TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

External Assessment 2023

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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.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 45 minutes**.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physics Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C5	/ 45

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.

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Question 1

Marker use

At an archery range, an arrow is fired at 70 ms^{-1} at a target with the centre placed at the same height as the release point 50 m away. The arrow is pointed 10° vertically upwards.

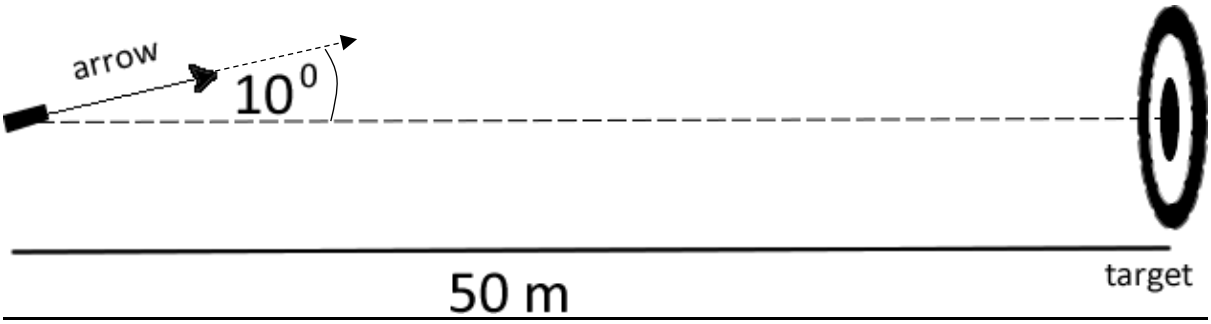

Figure 1: Diagram of an arrow released at a target, highlighting angle and distance.

a) Calculate the vertical and horizontal components of the arrow's velocity.

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b) Calculate the vertical distance by which the arrow misses the centre of the target.

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Total Q1

/5

Question 2

Marker use

A bow is pulled back by an archer with a 20 g arrow by 70 cm.

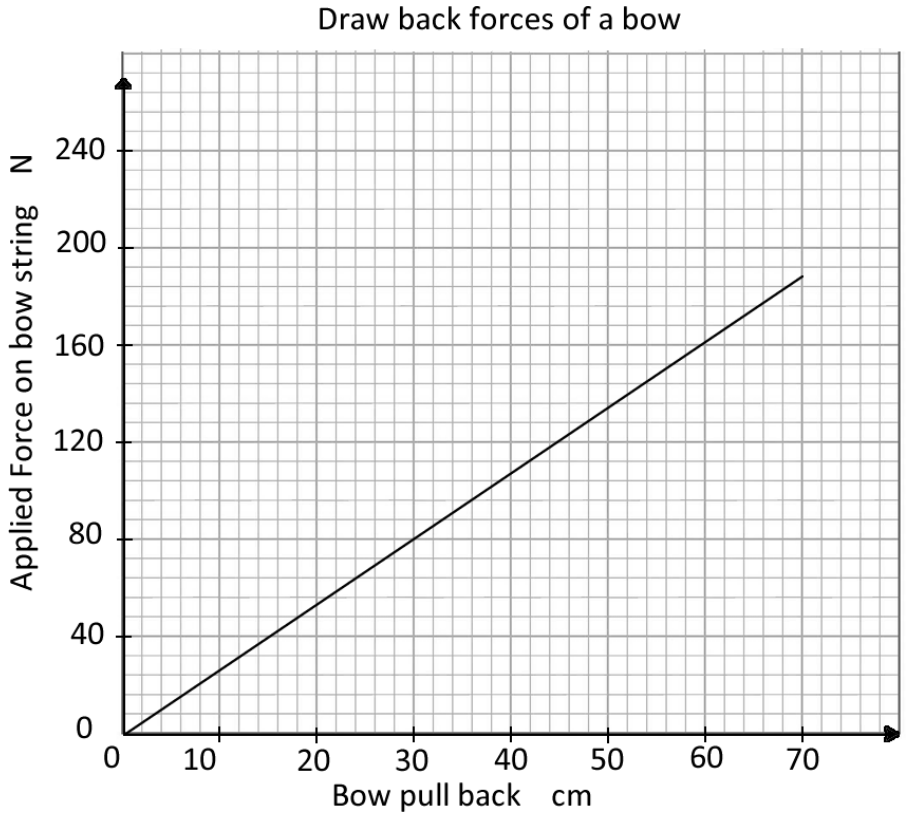

Figure 2: Graph of force applied by an archer on a bow string.

a) From Figure 2, calculate the stored energy available if the arrow is drawn back by 70 cm.

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b) If 60% of the available energy is transferred to the arrow, show that the speed of the released arrow is about 62 m s^{-1}.

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Total Q2

/4

Question 3

Marker use

When the Solar System formed, some 4 billion years ago, Earth was a spinning gas – liquid. As a result, the radius at the equator is 6378 km while at the poles it is 6357 km.

a) Using your knowledge of the laws of physics, explain why the Earth is 'flattened' at the poles. /2

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Earth has a rotational period of 24 hours and a mass of 5.97×10^{24} kg.

b) Without calculation, how will the gravitational field strength of Earth compare at the equator and poles? Justify your answer. /2

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c) Calculate the centripetal acceleration of an object on the equator. /3

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Question 3 continues

Marker use

d) Compare and justify the effect on the force of the ground on a person standing on the equator to that of a person standing at the South Pole:

i. due to the gravitational fields

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ii. due to the spin of the Earth.

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Total Q3

/11

Question 4

Marker use

A bullet of mass 15 g travelling at 350 m s^{-1} hits a metal plate at an angle of 30° to the surface. It bounces off at 30° to the surface at a speed of 200 m s^{-1}.

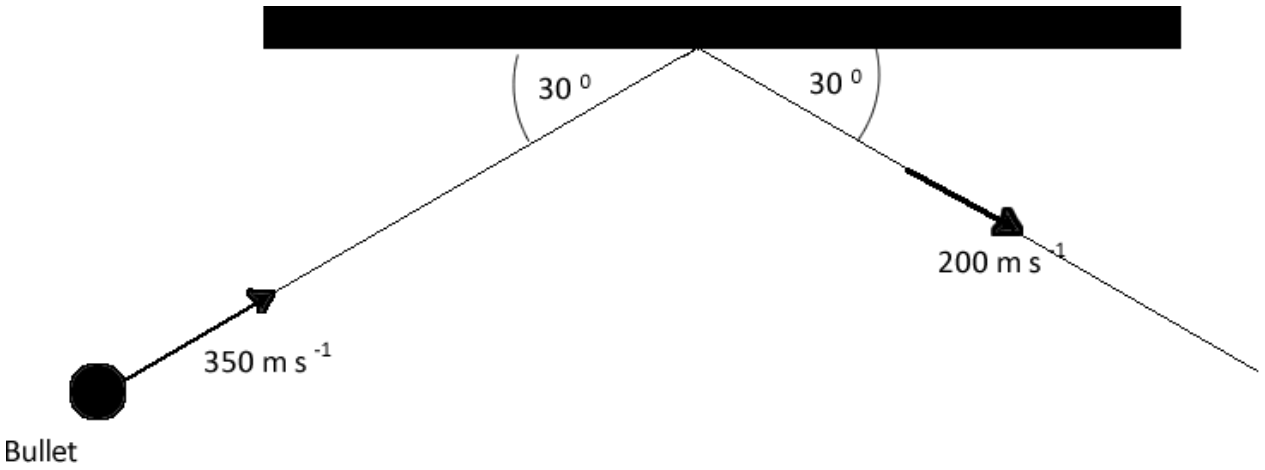

Figure 3: Diagram of a bullet hitting a metal plate and bouncing off, highlighting angle and speed.

a) Draw a vector diagram that allows the change in momentum to be calculated. /2

b) Calculate the magnitude of the change in momentum of the bullet. /3

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Question 4 continues

Marker use

c) Calculate the angle of the change in momentum of the bullet from the initial momentum.

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The time of contact of the bullet with the metal plate is 2.00×10^{-3} s.

d) Calculate the force of the bullet **on the metal plate**.

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Total Q4

/10

Question 5

Marker use

A lump of plasticene of mass 100 g is suspended as a pendulum from a string. An air gun pellet of mass 5 g is fired into it at 100 m s^{-1}.

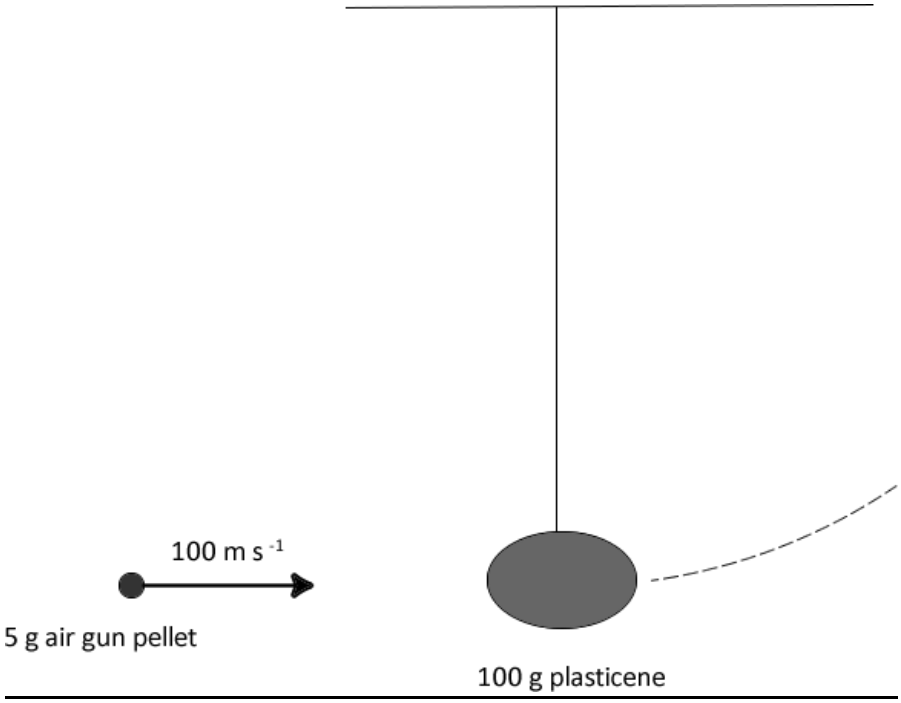

Figure 4: Diagram of an air gun pellet firing into a pendulum made of string and plasticene.

a) Calculate the speed of the combined pellet and plasticene lump immediately after collision.

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b) Calculate the loss in kinetic energy during the collision.

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Question 5 continues

Marker use

c) If all of this loss is due to deforming the plasticene when the pellet goes 2 cm into it, calculate the average force on the pellet.

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d) Calculate the maximum height to which the pendulum will swing.

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Total Q6

/8

Question 6

Marker use

A nearby Sun-like star called HD137496 has recently been found to have two (2) exoplanets, “HD137496b” and “HD137496c” orbiting around it.

The first, “b”, is larger than Earth and orbits its star every 1.62 Earth days.

a) Assuming HD137496 has a mass of 2.1×10^{30} kg, calculate the orbital radius of “b”. /3

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Earth orbits at 1.50×10^{11} m from the Sun and Mercury at a distance of only 5.80×10^{10} m.

b) Comment on the likelihood of life on “b” given its orbital distance. /1

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c) Planet “c” has an orbital radius of 1.21 that of Earth’s orbit. Calculate its orbital period in earth days. /3

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Total Q6 /7

End of Section A

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PHYSICS

PHY415115

Section B Electromagnetism

Pages: 20
Questions: 6
Information Sheet: 1

Suggested working time: 45 minutes

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Marker use	
C6	/ 45

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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 6 identify and apply principles of electricity and magnetism.

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Question 7

Marker use

A charged ball of mass 3.00 x 10^{-6} kg is suspended by a cotton thread between two (2) parallel plates that are 4.00 cm apart.

When 500 V is placed across them, the ball swings 30° as shown in Figure 5.

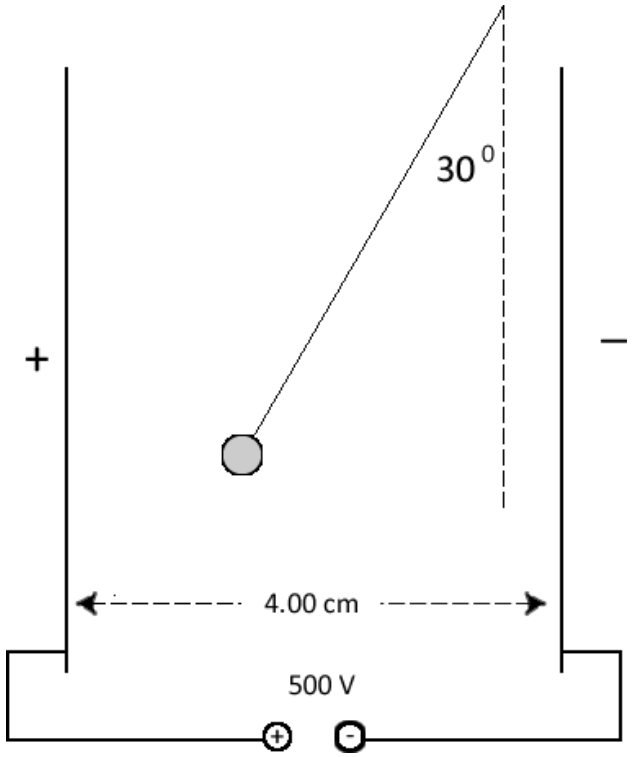

Figure 5: Diagram for annotation to answer Question 7 a).

Spare diagram used (X) ☐

a) On Figure 5, sketch and label the forces on the ball. /2

b) Calculate the electrostatic force on the ball. /3

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Question 7 continues

Marker use

c) Calculate the electrostatic field strength between the plates.

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d) Calculate the charge on the ball.

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Total Q7

/8

Question 8

Marker use

Two (2) charges, A, −3.00 μC and B, −6.00 μC are placed 5.00 cm apart.

a) Calculate the force of A on B.

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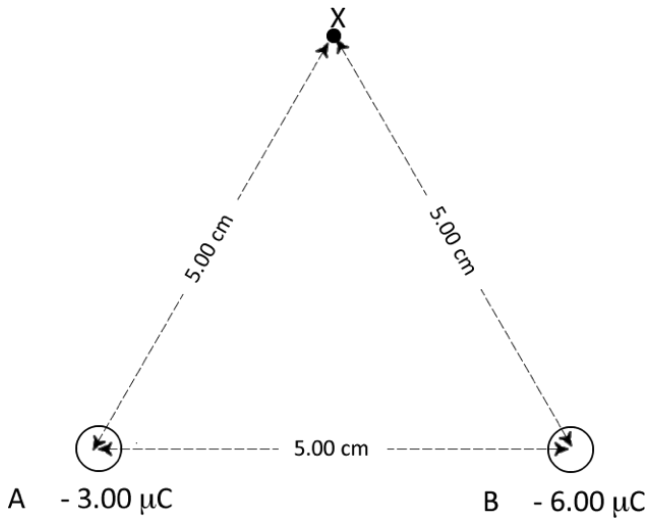

Figure 6: Diagram of the distance between charges A and B, highlighting X.

Spare diagram used (X) ☐

b) At the point X, 5.00 cm from both A and B, as seen on Figure 6, calculate and mark on the diagram the electrostatic field strength:

/2

i. E_A due to A

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ii. E_B Due to B

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Question 8 continues

Marker use

c) Calculate the magnitude of the total electrostatic field strength at X.

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d) On Figure 7 sketch the electrostatic field around A and B.

/2

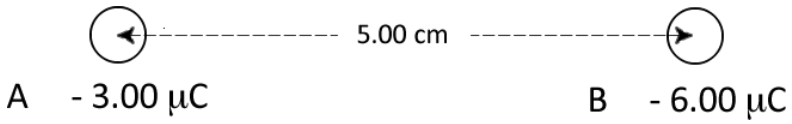

Figure 7: Diagram for sketching answer to Question 8 d).

Spare diagram used (X) ☐

Total Q8

/8

Question 9

Marker use

Two (2) parallel wires 5.00 cm apart are carrying currents of 5.00 A and 10.00 A respectively as shown in Figure 8.

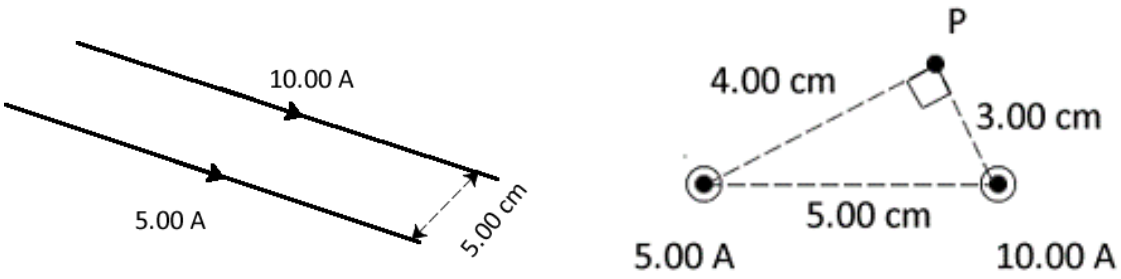

Figure 8: Diagram of the currents carried by two (2) wires and the distance between them.

Spare diagram used (X) ☐

a) Calculate the force per unit length between them.

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b) At the point P, 4.00 cm above the 5.00 A wire and 3.00 cm above the 10.00 A wire, calculate:

i. the magnetic flux density, B_1, due to the 5.00 A wire and sketch it on Figure 8.

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ii. the magnetic flux density, B_2, due to the 10.00 A wire and sketch it on Figure 8.

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Question 9 continues

Marker use

c) Calculate the magnitude of the total magnetic flux density at P.

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/2

d) On Figure 9 sketch the magnetic field lines around the two (2) wires.

/2

Figure 9: Diagram for sketching answer to Question 9 d).

Spare diagram used (X) ☐

Total Q9

/9

Question 10

Marker use

Students are going to carry out a magnetic force on a current against angle experiment. From the data derived in the experiment, they will measure the flux density, B, between the magnets used.

A pair of magnets is placed on an electronic balance and a 1.0 cm wire is placed horizontally in the field between the magnets. The wire carrying a current can be rotated through an angle θ up to 180° in the magnetic field.

10 A was passed through the wire for the entire experiment.

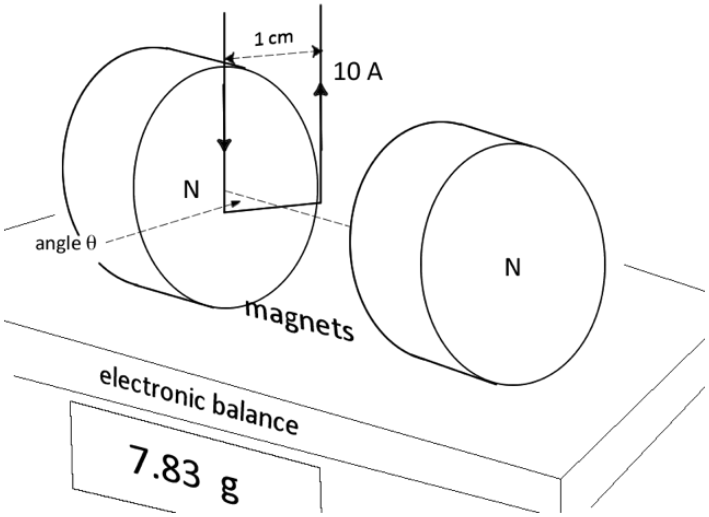

Figure 10: Diagram of a current against angle experiment.

Below are four (4) data results:

Angle degrees	0°	40°	90°	160°
Balance reading grams	0	7.83	12.2	4.17
Force on the wire N				

Table 1

Spare diagram used (X) ☐

a) Which force equation applies to the wire?

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Question 10 continues

Marker use

b) Complete Table 1 so that the data can be analysed using a graph.

/2

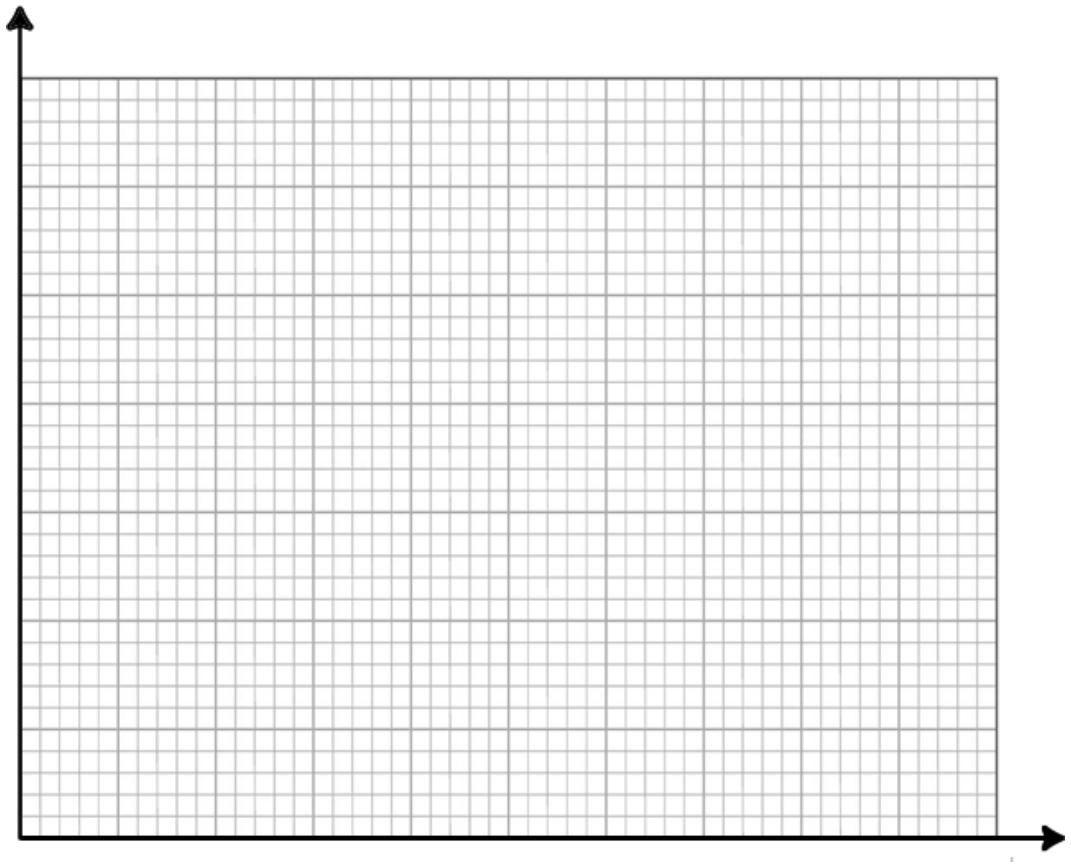

Figure 11: Graph for completion to answer Question 10 c).

Spare diagram used (X) ☐

c) Plot your new data on Figure 11.

/2

d) From the graph, calculate the value of B between the magnets.

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Total Q10

/7

Question 11

Marker use

The Large Hadron Collider on the Swiss – French border accelerates protons to extremely high energies. The protons move in large circles controlled by magnetic fields.

At full energy, a proton has a momentum of 7 TeV c^{-1}. (c is the speed of light)

a) By carefully looking at the units, show that this is 3.73 x 10^{-15} N s. /2

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b) Show that the speed of the proton **appears** to be well above the speed of light. /1

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c) The protons are kept in a circle of radius 4.23 km. Calculate the magnetic flux density required to keep them in this circle. /2

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d) A bunch of protons in each burst comprises of approximately 10^{11} protons squeezed to the width of a human hair, about 64 μm at each point of collision. By looking at the force between just two protons separated by 64 μm comment on the difficulties of keeping so many protons close together. /3

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Total Q11 /8

Question 12

Marker use

A magneto is a simple generator used in older piston engine aircraft and small petrol engines.

A magnet spins between the poles of a laminated iron horseshoe. A coil of windings connected to a load XY are wrapped around the horseshoe as shown.

The magnet is spinning anticlockwise. The north pole is entering the horseshoe at A and the south at B.

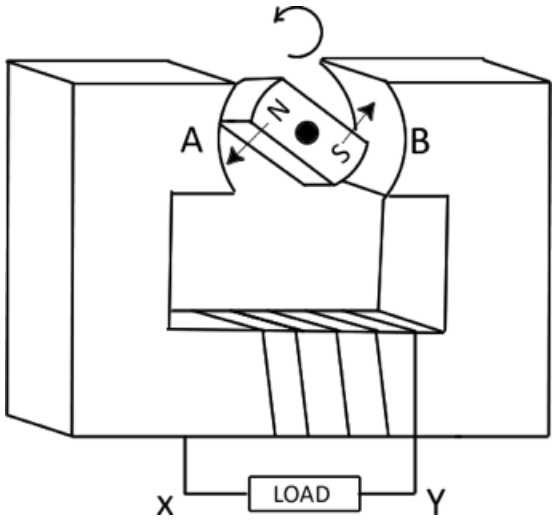

Figure 12: Diagram for sketching answer to Question 12 a).

Spare diagram used (X) ☐

The horseshoe core closes the magnetic field in a loop.

a) On Figure 12, sketch the magnetic field lines in the horseshoe created by the magnet. /1

b) Circle or underline the correct words in the statements below: /2

i. “The magnetic flux density in the coil is INCREASING / DECREASING.”

ii. “The induced current through the load will go from X to Y / Y to X.”

c) Justify the direction of the induced current through the load resistor. /2

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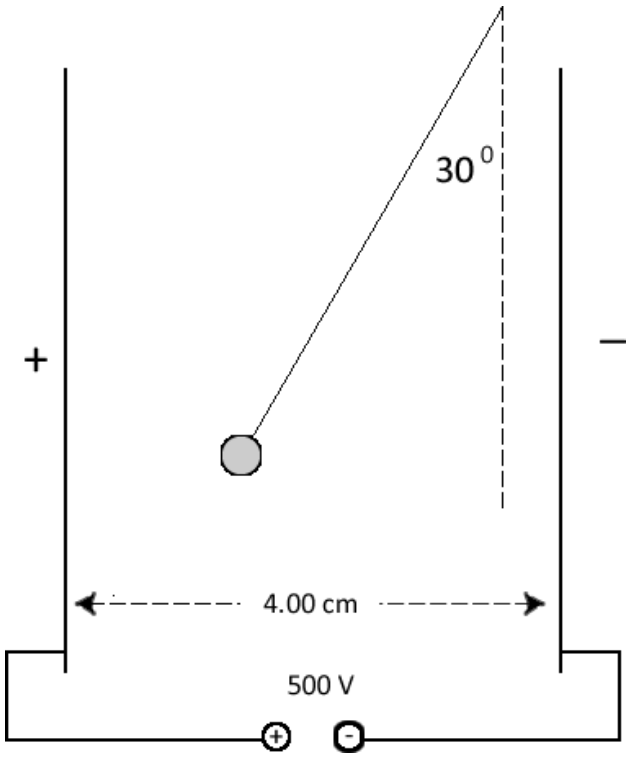
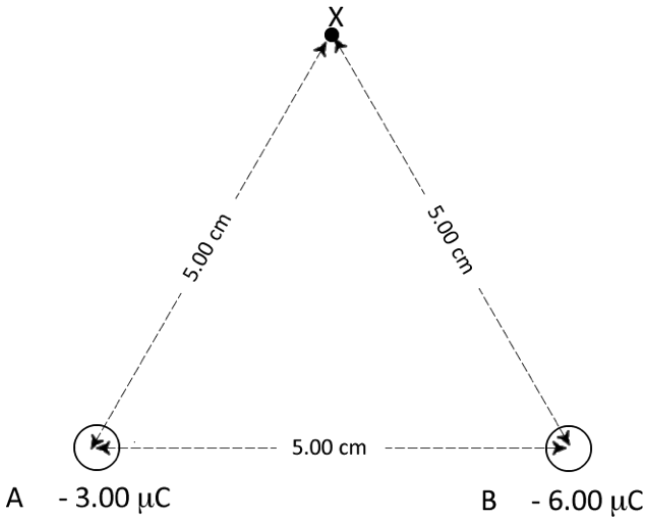
Total Q12 /5

Spare Diagrams

Question 7 a)

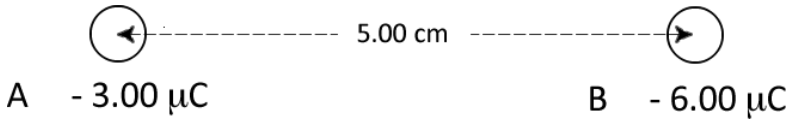


Question 8 b)

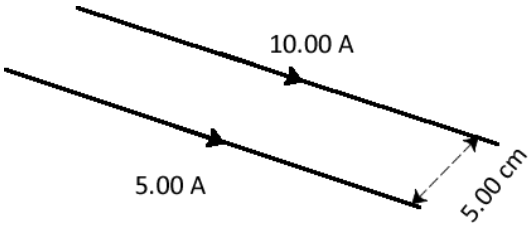


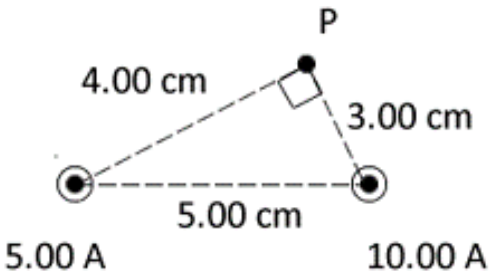
Spare Diagrams

Question 8 d)



Question 9 b)





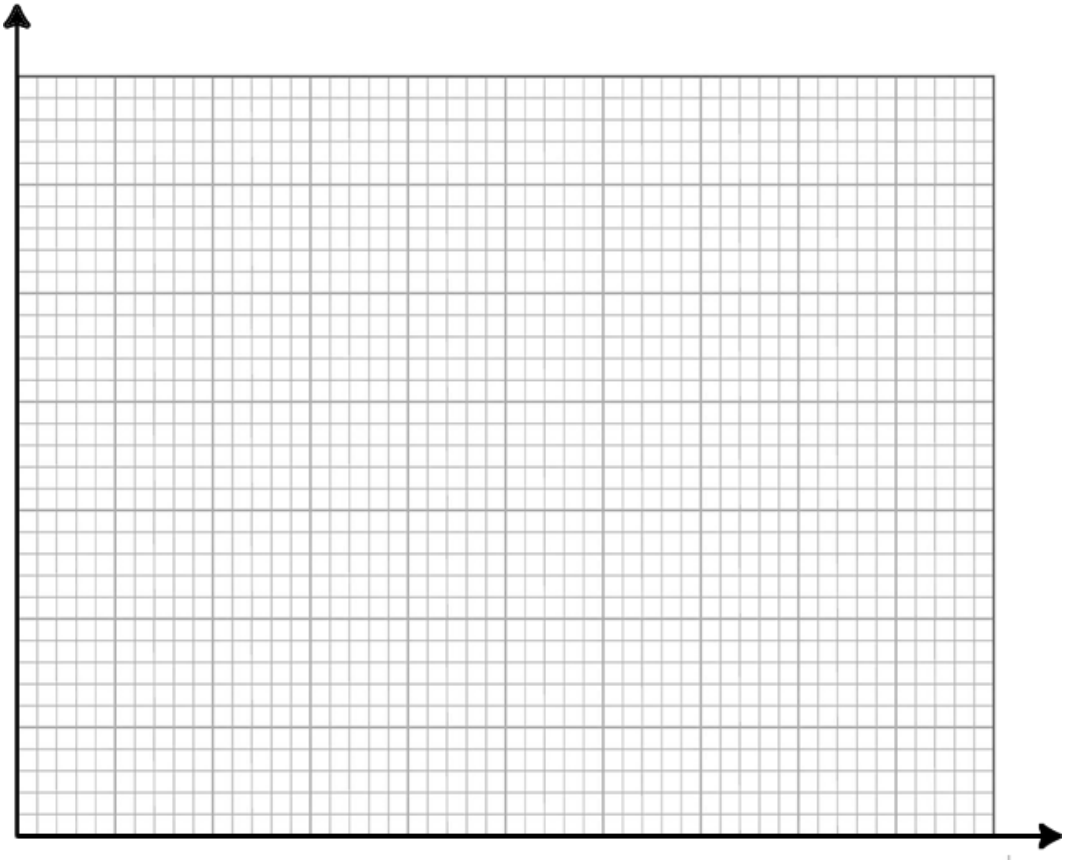
Question 9 d)

Spare Diagrams

Question 10 b)

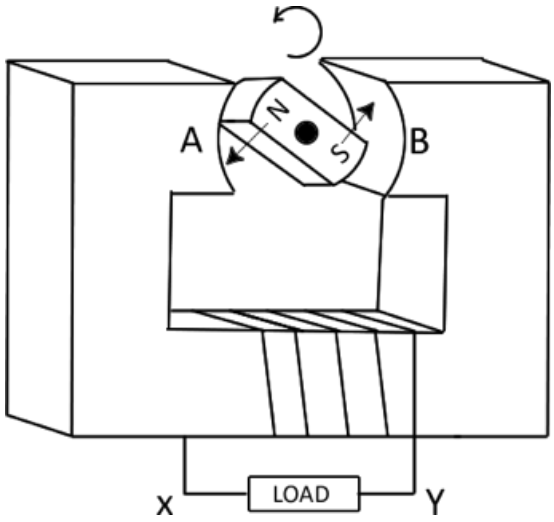
Angle degrees	0°	40°	90°	160°
Balance reading grams	0	7.83	12.2	4.17
Force on the wire N				

Question 10 c)



Spare Diagrams

Question 12 a)



End of Section B

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PHYSICS

PHY415115

Section C Waves

Pages: 16
Questions: 6
Information Sheet: 1

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 A piano string plays at a fundamental frequency of 440 Hz. Its length in one (1) piano is 0.389 m.

a) Calculate the wave velocity in the string.

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The string is under 667 N of tension.

b) Calculate the mass of the 0.389 m long wire.

/2

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In a piano, the A note usually has three (3) identical strings that must be tuned to each other. Suppose two are under 667 N of tension but the third has only 658 N of tension.

c) Show that the third string's fundamental frequency is only 437 Hz.

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d) What will happen when this group of strings is played? Give a numerical value associated with your comment.

/2

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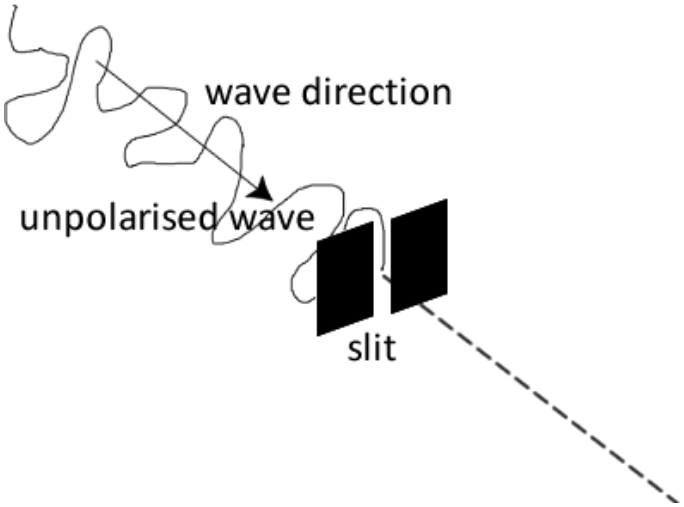
Total Q13

/8

Question 14

Marker use

A string passes through a slit that restricts movement of the string if disturbed. An unpolarised wave is then set up to pass through this slit from the left.



Spare diagram used (X) ☐

Figure 13: Diagram for sketching answer to Question 14 a).

a) Sketch on Figure 13 the wave after passing through the slit. /1

Consider now polarised light falling on a plastic polarising filter that acts like the above slit on light. The filter is at 45° to the line of light polarisation.

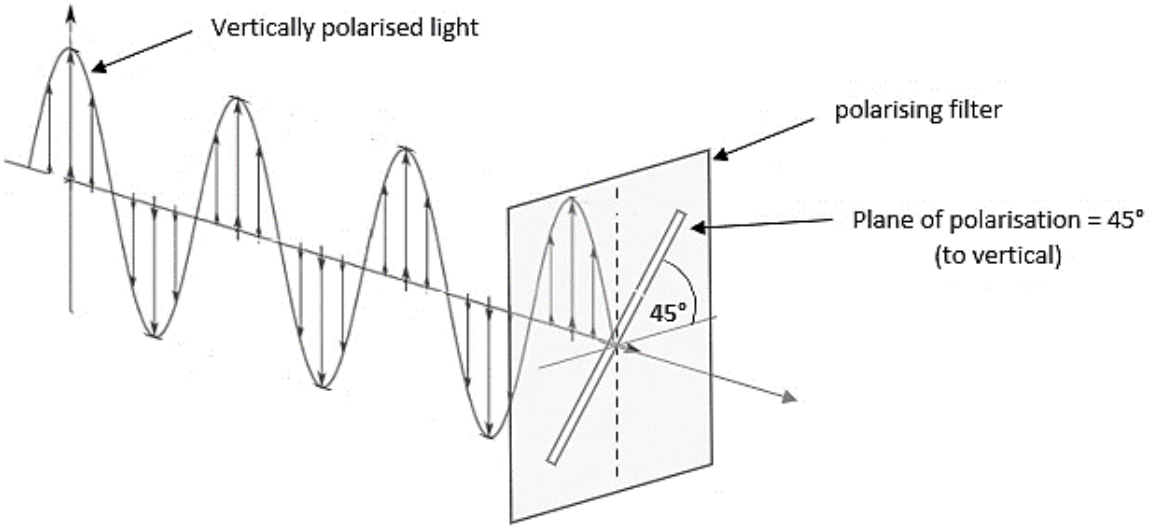


Figure 14: Diagram of polarised light falling on a plastic polarising filter, highlighting the angle.

Question 14 continues

Marker use

b) Using a suitable diagram, show that the component of the incident light of amplitude A is 0.707 A.

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If two (2) of these filters are placed at 90° to each other, no light is transmitted. A favourite teacher trick is to place a third filter between the two at 45° whereupon, light is again transmitted.

c) Using a diagram to help, explain why some transmission now occurs.

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Total Q14

/5

Question 15

Marker use

A particle is vibrating (oscillating) in an intense continuous sound wave. The speed of the sound wave is 340 m s^{-1}.

A graph of its displacement is given below.

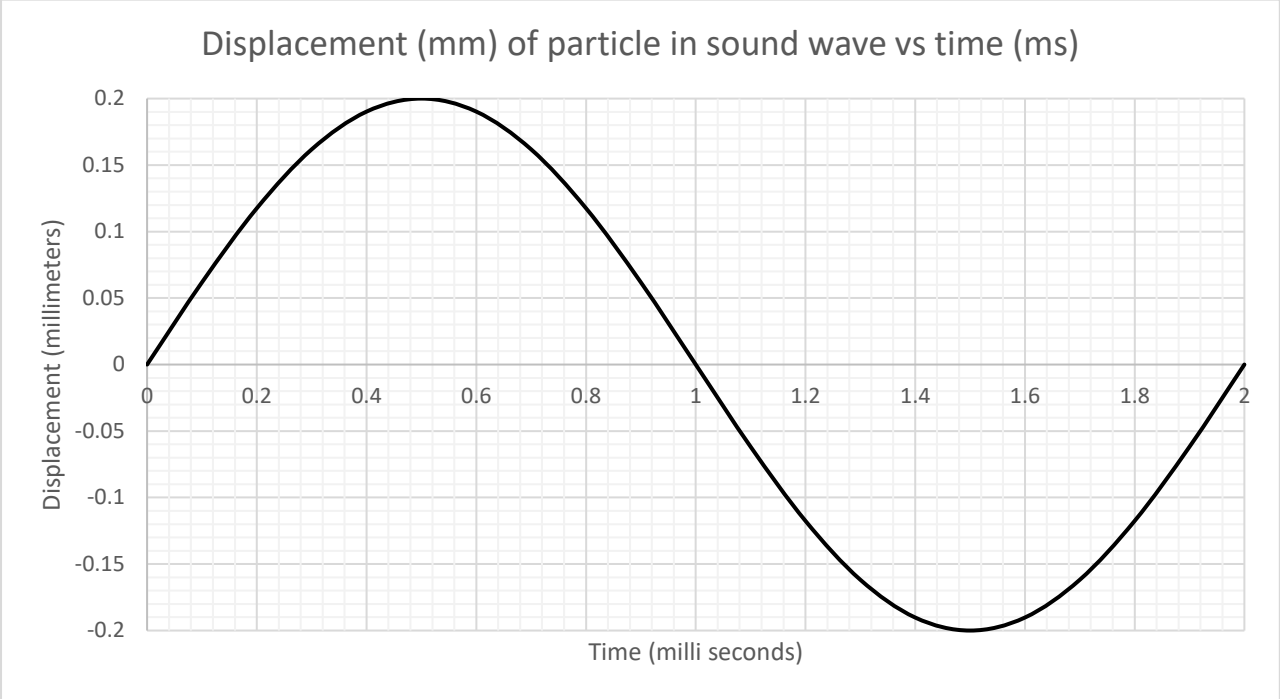

Figure 15: Graph of a particle's displacement (mm).

Spare diagram used (X) ☐

a) Determine the:

i. period of the wave

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ii. frequency of the wave

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iii. wavelength of the wave

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Question 15 continues

Marker use

b) Estimate the speed of the particle at a time of 1.0 ms using an appropriate tangent. Explain your working.

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c) The sound waves are in a tube closed at one end of length 0.510 m.

i. Calculate the ratio of tube length to wave length.

/1

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ii. Sketch the wave pattern inside the tube.

/2

Total Q15

/11

Question 16

Marker use

Tasmania has several radio telescope antennae at Mt Pleasant Observatory. Two (2) are pointing towards a very distant radio source as in Figure 16 below.

Figure 16: Photo of a radio telescope antennae pointing towards a distant radio source.

The antennae are tuned to 3.00 GHz signals.

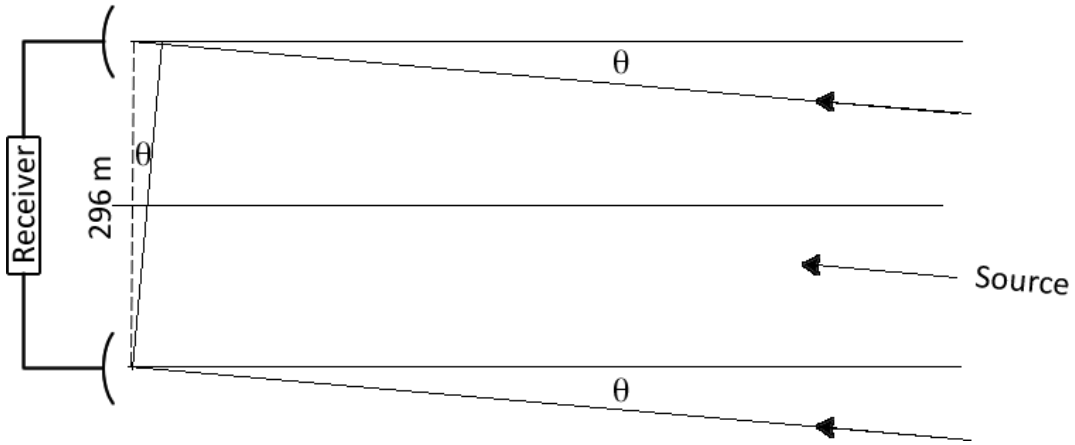

Figure 17: Diagram of an antennae receiving radio signals.

a) At great distances the source can be considered as a point source. Give a reason why this is important. /2

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Question 16 continues

Marker use

b) Calculate the observed wavelength.

/1

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The antennae are separated by 296 m.

The antennae are connected to a receiver with identical length cables.

c) If the angle θ is zero, would you expect a strong or weak signal at the station from the source? Justify your reasoning.

/2

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d) What difference in path lengths would you expect to see the first weak signal at the receiver?

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e) Calculate the angle θ at which the first weak signal is observed.

/2

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Total Q16

/8

Question 17

Marker use

A ray of light is incident on a triangular prism with a refracting angle of 60°, as shown. The refractive index of the glass is 1.50 and the angle of incidence is 24°.

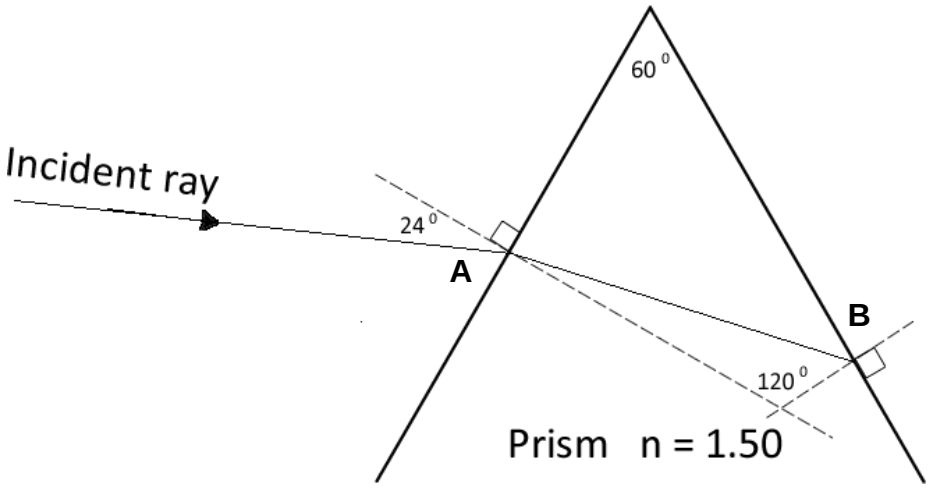

Figure 18: Diagram of an incident ray on a triangular prism, highlighting the refracting angle.

a) Calculate the angle of refraction at A.

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b) Calculate the angle of incidence at B.

/2

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c) Calculate the critical angle at B.

/2

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Question 17 continues

Marker use

d) Explain why the ray does not leave the prism at B.

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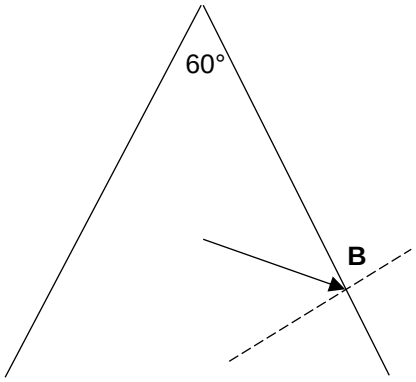
/1

e) Sketch and label the subsequent path of the ray at B.



/1

Spare diagram used (X) ☐

Figure 19: Diagram for sketching answer to Question 17 e).

Total Q17

/7

Question 18

Marker use

In a very early radar experiment (1935), a receiver of radio waves was placed several kilometres away from a commercial radio transmitter operating at a frequency of 6 MHz. A metal plane then flew overhead between the transmitter and the receiver.

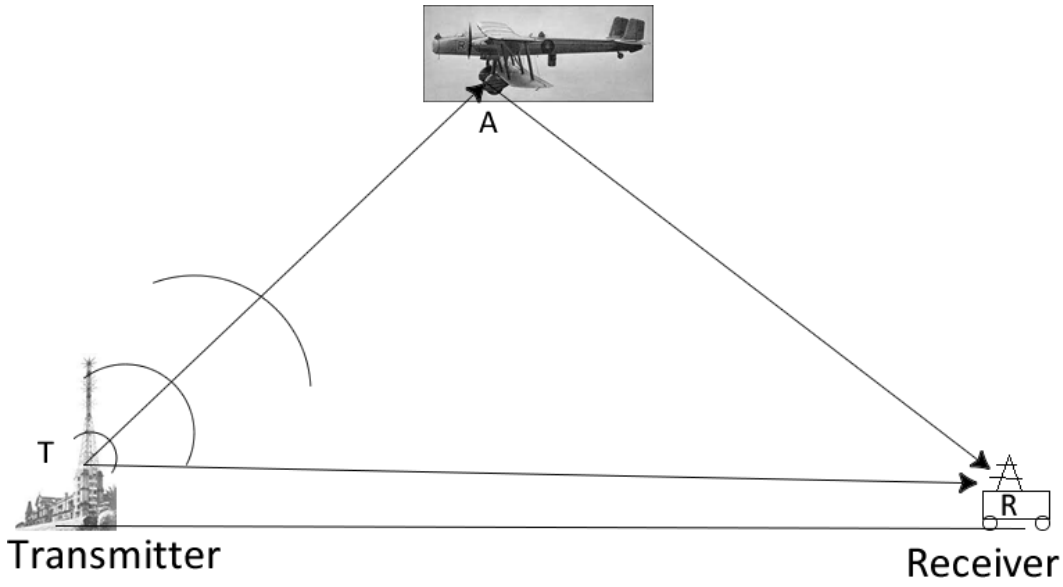


Figure 20: Diagram of a metal plane flying overhead between a transmitter and a receiver.

a) Calculate the wavelength of the radio wave.

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/1

b) Explain why the plane had to be metal rather than wood.

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/2

c) In terms of the points T, A, R on Figure 20, give an expression for the path difference between the two (2) paths to the receiver.

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/1

Question 18 continues

Marker use

As the plane flew over, the signal at the receiver started oscillating up and down in strength.

d) Explain why the signal changed as the plane flew over.

/2

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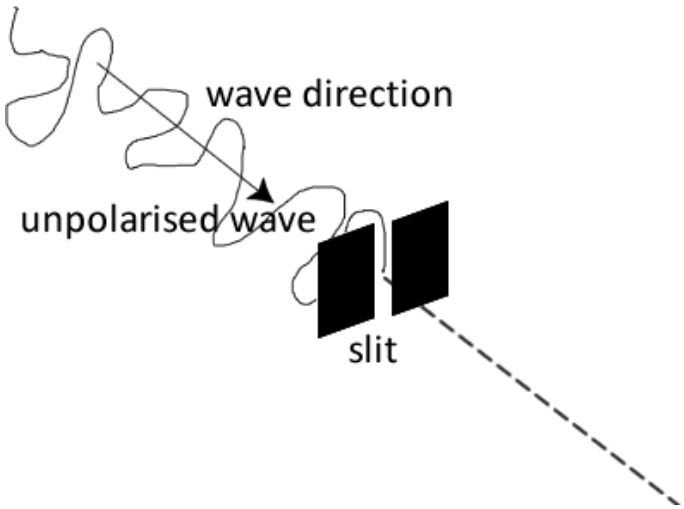
Total Q18

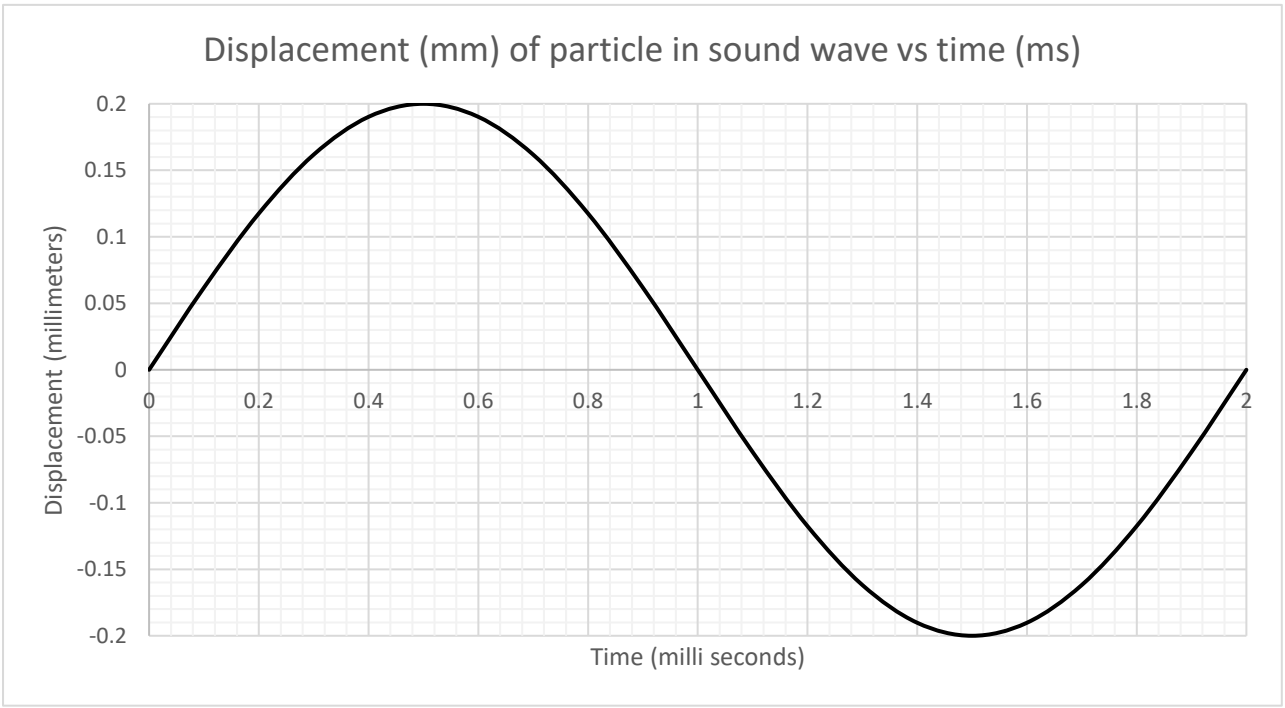
/6

Spare Diagrams

Question 14 a)

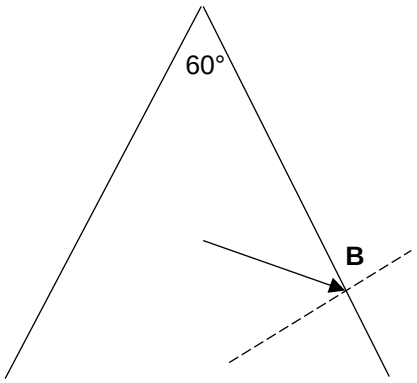


Question 15 b)



Spare Diagrams

Question 17 e)



End of Section C

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PHYSICS

PHY415115

Section D Twentieth Century

Pages: 12
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.
- The exam is **three (3) hours** in length. The suggested working time for this section is **approximately 45 minutes**.
- TASC-approved scientific calculators can be used throughout the exam.
- The Physics Information Sheet can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address the listed criterion.

Marker use	
C8	/ 45

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.

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Question 19

Marker use

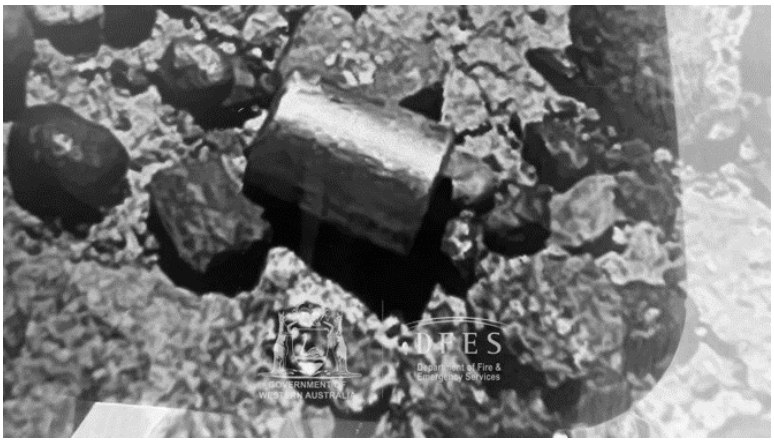

Figure 21: Photo of a radioactive capsule on the side of a road.

Recently, a radioactive source used in industry was lost on the side of a remote road in WA and subsequently found. The source was $^{137}_{55}Cs$, a beta emitter. Its half-life is 30.1 years. This is commonly available in schools but the activity of this source was 19 GBq, much greater than that allowed in schools!

a) Give the decay equation of $^{137}_{55}Cs$ to barium-137.

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/2

b) Calculate the number of atoms associated with this particular source.

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/2

Some atoms decay to a metastable barium atom with a half-life of 153 seconds.

c) Give the subsequent decay equation of the metastable barium atom.

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/1

Total Q19

/5

Question 20

Marker use

The mass of Cs-137 is 136.907089 u while that of Ba-137 is 136.905827 u.

a) Calculate the mass difference during the decay of Cs-137.

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b) Calculate the maximum Ek of the emitted electron in MeV.

/2

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c) Which of the three (3) emissions from the lost source in Question 19 allowed it to be found using detectors in vehicles? Justify your answer.

/2

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Total Q20

/6

Question 21

Marker use

Stars are catalogued by their surface temperature and brightness. Two (2) extremely hot star types, A type and White Dwarf type have surface temperatures of about 10 000 K.

a) Calculate the peak wavelength associated with this temperature and nominate the colour associated with the wavelength. /2

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White Dwarf stars are 10^6 times less bright than A type stars.

b) Account for this difference in terms of the physical size of the stars. /1

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A typical A star may emit 20 times the energy of the Sun each second as electromagnetic radiation.

c) Given the Sun emits 3.84 x 10^{26} J s^{-1} , calculate the mass loss each second of an A star as radiation. /2

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d) The Sun is halfway through a life of about 9 billion years as an ordinary star. Given your result for item c), comment on the likely life of an A star compared with the Sun. Provide justification. /2

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Total Q21 /7

Question 22

Marker use

The Compton Scattering Experiment of 1923 showed conclusively that light has both wave and particle properties.

a) By combining two (2) equations for energy, show that the momentum of a photon can be given by $p = \frac{h}{\lambda}$. /2

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b) An X-ray photon has an energy of 60 keV. Calculate the momentum of this photon. /2

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c) The above photon strikes an electron and is scattered through an angle of 60° leaving with a wavelength of 2.18 x 10^{-11} m.

i. Calculate the momentum of the scattered photon. /2

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ii. Sketch an appropriate diagram that allows the momentum of the electron to be evaluated. /2

Total Q22 /8

Question 23

Marker use

X-rays are produced by high energy electrons striking a heavy metal element, usually tungsten. Two (2) principal mechanisms exist that produce a continuous spectrum and a characteristic spectrum.

a) Sketch a graph showing how the intensity of X-rays produced by a typical X-ray tube varies with their wavelength. Show and label the **two (2)** spectral types. /2

b)

i. Describe, using a sketch diagram if needed, the mechanism that produces the continuous spectrum. /2

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Question 23 continues

Marker use

ii. Describe, using a sketch diagram if needed, the mechanism that produces the characteristic spectrum.

/2

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c) An X-ray tube is operated at around 100 kV. How does the changing operating voltage affect:

i. the continuous spectrum in frequency and intensity?

/2

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ii. the characteristic spectrum?

/1

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d) Calculate the minimum wavelength of emissions from a 100 kV tube operation.

/2

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Total Q23

/11

Question 24

Marker use

The photoelectric effect was recently tested (February 2022) using carbon monoxide molecules. It was found that the electron emission times are a few attoseconds (10^{-18} s) after the light is turned on.

In 1900, the understanding of light gave incorrect predictions for the photoelectric effect.

a) Using Einstein's photoelectric equation and modern theory explain why the following statements are **wrong**:

i. Red light should be more effective than blue for the production of photoelectrons. /2

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ii. Brighter light should give faster photoelectrons. /2

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iii. There should be a time delay between the light illumination and the photocurrent. /2

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Question 24 continues

Question 24 continued

Marker use

A monochromatic light source of wavelength 405 nm is shone on a clean calcium plate placed in a photoelectric tube. The photocurrent is stopped with a PD of 0.20 V.

b)

i. Calculate the energy in eV of a photon of this wavelength.

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/1

ii. Calculate the work function of the calcium metal in eV.

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/1

End of Section D

Total Q24

/8

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