insight
▸innovative ▸engaging ▸evolving

Year 12 *Trial Exam Paper*

2018

PHYSICS

Written examination

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	19	19	110
			Total 130

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners, rulers, pre-written notes (one folded A3 sheet or two A4 sheets bound together by tape) and one scientific calculator.
- Students are NOT permitted to bring sheets of blank paper or correction fluid/tape into the examination.

Materials provided

- Question and answer book of 39 pages
- An answer sheet for multiple-choice questions
- A formula sheet

Instructions

- Write your **name** in the box provided above, and on the answer sheet for multiple-choice questions.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- You must answer all questions in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.
- You may keep the formula sheet.

Students are NOT permitted to bring mobile phones and/or any unauthorised electronic device into the examination.

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1

An electron is moving in a straight line in the presence of a field. Its path is deflected by a force that is perpendicular to its path.

Which of the following types of fields could achieve this deflection?

A. a gravitational field only

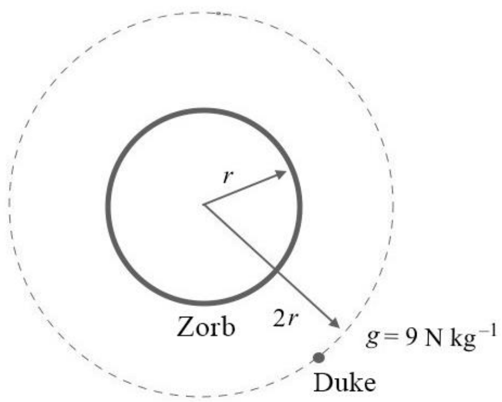
B. either an electric field or a magnetic field

C. an electric field only

D. either an electric field, a gravitational field or a magnetic field

Question 2

Duke is orbiting above the planet Zorb, which has a radius of r, as shown in the diagram below. He measures the gravitational field strength at an altitude of r above the surface of the planet to be $g = 9$ N kg^{-1}.



When his altitude increases to $2r$ above the surface, what will be the gravitational field strength at this new position?

A. $g = 4.5$ N kg^{-1}

B. $g = 2.25$ N kg^{-1}

C. $g = 4$ N kg^{-1}

D. $g = 1$ N kg^{-1}

Question 3

On a metallic object, the magnetic field around the north pole of a bar magnet may exert

A. an attractive force only.

B. either an attractive force or a repulsive force.

C. a repulsive force only.

D. either no force, an attractive force or a repulsive force.

Question 4

Which one of the following fields may be described as static and non-uniform?

A. the gravitational field around a point mass

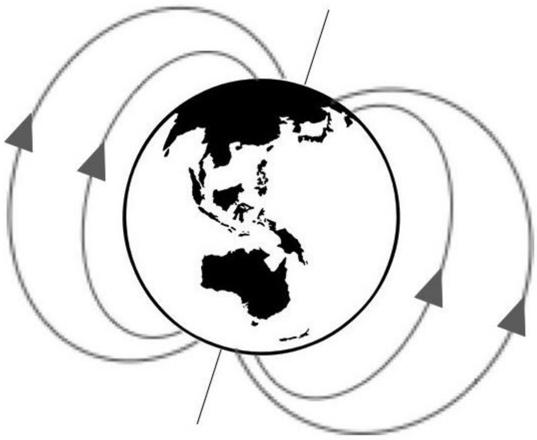
B. the electric field between two parallel plates at a constant potential difference

C. the magnetic field around a solenoid connected to an AC power supply

D. the electric field between two plates connected to an AC power supply

Question 5

The magnetic field lines around the Earth run from the South Pole to the North Pole, as shown in the diagram below. A current of 1.5 A flows through a wire on the surface of the Earth from east to west.



The wire will experience a force in the direction of

A. up.

B. down.

C. north.

D. south.

Question 6

Which of the following actions would **not** increase the EMF generated by a rotating coil inside a magnetic field?

A. increasing the period of the rotating coil

B. increasing the strength of the magnetic field

C. increasing the number of loops in the rotating coil

D. increasing the speed of rotation of the coil

Question 7

Power transmission is commonly carried out by stepping up the voltage before transmission. After transmission, the voltage is stepped down prior to reaching consumer households.

Which of the following statements is the most correct explanation of why transformers are used in the transmission of power through power lines?

A. Stepping up and stepping down the voltage results in zero loss of power in the transmission line.

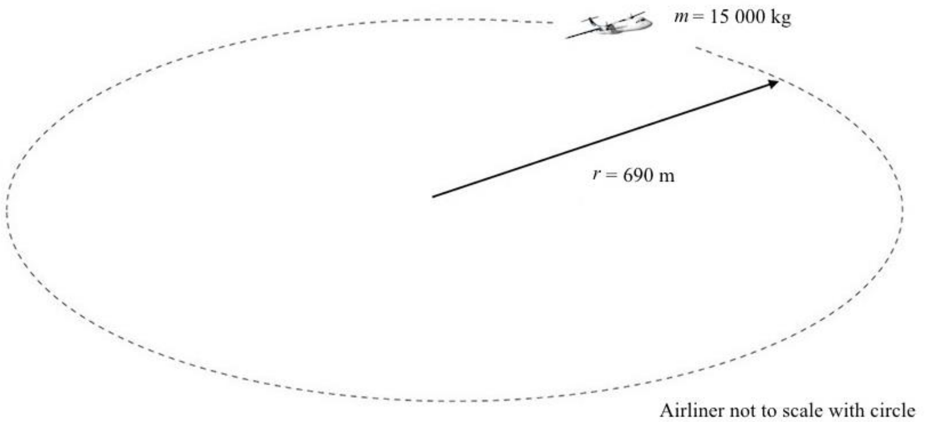
B. The step-up ratio must be the same as the step-down ratio or else no power can be transmitted.

C. The process of stepping up the voltage of the electricity before transmission reduces the amount of current present in the lines and hence reduces the amount of power lost in the lines.

D. Conservation of energy means the resistance of the transmission line is reduced and this is the key factor in lowering the transmission losses.

Question 8

A passenger airliner with a total mass of 15 000 kg is making a circular horizontal turn at a constant speed, as shown in the diagram below. The wings are experiencing a net force, directed towards the centre of the circle, of 125 500 N. The circular horizontal turn has a radius of 690 m.



Which of the following is closest to the speed of the airliner?

A. 57.8 m s^{-1}

B. 72.1 m s^{-1}

C. 76.0 m s^{-1}

D. 13.4 m s^{-1}

The following information applies to Questions 9 and 10.

Erica, who has a mass of 55 kg, is seated in the Rocketing Upwards ride, which accelerates her initially upwards at a rate of 3.0 m s^{-2}.

Question 9

Which of the following is the correct magnitude and direction of the force that Erica exerts on the seat of the ride?

A. 374 N upwards

B. 374 N downwards

C. 704 N upwards

D. 704 N downwards

Question 10

Erica travels from **rest** at the ground level ($h = 0$ m), then **stops** at the highest level where $h = 20$ m. Which of the following is closest to the work done on her by the ride?

A. 1078 J

B. 10 780 J

C. 20 780 J

D. 1100 J

Question 11

Diffraction of waves may be observed when

A. waves move from one medium to a different medium.

B. there is a change in the speed of the wave.

C. waves move through an aperture.

D. waves collide against an obstacle at an angle.

Question 12

Deep-sea divers breathe a mixture of helium and air known as trimix so that they do not suffer from decompression sickness. A side-effect of this mixture is that their voice changes pitch due to a change in the speed of sound in trimix. A sound with frequency $f = 440$ Hz in air changes pitch to a frequency of $f = 1300$ Hz, although the wavelength remains constant in both mediums.

Given that the speed of sound in air is 340 m s^{-1}, the speed of sound in trimix is closest to

A. 115 m s^{-1}

B. 263 m s^{-1}

C. 1300 m s^{-1}

D. 1005 m s^{-1}

Question 13

Light may be modelled as a stream of particles, known as photons.

Which of the following experiments demonstrates the particle-like nature of light?

A. light emitted during electron transitions in an emission spectrum experiment

B. incident light on a photocell experiment, demonstrating the photoelectric effect

C. light absorbed by valence electrons during an absorption spectrum experiment

D. all of the above

Question 14

X-rays directed through very thin layers of crystal form a diffraction pattern with the same fringe spacing as the diffraction pattern formed by an electron beam passed through the same layers of crystal.

Which conclusion can be drawn from this observation?

A. The X-rays interact with the thin layers of crystal in the same particle-like manner as the electrons, hence forming the same pattern as the electron beam.

B. The X-rays and the electron beam behave in a wave-like manner and have the same frequency, hence the same pattern.

C. The electron beam and the X-rays behave in a wave-like manner and have the same wavelength, hence the same pattern.

D. The electron beam travels through the thin layers of crystal in a particle-like manner, hence forming the same pattern as the X-rays.

Question 15

An emission spectrum experiment detected a photon of light with a wavelength of 560 nm.

The energy of the photon is closest to

A. 3.55 eV

B. 3.55 MeV

C. 2.22 eV

D. 2.22 MeV

Question 16

Jamila and Keenan are discussing the single-slit diffraction experiment using electrons, and how it is related to Heisenberg's uncertainty principle.

Jamila says, 'The diffraction pattern of the electrons is more spread out as the slit width is decreased, because decreasing the uncertainty in the position of the electrons results in increasing the uncertainty in the momentum of the electrons. Thus, this experiment illustrates Heisenberg's uncertainty principle.'

Keenan says, 'For a given slit width, increasing the momentum of the electrons results in a diffraction pattern that is less spread out. This shows that Heisenberg's uncertainty principle is not applicable in diffraction.'

Who is correct?

A. Both Jamila and Keenan are correct.

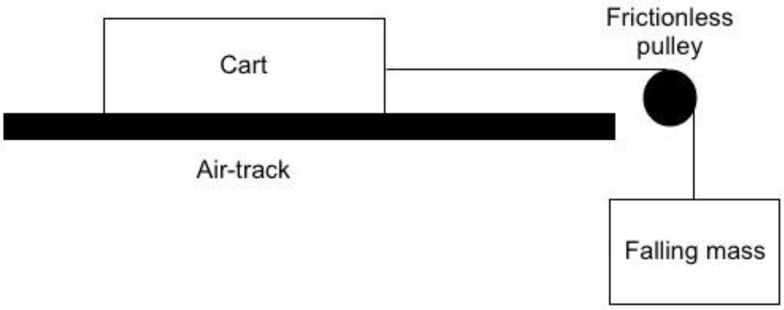
B. Jamila is correct, and Keenan is incorrect.

C. Both Jamila and Keenan are incorrect.

D. Jamila is incorrect, and Keenan is correct.

Question 17

An experiment on a frictionless air-track, as represented in the diagram below, is carried out to determine the relationship between a net force provided by a constant falling mass, the mass of a cart travelling on the air-track and the acceleration of the cart.



Which of the following options correctly identifies the classification of the variables involved?

A. Acceleration is the dependent variable, the net force is the independent variable and the mass of the cart is the controlled variable.

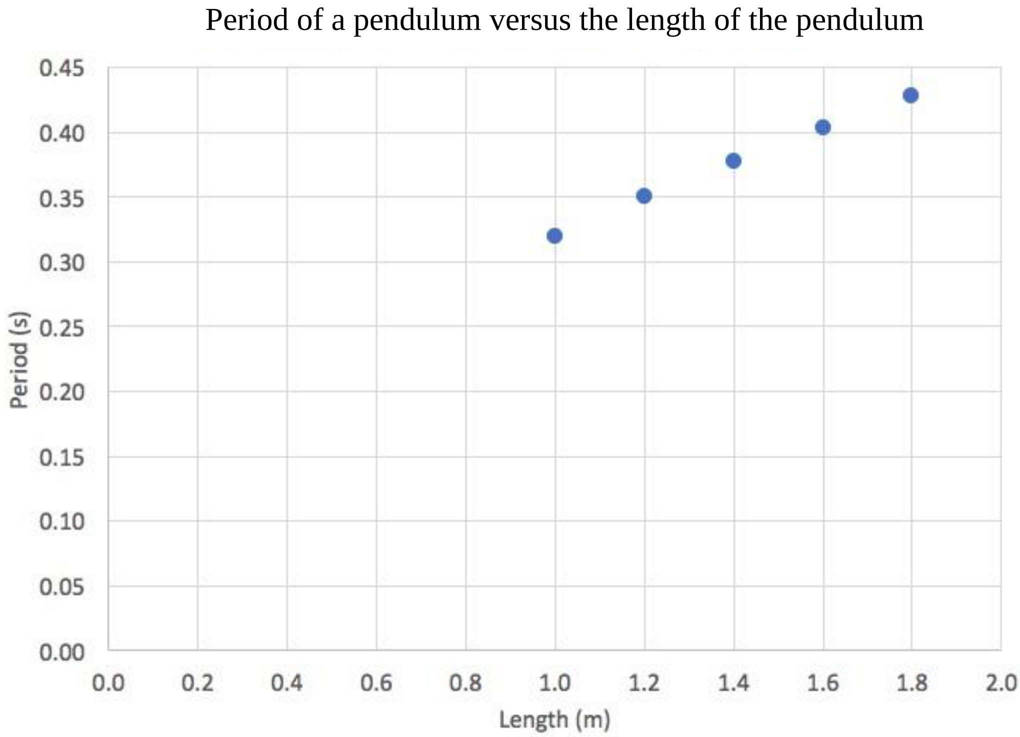
B. Acceleration is the independent variable, the net force is the dependent variable and the mass of the cart is the controlled variable.

C. Acceleration is the dependent variable, the net force is the controlled variable and the mass of the cart is the independent variable.

D. Acceleration is the independent variable, the net force is the controlled variable and the mass of the cart is the dependent variable.

Question 18

Ally and Billy carry out an experiment to determine the relationship between the period of a pendulum and the length of the pendulum. They plot their data, as shown in the graph below.



Ally says to Billy, 'By linearly extrapolating the graph, if I reduce the length of the pendulum to 0.5 m, I estimate the period of the pendulum would reduce to 0.25 s.' Billy disagrees with Ally's prediction, saying, 'That is an improper use of the graph.'

Which of the following is the most correct reason that Billy could provide?

A. 'It is never correct to extrapolate a graph, because it is an unscientific practice.'

B. 'There is no data point at the length of 0.5 m and actual measurements have to be made.'

C. 'The relationship cannot be assumed to continue as linear within the region of 0.5 m.'

D. 'The textbook clearly says the relationship is not linear, therefore you should not extrapolate.'

Question 19

Shawn takes several measurements of the natural frequency of a violin string using a frequency analyser and obtains the following readings on the instrument.

442.4 Hz, 441.1 Hz and 440.9 Hz

Which of the following is the best representation of the average and the uncertainty of these readings?

A. 441.47 ± 0.67 Hz

B. 441.50 ± 0.70 Hz

C. 441.5 ± 0.7 Hz

D. 441 ± 1 Hz

Question 20

Which of the following statements does **not** correctly describe a hypothesis within the framework of the scientific method?

A. A hypothesis is a tentative explanation for an observed phenomenon.

B. A hypothesis may be supported by experimental evidence.

C. A hypothesis is useful only if it is supported by experimental evidence.

D. A hypothesis may be disproved by experimental evidence.

END OF SECTION A

SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

Where an answer box is provided, write your final answer in the box.

If an answer box has a unit printed in it, give your answer in that unit.

In questions where more than one mark is available, appropriate working **must** be shown.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Take the value of g to be 9.8 m s^{-2}.

Question 1 (6 marks)

In a distant solar system, a planet is observed orbiting a star. The mass of the star is estimated to be 2.9×10^{30} kg and the planet is believed to have an orbital radius of 1.4×10^{12} m about the star, as shown in Figure 1.

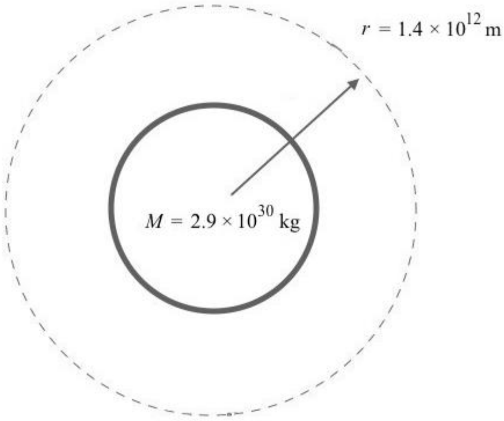


Figure 1

a. Calculate the gravitational field strength of the star at the orbital radius of the planet.

2 marks

N kg^{-1}

b. Determine the acceleration of the planet about the star.

1 mark

m s^{-2}

c. Is it possible to determine the mass of the planet from the two numerical pieces of information given in this question? Give an explanation for your answer.

3 marks

Question 2 (4 marks)

Two charges are arranged in a vertical line, as shown in Figure 2, which also contains a point, *X*, on a horizontal line midway between the two charges. These two charges are fixed in the positions shown and are unable to move.

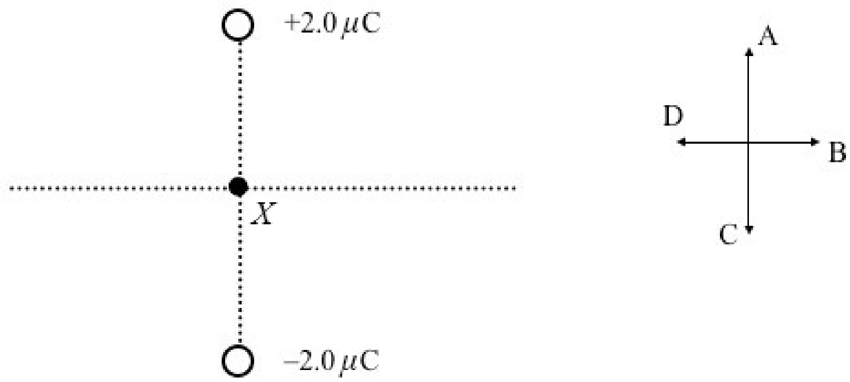


Figure 2

a. On Figure 2, draw an arrow to represent the direction of the electric field strength at the point *X*, due to both charges.

1 mark

b. A small negatively charged sphere is now positioned at *X* and released.

State the direction (using the direction guide A–D) in which the sphere would move after it is released.

1 mark

c. The distance between the two charges is 0.50 m.

Calculate the force acting on each charge due to the presence of the other charge.

2 marks

N

Question 3 (8 marks)

Electric and magnetic fields can be used to change the speed and direction of motion of charged particles. Figure 3 shows a schematic diagram of an electron gun. The plates X and Y are used to accelerate electrons emitted from the tungsten filament, and in region Z a uniform magnetic field is used to direct the beam onto a particular point on the target.

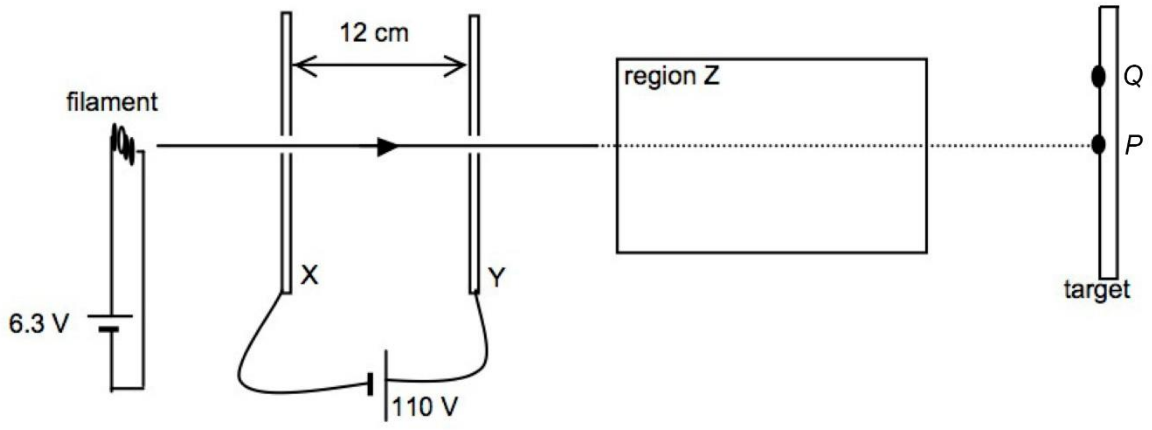


Figure 3

Data

accelerating voltage = 110 V

mass of electron = 9.1×10^{-31} kg

charge of electron = 1.6×10^{-19} C

a. Calculate the magnitude of the electric field strength between the plates X and Y.

2 marks

____

____

____

____

____

V m^{-1}

b. The electrons emitted from the filament can be assumed to be initially at rest.

Determine the speed of the electrons entering region Z after being accelerated by the electric field.

3 marks

$\square$ m s^{-1}

c. When the magnetic field in region Z is zero, the electrons strike the target at *P*.
The beam of electrons is required to be moved to point *Q* by altering the magnetic field strength in region Z.

Using your knowledge of magnetic fields and force, explain in which direction the magnetic field in region Z must be so that the beam of electrons strikes the target at *Q*. In describing your chosen direction, use one of *up*, *down*, *left*, *right*, *into the page* or *out of the page*.

3 marks

Question 4 (6 marks)

Figure 4 shows a schematic diagram of a conductor that is completely within a uniform magnetic field of 0.8 T. The length of the conductor is 12 cm. The magnitude of the current through the conductor is 0.6 A, in the direction shown on the diagram.

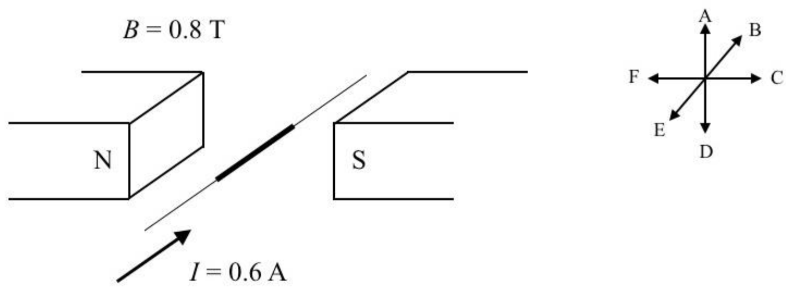


Figure 4

a. Determine the size and direction (using the direction guide A–F) of the force acting on the conductor.

3 marks

N	Direction

b. The power supply is now disconnected from the conductor, and a voltmeter is connected instead, as shown in Figure 5. The conductor is now moved upwards at a constant velocity, $v = 0.15 \text{ m s}^{-1}$.

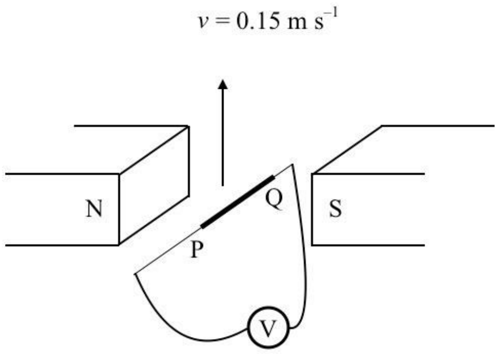


Figure 5

Calculate the EMF generated between P and Q, the two ends of the conductor.

2 marks

V

c. Determine the direction of the current in the conductor. Circle the correct answer in the list below.

1 mark

From P to Q.

From Q to P.

There is no current.

Question 5 (6 marks)

A new generator is being designed to supply electrical power to a country town several kilometres away from the generator. The system consists of a generator, two ideal transformers, T1 and T2, and a transmission line, as shown schematically in Figure 6.

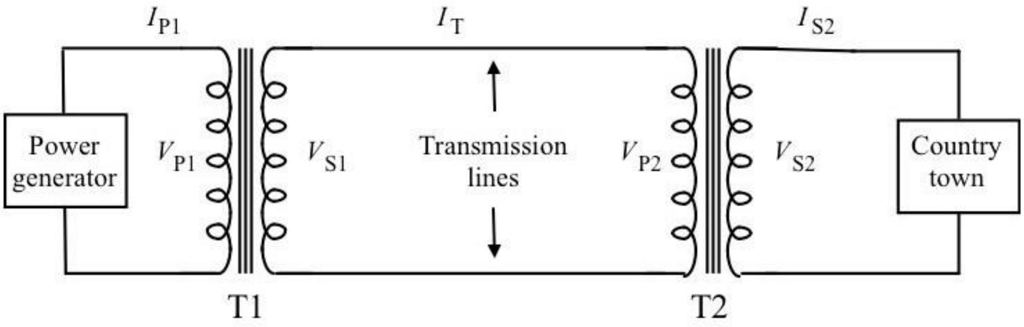


Figure 6

The generator is anticipated to supply 8.4×10^5 W of power at 240 V RMS on the primary side of T1. The power is transferred via a step-up transformer T1, using transmission lines with a total resistance of 3.0 Ω, and finally a step-down transformer T2, with the same turns-ratio as T1.

The town engineer is considering which turns-ratio to use for both of the transformers T1 and T2, and is aware that the voltage to appliances in the town must not exceed 240 V RMS.

a. What is the peak-to-peak voltage for an RMS voltage of 240 V?

1 mark

____

____

V

b. Show that I_{P1}, the anticipated current in the primary coil of transformer T1, is 3500 A. Show your working.

2 marks

____

____

____

____

c. The anticipated current in the primary coil of transformer T1 is 3500 A. The town engineer is considering implementing a turns-ratio of 100.

Calculate the power loss in the transmission line for the stated turns-ratio.

3 marks

____

____

____

____

____

____

W

Question 6 (5 marks)

Two boxes, labelled A and B, are stacked one on top of the other in a lift, as shown in Figure 7. The mass of box A is 3 kg and the mass of box B is 7 kg. The lift is currently stationary.

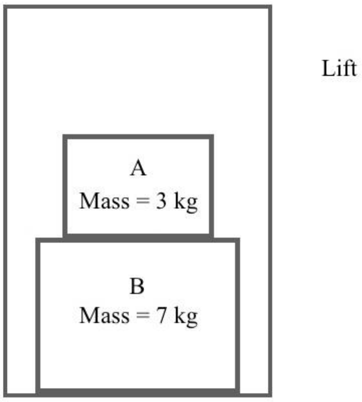


Figure 7

a. Calculate the magnitude of the force exerted on box A by box B, and state the direction of the force using either *up* or *down*.

2 marks

N	Direction

b. The lift now accelerates down at $a = 3.5$ m s^{-2}.

Calculate the magnitude of the force on box B by box A, and state the direction of the force using either *up* or *down*.

3 marks

N	Direction

Question 7 (11 marks)

Loadzafun Park has a ride consisting of a carriage, C1, starting at point *P*, as shown in Figure 8, rolling down a set of smooth, frictionless rails and then colliding with a stationary carriage, C2, at point *Q*. The two carriages stick together, and continue up the same set of frictionless rails to point *R*.

The total mass of carriage C1, including passengers, is 850 kg, and its initial velocity is 3.5 m s^{-1}.

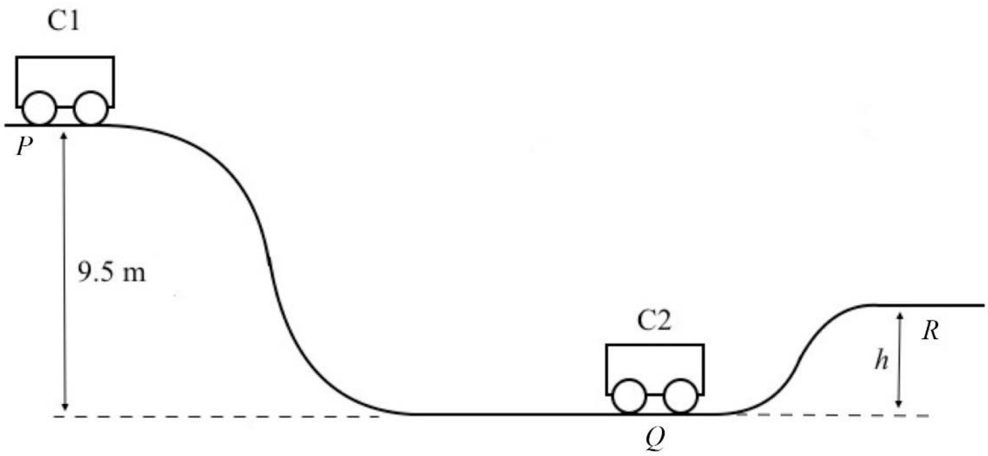


Figure 8

a. What is the velocity of carriage C1 just before it collides with carriage C2 at point *Q*?

3 marks

m s^{-1}

The total mass of carriage C2 is 550 kg, and it is stationary prior to carriage C1 colliding with it. The collision may be considered an isolated collision. After the collision, both carriages stick together and travel up the rail to point *R*, where they both come to a halt.

b. Explain what is meant by 'isolated collision', stating the necessary condition for it to occur and the outcome for the momentum of the system.

3 marks

c. Determine the velocity of the combined carriages just after the collision.

2 marks

m s^{-1}

d. Calculate the height, *h*, of the point *R* above the level of *Q*.

3 marks

m

Question 8 (5 marks)

A parcel with a mass of 4.5 kg is placed on the roof of a 750 kg car that is travelling at a speed of 17 m s^{-1} and going around a roundabout with a radius of 8 m. The parcel remains motionless relative to the roof of the car due to the friction between the parcel and the roof; however, it is about to begin to slide.

a. Calculate the magnitude of the friction force of the roof of the car on the parcel.

2 marks

N

b. The car now speeds up to 19 m s^{-1}.

What is the minimum radius that the car should travel around the roundabout so that the parcel remains motionless relative to the roof of the car?

3 marks

m

Question 9 (3 marks)

Teng and Sophie are discussing an experiment involving a mass suspended on a spring, as shown in Figure 9. Initially, the position of the mass is at the natural length of the spring. The mass is released and allowed to fall freely under gravity, and to extend the spring. At the maximum extension of the spring, the mass stops momentarily prior to it springing back upwards.

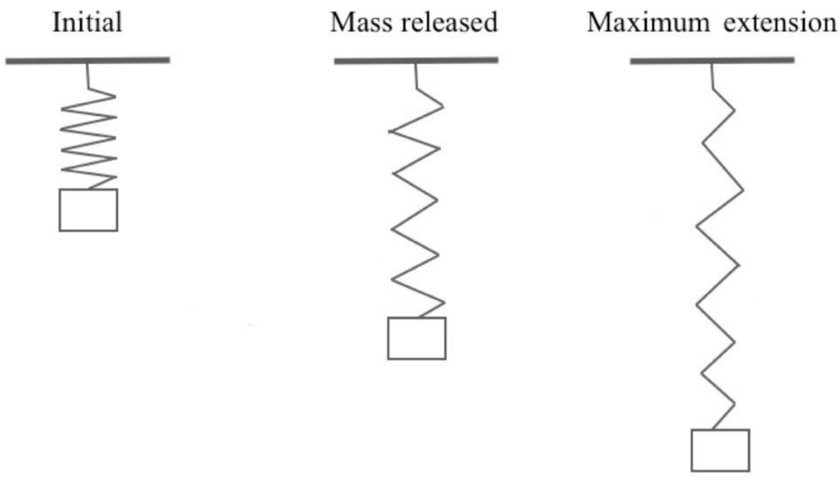


Figure 9

Regarding the kinetic energy of the mass as it falls between these two positions, Teng and Sophie make the following statements. Teng says, 'At the halfway point where the force due to gravity on the mass equals the elastic force of the spring, the kinetic energy of the system reaches its maximum.' Sophie says, 'At the halfway point, the majority of the total energy of the system is in the form of kinetic energy.'

Evaluate their opinions. Detailed calculations are **not** necessary.

Question 10 (3 marks)

Rhonda is a pilot and has a mass of 65 kg when in her full uniform and gear. On one occasion she performs a loop while flying at a constant speed of 235 km h^{-1} around the loop, as shown in Figure 10.

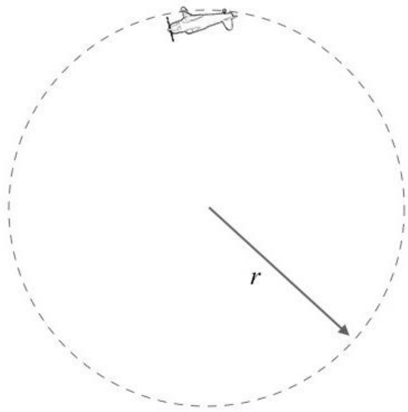


Figure 10

a. Convert Rhonda's speed of 235 km h^{-1} to m s^{-1}.

1 mark

m s^{-1}

b. At the top of the vertical loop, where Rhonda is flying upside down, a scale measured the normal reaction force on Rhonda by her seat to be magnitude 853 N.

Determine the radius, *r*, of the loop.

2 marks

m

Question 11 (6 marks)

Muons are unstable particles generated from the collision of high-energy photons with air molecules in the upper atmosphere of Earth, and they travel close to the speed of light towards the surface of Earth.

Classical physics predicts that muons will not be detected near to the surface of Earth because they have a very short half-life, and are expected to all decay before they completely move through the atmosphere.

However, scientists are able to detect these muons at Earth's surface.

a. With particular reference to time dilation and frames of reference, explain why muons may be detected despite their short lifetime. Take the mean lifetime of a muon to be 2.2 microseconds (i.e. 2.2×10^{-6} s).

3 marks

b. In the frame of reference of the muons, they travel about 600 m into the atmosphere before they decay completely. However, to physicists on Earth they are detected about 20 km after they are generated in the atmosphere. This apparent contradiction is due to the relativistic effects of length contraction.

At what proportion of the speed of light must the muons be travelling to enable their detection? Give your answer to five significant figures.

3 marks

	c

Question 12 (5 marks)

Ayden is investigating the phenomenon of refraction using a laser beam and a large container of water with a thick separate layer of oil on top of the water, as shown in Figure 11. The refractive indices of air and water are, respectively, $n_{\text{air}} = 1.00$ and $n_{\text{water}} = 1.33$, whereas the refractive index of the oil is unknown.

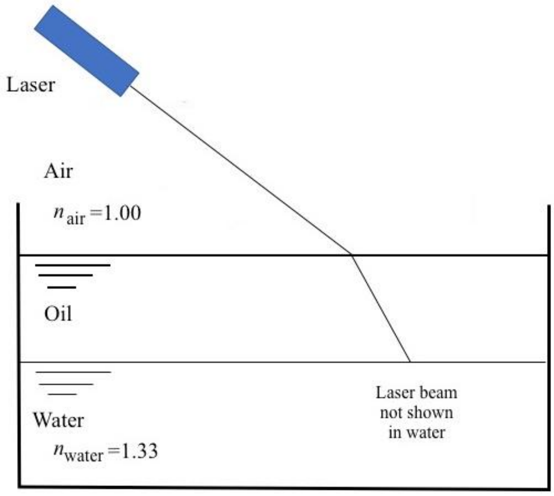


Figure 11

a. Ayden measures the incident angle of the laser beam to be 28°, and the refracted angle in the oil is 18.5°.

Use this information to determine the refractive index of the oil.

2 marks

b. The laser beam continues to travel from the oil into the water, being refracted at the interface between the oil and water.

State whether the refracted angle in water is smaller or larger than the incident angle in oil, and provide a detailed reasoning for your choice.

3 marks

Question 13 (2 marks)

Danica and Lewis are motoring enthusiasts who attended the Melbourne Grand Prix this year. They took sound frequency analysers with them to record the frequency of the sound made by the Formula 1 engine of ace driver Francesca as she drove at a constant speed down the middle of the main straight. This frequency may be considered as a pure tone. Positioned at either end of the main straight, Danica recorded the frequency as 567 Hz, whereas Lewis recorded the frequency as 1275 Hz.

a. Identify whether Danica or Lewis is at the start of the main straight.

1 mark

---

b. On another lap, Francesca battled a headwind, resulting in a slower speed down the main straight, even though the engine was still producing the same power and, hence, the same sound frequency as in previous laps.

State whether the frequency recorded by Lewis will increase or decrease.

1 mark

Question 14 (6 marks)

Shan is carrying out an experiment to investigate the wave-like behaviour of light, using several monochromatic lasers of different wavelengths, some double-slit slides with varying slit separation (*w*) and a screen. She shines a laser beam through a double-slit slide and obtains a pattern on the screen. The pattern is a series of bright fringes, with no laser illumination between them, as illustrated in Figure 12.

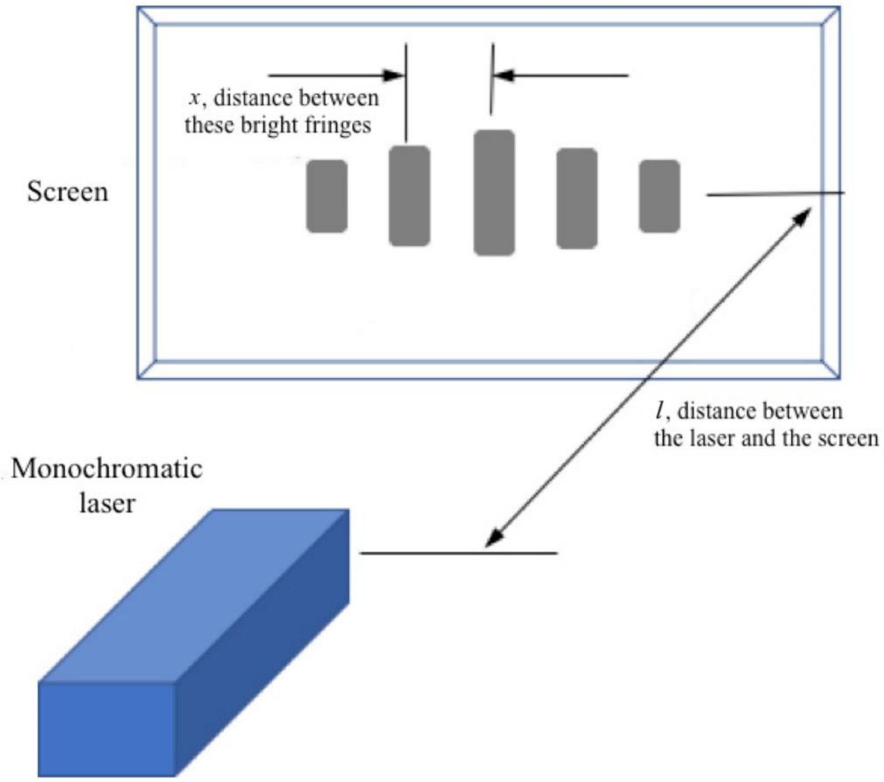


Figure 12

a. Using a double-slit slide with a slit separation of 10 μm, Shan investigates the effect of increasing the wavelength of the laser used.

State whether the distance between the fringes, x, will increase or decrease with increasing laser wavelength.

1 mark

___

b. Shan proceeds to investigate the effect of increasing the slit separation of the double-slit slide, using only a helium–neon laser with a wavelength of 633 nm.

State whether the distance between the fringes, x, will increase or decrease with increasing slit separation.

1 mark

___

c. Identify the name of the pattern on the screen. Circle the correct answer in the list below.

1 mark

Diffraction

Interference

d. Explain how the pattern on the screen that is produced by the laser beam shining through a double slit supports the idea that light behaves as a wave.

3 marks

Question 15 (6 marks)

A teacher is demonstrating the photoelectric effect in class by bombarding a metal sample with monochromatic light in an evacuated tube. She records the following single piece of data: when the frequency of the incident light is 6.45×10^{14} Hz, she finds the stopping voltage to be 1.47 V.

a. Determine the energy of the most energetic photoelectrons emitted from the metal sample. Give your answer in joules.

1 mark

____

____

| J |

b. Use your result to determine the work function of the metal sample. Give your answer in eV.

3 marks

____

____

____

____

____

____

| eV |

c. The teacher now changes the light source to one with a longer wavelength, and photoelectrons are still emitted.

Will the stopping voltage increase, decrease or stay the same?

1 mark

____

d. The teacher now increases the intensity of the light.

Will the stopping voltage increase, decrease or stay the same?

1 mark

____

Question 16 (7 marks)

The energy-level diagram for an element, Z, is shown in Figure 13 below.

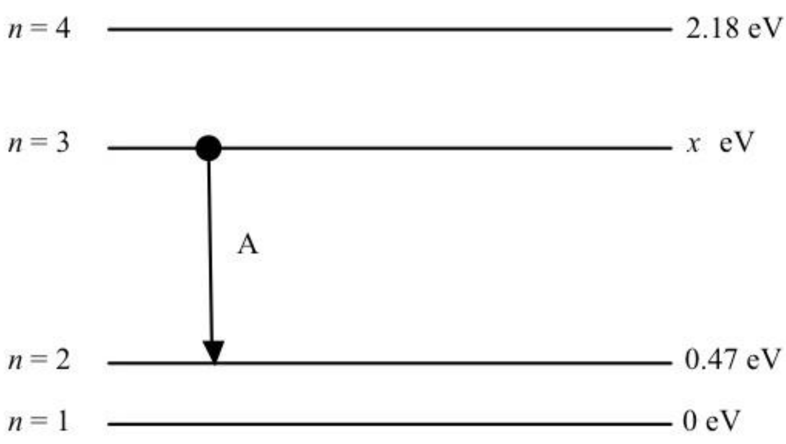


Figure 13

a. The arrow labelled A represents one of the possible energy-level transitions that element Z can undergo when excited into the $n = 3$ state.

On Figure 13, draw the other **two** possible transitions.

2 marks

b. The energy-level transition shown by the arrow labelled A is associated with the emission of a photon of momentum 7.1×10^{-28} N s.

Determine the value for *x* of the $n = 3$ energy level of element Z.

3 marks

eV

c. Explain why a beam of photons with energy 0.55 eV, incident on a gaseous sample of element Z, will not be absorbed.

2 marks

Question 17 (5 marks)

A research scientist is investigating the structure of a crystal, using diffraction techniques. Figure 14 is a schematic diagram showing a crystal being bombarded by radiation and producing a diffraction pattern.

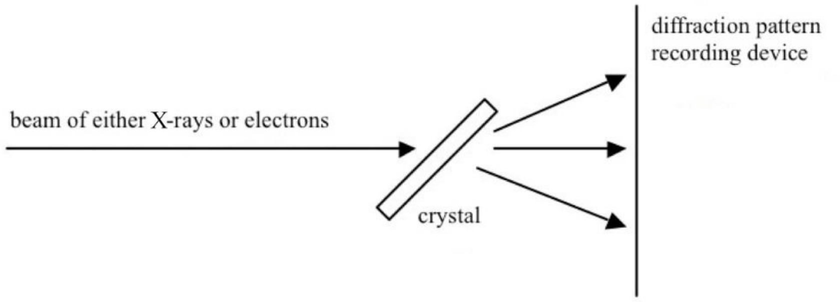


Figure 14

In one experiment the scientist chooses to use a beam of X-rays, and in a second experiment he chooses to use a beam of electrons to strike the crystal.

In each case the X-rays and electrons have the same wavelength of 2.0×10^{-10} m.

a. Determine the energy of a single X-ray photon used in the experiment.

2 marks

J

b. Determine the kinetic energy of a single electron used in the experiment.

3 marks

J

Question 18 (5 marks)

Jack has a height of 183 ± 2 cm and his older sister Venus has a height of 154 ± 3 cm.

a. Determine the percentage uncertainty in Jack's height. Give your answer to one decimal place.

1 mark

%

b. Determine how much taller Jack is compared to Venus. Include the uncertainty for this difference in your answer.

2 marks

cm

c. Find the ratio of Venus' height to her brother's height, accurate to two decimal places. Include the uncertainty in this ratio. You may use the additional information that the percentage uncertainty in Venus' height is 1.9%.

2 marks

Question 19 (11 marks)

As part of a practical investigation, a group of students decides that they will release a ball bearing into a tall cylinder of oil and record several values of the variable t, the time it takes for the ball bearing to hit the bottom of the cylinder. They will do this for different depths of oil in the cylinder, the variable x.

Their initial hypothesis is that the greater the depth of oil, the longer the time it will take for the ball bearing to reach the bottom of the cylinder.

a. For this experiment, state the dependent and independent variables.

2 marks

The dependent variable is ________________________________.

The independent variable is ______________________________.

b. Give an example of a quantity that should be controlled and kept constant, as best as possible, as the students collect data.

1 mark

____

c. Explain why repeat measurements of a single trial within the experiment should be made.

1 mark

____

____

The measurements made by the group are shown in the table below, and a preliminary graph of the data is shown in Figure 15. The data shown in the table are the average of three measurements (which are not shown). The uncertainties associated with the measurements are shown on the graph in Figure 15.

x = depth of oil (m)	***t = time to hit bottom (s)***
0.10	0.92
0.20	1.35
0.80	2.75
1.20	3.35
2.00	4.35
3.00	5.20

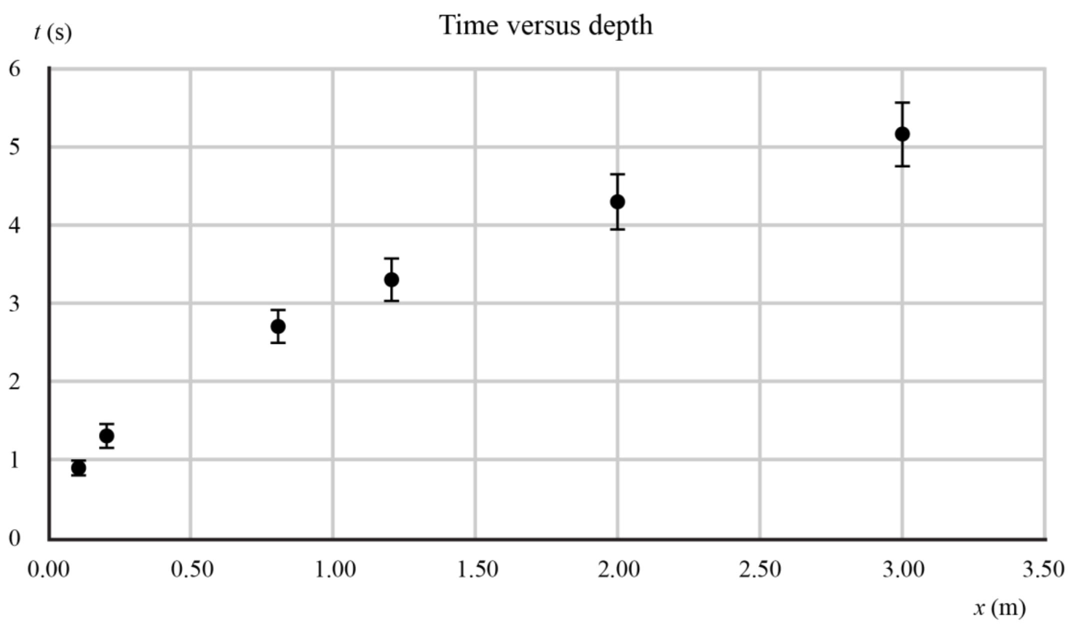


Figure 15

d. From the graph, accurately estimate the absolute error in the timing measurement when the depth of oil is 3.00 m.

1 mark

s

e. One of the students in the group suggests that the data could be perhaps better modelled by a non-linear relationship.

Of the options below, which would be the best proportionality to model the data? Circle your answer.

1 mark

- Time taken to fall is inversely proportional to the depth of oil; $t \propto \frac{1}{x} \Rightarrow t = \frac{k}{x}$.
- Time taken to fall is proportional to the square of the depth of oil; $t \propto x^2 \Rightarrow t = kx^2$.
- Time taken to fall is proportional to the square root of the depth of oil; $t \propto \sqrt{x} \Rightarrow t = k\sqrt{x}$.

f. In order to test the choice of model to fit the data, a new variable, *z*, is to be computed from each value of *x*, using the model of your choice from **part e.**

Complete the second column (labelled *z*) in the table below according to the model you selected:

- $z = \frac{1}{x}$
- $z = x^2$
- $z = \sqrt{x}$

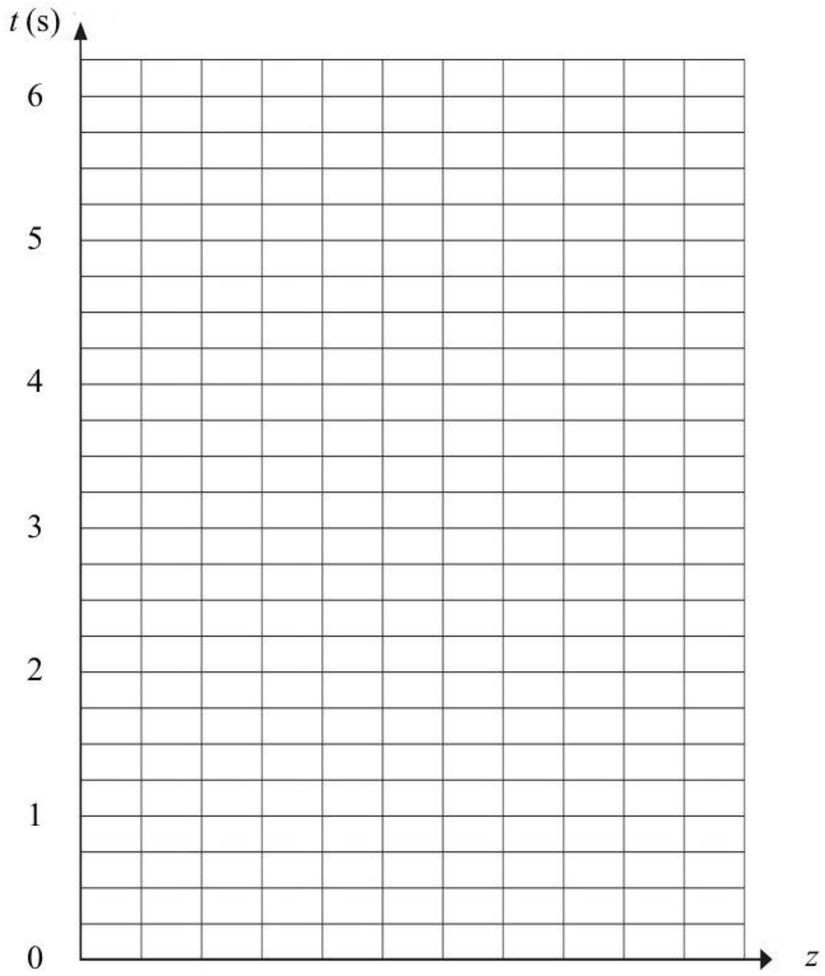
2 marks

***x* = depth of oil (m)**	***z* = new variable to test the model chosen**	***t* = time to hit bottom (s)**
0.10		0.92
0.20		1.35
0.80		2.75
1.20		3.35
2.00		4.35
3.00		5.20

g. To test the fit of the model chosen, the data in the table on the opposite page is to be plotted on a graph.

On the grid provided below, plot the data from the table. The *y*-axis scale has been done for you. You will need to choose the scale for your *z* variable in the middle column of the table.

2 marks



h. Does your graph support or not support your choice to **part e.**? For either answer explain why.

1 mark

END OF QUESTION AND ANSWER BOOK