OFFICE OF TASMANIAN ASSESSMENT, STANDARDS & CERTIFICATION

External Assessment 2022

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PHYSICS

PHY415115

Section A Newtonian Physics

Pages	12
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 diagrams.
- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The **Physics Information Sheet** can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 5 identify and apply principles of Newtonian mechanics including gravitational fields.

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**

Question 1

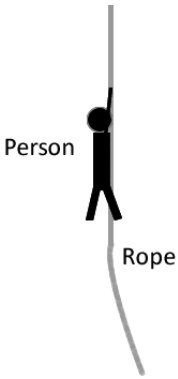
Marker use

A person of mass 90.0 kg slides down a rope that would break if a force exceeding 700 N is exerted on it!

a) Sketch and label the forces on the person as they slide down the rope either in the space provided or on the diagram below.

/1

Spare diagram used (✓)



b) Calculate the minimum acceleration the person must have while sliding in order to not break the rope.

/3

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c) Calculate the minimum speed of the person when reaching the ground 4.00 m below the starting point.

/2

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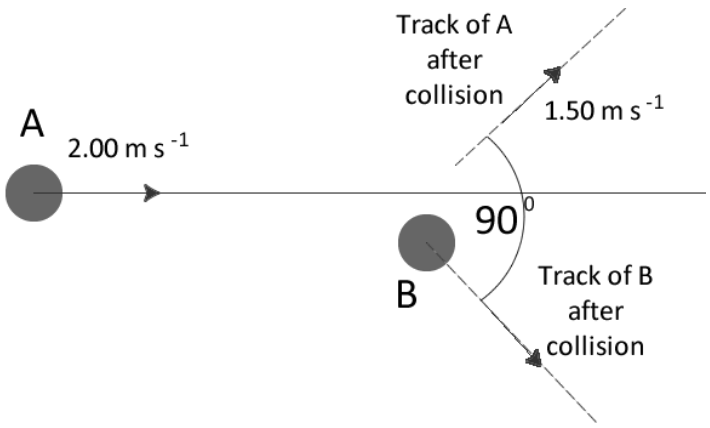
Total Q1

/6

Section A continues

Marker use

Question 2



Two identical billiard balls of mass 0.170 kg collide. The first, A, is moving at 2.00 m s^{-1}, striking a second stationary ball, B. The balls separate at 90° with ball A moving at 1.50 m s^{-1}.

a) Sketch a suitable vector diagram that will allow the velocity of the second ball, B, to be calculated.

/ **2**

b) Calculate the speed of the second ball (B).

/ **2**

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c) Show that the second ball, B, moves at an angle of 48.6° to the original line of motion.

/ **2**

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d) Is this collision elastic? Justify your answer.

/ **2**

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Total Q2

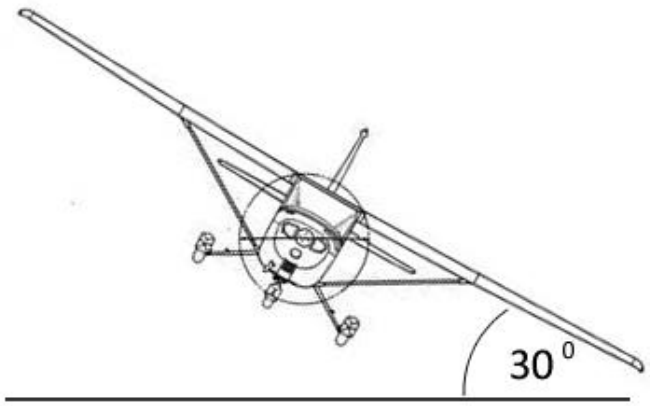
/ **8**

Section A continues

Marker use

Question 3

A plane of mass 900 kg turns in a horizontal circle by tilting 30° and slightly increasing its speed.



Spare diagram used (✓) ☐

For the plane to remain turning in a horizontal circle, the vertical forces must add to zero.

a) Justify this statement in terms of Newton's Laws. /2

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Air exerts a force called 'lift' on wings at 90° to their surface.

b) Sketch and label the forces on the plane either on the diagram above or to the left of the diagram. /2

c) Calculate the unbalanced force acting on the plane. /3

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d) If the plane is travelling at 63.0 m s^{-1}, what is the radius of its turn? /2

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Total Q3 /9

Section A continues

Marker use

Question 4

The asteroid 130 Elektra is orbiting the Sun with a period of 5.53 Earth years.

a) Given the Earth's orbital radius of 1.50×10^8 km, find the orbital distance of Elektra from the Sun. **2**

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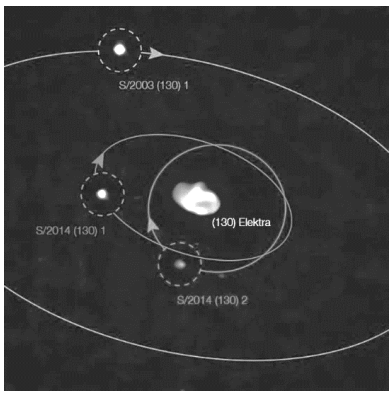
Elektra has 3 moons. These are very small, a few kilometres in size each. One of these orbits at a distance of 501 km from Elektra with a period of 1.19 Earth days.



b) Show that the acceleration of this moon is approximately 1.9×10^{-3} m s^{-2}. **2**

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c) What is Elektra's gravitational field strength in the vicinity of this moon? **1**

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d) What is the mass of Elektra? **3**

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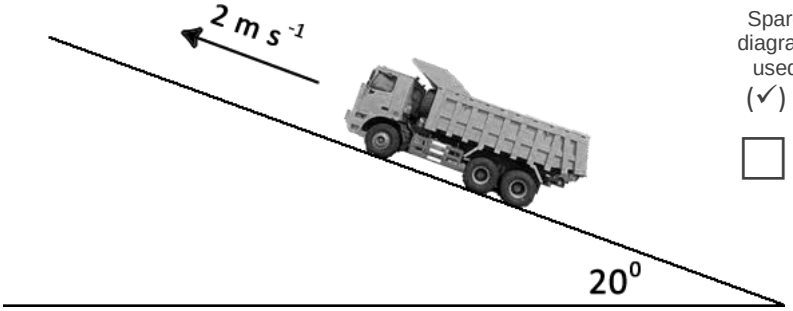
Total Q4 **8**

Section A continues

Marker use

Question 5

A 50 000 kg truck is climbing a hill of inclination 20° to the horizontal. It is moving at a constant speed of 2 m s^{-1}. The road surface and air are providing resistance forces to the motion.



Spare diagram used (✓) ☐

a) Sketch and label the forces acting on the truck while driving up the hill, either on the diagram or to the left of the diagram. /2

b)

i. Calculate the potential energy gained per second by the truck. /2

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ii. Calculate the work done per second against a resistance force of one tenth (0.1) of the weight. /2

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c) If the engine is operating at 550 kW, calculate the percentage of energy generated by the engine used to move the truck up the slope. /2

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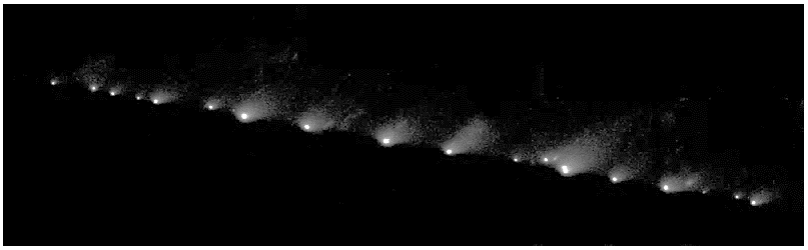
Total Q5 /8

Section A continues

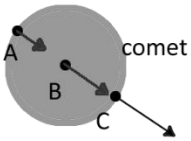
Marker use

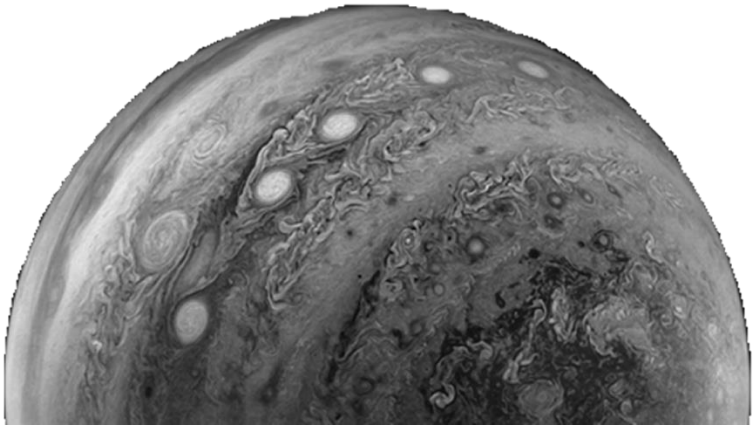
Question 6



Comet Shoemaker- Levy 9 fell apart (fragmented) before it crashed into Jupiter in 1994. It was "spaghettified".

Consider the parts, A, B, C on a comet near a huge mass like Jupiter, as in the diagram below.





Spare diagram used (✓)

☐

a) The vectors on the diagram at A, B, and C represent the relative gravitational field strengths of Jupiter at these points. Explain their relative sizes, justifying your answers.

/2

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b) Explain why the comet broke apart as it approached Jupiter.

/2

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Question 6 continues

Marker use

/2

c) If a similar comet is now in orbit around Jupiter, but only the point B has an acceleration appropriate to the orbit, what will happen to its shape?

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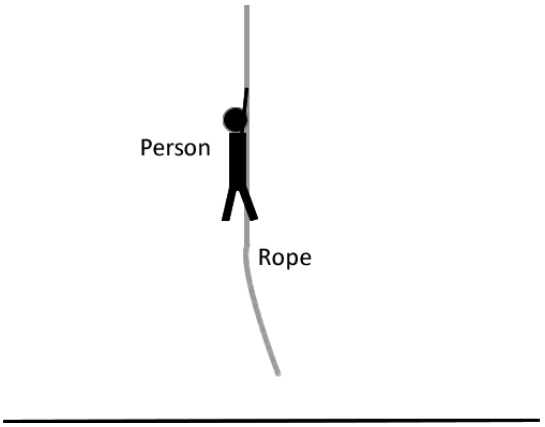
Total Q6

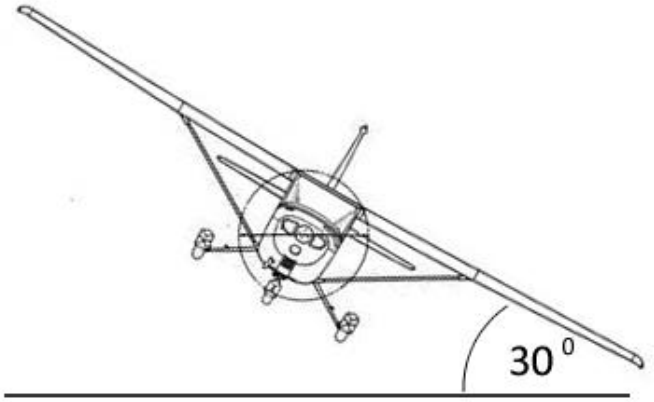
/6

Spare Diagrams

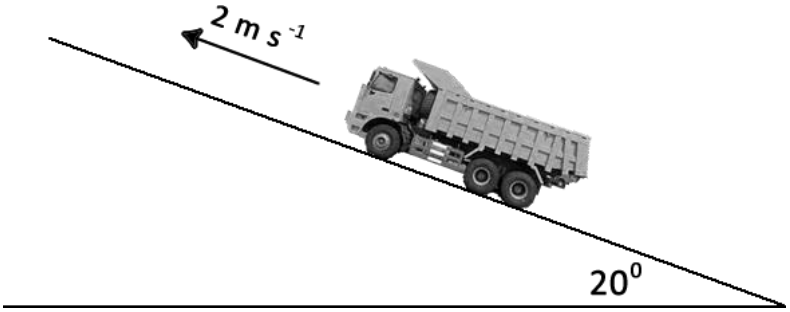
Question 1 a)



Question 3 b)

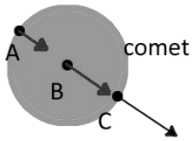


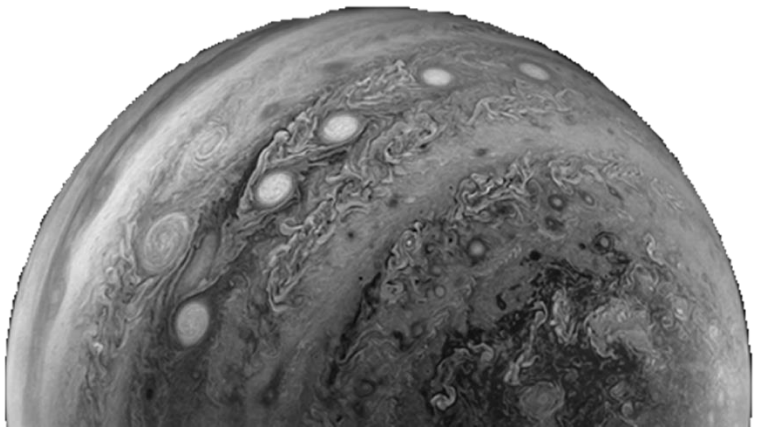
Question 5 a)



Spare Diagrams

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:

- Answer **all** questions and **all** items within each question.
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- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The **Physics Information Sheet** can be used throughout this exam.
- All answers must be written in **English**.
- You **must** make sure your answers address:
  - Criterion 6 identify and apply principles and theories of electricity and magnetism.

Marker Use	
C6	/ 45

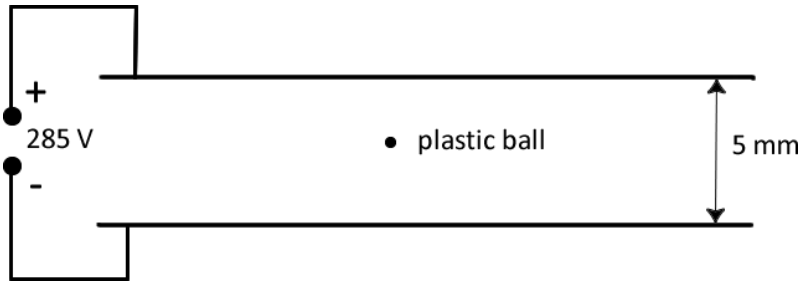
Guide to Exam Structure

	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**

Question 7

Marker use

In a Millikan-type experiment, a small plastic ball of radius 9.03 x 10^{-7} m and density of 941 kg m^{-3} is held stationary between two metal plates with a PD of 285 V, as shown. The plates are separated by a distance of 5.00 mm.



Spare diagram used (✓) ☐

a) Show that the volume of the sphere is 3.08 x 10^{-18} m^3.

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1

b) Calculate the **weight** of the sphere.

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2

c)

i. Sketch the electric field between the plates on the diagram above.

1

ii. Calculate the electric field strength between the plates.

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1

d) Calculate the charge on the sphere.

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2

e) If the above value is 3 elementary charges, what is the experimental value of the elementary charge?

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1

Total Q7

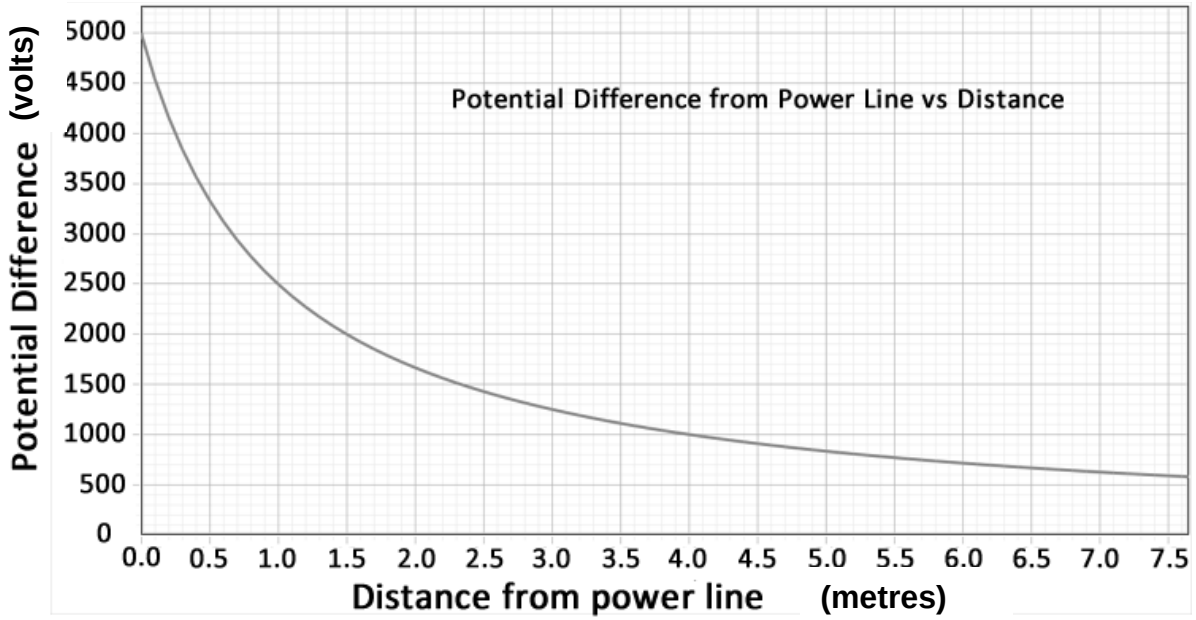
8

Question 8

Marker use

A high voltage cable has come down on the road! It is at +5000 V relative to the earth.

The graph below gives the potential difference with distance from the cable.



Spare diagram used (✓) ☐

A person walks towards the cable with steps 1.0 m apart.

a) Using the graph above, estimate the potential difference between the feet at: /3

i. 5 m .....

.....

ii. 1 m .....

.....

b) If a wet human body has a resistance of 1000 Ω , calculate the possible current flow through a person at: /2

i. 5 m .....

.....

ii. 1 m .....

.....

c) What safety advice would you give to power line technicians about walking toward a downed power line based on the above? /1

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Total Q8 /6

Section B continues

Marker use

Question 9

A physicist repeats Coulomb's electrostatic experiment by carrying out a force vs distance experiment between two identically charged spheres.

Three representative points are given in the table below.

	A	**B**	**C**
Distance (mm)	1.00	1.50	2.00
Force measured ($\times 10^{-3}$ N)	9.92	4.41	2.48

a) Calculate suitable values for A, B and C in the table that will allow a straight-line graph to be created. **3**

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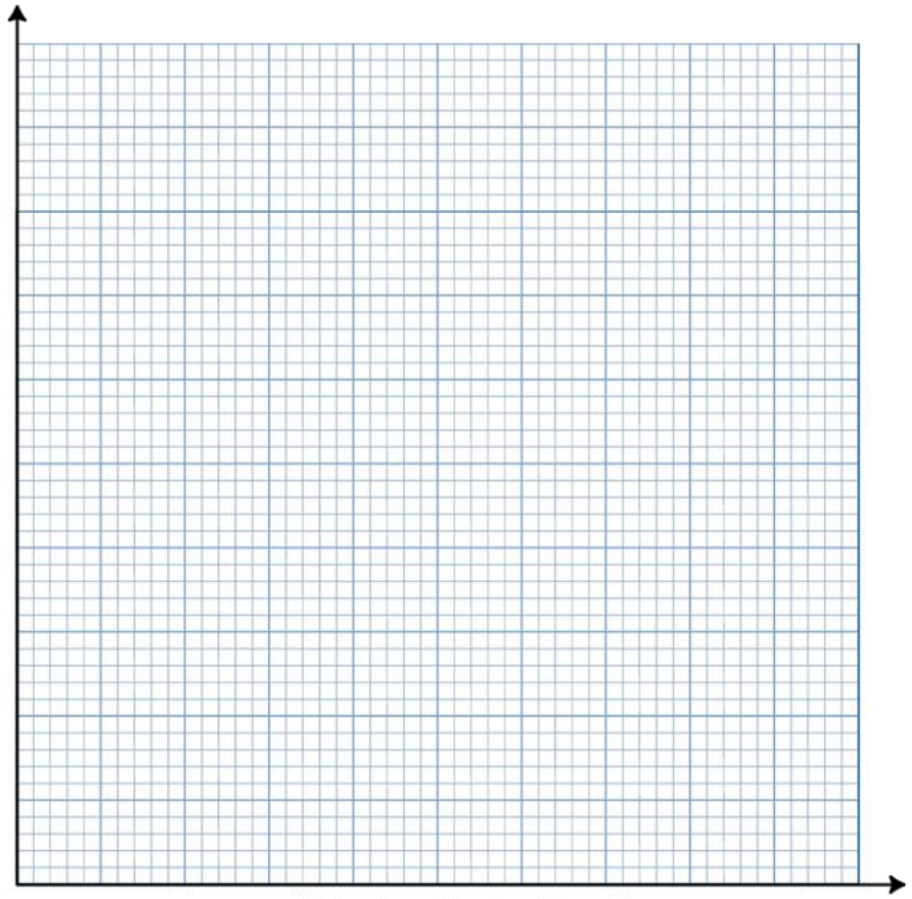
Question 9 continues

Marker use

2

b) On the graph below, plot these points and draw a line of best fit. Label all axes.



Spare diagram used (✓)

☐

c) Deduce from your graph the value of the charge on each sphere. Show all working.

4

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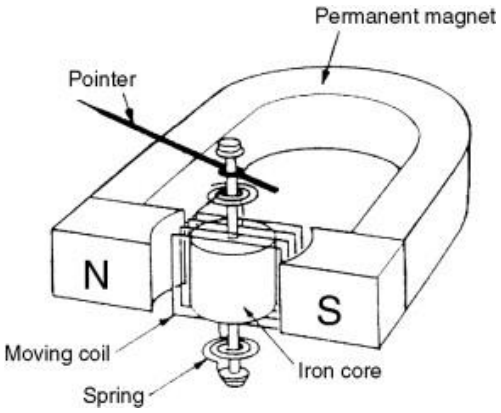
Total Q9

9

Section B continues

Marker use

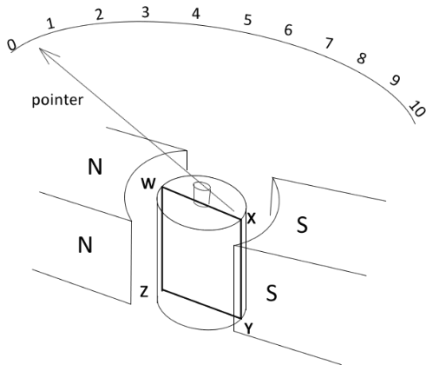
Question 10



An old moving coil ammeter has a rectangular coil 1.00 x 1.00 cm wrapped on an iron core rotating in a radial magnetic field.

When the coil rotates, the motion is resisted by spiral springs. These require 2.67×10^{-3} N on each active side of the coil for one degree of rotation.

Consider the coil WXYZ below.



a) To deflect the pointer to the right, will the current have to flow ZYXW or WXYZ? Justify your answer. **2**

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When a current of 1.00 A is flowing through the coil, the pointer moves through 9° to the 1.00 A mark on the scale.

b) Calculate the force on each side of the coil. **2**

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Question 10 continues

Marker use

c) If the coil has 20 turns, calculate the magnetic flux density of the magnetic field.

3

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Total Q10

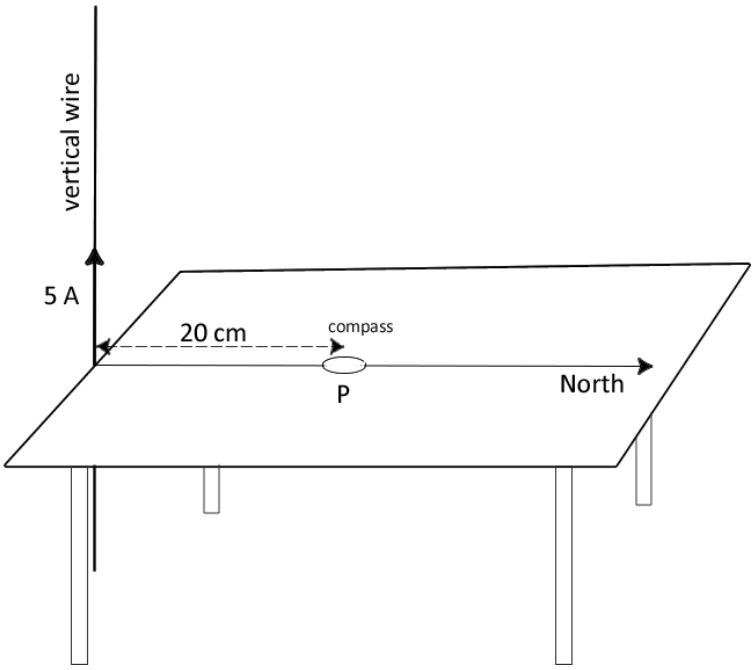
7

Section B continues

Marker use

Question 11

A vertical wire carrying a current of 5.00 A upwards is placed against the edge of a table.



a) Calculate the magnetic flux density due to the current at P 20 cm North of the wire.

2

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A compass is placed at P, 20 cm from the vertical wire and is found to point N 20^{o} W when the current is turned on.

b) Calculate the horizontal component of the Earth's magnetic flux density at this point.

3

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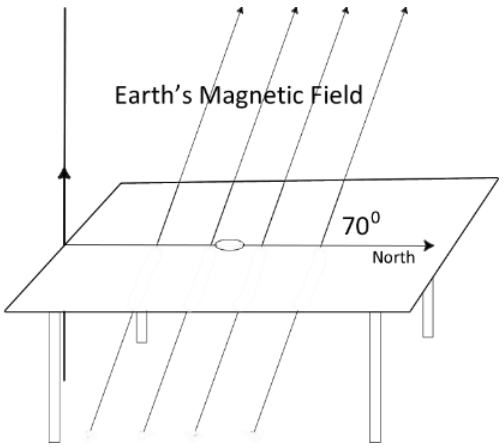
Question 11 continues

Marker use

The angle of dip of the earth's magnetic flux density in the room is -70^{o}.



c) Calculate the magnitude of the Earth's flux density in the room.

/ 2

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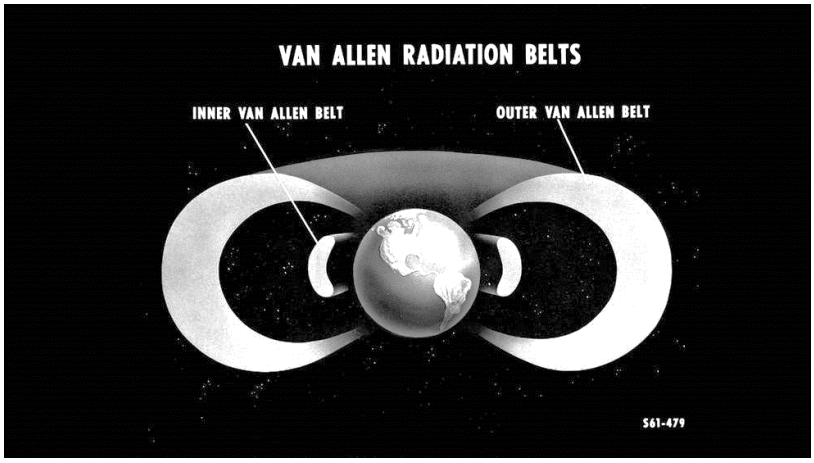
Total Q11

/ 7

Section B continues

Marker use

Question 12



The Earth is surrounded by charged particles trapped in the Van Allen Belts. The inner belt is dominated by protons while the outer is dominated by electrons.

A typical flux density in these regions is 3.7 μT, but the field gets weaker the further from Earth.

a) Calculate the gyromagnetic radius of a proton moving at 60° to the field of 3.7 μT in the inner belt at a speed of 2.0×10^8 m s^{-1}. **2**

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b) Given electrons have a smaller mass than protons, why are they more likely to be found in the Outer Belt where the field is weaker? **1**

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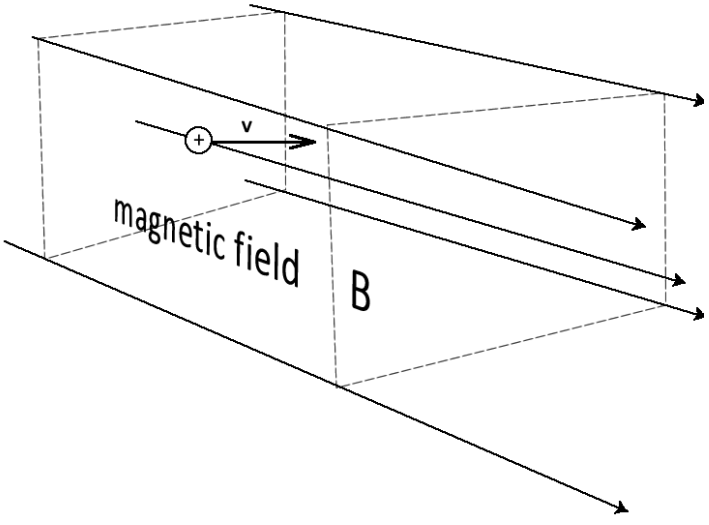
c) Charged particles trapped in the field move at angles to the field lines. Sketch the subsequent motion of a positive charge in the field below. **2**

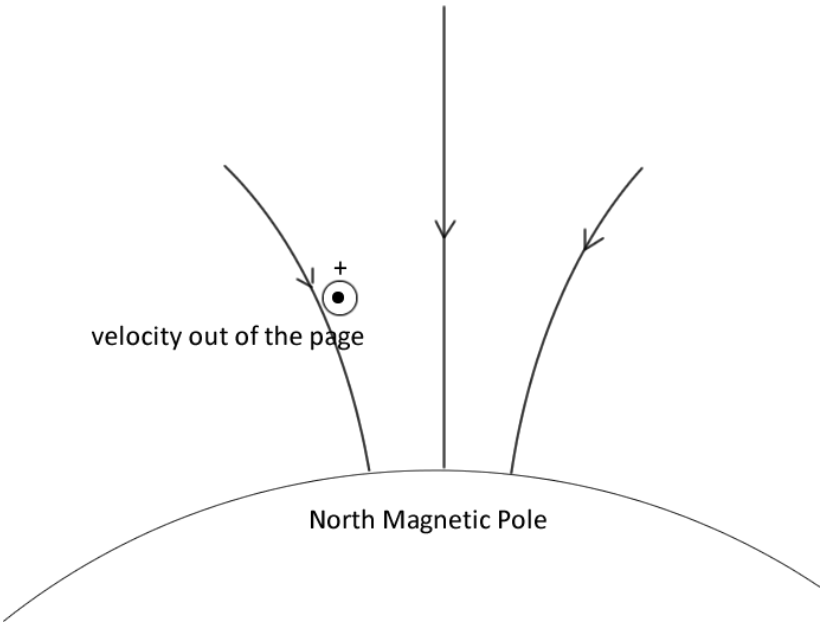


Spare diagram used (✓) ☐

Question 12 continues

Marker use

At the poles, the magnetic field lines close inwards as below.



Spare diagram used (✓) ☐

Consider a positively charged particle moving out of the page in the field.

d) Sketch on the diagram the direction of the magnetic force on the particle. 1

e) Describe and justify what happens to the charged particle as the field pinches inwards. 2

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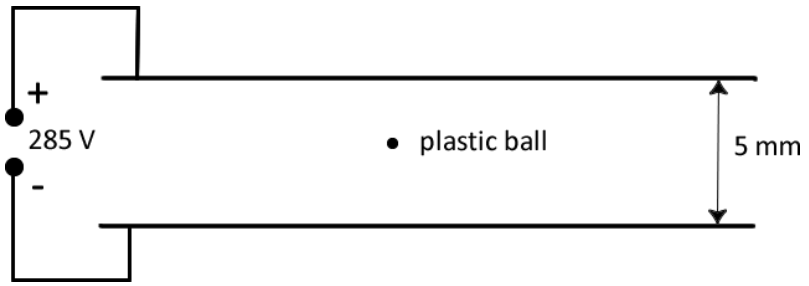
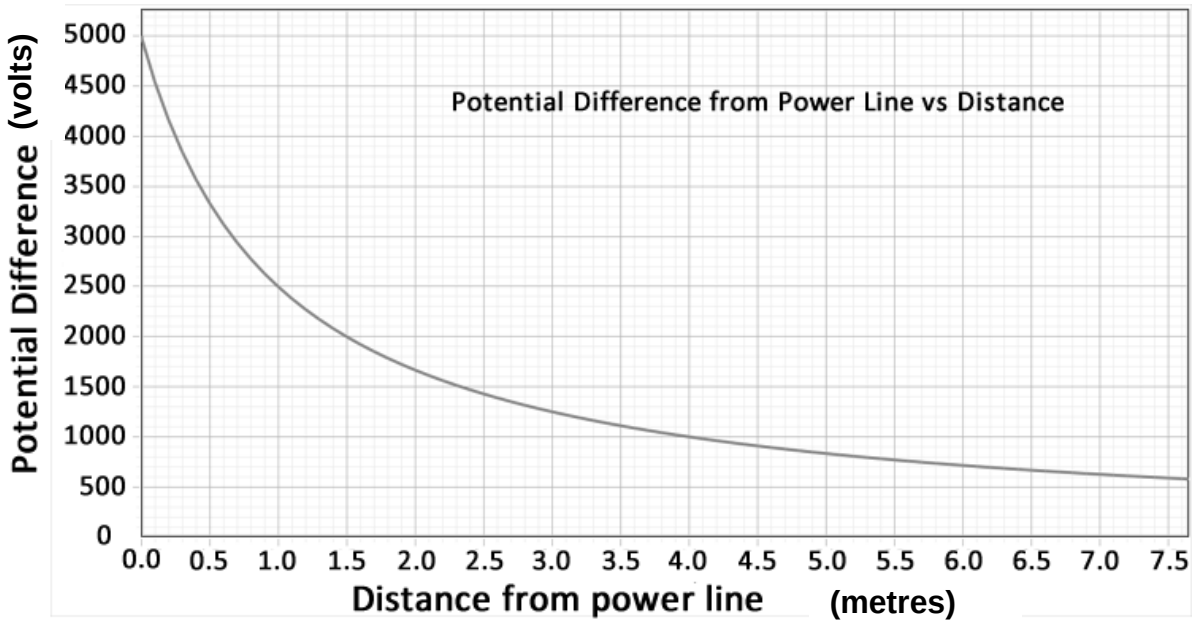
Total Q12 8

Spare Diagrams

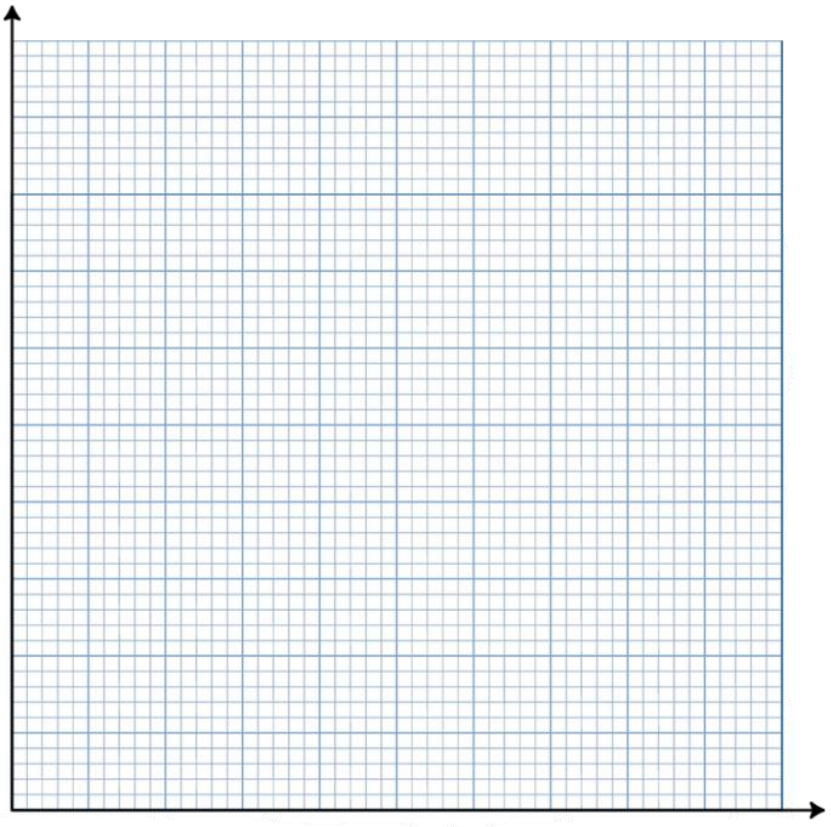
Question 7 c)



Question 8 a)

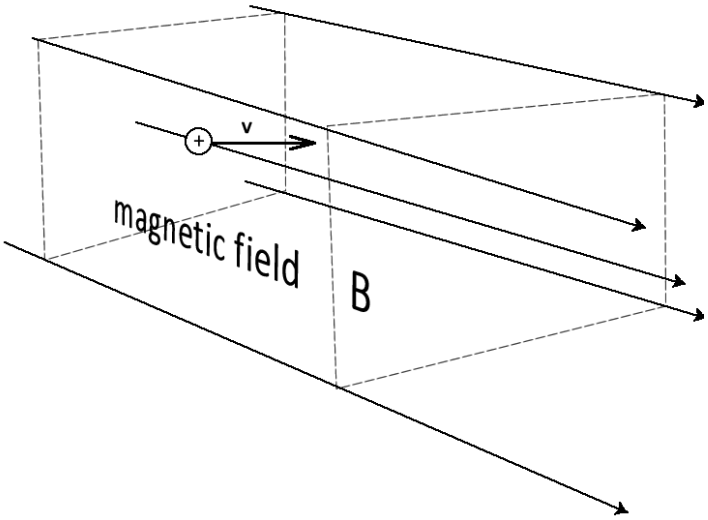


Question 9 b)

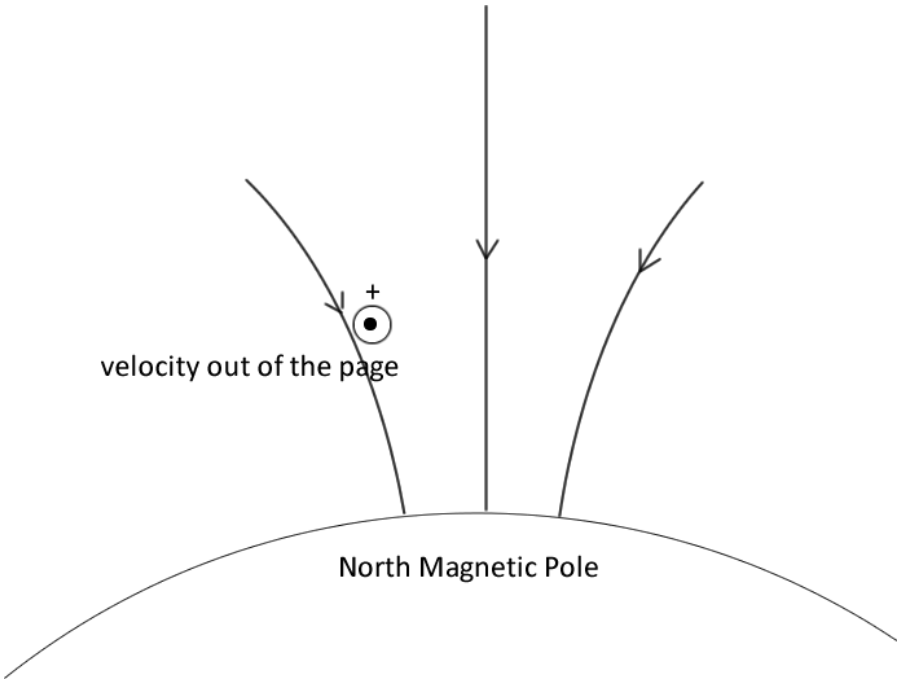


Spare Diagrams

Question 12 c)



Question 12 d)



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End of Section B

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PHYSICS

PHY415115

Section C Wave Motion

Pages	16
Questions	6
Information Sheet	1

Suggested working time: 45 minutes

Instructions:

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

Marker Use	
C7	/ 45

Guide to Exam Structure

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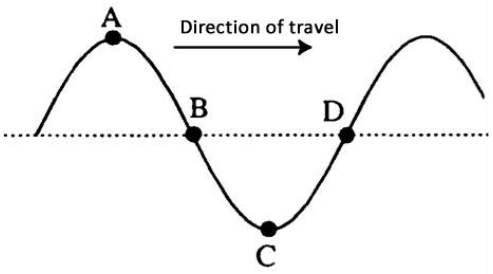
Section A	6	6	45 minutes	45 marks
Section B	6	6	45 minutes	45 marks
Section C	6	6	45 minutes	45 marks
Section D	6	6	45 minutes	45 marks
Totals	**24**	**24**	**180 minutes (3 hours)**	**180 marks**

Question 13

Marker use

A transverse wave is moving to the right along a wire.



a) At the instant shown in the diagram:

i. In which direction is point B moving?

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1

ii. Compare with appropriate reasoning, the velocities at the points A, C and D.

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3

iii. Which of the points shown have the greatest magnitude of acceleration?

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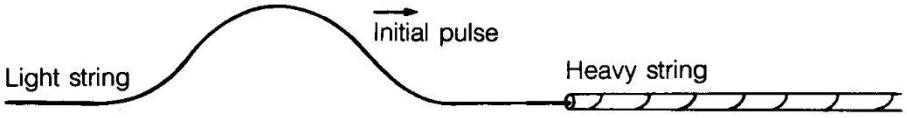
1

b) Consider the following diagram that represents a transverse pulse in a light string approaching a boundary with a heavy string.



i. Draw a diagram below to represent the expected disturbances in the strings after the pulse has passed the light string/heavy string boundary.

2

Question 13 continues

Marker use

/ 2

ii. Would the transmitted pulse be faster or slower than the reflected pulse? Justify your answer.

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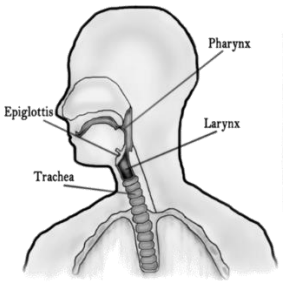
Total Q13

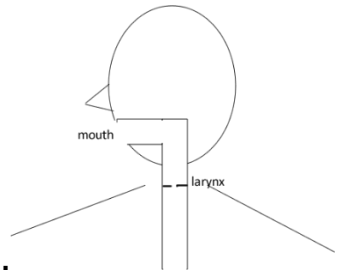
/ 9

Section C continues

Marker use

Question 14





In a highly oversimplified model of the human voice production, the distance from the vibrator in the throat (the larynx) to the mouth is about 0.17 m. The speed of sound at human body temperature is 354 m s^{-1}.

a) Treating the throat as a pipe with one end closed, show that the fundamental frequency of this particular person's vocal system is approximately 500 Hz. **2**

.....

.....

b) Which of the following sequences of frequencies most closely matches the harmonics of the pipe? Justify your answer. **2**

SEQUENCE 1: 500, 1000, 1500 Hz

SEQUENCE 2: 500, 1500, 2500 Hz

.....

.....

Because of the chest cavity and other resonators, the natural fundamental frequency of the human voice is usually much lower, for an adult male, about 100 Hz and an adult female about 260 Hz.

c) Calculate the effective closed pipe length that 260 Hz frequency represents. **1**

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.....

Inhaling helium gas from a balloon then speaking until dizzy is a party trick.

A girl inhales helium gas and her natural voice changes from 260 Hz to 750 Hz.

d) Calculate the speed of sound in helium gas. **2**

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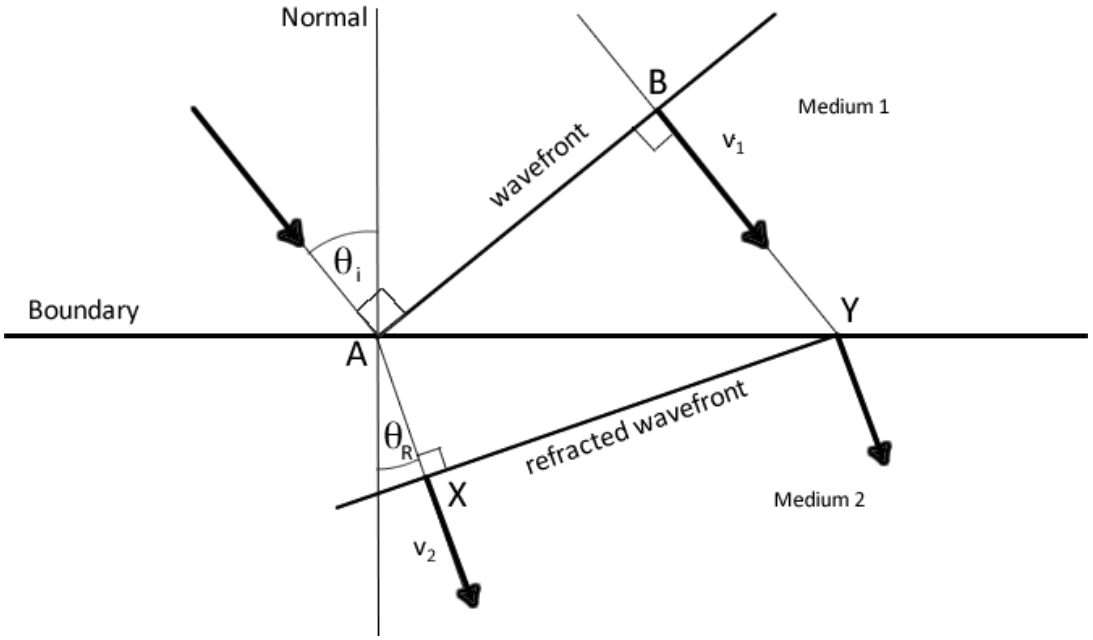
Total Q14 **7**

Section C continues

Marker use

Question 15



The diagram above represents a wave crossing a boundary from **Medium 1** into **Medium 2** and slowing in speed from v_1 to v_2.

The points A and B are on the wave front in **Medium 1**. A has just reached the boundary.

The wave front now moves into **Medium 2** and A moves to X. B moves down to the surface at Y. The time taken is t.

The new refracted wavefront is represented by the line XY and the angles of incidence θ_i and refraction θ_R are shown.

a) In terms of v_1 , v_2 and t give the expression:

i. for the distance travelled AX.

.....

.....

1

ii. for the distance travelled BY.

.....

.....

1

b) Relate the angles ∠ BAY and ∠ AYX to the angles of refraction and incidence.

.....

.....

.....

2

Question 15 continues

Marker use

3

c) Using triangles Δ ABY and Δ AXY, show that $\frac{\sin\theta_i}{\sin\theta_R} = \frac{v_1}{v_2}$.

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.....

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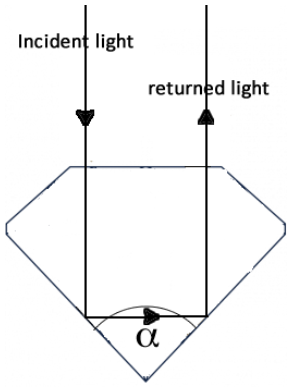
Total Q15

7

Section C continues

Marker use

Question 16



IDEAL CUT DIAMOND

A diamond with an 'ideal cut' sends light back to the eyes by total internal reflection. The ray of light is exactly reversed in direction. Diamonds have a refractive index of 2.42.

a) Calculate the critical angle of the diamond - air boundary.

.....

.....

.....

/2

b)

i. What is the angle of incidence of the incoming light at the diamond - air boundary?

.....

.....

/1

ii. Explain why the returned light ray is as bright as the incident light ray.

.....

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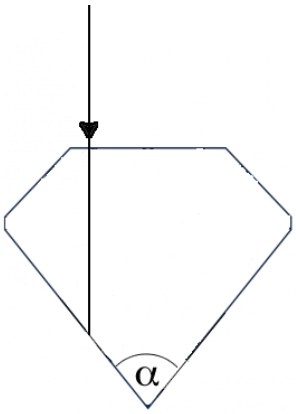
/1

c) Sketch the paths of reflected and refracted rays on the diagram below when the angle α is smaller than in Part b).

/2



Spare diagram used (✓)

☐

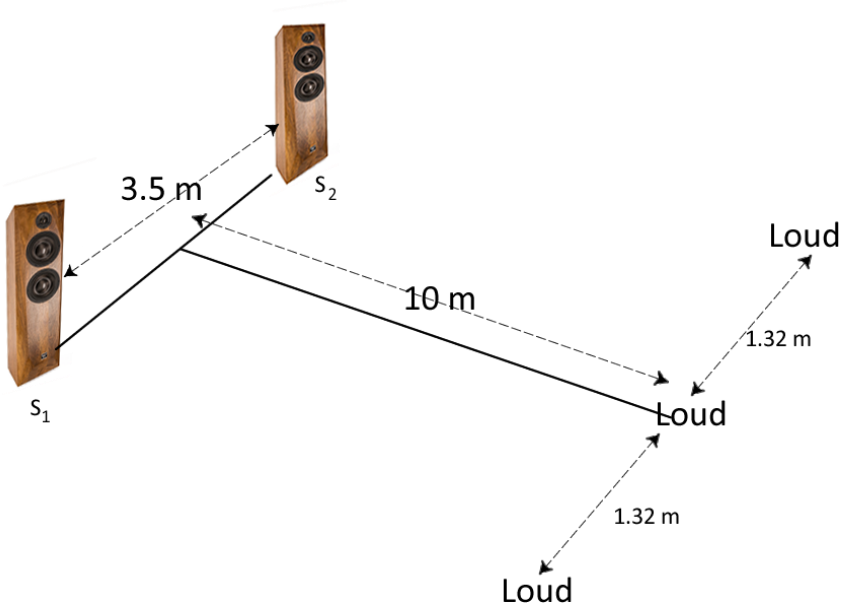
Total Q16

/6

Section C continues

Marker use

Question 17



A teacher set up two loudspeakers, S_1 S_2 placed 3.5 m apart and connected a signal generator to each, to demonstrate 2D interference. The teacher tried setting 340 Hz on each, but ended up getting a horrible pulsation of about 4 Hz.

a)

i. What is happening to create this phenomenon and what is this phenomenon called? / 2

.....

.....

.....

ii. If one speaker is precisely emitting 340 Hz, what possible frequencies are emitted from the other speaker? / 1

.....

.....

An astute student steps in and connects both speakers to **one** signal generator. This is an immediate success!

In using one generator and two speakers, two essential conditions for the sound emissions to produce classic 2D interference are now met.

b) Give these **two (2)** conditions. / 2

.....

.....

Question 17 continues

Marker use

A frequency is then selected by the teacher and the students in the class walk back and forth to find antinodal areas. At a distance of 10 m, students found antinodes were about 1.32 m apart.

c) Calculate the frequency of the sound produced by the signal generator.

2

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d) What will happen to the antinodal positions if the speakers are moved closer together?

2

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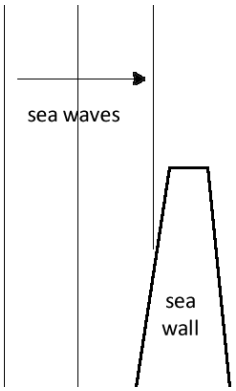
Total Q17

9

Section C continues

Marker use

Question 18



Harbour

Spare diagram used (✓) ☐

On the diagram above, waves are striking a sea wall protecting a harbour.

a) Sketch the subsequent waves as they pass the sea wall. /2

b) What is the term given to the phenomenon you have sketched? /1

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.....

Consider a conventional microscope using light.

c) What is a typical wavelength of optical light? /1

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d) The COVID-19 viruses have a size of 100 nm.

i. Why can't conventional optical microscopes see these objects? Use a sketch to help illustrate your answer. /2

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ii. Suggest a radiation that might image viruses and give a reason why it might work. /1

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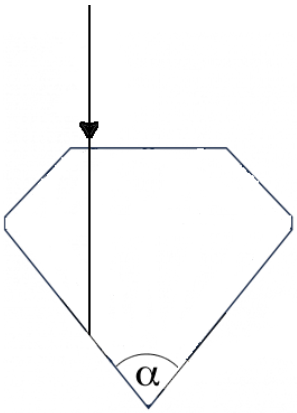
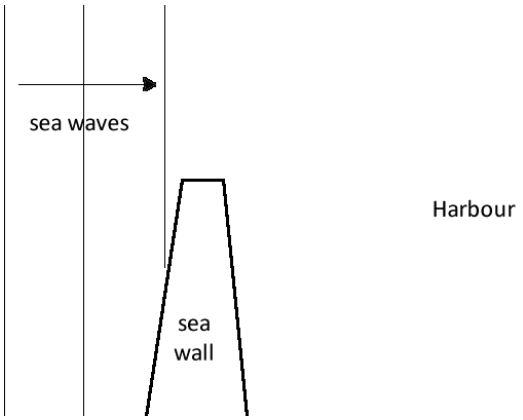
Total Q18 /7

Spare Diagrams

Question 16 c)



Question 18 a)



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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.
  - Spare diagrams have been provided at the end of each section. Indicate in the box provided if you have used the spare diagrams.
- The exam is **three (3)** hours in length. It is suggested that you spend **approximately 45 minutes** in total answering the questions in this section.
- The **Physics Information Sheet** can be used throughout this exam.
- All answers must be written in **English**.
- 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.

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**

Question 19

Marker use

A red giant star has a mass roughly equivalent to our own Sun but the core has collapsed into an extremely dense centre at a temperature of about 10^8 K, while the outer star swells to a huge red ball. Our Sun will become a red giant star in the future.

In the core of this star, carbon is created. It is thought that **all** the carbon in the Universe has been created in these red giants!

Carbon generation is known as the 'triple-alpha process'.

Initially two ${}^4_2He$ nuclei fuse to create an isotope of beryllium, (Be).

a) Write the equation for this reaction.

.....

1

Mass of ${}^4_2He$ = 4.00260 u Mass of the Be isotope = 8.005305 u

b) Calculate the mass difference in the equation and the energy associated with this mass difference in MeV.

2

.....

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.....

.....

c) Does this reaction require an energy input or emit energy?

.....

1

.....

d) Calculate the binding energy per nucleon of the Be-8 nucleus.

.....

2

.....

.....

Question 19 continues

Marker use

The Be-8 isotope has an **extremely** short half-life but now absorbs another $^{4}_{2}He$ nucleus to form carbon.

e) Given the conditions in the core, give reasons why can this very unlikely absorption occur. **2**

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f) Write the equation for the absorption of $^{4}_{2}He$ into Be. **1**

.....

Mass of $^{12}_{6}C$ = 12.00000 u

g) Calculate the energy now emitted in this reaction in MeV. **2**

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h) In what form of energy or particle will this emission be? **1**

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Total Q19 **12**

Marker use

Question 20

Polonium-210 is an alpha emitter. It was used in 2006 to poison Alexander Litvinenko in London by administering 4.4 GBq of Polonium-210 in a cup of tea. This is vastly greater than the nominal lethal dose!

Polonium-210 has a half life of 138.4 days.

a) Calculate the mass of Po-210 used given that it had an activity of 4.4 GBq when administered.

3

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It is estimated that the time between production of the Po sample in Russia and its use was 60 days.

b) Calculate the initial activity of the Po-210 sample.

2

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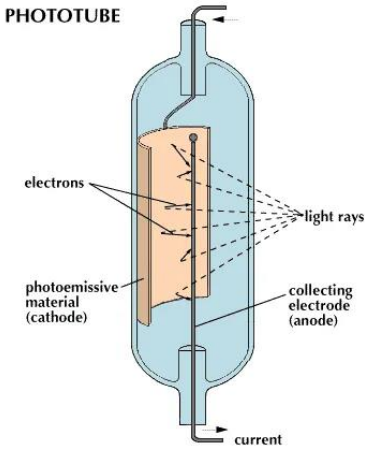
Total Q20

5

Section D continues

Marker use

Question 21



The photoelectric effect was found by Heinrich Hertz during his work with radio waves.

Photoelectric effect tubes are used for night vision enhancement but **not** for infrared vision.

a) What effect will increasing the intensity of light incident on a phototube have on:

i. the photocurrent?

.....

1

ii. the threshold frequency?

.....

1

Zinc has a work function of 4.3 eV.

b) Calculate the threshold frequency for zinc.

.....

2

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.....

c) UV photons of wavelength 1.85 x 10^{-7} m strike the zinc metal. Calculate the maximum kinetic energy of the emitted photoelectrons.

2

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d) Infrared vision is used to detect warm objects amongst a cooler background. Briefly explain why the photoelectric effect cannot be used with infrared devices.

2

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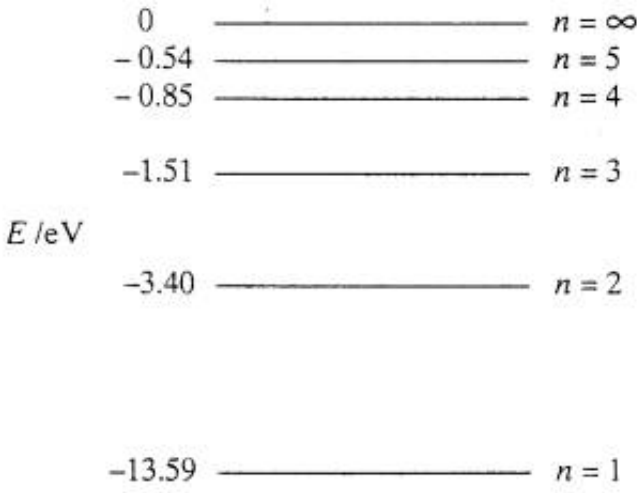
Total Q21

8

Section D continues

Marker use

Question 22



The energy levels for the hydrogen atom are given in the diagram above.

a) What is the ionization energy of the hydrogen atom in joules?

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2

b) Show that the wavelength of an emission between n = 3 to n = 2 is about 660 nm.

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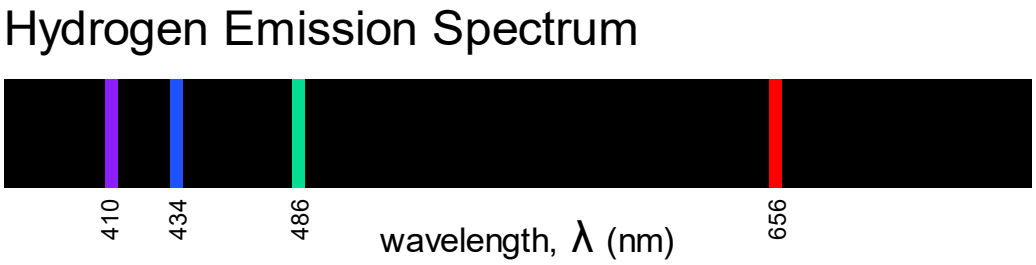
2

Question 22 continues

Marker use

The visible wavelength spectrum of hydrogen is given below.



c) Show on the energy level diagram, the transition corresponding to the 434 nm wavelength.

.....

1

d) Name the part of the electromagnetic spectrum that photons belong to if the transition

i. drops to n = 1.

.....

1

ii. drops to n = 3.

.....

1

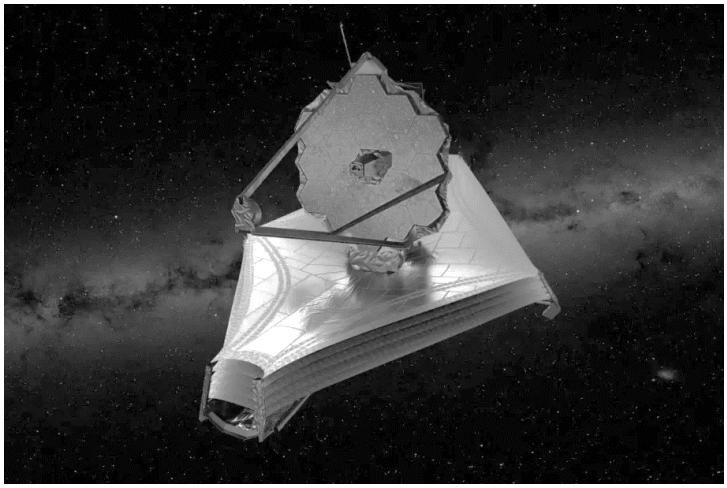
Total Q22

7

Section D continues

Marker use

Question 23



The new James Webb telescope is parked in space beyond the Moon. It is designed to capture images in infrared, not visible light.

Part of setting it up involved cooling the whole telescope to a temperature of 50 K.

a) Calculate the peak wavelength associated with a body at a temperature of 50 K.

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.....

.....

2

b) In what part of the spectrum is this wavelength?

.....

.....

1

The expansion of the universe leads to a stretching of the wavelengths of electromagnetic radiation as the light reaches Earth from extreme distances.

c) If wavelengths stretch, what effect will this have on visible light from extreme distances?

.....

.....

1

d) Give and justify a reason why the telescope must be cooled to such a low temperature.

.....

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2

Total Q23

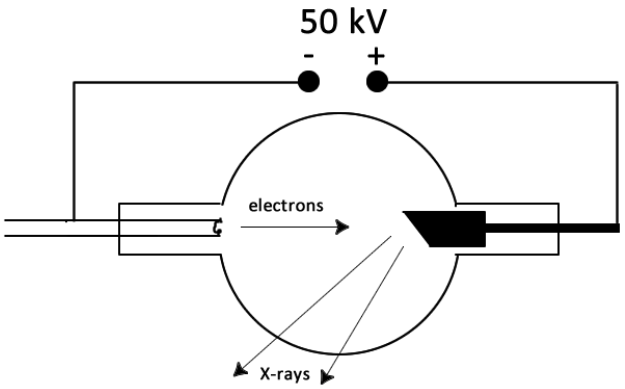
6

Section D continues

Marker use

Question 24

An X-ray tube is operating at 50 kV.



a) Show that the minimum wavelength of the emitted X-rays is 24.8 pm.

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/2

b) Calculate the momentum of such photons.

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/2

c) What will happen to the intensity and minimum wavelength of the emitted X-rays when :

i. The current of the tube is increased?

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/1

ii. The potential difference between the cathode and anode is increased?

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.....

.....

/2

Total Q24

/7

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End of Section D

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