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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 this 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 the 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

A 60 kg student is in a lift standing on bathroom scales. She is to ascend from rest to a higher level and stop. The trip up takes 6 seconds.

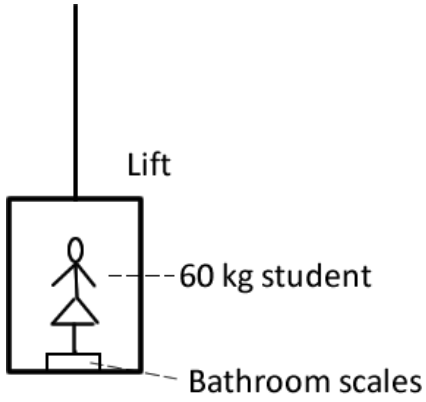


Figure 1: Diagram of lift.

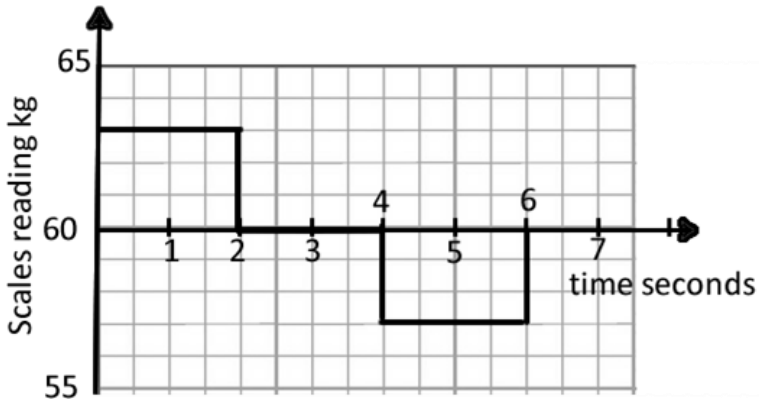


Figure 2: Graph of scales.

Figure 2 is a graph of the scale's reading against time.

a) For the time intervals below, describe (without calculation) the acceleration of the student. Justify your answer:

i. from 0 to 2 seconds. /2

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ii. from 2 to 4 seconds. /2

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iii. from 4 to 6 seconds. /2

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Question 1 continues

Marker use

b)

i. Calculate the acceleration of the lift at 1 second. /3

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ii. Calculate the velocity of the lift at 2 seconds. /1

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c) Using Figure 3, complete a velocity ~ time graph for the whole trip between levels. /2

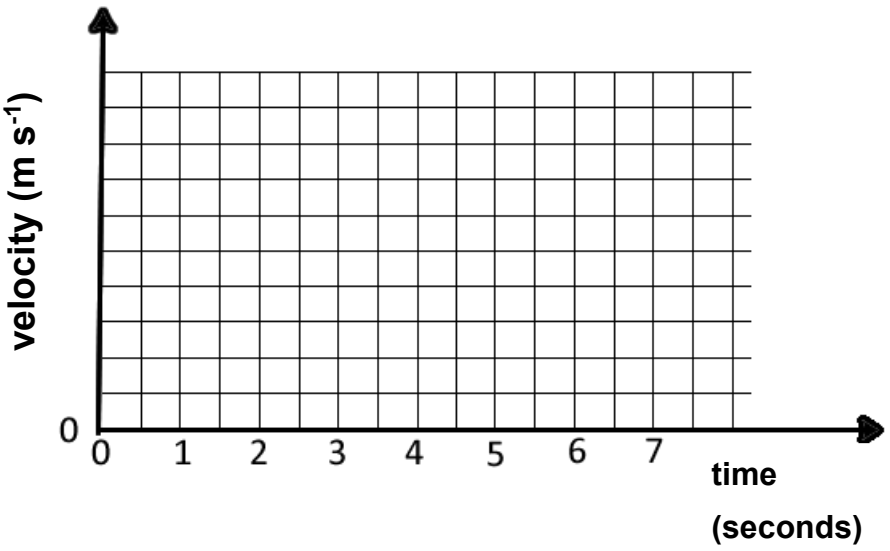


Figure 3: Graph of velocity against time.

Spare diagram used (X) ☐

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d) Calculate the distance travelled vertically. /2

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Total Q1 /14

Question 2

Marker use

A car of mass 1 500 kg is driving around a curved circular track. The track is angled at 30° to the horizontal and has a radius of 150 m. The driver is at a speed where they can take their hands **entirely** off the steering wheel and the car neither climbs nor slides down the incline.

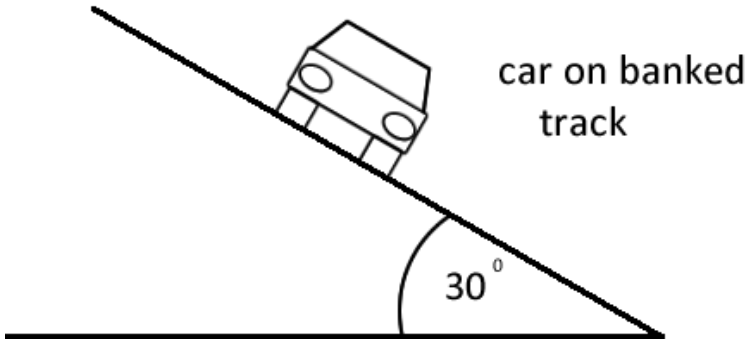


Figure 4: Diagram of car on corner.

Spare diagram used (X) ☐

a) Sketch and label the forces on the car on the diagram in Figure 4 if friction between the tyres and the track can be ignored. /2

b) Are the forces on the car balanced or unbalanced? Justify your reasoning. /2

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c) Calculate the speed at which the car is driving in m s^{-1}. /3

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Total Q2 /7

Question 3

Marker use

A Grade 8 student was caught by his teacher firing paper pellets using an elastic band at his friends' heads. As punishment, the teacher makes the student draw a force vs distance graph of the elastic band and then calculate the speed of a 2 gram paper pellet.

The student does this by hanging masses from the elastic band and measuring the stretch.

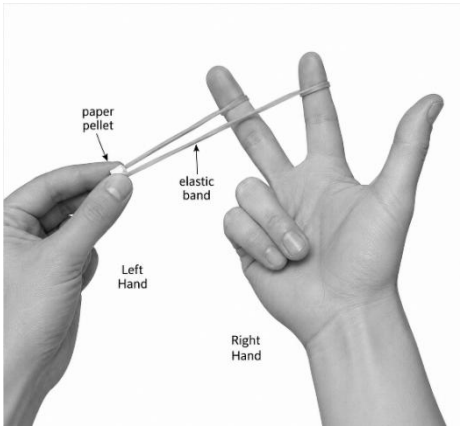


Figure 5: Diagram of paper pellet firing

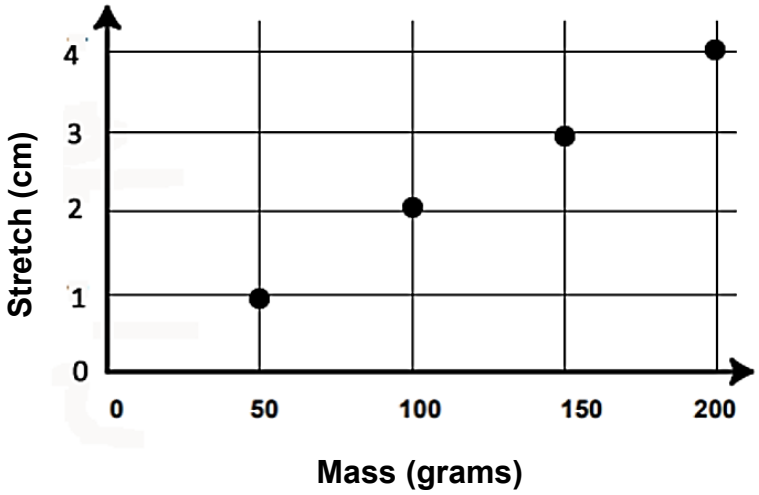


Figure 6: Graph of stretch vs mass.

a) Calculate the energy stored when stretched to 4 centimetres. /2

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b) Estimate the launch speed of the 2 gram paper pellet after releasing the elastic from a 4 centimetre stretch. /2

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Total Q3 /4

Question 4

Marker use

At a Red Bull track, a jump is arranged for motorbikes to cross a gap of 70 m. The motorbike riders will leave the ramp at an angle of 45° and land on a similar ramp at the same height, as shown in Figure 7.

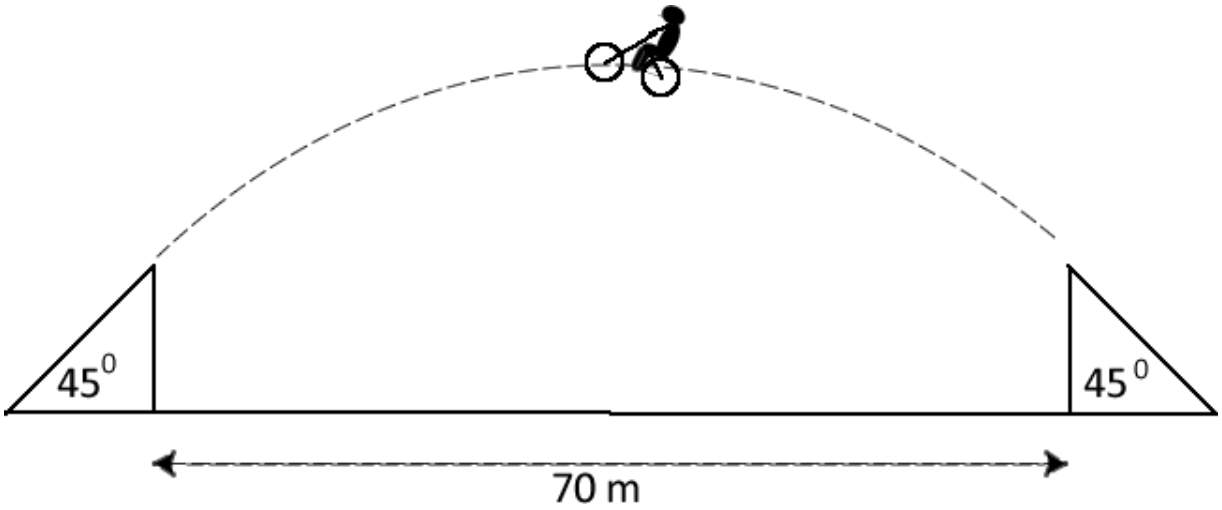


Figure 7: Diagram of a motorbike jump.

a) Show that the time to cross this gap and land safely is 3.8 seconds. /3

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b) Calculate the speed at which the motorbike must leave the ramp to safely cross. /2

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Total Q4 /5

Question 5

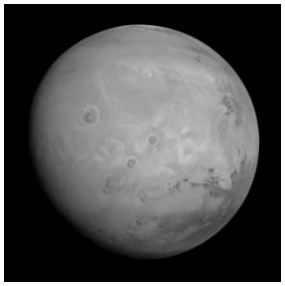


Figure 8: Image of Mars.

Marker use

A billionaire wishes to land people on the planet Mars.

Earth is at a distance of 1.50×10^8 km from the Sun and has an orbital period of 365 days. Mars has an orbital period of 687 days.

a) Calculate the orbital distance of Mars around the Sun. /3

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The Martian moon Deimos has an orbit at a distance of 23 460 km from the centre of Mars with a period of 30.3 hours. /3

b) Calculate the mass of Mars.

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Mars has a radius of 3 376 km.

c) Calculate the gravitational field strength on the surface of Mars. /2

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Total Q5 /8

Question 6

Marker use

Asteroids can pass each other close enough for gravity to change their directions and speeds so that their orbits around the Sun completely alter.

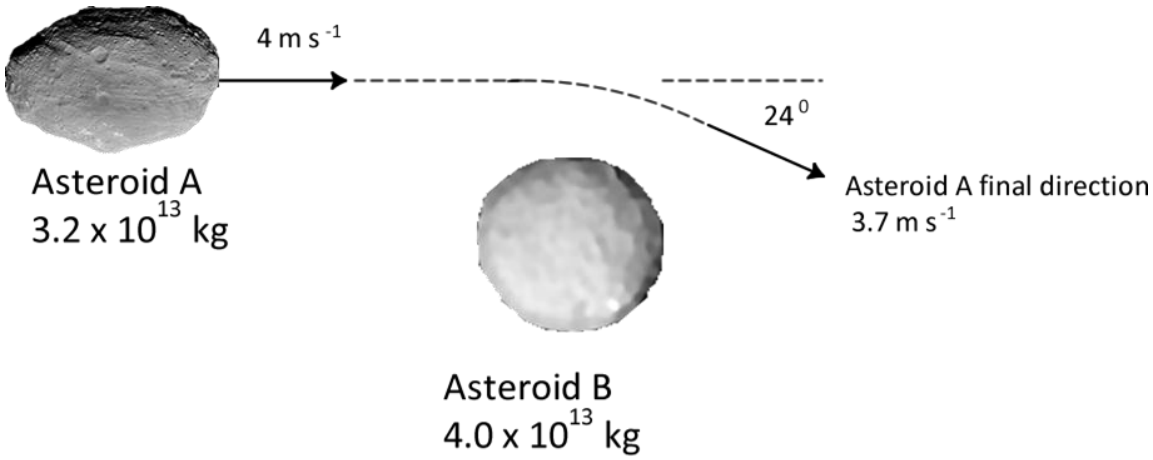


Figure 9: Diagram of passing asteroids.

Asteroid A has a mass of 3.2×10^{13} kilograms, and moves from the "left" at 4 m s^{-1} relative to Asteroid B. Asteroid B has a mass of 4.0×10^{13} kilograms taken at rest relative to Asteroid A.

After passing, Asteroid A is now found to have altered direction by 24° and is now moving at 3.7 m s^{-1}.

a) Calculate the original total momentum of the system before the interaction. /1

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b) Construct an appropriate diagram that will allow you to calculate the momentum of Asteroid B after the interaction. /2

Question 6 continues

Marker use

/4

c) Calculate the new speed and direction of Asteroid B relative to its previously stationary state.

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Total Q6

/7

Spare Diagrams

Question 1 c)

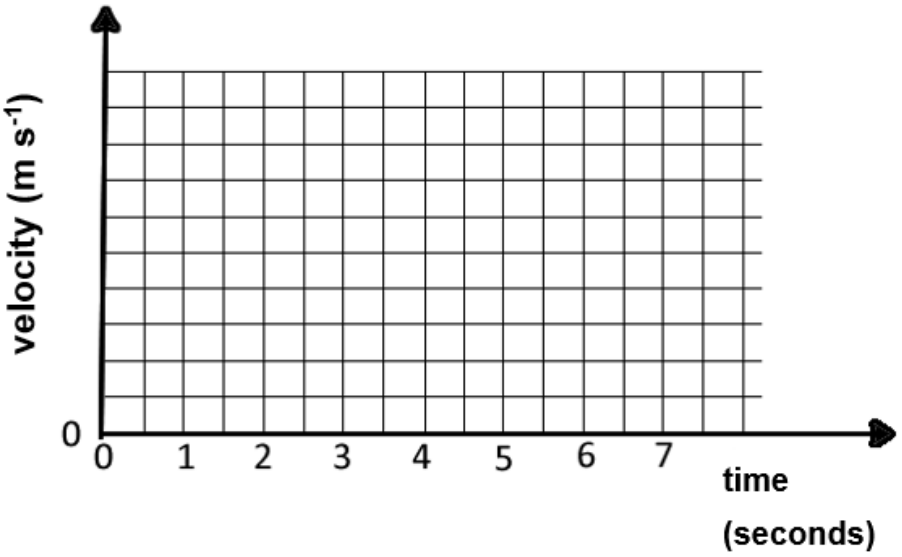


Figure 3: Graph of velocity against time.

Question 2 a)

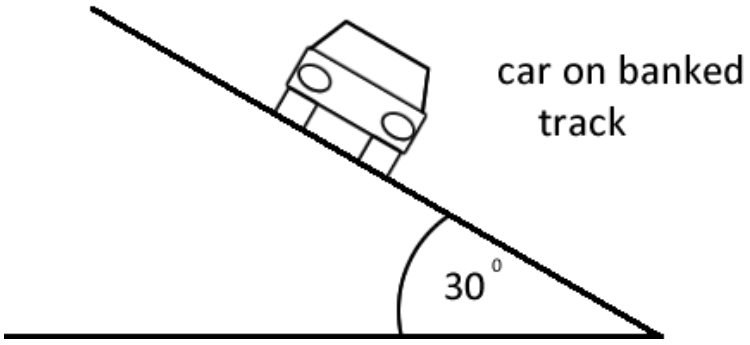


Figure 4: Diagram of car on corner.

End of Section A

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External Assessment 2026

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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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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

An experimenter carries out Coulomb's study of repulsion between two identical charges, q, at separations, r, using a torsion pendulum balance.

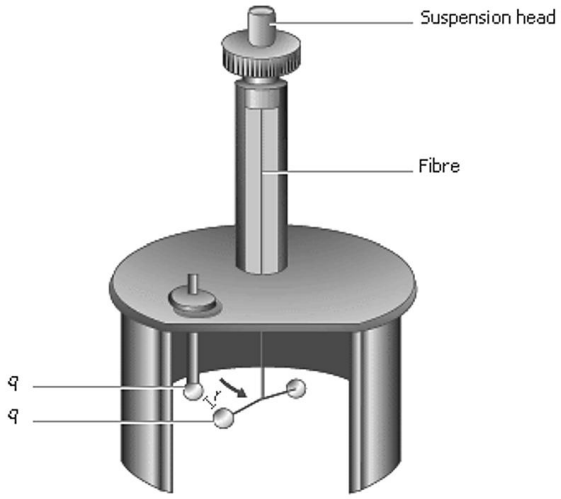


Figure 10: Diagram of Coulomb experiment.

Three (3) results are given in Table 1.

Distance r (mm)	10	6	4
Force F (N)	1.3×10^{-4}	3.6×10^{-4}	8.1×10^{-4}

Table 1

a)

i. Give the formula in the space below for the force between **two (2)** charges in this situation. /1

ii. Using the formula in item a) i., fill the empty boxes in Table 1. This will possibly give a straight-line graph from the data in Table 1. /1

Question 7 continues

Marker use

b) On the Figure 11 graph, plot these points labelling the axes.

/3

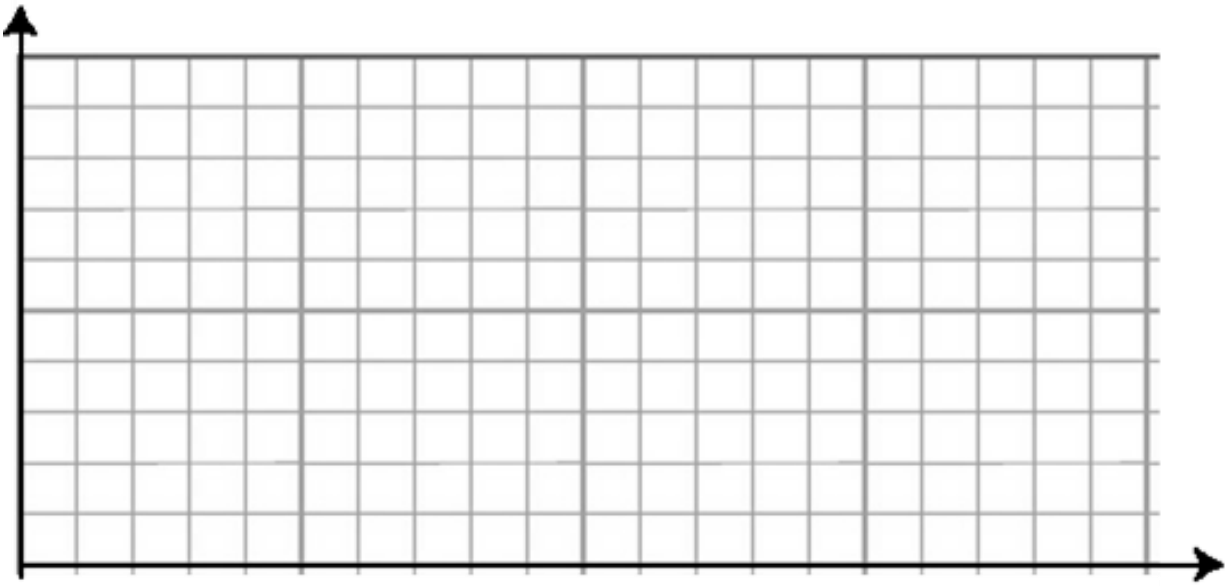


Figure 11: Graph for answering Question 7 b).

Spare diagram used (X) ☐

c) From the Figure 11 graph, calculate the value of the charge, q, used in the experiment.

/3

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Total Q7

/8

Question 8

Marker use

J.J. Thomson discovered the electron in 1897. This was done by deflecting cathode rays using an electric field and a magnetic field.

Consider a typical school electron beam tube used to demonstrate electric and magnetic field effects on cathode rays (electron beams).

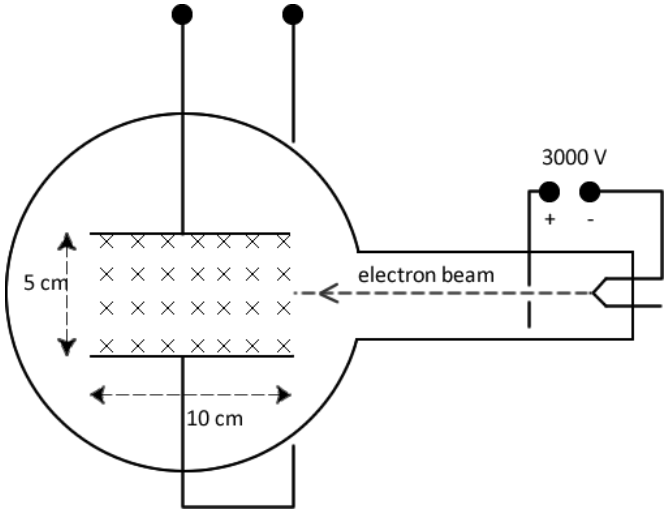


Figure 12: Diagram of electron beam tube.

Spare diagram used (X) ☐

An electron gun at 3000 V is used to accelerate electrons into the parallel plates and magnetic field.

a) Using our current knowledge of the electron, calculate the speed of the electron beam as it leaves the electron gun. /2

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b) Why couldn't J.J Thomson calculate the speed of the electron in 1897 when he discovered the electron? /2

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Question 8 continues

Marker use

The beam enters midway between the parallel plates which are 5 cm apart and 10 cm long as in Figure 12. A uniform magnetic field into the page is applied to the beam which now goes into a curve of radius 2.5 cm.

c) Sketch the path of the electron beam on the Figure 12 diagram on page 6, taking into account the magnetic field direction. /2

d) Calculate the magnitude of the magnetic flux density of the uniform magnetic field. /2

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e) A potential difference is now applied to the parallel plates. Calculate the potential difference on the parallel plates required to make the electron beam move in a straight line. /3

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Total Q8

/11

Question 9

Marker use

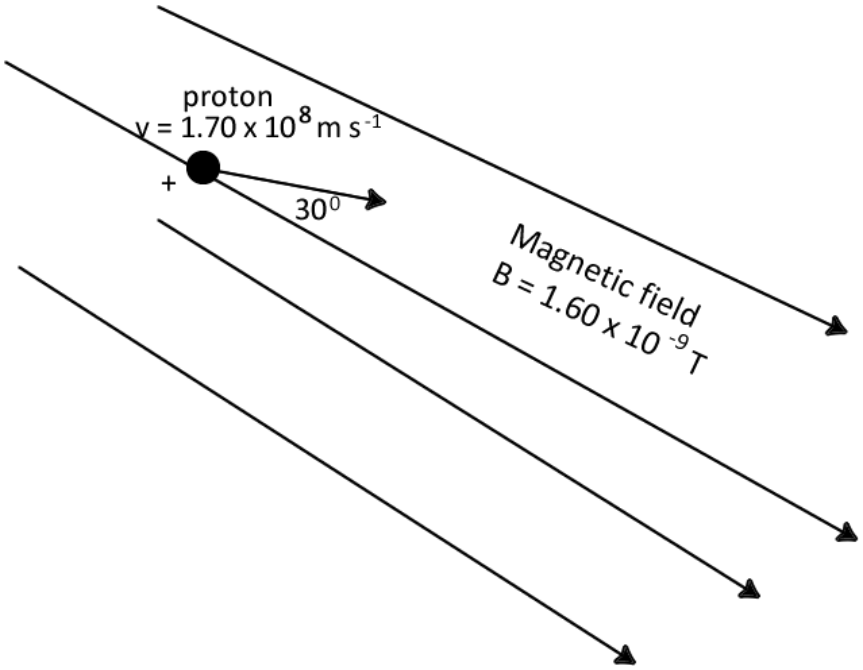


Figure 13: Diagram of proton in the Sun's magnetic field.

Spare diagram used (X) ☐

In the solar wind of the Sun, a proton is moving in the Sun's magnetic field at a speed of 1.70×10^8 ms^{-1}. It makes an angle of 30^0 as shown in Figure 13.

If the magnetic field has a flux density of 1.6×10^{-9} T:

a) Sketch the path of the proton on Figure 13. /1

b) Calculate the radius of the motion of the proton. /2

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c) If the distance between the Sun and the Earth is 1.5×10^{11} m, calculate the time the proton takes to traverse this distance, assuming the motion remains constant. /2

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Total Q9 /5

Question 10

Marker use

A metal detector consists of two (2) coils at the end of the search pole.

The transmitter coil has an alternating current passing through it. The second coil is called the receiver coil.

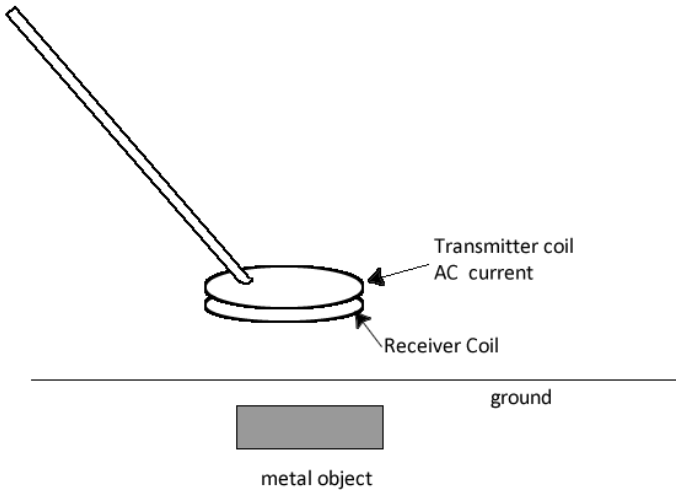


Figure 14: Diagram of metal detector.

Consider the coils over the top of a hidden metal object in the ground.

a) Sketch the field around the transmitter coil on Figure 14 when the current is anti-clockwise, when looking from above. /2

The transmitter coil has the AC current passing through it.

b) Giving the relevant law, what will be created in the metal object? /2

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c) How does the receiver coil detect the metal? Justify your reasoning. /2

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Total Q10

/6

Question 11

Marker use

A simple DC rotating motor is shown in Figure 15.

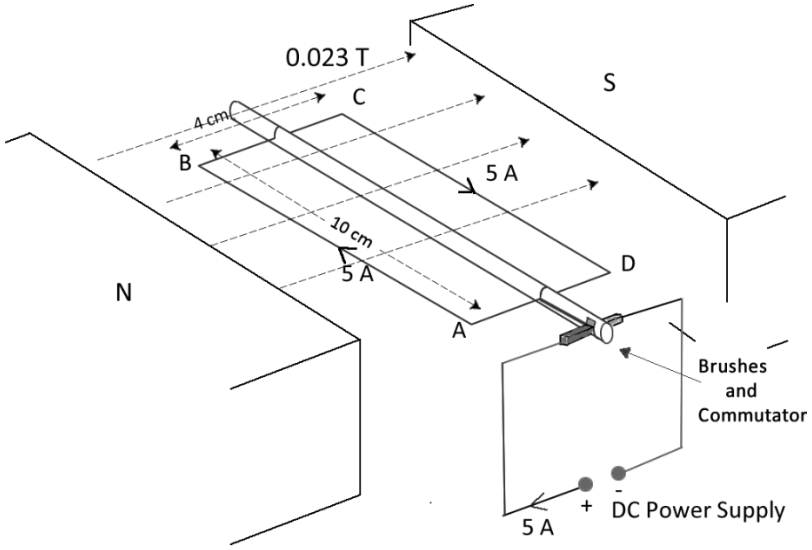


Figure 15: Diagram of DC motor.

The rotating rectangle ABCD, has 40 turns wrapped around it. Its dimensions are 10 cm (AB) by 4 cm (BC). It is in a magnetic field of flux density of 0.023 T as shown in Figure 15.

a) What effect does multiple turns have on the performance of the motor? /1

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The DC supply is turned on at 5.00 A in the direction ABCD as shown in Figure 15.

b) In which direction will the side AB move? /1

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c) Calculate the force on the side AB when the rectangle is in the horizontal plane as in Figure 15. /2

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Question 11 continues

Marker use

d) Describe the purpose of the brushes and commutator system.

/2

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e) Sketch on the axes of Figure 16 the force on the side AB as it moves in a complete circle starting from the position shown in Figure 15.

/2

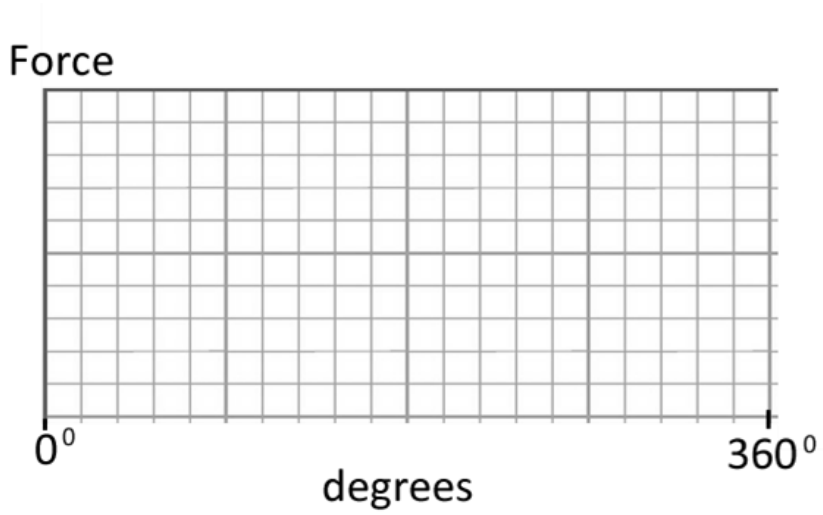


Figure 16: Axes for Question 11 e) answer.

Spare diagram used (X) ☐

Total Q11

/8

Question 12

Marker use

A vertical wire runs through a horizontal table. A current of 3 A is passed upwards through the wire.

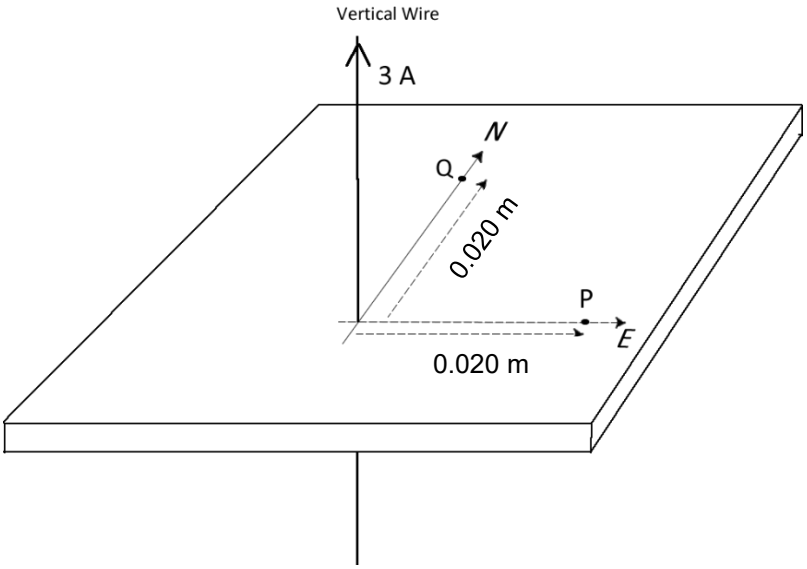


Figure 17: Diagram of table

Consider the point P, 0.020 m due EAST of the wire.

a) Calculate the magnetic flux density, both magnitude and direction, caused by the current in the wire at the point P.

/3

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Question 12 continues

Marker use

A compass is placed at the position Q, 0.020 m directly north of the wire. When the current is turned on, the compass points to the position N 57° W.

b)

i. Draw below a vector diagram of the horizontal magnetic flux densities at Q that account for the compass needle pointing at N 57° W.

/2

ii. Calculate the horizontal component of the Earth's magnetic flux density at Q.

/2

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Total Q12

/7

Spare Diagrams

Question 7 b)

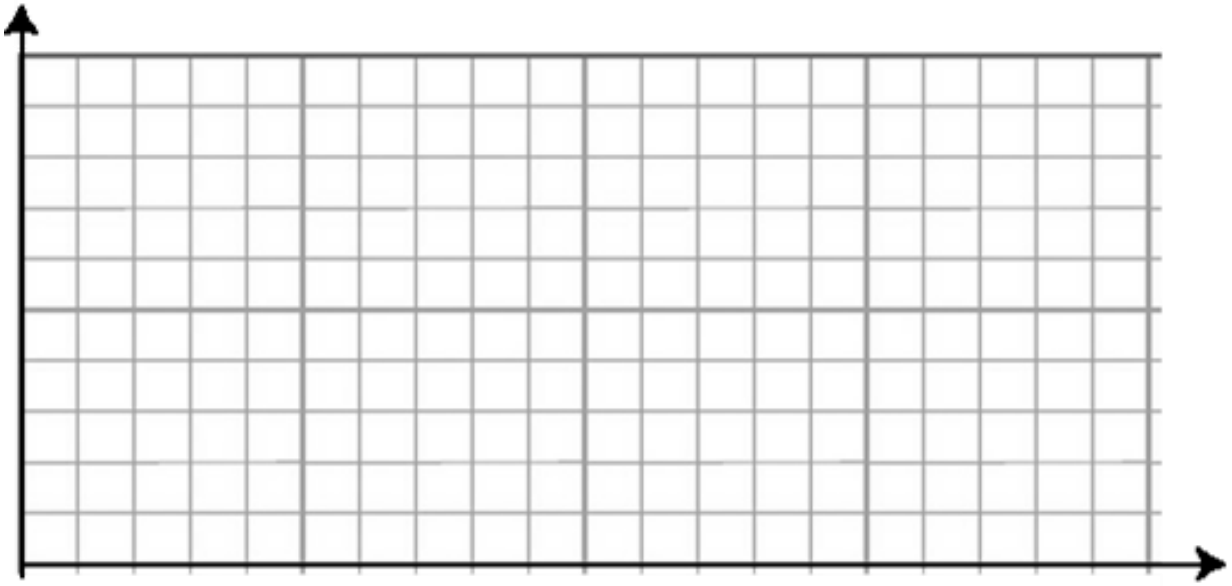


Figure 11: Graph for answering Question 7 b).

Question 8 c)

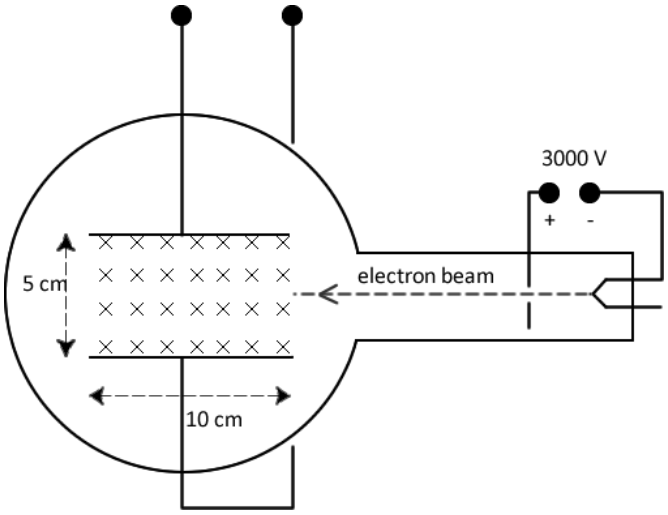


Figure 12: Diagram of electron beam tube.

Spare Diagrams

Question 9 a)

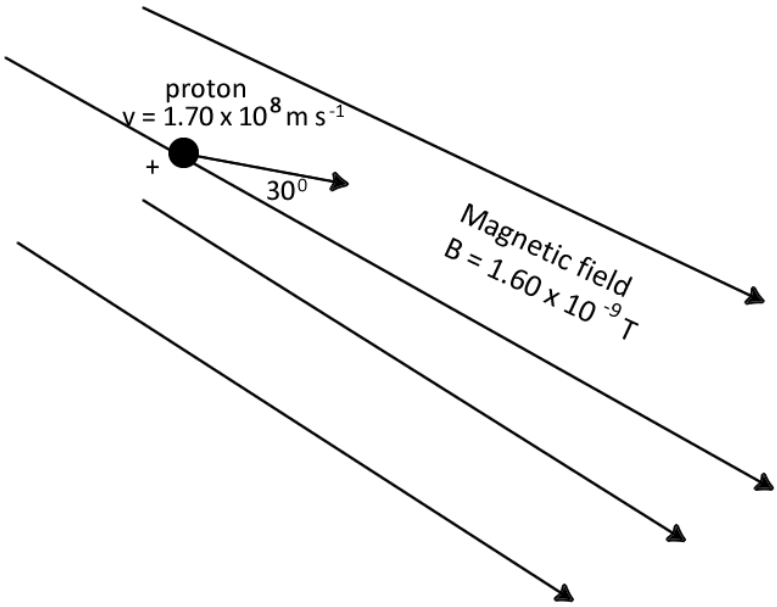


Figure 13: Diagram of proton in the Sun's magnetic field.

Question 11 e)

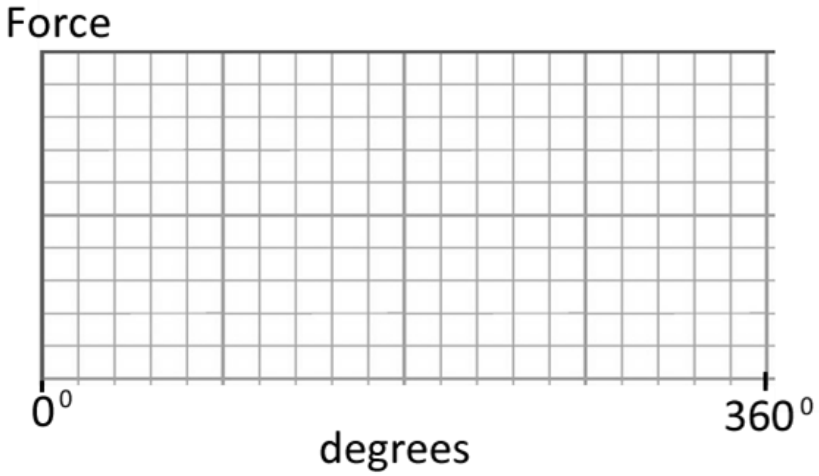


Figure 16: Axes for Question 11 e) answer.

End of Section B



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PHYSICS

PHY415115

Section C Waves

Pages: 16

Questions: 6

Suggested working time: 45 minutes

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Marker use	
C7	/ 45

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Criterion

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

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

Question 13

Marker use

The human eye is a ball with internal features of different refractive indices.

Eye Section	Refractive Index
Cornea	1.377
Aqueous Humour	1.337
Crystalline Lens	1.410
Vitreous Humour	1.337

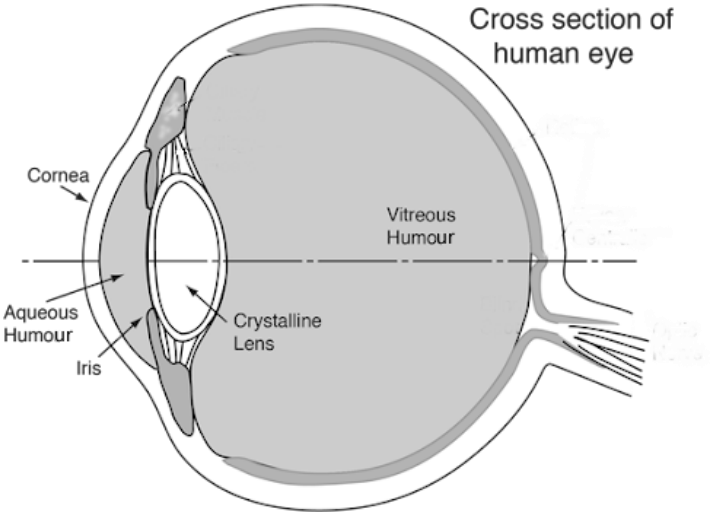


Figure 18: Diagram of a human eye.

Consider a ray of light passing from air into and then through the eye.

a)

i. From the four (4) options, select the boundary at which **most** refraction takes place. /1

[Tick the **one (1)** correct answer ✓]

☐ air into the cornea

☐ cornea into aqueous humour

☐ aqueous humour into lens

☐ lens into vitreous humour.

ii. Justify your answer to item a) i. /1

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Question 13 continues

Marker use

The cornea and aqueous humour can be considered a triangular prism with an angle at the top of 20° and an average refractive index of 1.36 as shown in Figure 19.

A ray of light strikes the cornea at an angle of incidence of 20°.

b) Calculate the angle of refraction of this ray of light.

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/2

c) Sketch on Figure 19 the ray's passage through the cornea. Include the normal at the cornea-lens surface.

/2

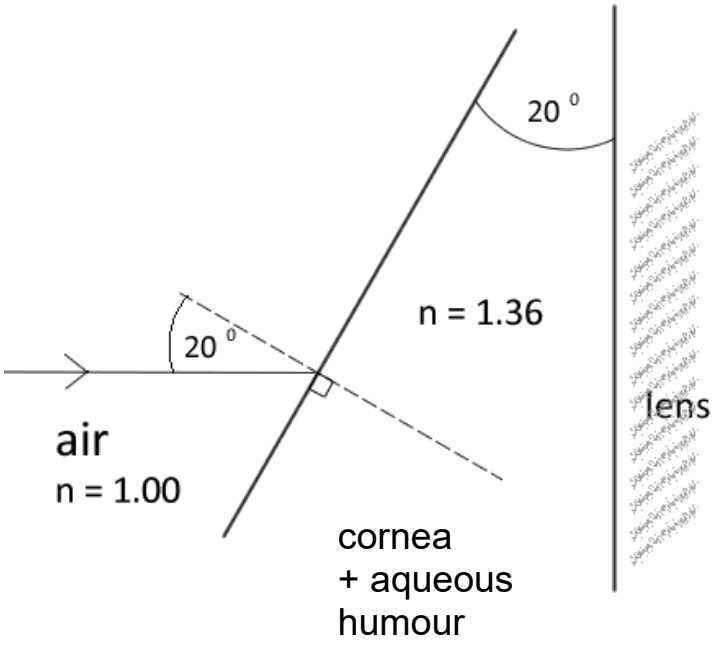


Figure 19: Diagram of a simplified eye.

Spare diagram used (X) ☐

d) Calculate the subsequent angle of incidence onto the lens surface.

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/3

Total Q13

/9

Question 14

Marker use

Two (2) microbes are viewed with light of two (2) different wavelengths, A and B, by a microscope. The diagram in Figure 20 shows light of the two (2) wavelengths approaching the microbes, one of long wavelength (A), the other of a much shorter wavelength (B).

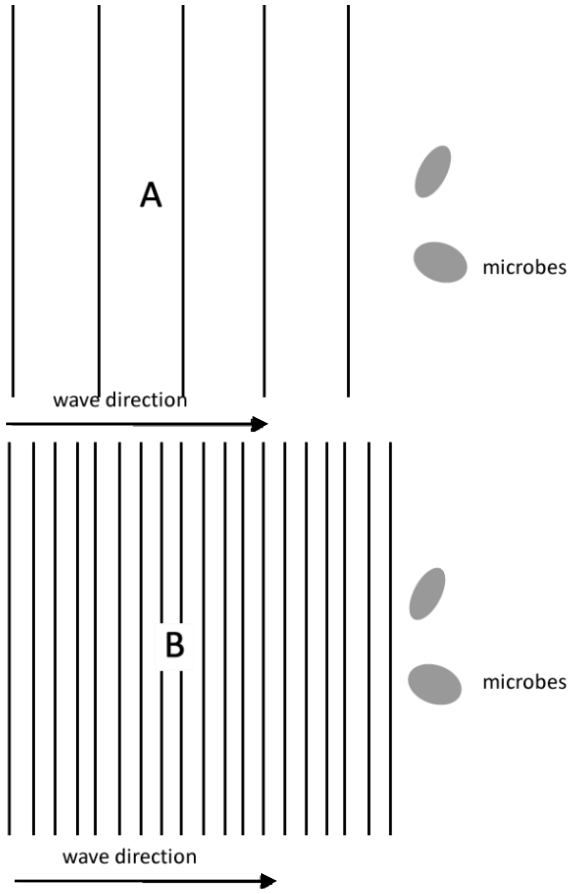


Figure 20: Diagrams of incident waves.

Spare diagram used (X) ☐

a) Sketch on the Figure 20 diagrams the wave sets after passing the microbes. /2

b) Which of the wavelengths, A or B, will provide the clearest image of the microbes? Mention the relevant physical phenomena that applies in this situation and justify your answer with reference to your diagrams in Figure 20. /3

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Total Q14 /5

Question 15

Marker use

A Young's double-slit type experiment is carried out with two (2) coherent wavelengths of red and blue light shining on the slits. The red light has a wavelength of 600 nm and the blue light has a wavelength of 450 nm.

The slits are 0.2 mm apart and a screen is placed 0.5 m from the slits.

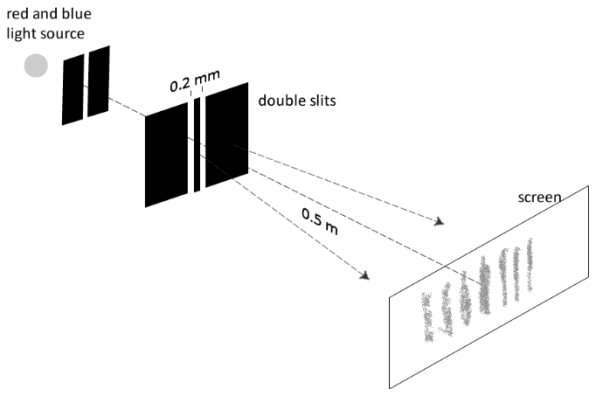


Figure 21: Diagram of a Young's double-slit type experiment.

a) Using superposition principles, explain how bright bands are formed on the screen. /2

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b) Calculate the distance between each bright band for each colour.

i. Red light. /1

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ii. Blue light. /1

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c) Show that the patterns both have a bright band 4.5 mm from the central bright fringe. /3

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Total Q15 /7

Question 16

Marker use

Two strings are stretched. One is attached to a fixed end while the other is attached to a free end. A pulse is sent up each as shown in Figure 22.

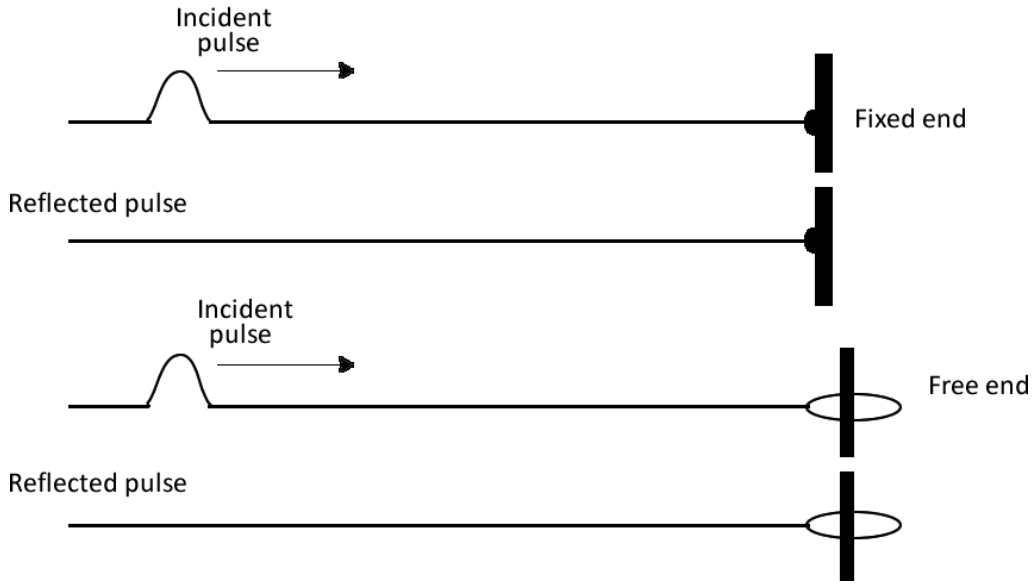


Figure 22: Diagram of incident pulse.

Spare diagram used (X) ☐

a) Sketch the reflected pulses on the diagram in Figure 22. /2

b)

i. For the fixed end string, in what direction will the incoming pulse pull on the fixture holding the string? /1

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ii. Explain the orientation of your reflected pulse for the fixed end string in terms of Newton's Laws. /2

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Question 16 continues

Marker use

c) A 50 cm string of mass 15 g is stretched and held rigidly with a tension of 150 N. Calculate the speed of a pulse along the string.

/3

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The 50 cm string is plucked in the **centre** of the string.

d) Calculate the fundamental frequency at which the string vibrates.

/2

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Total Q16

/10

Question 17

Marker use

A piano tuner uses a 262 Hz tuning fork to assist tuning a piano. When a string is played and the tuning fork is struck, beats are heard at a frequency of 2 Hz. When the tension of the string is reduced slightly, the beat frequency increases to 3 Hz.

a) Giving your reasoning, what is the original frequency of the piano string?

/3

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b) When the string is tuned to the fundamental frequency of 262 Hz, what is the frequency of the string's third harmonic?

/1

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A pipe that is closed at one end resonates at the same fundamental frequency of 262 Hz.

c) Calculate the length of the pipe ignoring end correction effects.

/2

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d) Calculate the frequency of the third (3^{rd}) overtone of the pipe.

/2

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Question 17 continues

Marker use

e) Sketch the third (3rd) overtone labelling the nodes and antinodes in the diagram in Figure 23.

/2



Figure 23: Diagram of closed pipe.

Spare diagram used (X) ☐

Total Q17

/10

Question 18

Marker use

Sound travels faster in warm air than in cold air.

a) Is the relative refractive index of sound travelling from warm air to cold air greater or less than 1? Justify your answer. /2

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In daytime, air close to the ground is warmer than the air above.

b) **During the day**, will sound tend to bend back towards the ground or up into the sky? Use the diagram in Figure 24 to help explain your answer. It has an arbitrary line "separating" warm and cold air. /2

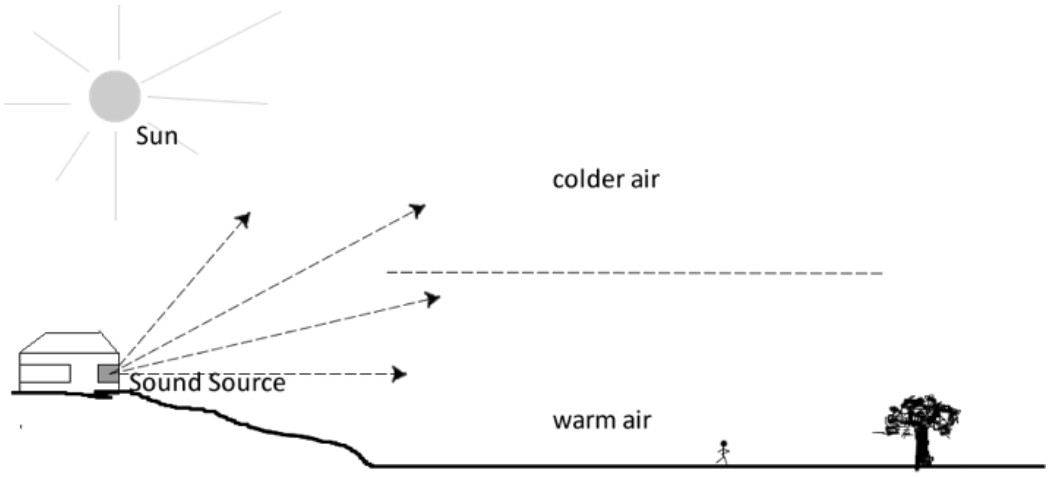


Figure 24: Diagram of sound travelling from warm air into cold air.

Spare diagram used (X) ☐

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Total Q18 /4

Spare Diagrams

Question 13 c)

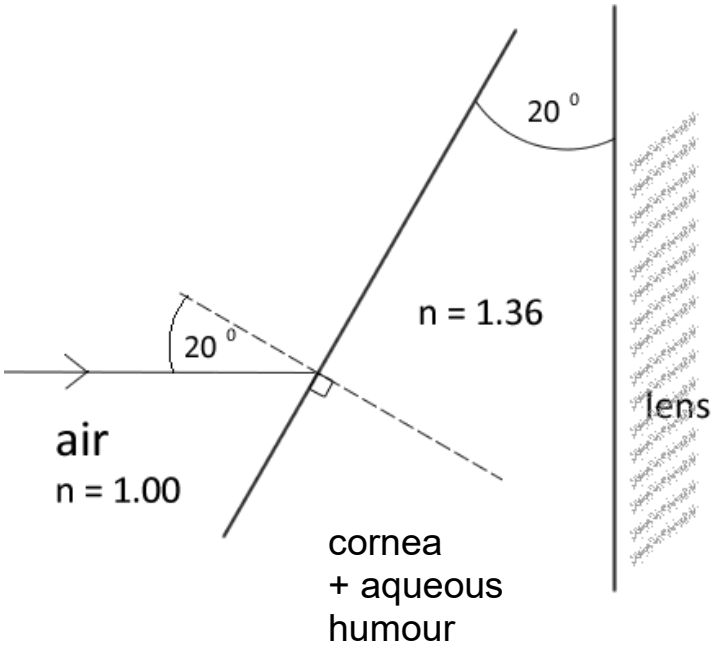


Figure 19: Diagram of a simplified eye.

Question 14 a)

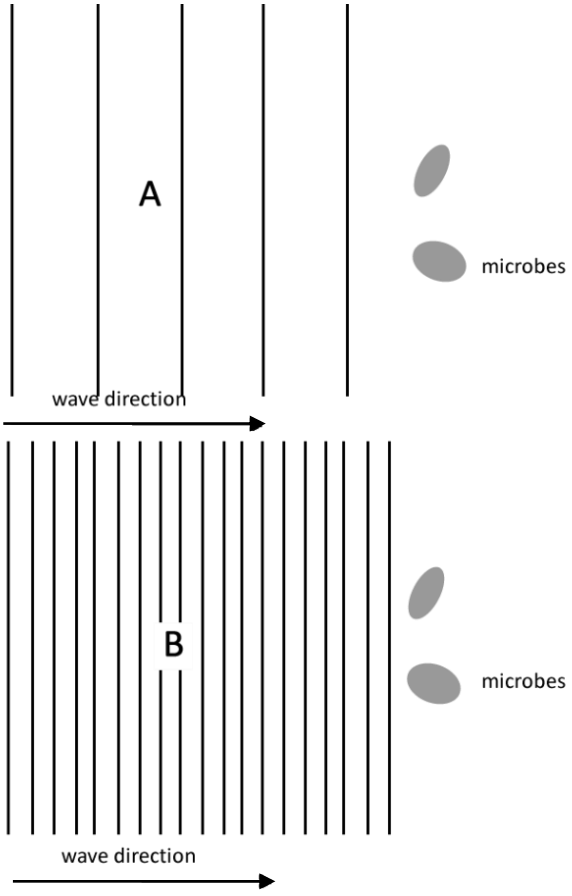


Figure 20: Diagrams of incident waves.

Spare Diagrams

Question 16 a)

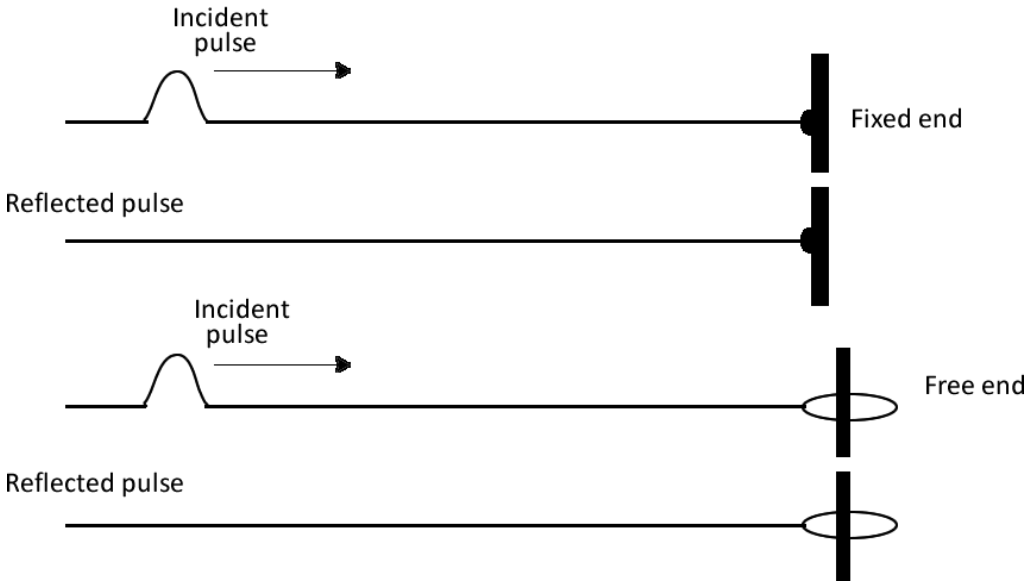


Figure 22: Diagram of incident pulse.

Question 17 e)



Figure 23: Diagram of closed pipe.

Question 18 b)

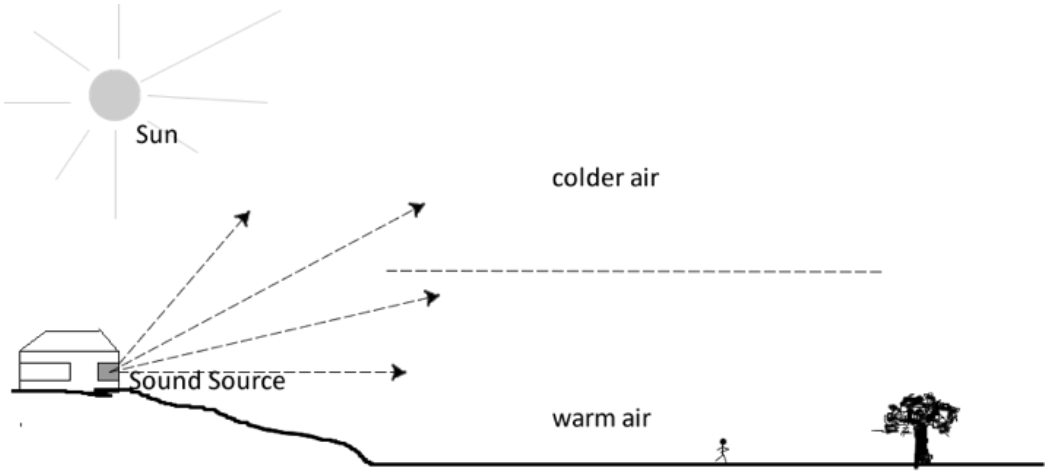


Figure 24: Diagram of sound travelling from warm air into cold air.

End of Section C

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External Assessment 2026

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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.
  - A spare diagram has been provided at the end of this 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 the 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

A Soviet nuclear-powered submarine, the *Komsomolets*, sank in the Barents Sea in 1989 after a fire in the engine compartment.



Figure 25: Photo of a submarine.

The submarine has both a U-235 nuclear reactor on board and two (2) plutonium-tipped torpedos.

A survey carried out by Norway and Russia in 2019 found "clouds" leaking from pipes with high levels of $^{137}_{55}Cs$. The level was 800 Bq kg^{-1}.

(Norway considers safe levels of $^{137}_{55}Cs$ in food as 600 Bq kg^{-1}.)

a) Complete the following nuclear reaction

/1

$$^{1}_{0}n \; + \; ^{235}_{92}U \;\rightarrow\; ^{137}_{55}Cs \; + \; \qquad Rb \; + \; 3\,^{1}_{0}n$$

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The half-life of $^{137}_{55}Cs$ is 30.4 years.

b) Calculate the number of atoms of Caesium in 1 kg of the contaminated water.

/3

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Question 19 continues

Marker use

Caesium decays by β^- emission into stable Barium $^{137}_{56}Ba$ by two paths. Directly, through emitting the β^- particle and indirectly through $^{137m}_{56}Ba$ with a gamma emission of 0.662 MeV.

c) Give decay equations for both of the above processes.

/3

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d) The half life of U-235 is 704 million years while the plutonium isotope in the torpedos have a half life of 24 000 years. Give at least **two (2)** reasons why the submarine's condition must be monitored.

/2

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Total Q19

/9

Question 20

Marker use

Cockroft and Walton fired high energy protons into $^{7}_{3}Li$ as their first target in 1932. The result was the Lithium nucleus splitting into alpha particles, $^{4}_{2}He$.

a) Which force allows the protons to initially be absorbed into the Lithium nucleus? /1

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b) Write the nuclear reaction for the process outlined above. /2

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The masses of $^{7}_{3}Li$ = 7.016004 u $^{4}_{2}He$ = 4.002604 u

c) Calculate the kinetic energy of **each** $^{4}_{2}He$ nucleus in eV after the collision. /3

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d) The protons were fired initially with an energy of 500 keV. Cockroft, Walton and Rutherford measured the $^{4}_{2}He$ particles at 8 MeV by passing the alpha particles produced through thin sheets of metal until all were absorbed. The results were claimed to offer the first confirmation of the famous equation, $E = mc^2$. /1
Why can the proton energy be ignored?

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Total Q20 /7

Question 21

Marker use

An X-ray tube in a hospital operates with a potential difference range of 10 – 200 kV. The target anode is a heavy metal (usually tungsten because of its excellent thermal properties). Currents can be varied from 10 to 800 mA.

It is set at 100 kV.

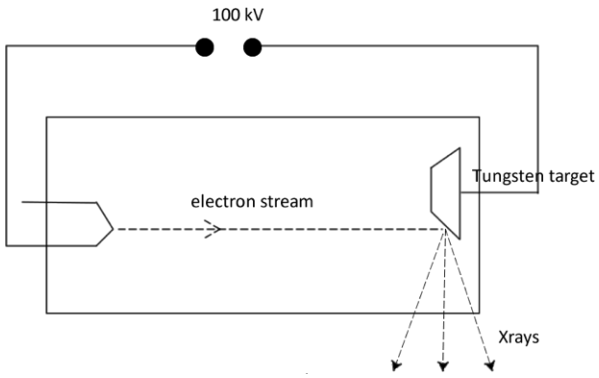


Figure 26: Diagram of X-Ray tube.

Figure 27 shows the intensity vs wavelength curve for a tungsten target in an X-ray tube at 100 kV.

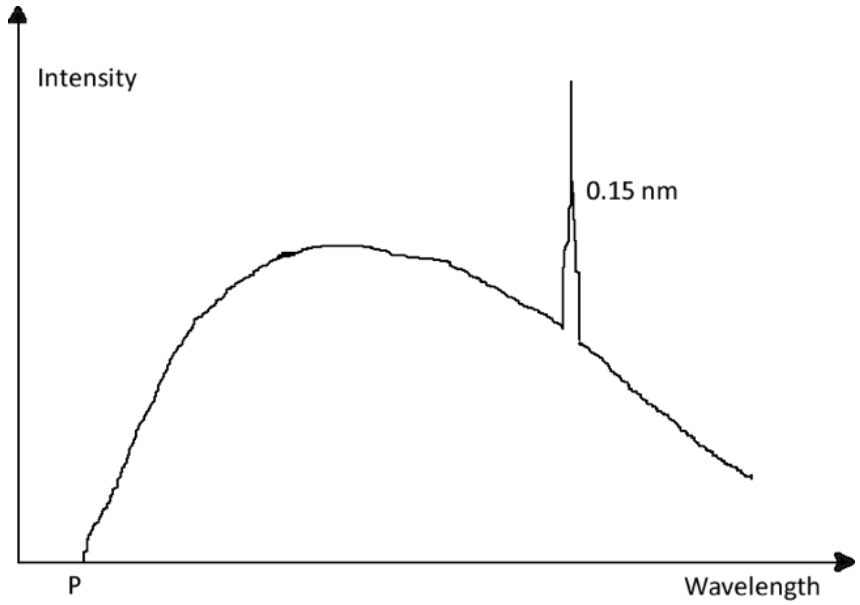


Figure 27: Graph of X-ray spectrum.

Spare diagram used (X) ☐

/2

a) Indicate on Figure 27:

i. the continuous spectrum

ii. the characteristic spectrum.

Question 21 continues

Marker use

b) Describe the physical process that produces the continuous spectrum. Use a diagram to help if needed. /2

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c) Describe the process that produces the characteristic spectrum. Use a diagram to help if necessary. /2

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d) Calculate the wavelength at the point P on Figure 27. /3

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Question 21 continues

Marker use

When X-rays enter the human body, ionisation occurs both in the targeted area, and around the targeted area due to high energy electrons that are produced.

e) Explain the process by which X-rays can produce high energy electrons when passing through matter.

/2

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Total Q21

/11

Question 22

Marker use

Electrons in a particular electron microscope are emitted at an energy of 20 keV.

a) Calculate the wavelength that these electrons exhibit in interference and diffraction situations. /3

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b) Given your knowledge of diffraction, what are the minimum size objects likely to be imaged? /2

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c) Compare the momentum of a photon of this wavelength to the momentum of the electron. /2

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Total Q22 /7

Question 23

Marker use

Stars are classified historically by their colour and their brightness when corrected for distance from us.

a) Calculate the approximate surface temperature of the following star types:

i. O-type stars – colour peaks in the blue, about 390 nm. /1

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ii. G-type stars (like our own Sun) – colour peaks in green, about 500 nm. /1

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iii. M-type stars (like Betelgeuse) – colour peaks in red, about 700 nm. /1

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b) **Two (2)** types of O stars are Blue Giants and White Dwarf stars. Given their names, compare their sizes and hence their intrinsic brightness. /2

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Total Q23 /5

Question 24

Marker use

A photoelectric experiment was carried out using the circuit in Figure 28.

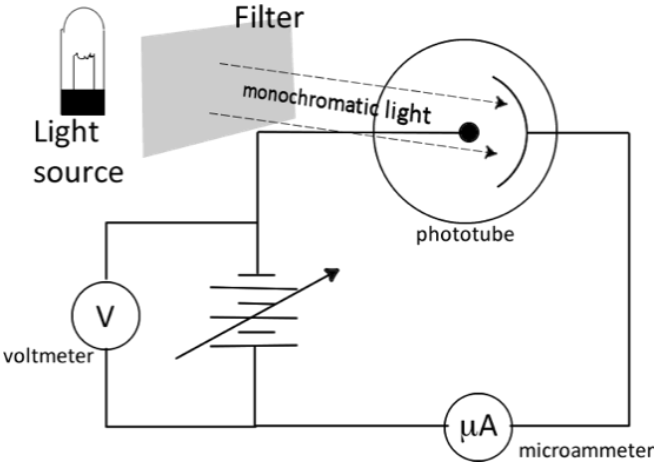


Figure 28: Diagram of photoelectric circuit.

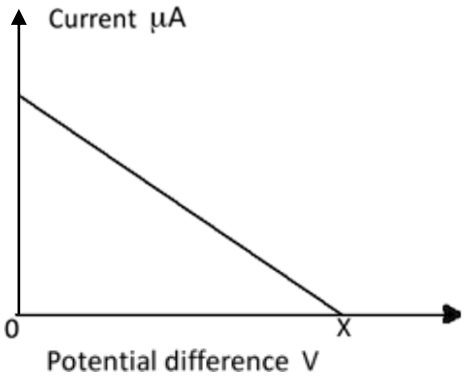


Figure 29: I~V graph.

With a filter in place, the potential difference b etween the collector electrode and the metal plate was increased and the current measured.

The current against voltage is shown in Figure 29.

a) Explain why the current drops to zero at the voltage point X. /2

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Question 24 continues

Marker use

The experimenter then used five (5) filters to give five frequencies and plotted the "stopping voltage" vertically against frequency as shown in Figure 30.

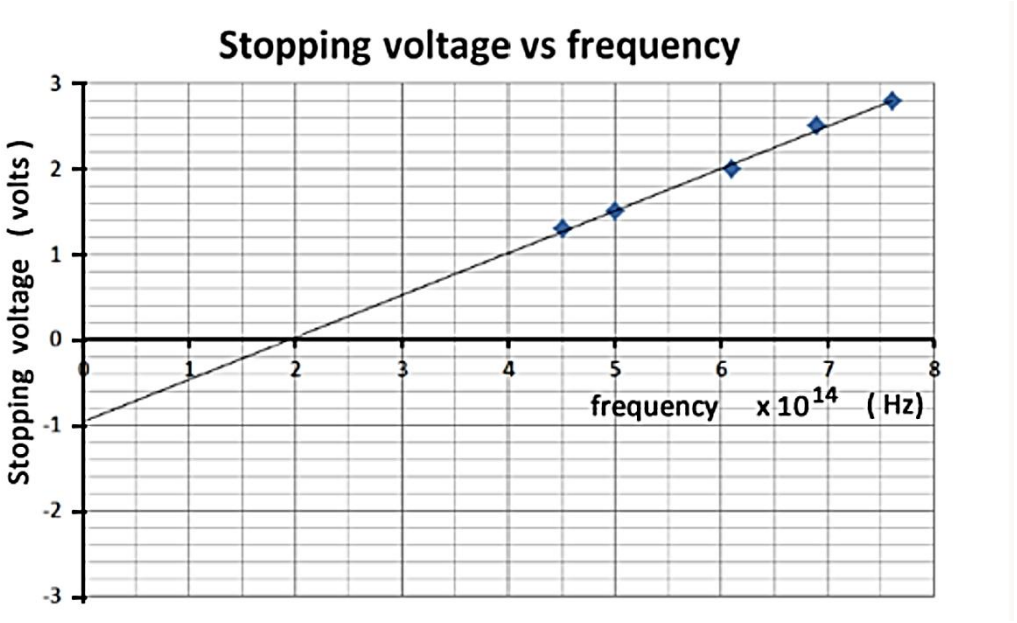


Figure 30: Photoelectric graph of stopping voltage vs frequency.

b)

i. Calculate the slope of the graph (Figure 30) giving the correct units. /1

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ii. What is the significance of the slope from item b) i.? /1

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c) Calculate the longest wavelength that will cause an electron to be emitted from this metal. /2

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Total Q24 /6

Spare Diagram

Question 21 a) i. and ii.

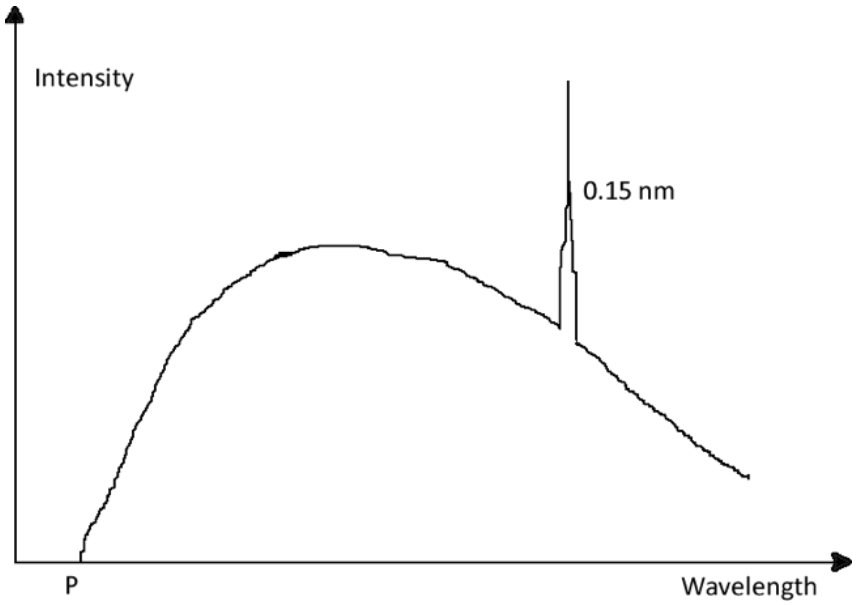


Figure 27: Graph of X-ray spectrum.

End of Section D

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