TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

External Assessment 2024

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PHYSICS

PHY415115

Section A Newtonian Physics

Pages: 16
Questions: 6
Information Sheet: 1

Preparation time for this exam: 15 minutes

Suggested working time: 45 minutes

Instructions:

- Answer **all** questions and **all** items within each question.
- Write your answers in the spaces provided in this exam paper.
- Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagram.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physics Information Sheet can be used throughout this exam.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 45 minutes**.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C5	/ 45

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Guide to Exam Structure

	Questions available	Questions to answer	Suggested working time	Marks available
Section A	6	6	45 minutes	45 marks
Section B	6	6	45 minutes	45 marks
Section C	6	6	45 minutes	45 marks
Section D	6	6	45 minutes	45 marks
Totals	**24**	**24**	**180 minutes (3 hours)**	**180 marks**

Criterion

You **must** make sure your answers address:

- Criterion 5 identify and apply principles of Newtonian mechanics including gravitational fields.

Question 1

Marker use

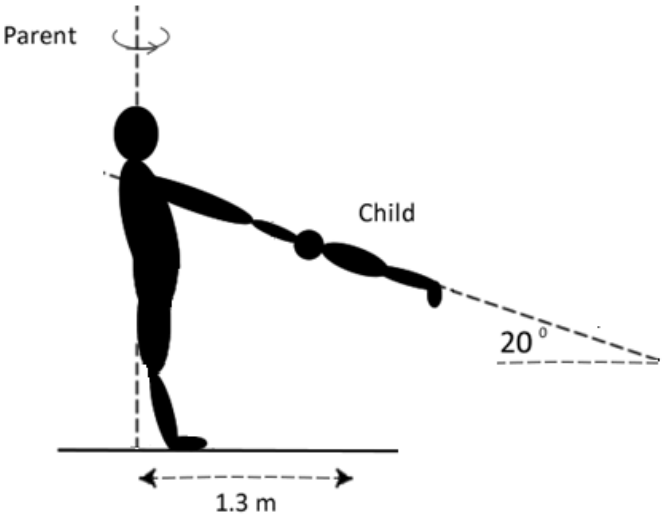

Figure 1: Diagram of parent swinging their child in a circle by the arms.

A parent is swinging their child in a circle by the arms. The child has a mass of 25 kg and the radius of the circle that describes the child's motion is 1.3 m. The child is supported at a constant angle of 20° to the horizontal.

a) Sketch and label the forces on the child.

/2

Figure 2: Representation of a child to sketch and label your answer.

Spare diagram used (X) ☐

Question 1 continues

Marker use

b) Calculate the magnitude of the force that the parent is exerting on the child's arms.

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c) Calculate the net force on the child.

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d) Calculate the tangential speed of the child.

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e) Calculate the time for the child to complete **one (1)** circle.

/2

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Total Q1

/10

Question 2

Marker use

A cart of mass 1.00 kg is released up an inclined ramp with an initial speed of 1.50 m s^{-1}. The ramp makes an angle of 15^{o} to the horizontal.

A frictional force of 10% of the cart's weight is present throughout its motion.

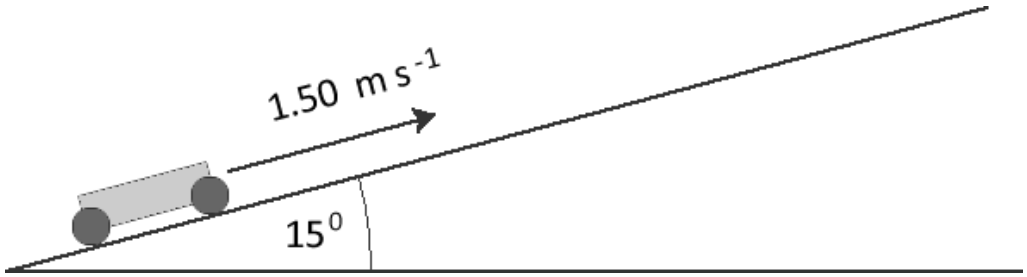

Figure 3: Diagram of a cart rolling up and down an inclined ramp.

a) Calculate the magnitude of the frictional force that is acting throughout its motion.

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b) Calculate the acceleration of the cart during its motion up the ramp, using a relevant vector diagram. /2

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Question 2 continues

Marker use

c) Calculate the maximum displacement of the cart up the ramp.

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d) Draw a velocity-time graph of the cart's motion from release until it returns to its initial position. Include intercept values on both axes and label important points. Provide calculations in the space provided below.

/4

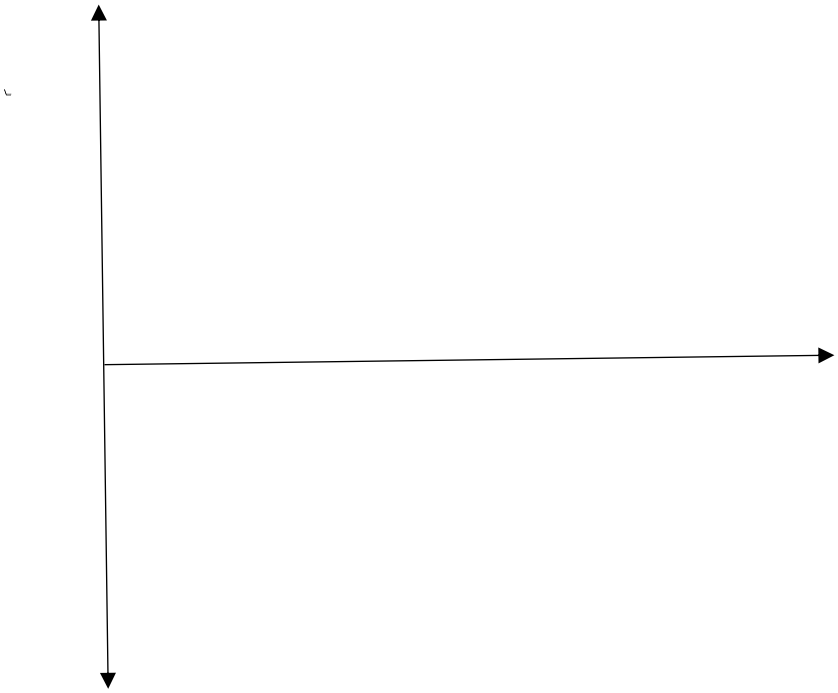

Figure 4: Axes to sketch your answer on.

Spare diagram used (X) ☐

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Total Q2

/9

Question 3

Marker use

A fascinating “star” called a neutron star or pulsar has a **diameter** of only about 30 km and a mass of 2.79×10^{30} kg. It is the remnants of the core of a supernova star.

a) Calculate the gravitational field strength at the surface of this object.

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A planet exists at an orbital radius of 9.0×10^{10} m from the neutron star.

b) Calculate the orbital period of the planet, in Earth days.

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Total Q3

/5

Question 4

Marker use

During a game of cricket, a player hits a “six”, where the ball is hit cleanly over the boundary, with a range of 120 m. It is struck at an angle of 40º.

Assume the ball is struck from ground height and arrives at ground height over the boundary.

a) If the initial speed of the ball is u and the time of flight is t, derive the following equations for time and speed.

i. $u\,cos40^0 = \frac{120}{t}$ /2

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ii. $u\,sin40^0 = 4.91t$

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b) Hence calculate the initial speed of the ball.

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Total Q4 /7

Question 5

Marker use

Football player A (Alice) has mass 65 kg and is initially running at 5.00 m s^{-1} towards north. Player A meets player B (Beatrix) who has mass 72 kg and is initially running at 5.50 m s^{-1} towards west. After colliding, the two players tangle with each other.

a) Calculate the total momentum of the two players with the aid of a vector diagram.

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b) Calculate the final velocity of the two entangled players.

/2

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Total Q5

/7

Question 6

Marker use

Ariane 5 is a large rocket.

a) On the diagram below, sketch the forces acting on the rocket during lift-off. Indicate the relative size of the forces by the vector drawn. /2

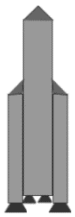

Figure 5: Diagram to sketch your answer on.

Spare diagram used (X) ☐

b) If its lift-off mass is 780 tonnes and it accelerates upwards at 2 m s^{-2} immediately on lift-off, calculate the magnitude of the force that the rocket motors provide. /2

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c) Some time into the flight, it has burnt a considerable amount of fuel, lowering its mass, but the motors provide the same force. If its acceleration is now 30 m s^{-2}, calculate the mass of the rocket. (You may assume that g=9.81 N / kg.) /3

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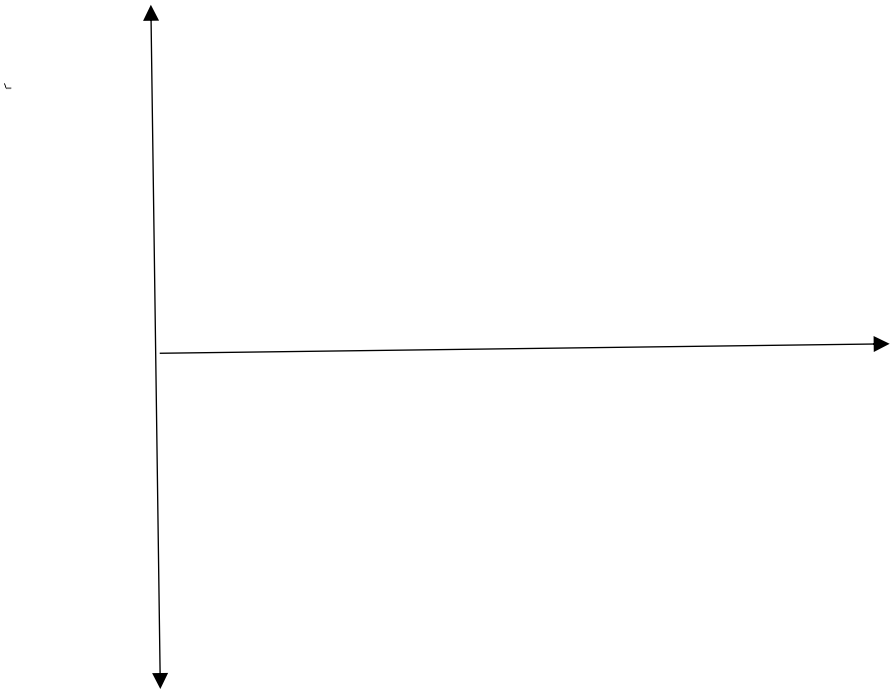
Total Q6 /7

Spare Diagrams

Question 1 a)

Question 2 d)



Question 6 a)

End of Section A

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PHYSICS

PHY415115

Section B Electromagnetism

Pages: 16
Questions: 6
Information Sheet: 1

Suggested working time: 45 minutes

Instructions:

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Marker use	
C6	/ 45

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Guide to Exam Structure

	Questions available	Questions to answer	Suggested working time	Marks available
Section A	6	6	45 minutes	45 marks
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Section C	6	6	45 minutes	45 marks
Section D	6	6	45 minutes	45 marks
Totals	**24**	**24**	**180 minutes (3 hours)**	**180 marks**

Criterion

You **must** make sure your answers address:

- Criterion 6 identify and apply principles of electricity and magnetism.

Question 7

Marker use

a) A calcium atom loses two of its electrons to form a doubly-charged positive ion with a charge of +3.2 x 10^{-19} C. Calculate the magnitude of the electrostatic force that it exerts on an electron which is 4.0 $\times$ 10^{-10} m from it. /2

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The mass of calcium ions can be determined in a 'time of flight' mass spectrometer by accelerating the ions through a potential difference and then finding the time taken for them to move at constant speed through a 'drift tube'.

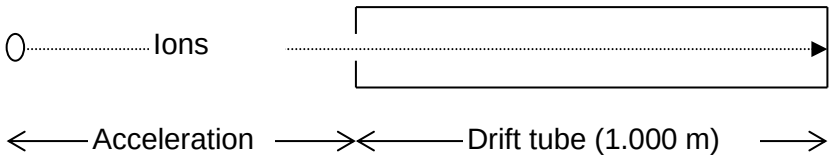

Figure 6: Diagram of ions moving through a drift tube.

b) If the time taken to travel through the drift tube is 2.275 μs and the length of the tube is 1.000 m, calculate the speed of the ions in the drift tube. /1

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c) If the ions were accelerated through a potential difference of 2.00 $\times$ 10^{4} V prior to entering the drift tube show that their kinetic energy in the drift tube is approximately 6 $\times$ 10^{-15} J. /2

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d) Calculate the mass of the ions in kg. /2

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Total Q7 /7

Question 8

Marker use

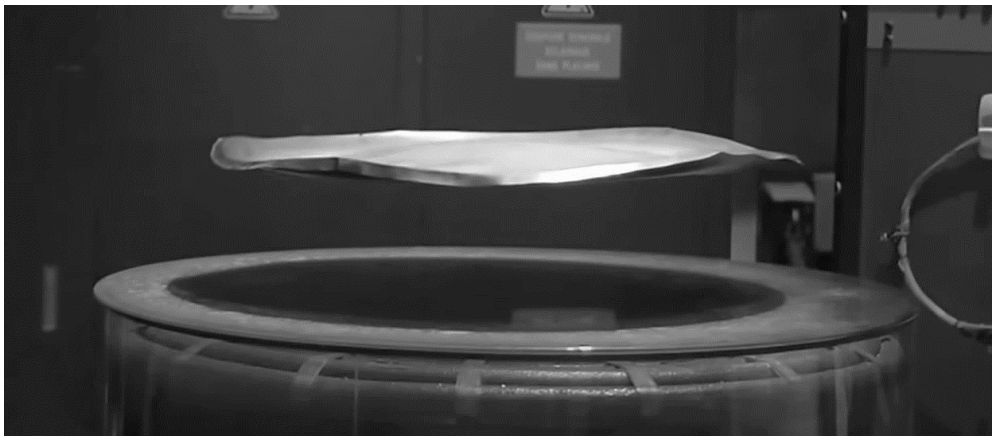

Figure 7: Picture of an aluminium plate over a large coil of wire.

In a science museum in Paris, there is an experiment where an aluminium plate is levitated over a large coil of wire. The coil carries 800 A of alternating current, changing at a frequency of 800 Hz.

a) Explain why the aluminium plate levitates, with reference to relevant principles and laws.

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b) Describe what would happen if direct current (rather than alternating current) was used.

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c) Describe what would happen if the aluminium plate was replaced with a thin steel plate. (Note that steel contains iron.)

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Total Q8

/5

Question 9

Marker use

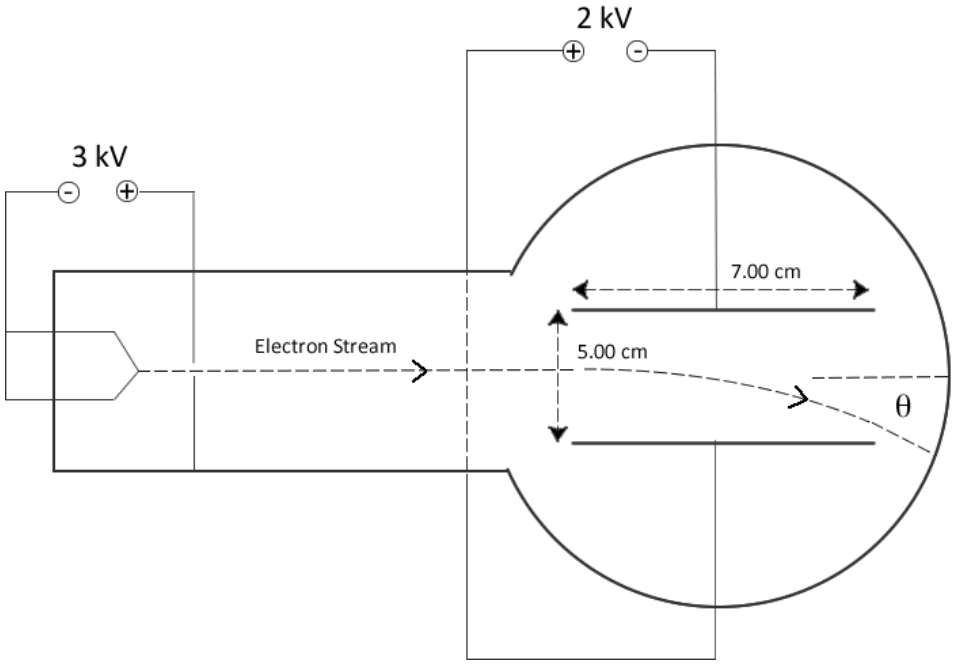

Figure 8: Diagram of a vacuum tube.

Spare diagram used (X) ☐

In a vacuum tube, an electron is accelerated between a cathode and anode with an accelerating voltage of 3000 V.

a) Calculate the speed with which the electron reaches the anode. (You may assume that its initial speed is negligible.) /3

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The same speed electron passes through a hole and enters a uniform electric field midway between two plates, 7.00 cm long and 5.00 cm apart. The plates are at a potential difference of 2000V.

b) Calculate the electric field strength between the plates. /1

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Question 9 continues

Marker use

c) Calculate the angle, θ, at which the electrons emerge from the electric field.

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A magnetic field is placed at right angles to the electric field to cancel the angle of emergence.

d) Calculate the magnetic field strength necessary to cancel the angle of emergence.

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e) Sketch the direction of the magnetic field on the diagram in Figure 8 on Page 6.

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Total Q9

/10

Question 10

Marker use

A rectangular coil of wire inside a uniform magnetic field can be made into either a simple electric motor or a generator of electricity.

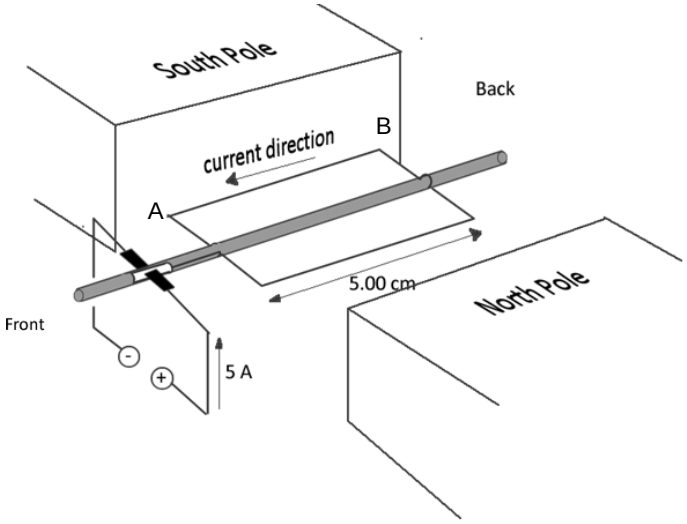

Figure 9: Diagram of a rectangular coil of wire inside a magnetic field.

In the above diagram (Figure 9), the rectangle is made of 30 turns of wire, with the size of the rectangle 5.00 cm by 2.00 cm.

The magnetic field has a flux density B of 0.2 T uniformly between the poles.

Commutator strips are mounted on the axle. Brushes connect the rectangle to a stationary circuit.

A DC current of 5 A is sent into the rectangle.

a) Calculate the magnitude of the force on the **side AB**.

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Question 10 continues

Marker use

b) Will the motor run clockwise or counter-clockwise as viewed from the front? Justify your reasoning.

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c) Why are the commutator strips wrapped only part way around the axle?

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Total Q10

/6

Question 11

Marker use

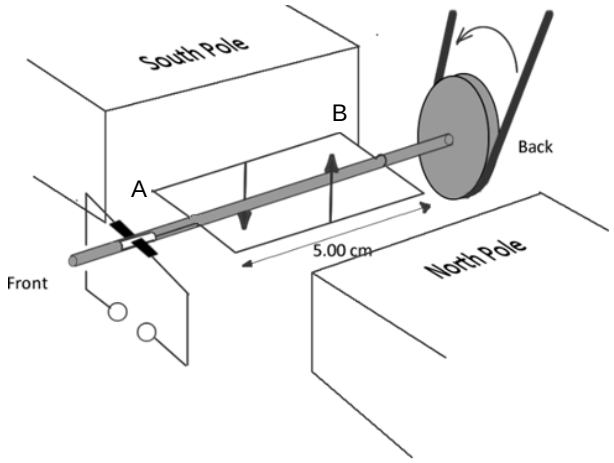

Figure 10: Diagram of rectangular coil connected to a pulley.

In Figure 10 above, the same 30-turn coil from Question 10 is now disconnected from the power source and connected to a pulley which rotates the coil at 50 Hertz.

The size of the rectangle is 5.00 x 2.00 cm.

The magnetic field has a flux density B of 0.2 T uniformly between the poles.

a) Show that the speed of the side AB is about 310 cm s^{-1}.

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Question 11 continues

Marker use

b) Calculate the maximum emf generated by the **side AB**.

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c) Sketch a graph of the potential difference generated at the outputs against time. Start from the position shown in Figure 11.

/2

Figure 11: Axes for you to sketch your answer on.

Spare diagram used (X) ☐

The output is now connected to a load of 20 Ω.

d) The current induced in side AB will result in a force that will oppose the motion of the coil. Calculate the magnitude of the force.

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Total Q11

/9

Question 12

Marker use

A + 4.0 µC charge and a + 6.7 µC charge are placed 10 cm apart as shown. A point P is located 7 cm from both charges.

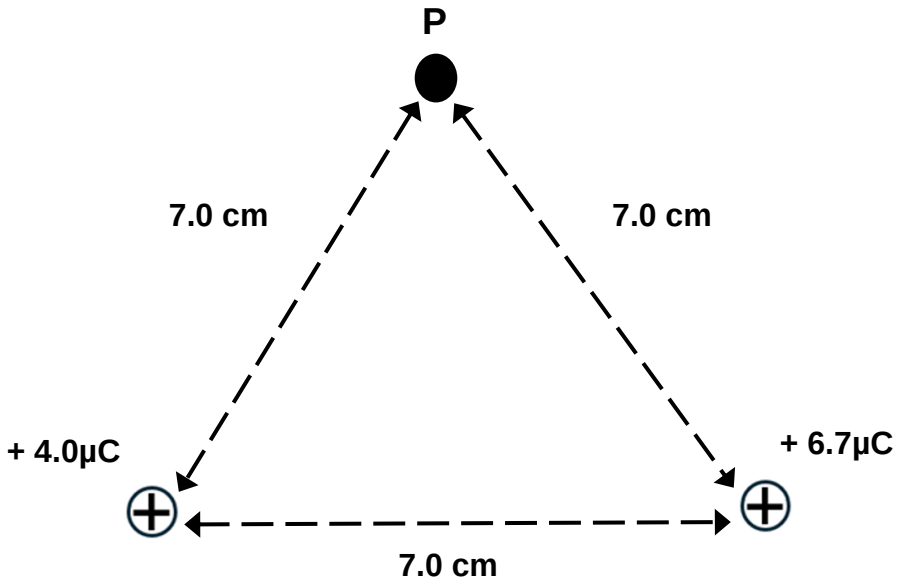

Figure 12: Diagram showing two different charges.

a) In the space below, draw the electric field around the two charges.

/2

Figure 13: Diagram of charges to sketch your answer on.

Spare diagram used (X) ☐

Question 12 continues

Marker use

b) With the aid of a suitable vector diagram, calculate the magnitude and direction of the electric field strength at the point P.

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c) Calculate the magnitude of the electrostatic force acting on a charge of -2×10^{-8} C, placed at point P.

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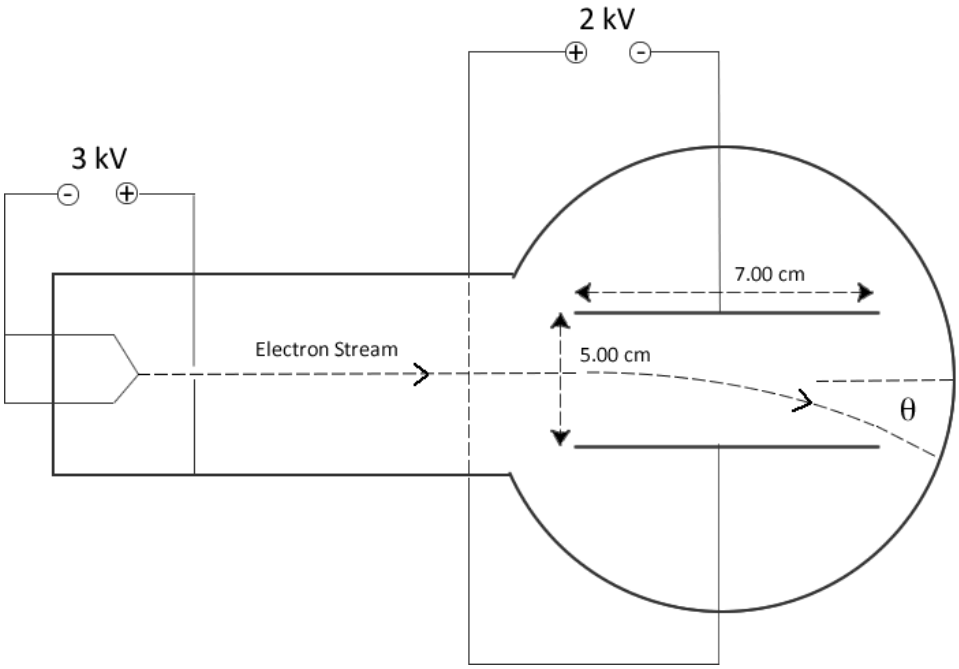
Total Q12

/8

Spare Diagrams

Question 9



Question 11 c)

Question 12 a)

End of Section B

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PHYSICS

PHY415115

Section C Waves

Pages: 20
Questions: 6
Information Sheet: 1

Suggested working time: 45 minutes

Instructions:

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Marker use	
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Section D	6	6	45 minutes	45 marks
Totals	**24**	**24**	**180 minutes (3 hours)**	**180 marks**

Criterion

You **must** make sure your answers address:

- Criterion 7 identify and apply general principles of wave motion.

Question 13

Marker use

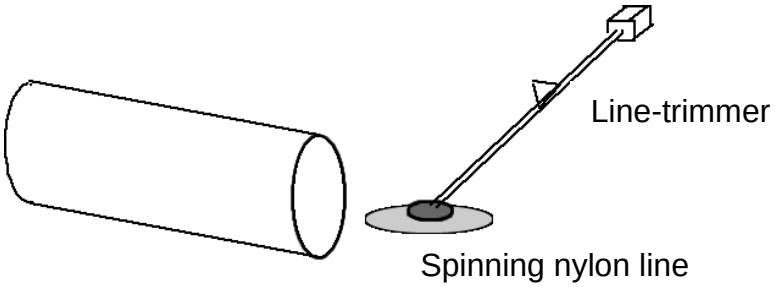

Figure 14: Picture of a line-trimmer in front of a large pipe.

A person is using a noisy line-trimmer in front of a large pipe. The pipe starts to emit a strong sound with a frequency of 40 Hz. The person investigates the pipe and finds it to be open at both ends.

a) Describe what is happening to produce this sound. Use a sketch to aid your explanation. (You may assume that the sound heard is at the fundamental frequency.)

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If the velocity of sound on this particular day is 343 m s^{-1}.

b) Calculate the approximate length of the pipe.

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Question 13 continues

Marker use

Air is compressible and so the diameter of the pipe plays a part in the sound. “End corrections” must be added to the real length of the pipe. The correction is as follows:

Corrected length of pipe = actual length of pipe + (0.6 x pipe diameter).

c) Sketch the wave pattern of the fundamental frequency. Show clearly the end corrections. /2

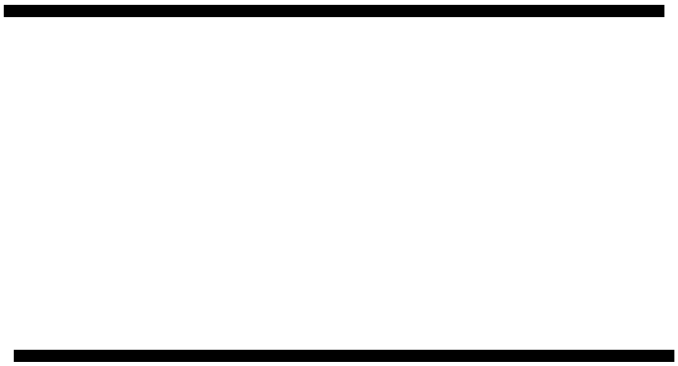

Figure 15: Diagram on which to sketch your answer.

Spare diagram used (X) ☐

d) The person then moves to a point near another pipe that is longer and closed at one end. The sound that they hear is the frequency of the first overtone. Sketch the wave pattern in the space below. (You may ignore end corrections in this sketch.) /2

Total Q13 /9

Question 14

Marker use

A harbour is protected by a sea wall with two gaps in it to permit vessels to pass in and out. The gaps are 200 m apart.

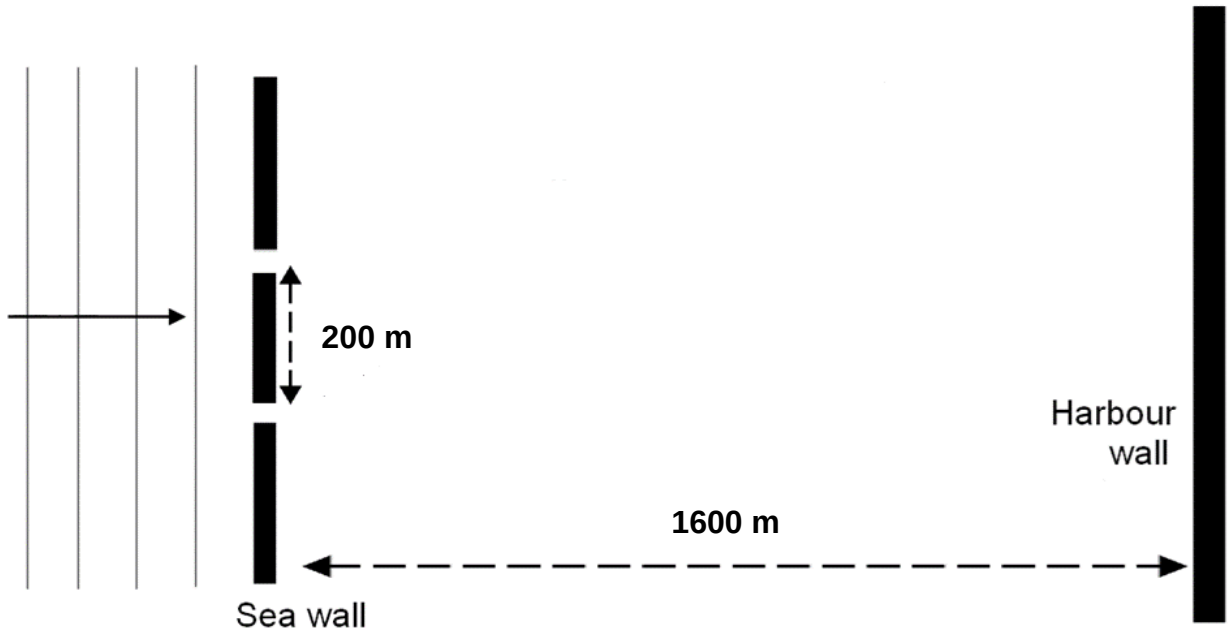

Figure 16: Diagram of a harbour protected by a sea wall.

Spare diagram used (X) ☐

Sea waves with a wavelength of 50 m strike square-on to the sea wall as shown above.

a) Sketch on the diagram above the subsequent wavefront patterns after passing through the gaps. Show only the first three wavefronts. /2

Question 14 continues

Marker use

Consider a point P in the harbour. A fishing boat is anchored there. The point P is 300 m from one gap and 425 m from the other gap.

b) Would the boat experience relatively calm or rough conditions? Clearly explain your reasoning. Include a sketch of a possible position of point P, relative to the gaps in the sea wall.

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At the harbour wall a distance of 1600 m away, alternating areas of rough and calm conditions are noted.

c) Estimate the distance between successive areas of rough water along the harbour wall.

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d) Explain why your calculation in c) is only an estimate.

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Total Q14

/8

Question 15

Marker use

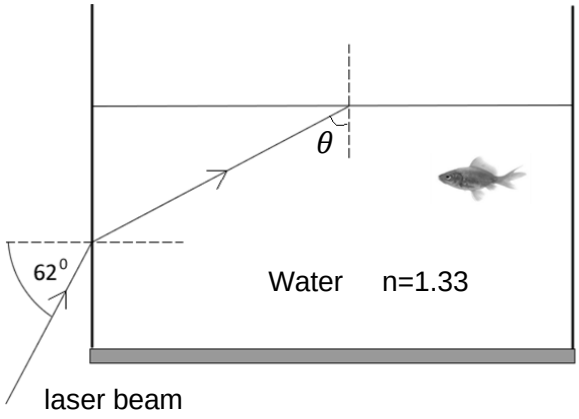

Figure 17: Diagram of a laser beam shone into a fish tank.

A laser beam is shone into a fish tank from the side, so as to later meet the water-air boundary at the top of the tank.

The angle of incidence of the beam to the glass at the side of the tank is 62 °.

The refractive index of water is 1.33 for this particular wavelength.

a) Calculate θ, the angle of incidence of the beam on the water-air boundary. Ignore the glass in your calculation. /3

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b) Will any light emerge into the air at the water-air boundary? Use calculations to help justify your answer. /2

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Question 15 continues

Marker use

The walls of the tank are glass with a refractive index of 1.58 and a thickness of 4 mm.

c) Use calculations to show why the glass could be ignored in part a).

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Total Q15

/8

Question 16

Marker use

A transverse pulse in a string strikes a rigid end P.

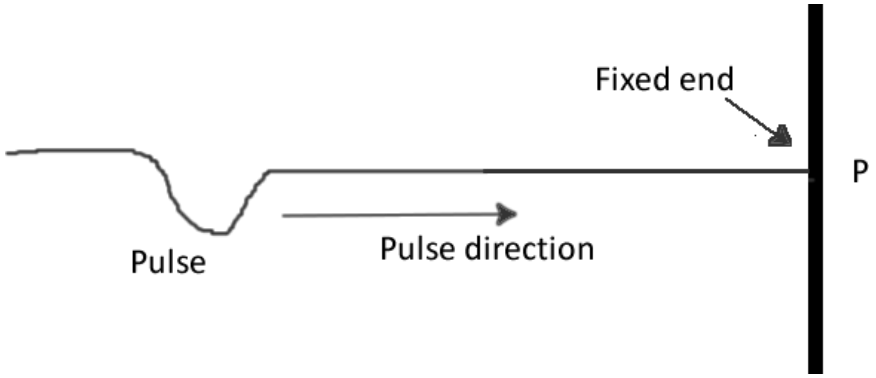

Figure 18: Diagram of a transverse pulse in a string.

Spare diagram used (X) ☐

a) Using Figure 18 above, sketch the reflected pulse. /1

A pulse in a similar string strikes a free floating end, Q.

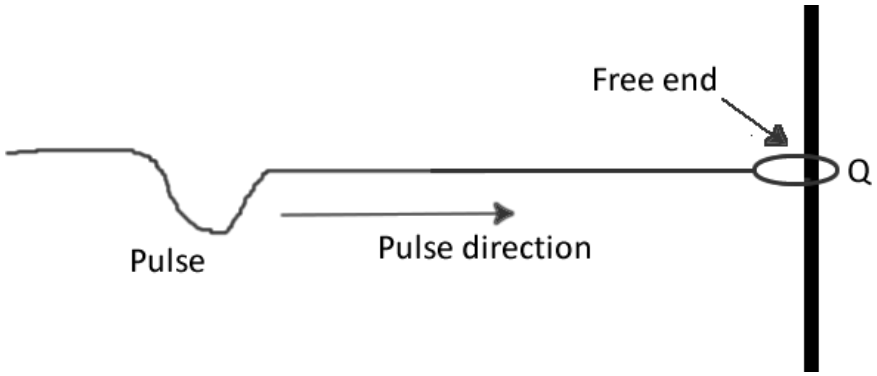

Figure 19: Diagram of a pulse in a similar string.

Spare diagram used (X) ☐

b) Using Figure 19 directly above, sketch the reflected pulse. /1

Question 16 continues

Marker use

The pulse is now travelling from one string (String A) into a heavier string (String B).

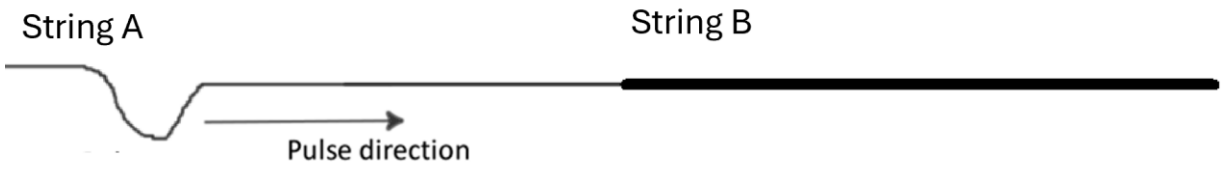

Figure 20: Diagram of a pulse travelling from one string to a heavier string.

Spare diagram used (X) ☐

c) String A has a tension of 17 N and linear density of 17 g m^{-1}. Calculate the speed of the pulse in the string. /2

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d) Describe how the speed of the pulse will change as it enters String B. /1

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e) On Figure 20 above, draw the resulting pulse(s) a few moments after the initial pulse has encountered the boundary between String A and String B. /2

Total Q16 /7

Question 17

Marker use

Seismic waves are mechanical waves passing through the Earth due to volcanic eruptions, earthquakes and similar major disruptions.

They are classified as two types, P (Primary) and S (Secondary) with different properties. One type is **transverse** while the other is **longitudinal**. The diagrams below (Figure 21) show how each type of wave propagates through the layers within the Earth.

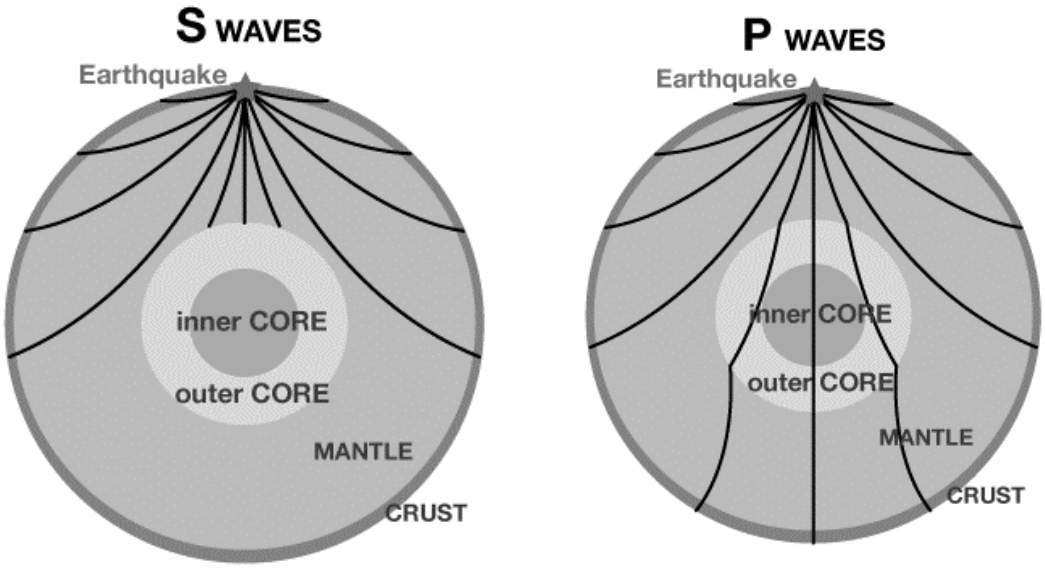

Figure 21: A ray diagram showing how S waves and P waves propagate through the different layers of the earth.

Image Source: https://www.usgs.gov/media/images/p-wave-and-s-wave-paths-through-earth

a) Transverse waves cannot travel through the **liquid** outer core but longitudinal waves can. Using the diagram above, determine whether S waves are transverse or longitudinal. /1

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b) Suggest a reason why transverse waves cannot travel through a liquid. /1

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Question 17 continues

Marker use

Some P waves pass from the mantle into the outer core. Examine the path of one of the P waves at this boundary in Figure 21 on the opposite page.

c) The diagram below models a P wave reaching the boundary between the mantle and the outer core. Continue this diagram to show what happens to the wave after it meets this boundary. /1

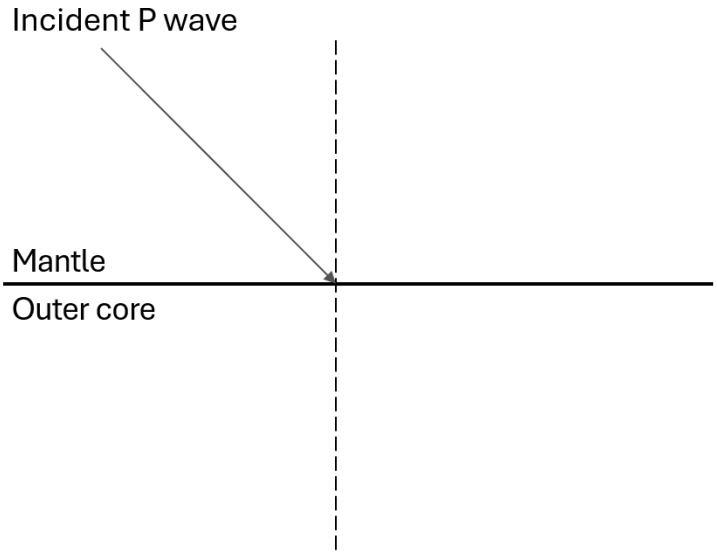

Figure 22: Diagram to sketch your answer.

Spare diagram used (X) ☐

d) Using the diagram above (Figure 22), determine whether the wave speeds up or slows down when it crosses the boundary. /1

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e) In reality the density of the mantle and outer core both increase steadily with depth into the Earth, rather than existing as a clear boundary. Explain the resulting curved paths of P waves through these layers. /2

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Total Q17 /6

Question 18

Marker use

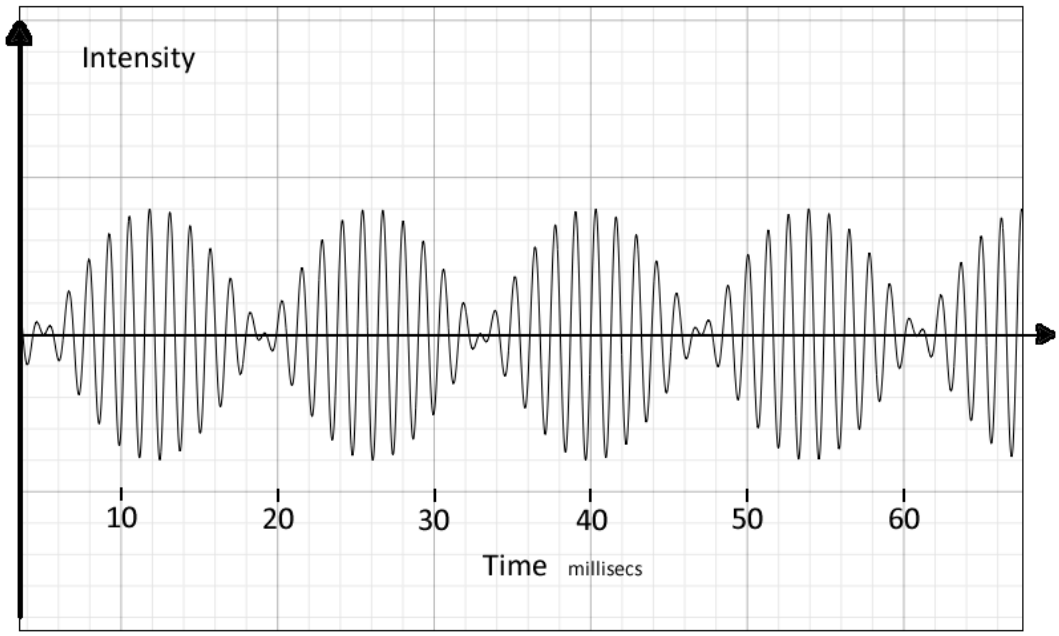

Figure 23: Graph showing intensity and time for two instruments playing at equal volume.

Spare diagram used (X) ☐

Two instruments are playing at equal volume. The resultant sound is a horrible beating noise. Their combined output is shown on the graph above in Figure 23. The vertical axis is intensity, and the horizontal axis is time. (Note that the vertical axis does not cross the horizontal axis at time zero.)

a) Clearly indicate regions of constructive and destructive interference on the graph in Figure 23 above. /2

b) On the diagram above (Figure 23), mark an interval of time corresponding to one "beat". /1

c) Estimate the "beat frequency" of the beat pattern shown above (Figure 23). /2

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d) If one instrument is playing at 910 Hz, give possible frequencies of the other instrument based on your calculation above. /2

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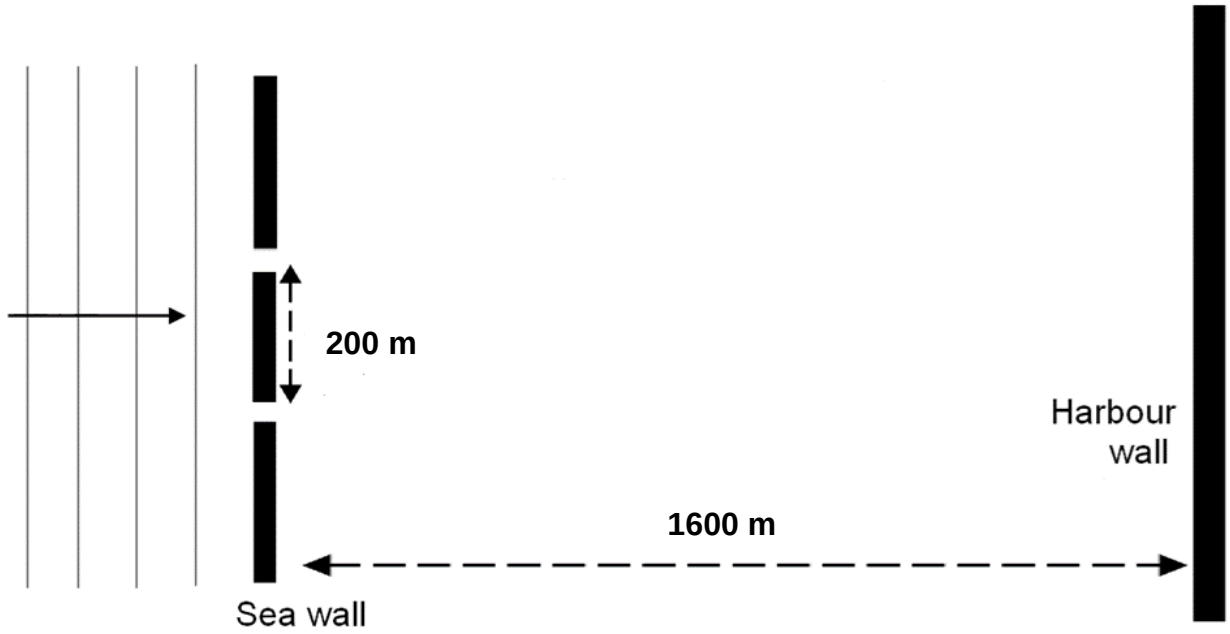
Total Q18 /7

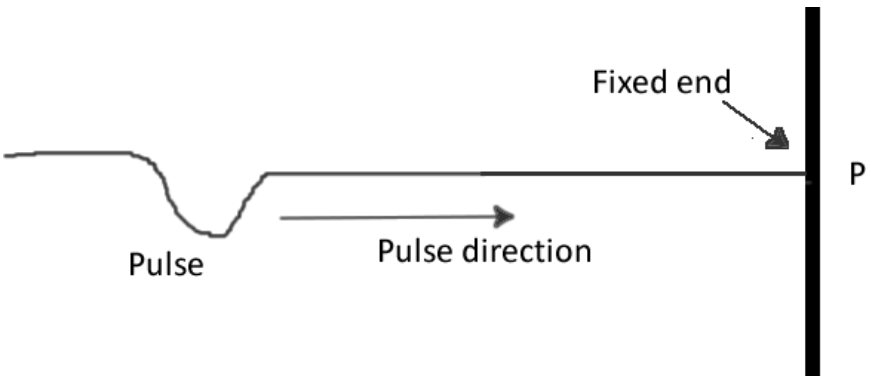
Spare Diagrams

Question 13 c)

Question 14 a)



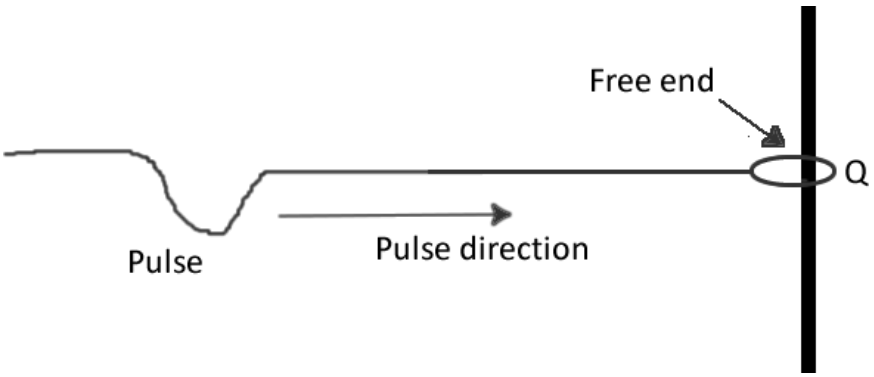
Question 16 a)



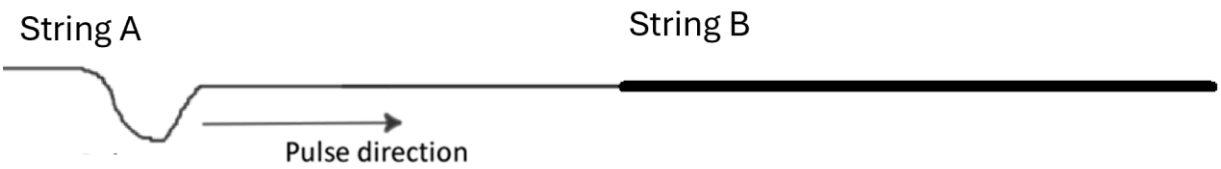
Spare Diagrams continue

Spare Diagrams

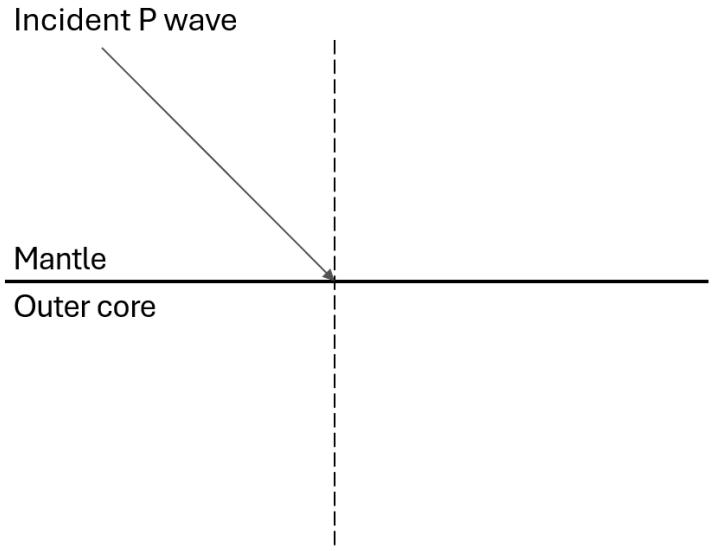
Question 16 b)



Question 16 e)



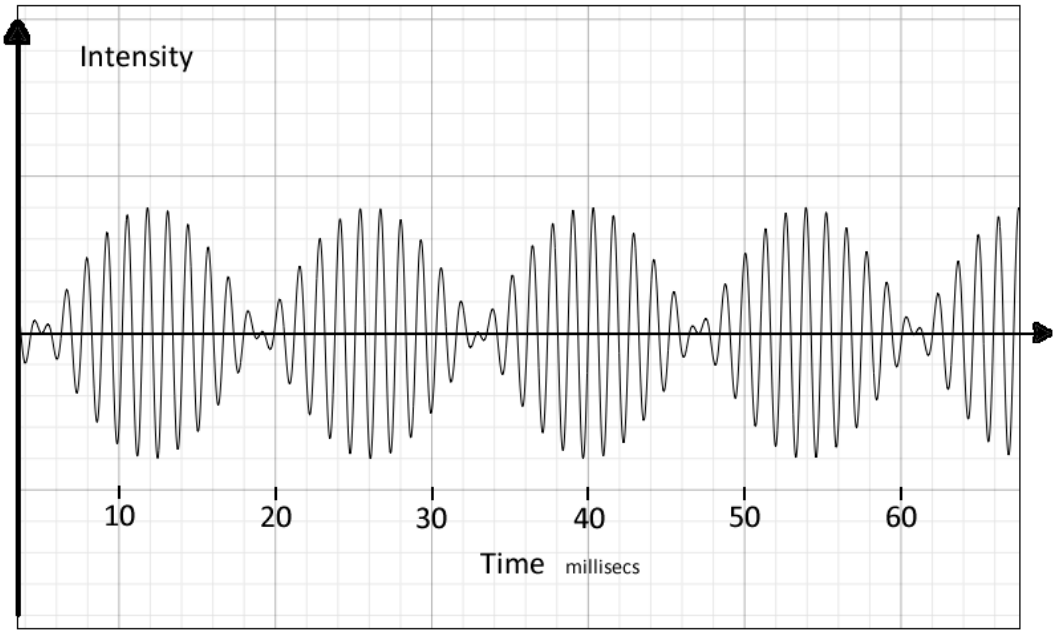
Question 17 c)



Spare Diagrams continue

Spare Diagrams

Question 18 a) and b)



End of Section C

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PHYSICS

PHY415115

Section D Twentieth Century

Pages: 16
Questions: 6
Information Sheet: 1

Suggested working time: 45 minutes

Instructions:

- Answer **all** questions and **all** items within each question.
- Write your answers in the spaces provided in this exam paper.
- Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagram.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physics Information Sheet can be used throughout this exam.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 45 minutes**.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C8	/ 45

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Guide to Exam Structure

	Questions available	Questions to answer	Suggested working time	Marks available
Section A	6	6	45 minutes	45 marks
Section B	6	6	45 minutes	45 marks
Section C	6	6	45 minutes	45 marks
Section D	6	6	45 minutes	45 marks
Totals	**24**	**24**	**180 minutes (3 hours)**	**180 marks**

Criterion

You **must** make sure your answers address:

- Criterion 8 identify and apply principles of the wave-particle nature of light, atomic and nuclear physics and models of the nucleus and nuclear processes.

Question 19

Marker use

Several companies are developing batteries for low power devices such as pacemakers. Some are based on nuclear decay of unstable nuclei.

One such device is a battery from China that produces 100 μW at 3 Volts, using energy released in beta decay of the isotope $^{63}_{28}Ni$ to $^{63}_{29}Cu$. The half-life of the decay is 101.2 years.

a) Give the decay equation.

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/2

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The beta particle energy is 50 keV on average.

b) Show that the **minimum** activity of the Ni-63 to provide 100 μW is approximately 1×10^{10} Bq. (This answer is well below the actual activity required.)

/2

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c) Calculate the mass of Ni-63 necessary to give this power output.

/3

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Question 19 continues

Marker use

d) Calculate the mass remaining after 70 years.

/2

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e) The decay does not produce gamma emissions. What does this imply about the daughter isotope immediately on its production?

/1

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Total Q19

/10

Question 20

Marker use

A caesium metal photoelectric tube is illuminated by the spectral lines of a mercury lamp and the subsequent stopping voltage of the photoelectrons are recorded. Three such results are provided in the table below.

Wavelength (nm)	Frequency (Hz)	Stopping voltage (V)
546		0.13
436		0.71
405		0.90

Table 1

a) Calculate the frequency data for the table (Table 1) above. /1

b) Plot frequency versus stopping voltage data on the graph below, labelling the horizontal axis. /2

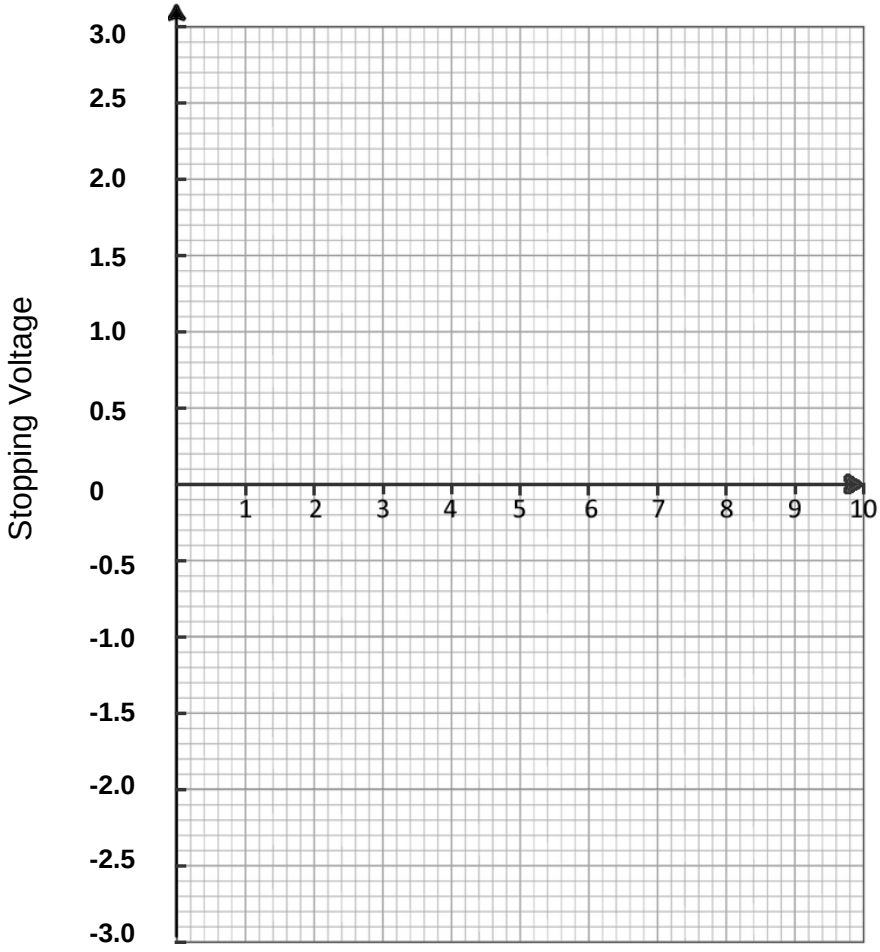

Figure 24: Graph to sketch your answer on.

Spare diagram used (X) ☐

Question 20 continues

Marker use

c) Explain why there is a relationship between frequency and stopping voltage.

/2

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d) Based on this data, determine experimental values for:

/2

i. Planck's Constant in electron-volt form.

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ii. The work function.

/1

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iii. The cut-off frequency of caesium.

/1

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Total Q20

/9

Question 21

Marker use

a) Calculate the mass defect (in atomic mass units) of $^{56}_{26}Fe$ given its atomic mass is 55.9349375 u. Assume 26 electrons are included.

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b) Calculate the binding energy per nucleon of this isotope.

/1

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$^{56}_{26}Fe$ is the last element that can be produced in nuclear fusion reactions in typical stars, as it has the greatest binding energy per nucleon.

c) Explain why nuclear fusion reactions producing elements larger than iron cannot be continuously sustained in typical stars.

/2

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Total Q21

/6

Question 22

Marker use

A Helium-Neon laser is rated at 3 mW light output power. It produces light at a wavelength of 633 nm.

Calculate:

a) The energy of one photon of the light.

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b) The number of photons emitted each second from the laser.

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..... /2

c) The momentum of one photon of this light.

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..... /2

The laser beam strikes a black surface and is absorbed.

d) Calculate the magnitude of the force that the beam exerts on the surface.

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Total Q22 /8

Question 23

Marker use

Figure 25: Photo of Aurora Australis.

Aurorae are caused by electrons and protons from the Sun striking oxygen and nitrogen atoms in the upper atmosphere.

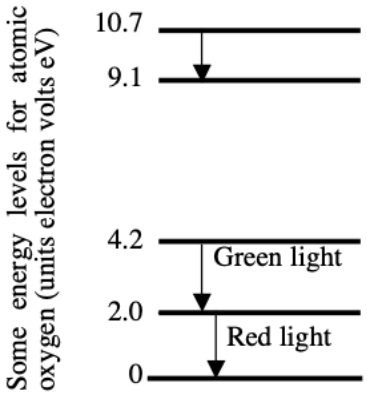

Figure 26: Picture of energy levels for oxygen atom.

Above are some energy levels for the oxygen atom.

a) Show that the transition from the 4.2 eV level to the 2.0 eV level produces photons of about 560 nm.

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Question 23 continues

Marker use

b) What is the minimum kinetic energy, in Joules, of incident electrons to produce the green light? Justify your answer.

/2

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c) If an excited oxygen atom decays from the 10.7 eV level to the 9.1 eV level, what part of the spectrum is the emitted photon most likely in?

/2

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Total Q23

/6

Question 24

Marker use

An X-Ray photon of wavelength 2.48 x 10^{-11} m, moving east, strikes a free electron.

a) Calculate the momentum of the photon.

/2

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After the collision, the photon is re-emitted backwards, reversing its direction by 180 ^{o}. Its wavelength is now 2.97 x 10^{-11} m.

b) Calculate the momentum of the scattered X-Ray photon.

/2

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c) Calculate the recoil speed of the electron. Assume that the electron's initial speed is negligible.

/2

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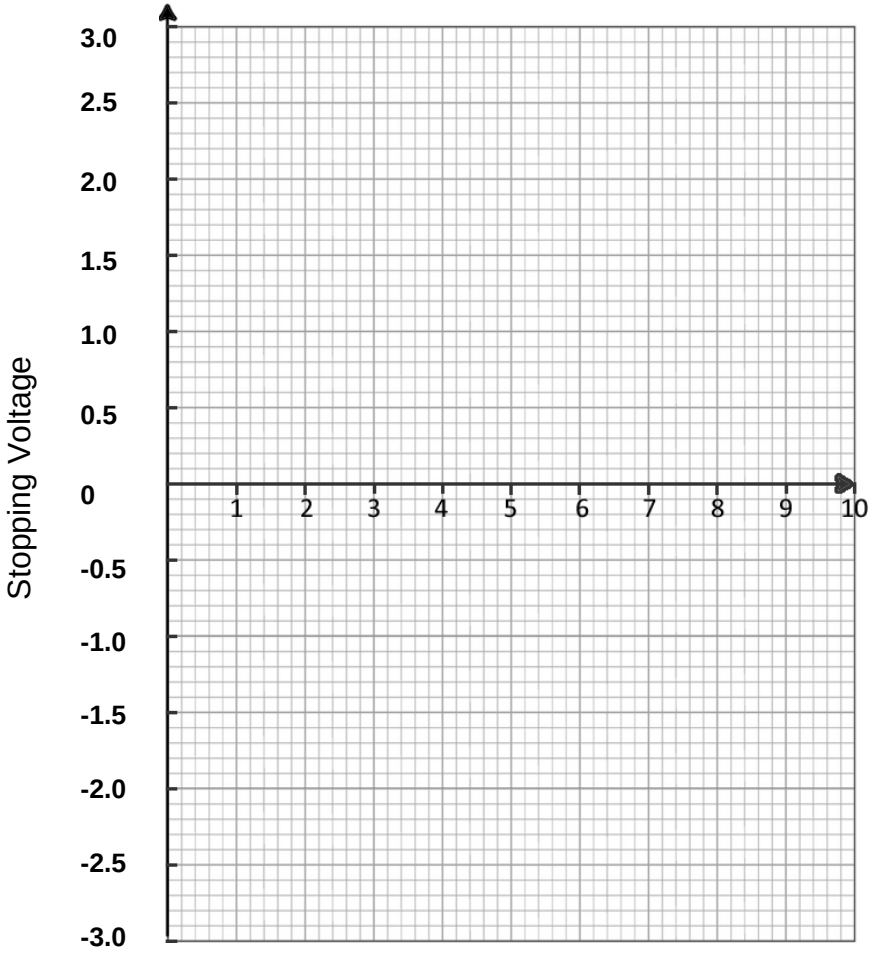
Total Q24

/6

Spare Diagram

Question 20 b)



End of Section D

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