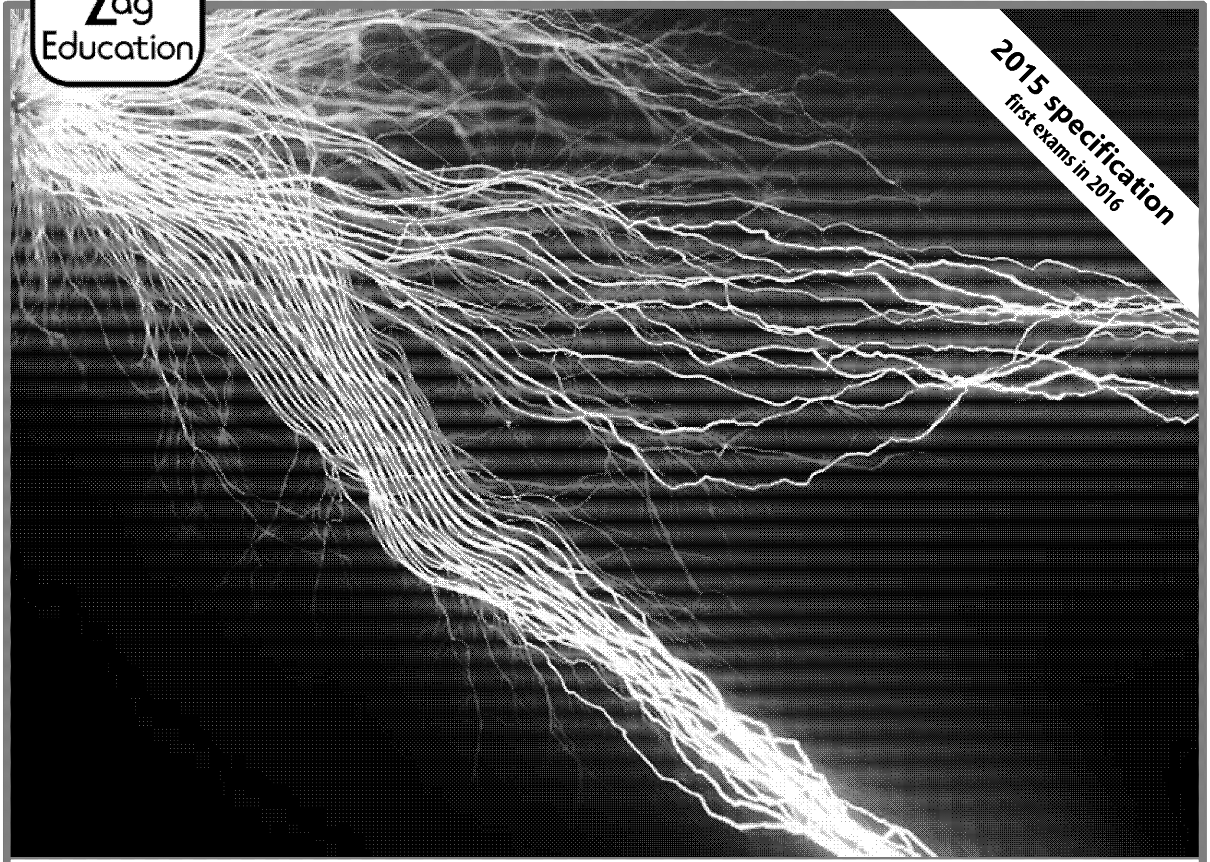

Topic Tests for AS / A Level Year 1 AQA Physics

Sections 1–5

2nd Edition, 8th November 2018

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Teacher's Introduction

These topic tests have been designed to help you and your students assess their knowledge of a topic after you have taught each section of **AS and A Level Year 1 AQA Physics Sections 1 to 5.**

Each topic test closely follows the content of the specification and includes:
- **Factual questions**: Some simpler factual questions are included to ensure that all the content and basics are covered, and to allow weaker learners access to some marks.
- **Short-answer questions**: These are not in exam style, and the purpose of these is to test different elements, knowledge and skills from the specification in a variety of styles.
- **Exam-style questions**: Where appropriate, topics may contain one or more exam-style questions, to prepare students for what they might meet in the exam, and to test exam skills.

Mathematical skills are also covered in these topic tests.

Tests have been designed to take approximately 25–60 minutes and are worth between 20 and 46 marks. The varying marks for each test reflect the content level coverage in each. Please note that some topic sections have been combined, as shown in the table:

Topic Test	Topic Number	Number of Marks
1	3.1.1/3.1.2/3.1.3	42
2	3.2.1.1/3.2.1.2/3.2.1.3/3.2.1.4	50
3	3.2.1.5/3.2.1.6/3.2.1.7	39
4	3.2.2.1/3.2.2.2/3.2.2.3/3.2.2.4	42
5	3.3.1.1/3.3.1.2/3.3.1.3	41
6	3.3.2.1/3.3.2.2/3.3.2.3	52
7	3.4.1.1/3.4.1.2	43
8	3.4.1.3/3.4.1.4	49
9	3.4.1.5/3.4.1.6	44
10	3.4.1.7/3.4.1.8/3.4.2.1/3.4.2.2	46
11	3.5.1.1/3.5.1.2/3.5.1.3	49
12	3.5.1.4/3.5.1.5	42
13	3.5.1.6	21

The topic tests are suitable for a classroom assessment, revision aid or homework task and are, therefore, suitable for use immediately after a topic is completed in class or at the end of teaching the course.

Students are able to see the number of marks awarded for each question, allowing them to gauge the level of detail they will require for the answers, as in exam conditions. Full answers with marks are included at the end of the resource. Additionally, this makes the resource a suitable tool for students to use independently.

It is recommended that students have access to a calculator to complete the questions. Students may also need a sheet containing Physics data and formulae, which can be found on the exam board website.

I hope you find these tests useful during your teaching.

September 2016

Second edition, November 2018
Improvements and corrections have been made to this resource, including rewording questions for greater clarity and context, corrections to answers, improving quality of graphs and reformatting units throughout.

Topic Test 1: Measurements and Their Errors (3.1)

1. State the SI unit for acceleration.

2. Which of the following quantities have the wrong units? State their correct u

   A Velocity (metres per second)
   B Displacement (metres)
   C Energy (seconds)
   D Force (joules)

3. Convert [illegible] fol[illegible] quantities into their SI base units.

   a) 50 [illegible]
   b) 100 µs
   c) 25.2 g
   d) 0.7 km

4. Complete the table by filling in the missing base quantities and their SI base u

Base Quantity	
Mass	
Current	
Time	

5. Two fr[illegible] re [illegible] a swimming pool, which is fitted with a diving board of he

a) i) Estimate th[illegible] [illegible] an average man.

Th[illegible] ati[illegible] for calculating the gravitational potential energy of an obj m[illegible] he body, g is the acceleration due to gravity and h is the height

ii) Assuming that the first friend has the mass of an average man, esti energy gained by the first friend as he climbs to the top of the divin

The second friend follows after. However, his mass is 10 kg greater than the

b) i) What effect would an extra 10 kg have on the gravitational potenti second friend?

   ii) Calculate the gravitational potential energy of the second friend in

6. Write the following prefixes in order of magnitude from smallest to greatest

   a) nm; µm; pm; mm
   b) TV; MV, kV; GV
   c) dm; cm

7. Define the term 'random error'.

8. State which of the following statements describes a source of systematic err

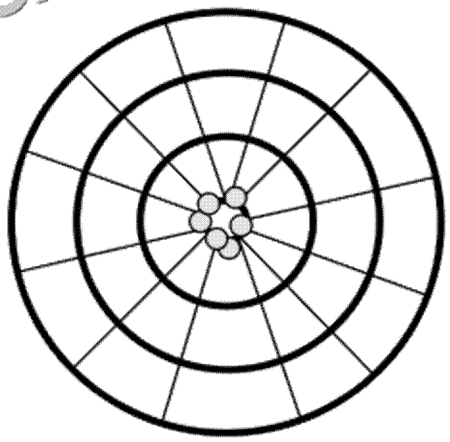
   A An experimenter making inconsistent readings of the same measureme
   B Digital scales not being set to a zero value before use.
   C Temperature fluctuations in both directions.
   D Vibrations in a spring as it is read.

9. Explain how you can reduce the contribution of random error in an experime

10. State which of the following statements is/are true:

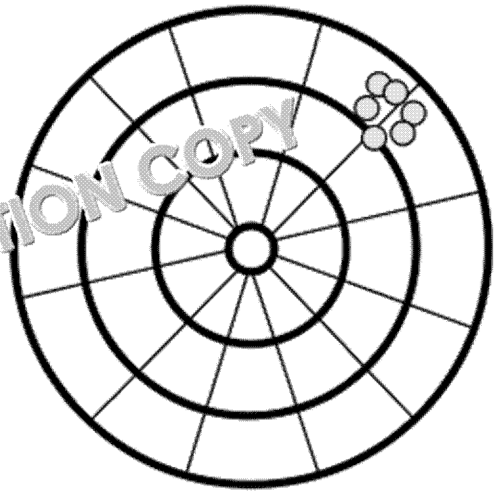
    A Precision is a term used to describe the relationship between a measured
    B Precision and accuracy are both terms that indicate how close a measured
    C Accuracy is a term used to discuss the relationship between a set of rep
    D It is possible for measurements to have both low accuracy and high pre

11. At the final of an archery competition, the last six shots of the competitors w first competitor had all six shots recorded close to each other at the bullseye.



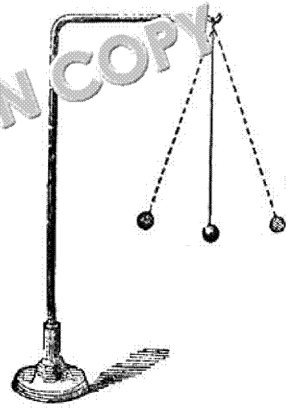
   a) Comment on the precision and accuracy of the first competitor's shots.
   b) Explain the result on the distribution of the shots if they became less ac

The second competitor had all her shots recorded close to each other but we
the target.



c) Comment on the precision and accuracy of the second competitor's sho
d) Describe the effect on the relationship between shots if the shots becam

12. For a classroom experiment students were given the task of investigating the
period of a pendulum and its length.



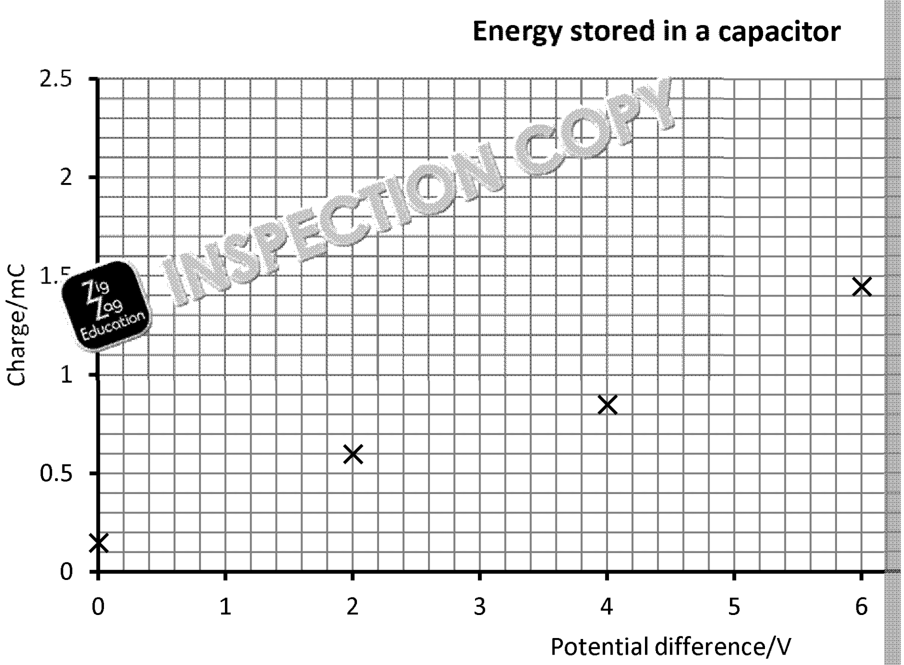
One student measured the length of string used for the pendulum to be 26.4

a) State the absolute uncertainty of the student's measurement.
b) Calculate the percentage uncertainty.

The cross-sectional area is given by the equation $A = \pi r^2$. The radius of the
3.0 ± 0.1 cm.

c) Calculate the absolute uncertainty in the cross-sectional area of the stri

13. A class of Year 12 students complete an experiment involving capacitors in a that the potential difference (V) across the two plates of the capacitor is dire (Q) stored by the plates. An example of one student's plotted results is demo



a) Calculate the gradient of the line of best fit

b) Given that the gradient for the line of worst fit is 0.29, calculate the unce

c) Calculate the percentage uncertainty of the gradient

From the graph and the table it can be seen that when zero potential differe there is still a reading for charge (and therefore current) which indicates tha

d) Suggest a reason for the zero error apparent in this experiment.

Topic Test 2: Particles, Antiparticles and Particle I
(3.2.1.1/3.2.1.2/3.2.1.3/3.2.1.4)

1. The *hypothesis* that an atom is comprised of constituent parts is a very old c ancient cultures. Our knowledge of the atom has developed significantly ove

   a) State the properties of the simple nuclear model of the atom, including t of subatomic particles.

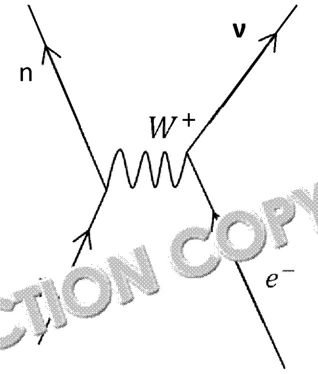
   b) State the charge and mass of the following particles in their SI base units

   - The proton
   - The neutron
   - The electron

2. State two fundamental interactions.

3. Calculate the specific charge of a helium-4 nucleus (${}^{4}_{2}H_e$).

4. Electron capture can be represented by the interaction diagram below:



   State which type of interaction results in a proton turning into a neutron in ele

5. Which of the following statements is true?

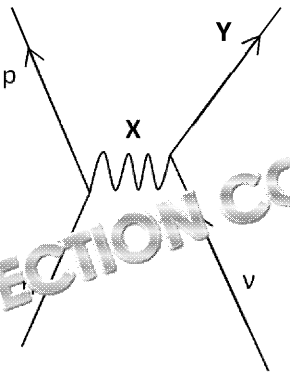
   A Isotopes are nuclei of the same element with the same nucleon number
   B Elements referred to as isotopes have the same nucleon number and at
   C ^{1}H and ^{2}H are examples of hydrogen isotopes
   D Isotopes are nuclei of the same element with the same number of proto neutrons.

6. State *the antiparticles* of the following particles:

   - Proton
   - Neutron
   - Electron
   - Neutrino

7. Comment on the mass and charge of antiparticles.

8. The neutron-neutrino interaction can be represented by the diagram below:



a) State the two missing particles **X** and **Y** from the interaction diagram.
b) State a property of the exchange particle **X**.

9. During pair production a photon creates a particle and its corresponding anti

a) State the minimum energy the photon required for pair production.

A photon can create an electron and its corresponding antiparticle in pair pr

b) Calculate the minimum wavelength of the photon required for the pair electron and its corresponding antiparticle.

10. The nucleus of a hydrogen-3 atom can be written in the form

$$^{3}_{1}H$$

a) State the proton number and the nucleon number.
b) Determine the number of neutrons in the nucleus of a hydrogen-3 atom

11. Two charged particles with the same charge will exert repulsive forces on ea in the nucleus of any atom. The protons that make up the nucleus of an atom due to each holding the same charge.

a) Explain why protons in the nucleus remain in close proximity to each ot bound together when there are repulsive forces present.
b) Sketch the graph of strong nuclear force against the separation of two n range properties.

12. a) Complete the following general radioactive decay equations and identify t

$$^{A}_{Z}X \rightarrow {}^{A-4}_{Z-?}Y + {}^{4}_{2}He$$

$$^{A}_{Z}X \rightarrow {}^{A}_{Z-?}Y + {}^{0}_{-1}e + ?$$

$$^{A}_{Z}X \rightarrow {}^{A}_{Z}X + ?$$

b) i) Predict the isotope in the following decay:

$$^{219}_{86}Rn \rightarrow {}^{?}_{?}Po + {}^{4}_{2}He$$

ii) Complete the following decay equation and indicate what type of p

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + ?$$

c) State why the existence of the neutrino was hypothesised and is neede

13. a) Describe the conversion of mass into energy that occurs during annihilat

An A Level student is investigating the energy released during annihilation.

The student is focusing on electron-positron annihilation and predicts that o formed from the annihilation will have energy of 6.8×10^{-14} J.

b) Comment whether the student's prediction is correct or incorrect.

The student also predicts that if the electron and positron had been moving of the gamma rays would have been greater than if the particles had been a

c) Is the student correct in their prediction? Give a reason for your answe

Topic Test 3: Classification of Particles and Intera Laws (3.2.1.5/3.2.1.6/3.2.1.7)

1. State the two classes of hadrons.

2. State the type of interaction:
   - that produces strange particles
   - by which strange particles decay

3. Name a particle which has non-zero strangeness.

4. Name a type of interaction that each of the following groups of particles inte
   - Leptons
   - Hadrons

5. Which of the following statements is **not** true?

   A All quarks have a charge of $-\frac{2}{3}$ and all antiquarks have a charge of $+\frac{1}{3}$
   B The strange quark has strangeness –1
   C In any reaction the baryon number is a conserved quantity
   D All baryons have a baryon number of +1

6. The word atom comes from the Greek word atomos, meaning 'indivisible', a considered to be the smallest possible unit of matter. However, in the late ni throughout the twentieth century, many smaller 'subatomic' particles were

   a) State the two largest classification groups of subatomic particles.
   b) Give two examples from each of the groups named in (a).
   c) Comment on the properties of each group of subatomic particles.

7. Interactions can be represented by decay equations.

   a) Complete the following decay equation: $\mu^- \rightarrow X + Y + v_\mu$
   b) State what decay the equation represents.

8. State whether the following equation is valid: $v_e + n \rightarrow \overline{p} + e^+$

   Give reasons for your answer.

9. The Σ^- baryon has a strangeness of -1. Indicate the quark composition of the

10. The proton and the neutron are both baryons. The proton and neutron have and are comprised of combinations of up and down quarks.
    a) State the quark composition of:
       - The proton
       - The neutron

    b) Sketch a diagram indicating the decay of a neutron in terms of quarks, i
    c) Explain why the majority of baryons will eventually decay into protons.

11. The following interaction is valid: $\pi^- + p \rightarrow K^0 + \Lambda^0$
    K^0 is a meson with strangeness +1.
    Λ^0 is a baryon with strangeness -1.

    a) State the type of interaction that the above interaction represents.
    b) By considering conservation laws, show that the interaction above is va

12. Sketch the β^+ decay in terms of change in quark character, including the fo

Topic Test 4: Electromagnetic Radiation and Quant
(3.2.2)

1. Which of the following statements is true?

   A Wave-particle duality is the property of light and matter displaying both behaviour.
   B Wave-particle duality is the property that all particles and waves are bo simultaneously.
   C Wave-particle duality is the discovery that light is in fact a particle.
   D Wave-particle duality is the discovery that particles are in fact waves.

2. State a phenomenon that illustrates:

   a) the wave-like behaviour of electrons
   b) the particle nature of electromagnetic waves

3. Define the term *work function*.

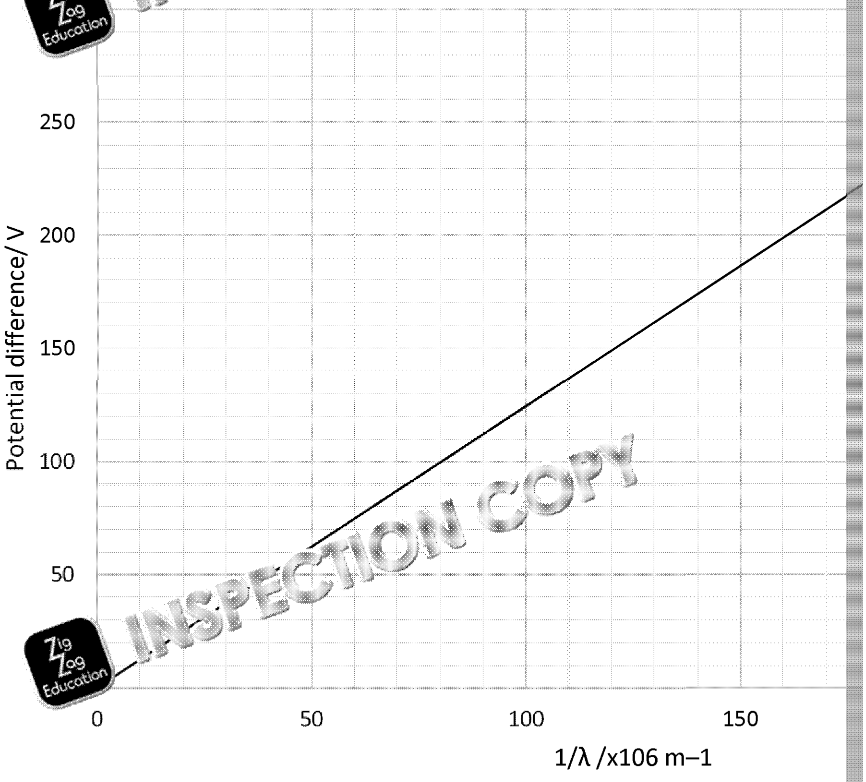
4. a) Calculate the wavelength of a photon with energy 4.13×10^{-18} J.
   b) Determine the photon's energy in electron volts.

5. Explain the process of the photoelectric effect. Your answer should refer to t frequency.

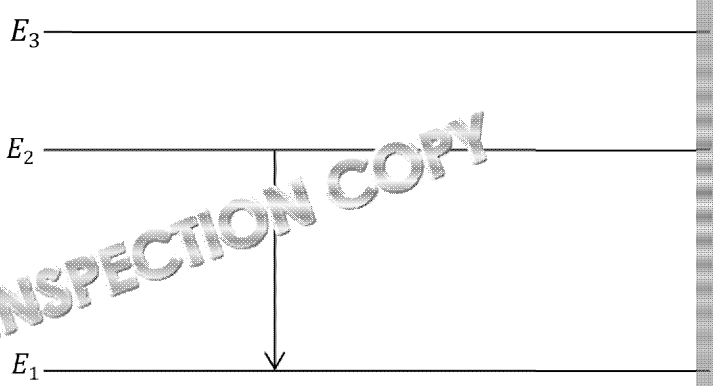
6. A physics student is investigating the maximum possible kinetic energy of the surface of copper when light is incident on its surface.

   State the measurements that will be needed to determine the maximum pos emission electron and explain how these will be used to obtain the value.

7. Calculate Planck's constant from the following graph:



8. An electron of a hydrogen atom transitions between two of its discrete ener below:



a) State whether a photon has been emitted or a photon has been absorb transition to occur.
b) Calculate the frequency of the photon from your answer to a).
c) Draw on the diagram energy transition for an electron in energy level E
   - excitation
   - ionisation
d) State the energy required to ionise the hydrogen atom with an electron

9. During a laboratory experiment, zinc plate is set up with a gold leaf electros photoelectric effect.

The work function of zinc is 4.26 eV and the frequency of UV light used is 8.1

a) Calculate the threshold frequency of the zinc plate.
b) Calculate the maximum velocity that the electrons will be released from
c) Sketch a graph to indicate how the kinetic energy of the electrons emitt the frequency of the UV lamp.

10. An electron diffraction experiment accelerates an electron across the poten up to $1.5 \times 10^5 \text{ m s}^{-1}$.

a) Calculate the de Broglie wavelength of an electron.

The potential difference in the experiment is increased.

b) Explain the effect on de Broglie's wavelength for the electron.
c) Suggest what will happen to the diffraction pattern with the change in t

The electron has a maximum kinetic energy of 6.2×10^{-18} J.

d) Determine the stopping potential for the electron.

Topic Test 5: Progressive and Stationary Waves (3

1. Define what is meant by a *progressive wave*.

2. Which of the following statements is **not** true?

   A Longitudinal waves oscillate perpendicular to the direction of wave prop
   B Longitudinal waves show areas of compression and rarefaction.
   C Transverse waves oscillate perpendicular to the direction of wave propa
   D Examples of transverse waves are ocean waves and electromagnetic wa

3. Sketch a longitudinal wave and label the direction of energy transfer.

4. State two properties that are shared by waves in the electromagnetic spectr

5. Explain what is meant by the term *plane polarised* when referring to a wave.

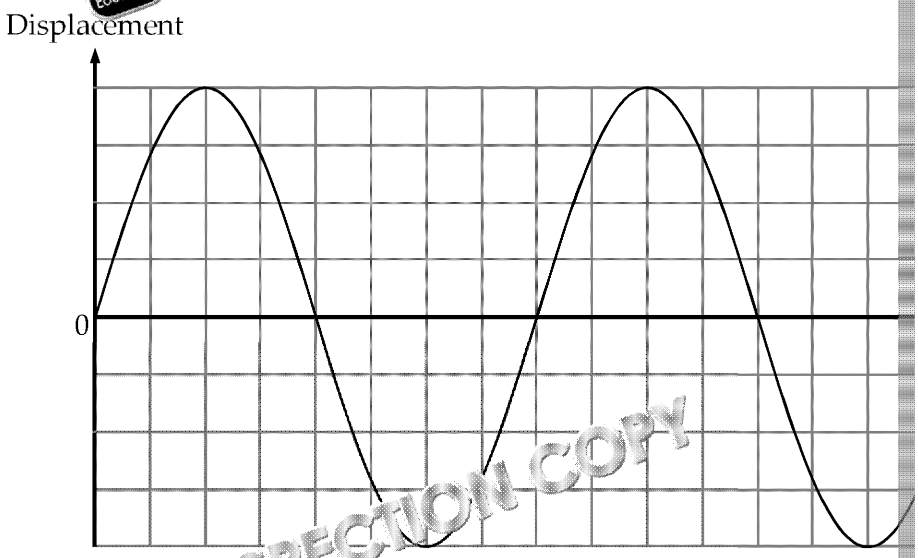
6. Give an example of a situation where plane polarisation is used.

7. A physics student is attempting to set up an experiment to demonstrate the microwaves.

   Explain the apparatus needed and how it can be used to demonstrate:
   - plane polarisation
   - no transmission of microwaves

8. Stationary waves can be formed from sound waves, microwaves and electro
   a) Explain how stationary waves are formed.
   b) Sketch a stationary wave labelling nodes and anti–nodes.

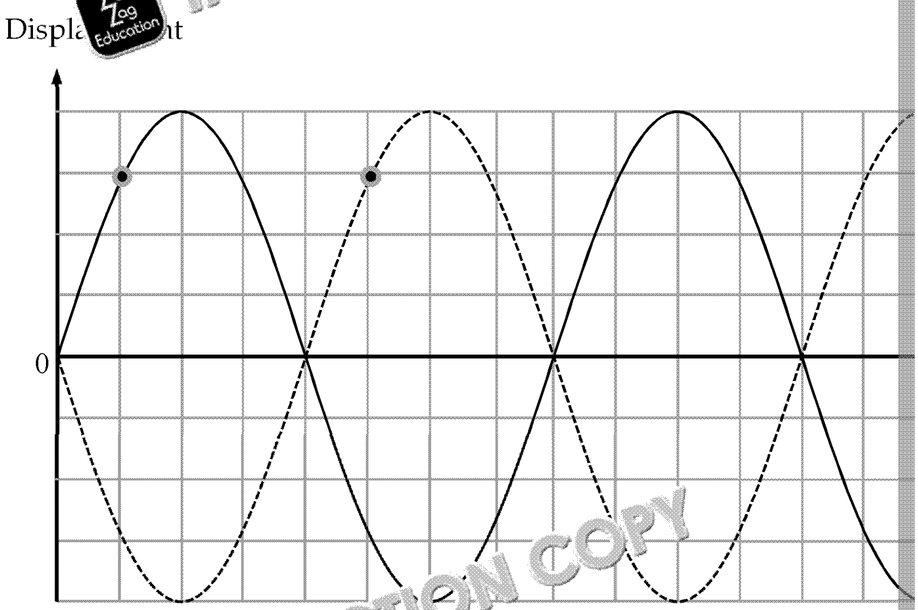
9. A student creates a displacement–time graph of a transverse wave, which wa during an experiment on wave properties.



a) Draw on the diagram above the following wave properties:
- Amplitude
- Period

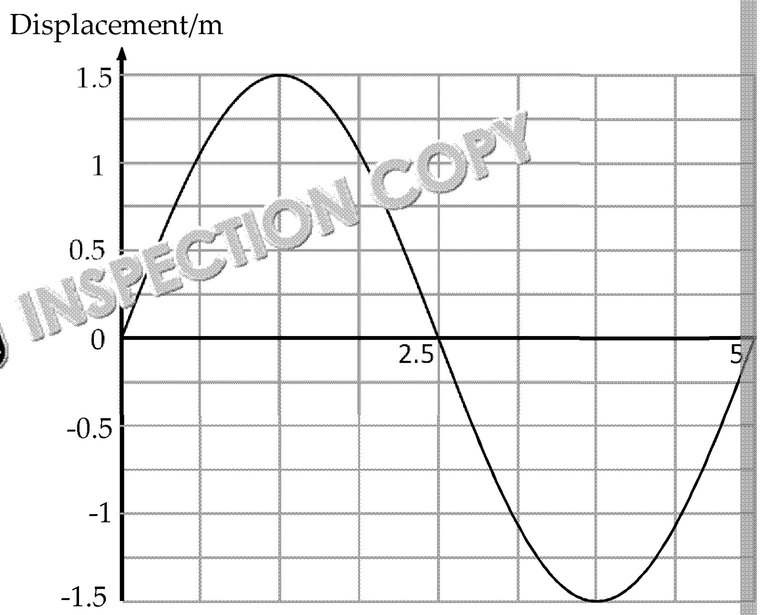
b) Define each of the following wave properties:
- Displacement
- Amplitude
- Wavelength

A second wave with the same frequency is illustrated on the graph. The stud
waves onto one another to make a direct comparison.



c) Explain what is meant by the *phase difference* between the points on eac
d) State the phase difference between the two waves in fractions of a wave
e) Give your answer to d) in radians.

10. A large swimming pool at a water park has a wave machine which produces displacement–time graph below illustrates the behaviour of the waves produ



a) State the period of the wave.

The distance between consecutive wave peaks is 7.0 m.

b) Calculate the frequency of the waves.
c) Calculate the wave speed.

11. A watch company is updating the design of the liquid crystal display in its wa glare from the Sun on the watch face. The new design utilises polarisation fil

a) Describe the effect of a polarisation filter on unpolarised light as it pass
b) Explain how the use of these filters would reduce glare.

12. Vibrating strings are fundamental to many common musical instruments, su

The strings of a cello are fixed at both ends, and the length of string most co mass per unit length 1.7×10^{-3} kg m^{-1}.

The string is released from maximum at $t = 0$.

a) Sketch the first harmonic vibration of a cello string.
b) Sketch the first harmonic vibration at $\frac{3}{4}T$, where T is the period of the o

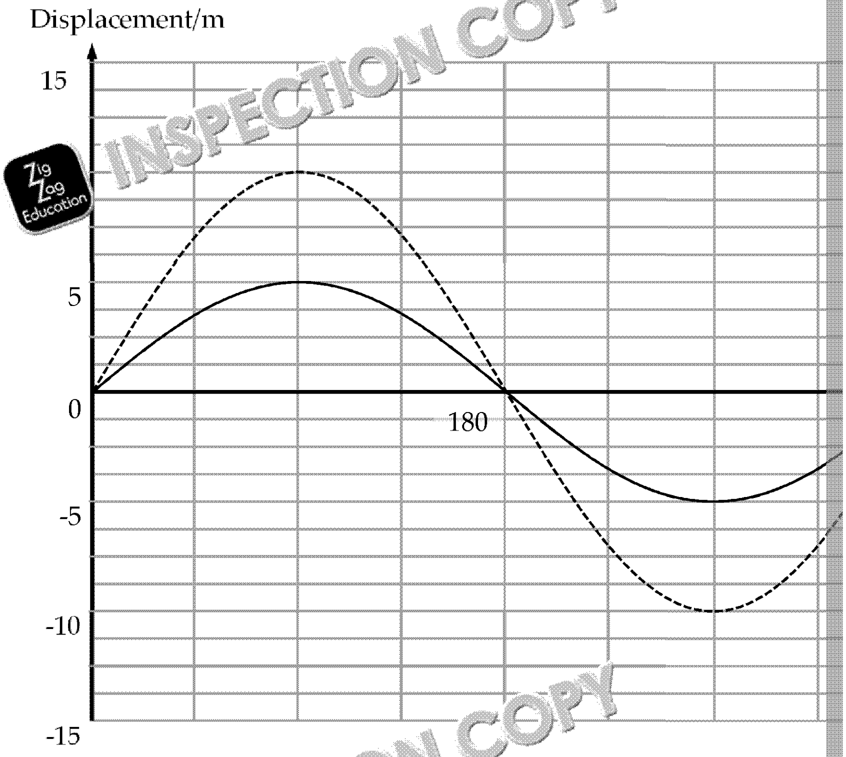
The string vibrates with wave speed $300\ \mathrm{ms}^{-1}$ in first mode of vibration.

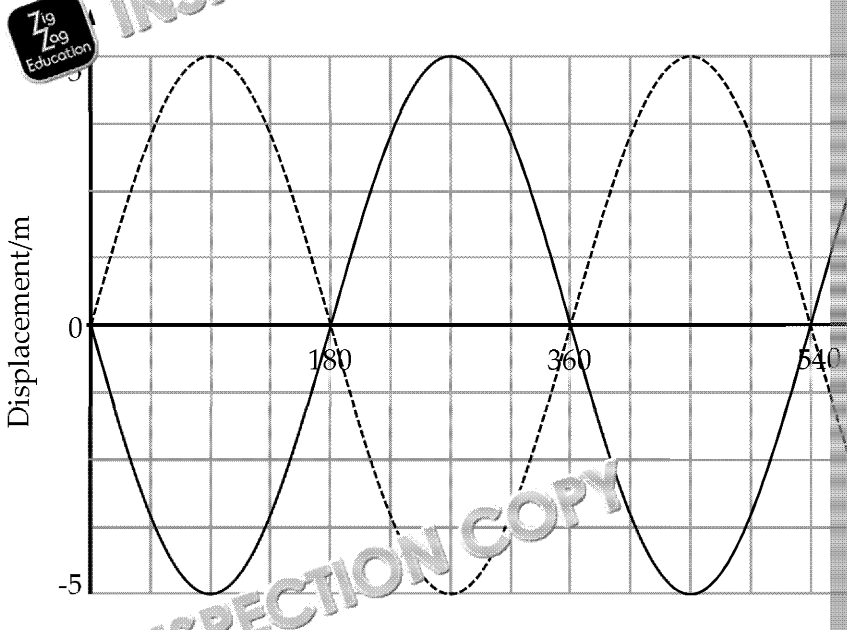
c) Determine the frequency of the first harmonic.
d) Calculate the tension in the string at the frequency given in your answe
e) Explain the effect on the frequency of vibration if the string of the cello i

Topic Test 6: Refraction, Diffraction and Interfere

1. Explain why it is possible for a resultant wave to obtain a smaller amplitude t comprising it.

2. Sketch the resultant wave of the superposition of the waves in the following





3. Describe the meaning of the term *coherence*.

4. Consider two sources of microwave radiation that are set up to create an int

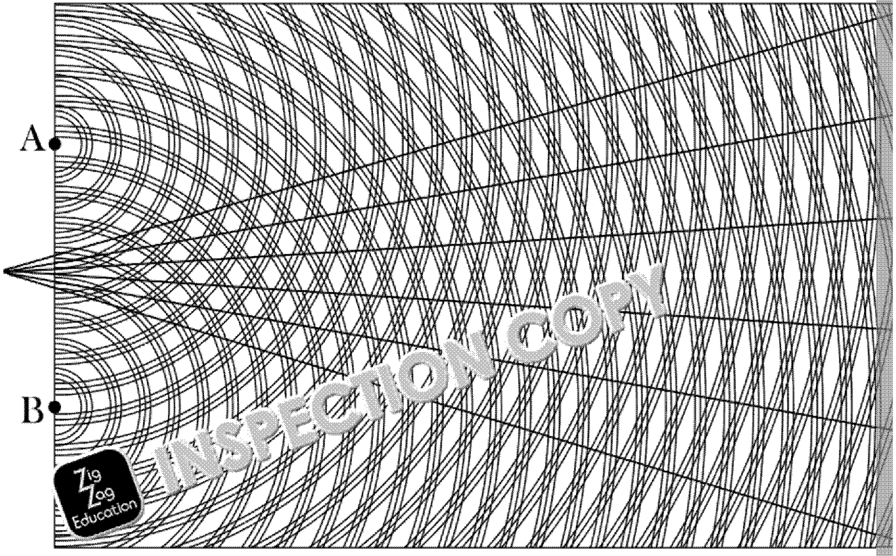
   a) Explain the effect on the microwaves after the two waves have interfere
   b) Indicate the situation required for destructive interference.
   c) Explain the amount of radiation a person is exposed to if the two microw amplitude, destructively interfere.

5. Optical fibres are used to carry information across large distances, which is co

   a) Explain how optical fibres transmit light across large distances.
   b) Explain why the core of an optical fibre has to be kept sufficiently narrow
   c) What effect would using white light instead of monochromatic light have optical fibre

6. At the O2 Academy in Brixton a sound engineer is planning the layout of two s coherent waves, to ensure that particular sections of the crowd will receive ac

   a) Describe a set-up that the sound engineer could use to determine the in *that will be created by the two speakers at A and B.*



Points X and Z represent the first- and second-order minima respectively of th created by the two sources of sound waves at A and B.

The path difference between the waves at point Z is $\frac{3}{2}\lambda$.

   b) State whether the two sound waves have arrived in phase or anti-phase

Point Y represents the first-order maximum of the interference pattern. The p

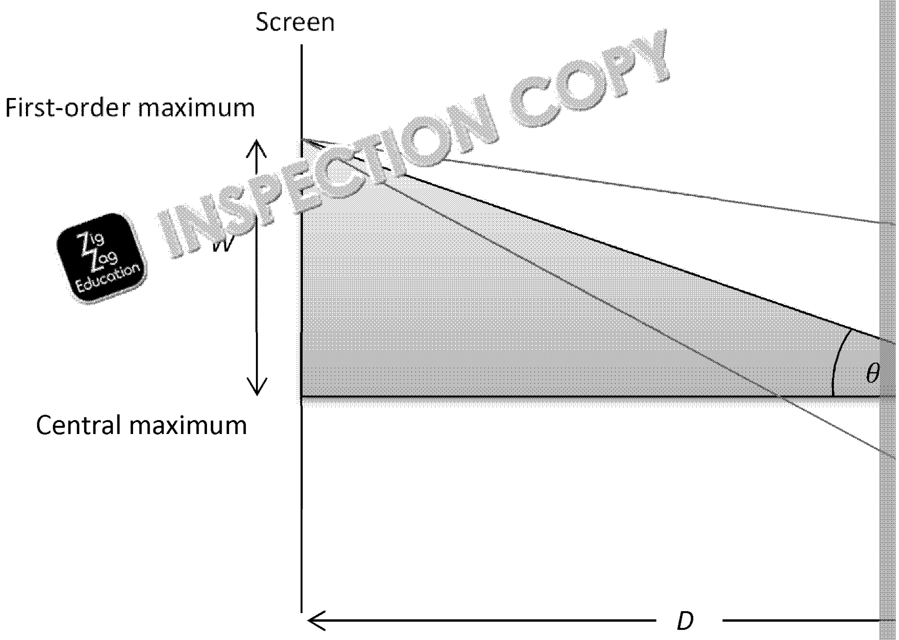
   c) Explain whether the sound heard at point Z will be louder or quieter tha
   d) Determine what the phase difference between the waves will be at poin

7. Two physicists have set up a diffraction grating experiment. The grating spaci 2.5×10^{-6} m. The angle between the zero order beam and the second order b

   a) Calculate the wavelength of light that the two physicists used for the ex
   b) Explain what would happen to the diffraction pattern observed if the ph wavelength to complete the experiment.

8. A Year 12 Physics class completed the Young's double slit experiment to det
properties of monochromatic light.

The diagram below illustrates the set-up of the experiment. Light rays travel
and the interference pattern is observed on the screen a distance D from th



a) Explain how the experiment uses coherent light sources to create the in
the screen.

b) If the diffraction grating technique was used instead, explain whether th
intensity would be the same or different from the double slit technique.

c) Comment on the difference in the separation between the fringes if the
had been used.

The experiment measured the distance between the slits s = 0.75 mm, the wi
bright fringes to be [illegible] mm, and the wavelength of light used was 540 n

d) Calculate the distance D between the double slits and the fringes on the

9. The sun hits a row of shop-front windows in the local high street. The sun's li
through the glass window at roughly 2 × $10^8\ \mathrm{m\ s^{-1}}$.

a) Explain why light refracts as it travels through the glass.

b) Calculate the refractive index of the glass.

c) Explain what you would conclude about the speed of light in the glass w

d) The light reaches the window at an incident angle of 33°. Calculate the a
the glass.

10. A fisherman is wading in a pond on a weekend fishing trip. The pond has ligh
for when the sun goes down. The refractive index for water is 1.33.

a) State what is meant by the term *critical angle*.

b) Calculate the critical angle for water.

c) The pond's lights are directed to the surface at an angle of 57° to the no
Explain what effect this will have on the light rays seen by the fisherman at t
between the pond's surface and the air.

d) Light passes from air into water at the same angle. Describe how the pat
[illegible] from water to air, as in c).

e) A [illegible] of glass is placed over the water. The light rays reach the water–
incident angle, 57°.
The refractive index of the glass is 1.21.
Show that the light will not undergo total internal reflection.

f) Calculate the angle between the light and the water–glass boundary aft

Topic Test 7: Scalars, Vectors and Moments (3.4.1

1. Which of the following statements is **not** true?

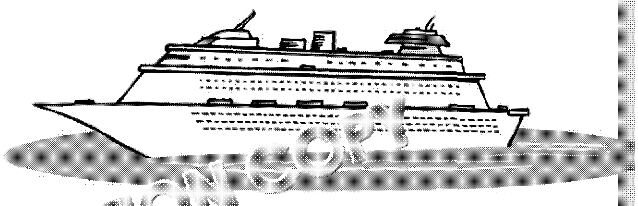
   A A scalar quantity is entirely defined by magnitude.
   B A vector quantity can only be entirely defined by magnitude and directi
   C A scalar quantity can be defined by either magnitude or direction.
   D A vector quantity has a magnitude.

2. State whether the following quantities are scalars or vectors.

   a) Velocity
   b) Fo
   c) W
   d) Mass
   e) Distance

3. Comment on what is missing from the following statement. Give a reason fo
   The tension in the rope was 100 N.

4. A group of friends are travelling to a festival in Croatia. For the last section o
   a ferry across to their destination island. The ferry is travelling at 6.3 ms^{-1} du
   The current is travelling in the same direction at 3 ms^{-1}.



   a) Calculate the ferry's resultant velocity.

   The current's direction then changes to due west but its speed remains uncha

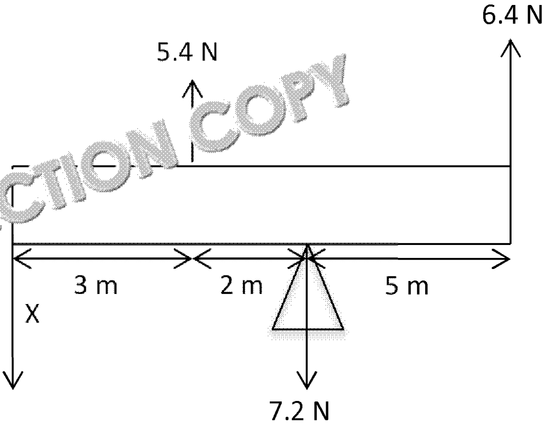
   b) Calculate the ferry's resultant velocity after the current's direction has c

5. Define the term *moment of force* with an equation.

6. Define the term *couple* in terms of forces.

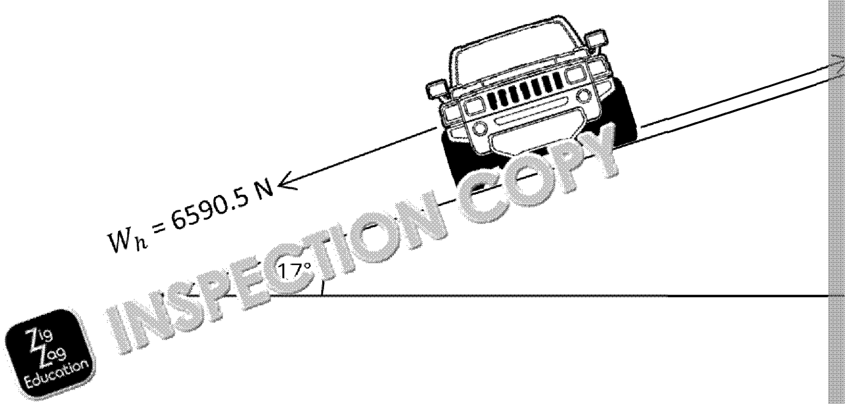
7. State the position of the centre of mass of a uniform sphere.

8. The diagram below represents the idea of principle of moments:



   Calculate the total moment around X and state its direction.

9. A car is parked on a hill. The force it feels pulling it down the hill is due to the weight.

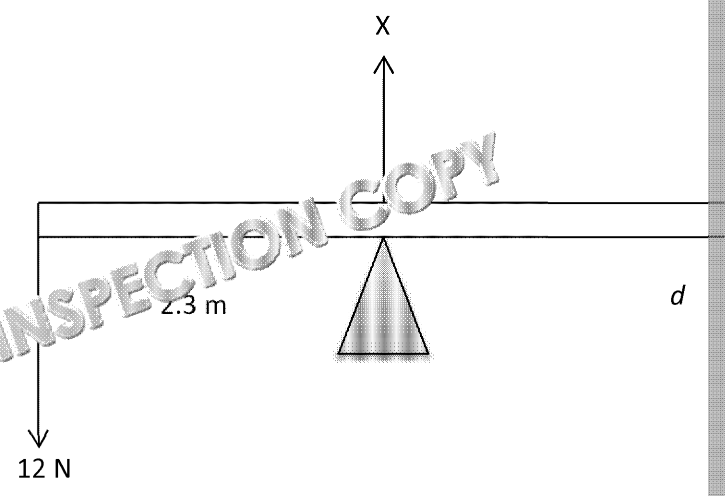


a) Determine the weight of the car.

Since the car is at rest when parked, the car is in equilibrium.

b) State the frictional force between the tyres and the road surface when t

10. For a circus performance a balancing apparatus is set up for its performers. T come up with has to be in equilibrium to ensure it remains balanced.



a) State the two conditions required for *equilibrium of forces*.
b) Calculate the distance *d* from the pivot.
c) Calculate the force X.

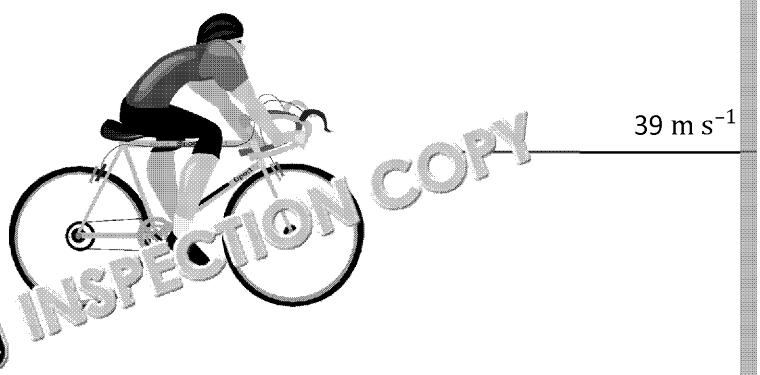
One of the circus performers climbs onto the left end of the balancing appar

d) Suggest one change that could be made to ensure the system remains i

11. A tugboat is held in equilibrium at the docks by three ropes attached to the p tension A on a bearing of 90°, the second rope is attached at a bearing of 18 third rope is attached with tension [illegible] at a bearing of 310°.

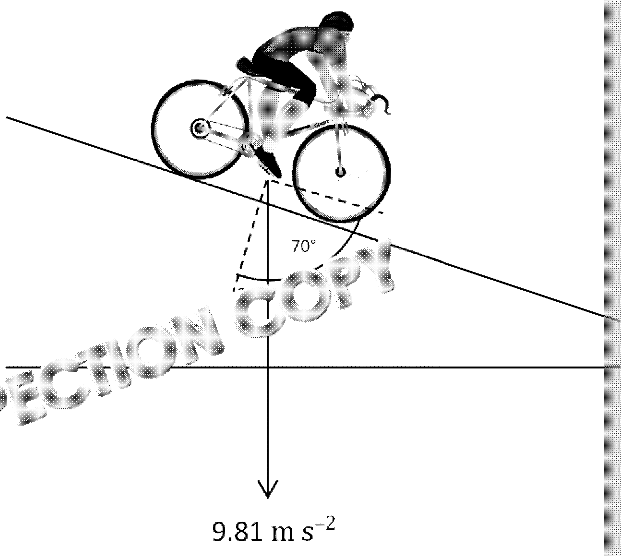
a) Draw the free body diagram to illustrate how the tugboat is tied at the p
b) Calculate the tensions A and B.

12. A cyclist, touring the French countryside for the summer, starts his journey t
39 m s^{-1} due north. However, there is a strong wind travelling due west at 8



a) Draw the vector triangle for the speed of the air relative to the cyclist w
b) Calculate the velocity of the air relative to the cyclist.

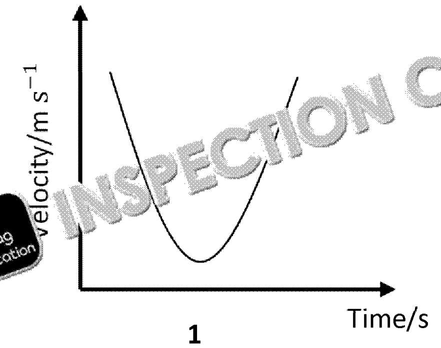
The cyclist then starts travelling down a smooth hill. In this case, ignore the e



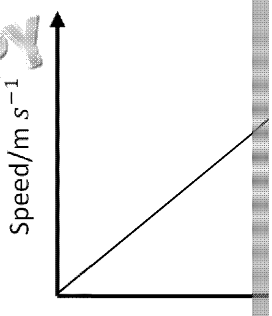
c) State the equation for calculating the cyclist's component of accelerati
d) Calculate the cyclist's component of acceleration down the hill.

Topic Test 8: Projectile Motion and Motion along S
(3.4.1.3/3.4.1.4)

1. Two graphs are shown below for the motion of two objects.



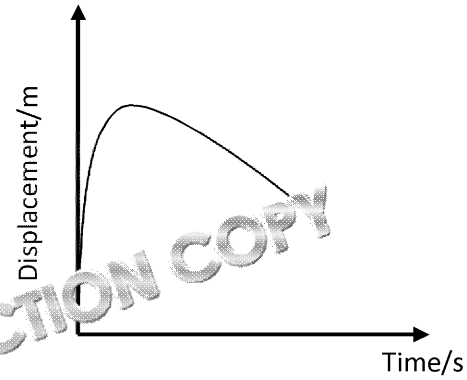
1



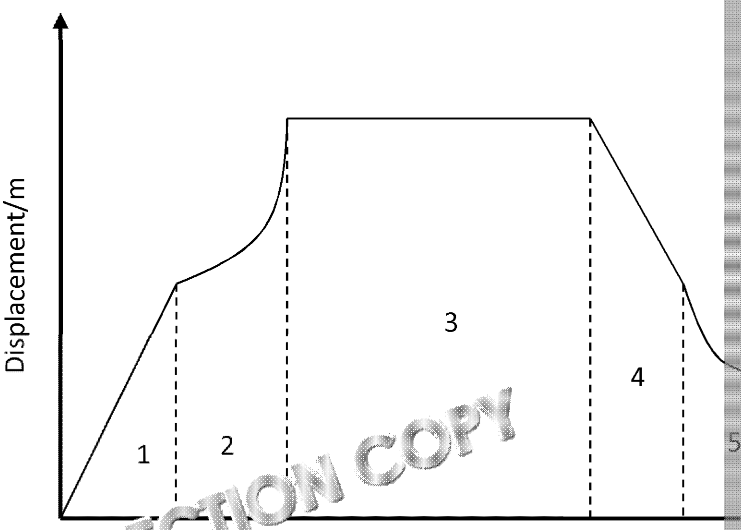
2

a) Describe how the acceleration of the object could be found from graph
b) Describe how the distance covered by the object could be found from g

c) Explain how you could calculate instantaneous velocity from the followi



2. The mo[illegible] a rally car was recorded during its race and the following displa



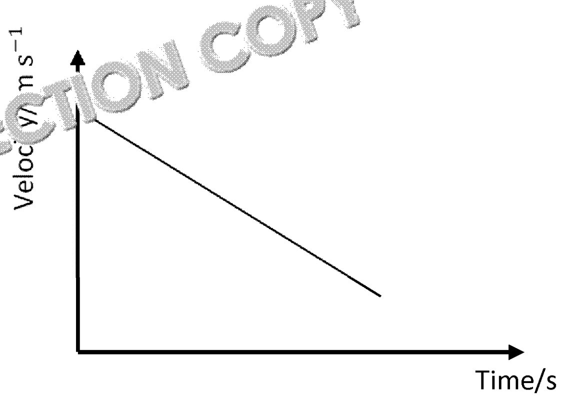
a) De[illegible] t[illegible] motion at:
- [illegible]e 1
- Stage 3
- Stage 4

b) Sketch a velocity–time graph for stage 2 of the car's journey.

3. A runner records his motion during the first section of a marathon.

a) Calculate the runner's displacement during the first 50 minutes of the m
b) Calculate the runner's acceleration during the first 50 minutes of the ma

4. The transport department of the local council has been recording the motion local primary and secondary schools to understand whether safe road practic one vehicle is described in the velocity–time graph.



Explain how the department could use their knowledge of the equation of a s $y = mx + c$, to determine the vehicle's initial velocity and acceleration.

5. A running group is out on a weekly run in their local park. During the final str her shoelaces. Runner 2 approaches Runner 1 at a running velocity of 2 m s^{-} velocity. Runner 1 starts from rest, as Runner 2 passes and accelerates at 1.2

a) Calculate what time the runners will be side by side again.
b) Determine the velocity at which Runner 2 would have needed to be runn for the two runners to be side by side again after 3 seconds.

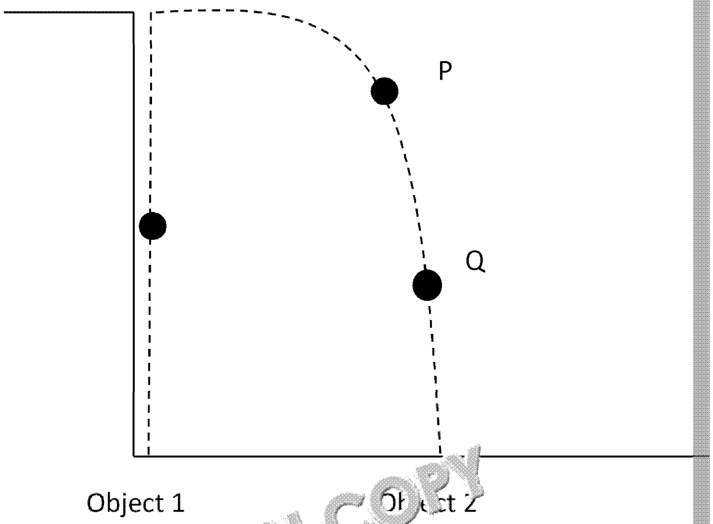
6. A child is playing with a toy rocket in their back garden. The rocket is launche the rocket straight into the air from its launch pad. The rocket is released at negligible.

   a) What will the rocket's velocity be when it reaches its maximum height?

   The garden has a fence around it that stands 2 metres high.

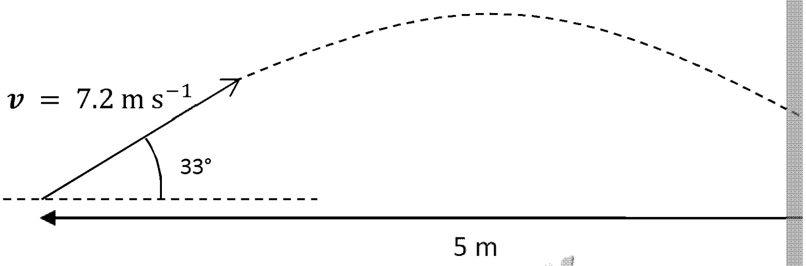
   b) Show by calculation whether the rocket will reach the height of the fenc

7. Two identical objects are dropped from an identical height. Object 1 is dropp thrown horizontally. The diagram indicates the motion of each object. Ignore assume the objects do not reach terminal velocity before hitting the ground.



   a) State which object is displaying projectile motion.
   b) State which velocity component will be affected by acceleration.
   c) Draw the ball's vertical and horizontal velocity components at:
      - P
      - Q

8. Chris hits a golf ball off the edge of a cliff at a velocity of 7.2 m s^{-1} and an a



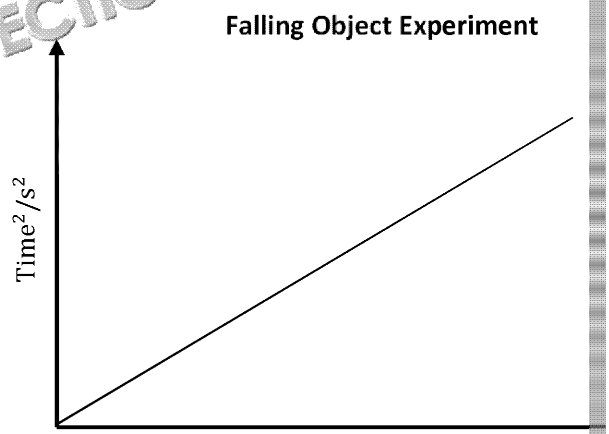
   a) Resolve the velocity vector into its horizontal and vertical components.
   b) Calculate the velocity vector's horizontal and vertical components.
   c) Calculate the height of the golf ball at the point it has travelled a horizo

9. A group of Year 12 physicists carry out an experiment to determine the accel in free fall, g.

The experimental method involves dropping a steel ball from an initial veloci electronic timer is used to measure how long it takes for the steel ball to fall repeats the experimental method once.

The students plot a graph of t^2 against h, similar to the graph below. They us $s = ut + ½gt^2$ to calculate g.

Ignore the effects of air resistance.



a) Explain how you could use the graph to calculate the acceleration due to
Hint: Compare $s = ut + ½gt^2$ to equation for a straight line.

b) Suggest one limitation of the experiment.

10. While on holiday a group of friends decide to take part in a skydive. After a p releases her parachute to reduce the speed she falls to Earth at.

The skydiving company has only catered for skydivers ranging from 50–90 kg. friends [illegible] over 90 kg.

a) Explain what effect this will have on their motion during their skydive.

b) Suggest how the company could compensate for the additional mass of

c) Explain what happens to a skydiver as they approach and reach terminal

d) Sketch a velocity–time graph and acceleration–time graph to illustrate a before the parachute is opened.

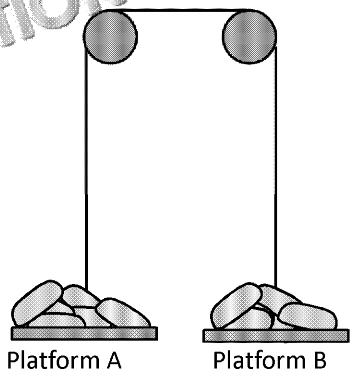
e) Explain how the acceleration–time graph would alter if the effect of air r

Topic Test 9: Momentum and Newton's Laws of Moti

1. State Newton's first and second laws of motion.

2. Explain in terms of Newton's third law of motion how a rocket is able to lift o
launch pad.

3. A pulley system consists of two weighted platforms, each of which carries ba
of a scaffolding.



a) Explain, in terms of Newton's laws, how the weight of the sand on each
platforms are moving at a constant velocity.

A sandbag falls off Platform B.

b) Explain, in terms of Newton's laws, how the forces acting on the platfor
sandbag falls off Platform B, and, therefore, how the platforms' motion

4. A group of friends are playing a game of beach volleyball while on holiday in
hits the ball over the net. The ball is 0.5 kg and travels with an average veloci

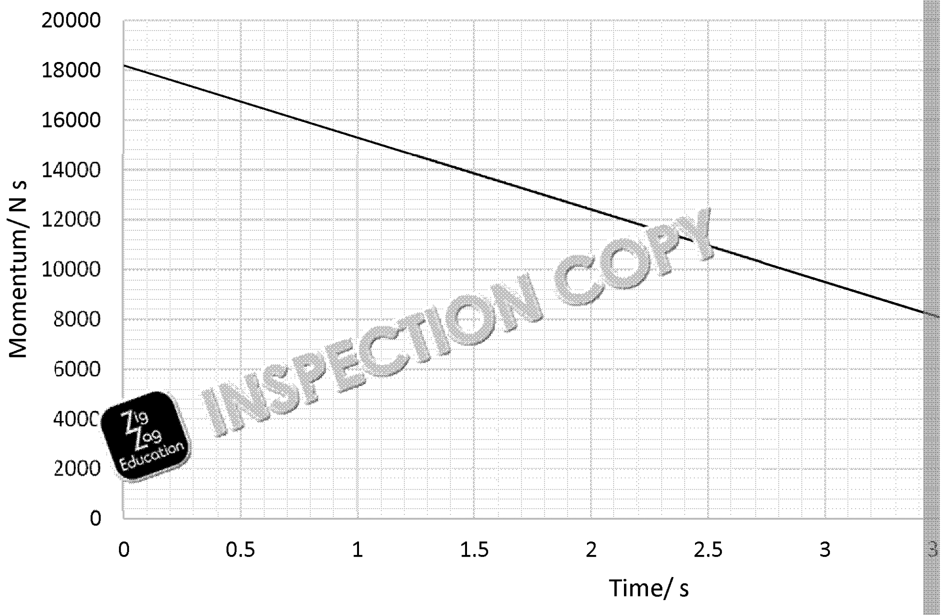
a) Define the term *linear momentum*.

b) Calculate the linear momentum of the volleyball.

5. A family is driving their car weighing 1.5×10^3 kg and travelling at 12.1 ms
a cyclist pulls out in front of the car. The car reduces its speed to $4.4\ \mathrm{ms}^{-1}$ ov

a) Explain what is meant by the equation $F = \frac{\Delta p}{\Delta t}$.

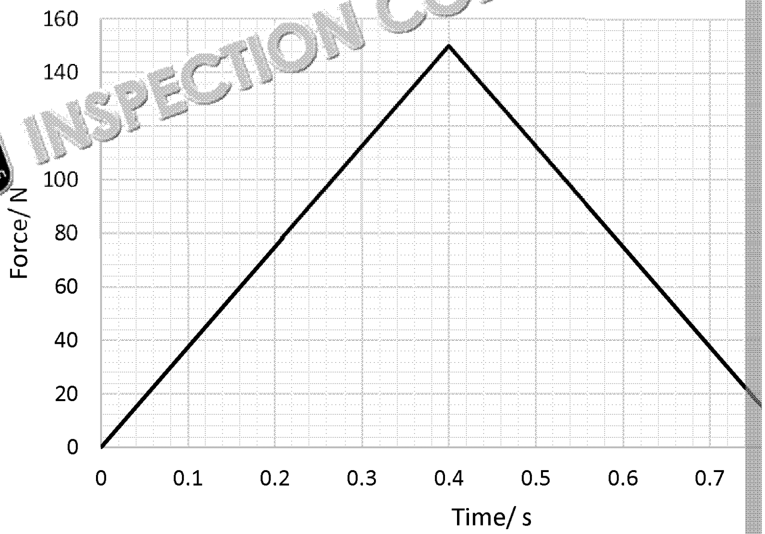
The following graph indicates the car's change in momentum over the 4 seco



b) Calculate the net force of the car.

c) Explain why knowledge of net force and momentum change would be b situations involving car and passenger safety.

6. During a golf tournament, various golf outlet companies recorded and invest during impact to attempt to find ways to improve the design of their clubs. T impact with a golf club was plotted for the first golfer:



a) Define the term *impulse*.

b) Describe how you could use the graph to determine the impulse on the

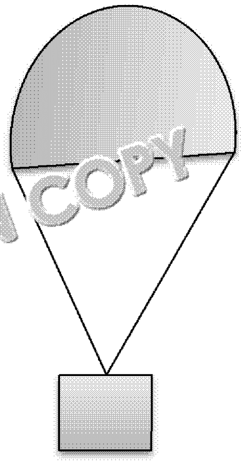
c) Calculate the impulse of the golf ball from the graph.

d) Explain the effect on impulse if the ball was in contact with the golf club the force applied remained the same.

The same measurements were taken for a second golfer. The average force applied to the 0.[illegible] kg golf ball was 120 N and the impact time was recorded

e) Calculate the velocity of the golf ball as it is released from contact with t **Hint:** the golf ball will initially be at rest ($u = 0$) as it sits on the tee befor

7. During a humanitarian crisis a charity released food and water aid from plan

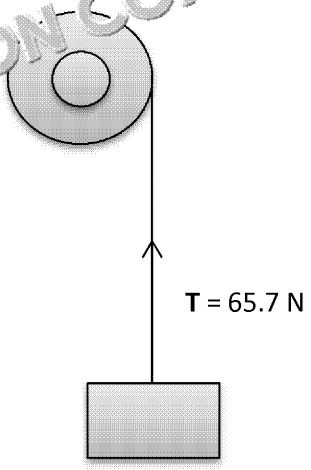


a) Sketch the forces acting on the aid supply box.

The charity found that the packages were accelerating at too fast a rate to t the contents of the packages were getting destroyed on impact.

b) Suggest two factors that could be changed to reduce the rate at which to the ground.

8. In a factory, warehouse packages are moved from the factory floor to the ba simple version of the pulley system is demonstrated below, with a 6.7 kg pa



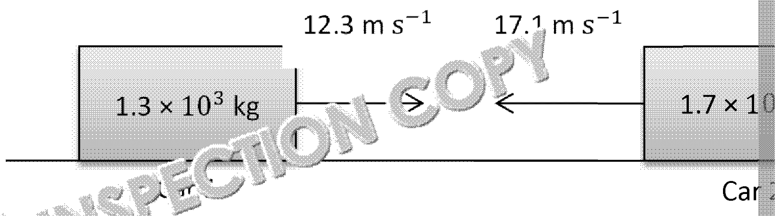
a) Calculate the net force acting on the package.
b) Describe how the motion of the package changes due to the forces acti

A factory staff member alters the tension of the rope and the package accele

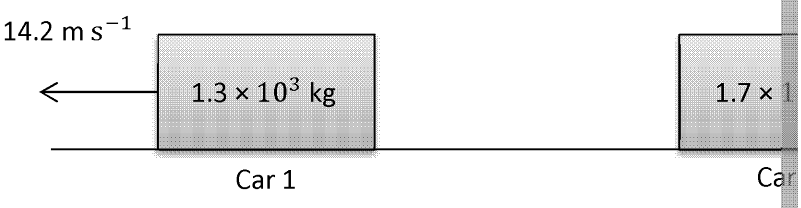
c) Calculate the tension in the rope after the staff have made the alteratio

9. Two cars collide at a large crossroads. The following diagram describes the m
after impact.

Before



After



a) Define the principle of conservation of momentum.
b) Calculate the velocity, indicating magnitude and direction, of Car 2 after
c) Determine whether the collision was perfectly elastic or inelastic. Give r
d) Explain what could be altered in order to reduce the speed of Car 1 after
this would be beneficial.
e) Indicate how society could use knowledge of collisions to minimise the d
d[illegible] collision.

Topic Test 10: Work, Energy, Power and Materials (3.4.1.7/3.4.1.8/3.4.2.1/3.4.2.2)

1. Define the term *work done* by a force.

2. Explain what is meant by the *principle of conservation of energy*.

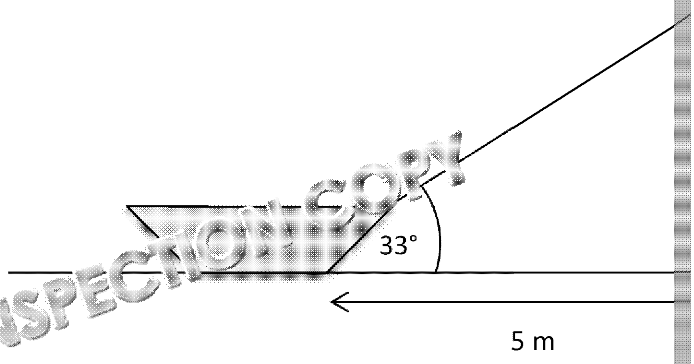
3. Explain the energy transfers occurring in the following situations:

   a) A cyclist starting to cycle their bike.
   b) A car wheel travelling across a tarmac road.
   c) A woman singing into a microphone.

4. In the following situations, indicate whether tensile deformation or compres is occurring:

   a) A dog owner pulling on the lead of their dog
   b) A child jumping on a bed

5. A family are going sledging on New Year's Day. To speed up the walk, the da sledge. He pulls with a force of 50 N along a distance of 5 m.



What is the work done pulling the child along in the sledge?

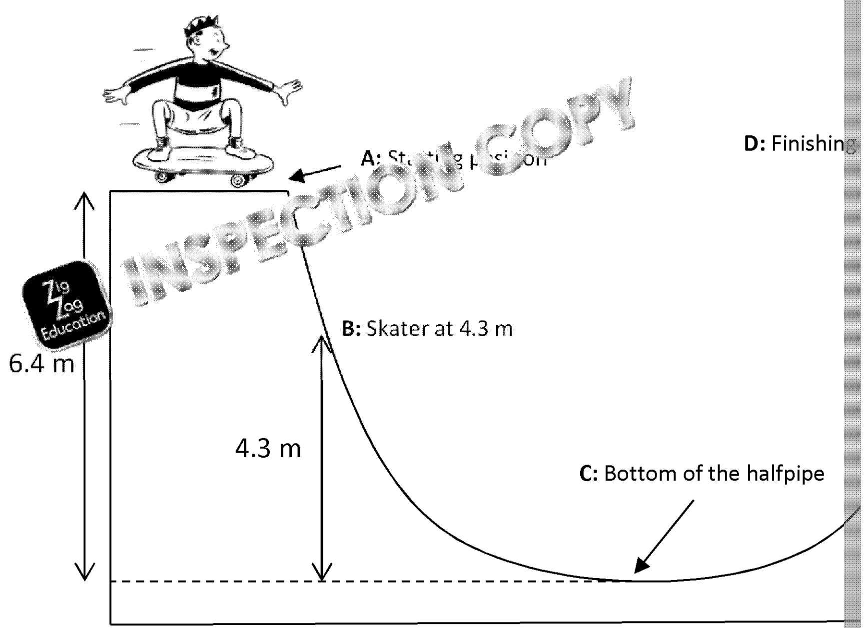
A 210 N m
B 250 N m
C 136 N m
D 120 N m

6. A cylinder has a mass of 0.3 kg, a height of 30 cm and a radius of 2.3 cm.

   Calculate the density of the cylinder.

7. A skateboarder competing in a halfpipe competition completes his final run. and his board together weigh 85 kg.

The following diagram indicates the skateboarder's journey down the halfpip

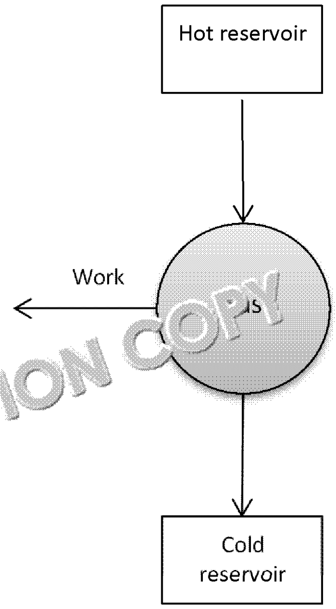


a) Calculate the gravitational potential energy of the skateboarder at the t
b) Calculate the maximum velocity the skateboarder could achieve at B.
c) Explain why the skater will not achieve their maximum possible velocity

8. In Italy, Vespas are a common mode of transport. The engine generates a ma and can reach a maximum speed of 26 [illegible] flat roads.

a) Calculate the power generated by the Vespa's engine.
b) Explain how travelling up a hill affects the maximum speed that a Vespa

9. A heat [illegible] works by providing heat to natural gas. It transfers the gas in tl temperature to a lower temperature. The engine then releases the colder ga completing this cycle, work is generated by the engine.

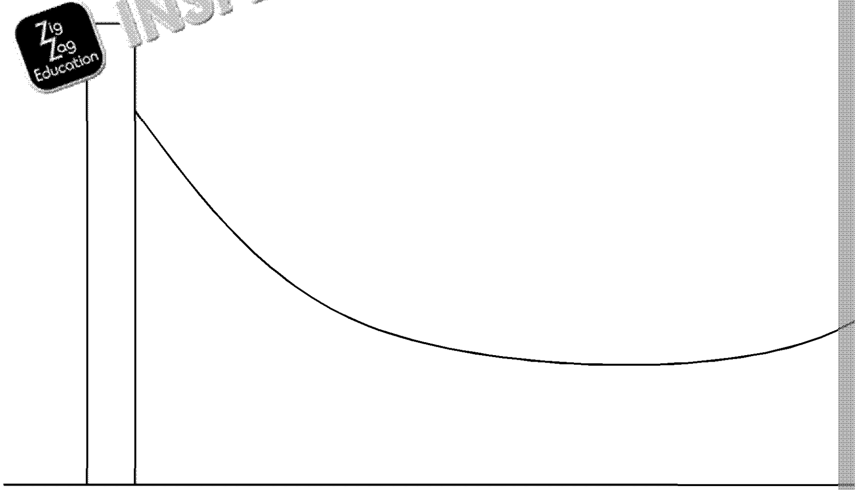


The input energy supplied by the hot reservoir is 400 J and output work done is 2

a) Explain why the output energy is not equal to the input energy.
b) Calculate the power generated by the engine in 20 seconds.
c) Calculate the percentage efficiency of the engine.
d) Explain why it is ethically important for companies using these heat engi high efficiencies.

10. The following force diagram illustrates a slack line tied between trees.

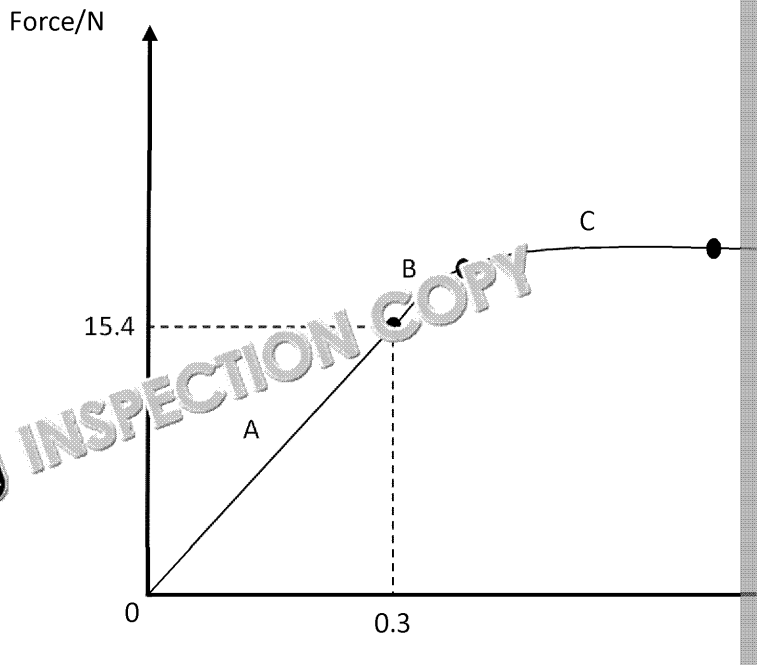
Draw the tensile and compressive forces acting on the slack line and the tree



11. Wire A is said to have a larger force constant (*k*) than B.

a) State what that means about wire A compared to wire B.
b) If you wanted to ensure that both wires experienced the same applied f stretched, what would you have to do differently with wire A compared
c) Calculate the force used to stretch wire A if it was stretched a distance o rest position and has a force constant of 1.2 N m^{-1}.

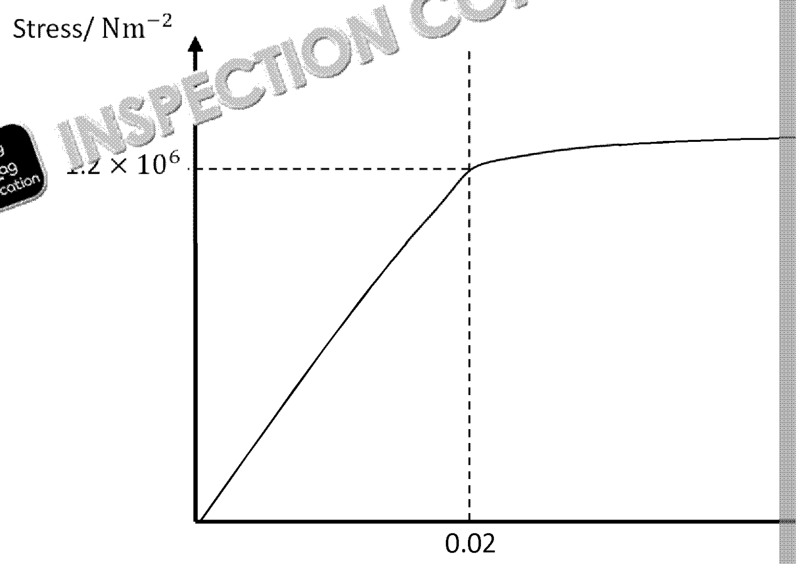
12. An experiment was carried out on different spring characteristics. The results plotted on a graph:



a) Calculate the work done in stretching the spring during stage A.
b) Given that E = ½kx^2, sketch the graph of E plotted against x for stage A.
c) Calculate the elastic potential energy of the string during stage A if the e

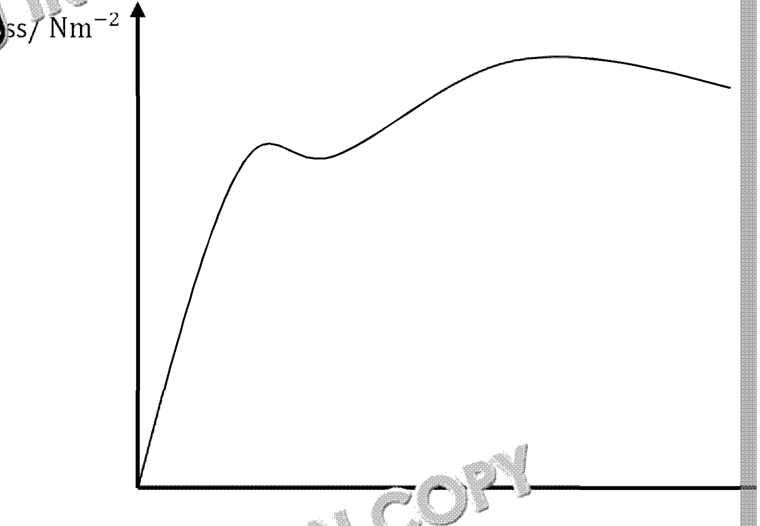
13. A Year 12 Physics class carries out an experiment to investigate the Young m

The students plotted the following graph of their results of the experiment:



a) Indicate the position of the elastic limit on the graph.
b) Calculate the Young modulus for the linear section of the graph.
c) Explain how the Young modulus would alter if you changed the length of

The Year 12 class repeated the experiment again for another material. They p
obtained the graph below:



d) Indicate which regions/points illustrate:
- ultimate tensile stress
- plastic behaviour

Topic Test 11: Electricity and Resistivity (3.5.1.1/

1. Define the term *current*.

2. Define the unit for *charge*.

3. Explain the differences between the charge carriers in the following materia

   Additionally, state how the charge carriers behave when a voltage is applied.
   - Insulator
   - Metallic conductor
   - Semiconductor

4. A simple electric circuit is set up with 3.2 A flowing through one of its light b

   a) Calculate the charge flowing through the bulb.
   b) Determine the number of electrons passing through the bulb.

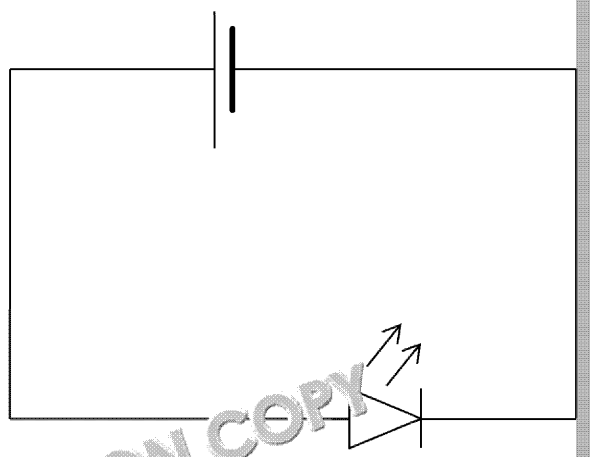
5. A superconductor is a special type of conductor.
   a) Explain the properties of a superconductor.
   b) State two applications of superconductors.

6. During a storm, a car is hit by lightning and current flows through its metal e

   a) State what causes a current in the metal exterior.
   b) State how your answer to a) would be different if the material was an e

7. a) Describe how, in general, charge comes to exist in an object or a partic
   b) State the equation for the net charge on a particle.
   c) Calculate the charge in coulombs of the relative charge +6.7e.
   d) Explain what is meant by the charge of an object or particle being quant

8. The following circuit consists of a cell and a LED. When 0.02 A passes through
   LED for [illegible] seconds, 43 J of work is done.



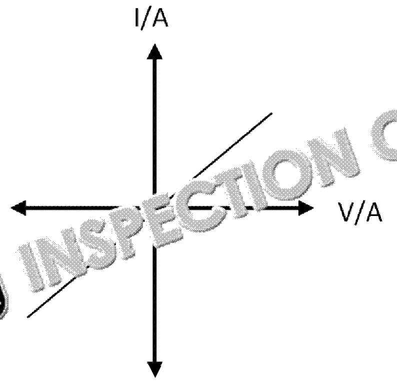
   a) Calculate the potential difference across the LED.
   b) Calculate the resistance of the LED.

9. A university research group are carrying out a range of tests on the resistanc
   components. The group measures how a component's potential difference a
   passing through it.

   a) State Ohm's law.
   b) Sketch a general circuit that the research group could use to observe th
   of different electrical components.

The group plot I–V graphs for each component tested. Plots of two compone

1



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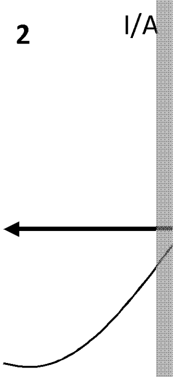


c) Indicate how the research group used the circuit for b) to obtain the gra
d) State and explain which component was measured to produce each gra

The resistance of a NTC thermistor and diode were also measured.

e) Sketch the graph that the students should obtain for the two componen
f) Explain the shape of the I–V curve for the diode.
g) Sketch a graph of the relationship the students would observe between and temperature of the NTC thermistor.

10. A local energy company are updating their machines to improve energy effic their carbon footprint.

Copper wires are used frequently within their machines. A model wire has a area of 3.14 × 10^{-5} m^2 and an average length of 10.5 cm and a resistance o

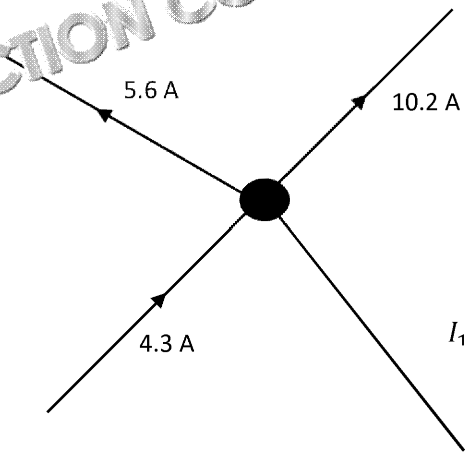
a) Describe an experiment that the energy company could use to investiga of the wires they use.
b) Calculate the resistivity of the model wire.
c) State what would happen to the resistivity of the wire if the temperatu
d) Calculate the potential difference across the wire if the electrical power wire is 130 W.
e) Calculate the energy transfer (work done) in the wire if electricity travel wire for 5 minutes.

Topic Test 12: Circuits and Potential Dividers (3.5

1. State the law of conservation of current at a junction

2. State the purpose of a potential divider.

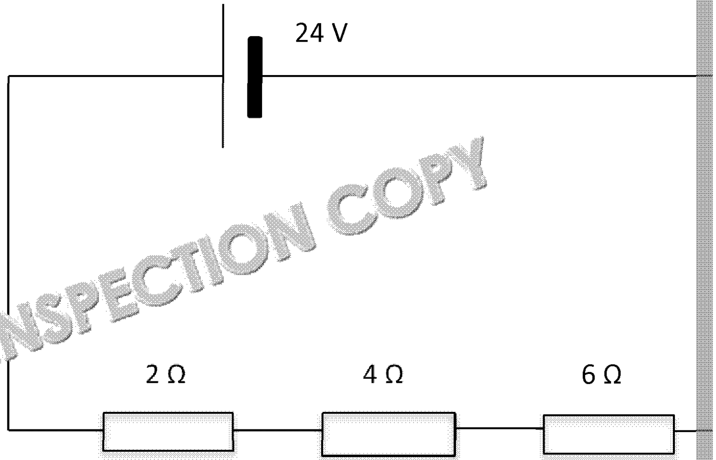
3. Below is a diagram representing the current flowing in and out of a junction



Which of the following rows correctly identifies the magnitude and directio

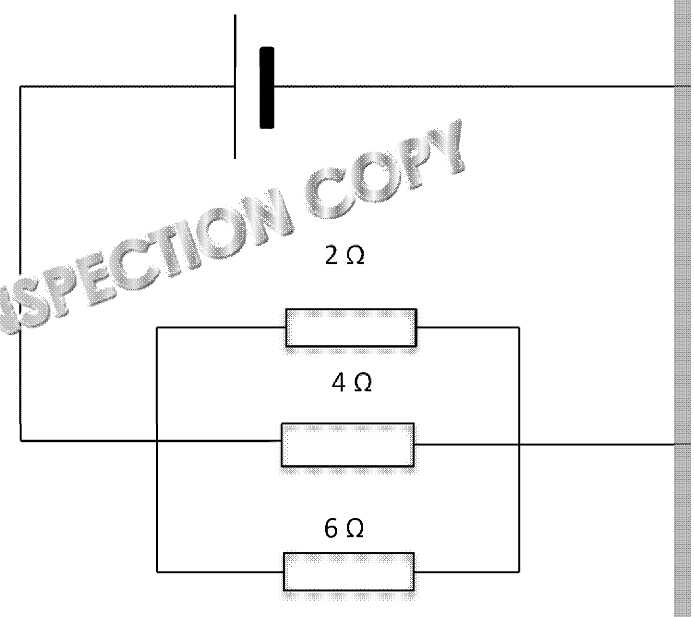
A	15.8	
B	11.5	
C	15.8	
D	11.5	

4. An electrical circuit, with a current of 2 A flowing through it, is set up as follo



a) State the equation for calculating the total resistance (R_T) in a series circ
b) Calculate the total resistance in the circuit.
c) Calculate the potential difference across each resistor.
d) Explain what would happen to the potential difference across each resist

5. An electric circuit is set up as follows:



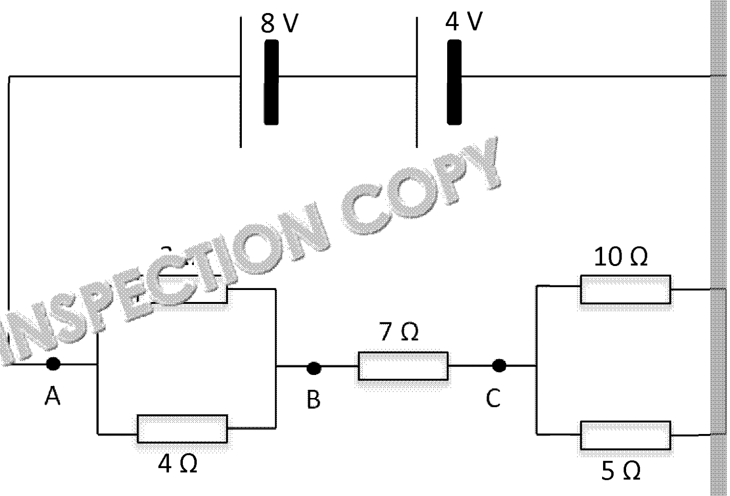
Calculate the total resistance in the circuit.

6. An electronics student was provided with four 10 Ω resistors. The student is circuit, a combination of series or parallel, which has a total resistance of 10

The student has to use at least two resistors.

Draw the circuit required to achieve [illegible]uit.

7. The following circuit has a current of 1.03 A passing through it.



a) Calculate the total resistance of the circuit.
b) State whether the current at D is the same or different to the current at
for your answer.
c) Calculate the potential difference between:

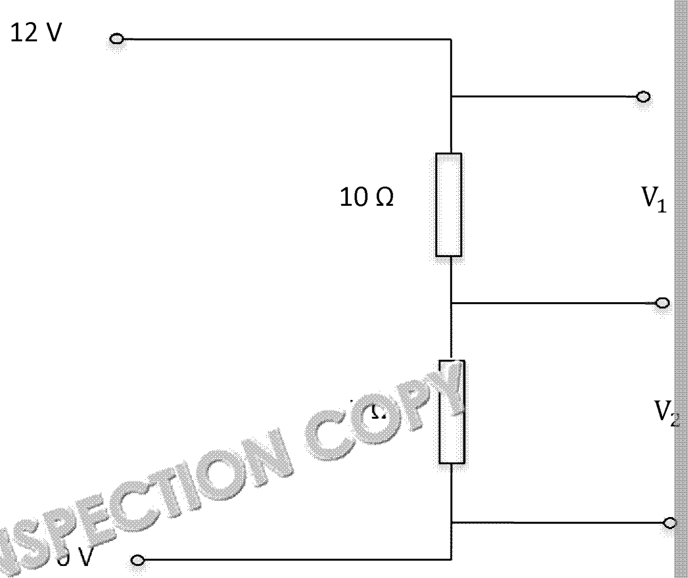
- A and B
- B and C
- C and D

d) If the 7 Ω resistor was switched with a 10 Ω resistor, explain the effect o
between:

- B and C
- A and B

Note that the current and the potential difference across C and D are both ke

8.



a) Calculate the voltage across the 7 Ω resistor.
b) Explain what will happen to V_1 and V_2 if the 10 Ω resistor is swapped wit
c) State how you would alter the components of your circuit if you needed

9. a) Sketch a potential divider circuit with a pd of 24 V and the following co

   - 15 Ω fixed resistor
   - LDR

   b) Calculate V_{out} if the output is connected across the LDR and its resistanc

   c) Explain what would happen to V_{out} if the light intensity incident on the L

10. A refrigeration company are designing a new model for a fridge.

    The key aim of the company is to include an electrical circuit that notifies th has been left open too long and the temperature inside the fridge becomes t

    The circuit uses a thermistor to detect changes in temperature and has a c alarm.

    a) Sketch a circuit that could alert a customer to the rise in temperature b output voltage of the circuit to an alarm.

    b) Explain how your circuit would fulfil the company's aim and explain wha increasing the value of the fixed resistor would have on the outcome.

Topic Test 13: Electromotive Force and Internal R

1. Explain what is meant by the term *internal resistance*.

2. Define *terminal potential difference*.

3. Explain what is meant by the term *lost volts*.

4. Calculate the electrical energy given to the [illegible] C of charge in a source with an e

5. State two forms of the equation for emf in terms of potential difference and

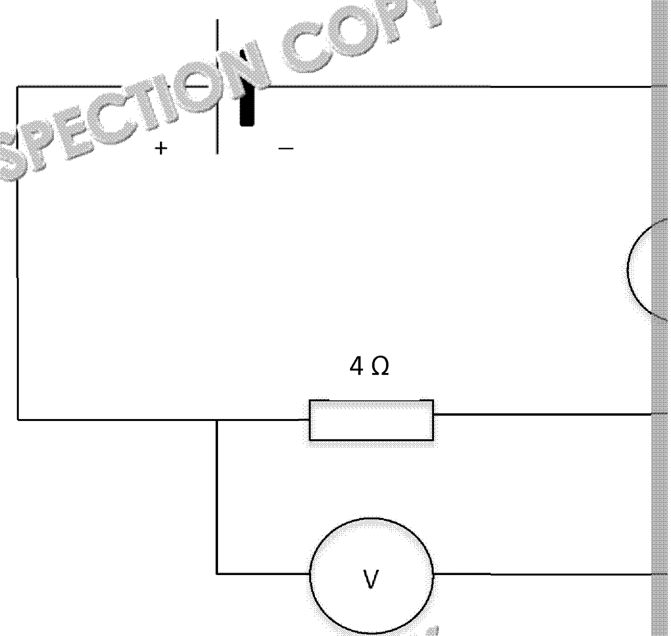
6. The emf of a cell is 24 V. The cell holds an internal resistance of 0.2 Ω.

   A physics student is testing the electrical properties of the cell and sets up th flow through the cell.

   What is the terminal potential difference across the cell?

   A 23.8 V
   B 24.2 V
   C 24 V
   D 18 V

7. A simple circuit is shown below:



   a) Explain what would happen to the readings on the voltmeter and ammet replaced with a resistor of higher resistance.

   The internal resistance of the cell is 0.4 Ω and the emf is 14 V. The reading o ammeter is 0.2 A

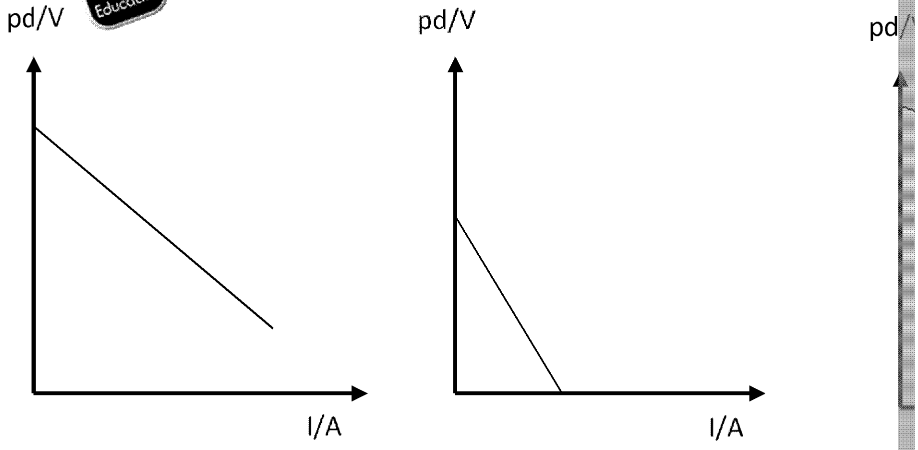
   b) Calculate the reading on the voltmeter.

8. A student is set the task of determining the emf and internal resistance of a b student is provided with the following apparatus:

- Circuit leads
- A battery
- Voltmeter
- Ammeter
- Variable resistor

a) Describe an experimental method that would allow the student to deterr the battery and the internal resistance.

The graphs of three different batteries used in the experiment were plotted:



b) State which batteries have the highest and lowest emfs and internal resis

The student carries out the experiment and obtains the following results:

c) Determine the internal resistance and emf of the battery used in the stuc

Answers

Topic Test 1: Measurements and Their Errors (3.1)

1. $\mathrm{m\,s^{-2}}$ (1)

2. Incorrect:
   C Energy (1)
   should be joules (1)
   D Force (1)
   should be newtons (1)

3. a) 0.[illegible])
   b) 0.[illegible]1)
   c) 0.0[illegible] kg (1)
   d) 700 m (1)

4. ½ for each correct answer.

Base Quantity	
Mass	
Length	
Temperature	
Current	
Quantity of Matter	
Time	

5. a) i) 60–90 kg (1)
   ii) $E = mgh$

$$E = (60 \text{ to } 90) \times 9.81 \times 5.6$$

   E = 3300–4940 J (1)
   Accept any answer for energy that falls between these two values.
   b) i) Gravitational potential energy of the second friend at the end of the divi
   ii) $E = mgh$
   E = (70 to 100) × 9.81 × 5.6
   E = 3845–5493 J (1)
   E = 3.85–5.49 kJ (1)
   Accept any answer that falls between these two values.

6. a) pm; nm; μm; mm (1)
   b) kV; MV; GV; TV (1)
   c) cm; dm (1)

7. Random *error*: refers to a measurement error that causes repeated measurements another and results in a spread of measured values around a true value. (1)
   The error is randomised as a result of sources that cannot be predicted. (1)

8. B (1)

9. Give full marks (1) for identification of any one of the possible answers:
   - Repeating the experiment (1)
   - Taking the mean of measured values (1)
   - Identifying the anomalies (1)

10. D (1)

11. a)
- High accuracy due to each shot hitting the target centre (true value). (1)
- High precision due to all the shots being in extremely close proximity to ea

  OR
- High precision due to the shots recorded having a small spread. (1)

b) If each shot became less accurate then each shot would be recorded further aw value). (1)

c)
- High precision due to shots recorded in close proximity to each other. (1)

  OR

  High precision due to the shots recorded having a small spread. (1)
- Low accuracy due to each of the shots being recorded a significant distanc value). (1)

d) If the shots recorded [illegible] less precise it would result in increase in the sprea distances between each of the shots). (1)

12. a) 0.1

b) percentage uncertainty $= \frac{0.1}{26.4} \times 100 = 0.4\ \%$ (1)

c) The rule for determining the uncertainty in a measurement that is determined measurement is:

If $C = B^n;\ B \pm b$

Then $C = (B)^n \pm (nb)$

Therefore:

$A = \pi r^2$

$A = \pi \times (3)^2 = 28.3\ \text{cm}^2$ (1)

% uncertainty in $\text{A} = 2 \times \%$ uncertainty in r (1)

% uncertainty in $\text{r} = \frac{0.1}{3} \times 100 = 3.3\ \%$

% uncertainty in $\text{A} = (2 \times 3.3) = 6.7\ \%$

Absolute uncertainty in A; $\Delta\text{a} = \frac{6.7}{100} \times 28.3 = \pm$ [illegible] cm² (1)

13. a) Gradient of line of best fit $=$ [illegible] $\frac{[illegible] \times 10^{-3}}{8-0} = 0.23 \times 10^{-3}$ F (1)

b) uncertainty = |gradient of line of best fit − gradient of line of worst fit| (1)

uncertainty $= |$[illegible] $\times 10^{-3} - 0.29 \times 10^{-3}| = 0.06 \times 10^{-3}$ F (1)

c) percentage uncertainty $= \frac{\text{uncertainty}}{\text{gradient of best fit line}} \times 100$ (1)

percentage uncertainty $= \frac{0.06 \times 10^{-3}}{0.23 \times 10^{-3}} \times 100$

percentage uncertainty $= 26.1\ \%$ (1)

d) Ammeter has been calibrated incorrectly (i.e. gives a non-zero reading when th capacitor). (1)

Topic Test 2: Particles, Antiparticles and Particle Interactions (3.2.1.1/3.2.1.

1. a)
   - Made up of a nucleus containing protons and neutrons, with charge $+e$ ar
   - Protons and neutrons have approximately the same mass and are referre
   - Electrons sit outside the nucleus and have charge $-e$ and a significantly s

   b)
   - **Charge**: 1.6×10^{-19} C

     Mass: 1.67×10^{-27} kg (1)
   - **Charge**: 0 (neutral)

     Mass: 1.67×10^{-27} kg (1)
   - **Charge**: -1.6×10^{-19} C

     Mass: 9.11×10^{-31} kg (1)

2. Give full marks (2) for identification of any two of the following possible answers:
   - Gravity
   - Electromagnetic
   - Weak nuclear
   - Strong nuclear

3. $$specific\ charge = \frac{charge\ of\ nucleus}{mass\ of\ nucleus}\ (1)$$

   $$charge\ of\ nucleus = charge\ of\ nucleons$$

   $$charge\ of\ nucleus = charge\ of\ total\ protons\ present\ (since\ charge\ of\ n$$

   $$charge\ of\ nucleus = 2\times1.6\times10^{-16} = 3.2\times10^{-19}\ \mathrm{C}\ (1)$$

   $$mass\ of\ nucleus = mass\ of\ 4\ nucleons$$

   $$mass\ of\ nucleus = 4\times1.67\times10^{-27} = 6.68\times10^{-27}\ \mathrm{kg}\ (1)$$

   $$specific\ charge = \frac{3.2\times10^{-19}}{6.68\times10^{-27}}$$

   $$specific\ charge = 4.79\times10^{7}\ \mathrm{C\ kg^{-1}}\ (1)$$

4. Weak nuclear interaction (1)

5. C (1)

6.
   - antiproton (1)
   - antineutron (1)
   - positron (1)
   - antineutrino (1)

7. The mass of an antiparticle is equal to the rest mass of its corresponding particle. (1)
   The charge of an antiparticle is equal but opposite to the charge of its correspondin

8. a) **X**: W^- (1)

   Y: β^- (or e^-) (1)

   b) Give full marks (1) for identification of any one of the following possible answe
   - They have non-zero rest mass (1)
   - They are negatively charged (1)
   - They have a very short range (maximum range of 0.001 fm) (1)

9. a) $2E_o(=2m_oc^2)$ (1), where E_o is the rest energy of the particle created.

b) energy of photon = sum of rest energy of electron and positron

$$hf_{min}=2E_o$$

$$h\frac{c}{\lambda_{\mathrm{min}}}=2E_o$$

$$\lambda_{\mathrm{min}}=\frac{hc}{2E_o}\,(1)$$

E_o(of electron/positron)$=m_oc^2$ (1)

$E_o=$ [illegible]$1\times10^{-31}\times(3\times10^8)^2$

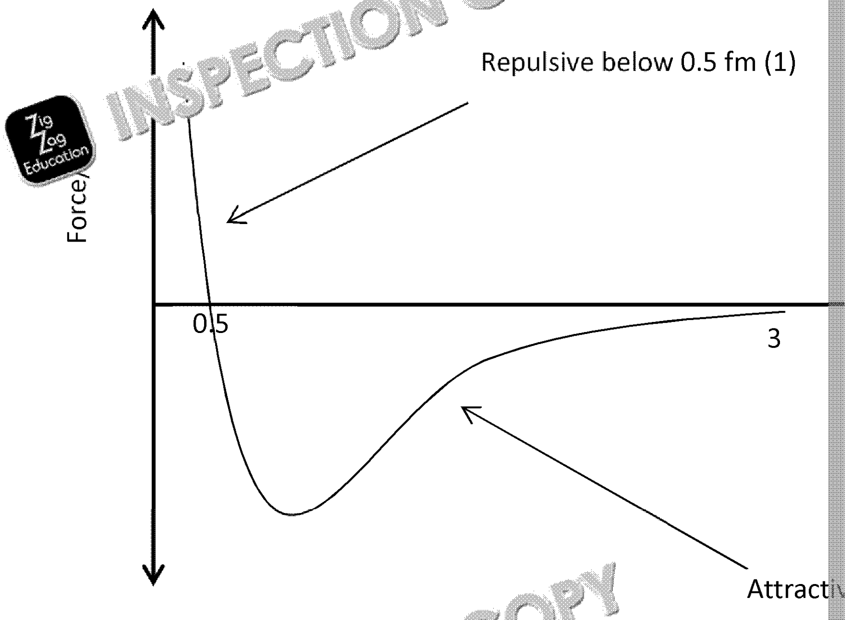
$$E_o=8.2\times10^{-14}\mathrm{J}\ (1)$$

$$\lambda_{\mathrm{min}}=\frac{6.63\times10^{-34}\ \times3\times10^8}{2\times8.2\times10^{-14}}$$

$$\lambda_{\mathrm{min}}=1.2\times10^{-12}\ \mathrm{m}\ (1)$$

10. a) Proton number: Z=1 (1)
Nucleon number: A= 3 (1)
b) N = (A – Z)
N = 2 neutrons. (1)

11. a) There is another force present called the strong nuclear force (1) that acts betw
electrostatic repulsive force and bind the nucleus. (1)
b) (1) for correct curve shape.



12. a) $^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y \rightarrow {}^{4}_{2}He$; Alpha (1)

$^{A}_{Z}X \rightarrow {}_{Z+1}^{A}Y \rightarrow {}_{-1}^{0}e + \overline{v}_e$; β^- (1)

$^{A}_{Z}X \rightarrow {}^{A}_{Z}X + \gamma$; Gamma (1)

b) i) $^{219}_{86}Rn \rightarrow {}^{215}_{84}Po + {}^{4}_{2}He$ (1)

ii) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}_{-1}^{0}e + \overline{v}_e$ (1); β^- particle (electron) (1)

c) To account for energy conservation during beta decay (1)

13. a) During annihilation a particle and its antiparticle meet and destroy each other [illegible] converted into energy of [illegible] particles. (1)

b) The rest mass of a positron is equal to the rest mass of an electron.
Δm [illegible] m_e [illegible] $ass) = 2 \times (9.1 \times 10^{-31}) = 1.82 \times 10^{-30}$ kg (1)
ΔE (energy transformed into 2 photons $= \Delta mc^2$
$\Delta E = (1.82 \times 10^{-30}) \times (3 \times 10^8)^2$
$\Delta E = 1.64 \times 10^{-13}$ J (1)
The energy of one photon will be at least $\frac{1}{2}\Delta E$ ($= 8.2 \times 10^{-14}$ J), which is the
student's prediction is less than this and, therefore, is incorrect. (1)

c) Yes (1), as the electron and positron will have kinetic energy in addition to their
converted into the energy of the photon. (1)

Topic Test 3: Classification of Particles and Interaction Conservation Laws

1. Mesons (1); Baryons (1)

2.
- Strong interaction (1)
- Weak interaction (1)

3. Kaon (K) (1)

4.
- Full marks (1) for any of the following:
    - Weak nuclear interaction
    - Electromagnetic interaction
    - Gravitational interaction
- Full marks (1) for any of the following:
    - Strong nuclear interaction
    - Electromagnetic interaction
    - Gravitational interaction
    - Weak nuclear interaction

5. A (1)

6. a) Hadrons (1) and leptons (1)

b) Hadrons:
(1) each for two of:
- Proton
- Neutron
- Kaon
- Pion

Leptons:
(1) each up to two of:
- Electron
- Neutrino
- [illegible]

c) Hadrons:

- Comprised of quarks and anti-quarks (1)
- Only particles which are subject to strong nuclear interaction (and are su

Leptons:

- Fundamental particles (not comprised of any smaller particles) (1)
- Subject to all interactions except the strong nuclear interaction (1)

7. a) $\mu^- \rightarrow e^- + \overline{v}_e + v_\mu$

   (1) Mark for identifying **X**

   (1) Mark for identifyin

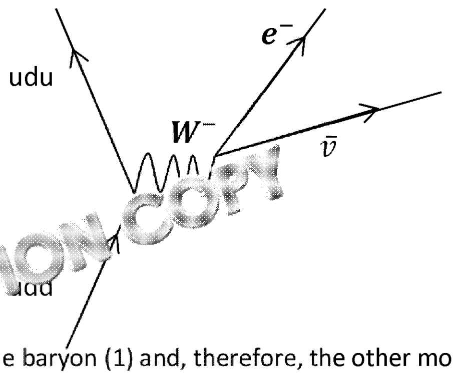
   b) Muon decay (1

8. No (1); umber and baryon number are not conserved before and after deca

9. dds (1)

10. a)
    - uud (1)
    - ddu (1)

    b)
    - (1) mark for neutron and proton in terms of their quark composition
    - (1) mark for force carrier (W^-)
    - (1) mark for identification of e^- and $\overline{v}$

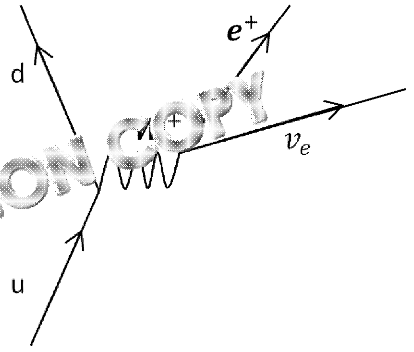


c) roton is the most stable baryon (1) and, therefore, the other more u
ore stable states. (1)

11. a) Strong interaction (1)

    b) Baryon number: 0 + 1 → 0 + 1 (1 before and after) (1)
    Lepton number: 0 + 0 → 0 + 0 (0 before and after) (1)
    Strangeness: 0 + 0 → + 1 – 1 (0 before and after) (1)
    Charge: -1 + 1 → 0 + 0 (0 before and after) (1)

12.
- Correct quark change (1)
- Correct force carrier (1)
- Correct directions (1)



Topic Test 4: Electromagnetic Radiation and Quantum Phenomena (3.2.2)

1. A (1)

2. a) Electron diffraction (1)
   b) Photoelectric effect (1)

3. The work function of a metal refers to the minimum energy required to remove an e
outside its surface. (1)

4. a) $E = hf$ (1)

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

λ [illegible] $\frac{(6.[illegible] \times 10^{-34}) \times (3 \times 10^{8})}{(4.13 \times 10^{-18})} = 4.8 \times 10^{-8}$ m (1)

b) $E(eV) = \frac{E(J)}{e}$

$E = \frac{4.13 \times 10^{-18}}{1.6 \times 10^{-19}}$ (1)

$E = 25.8$ eV (1)

5.
- Photons are directed towards the surface of a metal, and one photon will relea
frequency above the threshold frequency. (1)
- Electrons are emitted when the photon has a frequency above the threshold fr
electron with sufficient energy to overcome the work function of the metal and

6.
- The work function of copper will need to be obtaine[illegible]h certified list of meta
- The frequency of the light incident on the m[illegible]ace will need to be meas
- Use the equation $E_k = hf - \phi$ t[illegible] value for maximum kinetic energy. (1

7. $V = m\frac{1}{[illegible]}$

Gradie[illegible] $= V\lambda$ (1)

$m = \left(\frac{E}{e}\right)\lambda$

$m = \frac{hf\lambda}{e}$

$m = \frac{hc}{e}$ (1)

$m = \frac{270}{217 \times 10^{6}} = 1.24 \times 10^{-6}$ (1)

$h = \frac{me}{c} = \frac{(1.24 \times 10^{-6}) \times (1.6 \times 10^{-19})}{(3 \times 10^{8})}$

$h = 6.61 \times 10^{-34}$ J s (1)

8. a) Emitted (1)

b) $E_{photon} = E_2 - E_1$

$hf = E_2 - E_1$ (1)

$hf = 10.2\,eV$ (1)

$hf = 10.2 \times 1.6 \times 10^{-19}$

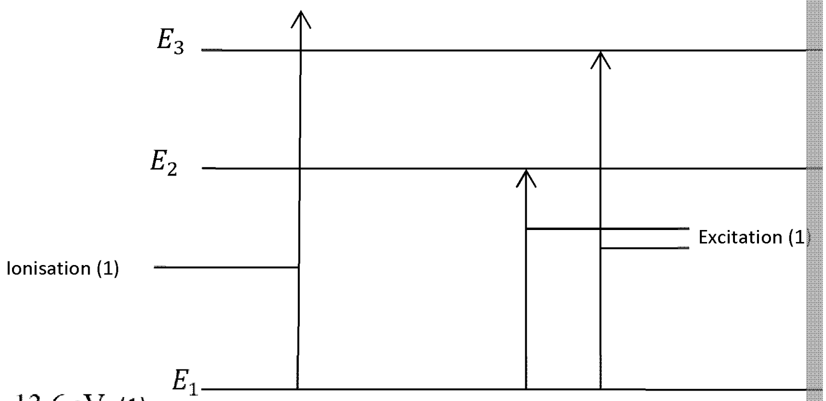
$hf = 1.63 \times 10^{-18}\,\text{J}$

$f = \frac{1.63 \times 10^{-18}}{6.63 \times 10^{-34}}$ (1)

f [illegible]6×10[illegible] Hz

$f = 2.5 \times 10^{15}$ (1)

c)



d) $E > 13.6\,\text{eV}$ (1)

9. a) $f_o = \frac{\phi}{h}$

$f_o = \frac{(1.6 \times 10^{-19} \times \text{[illegible]})}{(6.63 \times 10^{-34})}$ (1)

$f_o =$ [illegible]3×10^{15} Hz (1)

b) $KE_{\max} = hf - \phi$ (1)

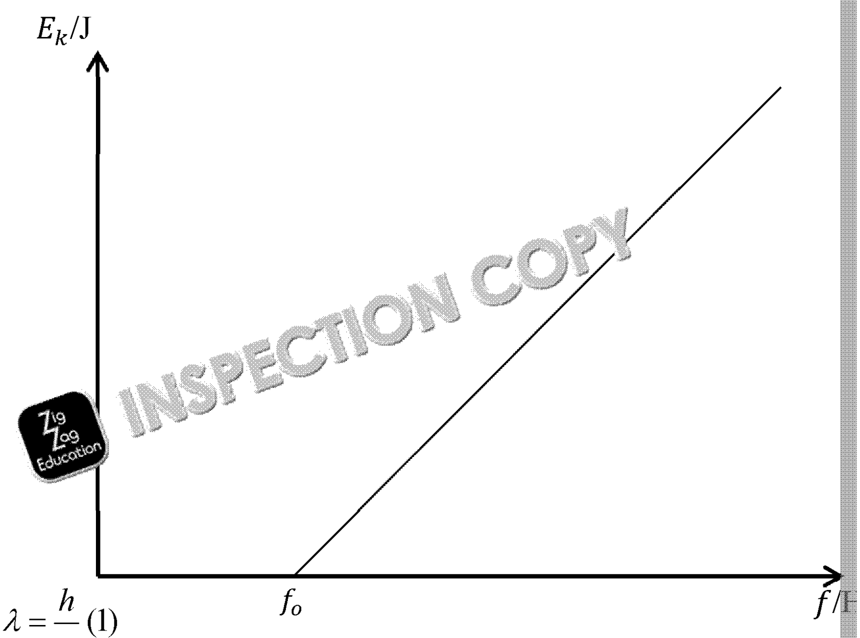
$\frac{1}{2} m v_{\max}{}^2 = hf - \phi$

$v_{\max} = \sqrt{\frac{2(hf - \phi)}{m}}$ (1)

$v_{\max} = \sqrt{\frac{2((6.63 \times 10^{-34} \times 8.1 \times 10^{15}) - (4.26 \times 1.6 \times 10^{-19}))}{(9.11 \times 10^{-31})}}$

$v_{\max} = 3.2 \times 10^{6}\ \text{ms}^{-1}$ (1)

c)



10. a) $\lambda = \frac{h}{p}$ (1)

$$\lambda = \frac{h}{mv}$$

$$\lambda = \frac{6.63\times10^{-34}}{(9.1\times10^{-31}\times1.5\times10^{5})} \text{ (1)}$$

$$\lambda = 4.85\times10^{-9} \text{ m (1)}$$

b)
- If the potential difference V increases then the *KE* of the electron increas
- If *KE* increases then the velocity v of the electron must increase (since *K*

  m is constant), and therefore the wavelength of the electron must dec

c) The diameter of the diffraction rings will decrease (1) as smaller wavelengths di
(1)

d) $eV = E_{\text{max}}$

$$V = \frac{E_{\text{max}}}{e} \text{ (1)}$$

$$V = \frac{(6.2\times10^{-18})}{(1.6\times10^{-19})} \text{ (1)}$$

$$V = 38.75 \text{ V}$$

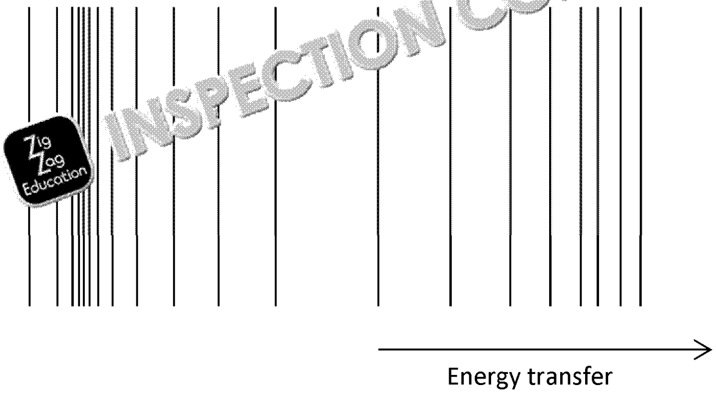
$$V = 38.8 \text{ V (1)}$$

Topic Test 5: Progressive and Stationary Waves (3.3.1)

1. A wave that travels from one point to another through matter or a vacuum and tran points but not matter. (1)

2. A (1)

3. 1 mark for correct sketch of wave.
   1 mark for correct energy transfer label.



4. Give full marks (2) for identification of any two of the following possible answers:
   - They all travel at the speed of light. (1)
   - They are all transverse waves. (1)
   - They all transfer energy. (1)
   - They can all be reflected, diffracted and refracted. (1)
   - They can all be polarised. (1)
   - They comprise electric and magnetic waves oscillating perpendicular to each ot

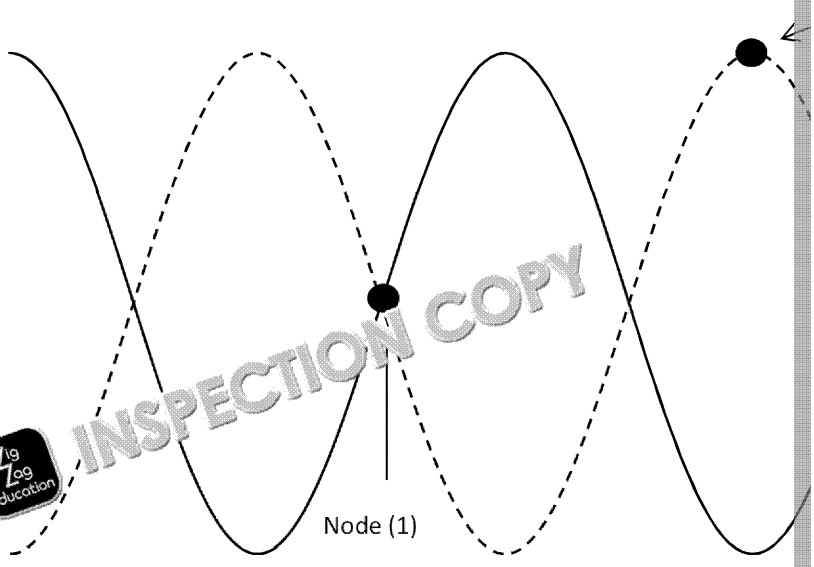
5. Plane polarisation refers to a wave only oscillating in one direction (one plane). (1)

6. Give full marks (1) for identification of one of the following possible answers:
   - Communications: decrease the amount of interference between different c different transmitters will transmit waves in different planes, e.g. radio, TV
   - Liquid crystal screens on watch faces to reduce glare
   - The lens of sunglasses to reduce the amount of sunlight reaching the eyes

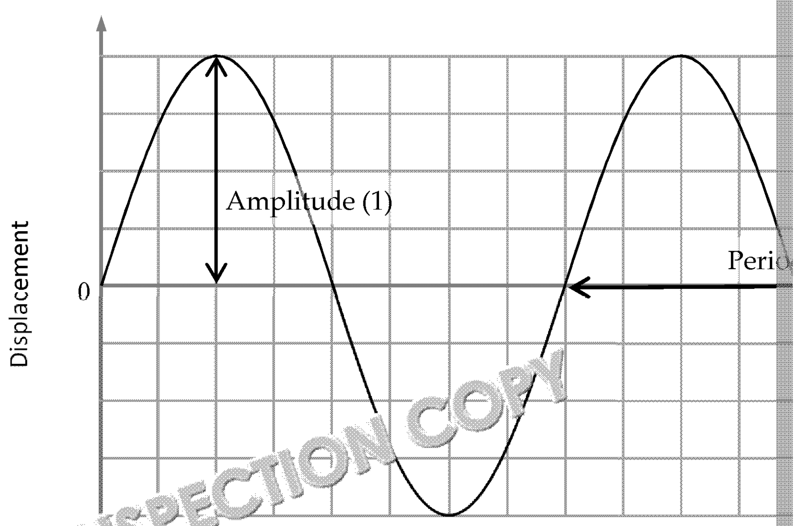
7. - Set up a microwave transmitter that transmits unpolarised microwaves and, d set up a microwave receiver, connected to an oscilloscope, to detect wave sign
   - Place a metal grille in between the transmitter and receiver, and the grille will allow microwaves to oscillate through in one direction. (1)
   - To completely prevent the transmission of microwaves a second metal grille w degree angle with respect to the first grille. (1)

8. a) A stationary wave is formed from the two waves, travelling in opposite directio first. (1) Since the waves then travel at the same frequency, at particular points interfere destructively, creating zero amplitude (node), and at particular points constructively, creating maximum amplitude (antinode), so that the wave app

b)



9. a)



b)
- Displacement is the distance the wave particle is displaced from its equilib
- Amplitude is the maximum distance the wave particle is displaced from its
- Wavelength is the length of one full wave (the distance between two cons troughs). (1)

c) The phase difference between two waves refers to the difference between two of the waves' cycles. (1)

d) ½ of a wave cycle (1)

e) 3.14 or π (1)

10. a) $T =$ the time it takes to complete one full wave = 5 seconds. (1)

b)
$$f = \frac{1}{T}$$
$$f = \frac{1}{5}$$
$$f = 0.2 \text{ Hz } (1)$$

c)
$$v = f\lambda \ (1)$$
$$v = 0.2 \times 7$$
v [illegible] m [illegible]

11. a) Oscillations which do not line up with the filter are removed (1) so only one mo
remains (1).

b) The unpolarised light incident on the watch is plane polarised by the filter (1) th
the watch face is reduced (1).

12. a) (1) mark for correct sketch

b) (1) mark for correct sketch

c)

$$\lambda_1 = 2 \times \left(690 \times 10^{-3}\right)$$

$$\lambda_1 = 1.38\text{ m (1)}$$

$$f_1 = \frac{v}{\lambda_1}\text{ (1)}$$

$$f_1 = \frac{300}{1.38}$$

$$f_1 = 217.4\text{ Hz (1)}$$

d)

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}\text{ (1)}$$

$$T = \left(2Lf\right)^2 \times \mu\text{ (1)}$$

$$T = (2 \times (690 \times 10^{-3}) \times 217.4)^2 \times 1.7 \times 10^{-3}$$

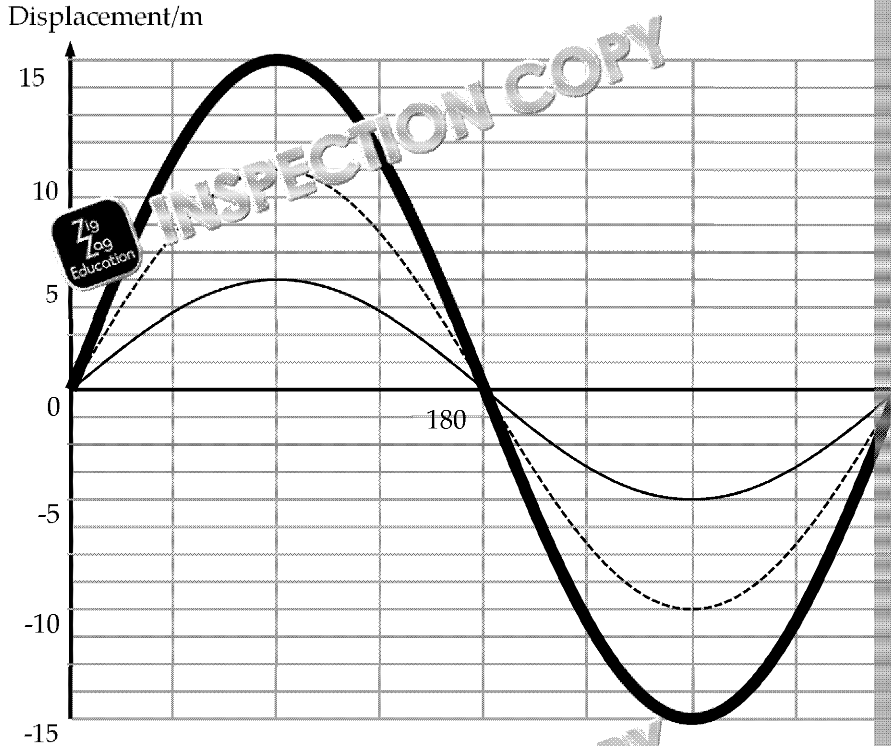
$$T = 153\text{ N (1)}$$

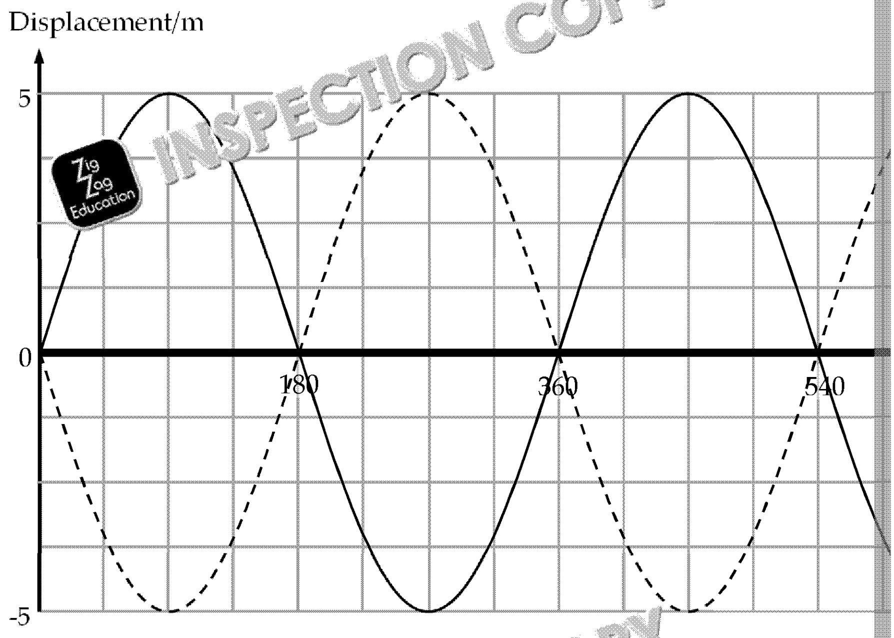
e) The frequency of vibration would increase. (1)

Topic Test 6: Refraction, Diffraction and Interference (3.3.2)

1. Since displacement is a vector, at a particular point the two waves combining to ma displaced in the opposite direction and, therefore, their sum could be less than thei

2. (1) mark for correct sketch of each resultant wave. The thickest black curve represen





3. Two waves, emitted from two different sources, which have constant phase differen

4. a) The activity/amount of microwave radiation detected will be greater as when t the resultant wave has increased amplitude (1), and since intensity is dire squared, the radiation intensity detected will be greater. (1)
   b) Destructive interference occurs when two waves are in anti-phase. (1)
   c) If two waves, with the same amplitude, destructively interfered then the result person will detect almost no microwave radiation (apart from background rad

5. a)
- Light enters one end of the fibre-optic core and approaches the boundar greater angle than the critical angle of this boundary. (1)
- The cladding material is also of lower refractive index and, therefore, tot core–cladding boundary when the light reaches it. (1)
- This process is continually repeated down the length of the fibre with the at the other end. (1)

b) To prevent modal dispersion. (1)

c) Material dispersion / Pulse broadening would occur from light of different optical fibre at different speeds. (1)

6. a)
- Engineers could connect the two loudspeakers to an audio signal generat sound waves. The sound waves that travel out will overlap and cause an
- Engineers [illegible] detect where the maxima and minima occur in the audien [illegible] where there are areas of louder and quieter sound. (1)

b) Antiphase. (1)

c) The sound will be softer at point Z (1), as point Z is a minimum and therefore d occurred whereas point Y is a maximum and constructive interference will hav

d) As Z has a path difference of $\frac{3}{2}\lambda$ and one full wavelength, $\lambda = 2\pi$, the phase difference between waves at Z is 3π. (1)

7. a) $d\sin\theta = n\lambda$ (1)

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

$$\lambda = \frac{(2.5\times10^{-6})\times\sin 42}{2} \text{ (1)}$$

$$\lambda = 8.4\times10^{-7}\text{ m (1)}$$

b) The angle of diffraction between the bright fringe and the central maximum w

8. a)
- The experiment uses a monochromatic light source that therefore emits l and uses a single slit to initially diffract the light. (1)
- By diffracting the light, it can reach a double split, and does so in phase a [illegible] to the nature of the original monochromatic source used. (1)
- The double slit then acts as a source of coherent waves, the waves diffract from creating an interference pattern. (1)
- The light diffracting from the double slit is projected onto a screen that di indicating the maximum and minimum interference pattern. (1)

b) The condition will be the same for both techniques. (1)

c) The spacing between the slits (s) for a diffraction grating is significantly smalle therefore the separation between fringes (W) will be greater for the diffractio

d) $D = \frac{sW}{\lambda}$ (1)

$D = \frac{(0.75\times10^{-3})\times(1.1\times10^{-3})}{(540\times10^{-9})} = 1.53\text{ m}$ (1)

9. a) Light refracts when travelling from one medium to another as the light change therefore its path direction will alter. (1)

b) $n = \frac{c}{v}$ (1)

$$n = \frac{3\times10^{8}}{2\times10^{8}}$$

$$n = 1.5\text{ (1)}$$

c) Th[illegible] speed in the material it has travelled into will be the same as the spe con[illegible]m. (1)

d) $n_{\text{air}}\sin\theta_{\text{air}} = n_{\text{glass}}\sin\theta_{\text{glass}}$ (1)

$\sin\theta_{\text{glass}} = \frac{1\times\sin33°}{1.5}$

$\sin\theta_{\text{glass}} = 0.36$ (1)

$\theta_{\text{glass}} = 21.3°$ (1)

10. a) Critical angle refers to the angle of incidence which, if exceeded, causes total i

b) $\sin C = \frac{n_2}{n_1}$ (where $n_2 > n_1$) (1)

$\sin C = \frac{1}{1.33}$

$C = 48.8°$ (1)

c) Since the angle that the light reaches the boundary is greater than the critical a the light is travelling from a medium with greater refractive index (water) than total internal reflection will occur and the fisherman will not see the lights. (1)

d) The light will still be travelling at a greater angle than the critical angle, but now medium with a lower refractive index than the one it is travelling into (wat reflection won't occur in this situation. (1)

e) $\sin C = \frac{n_2}{n_1}$ (1)

$C = \sin^{-1}\frac{n_2}{n_1}$ (1)

$C = \sin^{-1}\frac{1.21}{1.33}$

$C = 65.5°$, which is greater than the angle of incidence, 57°, so total internal re

f) $n_1 sin\theta_1 = n_2 sin\theta_2$ (1)

$\theta_2 = \sin^{-1}\left(\frac{n_1}{n_2} sin\theta_1\right)$ (1)

$\theta_2 = \sin^{-1}\left(\frac{1.33}{1,21} sin57\right)$

$\theta_2 = 67.2°$ (1)

Topic Test 7: Scalars, Vectors and Moments (3.4.1.1)

1. C (1)

2. a) Vector (1)
   b) Vector (1)
   c) Vector (1)
   d) Scalar (1)
   e) Scalar (1)

3. A direction (1); since tension (force) is a vector quantity and therefore is defined by b

4. a) 6.3 ms^{-1} + 3 m[illegible] ms^{-1} (1), due east. (1)
   b) 6.[illegible] = 3.3 ms^{-1} (1), due east. (1)

5. moment [illegible] force × perpendicular distance from the pivot (1)

6. A pair of forces that are opposite in direction but equal in magnitude that cause a ro

7. At its centre. (1)

8. a) Moment = force × perpendicular distance from the pivot
   Sum of anticlockwise moments:
   - (5.4 × 3) + (6.4 × 10) = 80.2 N m (1)

   Sum of clockwise moments:
   - (7.2 × 5) = 36 N m (1)
     Total net moment = clockwise – anticlockwise.
     Total net moment = 36 – 80.2 = -44.2 N m; in the anticlockwise direction. (

9. a)
$$W_h = W \sin\theta$$
$$W = \frac{W_h}{\sin\theta}\ (1)$$
$$W = \frac{6590.5}{[illegible]}$$
$$W\ [illegible] \times 10^4\ \text{N}\ (1)$$
   b) When an object is in equilibrium the net force acting on the body in the vertica zero.
$$W_h = F_f$$
$$F_f = 6590.5\ \text{N}\ (1)$$

10. a)
   - The net force acting on the body must be zero. (1)
   - The sum of the anticlockwise moments about a point must be equal to th about the same point. (1)

   b) Sum of anticlockwise moments about X: 2.3 × 12 = 27.6 Nm (1)
   Sum of clockwise moments about X: *d* × 10 = 10*d* Nm (1)
   For equilibrium:
   Sum of anticlockwise moments = sum of clockwise moments
   27.6 = 10*d*
   d = $\frac{27.6}{10} = 2.76$ m (1)

   c) For equilibrium net fo[illegible] zer[illegible]
   X = 12 + 10 = 2[illegible]

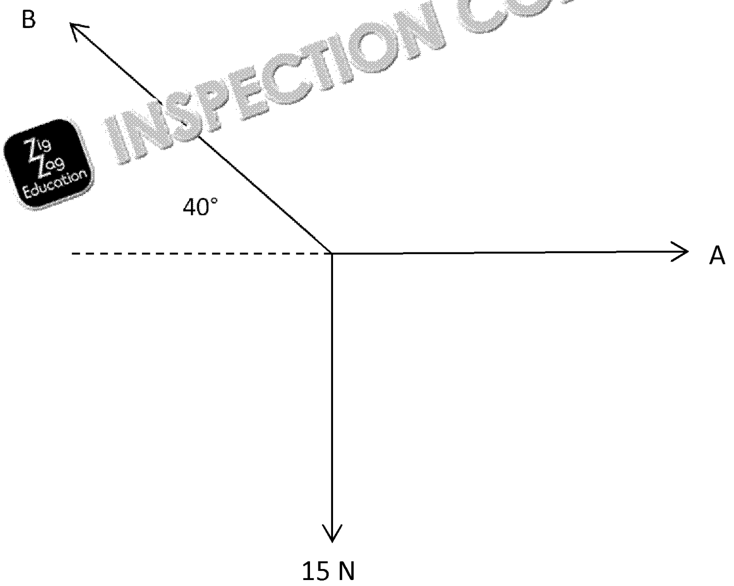
d) There will be increased force due to weight of the performer. To ensure equili

- The force on the right-hand side could be increased to ensure the net forc moments are equal. (1)

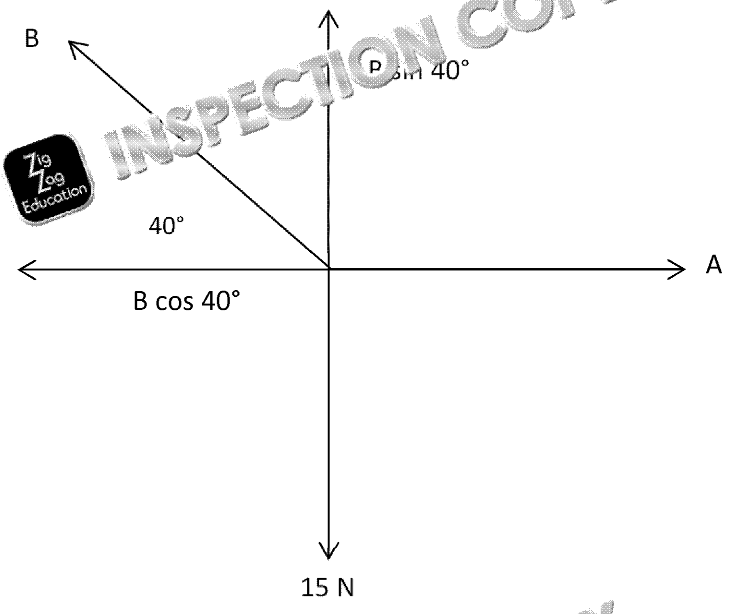
OR

- The distances between the pivot triangles could be altered so that the su The contribution of the X force would need to increase to ensure the net f

11. a) 1 mark for each correct force vector in diagram.

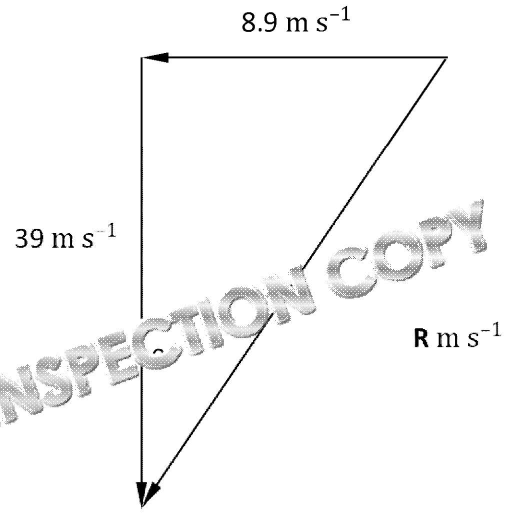


b) Since the tugboat is in equilibrium the net force must be zero, and therefore th direction must be zero and the sum of the forces in the vertical direction must



- Resolving the force vector B (1)
- Vertical components:
  $15 = B \sin 40°$
  $B = \frac{15}{\sin 40°} = 23.$[illegible]
- Horizontal components:
  $A = B \cos 40°$
  $A = 23.3 \cos 40° = 17.9$ N (1)
- Note: the question can also be answered by drawing accurate scale drawi

12. a)



- Correct order of vector addition (1)
- Correct choice of angle (1)
- Correct direction of resultant vector (1)

b) Magnitude: **R** = $\sqrt{(39^2) + (8.9^2)} \;=\; 40 \text{ m s}^{-1}$ (1)
Direction: $\tan\theta \;=\; \frac{8.9}{39};\ \theta \;=\; \tan^{-1}(0.23) = 13^\circ$ (1)

c) $a_h = a\cos\theta$ (1)

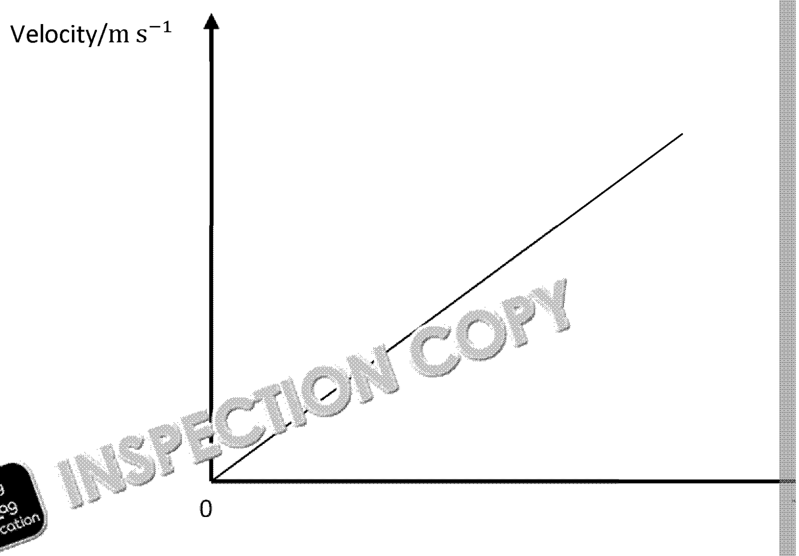
d) $a_h = 9.81 \times \cos 70$ (1)
$a_h = 3.36 \text{ m s}^{-2}$ (1)

Topic Test 8: Projectile Motion and Motion along a Straight Line (3.4.1.3)

1. a) Acceleration can be determined by the gradient of a velocity–time graph. (1)
b) Distance can be determined by the area under a speed–time graph. (1)
c) Instantaneous velocity can be determined by the gradient of a displacement–ti

2. a)
- Stage one: The car is moving with constant velocity. (1)
- Stage three: The car is moving with zero velocity or the car is stationary (1
- Stage four: The car is moving with constant velocity. (1)

b)
- Correct identification of a linear (straight-line) relationship (1)
- Correct axis labels (1)



3. a) Displacement = area under the velocity–time graph:
Displacement $=$ Area of rectangle $+$ Area of right-angled triangle
Displacement $= (l \times w) + (½(b \times h))$ (1)
Length of rectangle $(l) = 50$
Width of rectangle $(w) = 50$
Height of triangle (h) = 130
Base of triangle $(b) = 50$

$$\text{Displacement} = (50 \times 50) + (0.5 \times 130 \times 50)$$

Displacement $= 5750$ m (1)

b) Acceleration = gradient of velocity–time graph
Acceleration $= \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$ (1)
Acceleration $= \frac{130}{50}$
Acceleration = 2.6 m min^{-2} (1)
Acceleration $= \frac{2.6}{60 \times 60}$
Acceleration $= 7.2 \times 10^{-4}$ m s^{-2} (1)

4. Full marks given for:
- Correct identification that the graph can be defined by $v = u + at$ and a comp
at and $y = mx + c$ (1)
- Demonstrates that $a = m$ and therefore a can be evaluated by finding the grad
- Demonstrates that $c = u$ and therefore u can be evaluated by determining the

5. a) The runners will be side by side again when their displacements are equal to ea
$s_1 = s_2$
$u_1 t + ½a_1 t^2 = u_2 t + ½a_2 t^2$ (1)
$u_1 = 0$ m s^{-1} since Runner 1 is starting from rest; $a_1 = 1.2$ m s^{-2}
$u_2 = 2$ m s^{-1}; $a_2 = 0$ m s^{-2} since Runner 2 is running with a constant velocity
$0 + \frac{1}{2} \times 1.2 \times t^2 = 2t + 0$ (1)
$t = \frac{2}{½ \times 1.2} = 3.33$ s (1)

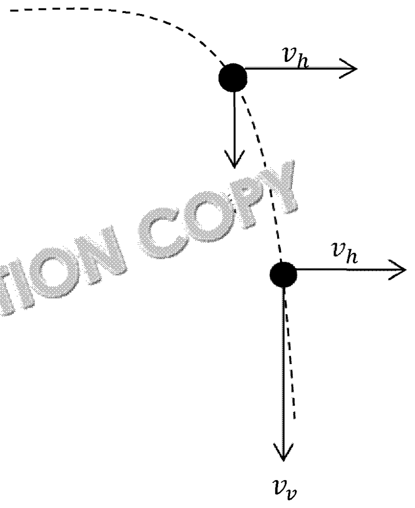
b) $u_1 t + ½a_1 t^2 = u_2 t + ½a_2 t^2$
$u_1 = 0$ m s^{-1}; $a_1 = 1.2$ m s^{-2}; u_2= ?; a_2 = 0; t = 3 s (1)
$½ \times (1.2) \times (3)^2 = u_2 \times 3$
$u_2 = \frac{½ \times 1.2 \times (3)^2}{3} = 1.8$ m s^{-1} (1)

6. a) 0 m s^{-1} (1)

b) $v^2 = u^2 + 2as$
$s = \frac{v^2 - u^2}{2a}$
$s = \frac{0 - 25}{2 \times (-9.81)} = 1.27$ m (1)
Therefore, since the toy rocket can only reach a maximum height of 1.27 m it w
fence. (1)

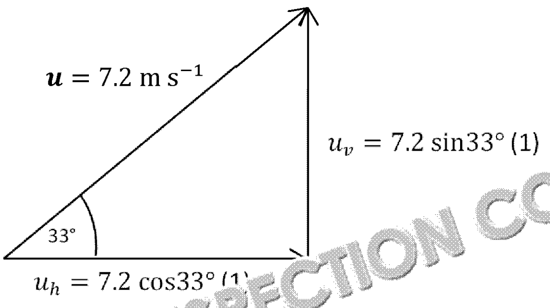
7. a) Object 2 (1)

b) Vertical component will be affected by the acceleration as acceleration is acting e c)



- (1) mark for v_h remaining the same at P and Q
- (1) for v_v being greater at Q

8. a) $u_h = a = h\cos\theta;\ u_v = o = h\sin\theta$



b) $u_h = 7.2\cos33° = 6.038\ \mathrm{m\,s^{-1}}$ (1)
$u_v = 7.2\sin33° = 3.921\ \mathrm{m\,s^{-1}}$ (1)

c) Time is found from the horizontal velocity.
$s = u_h t$
$t = \frac{s}{u_h}$ (1)
$t = \frac{5}{6.038}$
$t = 0.8281$ s (1)
Horizontal height found
$s_v = u_v t + \frac{1}{2}at^2 = u_v t - \frac{1}{2}gt^2$ (1)
$s_v = 3.921 \times 0.8282 - \frac{1}{2} \times 9.81 \times 0.8282^2$
$s_v =$ -0.117 m (i.e. 0.117 m below the level of the cliff edge) (1)

9. a) Full marks given for:
- Correct comparison between $y = mx$ [illegible] $s = ½gt^2$ (1)
- Correct rearrangement to t^2 = [illegible] achieve a direct comparison betwee gradient (1)
- Correct identification that if the gradient (m) = $\frac{2}{g}$, then g can be evaluated

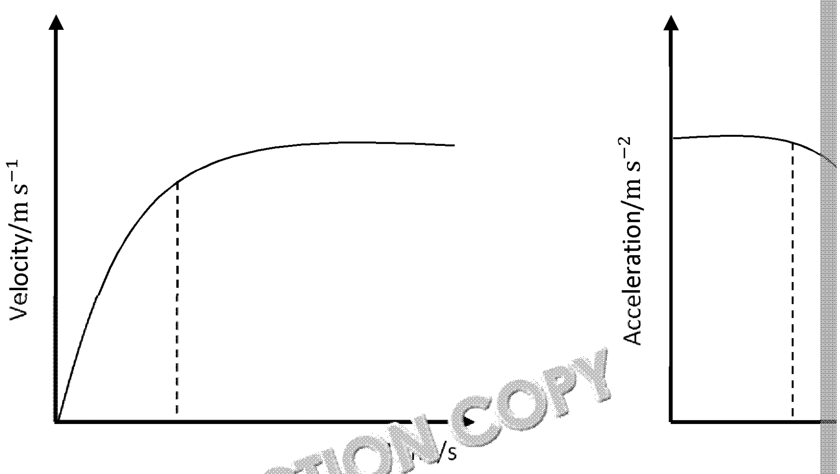
b) Give marks (1) for identification of any one of the following possible answer
- Only one repeat measurement taken; therefore, any random error presen will affect the accuracy of the result for g. (1)
- Systematic error may be present from a fault or error in the calibration of affect the accuracy of the result for g. (1)
- Air resistance will have an effect as it will increase the time the ball takes of the result for g. (1)

10. a)
- If the mass of the skydiver increases, the weight will increase. (1)
- Therefore, the skydiver will experience a greater net force in the downwa ground with an increased terminal velocity. (1)

b) To ensure that the skydiver can reach terminal velocity (or a constant velocity) not still accelerating when he reaches the ground, the company could introdu
- A parachute with increased cross-sectional area to increase the drag forc
- Alter the timings of the parachute release, in order to increase the time p decelerate and reach terminal velocity (1)

c) Give full marks for any suitable answer
- As the skydiver initially jumps out of the plane, only weight is acting on th is 9.81 $\mathrm{m\ s^{-2}}$. (1)
- As the skydiver's speed increases, the contribution of drag also increases, which the skydiver accelerates to the ground. (1)
- Eventually the drag force will be equal to the weight of the skydiver, and acceleration will be zero and the skydiver will reach a constant terminal v

d) (1) mark for each correct graph.



e) If air resistance was not present there would be no drag force and, therefore, t constant rate of 9.81 $\mathrm{m\ s^{-2}}$. (1)

Topic Test 9: Momentum and Newton's Laws of Motion (3.4.1.5)

1. Newton's first law of motion: states that an object will remain at rest or at a consta net external force. (1)

   Newton's second law of motion: states that net external force is directly proportion momentum, and acts in the same direction. (1)

2. As a rocket begins its launch it releases huge quantities of hot gas exhaust through
   - The change in momentum of the gas downwards creates a force. Due to Newt upwards is exerted on the rocket. (1)
   - It creates a greater force acting upwards compared to the weight acting down the upwards direction causing the rocket to accelerate by Newton's second la Must include reference to Newton's laws.

3. a) Since the platforms are moving with constant velocity, due to Newton's first la force acting on the platforms is zero and therefore, weights must be equal in mag
   b) Due to a sandbag falling off Platform B, the weight of Platform A is now greate on A) is now greater (1), Due to Newton's second law of motion ($F_{net} = ma$) t accelerating downwards. (1)

4. a) Linear momentum is the product of the mass of the object and the speed the
   b) *p* = *mv* (1)
   p = 0.8 × 5.6 = 4.5 kg m $\mathrm{s^{-1}}$ (1)

5. a) The equation states that net force is equal to the change in linear momentum d
rate of change of momentum). (1)

b) $F = \frac{\Delta p}{\Delta t}$

$F = \frac{6.6 \times 10^3 - 18.2 \times 10^3}{4 - 0}$ (1)

F = -2900 N, *F* = 2900 N; the negative sign simply indicates that force is in the o

c) Society can evaluate the consequences of car collisions and impacts to forward
manufacturing. (1)

6. a) Impulse is defined as product of the force applied during collision and the durat

OR

Impulse is defined as the change of momentum during the collision. (1)

b) Impulse is equal to the area under a force–time graph for the collision. (1)

c) Impulse = Area of two right-angled triangles (1)

OR

Impulse = Area of rectangle made up of two right-angled triangles (1)

Impulse = 0.4 × 150 = 60 Ns (1)

d) *I* = *F*Δ*t*; therefore, if *F* remained constant but the change in time of the collision
increase. (1)

e) *I* = *F*Δ*t*

Δ*p* = *F*Δ*t* (1)

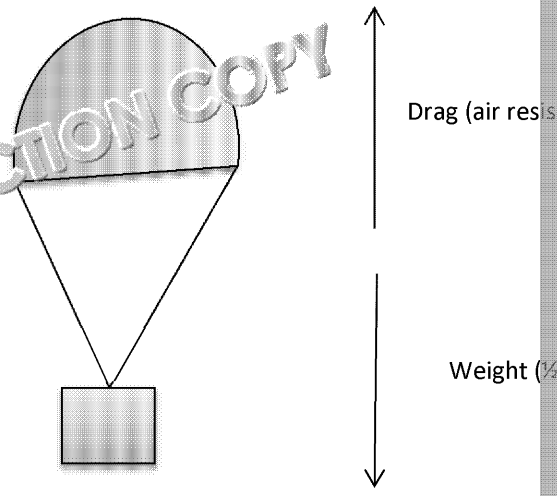
mv – *mu* = *F*Δ*t* (1)

since *u* = 0

$v = \frac{F\Delta t}{m}$ (1)

$v = \frac{(120 \times 0.5)}{0.04} = 1.5 \times 10^3\ \mathrm{ms^{-1}}$ (1)

7. a)



b) The drag could be increased by making the parachute larger (1) or the weight re
package. (1)

8. a) *W* = *mg* = 6.7 × 9.8 = 65.7 N (1)

Net Force = **T** – **W**

Net Force= 65.7 – 65.7

Net Force= 0 N (1)

b) The package will remain stationary as an object needs a net force in order to ch
(accelerate) and in this case the tension and the weight are balanced so there is

c) $\mathrm{F_{net}} = \mathrm{mass} \times \mathrm{acceleration}$

$\mathrm{F_{net}} = 6.7 \times 0.6$ [illegible]

T [illegible] + [illegible]

T [illegible] 5.7 = 69.7 N (1)

9. a) The principle of conservation of momentum states that if there are no externa closed system will be conserved (the momentum before the collision will be e collision). (1)

b) $p_{before} = p_{after}$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ (1)

$(1.3 \times 10^3) \times (12.3) + (1.7 \times 10^3) \times (\text{-}17.1) = (1.3 \times 10^3) \times (\text{-}14.2) + (1.$

$15\,990 + (\text{-}29\,070) = (\text{-}18\,460) + (1.7 \times 10^3)v_2$

$v_2 = \frac{15\,990 - 29\,070 + 18\,460}{1.7 \times 10^3}$

$v_2 = 3.2 \text{ m s}^{-1}$ to the right. (1)

c) $E_{k\text{ before}} = ½m_1{u_1}^2 + ½m_2{u_2}^2$

$E_{k\text{ before}} = ½ \times (1.3 \times 10^3) \times (12.3)^2 + ½ \times (1.7 \times 10^3) \times (\text{-}17.1)^2$ (1)

$E_{k\text{ before}} =$ [illegible] J (1)

$E_{k\text{ after}} = ½m_1{v_1}^2 + ½m_2{v_2}^2$

$E_{k\text{ after}} = ½ \times (1.3 \times 10^3) \times (\text{-}14.2)^2 + ½ \times (1.7 \times 10^3) \times (3.2)^2$ (1)

$E_{k\text{ after}} = 1.40 \times 10^5$ J (1)

Therefore, since the kinetic energy after the collision is not equal to the kineti collision is inelastic. (1)

d) Reducing the velocity of Car 2 will reduce the velocity at which Car 1 is reboun quantity of damage inflicted onto Car 1 and other vehicles nearby. (1)

e) Society could utilise the knowledge of collision and impact effects by validatin steps to improve passenger safety, e.g. seatbelts. (1)

Topic Test 10: Work, Energy, Power and Materials (3.4.1.7/3.4.1.8)

1. The magnitude of force multiplied by the distance travelled in the direction of the f

2. The phenomenon that energy cannot be destroyed or created, but only transferred energy forms. (1)

3. a) Chemical energy (cyclist's muscles) to kinetic energy (movement of bike cogs a
   b) Kinetic energy (from movement of the tyres) to thermal energy (friction) (1)
   c) Sound energy (singer's voice) to electrical energy (speakers) (1)

4. a) Tensile deformation (1)
   b) Compressive deformation (1)

5. A (1)

6. $\rho = \frac{m}{v}$

$V = \pi r^2 \times \text{h}$ (1)

$V = \pi \times ((0.023)^2 \times 0.3)$

$V = 4.99 \times 10^{-4}$ (1)

$\rho = \frac{0.3}{5 \times 10^{-4}} = 602 \text{ kg m}^{-3}$ (1)

7. a) $E_p = mg \times \text{h}$

$E_p = 85 \times 9.81 \times 6.4$ (1)

$E_P = 5.34 \times 10^3$ J (1)

b) $E_{total} = E_p + E_k$

$E_{total} = E_p\,max = E_k max = E_p$ (at 4.3 m) + E_k (at 4.3 m) (1)

$5.34 \times 10^3 = (85 \times 9.81 \times 4.3) + (½ \times 85 \times v^2)$ (1)

$$v^2 = \frac{(5.34 \times 10^3) - (85 \times 9.81 \times 4.3}{(½ \times 85)}$$

v = [illegible] m s^{-1} [illegible]

c) The potential energy of the skater at the top of the halfpipe will not be convert the bottom (1), some of the energy will be converted into heat via friction as t (1)

8. a) $P = Fv$

$P = 150 \times 26$ (1)

$P = 3900\ \text{W}\ (1)$

b) The Vespa experiences an additional resistive force from its weight down the hi greater force (1); the maximum power of the engine is fixed, so the velocity of t

9. a) The total input thermal energy has not been entirely converted into mechanica energy has been converted into thermal energy [illegible] lower temperature in the c

b) $P = \frac{W}{t}$ (1)

P [illegible]

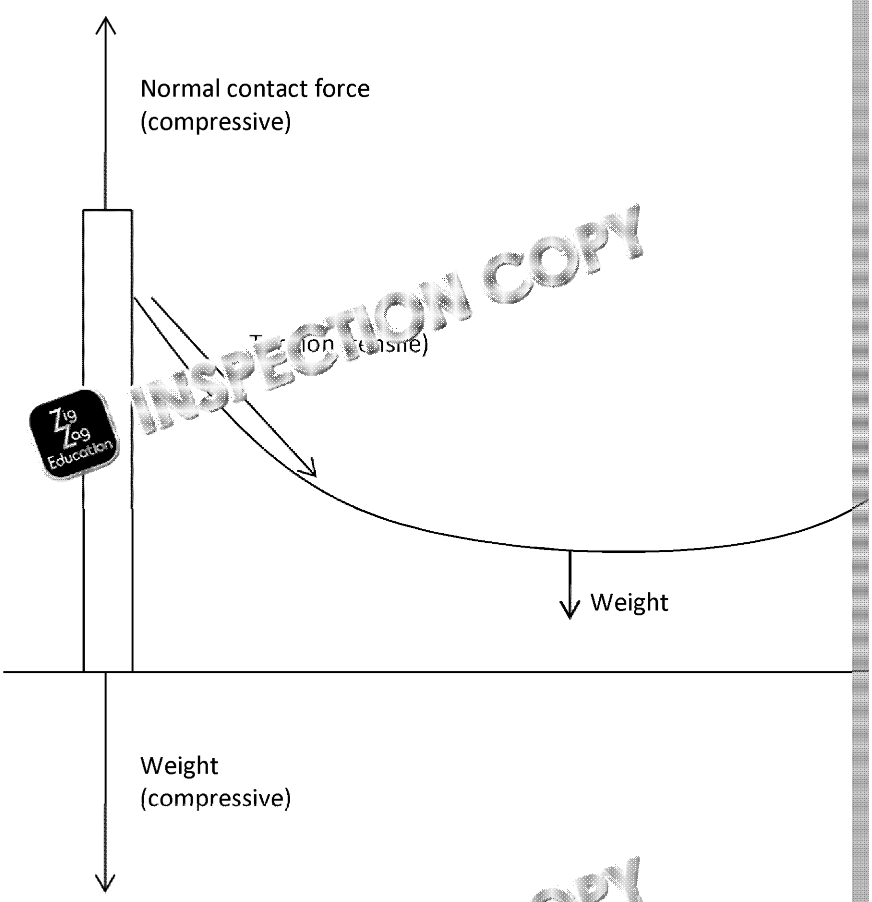
$P = 12.5\ \text{W}\ (1)$

c) $\text{efficiency} = \frac{\text{useful output energy}}{\text{total input energy}} \times 100\ \%$ (1)

$\text{efficiency} = \frac{250}{400} \times 100 = 62.5\ \%$ (1)

d) Less energy used results in less environmental impact from energy production.

10.



Note: Give full marks (3) if student has identified the three forces on the right-hand side o

11. a) That wire A is stiffer, [illegible] greater stiffness, than B. (1)

b) To achieve the same applied force for each, would have to extend wire B over a a [illegible] k. (F = kx) (1)

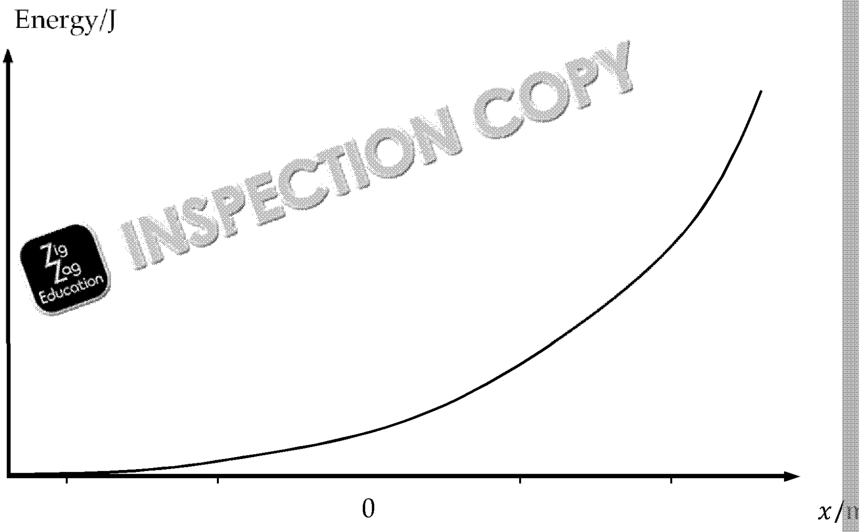
c) F [illegible] (1)

$F = 1.2 \times 0.1$

$F = 0.12\ \text{N}(1)$

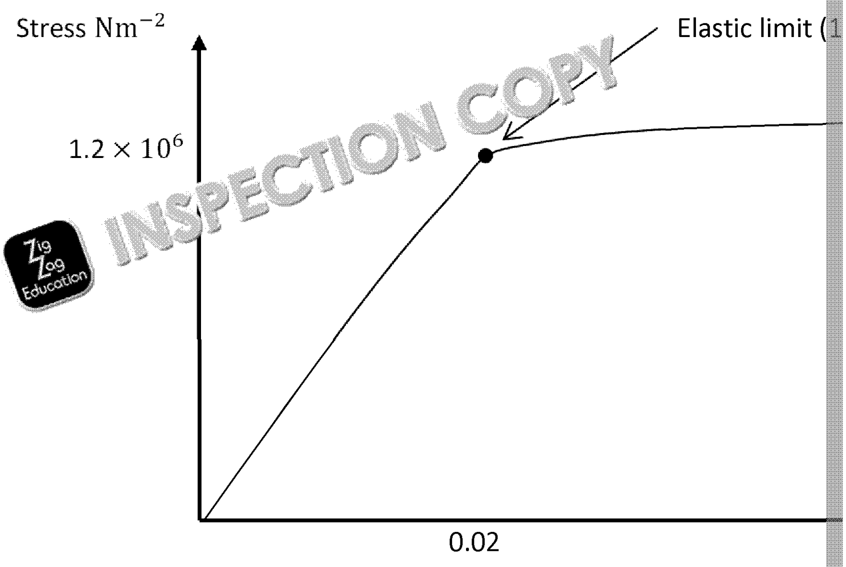
12. a) Work done = Area under force–extension graph. (1)
$W = ½ \times 0.3 \times 15.4 = 2.3$ J (1)

b)
- Correct shape (1)
- Correct axis labels (1)



c) k = gradient of slope = $\frac{15.4}{0.3} = 51.3\ \text{Nm}^{-1}$ (1)
$E = ½ \times 51.3 \times 0.1^2 = 0.26$ J (1)

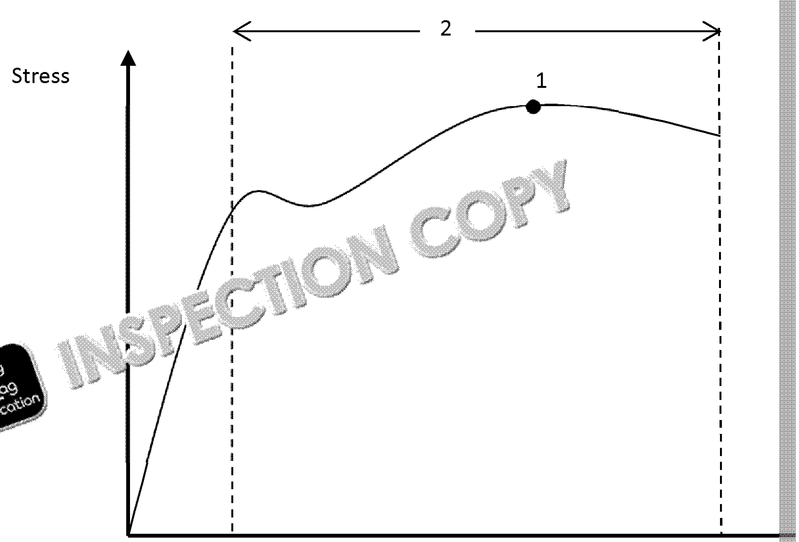
13. a)



b) $\text{Young' modulus} = \frac{\text{tensile stress}}{\text{tensile strain}} = \text{gradient of the graph}$ (1)
$\text{Young' modulus} = \frac{1.2 \times 10^6}{0.02} = 6.0 \times 10^7\ \text{Nm}^{-2}$ (1)

c) Young modulus would not alter if you changed the size of the wire, as Young m
used. (1)

d)



1: Ultimate tensile stress (1)
2: Plastic deformation (1)

Topic Test 11: Electricity and Resistivity (3.5.1.1/3.5.1.2/3.5.1.3)

1. *Current:* is defined as the rate of flow of charge ($I = \frac{\Delta Q}{\Delta t}$). (1)

2. The unit for charge is the coulomb (C) and it is defined as the amount of charge tha current is 1 ampere. (1)

3.
   - Insulator: Each electron (potential charge carrier) is fixed to an atom (1) and, th no current flows as no electrons can move. (1)
   - Metallic conductor: Majority of electrons are fixed to atoms but some are deloc metal's charge carriers. When a voltage is applied, the delocalised electrons
   - Semiconductor: Delocalised electrons are the material's charge carriers, and th temperature increases. (1) When a voltage is applied, the number of charge car flo

4. a) $Q = It$ (1)
   $Q = 3.2 \times 80 = 256 \text{ C}$ (1)
   b) Since the absolute charge of one electron is 1.6×10^{-19} C
   $\text{Number of electrons} = \frac{\text{Total Charge}}{\text{Charge of one electron}}$ (1)
   $\text{Number of electrons} = \frac{256}{1.6 \times 10^{-19}} = 1.6 \times 10^{21}$ electrons (1)

5. a) Give full marks (2) for identifying any two of the following possible answers:
   - Superconductor is made of material that has zero resistivity when cooled is material dependent. (1)
   - When current passes through a superconductor that has been cooled bel potential difference across it. (1)
   - When current passes through a superconductor that has been cooled bel has no heating effect. (1)

   b) Give full marks (2) for identifying any two of the following possible answers:
   - High-power electromagnets that produce strong magnetic fields in MRI sc
   - High-power electromagnets that produce strong magnetic fields in partic
   - Produce strong magnetic fields for lightweight electric motors. (1)
   - Produce strong magnetic fields for power cables that reduce energy lost i cables. (1)
   - Magnetic levitation to reduce friction and increase efficiency and speeds i

6. a) Current occurs in a metal due to the movement of electrons. (1)
   b) Current occurs in an electrolyte due to the movement of ions. (1)

7. a) Charge occurs on an object or particle due to either the gain or loss of an elect

b) $Q = \pm ne$ (1)

c) $Q = 6.7 \times 1.6 \times 10^{-19} = 1.07 \times 10^{-18}$ (1)

d) As charge occurs due to a particle gaining or losing an electron, charge can only
are multiples of e. (1)

8. a) $V = \frac{W}{Q}$ (1)

$Q = It = 0.02 \times 500 = 10$ C (1)

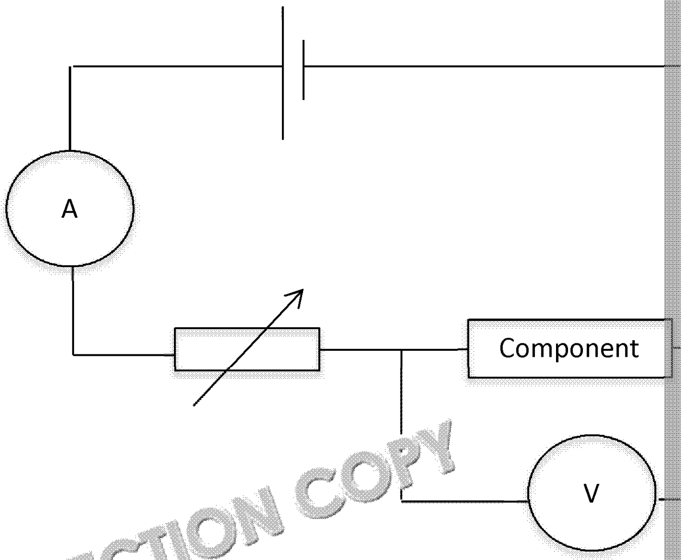
$V = \frac{43}{10} = 4.3$ V (1)

b) $R = \frac{V}{I}$ (1)

$R = \frac{4.3}{[illegible]} = 215$ (1)

9. a) Oh[illegible]: the potential difference is directly proportional to the current throu

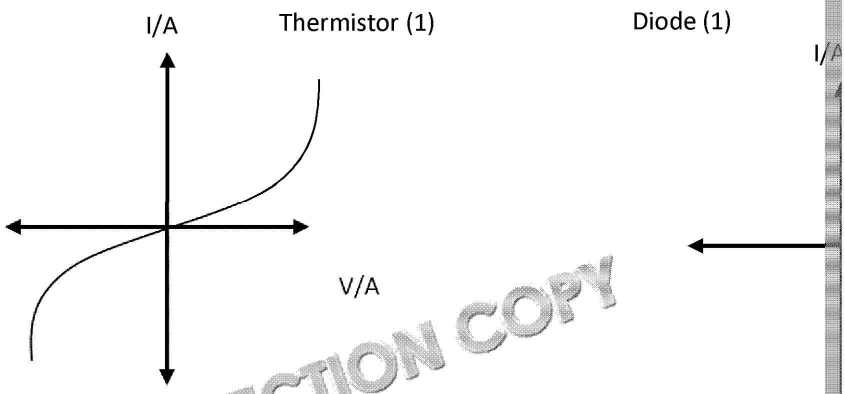
b)



c)
- Take a note [illegible] resistance of the variable resistor and the corresp
[illegible] vo[illegible] (1)
- [illegible]st the variable resistor in uniform intervals and continue to take readi
[illegible]en data is collected to plot a graph of current against potential differenc

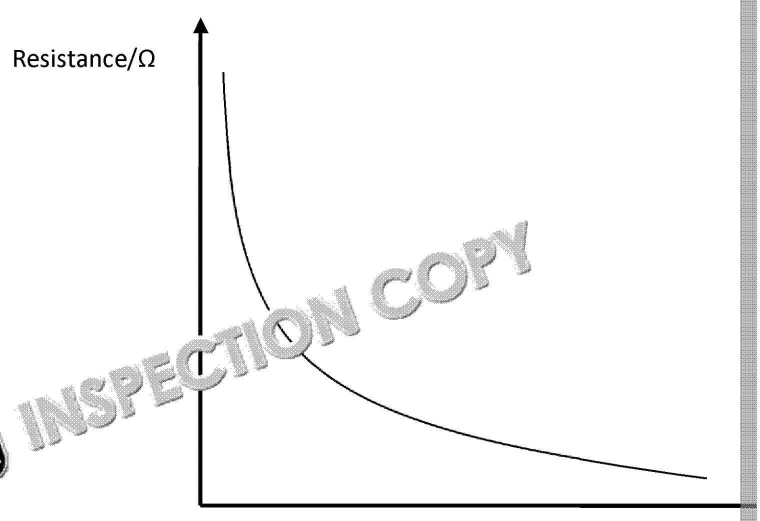
d) 1: A resistor (1); resistors are ohmic conductors so have linear I–V graphs (1)
2: A filament bulb (1); resistance increases at higher currents (as temperature i

e) (1) mark for each correct identification.



f) Th[illegible] due to the diode only allowing current to flow through in o
n[illegible] being allowed to pass in the other direction (backward bias). (1)

g)



10. a)
- Take a wire of known resistance and measure the length of wire with a m wire with a micrometre to determine its cross-sectional area. (1)
- Use the measurements with the equation $\rho = \frac{RA}{L}$ to determine resistivity multiple times to obtain an average and reduce error. (1)

b) $\rho = \frac{RA}{L}$

$\rho = \frac{2.4 \times (3.14 \times 10^{-5})}{(10.5 \times 10^{-2})}$ (1)

$\rho = 7.18 \times 10^{-4}\ \Omega\ \text{m}$ (1)

c) The resistivity of the wire would increase. (1)

d) $P = \frac{V^2}{R}$ (1)

$V = \sqrt{PR}$

$V = \sqrt{130 \times 2.4}$

$V = 17.7$ V (1)

e) $W = Pt$ (1)

$W = 130 \times 300$

$W = 3.9 \times 10^{4}$ J (1)

Topic Test [illegible] Circuits and Potential Dividers (3.5.1.4/3.5.1.5)

1. The total current leaving the junction is equal to the total current entering the junct

2. The purpose is to split the input source voltage across the components making up th voltage. (1)

3. D (1)

4. a) $R_T = R_1 + R_2 + R_3 + \cdots$ (1)

b) $R_T = 2 + 4 + 6 = 12\ \Omega$ (1)

c) **2 Ω resistor**: *V* = *IR* = 2 × 2 = 4 V (1)

4 Ω resistor: *V* = *IR* = 2 × 4 = 8 V (1)

6 Ω resistor: *V* = *IR* = 2 × 6 = 12 V (1)

d) The total potential difference would be split equally across each resistor. (1)

OR

The potential difference will be 8 V across each 2 Ω resistor. (1)

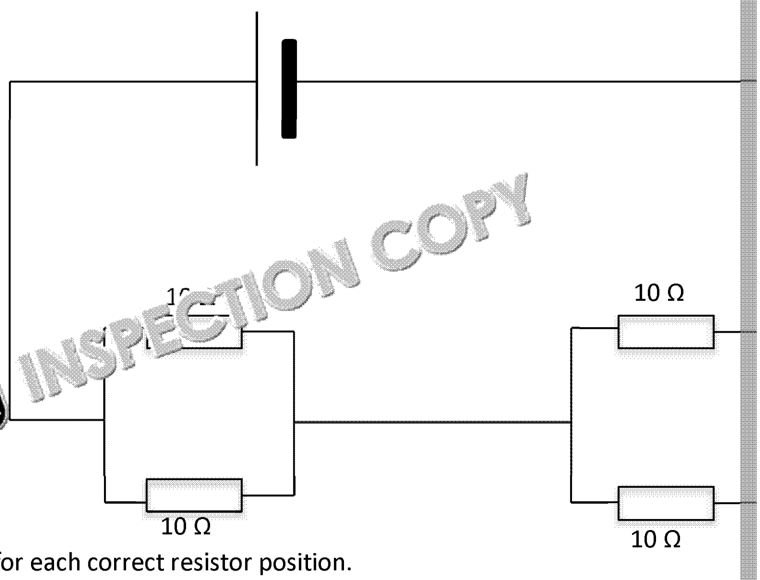
5. a) $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_T} = \frac{1}{2} + \frac{1}{4} + \frac{1}{6} = \frac{6}{12} + \frac{3}{12} + \frac{2}{12}$ (1)

$\frac{1}{R_T}$ [illegible]

$R_T = \frac{12}{11} = 1.1\ \Omega$ (1)

6. The circuit would need to be constructed as follows:



Give (1) mark for each correct resistor position.
Also allow two sets of resistors in parallel with each other.

7. a) First parallel circuit (A to B): $\frac{1}{\mathrm{R_T}} = \frac{1}{2} + \frac{1}{4} = \frac{2}{4} + \frac{1}{4} = \frac{3}{4}$; therefore $\mathrm{R_T} = 1.3\ \Omega$ (1)
Second parallel circuit(C to D): $\frac{1}{\mathrm{R_T}} = \frac{1}{10} + \frac{1}{5} = \frac{1}{10} + \frac{2}{10} = \frac{3}{10}$; therefore $\mathrm{R_T} = 3.3$
To determine the total resistance in the circuit, the two parallel circuits are in
$\mathrm{R_T} = 1.3 + 3.3 + 7 = 11.6\ \Omega$ (1)

b) The current at D is the same as the current at A (1) as the electrical circuit bet
series and, therefore, current is constant OR Kirchoff's second law states that
current out of a junction. (1)

c) A and B: *V* = *IR* = 1.03 × 1.3 = 1.3 V (1)
B and C: *V* = *IR* = 1.03 × 7 = 7.2 V (1)
C and D: *V* = *IR* = 1.03 × 3.3 = [illegible] (1

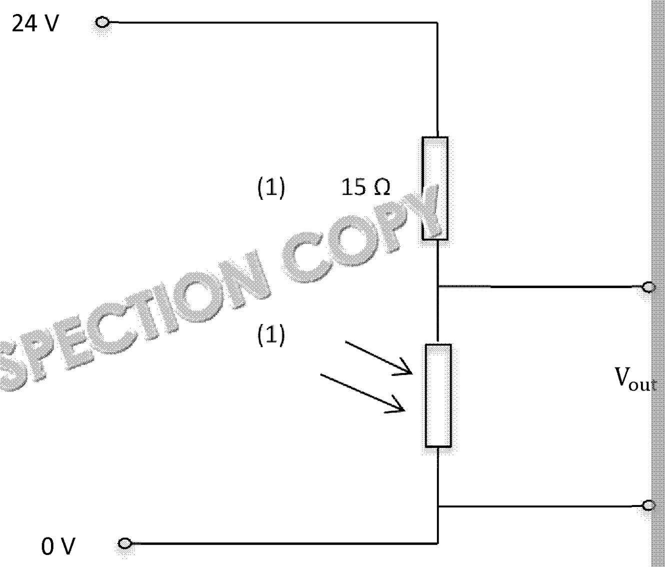
d) B and C: The potential difference would increase due to voltages and resistance
(1)
A [illegible] Since the total voltage remains constant, the potential difference wou
po [illegible] account for the increase across B and C ($V = V_1 + V_2 + V_3$). (1)

8. a) $V_2 = \frac{R_2}{R_1 + R_2} V_{in}$ (1)
$V_2 = \frac{7}{10 + 7} \times 12$
$V_2 = 4.9\ \mathrm{V}$ (1)

b) V_1 would decrease if $\mathrm{R_1}$ decreased, since *V* = *IR* and *I* is constant in a series cir
If $\mathrm{R_1}$ decreased then V_1 will decrease and since the input voltage is split bet
increase. (1)

c) Since the total input voltage is 12 V and the input voltage is split across compo
$V_2 = 6$ V. Therefore, the two resistors would need to be of the same resista
result ($\frac{V_1}{V_2} = \frac{R_1}{R_2}$). (1)

9. a)

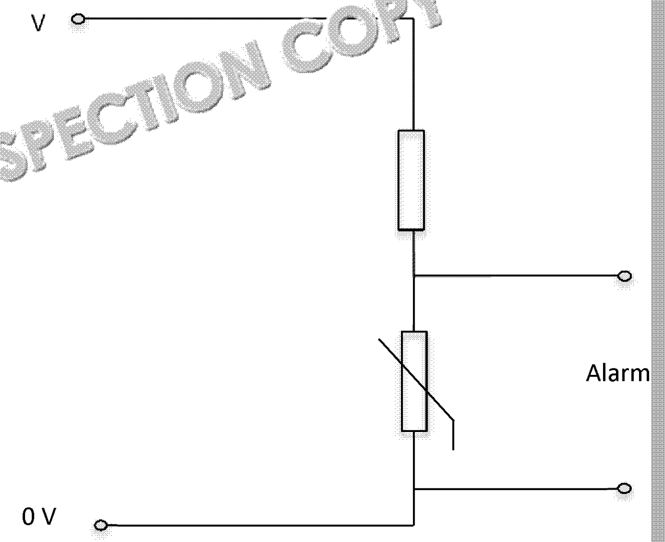


b) $V_{out} = \frac{R_2}{R_1 + R_2} \times V_{in}$ (1)

$V_{out} = \frac{8}{15 + 8} \times 24 = 8.3$ V (1)

c) If the light intensity increased then the resistance would decrease (1), and the would decrease due to *V* = *IR* with *I* constant in a series circuit. (1)

10. a)
- Correct sketch of potential divider circuit (1)
- Correct use of thermistor (1)
- Correct arrangement of resistor and thermistor (1)



Accept thermistor and resistor in reversed positions.

b) When the temperature of the fridge increases, the resistance across the thermistor decreases, so will the output voltage across the thermistor (1). The company can se certain cut-off voltage the alarm will sound (1).
If thermistor and resistor are reversed in 10 a), accept reverse argument.

Topic Test 13: Electromotive Force and Internal Resistance (3.5.1.6)

1. Internal resistance is the resistance from the power supply. (1)

2. Terminal potential difference is the potential difference measured between the ter

3. Lost volts refers to the difference between the available emf and the measured ter wasted per coulomb in overcoming the internal resistance. (1)

4. $E = \varepsilon Q$

   $E = 24 \times 6.3$ (1)

   $E = 151.2$ J (1)

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

   $\varepsilon = V + Ir =$ pd + 'lost volts' (1)

6. A (1)

7. a) If the resistance of the resistor increased, the current would decrease (1) so th decrease, so the reading on the voltmeter would increase. (1)

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

   $V = 14 - (0.2 \times 0.4) = 13.92$ V (1)

8. a)
   - A simple circuit set-up of a battery connected in series with an ammeter leads. The voltmeter would be connected in parallel with the variable res leads. (1)
   - Note the initial reading of the ammeter and voltmeter and then alter the noting the reading on the ammeter and the voltmeter at each value. (1)
   - After a sufficient number of values have been recorded, plot pd readings draw the line of best fit to determine the emf from the y-intercept and in (Comparison of $V = -Ir + \epsilon$ and $y = mx + c$) (1)

   b) Graph 2 has the lowest emf and Graph 3 has the greatest. (1)

   Graph 3 has the lowest internal resistance, and Graph 2 has the greatest. (1)

   c) $y = mx + c$

   $V = \varepsilon - Ir$

   $\varepsilon = y\text{-}intercept$ (1)

   $\varepsilon = 1.7$ V (1)

   $-r = gradient$ (1)

   $$r = -\frac{0.8 - 1.7}{0.9 - 0}$$

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