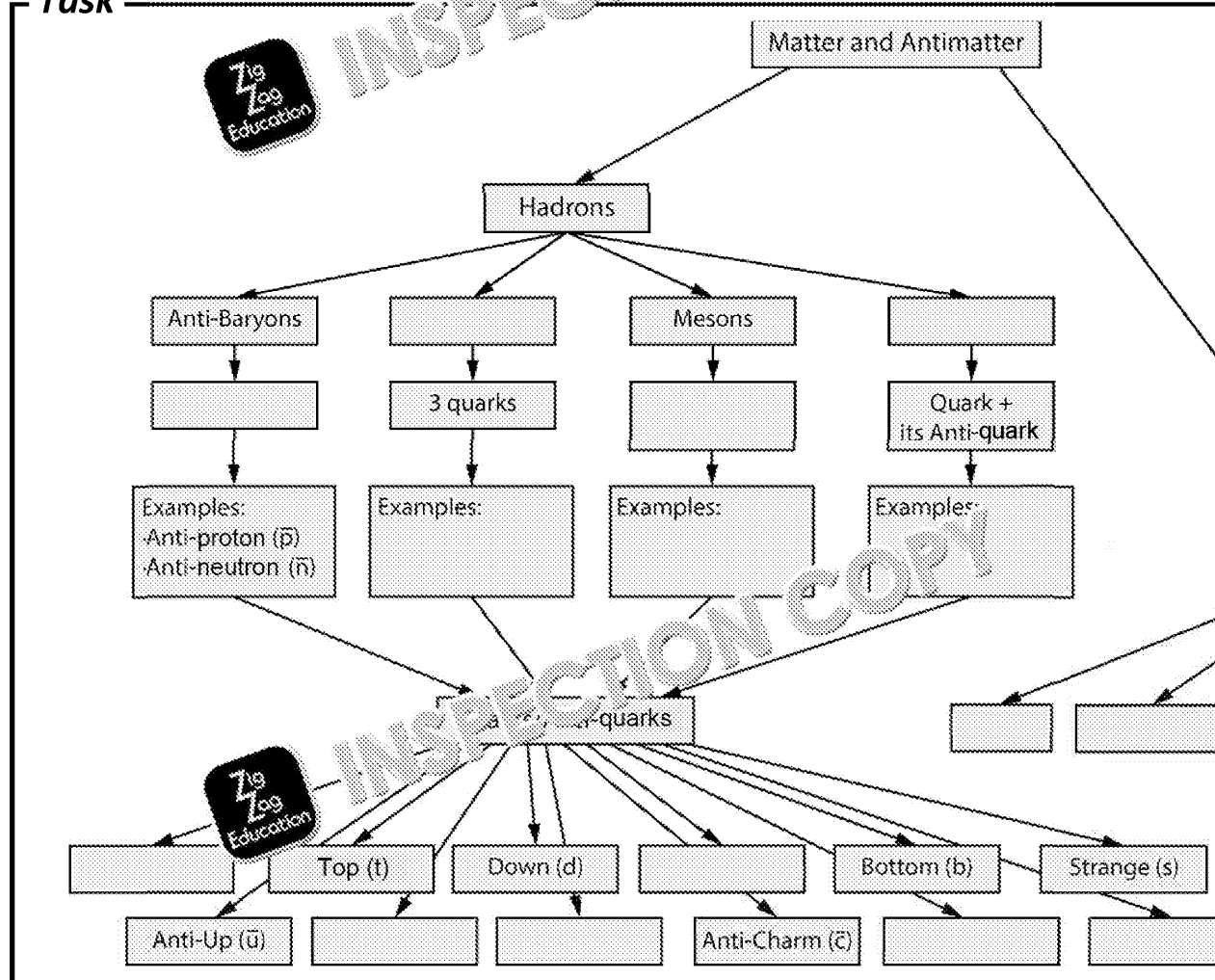
HOMWORK FIVE: CLASSIFICATION OF

Activity 1: Drop-down Spider Diagram

Aim: To summarise your knowledge of the subject using a drop-down spider diagram.

One of the most challenging parts of this course is understanding the concept of subatomic particles. As you cannot directly see them in action makes it extremely hard to visualise the concepts that are discussed. Understanding subatomic particles is becoming more and more important as we move forward with how they are classified. This

Task



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Activity 2: Grid Activity

The second hurdle, after becoming comfortable with how particles are classified, is to understand the properties of these particles.

Task

Your task is to fill in the grid below that outlines the properties of all the particles. Similarly, this task should allow you to organise all the information you have learned into one place. This table will also act as an effective revision tool.

	Quark Property	Baryon Number	Lepton Number	Examples	Antiparticle	Charge
Baryons		+1	0	Protons (p)	Antiproton ($\bar{p}$)	
					Antineutron ($\bar{n}$)	
Mesons	Quark and Antiquark pair	0				+1
				Kaons K^+, K^0, K^-		
Leptons	-		+1	Electron (e^-)	Positron (e^+)	
				Muon (μ^-)	Antimuon ($\bar{\mu}$)	

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Activity 3: Summary Questions

1. State conserved quantities involved in particle and antiparticle interaction.
2. Comment on the charge, baryon number and strangeness of the following particles:

- a) Up
- b) Antiup
- c) Down
- d) Antidown
- e) Strange
- f) Antistrange

3. A neutron can decay into a proton, the decay equation is demonstrated

$$udd \rightarrow u?u + {}^0_1e + ?$$

- a) Complete the decay equation

A number of other particles follow the same course and decay into a proton.

- b) Explain why this is the case.

4. The following equation represents Kaon decay:

$$K^{-1} \rightarrow \pi^0 + \mu^+ \rightarrow \overline{\nu}_\mu$$

- a) State the interaction represented in the above Kaon decay
- b) Comment on whether the decay equation is valid

5. A strong interaction can be represented by the following equation:

$$\pi^- + p \rightarrow K^0 + \Lambda^0$$

- a) State the quantities conserved in the above strong interaction equation
- b) Show that your answer to (a) is conserved
- c) Explain what the quantum number strangeness represents

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HOMWORK FIVE: CLASSIFICATION OF PARTICLES

Activity 1: Mind Map

Aim: To summarise your knowledge of the subject using a drop-down spider diagram.

One of the most challenging parts of this course is understanding the concepts of subatomic particles. Considering we cannot see them and we cannot directly see them in action, it is difficult to visualise the concepts that are discussed or attach any relevance or meaning to them.

The first hurdle in understanding subatomic particles is becoming comfortable with the way they are classified. This task is designed to help you do just that.

Task

Your task is to complete an extensive mind map which classifies all the subatomic particles that have been discussed in class.

The mind map should include reference to:

- Hadrons
- Leptons
- Baryons
- Mesons
- Quarks
- Charge, mass and quantum numbers of quarks, leptons and their antiparticles
- Quantum numbers
- Relationship between particles and the four fundamental interactions
- Conservation laws

Extension Task

Research in the field of quantum mechanics is continually discovering new particles, expanding on what we know about subatomic particles.

Recently there have been developments in new particles such as the Higgs boson, which challenges our theories about how gravity interacts between masses with gravitational fields. Some scientists have argued that this field is currently one of the most mysterious fields of physics. It is a testament to that our knowledge and understanding of particles at subatomic levels was limited before this course is being taught, some of the things that could be proved as something that was once thought of as impossible.

Your task is to research with additional research into new discoveries of subatomic particles that might not have been discussed in this course, and add any additional notes to your mind map. The suggested reading list below to aid your research:

- 🔗 <http://www.scientificamerican.com/article/new-particles-found-at-las-vegas>
- 🔗 <http://www.sciencemag.org/news/2015/07/strange-new-subatomic-particle-discovered>
- 🔗 <http://home.cern/about/physics/standard-model>
- 🔗 <http://home.cern/about/updates/2015/09/atlas-and-cms-experiments-show-higgs-boson>
- 🔗 <http://discovermagazine.com/2015/oct/13-beyond-higgs-boson>

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Activity 2: Summary Questions

1. State conserved quantities involved in particle and antiparticle interaction.
2. Comment on the charge, baryon number and strangeness of the following particles:

- a) Up
- b) Antiup
- c) Down
- d) Antidown
- e) Strange
- f) Antistrange

3. A neutron can decay into a proton, the decay equation is demonstrated below:

$$udd \rightarrow u?u + {}^0_1e + ?$$

- a) Complete the decay equation

A number of other particles follow the same course and decay into a proton and an electron.

- b) Explain why this is the case.

4. The following equation represents Kaon decay:

$$K^{-1} \rightarrow \pi^0 + \mu^+ \rightarrow \overline{\nu}_\mu$$

- a) State the interaction represented in the above Kaon decay
- b) Comment on whether the decay equation is valid

5. A strong interaction can be represented by the following equation:

$$\pi^- + p \rightarrow K^0 + \Lambda^0$$

- a) State quantities conserved in the above strong interaction equation
- b) Show that your answer to (a) is conserved
- c) Explain what the quantum number strangeness represents

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HOMework SIX: BE THE SCIENTIST

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 (professional) scientific report that accurately and effectively displays the results, conclusions and considerations.

Task

Write a scientific report on the famous gold leaf electroscope photoelectric experiment. The aim of the experiment is to determine the value of Planck's constant h using the equation, $KE_{\text{max}} = hf - \phi$

Remember: It is essential that this aim forms the basis of your report and you refer to it throughout. It may be useful to ask yourself after writing each paragraph whether your writing has relevance to / has addressed the aim of your experiment.

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 follows the format of a professional scientific report.

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

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Scientific report structure:

This may be a very new and unfamiliar way of writing for you, and some of you may have not been asked to complete before.

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

- 📄 <http://unilearning.uow.edu.au/report/2b.html>
- 📄 <http://www.monash.edu.au/lis/lonline/writing/science/7.xml>
- 📄 <https://writing.wisc.edu/Handbook/ScienceReport.html>
- 📄 <http://www2.hull.ac.uk/li/pdf/Scientific%20Reports.pdf>
- 📄 http://biology.kenyon.edu/Bio_InfoLit/how/writing.html

Additional reading for gold leaf experiment:

You will need to do additional reading on the gold leaf experiment to support the method and results sections if you have not covered this experiment in detail.

- 📄 <http://www.ambrosecollege.org.uk/library/client/documents/Science%20Mod%205%202.5.2%20The%20Photoelectric%20Effect.pdf>
- 📄 <https://www.stem.org.uk/elibrary/resource/28841/photoelectric-effect>
- 📄 <https://books.google.co.uk/books?id=TRIA5VgModIC&pg=PA570&dq=gold+leaf+electroscope+photoelectric+effect&source=bl&ots=imUOrfJnVwOpHDruktZ9AG3k&hl=en&sa=X&ved=0ahUKEwizwfOMtbjLAhUQgkMAE#v=onepage&q=gold%20leaf%20electroscope%20photoelectric>
- 📄 http://astro.uchicago.edu/~randy/YSI05_pdfs/photoelec.july28.pdf

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Your report should follow this basic structure:

Abstract

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

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 going to investigate it.

2. Method

- Explain the procedures and equipment used to carry out the experiment. The particular procedures and equipment.

3. Results

- Demonstrate the results obtained without explaining their significance.
- Format raw data into a useful and appropriate format to analyse for the reader, e.g. demonstrate results as a graph.

Note: Do not simply repeat the raw results given in the results section. Use an appropriate format such as a graph as this will provide a clear analysis.

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

4. Discussion

- Explain your findings indicating the significance of any trends detected.
- State your final conclusion.
- Explain the accuracy/precision of your results and suggest any limitations that might have affected the validity of the results or created errors.

5. Conclusion

- The conclusion should restate the outcome of your experiment, with reference to the aim.
- It should restate the limitations and considerations of the experiment and the validity of your answer.

Note: The conclusion should be 100–150 words and not introduce any new points not already discussed in the report.

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Extension Task

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

How to reference:

In any pursuit of the sciences, you will most likely come across scientific journals that is you writing them or reading them for research. It is, therefore, useful to learn how to reference.

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

The method:

- Make relevant notes of facts, information, theories and concepts you come across, making sure you note the book/website you are taking from.
- When including any of these facts, information, theories or concepts in your report 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. The numbers in the text are linked to the references sections by the numbers appearing e.g. [1]. It would appear in your references sections like so:

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

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

Specific formats are given below:

- **For a scientific journal:** *Surname, Initial. (Year). Title of article. Title of journal.*
- **For a website:** *Surname, Initials. Title. Place of publication. Available from [URL]. Day Month Year.*
- **For a book:** *Surname, Initial. (Year). Title of book. City published.*

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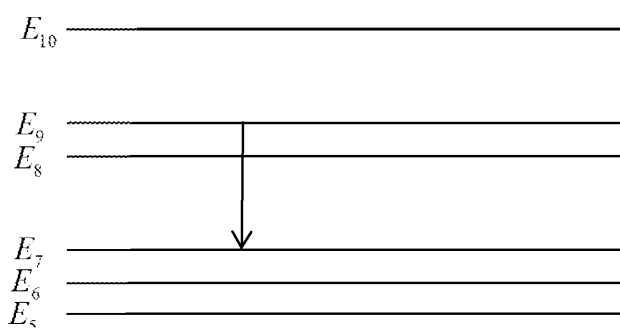


HOMEWORK SEVEN: EXCITATION, IONISATION AND WA

Activity 1: Exam-style Questions

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

1.
 - a) Explain the differences between ionisation and excitation of an atom.
 - b) Explain two situations when ionisation can occur.
2. Sketch a diagram to illustrate the process of ionisation and the process of excitation.
3. Comment on the kinetic energy of the incident electron and internal energy of the atom in a collision that causes excitation.
4. During the excitation process an electron from an inner shell of an atom moves from energy level $E_2 = 4.9 \text{ eV}$ to energy level $E_3 = 5.5 \text{ eV}$.
 - a) State whether a photon has been emitted or absorbed during the process.
 - 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 electron had moved to an energy level lower than E_2 .
5. Some of the energy levels of the mercury atom are displayed below.



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

The ionisation energy of a mercury atom is less than that of a hydrogen atom.

- d) Explain what this implies about the energy needed to remove an electron from the 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 atoms. The thin beam of electrons is fired at the metal foil at a speed of $2.6 \times 10^6 \text{ m s}^{-1}$.
 - a) Sketch the pattern obtained on the screen of this experiment. (1)
 - b) State the significance of this experiment. (1)
 - c) Calculate the wavelength of the electrons used in this experiment.

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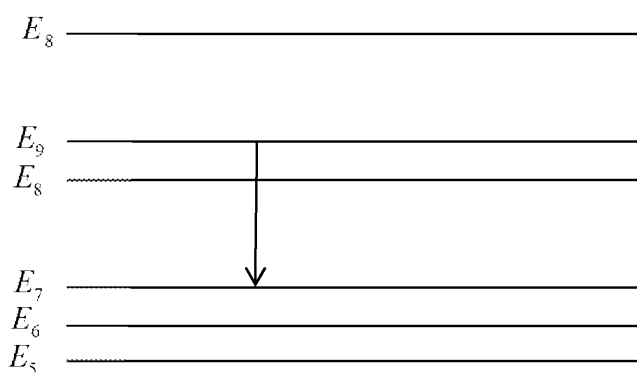


HOMEWORK SEVEN: EXCITATION, IONISATION AND WA

Activity 1: Exam-style Questions

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

1.
 - a) Explain the differences between ionisation and excitation of an atom.
 - b) Explain two situations when ionisation can occur.
2. Sketch a diagram to illustrate the process of ionisation and the process of excitation.
3. Comment on the kinetic energy of the incident electron and internal collision that causes excitation.
4. During the excitation process an electron from an inner shell of an atom moves from energy level $E_2 = 4.9 \text{ eV}$ to energy level $E_3 = 5.4 \text{ eV}$.
 - a) State whether a photon has been emitted or absorbed during the process.
 - b) Determine the energy of the photon from your answer to (a).
 - c) Explain the difference in the energy of photon from (b) if the electron moves from a higher energy level lower than E_2 .
5. Some of the energy levels of the mercury atom are displayed below.



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

The mercury atom absorbs a photon with frequency of $3.8 \times 10^{14} \text{ Hz}$.

- c) Sketch the possible energy transitions if the atom absorbs a photon with this frequency.
- d) Explain whether the photon from (c) could provide enough energy to ionise the mercury atom.

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

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

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

The thin beam of electrons is fired at the metal foil at a speed of $2.6 \times 10^6 \text{ m s}^{-1}$.

- 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 of the wavelength if the momentum of the electrons is doubled.



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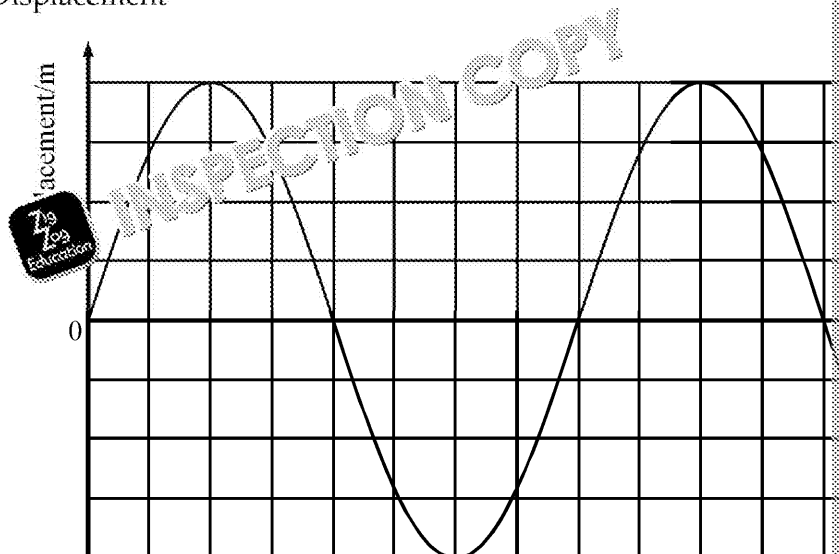
HOMWORK EIGHT: SUMMARY QUESTIONS

Activity 1: Summary Questions

Aim: Complete summary questions to demonstrate understanding of the wave

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

- Amplitude
- Wavelength
- Displacement

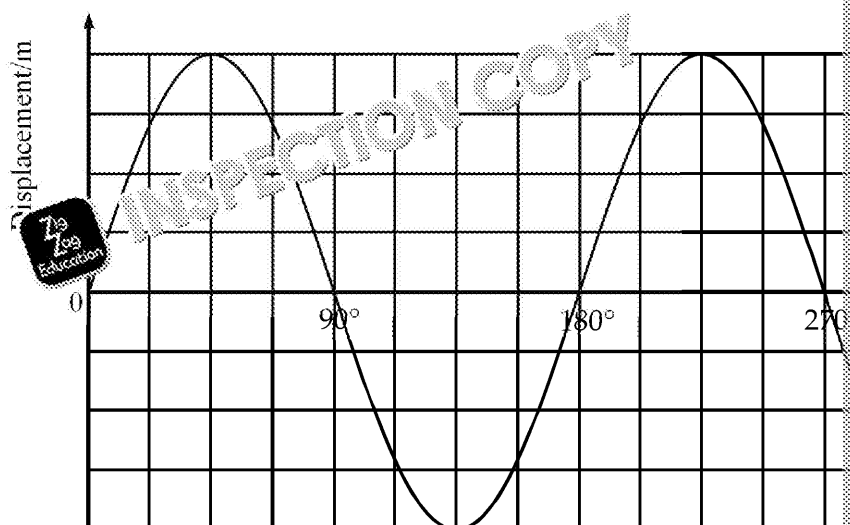


2. Sketch the snapshot of a sound wave.

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

- 45°
- $\frac{1}{2}$ of a fraction of a cycle



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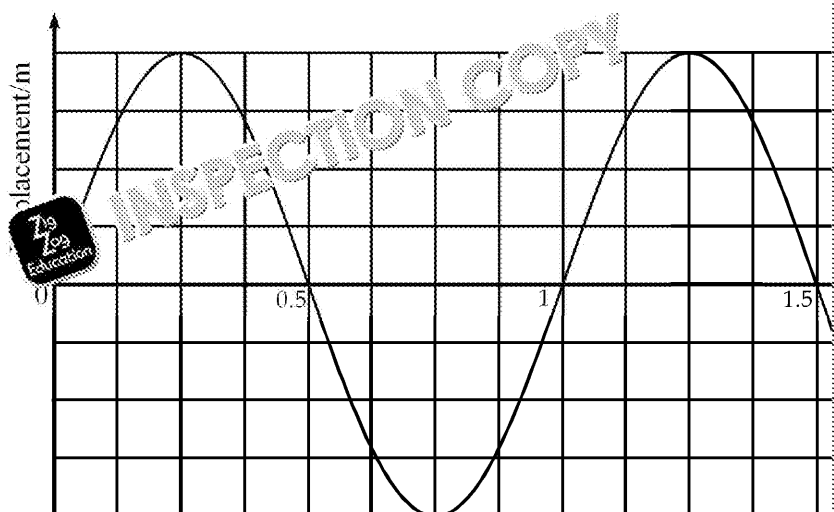
- c) Explain whether the wave represented in the graph is transverse or longitudinal.
- d) Give one example of a transverse wave and one example of a longitudinal wave.

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 doubled.
6. Polaroid filters are used in the manufacture of sunglasses in order to reduce glare.
- a) Comment on the speed of sunlight.
 - b) Explain what the effect **one** polaroid filter has on sunlight travelling through it.
 - c) Explain what would happen to the sunlight received if a second polaroid filter was placed at right angles to the first polariser.

One of the wavelengths that comprise the range of visible wavelengths that reach Earth is 500 nm.

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

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HOMWORK EIGHT: SUMMARY QUESTIONS

Activity 1: Summary Questions

Aim: Complete summary questions to demonstrate understanding of the wave.

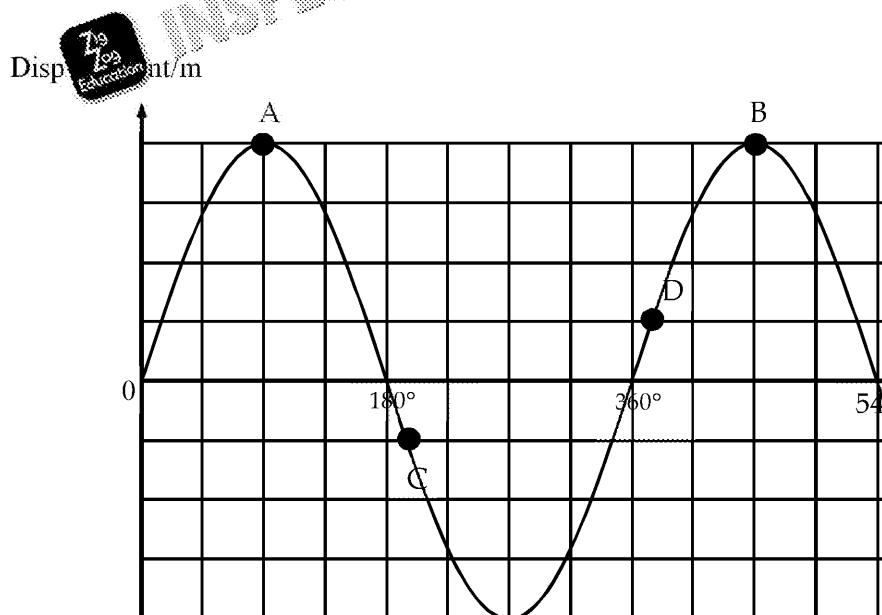
1. Sketch a snapshot of a sound wave.

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

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

a) A and B

b) C and D



c) Explain whether the wave represented in the graph is transverse or longitudinal.

d) Give one example of a transverse wave and one example of a longitudinal wave.

3. 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 a wave that travels 50 km in one cycle.

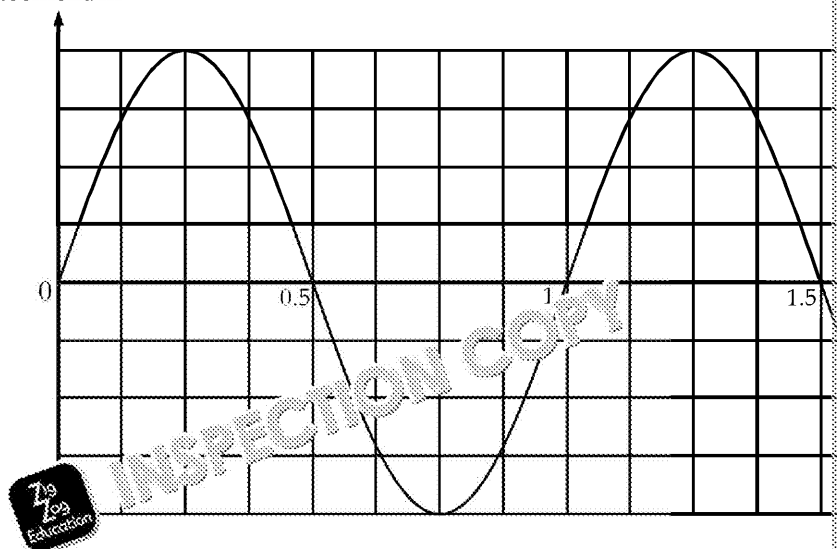
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4. A wave, with frequency 0.5 kHz, is represented by the following graph

Displacement/m



- Calculate the wave speed of the wave represented in the graph.
 - Calculate the period of the wave.
 - Comment on what will happen to the wave speed if the period was halved and the wavelength remained constant.
5. Polaroid filters are used in the manufacture of sunglasses in order to reduce glare.
- Comment on the speed of sunlight.
 - Explain what the effect **one** polaroid filter has on sunlight travelling through it.
 - Explain what would happen if a second polariser is introduced at an angle to the first.

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

- Calculate the frequency of light with wavelength of 500 nm.
- Comment on the effect on the frequency of light if the wavelength was halved.
- State another application of polarisation.

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HOMEWORK NINE: BE THE ENGINEER

Activity 1: Letter of explanation

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

Task

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

You are the sound engineer and you are expected to write an email, illustrating how you would set up one of the speakers, specifically facing the wall. Your professional opinion is required, and you must give your advice credibility and for the studio to take it seriously.

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]

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HOMWORK NINE: BE THE ENGINEER

Activity 1: Letter of Explanation

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

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 speaker. An email they suggest that they are going to set it up directly facing one of the

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 up, give your advice clearly and for the studio to take it on board.

The email must include reference to:

- Stationary waves
- Nodes and antinodes
- Harmonics
- Frequency

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HOMWORK TEN: BE THE DESIGNER

Activity 1: Design of an Experimental Set-up

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

Task

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

The company wants to ensure that the minimum pitch is heard at the seats. The minimum pitch is heard at the pillar positions as no audience members will be there.

Therefore, using your physics knowledge, your task is to provide the company with a 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 is 1.2 metres.
- The width of the seating in between each pillar is 1.2 metres.
- The speakers will be emitting sound waves of same wavelength which is 0.4 metres.

Sketch an experimental set-up that would achieve the theatre company's requirements. The sound waves should be heard at the rows of seats and minimum pitch to be heard at pillar positions. Provide dimensions so that the theatre company can accurately set up the plan themselves.

In addition, the company is seeking scientifically backed-up answers to questions for a quality assurance assessment that would allow it to adjust the set-up if any changes are needed.

Quality Assurance Assessment

1. Will the set-up still work if the two speakers are transmitting sound waves of different frequencies?
2. If the speakers are set back on the stage by a further 0.4 metres what would happen to the sound waves we transmit in order to achieve the same sound pattern reach the seats?
3. What would happen to the sound pattern if only one speaker was used and the distance between the slits of width 14 cm?
4. Can the same set-up be applied to Room 2 that has a stage that is 2.4 metres wide and the distance from the stage to the audience's seats is the same?

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Activity 2: Summary Questions

Aim: Complete summary questions to demonstrate an understanding of the

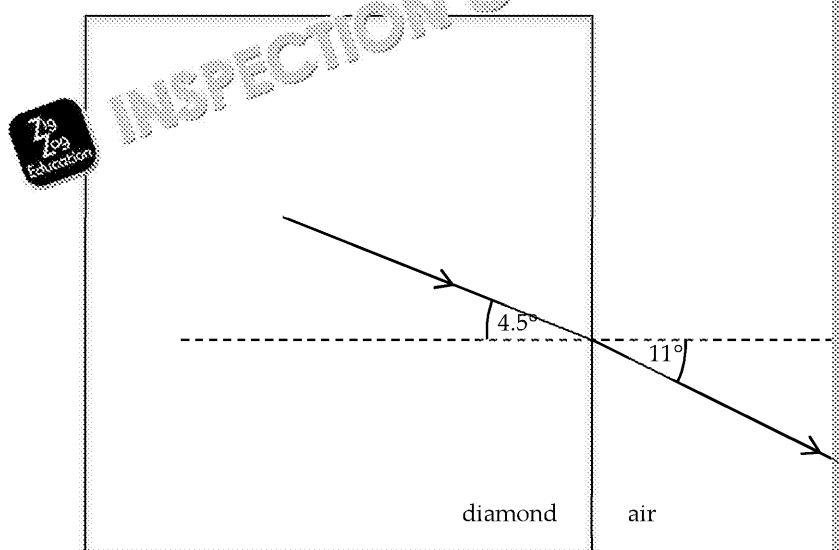
1. The sun emits light rays that can travel through air and eventually through glass.

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. 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.

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HOMWORK TEN: BE THE DESIGNER

Activity 1: Design of an Experimental Set-up

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

Task

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

The company wants to ensure that the maximum pitch is heard at the seats and the minimum pitch at the pillar positions, as no audience members will be there.

Therefore, using your physics knowledge, your task is to provide the company with a 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 is 1.5 metres.
- The speakers will be emitting sound waves of same wavelength which is 0.4 metres.
- The width of the seating in between each pillar is 1.2 metres.

Sketch an experimental set-up that would achieve the theatre company's requirements: maximum pitch heard at the rows of seats and minimum pitch to be heard at pillar positions. Provide the dimensions so that the theatre company can accurately set up the plan themselves.

In addition, the company is seeking scientifically backed-up answers to questions for a quality assurance assessment that would allow it to adjust the set-up if any changes are needed.

Quality Assurance Assessment

1. Will the set-up work if the two speakers are transmitting sound waves of different wavelengths?
2. For a few of the shows we push back the stage by 0.4 metres so that the stage is further from the audience for part of the performance. What would need to be altered to achieve the same results as the proposed plan?
3. What would happen to the sound pattern if only one speaker was used and the stage was 1.4 cm wide?
4. Can the same set-up be applied to Room 2 that has a stage width of 1.5 metres and the distance from the stage to the audience's seats is the same?

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Activity 2: Summary Questions

Aim: Complete summary questions to demonstrate an understanding of the

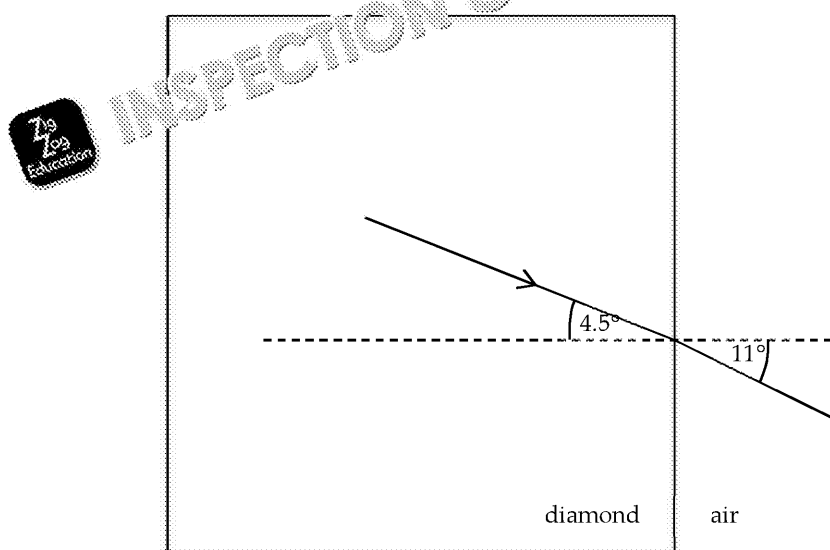
1. The sun emits light rays that can travel through air and then through glass made of glass.

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.

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HOMEWORK ELEVEN: PRACTICE QUESTIONS

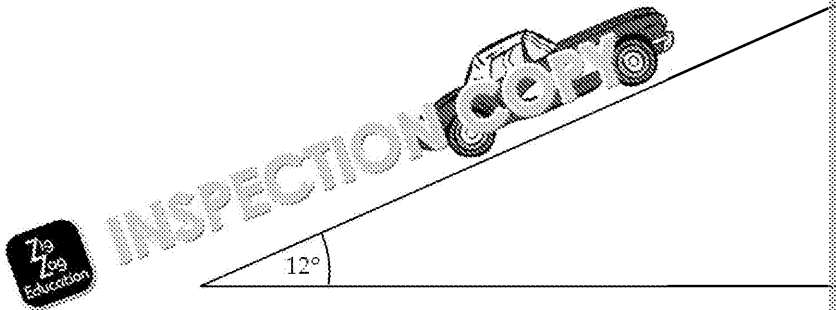
Activity 1: Summary Questions

Aim: Complete summary questions to demonstrate an understanding of the difference between scalar and vector quantities.

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

	Scalar
Velocity	☒
Distance	☐
Time	☐
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 ms^{-1} . After time t the boat begins to travel at 4.2 ms^{-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 acts vertically downwards).
There is a net force of 150 N acting on the car.
- b) Determine the magnitude and direction of the force of the engine.

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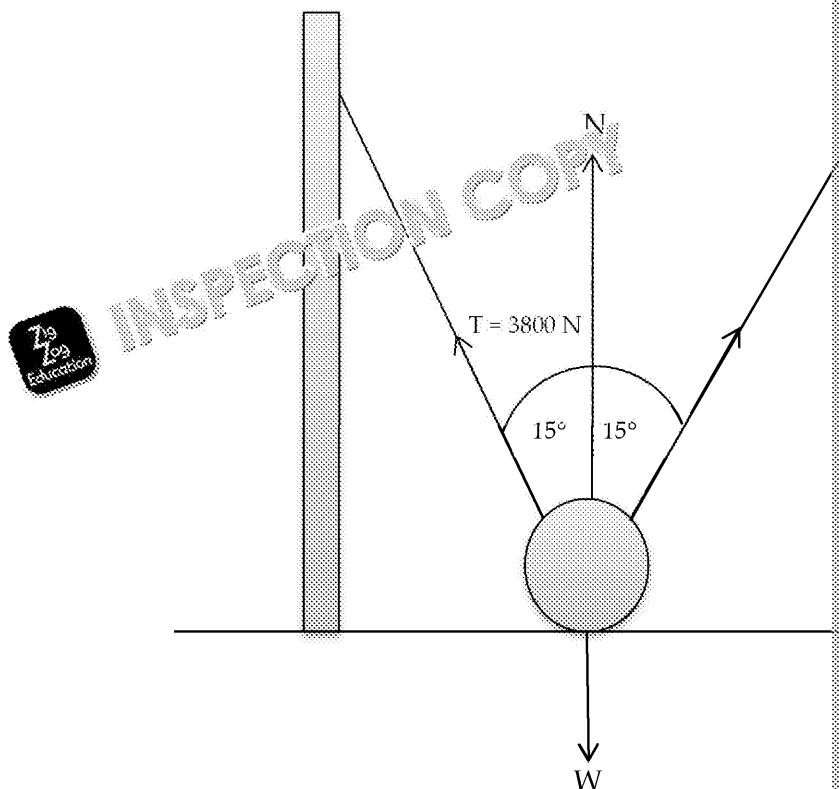
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Extension Question

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

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



- State whether tension is a scalar or a vector.
- Resolve the tension vector T into its horizontal and vertical components.
- 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.

- State the normal contact force.

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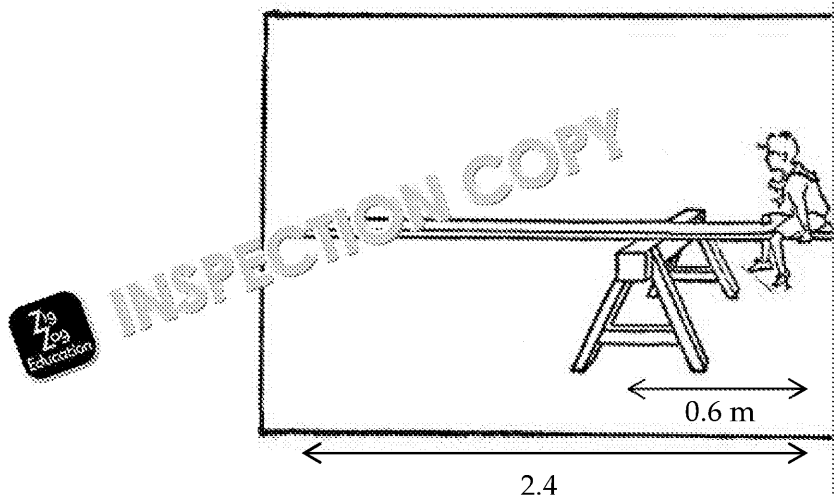
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Activity 2: Exam-style Questions

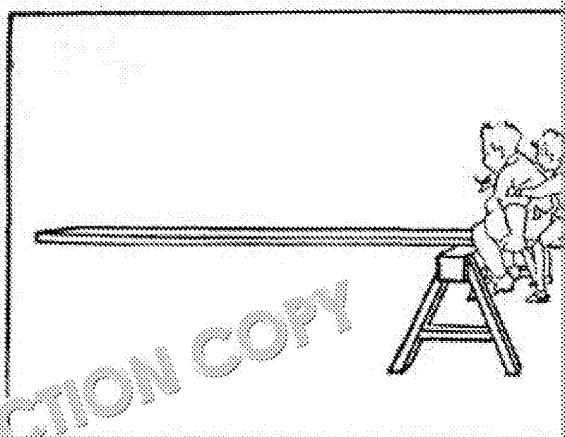
The local council is building a new playground and determining the best design.

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



- Calculate the clockwise moment about the pivot of the seesaw.
- Comment on the position of the centre of mass of the seesaw.
- Using your answer to (b) determine the weight of the seesaw.
- 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 and the friends move the pivot closer to the end of the seesaw until it is in equilibrium again.



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

Extension Question

- f) Using your answer to (e), calculate the distance of the two boys from the pivot.

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HOMEWORK TWELVE: BE THE DATA ANALYST

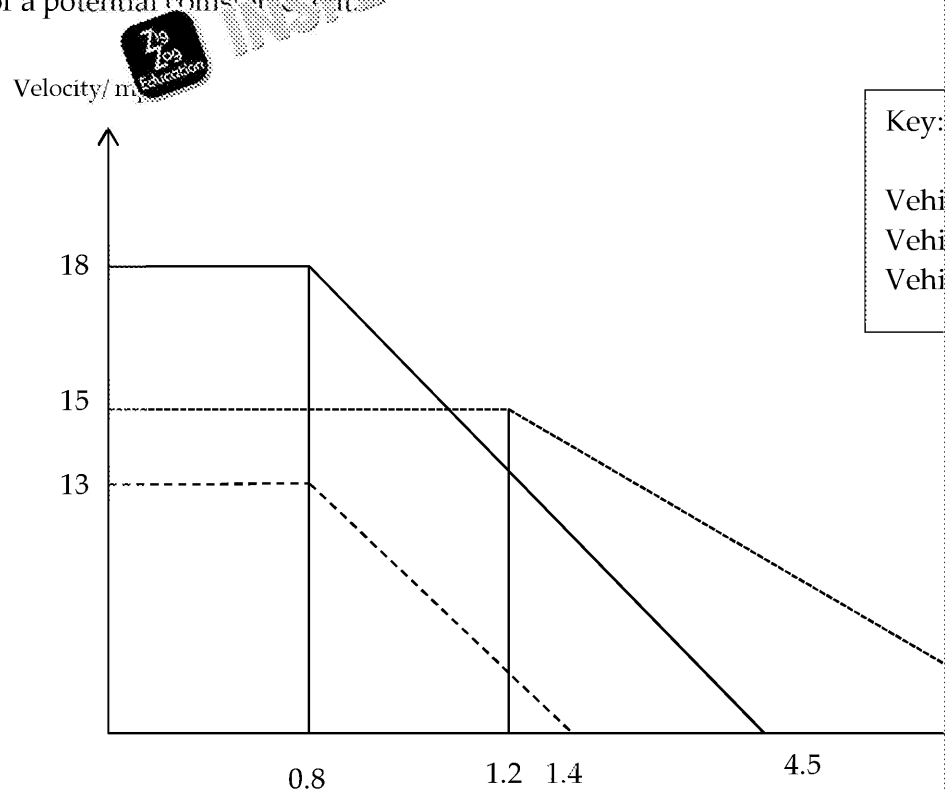
Activity 1: Unseen Data Question

Aim: The aim of this task is to get you comfortable with unseen data and develop your ability to apply your knowledge of physics to unfamiliar real-life contexts.

Task

The local council provided raw data on its website. Currently the local council wants to help it better understand the events before a potential crash and the factors that can help decrease risk of injury.

Below are extracts taken from the raw data that represent the motion of a vehicle before a potential collision event.



Each driver is aware of the potential collision event at $t = 0$ and we assume all vehicles have the same mass.

- One of the areas the council is researching is whether the time elapsed between the event and applying the brakes is important.
 - Identify the point at which each driver applies the brakes.
 - Comment on the effect this has.
 - What consequence will your answer to (b) have in a real-life context?
- The council wants to reduce the distance travelled during a collision.
 - Determine the greatest distance travelled out of the three vehicles.
 - Comment on why the vehicle in your answer to (a) has travelled this distance.

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Extension Questions

- c) From the data provided, suggest whether your initial speed or your mass has more effect on your ability to bring your vehicle to rest.
- d) Explain whether you can assume your answer to (c) to be the general case.

3. Another factor that the council is interested in investigating is the parabolic ability to decelerate.

- a) For any one of the vehicles draw two separate force diagrams, one before and one after the brakes are applied.
- b) Explain for your answer to (a) how the vehicle's motion alters once the brakes are applied using Newton's laws of motion.
- c) Calculate the time taken for the vehicle with the greatest deceleration.

Extension Questions

- d) Explain which car will have the greatest force on impact during collision.
- e) Suggest a step the council could take to reduce the force, and, then, explain how this would affect the vehicle in answer (d) could cause.

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HOMWORK THIRTEEN: BE THE REVIEWER

Activity 1: Promotional Article

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

Task

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

Write a brief specification review as if you were a journalist reviewing the new 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?	
How has the carbon footprint of the company improved?	

Additional Reading

The list below provides additional information on heat engines and will 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

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HOMWORK THIRTEEN: BE THE REVIEWER

Activity 1: Promotional Article

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

Task

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

Write a brief specification for the new engine as if you were a journalist reviewing the new 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 work to write your review.

Additional Reading

The list below provides additional information on heat engines and will 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.

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HOMEWORK FOURTEEN: GRAPH SKILL

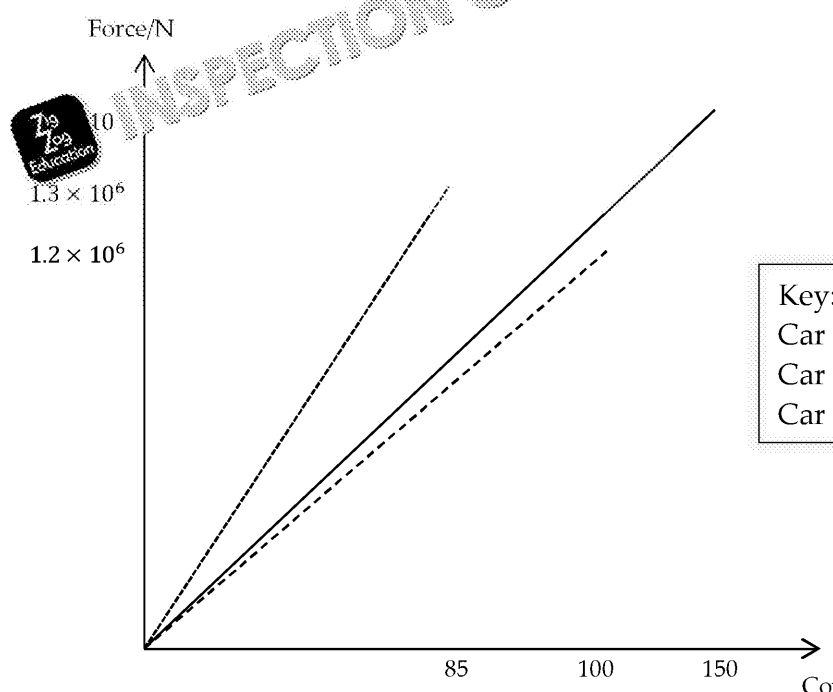
Activity 1: Graph Analysis Question

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 experiments carried out on three cars' suspensions.

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



- Explain the energy transformation that occurs during compression.
- Which car has spring suspension with greatest spring constant?
- What does your answer from (b) tell you about the properties of the spring suspension?
- 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 experiment. They want to determine the Young's modulus of the different springs used in each car.

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

	Length of Spring/m	Radius of spring/m
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 for the area of a circle is:

$$A = \pi r^2$$

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

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HOMWORK FOURTEEN: GRAPH SKILL

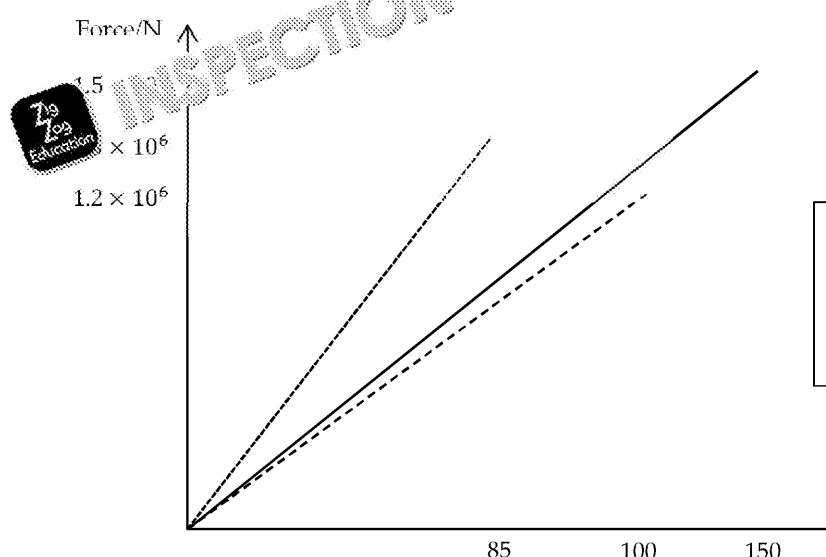
Activity 1: Graph Analysis Question

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 tests carried out on three cars' suspensions.

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



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

The data was collected from three different cars, but for the purpose of comparison, the compression was collected when all three cars were travelling with the same speed.

- Explain which car is the heaviest.

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

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

	Length of Spring/m	Radius of spring/m
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 area of the wire.

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

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HOMWORK FIFTEEN: BE THE RESEARCHER

Activity 1: Research Investigation

Aim: To understand the properties and I-V characteristics of common electrical components.

Task

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

From your own knowledge and from supplier or any knowledge gained from the internet, you must report on the following points:

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

You can present your research information in any appropriate format you like. The following 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 suggestions are given, however, you will need to read further.

Additional Reading:

- <http://www.electronics-tutorials.ws/blog/i-v-characteristic-curves.html>
- <http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/current-electricity-characteristics/>

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HOMWORK FIFTEEN: BE THE RESEARCHER

Activity 1: Research Investigation

Aim: To understand the properties and I-V characteristics of common electrical components.

Task

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

From your own knowledge and from supplier or any knowledge gained from the internet, you must report on the following points:

- Ohmic conductor
- I-V characteristic, R and ρ
- Explain the non-linear I-V characteristic graph
- Conductivity of the component
- Applications of the component

You can present your research information in any appropriate format you like. The following formats are:

- Table
- PowerPoint slide
- Mind map

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

Additional Reading:

- <http://www.electronics-tutorials.ws/blog/i-v-characteristic-curves.html>
- <http://physicsnet.co.uk/a-level-physics-as-a2/current-electricity/electrical-components/i-v-characteristics/>

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HOMWORK SIXTEEN: BE THE CONSULTANT

Activity 1: National Grid Recommendation

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

Task

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

Brief:

We are trying to reduce the power loss during transmission of electricity along a particular circuit section, and, therefore, we are attempting to re-evaluate the dimensions of the cable to 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 supply the current along cables with low resistivity. Please fill in our feedback form on the back of the best we can achieve this.

Available materials:

- plastic cable, length 230 km, radius 5.6 mm
- aluminium cable, length 230 km, radius 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

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The National Grid Recommendation Fee

	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 on the transmission? 2. Are there other methods of reducing the power loss in the cables?

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HOMWORK SIXTEEN: BE THE CONSULTANT

Activity 1: National Grid Recommendation

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

Task

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

Brief:

We are trying to reduce the power loss during transmission of electricity along a particular circuit section, and, therefore, we are attempting to re-evaluate the dimensions of the cable to 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 supply the current along cables with low resistivity. Please fill in our feedback form to help us achieve this.

Available materials:

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

You will need to complete some additional reading to complete your recommendation. A reading list is given below. However, you will need to do further reading.

Additional reading:

- http://www.cyberphysics.co.uk/topics/magnetism/electro/nat_grid.htm
- http://www.cyberphysics.co.uk/topics/magnetism/electro/nat_grid.htm
- <http://www2.nationalgrid.com/uk/>
- http://www.supertech.com/Cables_Oct_10.pdf
- <http://large.stanford.edu/courses/2010/ph240/yankowitz1/>

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The National Grid Recommendation Fees		
	Recommendation	
Material of Cable		
 Length of Cable		
Radius of Cable		
Optimal Current		
Additional queries		
 - What effect would a temperature increase in the cables have on the transmission? - Sketch a graph that would help to illustrate the effect temperature would have on the power loss of our cables. - Are there other methods of reducing the power loss in the cables? - What temperature would we need to keep the cables at in order to eliminate the power loss?		

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HOMWORK SEVENTEEN: BE THE ELECTRICIAN

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 available components.

Your task is to design circuits for two different companies which satisfy the specifications provided by each company. Along with each circuit design, you must write a short report summary explaining your design choices for the components used and how they meet the specifications.

Design Specification 1:

A refrigerator company is seeking a design for a circuit that can be implemented to alert customers when the fridge door has been open too long. When the door is open too 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 of objects it produces. The company wants a circuit which allows the shutter of the camera to only open when the light level is low compared to when the light level is high. The camera shutter controls how long the camera is exposed to light, and, therefore, when it is darker outside the sensor needs to be open longer 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 transistor can be used to control one circuit with the second half of the circuit on when it is on. The voltage supply to the first half of the circuit. Usually a transistor will 'switch' on when the voltage supply is above 0.7 V, which it allows current to flow into the second half of the circuit.

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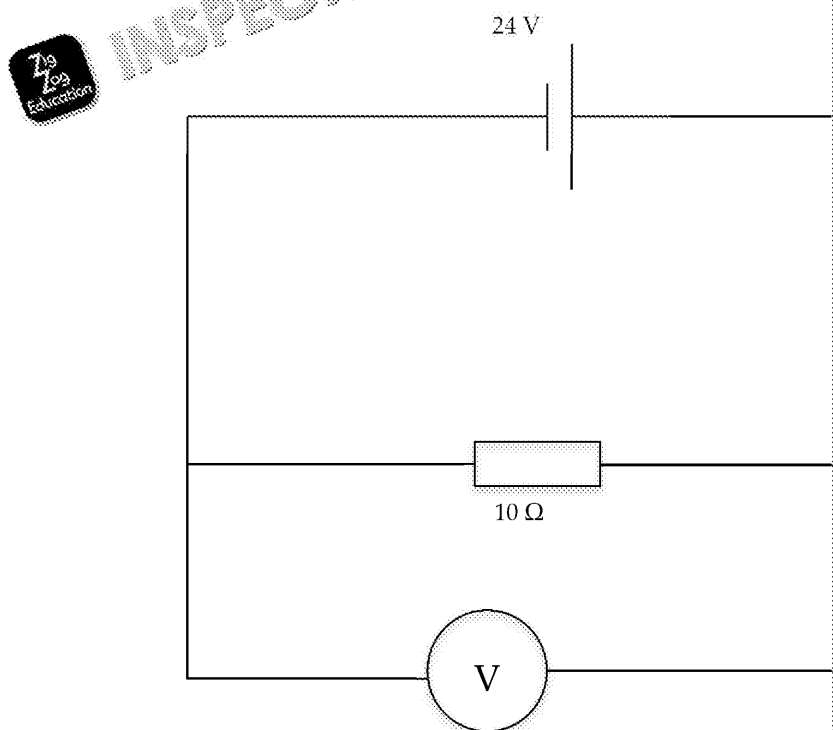
HOMWORK EIGHTEEN: EXAM-STYLE QUESTIONS

Activity 1: Exam-style Questions

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

Task

1. A cell has electromotive force of 24 V; however, it can only provide 23 V to the circuit.
Explain why the total possible emf is not supplied to the circuit.
2. The circuit below was constructed to investigate the properties of internal resistance. The internal resistance of the 24 V emf source is 0.5 Ω .



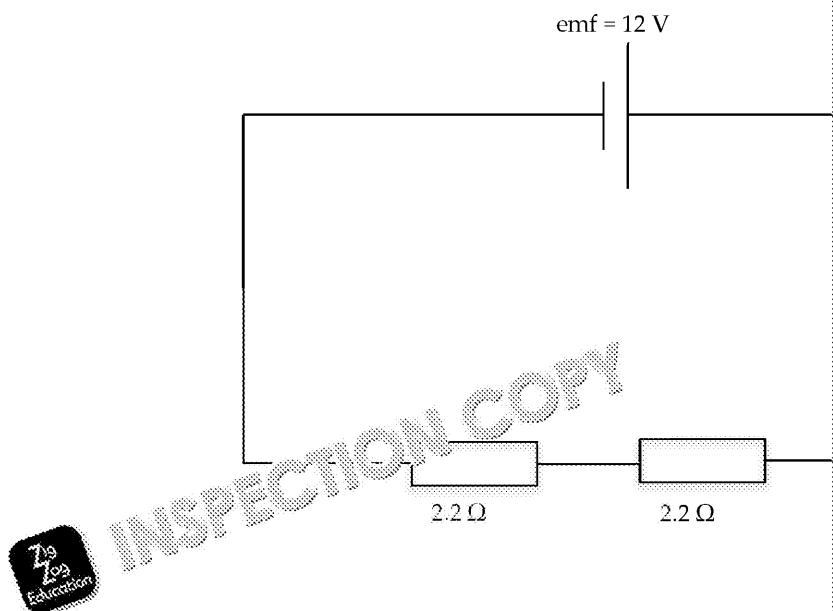
- a) Determine the reading on the voltmeter.
- b) Explain what would happen to the reading on the voltmeter if the source increased.

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



The internal resistance of the emf source is $0.2\ \Omega$.

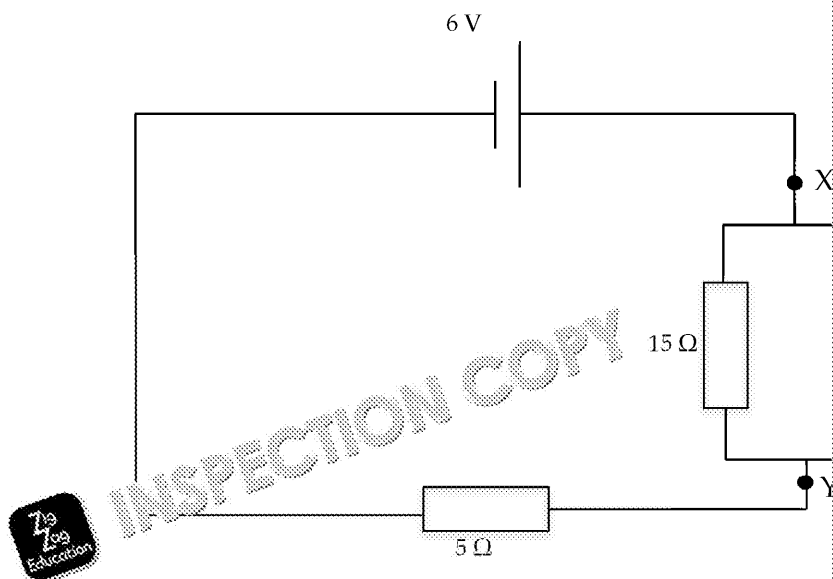
- Calculate the current flowing through the circuit
- Calculate the potential difference across one of the $2.2\ \Omega$ resistors

The current flows through the emf source for 500 seconds.

- Determine the energy supplied per coulomb of charge flowing through the circuit

Extension Questions

4. The current flowing through the circuit below is $0.5\ \text{A}$.



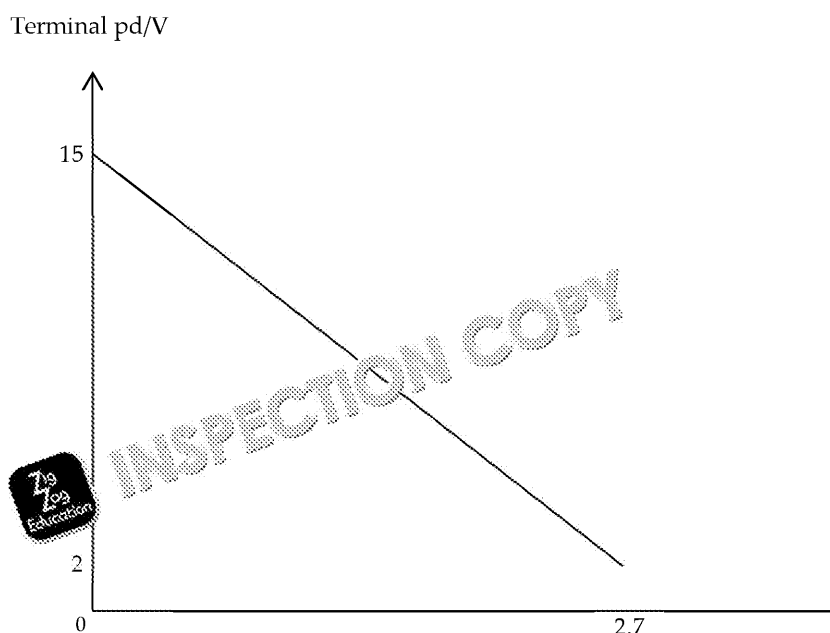
- Calculate the internal resistance of the battery.
- Calculate the voltage between X and Y.
- Determine the energy transferred from chemical to electrical energy in the first 20 seconds.

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



- State the emf of the source used in the experiment.
- Calculate the internal resistance of the source.
- Calculate the terminal potential difference when the current was 1
- Explain whether the terminal potential difference would have been when 0.8 A of current was flowing through the circuit.

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Answers

Homework One: Measurements and Their Errors

Activity 1

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 magn
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: $\text{kgm}^2\text{s}^{-2}$
D: kgms^{-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

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Activity 2: Data Analysis Extended Question

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

Possible random errors:

- Incorrect technique of measurement
 - Human limitation in taking measurement (parallax error and human reaction time)
 - 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) $\text{percentage uncertainty} = \frac{\text{absolute error}}{\text{measurement}} \times 100\%$

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 proximity to the theoretical value of 1.0 m and 2.0 s for acceleration due to gravity.
- f) The measurements 1, 3, 4, 5, 6 have high precision due to their close proximity to each other. The measurement for trial 2 is significantly out compared to the others as its precision is low.

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

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

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

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

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

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

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

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



Activity 1: Summary Questions

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

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

2. a) $E_p = mgh$
 $E_p = (70 - 80) \times 9.8 \times (205 \times 10^{-2})$
 $E_p = 1406.3 - 1607.2 \text{ J}$

- b) $E_p = 1406.3 - 1607.2 \text{ J}$
 $E_p = 1.4 - 1.6 \text{ kJ}$

3. $E = hf - \phi$
 $E = (6.63 \times 10^{-34} \times 1.3 \times 10^{16}) - (4.1 \times 1.6 \times 10^{-19})$
 $E = 7.96 \times 10^{-18}$
 $E = 7.96 \times 10^{-6} \text{ pJ}$

4. $1 \text{ kW} = 1000 \text{ J/s}$
 $1 \text{ kWh} = 1000 \times 3600 \times 60 \text{ s}$
 $1 \text{ kWh} = 3600000 \text{ J}$
 $\frac{2.28 \times 10^7}{3600000} = 6.3 \text{ kWh}$
 $\text{cost} = \text{kWh} \times 8p$
 $\text{cost} = 6.3 \times 8$
 $\text{cost} = 50.6 \text{ p}$

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Activity 2: Data Analysis Extended Question

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

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

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	1.1 ± 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 proximity to the true value of acceleration due to gravity.
- f) The measurements 1, 3, 4, 5, 6 have high precision due to their close values, but the measurement for trial 2 is significantly out compared to the others, so overall the precision is low.

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

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

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

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

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

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

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

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



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 achieved
- Explanation of the larger significance of the ideas and demonstration of findings.
- Explanation of what further work needs to be undertaken to confirm/improve experiment.

A good conclusion should not include:

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



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Homework Two: Constituents of the Atom and Stable and Unstable Nuclei

Note: A solution has not been included for this homework as answers will be up to the discretion of the student which information they include from the data.

Homework Three: Be the Journalist

Activity 1: Newspaper Article

Peer-marking Grid

*where 5 is 'does this very well' and 1 is 'does not do this well'

	Mark 1-5*	Comments and
Does the article cover the content outlined in the task sheet in sufficient detail?		
Does the article provide sufficient and accurate scientific content while ensuring accessibility to the reader?		
Does the article accurately use scientific terms and concepts where appropriate?		
Does the article demonstrate a clear understanding of the concepts?		
Is the article supported by facts and figures where possible?		
Is the use of spelling and grammar correct?		
Total score	/30	

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Homework Four: Be the Peer Reviewer

Activity 1: Peer Review

Question Number	Question Error	Correct Answer	Addi
1(a)	'strong'	electromagnetic	
1(d)	'electromagnetic'	strong	
2	'photon is always negatively charged' 'both have very short ranges'	- photon has a charge of zero - photon has infinite range	While photons mediate the force, which only acts between objects, it is not itself charged. As the photon does not have a mass, it has an infinite range.
4 (a)	proton-neutrino'	proton-antineutrino	
4 (b)	'Interaction 1'	Interaction 2	
5 (b)	'strong'	weak	Strong nuclear force binds neutrons and protons together, counteracts the electromagnetic repulsion between protons, and binds the protons and neutrons in the nucleus. The weak nuclear force is responsible for this, so as not to attract the nucleus, and is the force that binds protons and neutrons to create a nucleus.
6 (d)	'Yes,...'	No, the equation is invalid.	The decay is invalid because the lepton number is not conserved. $0 \rightarrow 0 + 1 + 1$

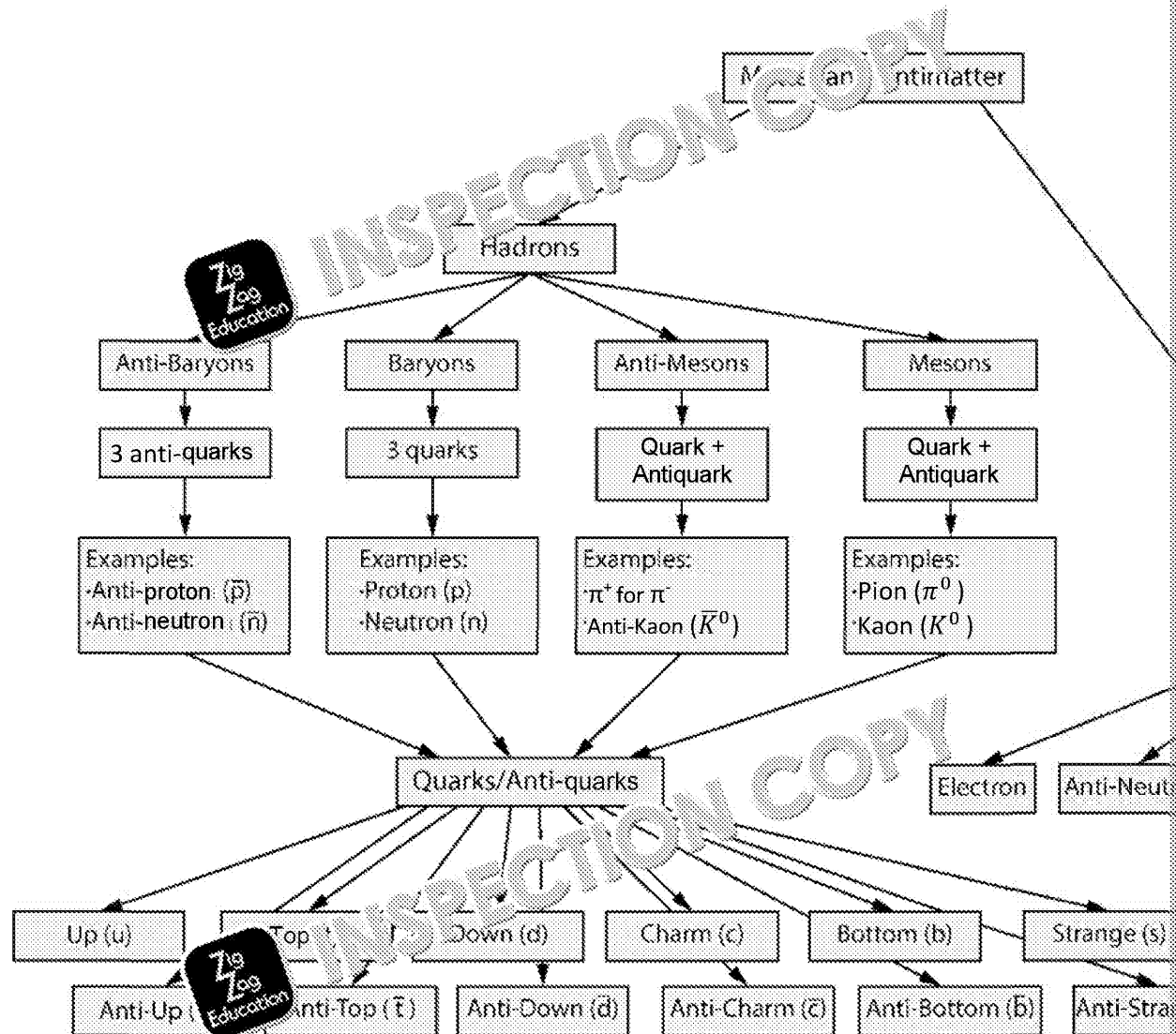
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Homework Five: Classification of particles

Activity 1: Drop-down Spider Diagram



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Activity 2: Grid Activity

	Quark Property	Baryon Number	Lepton Number	Examples	Antiparticle
Baryons	Three quarks	+1	0	Protons (p)	Antiproton ($\bar{p}$)
				Neutrons (n)	Antineutron ($\bar{n}$)
Mesons	Quark and Antiquark	0	0	Pions π^+, π^0, π^-	Antipion π^-, π^0, π^+
				Kaons K^+, K^0, K^-	Antikaons $\bar{K}^-, \bar{K}^0, \bar{K}^+$
Leptons	-	0	+1	Electron (e^-)	Positron (e^+)
				Neutrino (ν)	Antineutrino ($\bar{\nu}$)
				Muon (μ)	Antimuon ($\bar{\mu}$)

Activity 3: Summary Questions

1.
- Energy
 - Charge
 - Lepton number
 - Baryon number
 - Strangeness
2.
- a)

- Charge: $+\frac{2}{3}$
 - Baryon number: $+\frac{1}{3}$
 - Strangeness : 0

b)

- Charge: $-\frac{2}{3}$
 - Baryon number: $-\frac{1}{3}$
 - Strangeness : 0

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- c) • Charge: $-\frac{1}{3}$
 • Baryon number: $+\frac{1}{3}$
 • Strangeness : 0

- d) • Charge: $+\frac{1}{3}$
 • Baryon number: $-\frac{1}{3}$
 • Strangeness : 0

- e) • Charge: $-\frac{1}{3}$
 • Baryon number: $+\frac{1}{3}$
 • Strangeness : -1

- f) • Charge: $+\frac{1}{3}$
 • Baryon number: $-\frac{1}{3}$
 • Strangeness : +1

3. a) $udd \rightarrow udu + {}^0_{-1}e + \bar{\nu}_e$
 b) The proton is the most stable baryon and, therefore, since particles the more unstable baryons will decay into the proton.

4. a) Weak interaction
 b) No, since charge is not conserved in the decay.

5. a) Charge, strangeness and baryon number

- b) Charge:
 $-1 + 1 \rightarrow 0 + 0$
 $0 \rightarrow 0$

Strangeness:
 $0 + 0 \rightarrow +1 - 1$
 $0 \rightarrow 0$

Baryon number:
 $0 + 1 \rightarrow 0 + 1$

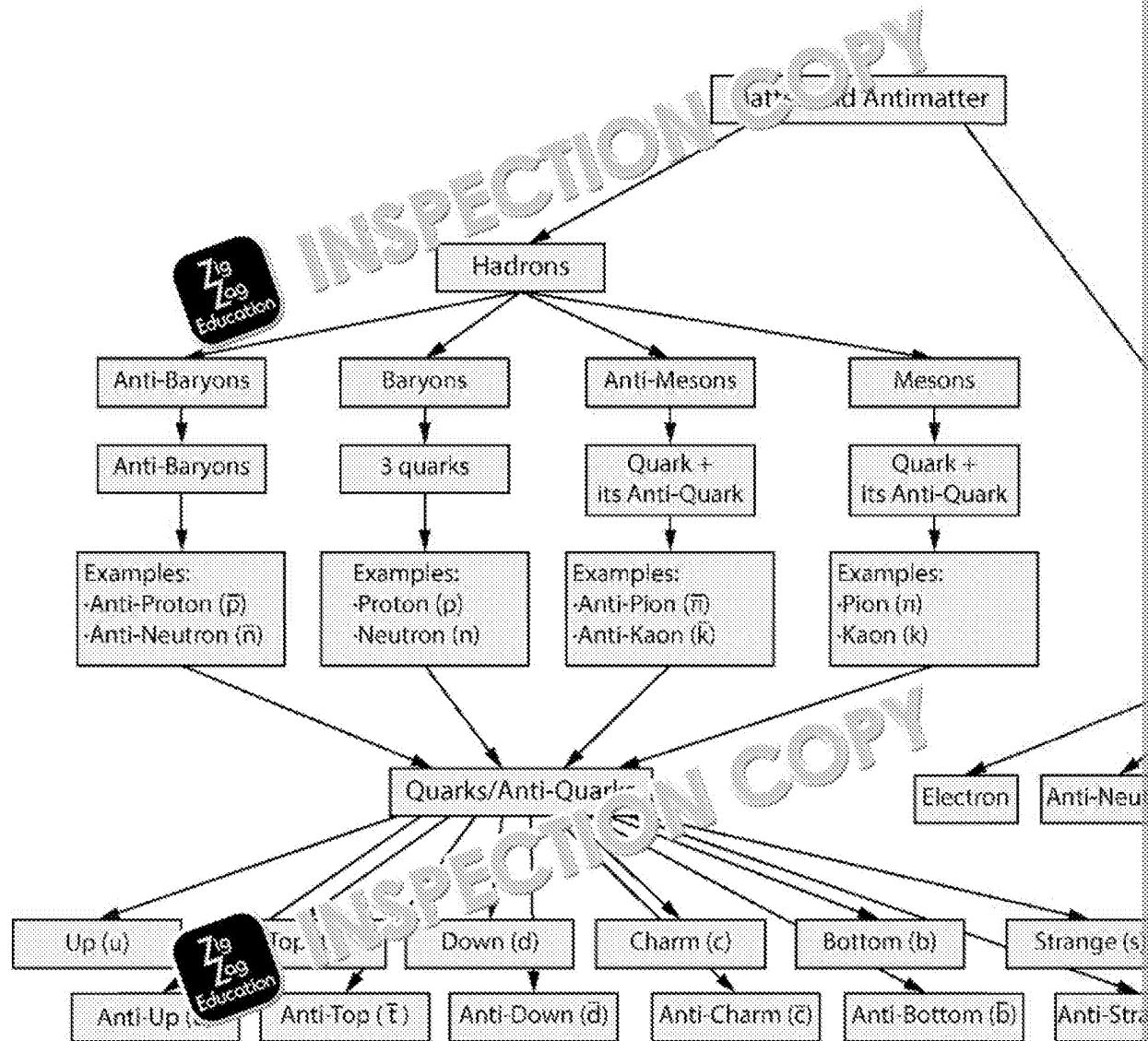
- c) Indicates that strange particles are always created in pairs.

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Homework Five: Classification of Particles

Activity 1: Mind Map



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Activity 2: Summary Questions

1.
 - Energy
 - Charge
 - Lepton number
 - Baryon number
 - Strangeness
2.
 - a)
 - Charge: $+\frac{2}{3}$
 - Baryon number: $+\frac{1}{3}$
 - Strangeness : 0
 - b)
 - Charge: $-\frac{2}{3}$
 - Baryon number: $-\frac{1}{3}$
 - Strangeness : 0
 - c)
 - Charge: $-\frac{1}{3}$
 - Baryon number: $+\frac{1}{3}$
 - Strangeness : 0
 - d)
 - Charge: $+\frac{1}{3}$
 - Baryon number: $-\frac{1}{3}$
 - Strangeness : 0
 - e)
 - Charge: $-\frac{1}{3}$
 - Baryon number: $+\frac{1}{3}$
 - Strangeness : -1
 - f)
 - Charge: $+\frac{1}{3}$
 - Baryon number: $-\frac{1}{3}$
 - Strangeness : -1
3.
 - a) $udd \rightarrow uud$
 - b) The proton and, there are more stable baryons
4.
 - a) Weak interaction
 - b) No, since it is a decay.
5.
 - a) Charge, strangeness, baryon number
 - b)

Charge: $-1 + 1 \rightarrow 0$
 $0 \rightarrow 0$

Strangeness: $0 + 0 \rightarrow 0$
 $0 \rightarrow 0$

Baryon number: $0 + 1 \rightarrow 1$
 $1 \rightarrow 1$
 - c) Indicates that it is always conserved

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Homework Six: Be the Scientist

Activity 1: Mock Scientific Report

Peer-marking Grid

	Mark 1–5*	Comments and
Does the report include all five sections?		
Does the report follow a coherent line of argument? 		
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'

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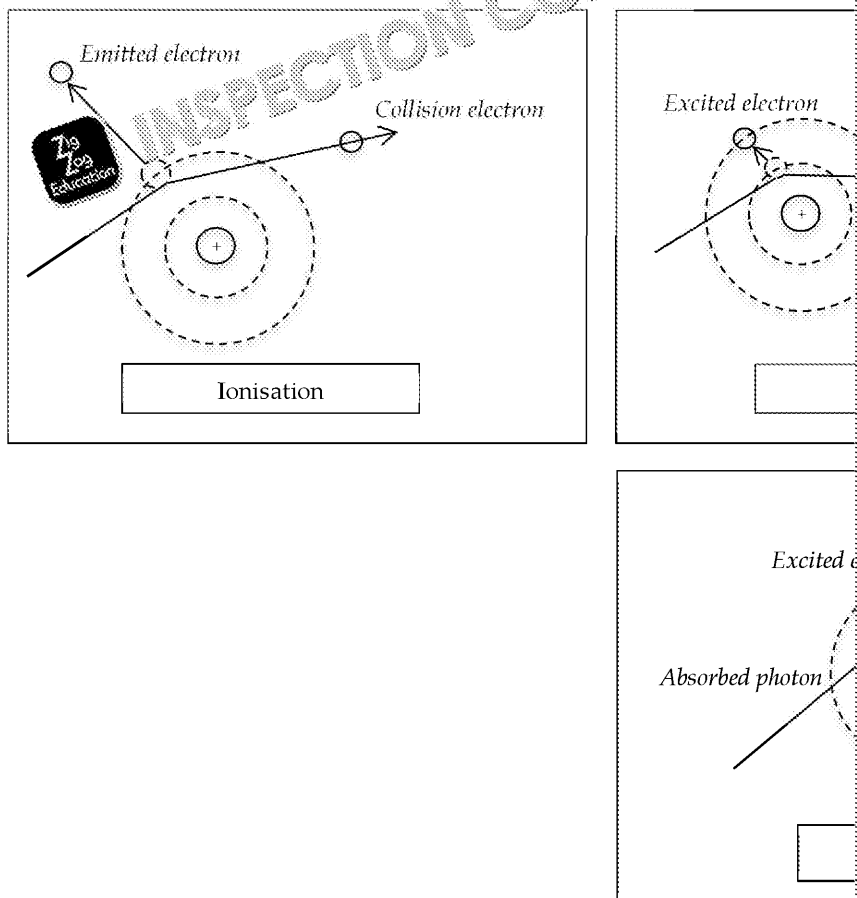


Homework Seven: Excitation, Ionisation and Wave-particle Duality

Activity 1: Exam-style Question

1. a) Ionisation is the process that creates ions (1), which are atoms that result of gaining or losing an electron (1), whereas excitation refers to an atom absorbing energy without creating an ion. (1)
- b)
 - Alpha, beta and gamma radiation can collide with the atoms causing ionisation of atoms. (1)
 - Electrons travelling in a fluorescent tube can collide with atoms causing excitation of the gas atoms. (1)

2.



3. The kinetic energy of the collision electron decreases after the collision as energy is converted into increasing the internal energy of the atom (1) to an outer shell energy level.
4. a) Absorbed (1)
 b) $E = 1.3 \times 10^{-19} \text{ J}$
 $E = (4.9 \times 1.6 \times 10^{-19}) - (3.6 \times 1.6 \times 10^{-19})$
 $E = 1.3 \times 10^{-19} \text{ J}$ (1)
 c) The energy of the photon would have to be equal to the energy difference between the two energy levels (1), and, therefore, the energy required to move the electron from the inner shell to the outer shell.

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5. a) Emitted (1)

b) $E = E_9 - E_7$ (1)

$$E = (-1.56 \times 1.6 \times 10^{-19}) - (-2.48 \times 1.6 \times 10^{-19})$$

$$E = 1.47 \times 10^{-19} \text{ J (1)}$$

c) $E = hf$

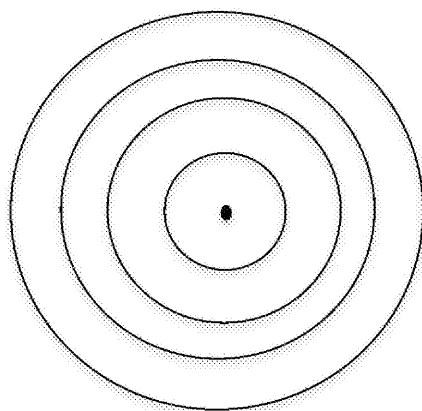
$$f = \frac{E}{h} \text{ (1)}$$

$$f = \frac{1.47 \times 10^{-19}}{6.63 \times 10^{-34}}$$

$$f = 2.22 \times 10^{14} \text{ Hz (1)}$$

d) The energy needed to remove an electron from its ground state and be greater than that of the mercury atom. (1)

6. a) (1) 



b) The interference pattern of the experiment is caused by the diffraction of particles; therefore, the experiment proves the wave-like nature of particles.

c) $\lambda = \frac{h}{p}$ (1)

$$\lambda = \frac{h}{mv} \text{ (1)}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.6 \times 10^6}$$

$$\lambda = 2.8 \times 10^{-10} \text{ m (1)}$$

Homework Section: Ionisation, Ionisation and Wave-particle Duality

Activity 1: Style Questions

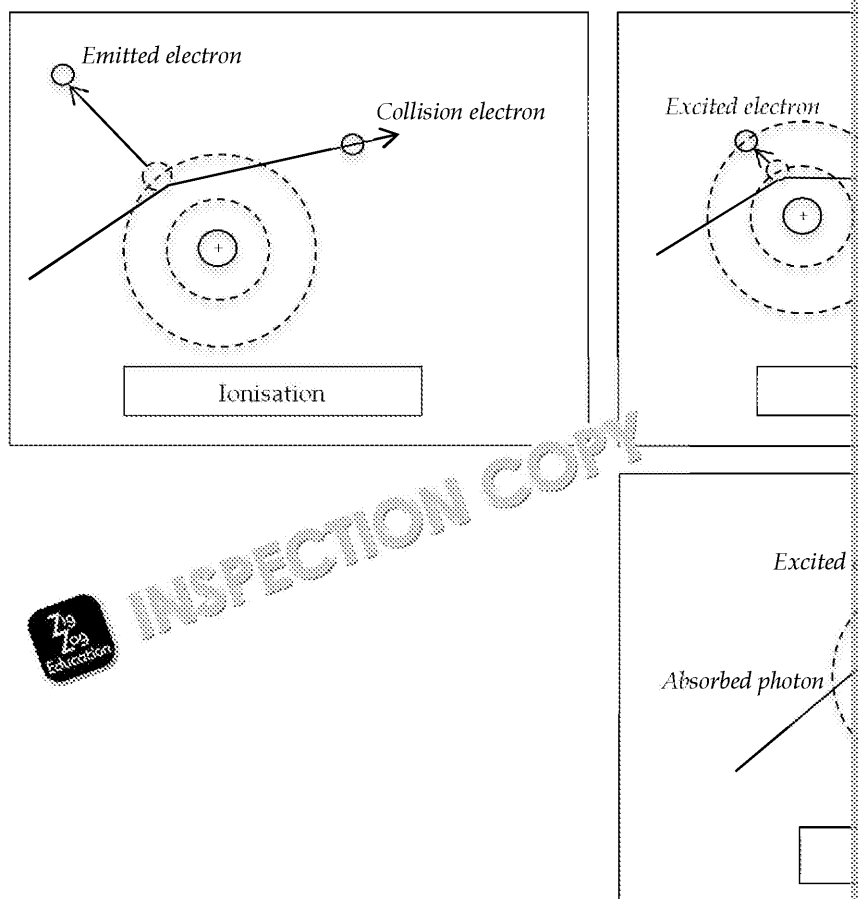
1. a) Ionisation is the process that creates ions (1), which are atoms that result of gaining or losing an electron (1), whereas excitation refers to an atom absorbing energy without creating an ion. (1)

- Alpha, beta and gamma radiation can collide with the atoms and cause ionisation of atoms. (1)
- Electrons travelling in a fluorescent tube can collide with atoms and cause ionisation of the gas atoms. (1)

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2.



3. The kinetic energy of the collision electron decreases after the collision energy is converted into increasing the internal energy (1) of the atom 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 difference between the two energy levels (1), and, therefore, the energy required to move the electron from the lower energy level to the higher energy level (1).

5. a) Emitted (1)

b) $E = E_9 - E_7$ (1)

$$E = (-1.56 \times 1.6 \times 10^{-19}) - (-2.25 \times 1.6 \times 10^{-19})$$

$$E = 1.47 \times 10^{-19} \text{ J (1)}$$



$$\lambda = \frac{hc}{E} \text{ (1)}$$

$$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.47 \times 10^{-19}}$$

$$\lambda = 1.35 \times 10^{-6} \text{ m (1)}$$

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c) $E = hf$ (1)

$$E = 6.63 \times 10^{-34} \times 3.8 \times 10^{14}$$

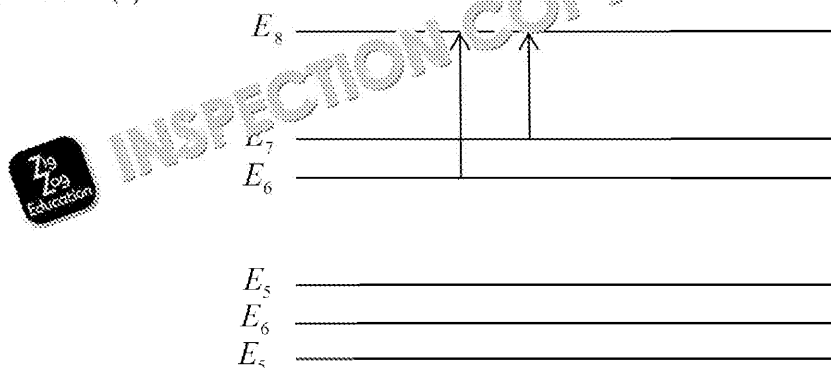
$$E = 2.52 \times 10^{-19} \text{ J (1)}$$

$$E = \frac{2.52 \times 10^{-19}}{1.6 \times 10^{-19}}$$

$$E = 1.58 \text{ eV (1)}$$

$$1.58 \text{ eV} = E_n - E_m$$

Therefore, any transition between any two levels with an energy difference of 1.58 eV is possible. (1)

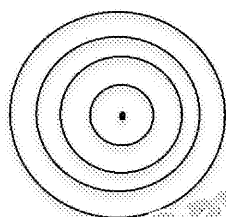


Only the transition from E_8 to E_{10} and E_9 to E_{10} is possible.

d) The photon energy ($E = 1.58 \text{ eV}$) is greater than the energy difference between E_9 to E_{10} (1) and, therefore, would provide enough energy to the electron to move 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 ionise it must 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 diffraction of particles, therefore, the experiment proves the wave-like nature of particles. (1)

c) $\lambda = \frac{h}{mv}$ (1)

$$\lambda = \frac{h}{mv} \text{ (1)}$$

$$\lambda = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 2.6 \times 10^6}$$

$$\lambda = 2.8 \times 10^{-10} \text{ m (1)}$$

d) If the momentum decreases then the wavelength of the electron increases, so the diffraction rings are larger. (1)

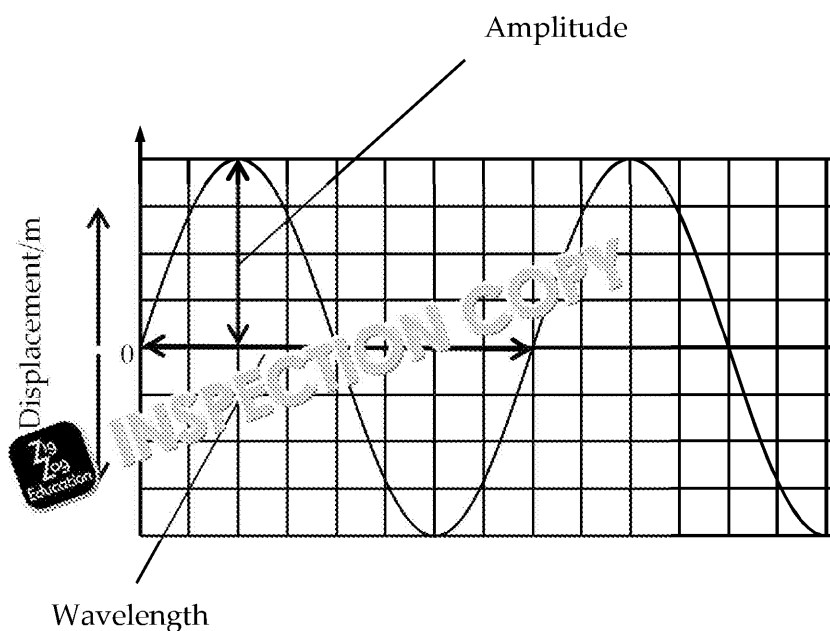
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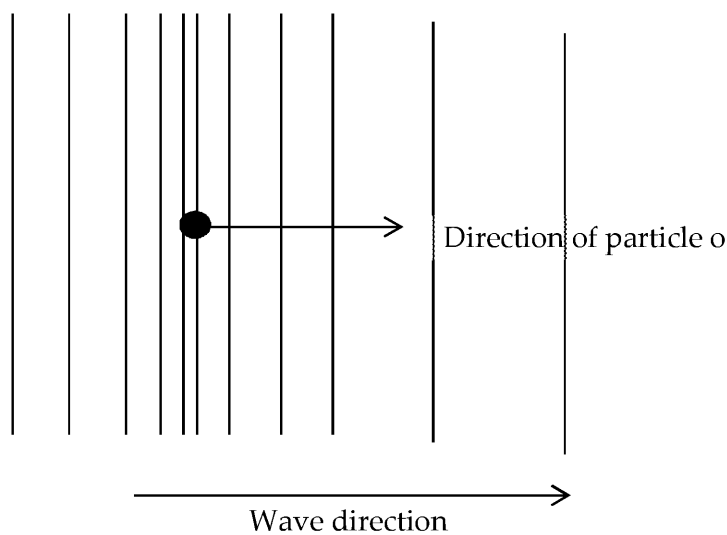
Homework Eight: Summary Questions

Activity 1: Summary Questions

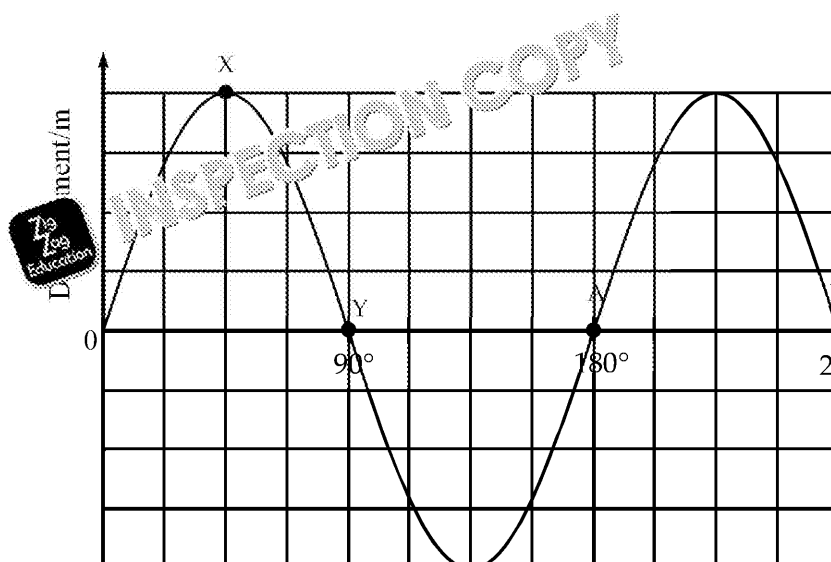
1.



2.



3.



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- a) X and Y represent an example of two points with phase difference
 b) A and B represent an example of two points with phase difference
 c) Transverse, because the particles on the graph oscillate perpendicular to the wave.
 d) Possible examples of transverse waves:
- Electromagnetic radiation
 - Waves on a string
- Possible example of longitudinal waves:
- Sound waves

4. $v = \frac{\text{distance travelled in one cycle}}{\text{time taken for one cycle}}$

$$v = \frac{50 \times 10^3}{1.7 \times 10^{-4}}$$

$$v = 2.9 \times 10^7 \text{ m/s}$$

5. a) $f = 0.5 \times 10^3 \text{ Hz}$

$$\lambda = 1 \text{ m}$$

$$v = f\lambda$$

$$v = 0.5 \times 10^3 \times 1$$

$$v = 500 \text{ ms}^{-1}$$

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, the

6. a) Sunlight (visible light) is an electromagnetic wave and all electromagnetic waves travel at the speed of light $3 \times 10^8 \text{ ms}^{-1}$.

- b) A polaroid filter only allows light oscillating in a certain orientation through it. Therefore, the filter takes unpolarised light (light that oscillates in all directions) and reduces it to a plane polarised wave (a wave that oscillates in only one direction). The intensity of light is reduced.

- c) The plane polarised light would be further polarised and no light would be transmitted.

d) $f = \frac{v}{\lambda}$

$$f = \frac{3 \times 10^8}{1 \times 10^{-6}}$$

$$f = 3 \times 10^{14} \text{ Hz}$$

- e) The frequency of light would be smaller.
 f) Radio wave transmission.

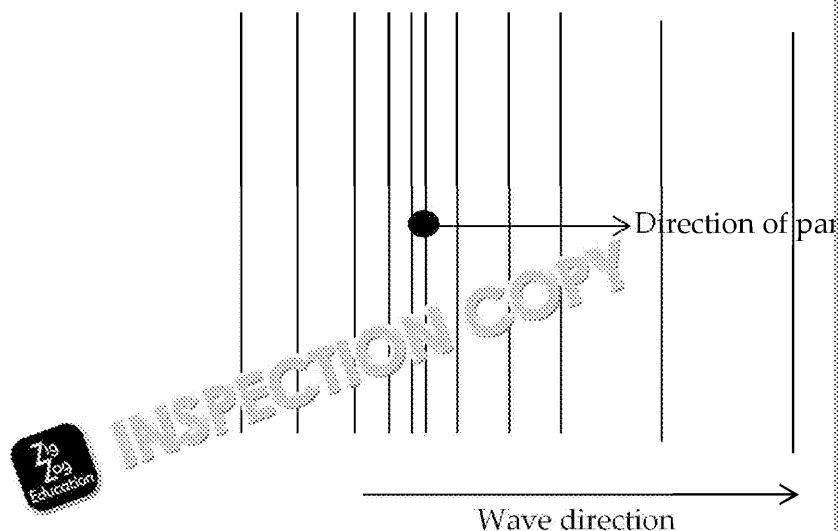
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Homework Eight: Summary Questions

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 direction.
 d) Possible examples of transverse waves:

- Electromagnetic radiation
- Waves on a string

Possible example of longitudinal waves:

- Sound waves

3.
$$v = \frac{\text{distance travelled in one cycle}}{\text{time taken for one cycle}}$$

$$v = \frac{50 \times 10^3}{1.7 \times 10^{-4}}$$

$$v = 2.9 \times 10^8 \text{ ms}^{-1}$$

4. a) $f = 0.5 \times 10^3 \text{ Hz}$

$$\lambda = 1 \text{ m}$$

$$v = f\lambda$$

$$v = 0.5 \times 10^3 \times 1$$

$$v = 500 \text{ ms}^{-1}$$

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, the speed of the wave decreases.

5. a) Sunlight (visible light) is an electromagnetic wave and all electromagnetic waves travel at the speed of light $3 \times 10^8 \text{ ms}^{-1}$.

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- b) A polaroid filter only allows light oscillating in a certain orientation through it. Therefore, the filter takes unpolarised light (light that oscillates in all directions) and reduces it to a plane polarised wave (a wave that oscillates in only one direction). The intensity of light is reduced.
- c) The plane polarised light would be further polarised and no light would be transmitted.
- 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 Ten: Design of an Experimental Set-up

Activity 1: Summary Questions

Note: This task is subjective and, therefore, there can be a number of varying answers to this task. A student is deemed to have a correct answer as long as they back up their answer 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 reflected wave will be travelling at the same frequency they will interfere to create a standing wave (a set of harmonics)
- Despite the standing wave creating points of maximum pitch, it will also create points of complete sound cancellation (nodes and antinodes)
- The set-up will result in uneven frequency balance

Homework Ten: Design of an Experimental Set-up

Activity 1: Summary Questions

The criteria can be met by setting up an experiment that mimics Young's double slit experiment with two speakers acting as coherent sources of sound waves. The equation for the double slit experiment can, therefore, be used to determine how far apart the speakers need to be in order to achieve the required interference pattern.

s = distance between speakers

D = distance between speakers and seats

w = width of the fringe

λ = wavelength of sound wave

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

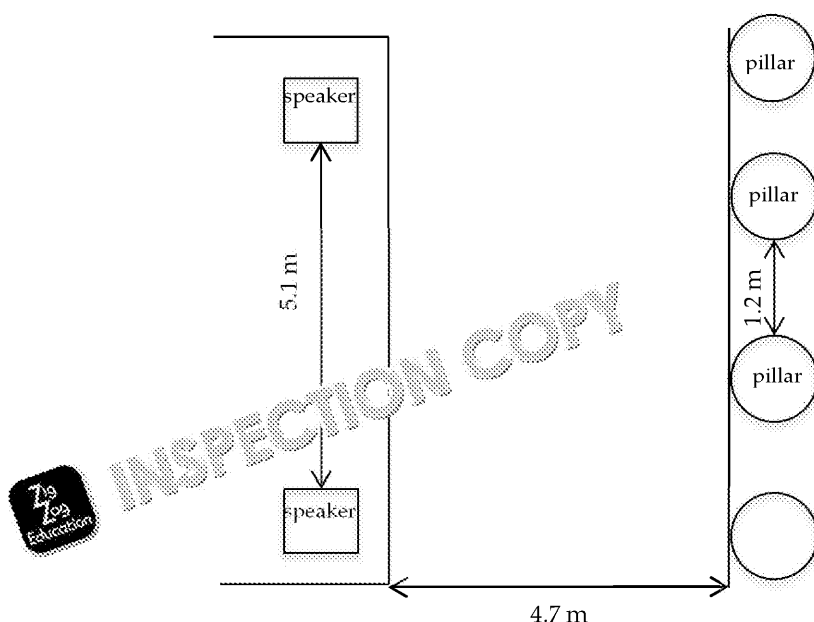
$$s = \frac{(130 \times 10^{-2}) \times 4.7}{1.2}$$

$$s = 5.1 \text{ m}$$

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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 the constant phase difference or frequency. Non-coherent sources will mean that 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 reach

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 calculation with the new parameters, I suggest that in order to achieve the same sound pattern, the speakers 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 used and the slits of width 14 cm?

Using this method essentially significantly reduces the distance between the fringes, therefore, significantly increases the separation between the fringes. Therefore, the pillars might not receive maximum pitch as the distance between the fringes (higher-pitched sound) will be greater and will not coincide with the spaces between the pillars.

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4. Can the same set-up be applied to Room 2 that has a stage width of 4 m? **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 set of speakers will be needed to ensure the same result. Therefore, since Room 2's stage width will be too small for the separation needed.

Activity 2: Summary Questions

1. $n = \frac{c}{v}$

$$n = \frac{3 \times 10^8}{2 \times 10^8}$$

$$n = 1.5$$

2. $n = \frac{c}{v}$

$$n = \frac{3 \times 10^8}{3 \times 10^8}$$

$$n = 1$$

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) $\sin \theta_c = \frac{n_2}{n_1}$

$$\theta_c = \sin^{-1} \left(\frac{n_2}{n_1} \right)$$

$$\theta_c = \sin^{-1} \left(\frac{1}{2.4} \right)$$

$$\theta_c = 24^\circ$$

4. a) Light carrying information enters the optical fibre at an angle greater than the critical angle. When the light ray hits the boundary between the inner core and the outer cladding, it undergoes total internal reflection and travels along the length of the fibre until it reaches the end.

- b) Reduce the width of the optical fibre as it will reduce the discrepancy in the distance travelled by the light undergoing total internal reflection and the length of the optical fibre.

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Homework Ten: Be the Designer

Activity 1: Design an Experimental Set-up

The criteria can be met by setting up an experiment that mimics Young's double slit experiment with two speakers acting as coherent sources of sound waves. The equation for the double slit experiment can, therefore, be used to determine how far apart the speakers have to be placed in order to achieve the required interference pattern:

s = distance between speakers

D = distance between speakers and seats

w = width of sound fringe

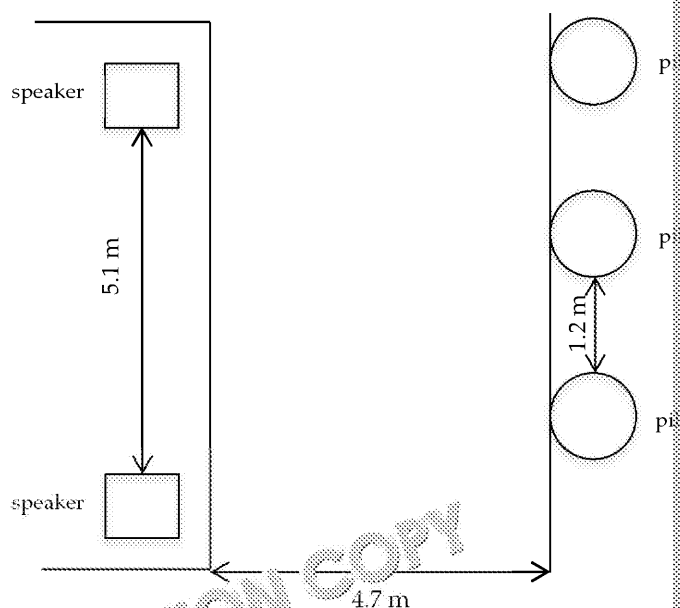
λ = wavelength of sound wave

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

$$s = \frac{(130 \times 10^3 \times 4.7)}{1.2}$$

$$s = 5.1 \text{ m}$$

Therefore, the two speakers have to be placed 5.1 metres apart on the stage to create an interference pattern that meets the theatre company's specification.



1. Will the set-up still work if the two speakers are transmitting sound of different frequencies?

No, as the two sources of sound waves will no longer be coherent meaning there will be no constant phase difference or frequency. Non coherent sources will mean that the waves will not interfere constructively or destructively.

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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 pattern reaching the audience?

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 calculation with the new parameters, I suggest that in order to achieve the same sound pattern, the speakers 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 used and the width of the slits is 14 cm?

Using this method essentially significantly reduces the distance between the speakers, which therefore significantly increases the separation between the fringes. Therefore, the pillars might not receive maximum pitch as the distance between the fringes (higher pitched sound) will be greater and will not coincide with the spaces in the pillars.

4. Can the same set up be applied to Room 2 that has a stage width of 4.7 metres and the distance 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 order to achieve the interference pattern necessary. To achieve the pattern for Room 2 you would need to use waves with smaller wavelength:

s = distance between speakers

D = distance between speakers and seats

w = width of sound fringe

λ = wavelength of sound wave

$$\lambda = \frac{wD}{s}$$

$$\lambda = \frac{4.7 \times 1.2}{5.1}$$

$$\lambda \leq 1.1$$

Therefore, if you use sound waves with wavelength of 1.25 metres or less then you can achieve the interference pattern necessary on the stage in Room 2.

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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) $\sin \theta_c = \frac{n_2}{n_1}$

$$\theta_c = \sin^{-1} \left(\frac{n_2}{n_1} \right)$$

$$\theta_c = \sin^{-1} \left(\frac{1}{2.4} \right)$$

$$\theta_c = 24^\circ$$

4. a) Light carrying information enters the optical fibre at an angle greater than the critical angle. Therefore, when it hits the boundary between the inner core and the outer core cladding, then it undergoes total internal reflection and continues to travel towards the opposing boundary. The process is then continued down the length of the fibre until it reaches the end.

- b) Reducing the width of the optical fibre will reduce the distance travelled by the light undergoing total internal reflection and therefore reduce the time taken for the light to travel the length of the optical fibre.

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Homework Eleven: Practice Questions

Activity 1: Summary Questions

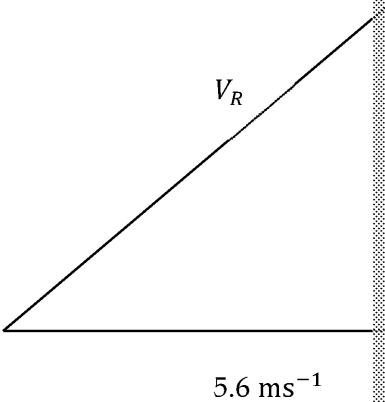
1. a)

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

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

2. $a^2 + b^2 = c^2$
 $v_R = \sqrt{a^2 + b^2}$
 $v_R = \sqrt{(5.6)^2 + (4.2)^2}$
 $v_R = 7 \text{ ms}^{-1}$

$\tan \theta = \frac{o}{a}$
 $\theta = \tan^{-1} \left(\frac{4.2}{5.6} \right)$
 $\theta = 36.9^\circ$



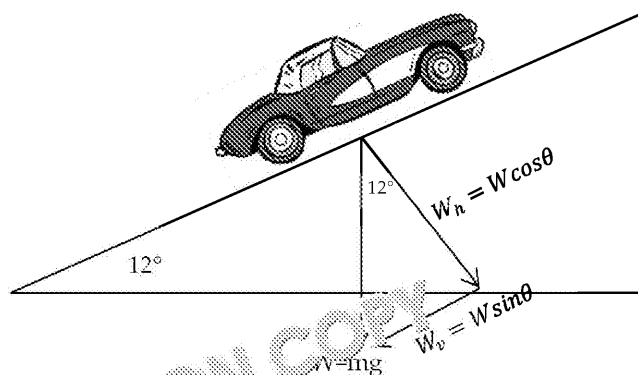
Therefore, the resultant velocity of the boat is 7 ms^{-1} on a bearing of 36.9° .

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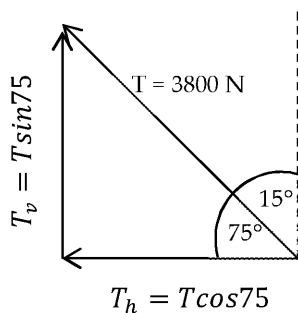
3. A 680 kg car is travelling up a steep incline.



- a) $W_v = W \sin \theta$
 $W_v = (680 \times 9.8) \times \sin 12$
 $W_v = 1385.5 \text{ N}$
- b) $F_{\text{net}} = F_{\text{engine}} - W_v$
 $F_{\text{engine}} = W_v + F_{\text{net}}$
 $F_{\text{engine}} = 1385.5 + 150$
 $F_{\text{engine}} = 1535.5 \text{ N; parallel to the incline}$

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) $T_{1v} = \text{Vertical tension in rope 1}$
 $T_{2c} = \text{Vertical tension in rope 2}$
 $W = (T_{1v} + T_{2c})$
 $W = 3670.5 + 3670.5$
 $W = 7341 \text{ N}$
- d) $W = N$
 $N = 7314 \text{ N}$

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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 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 holds
 $W_1 = \text{weight of seesaw}$
 $d_1 = \text{distance from centre of mass of seesaw to pivot}$
 $W_2 = \text{weight of boy}$
 $d_2 = \text{distance from boy to pivot}$
 $W_1 d_1 = W_2 d_2$ (1)
 $W_1 = \frac{W_2 d_2}{d_1}$ (1)
 $W_1 = \frac{(50 \times 9.81) \times 0.6}{(1.2 - 0.6)}$
 $W_1 = 490.5 \text{ N}$ (1)
- d) The weight of the ball will, therefore, be less than the weight of the seesaw. It will no longer be in equilibrium and will tip in the anticlockwise direction.
- e) *$W_1 = \text{weight of seesaw}$*
 $d_1 = \text{distance from centre of mass of seesaw to pivot}$
 $W_2 = \text{weight of boy 1} + \text{weight of boy 2}$
 $d_2 = \text{distance from two boys to pivot}$
 $W_1 d_1 = W_2 d_2$ (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)

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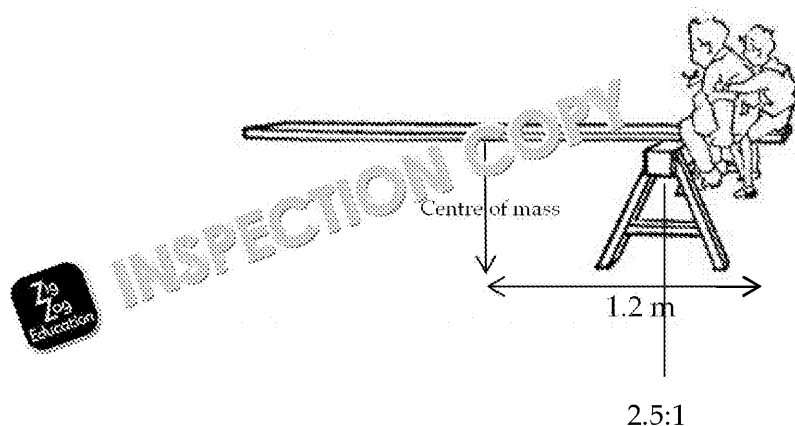
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Extension Question

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

$$2.5 + 1 = 3.5 \text{ (1)}$$

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

$$d_2 = 0.34 \text{ metres (1)}$$

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Homework Twelve: Be the Data Analyst

Activity 1: Unseen Data Question

1. a)
 - Vehicle 1 brakes at 0.8 seconds
 - Vehicle 2 brakes at 0.8 seconds
 - Vehicle 3 brakes at 1.2 seconds
 - b) The shorter the time elapsed between noticing the potential collision the less distance the vehicle travels.
 - c) If the time elapsed could be as short as potentially possible it would have been reduced, meaning the distance travelled by the vehicle was kept to a minimum, reducing the potential for collisions with other vehicles or objects on the road, reducing the number of accidents.
2. a) Using knowledge that total distance travelled will be equal to the area under the graph, it is safe to assume that it will either be vehicle 1 or vehicle 2.

Vehicle 1:

$$d = (15 \times 0.8) + (0.5 \times 18 \times 3.7)$$

$$d = 47.7 \text{ m}$$

Vehicle 2:

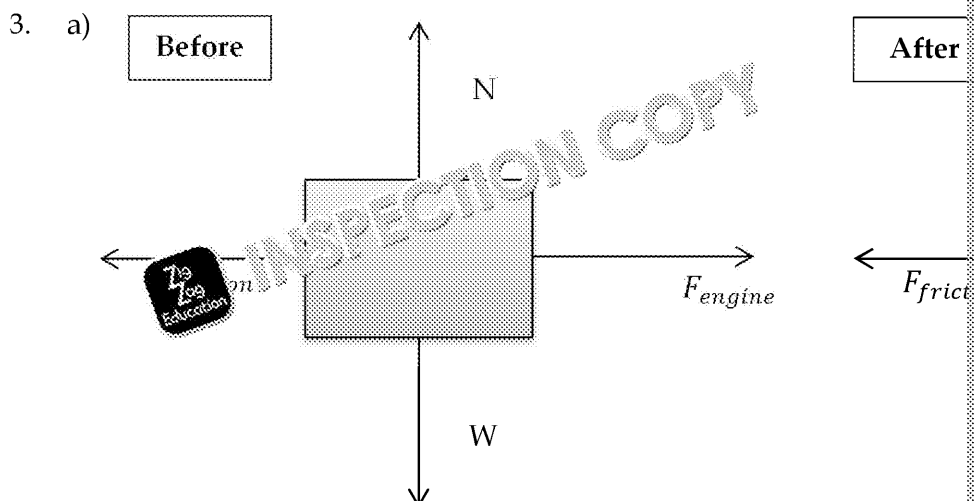
$$d = (15 \times 1.2) + (0.5 \times 4.5 \times 15)$$

$$d = 51.8 \text{ m}$$

Therefore, vehicle 2 travels the furthest.
 - b) Because the time elapsed between them noticing the potential collision is greater than for the other two vehicles. Therefore, a slower reaction time, meaning a longer distance travelled.

Extension Questions

- c) Your reaction time will have a greater influence on your ability to avoid a collision than your initial speed.
- d) No, as this is an extremely small sample size of three cars and, therefore, cannot be extended to every single registered driver. Additionally, this data does not include personal information about the driver, such as age and driver experience, which could affect the reaction time and, therefore, would differ for other drivers.



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- b) Before the brakes are applied:
- The force of the engine is equal to the frictional force
 - The weight force is equal to normal contact force
 - From Newton's first law it can, therefore, be said that since the car is moving at a constant velocity, the car travels with constant velocity

As soon as the brakes are applied:

- The weight and normal force are still equal
 - There is now no force from the engine and there is an additional frictional force acting in the opposite horizontal direction
 - The braking force and frictional force create a net force and, as a result, the vehicle will begin to decelerate.
- c) Using knowledge that the acceleration or deceleration can be found from a velocity–time graph, you can deduce that vehicle 1 has the greatest steepest gradient:

$$a = \text{gradient}$$

$$a = \frac{y_2 - y_1}{x_2 - x_1}$$

$$a = \frac{0 - 18}{4.5 - 0.8}$$

$$a = -4.9 \text{ ms}^{-2}$$

$$\text{deceleration} = 4.9 \text{ ms}^{-2}$$

Extension Questions

- d) Vehicle 1 has the greatest deceleration and, since all the vehicles have the same mass, then vehicle 1 will also have the greatest rate of change of momentum and therefore the greatest force upon impact:

$$F = \frac{\Delta(mv)}{\Delta t}$$

$$F = m \left(\frac{\Delta v}{\Delta t} \right)$$

$$F = ma$$

- e) The council could impose a reduced speed limit in that area so that vehicles are travelling at a smaller velocity initially and, therefore, the rate of change of momentum is smaller during deceleration and, therefore, so will the force upon impact.

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Homework Thirteen: 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 energy converted into work and the rest exhausted into the surroundings) ☐ Explanation of what is meant by the term ‘work’
How has their product improved?	☐ Statement about whether they believe the new model is better ☐ Difference in energy transfer between old and new model ☐ Difference in rate of energy transfer between the two models ☐ Difference in efficiency percentage ☐ Difference in 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 the carbon footprint of the company has changed ☐ Comment on the new efficiency of the model ☐ Comment on how the efficiency of the model affects the carbon footprint of the company

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Homework Fourteen: 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	Car 2
$\text{gradient} = \frac{1.5 \times 10^6}{0.15}$	$\text{gradient} = \frac{1.2 \times 10^6}{0.1}$
$\text{gradient} = 1 \times 10^7$	$\text{gradient} = 1.2 \times 10^7$
$k = \text{gradient}$	$k = \text{gradient}$
$k = 1 \times 10^7 \text{ Nm}^{-1}$	$k = 1.2 \times 10^7 \text{ Nm}^{-1}$

There, Car 2 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-extension graph. The greatest elastic potential can either be read off from the graph or determined by calculation:

elastic potential energy = area under force-extension graph

Car 1:

$$\text{area under the graph} = 0.5 \times 0.15 \times (1.5 \times 10^6)$$

$$\text{area under the graph} = 1.1 \times 10^5$$

$$E = \text{area under the graph}$$

$$E = 1.1 \times 10^5 \text{ J}$$

Car 2:

$$\text{area under the graph} = 0.5 \times 0.1 \times (1.2 \times 10^6)$$

$$\text{area under the graph} = 6 \times 10^4$$

$$E = \text{area under the graph}$$

$$E = 6 \times 10^4 \text{ J}$$

Car 3:

$$\text{area under the graph} = 0.5 \times 0.085 \times (1.3 \times 10^6)$$

$$\text{area under the graph} = 5.5 \times 10^4$$

$$E = \text{area under the graph}$$

$$E = 5.5 \times 10^4 \text{ J}$$

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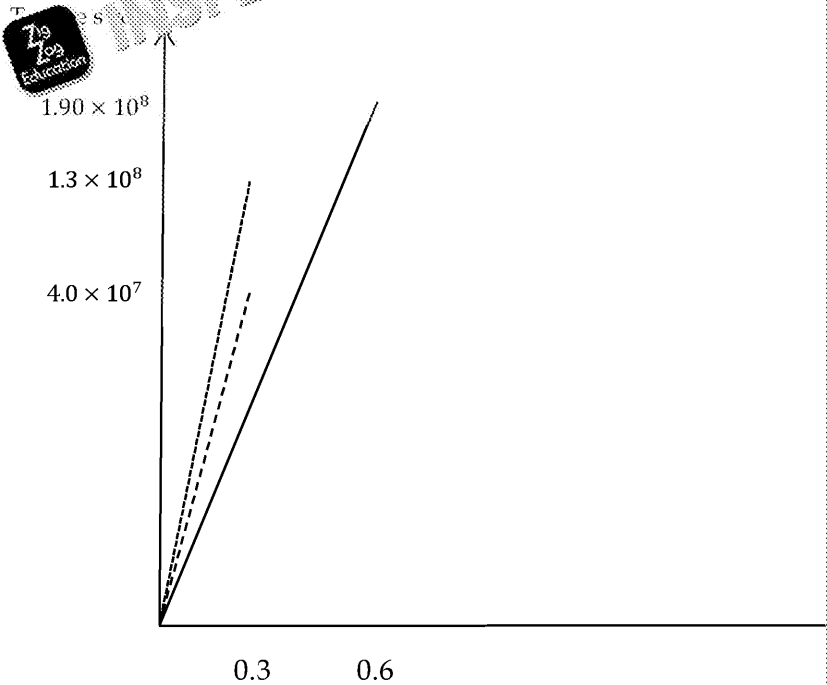


e) The equations needed:

$$\text{tensile stress} = \frac{F}{A}$$

$$\text{tensile strain} = \frac{\Delta L}{L}$$

	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) Young's modulus=gradient of stress strain graph :

Car 1	Car 2	
$\text{Young's modulus} = \frac{1.90 \times 10^8}{0.6}$	$\text{Young's modulus} = \frac{4.0 \times 10^7}{0.3}$	
$\text{Young's modulus} = 3.2 \times 10^8$	$\text{Young's modulus} = 1.3 \times 10^8$	

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Homework Fourteen: 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:

$$\text{gradient} = \frac{1.5 \times 10^6}{0.15}$$

$$\text{gradient} = 1 \times 10^7$$

$$k = \text{gradient}$$

$$k = 1 \times 10^7 \text{ Nm}^{-1}$$

Car 2:

$$\text{gradient} = \frac{1.2 \times 10^6}{0.1}$$

$$\text{gradient} = 1.2 \times 10^7$$

$$k = \text{gradient}$$

$$k = 1.2 \times 10^7 \text{ Nm}^{-1}$$

Car 3:

$$\text{gradient} = \frac{1.3 \times 10^6}{0.085}$$

$$\text{gradient} = 1.5 \times 10^7$$

$$k = \text{gradient}$$

$$k = 1.5 \times 10^7 \text{ Nm}^{-1}$$

Therefore, Car 3 has the greatest spring constant k .

- c) The spring used for Car 3 is the stiffest of the three cars.

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- d) The elastic potential energy stored is equal to the area under a force-extension graph
 greatest elastic potential can either be read off from the graph or determined by the equation
 $\text{elastic potential energy} = \text{area under force-extension graph}$

Car 1:

$$\text{area under the graph} = 0.5 \times 0.15 \times (1.5 \times 10^6)$$

$$\text{area under the graph} = 1.1 \times 10^5$$

$$E = \text{area under the graph}$$

$$E = 1.1 \times 10^5 \text{ J}$$

Car 2:

$$\text{area under the graph} = 0.5 \times 0.1 \times (1.2 \times 10^6)$$

$$\text{area under the graph} = 6 \times 10^4$$

$$E = \text{area under the graph}$$

$$E = 6 \times 10^4 \text{ J}$$

Car 3:

$$\text{area under the graph} = 0.5 \times 0.085 \times (1.3 \times 10^6)$$

$$\text{area under the graph} = 5.5 \times 10^4$$

$$E = \text{area under the graph}$$

$$E = 5.5 \times 10^4 \text{ J}$$

Therefore, considering the kinetic energy of the car has been converted by the spring, Car 1 will have held the greatest kinetic energy. Additionally, if all three cars are travelling at the same velocity v then Car 1 must also have the largest mass.

- e) The equations needed:

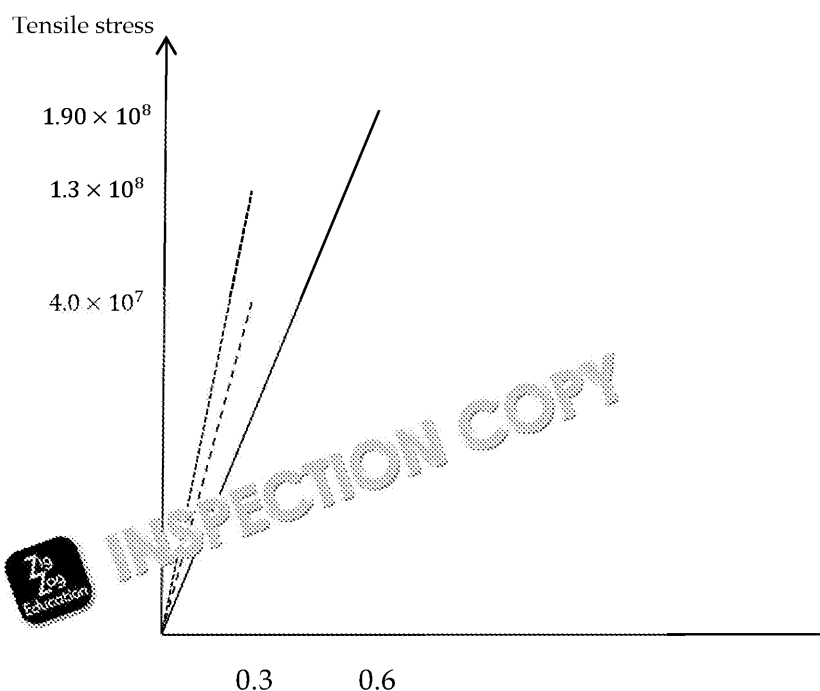
$$\text{tensile stress} = \frac{F}{A}$$

$$\text{tensile strain} = \frac{\Delta L}{L}$$

	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

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f) Car 1:

Young's modulus = gradient of stress strain graph

$$\text{Young's modulus} = \frac{1.90 \times 10^8}{0.6}$$

$$\text{Young's modulus} = 3.2 \times 10^8$$

Car 2:

Young's modulus = gradient of stress strain graph

$$\text{Young's modulus} = \frac{4.0 \times 10^7}{0.3}$$

$$\text{Young's modulus} = 1.3 \times 10^8$$

Car 3:

Young's modulus = gradient of stress strain graph

$$\text{Young's modulus} = \frac{1.3 \times 10^8}{0.3}$$

$$\text{Young's modulus} = 4.3 \times 10^8$$

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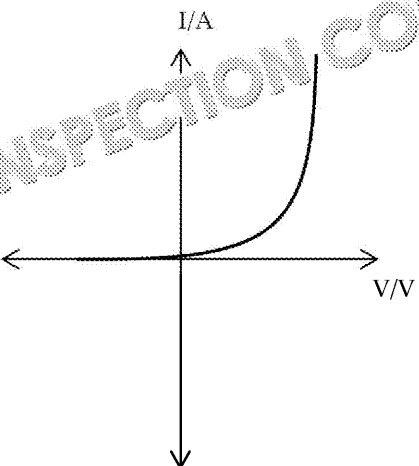
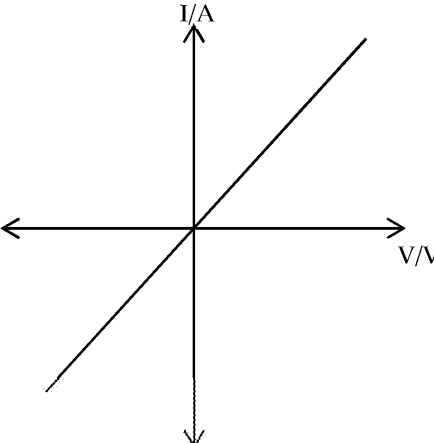
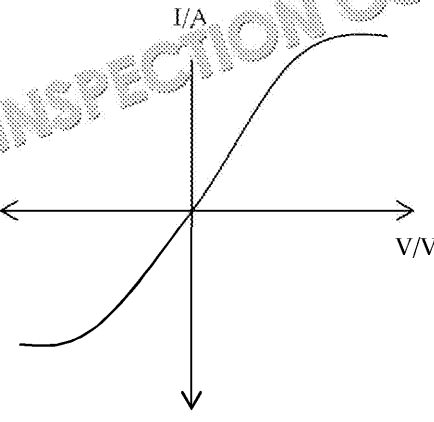


Homework Fifteen: Be the Researcher

Activity 1: Research Investigation

Any format for presenting information is acceptable as long as information 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	 Non ohmic conductor		A semiconductor diode allows current to pass in the forward direction and not in the reverse direction. That's why the curve equals zero for negative current. The diode is a light emitting diode (LED) as current passes through the component the temperature increases, therefore, resistance decreases and, therefore, there is an exponential relationship opposed to a linear relationship between I and V.
Metal Wire	An ohmic conductor		If the temperature can be kept constant then so can resistance and, therefore, since $V = IR$ and R is constant then V will be proportional to I and the graph will be a linear relationship (a straight line).
Filament Lamp	 Non ohmic conductor		As current passes through the filament the temperature increases, therefore, resistance is not a constant. Therefore, since $V = IR$ and R is not constant, the I-V graph is non-linear.

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Activity 1: National Grid Recommendation

The National Grid Recommendation Fee		
	Recommendation	Supporting explanation/evidence
Material of Cable	Aluminium	Aluminium is a conductor and, therefore, electricity. The other option was 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-section 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-section Despite 5.7 mm giving a greater cross-section 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 larger current and 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 increase then the resistance of the cables would increase proportionally. When the resistance of the cables increases then more power is lost with the current. To overcome this resistance and, therefore, the power loss from 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 lost. Superconducting materials have the property that, once cooled to below their critical temperature, the material displays zero resistivity and current can, therefore, flow without any power loss from the source, therefore reducing the amount of power loss.

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Activity 1: National Grid Recommendation

The National Grid Recommendation For		
	Recommendation	Supporting explanation/evidence
Material of Cable	Aluminium	- Aluminium and copper are both conductors that can transmit current and, therefore, electric cables are made of plastic cable, which is an insulator and not a conductor of current. - Aluminium is chosen over copper because of its lower density, this is compensated by its larger cross-sectional area.
Length of Cable	210 km	- To reduce power loss during transmission, the cable must have minimum resistance. - The equation for resistance is $R = \frac{\rho L}{A}$ where ρ is the resistivity of the cable whose ratio of length and cross-sectional area is constant. This cable has the shortest length.
Radius of Cable	5.65 mm	- To reduce power loss during transmission, the cable must have minimum resistance. - The equation for resistance is $R = \frac{\rho L}{A}$ where ρ is the resistivity of the cable whose ratio of length and cross-sectional area is constant. - Despite 5.7 mm giving a greater cross-sectional area, the 5.65 mm radius has a length of 210 km which is the smallest area.
Optimal Current	2.5 A	- The equation for current is $I = \frac{P}{V}$. - This current would provide the maximum power transfer for the minimum value of power required. - A higher power delivery would require a higher current which could induce further power loss due to the resistance of the cable.

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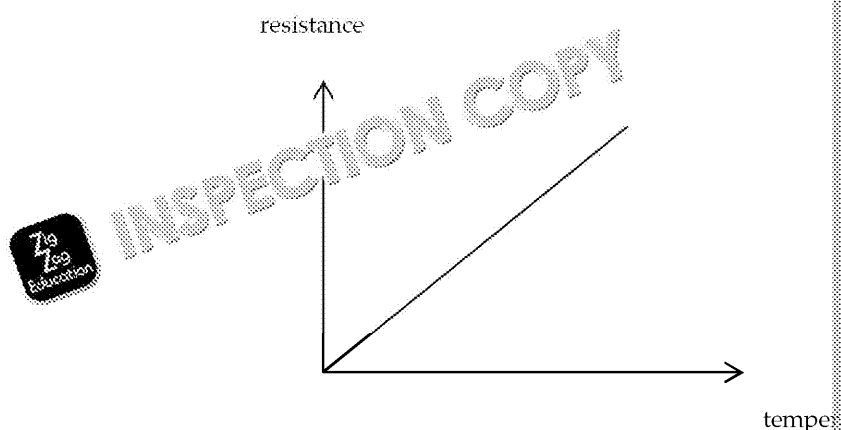


Additional queries

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 cables would increase proportionally. When the resistance of the cables increases then more power is lost with the current trying to overcome this resistance and, therefore, the power is lost from heating in the cables.

2. Sketch a graph that would help to illustrate the effect temperature has on the resistance of our cables.



3. Are there other methods of reducing the power loss in the cables?

The use of superconducting wires can reduce the amount of power lost in the cables. Superconducting materials have the property that, once cooled to below a certain temperature, the material displays zero resistivity and current can, therefore, flow without any loss from the source, therefore reducing the amount of power loss.

4. What temperature would we need to keep the cables at in order to eliminate power loss?

The critical temperature for aluminium is 1.2 K; therefore, if you wanted to achieve the superconductivity of aluminium to reduce power loss, the cables would need to be kept at a temperature of 1.2 K.

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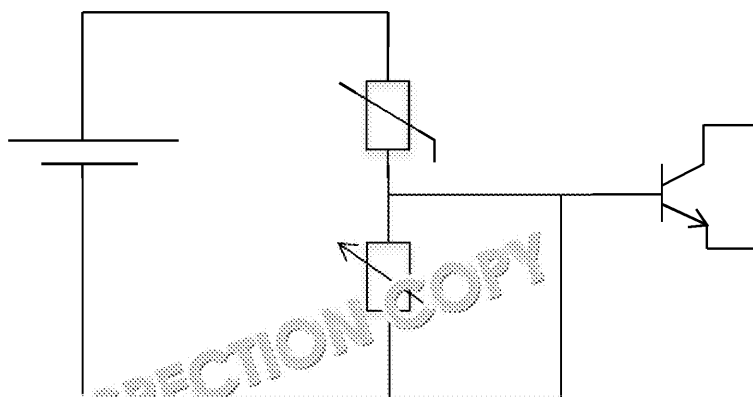
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Activity 1: Designing Your Own Circuit

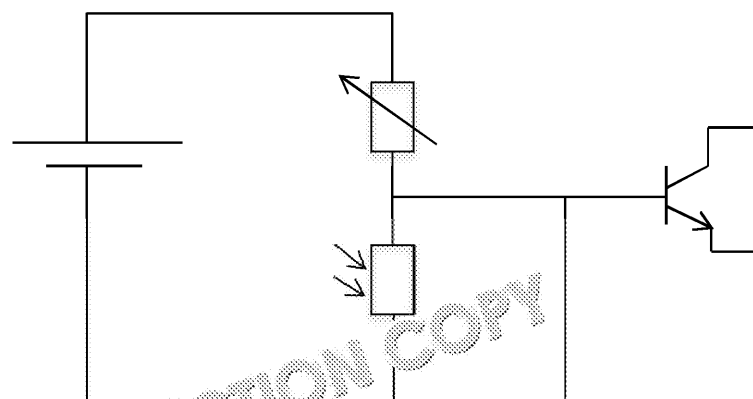
Design Specification 1:



The report should include the following points:

- The circuit design chosen is a series circuit to ensure the current flowing through the thermistor is the same, so that the voltage and resistance ratio is proportional to one another.
- A thermistor has been used as this device operates in the following way: as temperature increases the resistance decreases and, therefore, so does the voltage across it. Since the thermistor and resistor are connected in series, then the voltage across the resistor increases as the voltage across the thermistor decreases.
- Once the temperature increases above the 'acceptable' level and the voltage across the resistor reaches the 'switch on' voltage of the transistor, the transistor 'switches on' the 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 flowing through the LDR is the same so that the voltage and resistance ratio between the LDR and resistor is proportional to one another.
- A LDR has been used as this device operates in the following way: as light intensity increases the resistance decreases, and, therefore, so does the voltage across the LDR.
- When the light intensity falls below an 'acceptable level' the resistance across the LDR increases along with the voltage until it reaches 'switch on' voltage of the transistor. The transistor 'switches on' and current flows in the second circuit that controls the buzzer.

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Homework Eighteen: Exam-style Questions

Activity 1: Exam-style Questions

1. The source has its own internal resistance (1) and when current flows some of the possible volts are 'lost' in overcoming this resistance. Therefore the rest of the circuit is slightly lower than the emf of the source. (1)

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

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

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

$$I = 2.3 \text{ A (1)}$$

$$V = IR \text{ (1)}$$

$$V = 23 \times 10$$

$$V = 23 \text{ V (1)}$$

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

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

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

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

$$I = 2.6 \text{ A (1)}$$

b) $V = IR$

$$V = 2.6 \times 2.2$$

$$V = 5.7 \text{ V}$$

c) $E = \varepsilon Q$

$$Q = It \text{ (1)}$$

$$Q = 2.6 \times 500$$

$$Q = 1300 \text{ C (1)}$$

$$E = \varepsilon Q \text{ (1)}$$

$$E = 12 \times 1300$$

$$E = 15\,600 \text{ J (1)}$$

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Extension Questions

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

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

In parallel :

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

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

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

$$R_t = 6 \Omega \quad (1)$$

In series :

$$R = R_3 + R_t \quad (1)$$

$$R = 5 + 6$$

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

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

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

b) $V = \varepsilon - Ir \quad (1)$

$$V = 0.5 \times 6$$

$$V = 3 \text{ V} \quad (1)$$

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

$$Q = It \quad (1)$$

$$Q = 0.5 \times 20$$

$$Q = 10 \text{ C} \quad (1)$$

$$E = 6 \times 10$$

$$E = 60 \text{ J} \quad (1)$$

5. a) $\varepsilon = 15 \text{ V} \quad (1)$

b) $\text{gradient} = -r \quad (1)$

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

$$\text{gradient} = -4.8 \quad (1)$$

$$r = 4.8 \text{ V} \quad (1)$$

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

$$V = 15 - 1.2 \times 4.8$$

$$V = 9.2 \text{ V} \quad (1)$$

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

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

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