2022 HSC Physics Examination

NSW Education Standards Authority

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Exam Overview

Year	2022
Total Marks	100
Section I	20 marks (Questions 1-20, Multiple Choice)
Section II	80 marks (Questions 21-35, Extended Response)

Section I: Multiple Choice

20 marks - Questions 1-20

Allow about 35 minutes for this section

Question 1

1 An ideal transformer has 20 turns on the primary coil and an input voltage of 100 V.

How many turns are there on the secondary coil if the output voltage is 400 V?

A. 4

B. 5

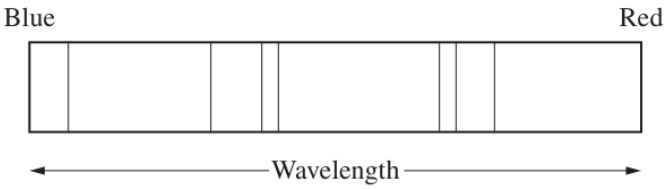
C. 80

D. 400

Figure 1: Q1

Question 2

2 The absorption lines in a star's spectrum are shown.



What feature of the star is directly responsible for these absorption lines?

A. Size

B. Colour

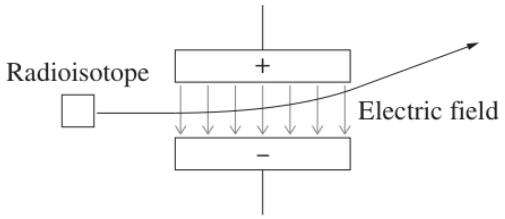
C. Distance from Earth

D. Chemical composition

Figure 2: Q2

Question 3

3 A radioisotope emits radiation which is deflected by an electric field, as shown.



What type of radiation is this?

A. Alpha

B. Gamma

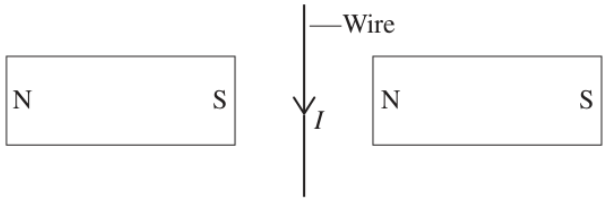
C. Beta positive (positron)

D. Beta negative (electron)

Figure 3: Q3

Question 4

4 A current-carrying wire is in a magnetic field, as shown.



What is the direction of the force on the wire?

A. Left

B. Right

C. Into the page

D. Out of the page

Figure 4: Q4

Question 5

5 Protons and neutrons are made up of quarks. The table shows the charges of these quarks.

Quark	*Charge*
Up	$+\frac{2}{3}$
Down	$-\frac{1}{3}$

What combination of quarks forms a neutron?

A. 1 up, 1 down

B. 1 up, 2 down

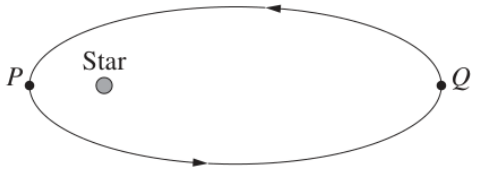
C. 2 up, 1 down

D. 2 up, 2 down

Figure 5: Q5

Question 6

6 The elliptical orbit of a planet around a star is shown.



Which type of energy is greater at position P than at Q?

A. Kinetic

B. Nuclear

C. Potential

D. Total

Figure 6: Q6

Question 7

7 A photon has an energy of 9.0×10^{-24} J.

What is the frequency of this radiation?

A. 1.00×10^{-40} Hz

B. 7.36×10^{-11} Hz

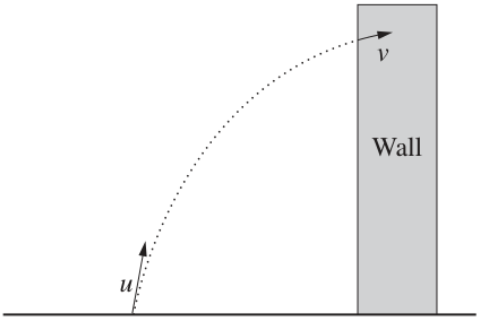
C. 1.36×10^{10} Hz

D. 5.97×10^{11} Hz

Figure 7: Q7

Question 8

8 An object is launched with an initial velocity, u, and hits a wall with a final velocity, v.



Which statement correctly compares components of u and v?

A. The vertical component of v is less than the vertical component of u.

B. The vertical component of v is greater than the vertical component of u.

C. The horizontal component of v is less than the horizontal component of u.

D. The horizontal component of v is greater than the horizontal component of u.

Figure 8: Q8

Question 9

9 The radiation emitted by a black body has a peak wavelength of 5.8×10^{-7} m.

What is its temperature?

A. 3000 K

B. 4500 K

C. 5000 K

D. 5500 K

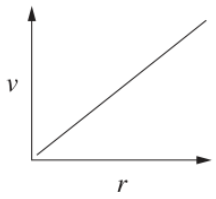
Figure 9: Q9

Question 10

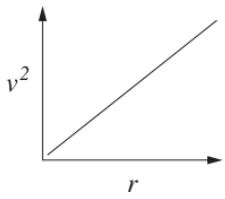
10 The orbital velocity, v, of a satellite around a planet is given by $v = \sqrt{\frac{GM}{r}}$.

Which graph is consistent with this relationship?

A.



B.



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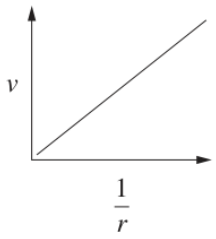


D.

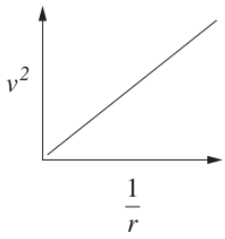
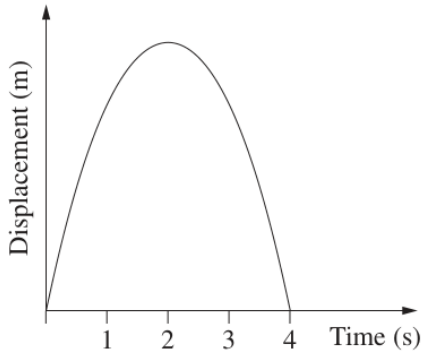


Figure 10: Q10

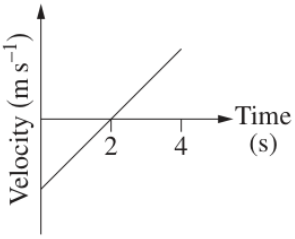
Question 11

11 A projectile is launched vertically upwards. The displacement of the projectile as a function of time is shown.



Which velocity–time graph corresponds to this motion?

A.



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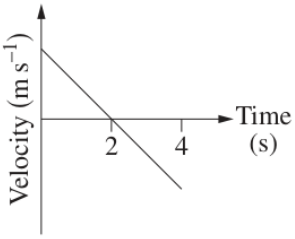

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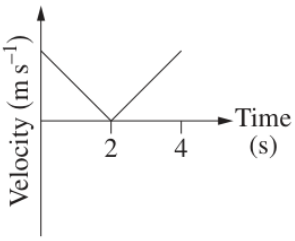


D.

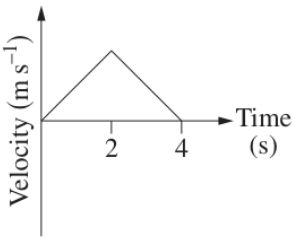
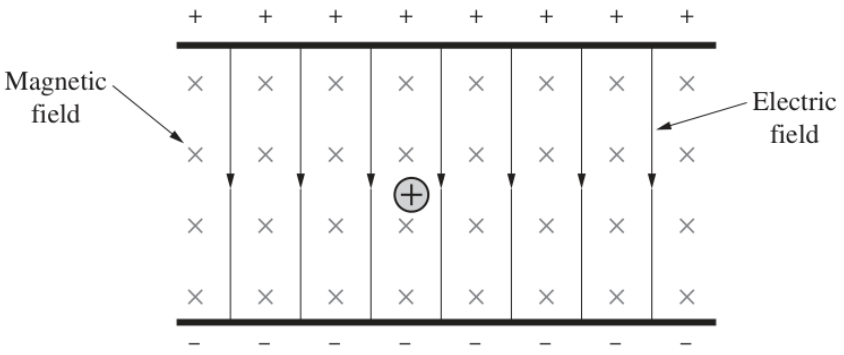


Figure 11: Q11

Question 12

12 The diagram shows a region in which there are uniform electric and magnetic fields. A positively charged particle moves in the region at constant velocity.



What is the direction of the particle's velocity?

A. Up the page

B. Down the page

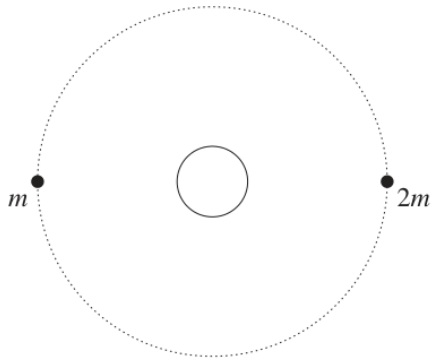
C. To the left

D. To the right

Figure 12: Q12

Question 13

13 Two satellites share an orbit around a planet. One satellite has twice the mass of the other.



Which quantity would be different for the two satellites?

A. Speed

B. Momentum

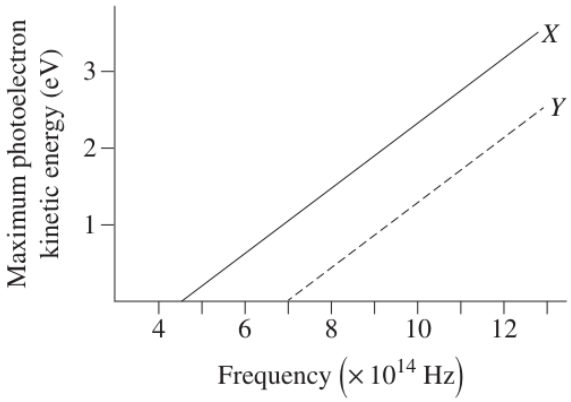
C. Orbital period

D. Centripetal acceleration

Figure 13: Q13

Question 14

14 Line *X* shows the results of an experiment carried out to investigate the photoelectric effect.



What change to this experiment would produce the results shown by line *Y*?

A. Increasing the frequency of the radiation

B. Using a metal that has a greater work function

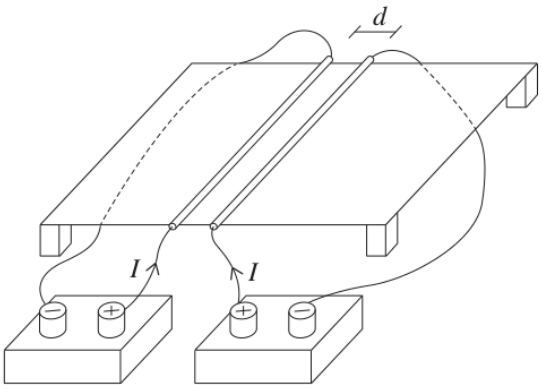
C. Decreasing the intensity of the incident radiation

D. Decreasing the maximum energy of photoelectrons

Figure 14: Q14

Question 15

15 Two wires separated by a distance, d, carry equal electric currents producing a magnetic force between them.



The separation between the wires is increased to $4d$ and the current in each wire is doubled.

What happens to the magnetic force between the wires, compared to the original force?

A. It does not change.

B. It increases by a factor of 4.

C. It decreases by a factor of 4.

D. It decreases by a factor of 8.

Figure 15: Q15

Question 16

16 The binding energy of helium-4 (He-4) is 28.3 MeV and the binding energy of beryllium-6 (Be-6) is 26.9 MeV.

Which of the following rows in the table is correct?

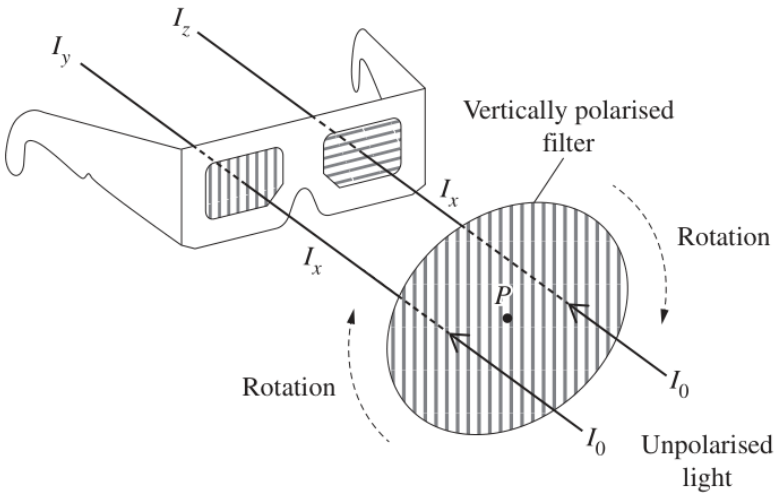
A.	He-4 requires more energy to separate into individual protons and neutrons	He-4 is less massive than Be-6
B.	He-4 requires less energy to separate into individual protons and neutrons	He-4 is less massive than Be-6
C.	He-4 requires more energy to separate into individual protons and neutrons	He-4 is more massive than Be-6
D.	He-4 requires less energy to separate into individual protons and neutrons	He-4 is more massive than Be-6

Figure 16: Q16

Question 17

17 Unpolarised light of intensity I_0 is incident upon a vertically polarised filter. The filtered light then passes through a pair of glasses. The glass have polarising filters, with one side polarised vertically and the other horizontally.

The filter undergoes one complete 360° rotation around point P, as shown.



Which of the following correctly compares I_y to the intensity at other positions?

A. I_y never equals I_x

B. I_y never equals I_z

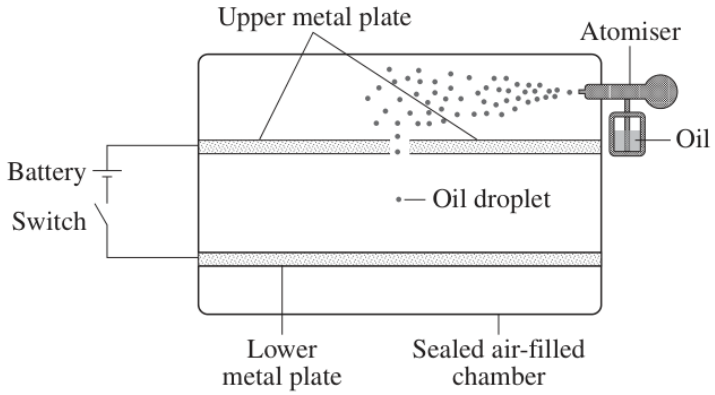
C. I_y sometimes equals I_z

D. I_y sometimes equals I_0

Figure 17: Q17

Question 18

18 A charged oil droplet was observed between metal plates, as shown.



While the switch was open, the oil droplet moved downwards at a constant speed. After the switch was closed, the oil droplet moved upwards at the same constant speed.

Assume that the only three forces that may act on the oil droplet are the force of gravity, the force due to the electric field and the frictional force between the air and the oil droplet. The magnitudes of these forces are F_G (due to gravity), F_E (due to the electric field) and F_F (due to the frictional force).

Which row of the table shows all the forces affecting the motion of the oil droplet in the direction indicated, and the relationship between these forces?

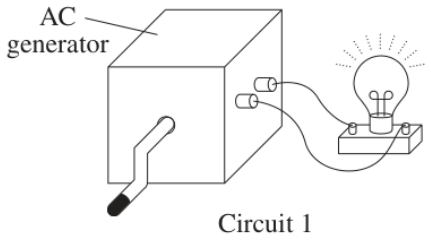
	Downwards motion	*Upwards motion*
A.	$F_G > F_F$	$F_E > F_F$
B.	$F_G > F_F$	$F_E > F_G + F_F$
C.	$F_G = F_F$	$F_G = F_E$
D.	$F_G = F_F$	$F_E = F_G + F_F$

Figure 18: Q18

Question 19

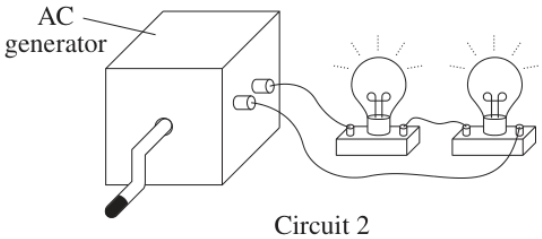
19 An AC generator is operated by turning a handle, which rotates a coil in a magnetic field.

The handle is turned at a constant speed and the AC voltage output of the generator causes a light globe connected to it to light up, as shown in Circuit 1.



Circuit 1

A second identical light globe is then connected in series to the generator output, as shown in Circuit 2. The handle is turned at the same constant speed.



Circuit 2

Which statement describes and explains the effort required to turn the handle in Circuit 2, compared to Circuit 1?

A. The handle in Circuit 2 is easier to turn because the smaller current in Circuit 2 produces less opposing torque.

B. The handle in Circuit 2 is easier to turn because the voltage output is shared equally across the two identical light globes.

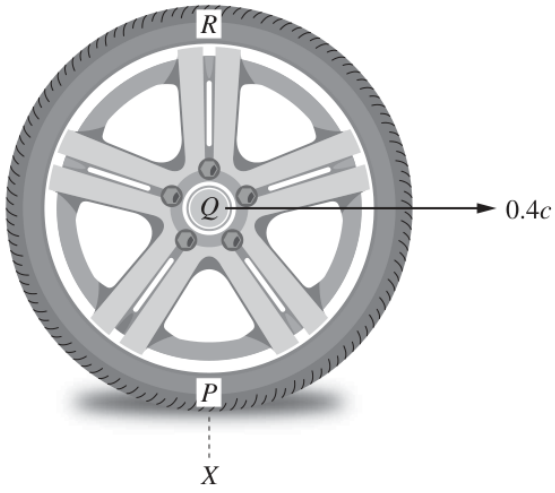
C. The handle in Circuit 2 is more difficult to turn because the larger current in Circuit 2 produces more opposing torque.

D. The handle in Circuit 2 is more difficult to turn because it takes more power to operate the two identical globes than it does to operate the single globe.

Figure 19: Q19

Question 20

20 In a thought experiment, a car is travelling at a uniform velocity of $0.4c$. The diagram shows one of the car's wheels as it rolls past a stationary observer at X.



Consider the instantaneous velocity of different points on the car's wheel relative to the ground. Assume that there is no slippage of the tyre on the road.

At the instant the centre of the wheel, Q, passes X, how would the observer describe the relativistic length contraction at points P, Q and R?

A. It is the same at P, Q and R.

B. It is zero at P and greatest at R.

C. It is equal at P and R, and least at Q.

D. It is zero at P and the same value at Q and R.

Figure 20: Q20

Section II: Extended Response

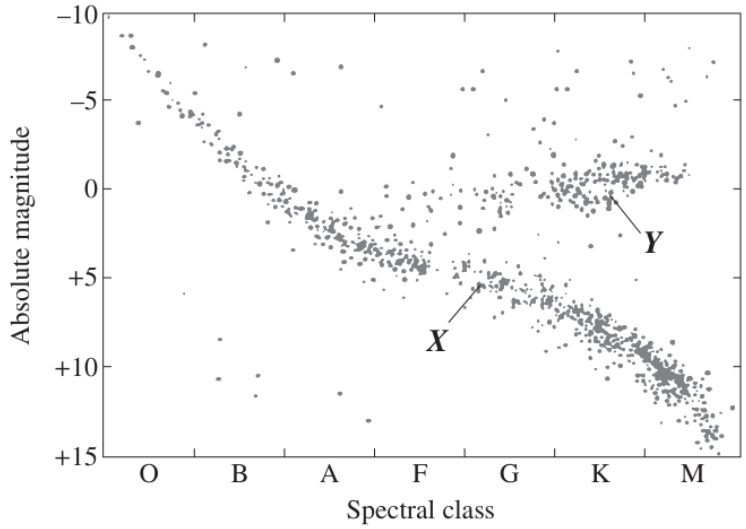
80 marks - Questions 21-35

Allow about 2 hours and 25 minutes for this section

Question 21 (4 marks)

Question 21 (4 marks)

The positions of two stars, *X* and *Y*, are shown in the Hertzsprung–Russell diagram.



(a) Compare qualitatively the surface temperature and luminosity of *X* and *Y*. **2**

Surface temperature: .....

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Luminosity: .....

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(b) Identify the elements undergoing fusion in the core of each star, *X* and *Y*. **2**

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Do NOT write in this area.

Figure 21: Q21

Part (a)

(a) Compare qualitatively the surface temperature and luminosity of *X* and *Y*. **2**

Surface temperature: .....

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Luminosity: .....

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Write in this area.

Figure 22: Q21a

Part (b)

(b) Identify the elements undergoing fusion in the core of each star, *X* and *Y*. **2**

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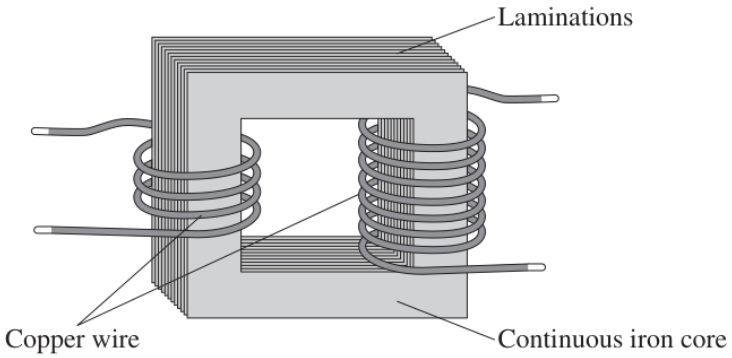
Figure 23: Q21b

Question 22 (4 marks)

Question 22 (4 marks)

The diagram shows features of a transformer. **4**



For TWO features of the transformer, describe how each contributes to the transformer's efficiency.

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Figure 24: Q22

Question 23 (4 marks)

Question 23 (4 marks)

Outline a method that could be used to determine a value for the speed of light. In your answer, identify ONE factor that would limit the accuracy of the experimental data. **4**

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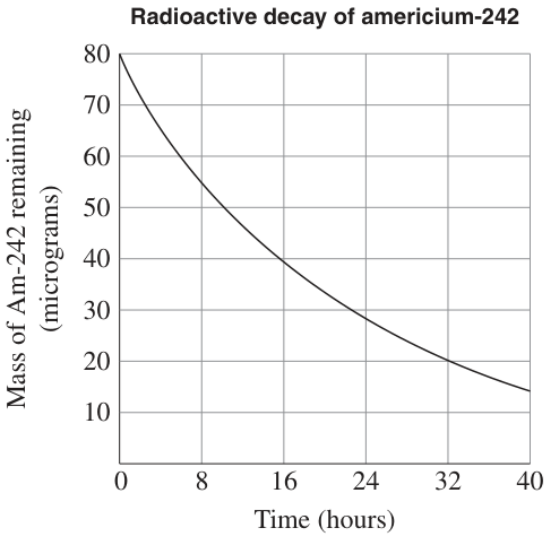
Figure 25: Q23

Question 24 (4 marks)

Question 24 (4 marks)

The radioactive decay curve for americium-242 is shown.



(a) Use the graph to find the half-life of Am-242 and hence show that the decay constant, λ, is 0.043 h^{-1}. **2**

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(b) Calculate how long it takes until the mass of Am-242 is 8 micrograms. **2**

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Figure 26: Q24

Part (a)

(a) Use the graph to find the half-life of Am-242 and hence show that the decay constant, λ, is 0.043 h^{-1}. **2**

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Figure 27: Q24a

Part (b)

(b) Calculate how long it takes until the mass of Am-242 is 8 micrograms. **2**

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Figure 28: Q24b

Question 25 (5 marks)

Question 25 (5 marks)

A rocket is launched vertically from a planet of mass M. After it leaves the atmosphere, the rocket's engine is turned off and it continues to move away from the planet. From this time the rocket's mass is 200 kg. The rocket's speed, v, at two different distances from the planet's centre, R, is shown.

Point	R (m)	v ($m\,s^{-1}$)
1	4.3×10^6	5500
2	2.5×10^7	2900

(a) Show that the magnitude of the change in kinetic energy from point 1 to point 2 is 2.2×10^9 J. **2**

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(b) Determine the mass M of the planet using the law of conservation of energy. **3**

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Figure 29: Q25

Part (a)

(a) Show that the magnitude of the change in kinetic energy from point 1 to point 2 is 2.2×10^9 J. **2**

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Figure 30: Q25a

Part (b)

(b) Determine the mass M of the planet using the law of conservation of energy. **3**

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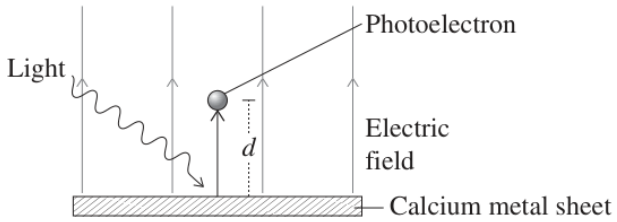
Figure 31: Q25b

Question 26 (6 marks)

Question 26 (6 marks)

Light of frequency 7.5×10^{14} Hz is incident on a calcium metal sheet which has a work function of 2.9 eV. Photoelectrons are emitted.

The metal is in a uniform electric field of 5.2 NC^{-1}, perpendicular to the surface of the metal, as shown.



(a) Show that the maximum kinetic energy of an emitted photoelectron is 3.2×10^{-20} J. **3**

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(b) Calculate the maximum distance, d, an emitted photoelectron can travel from the surface of the metal. **3**

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Figure 32: Q26

Part (a)

(a) Show that the maximum kinetic energy of an emitted photoelectron is 3.2×10^{-20} J. **3**

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Figure 33: Q26a

Part (b)

(b) Calculate the maximum distance, d, an emitted photoelectron can travel from the surface of the metal. **3**

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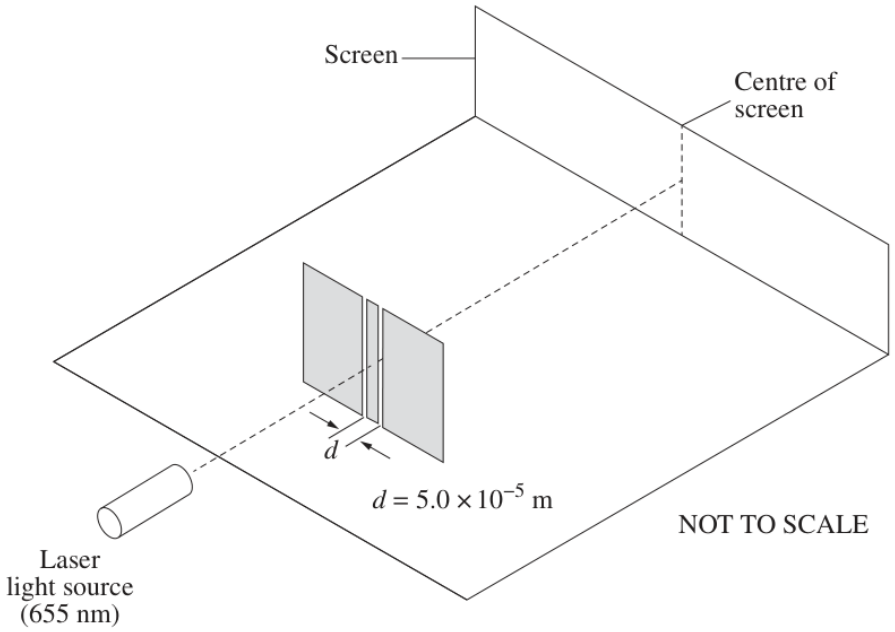
Figure 34: Q26b

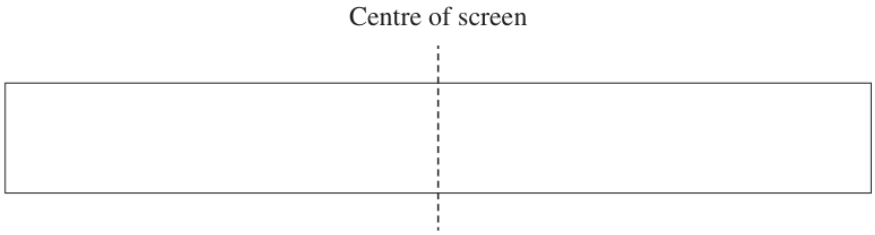
Question 27 (7 marks)

Question 27 (7 marks)

A laser producing red light of wavelength 655 nm is directed onto double slits separated by a distance, $d = 5.0 \times 10^{-5}$ m. A screen is placed behind the double slits.



(a) Newton proposed a model of light. Use a labelled sketch to show the pattern on the screen that would be expected from Newton's proposed model. **2**

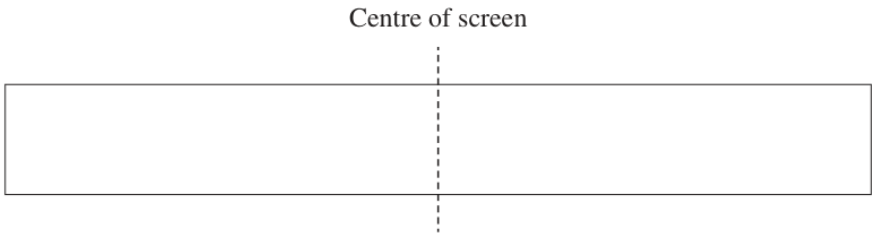


Question 27 continues on page 25

Figure 35: Q27

Part (a)

(a) Newton proposed a model of light. Use a labelled sketch to show the pattern on the screen that would be expected from Newton's proposed model. **2**



Question 27 continues on page 25

Figure 36: Q27a

Part (b)

(b) Calculate the angle, θ, between the centre line and the bright line at A. **3**

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Figure 37: Q27b

Part (c)

(c) The laser is replaced with one producing green light of wavelength 520 nm. **2**

Explain the difference in the pattern that would be produced.

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End of Question 27

– 25 –

Figure 38: Q27c

Question 28 (3 marks)

Question 28 (3 marks)

Two steps in the CNO cycle of nuclear fusion are shown. **3**

Step *X* $^{13}N \rightarrow {}^{13}C + e^{+} + \nu$

Step *Y* $^{13}C + {}^{1}H \rightarrow {}^{14}N$

Step *X* releases 1.20 MeV.

The masses in Step *Y* are shown in the table.

Isotope	*Mass* (*u*)
Carbon-13	13.003
Proton	1.007
Nitrogen-14	14.003

Propose a reason why Step *Y* releases more energy than Step *X*. Support your answer with calculations.

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Figure 39: Q28

Question 29 (4 marks)

Question 29 (4 marks)

An apple was thrown horizontally to the east from the window of a car which was moving with a uniform velocity to the north. **4**

Explain the horizontal and vertical components of the apple's motion during its flight.

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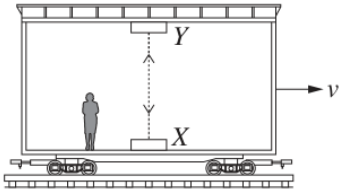
Figure 40: Q29

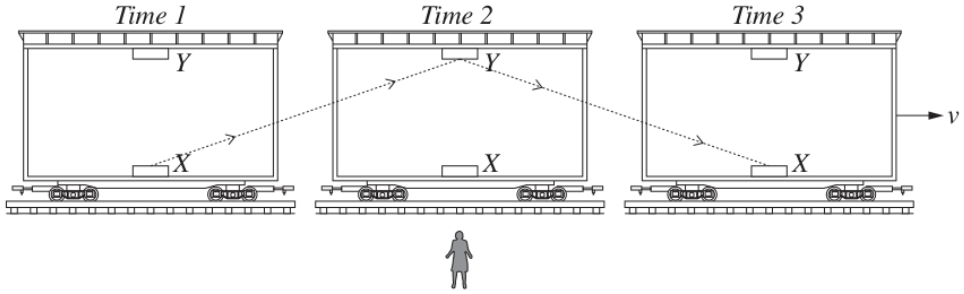
Question 30 (6 marks)

Question 30 (6 marks)

In a thought experiment, light travels from X to a mirror Y and back to X on a moving train carriage. The path of the light relative to an observer on the train is shown.



Relative to an observer outside the train, the path of the light is shown below, at three consecutive times as the train carriage moves along the track.



(a) Describe qualitatively how the constancy of the speed of light and the thought experiment above led Einstein to predict time dilation. **3**

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Question 30 continues on page 29

Figure 41: Q30

Part (a)

(a) Describe qualitatively how the constancy of the speed of light and the thought experiment above led Einstein to predict time dilation. **3**

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Question 30 continues on page 29

Figure 42: Q30a

Part (b)

(b) The train is travelling with a velocity $v = 0.96c$. To the observer inside the train, the return journey for the light between X and Y takes 15 nanoseconds. **3**

How long would this return journey take according to the observer outside the train?

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End of Question 30

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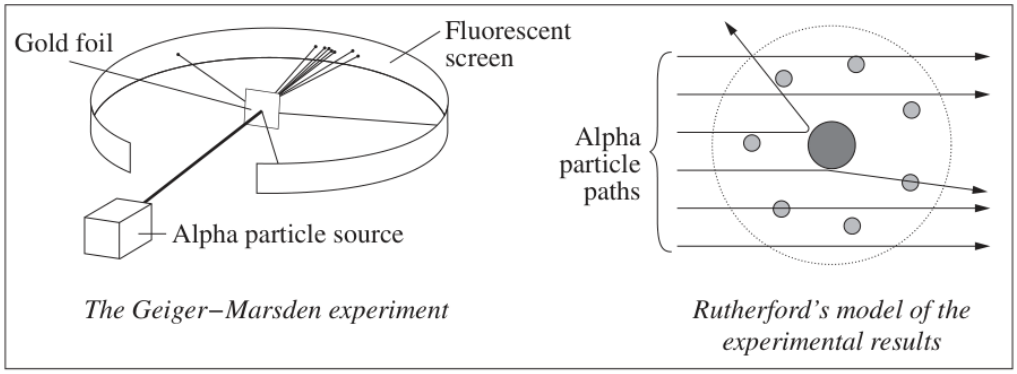
Figure 43: Q30b

Question 31 (9 marks)

Question 31 (9 marks)

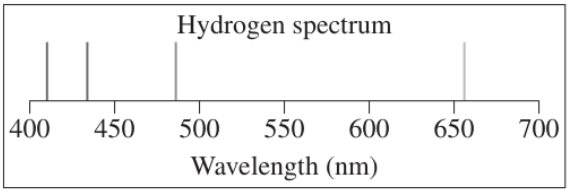
Following the Geiger–Marsden experiment, Rutherford proposed a model of the atom. **9**



The Geiger–Marsden experiment

Rutherford's model of the experimental results

Bohr modified this model to explain the spectrum of hydrogen observed in experiments.



The Balmer series

The Bohr–Rutherford model of the atom consists of electrons in energy levels around a positive nucleus.

How do features of this model account for all the experimental evidence above? Support your answer with a sample calculation and a diagram, and refer to energy, forces and photons.

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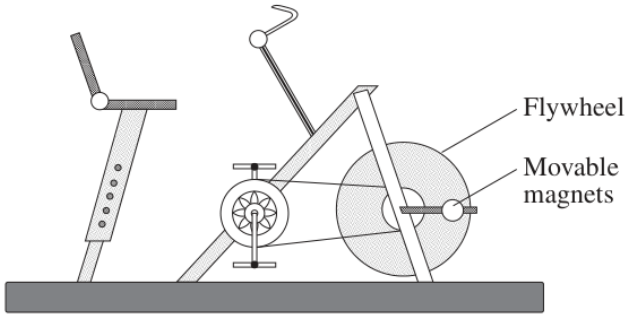
Question 31 continues on page 31

Figure 44: Q31

Question 32 (6 marks)

Question 32 (6 marks)

One type of stationary exercise bike uses a pair of strong, movable magnets placed on opposite sides of a thick, aluminium flywheel to provide a torque to make it harder to pedal.



(a) Explain the principle by which these magnets make it harder to pedal. **3**

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(b) The bike rider wants to increase the opposing torque on the flywheel. Justify an adjustment that could be made to the magnets to achieve this. **3**

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Figure 45: Q32

Part (a)

(a) Explain the principle by which these magnets make it harder to pedal. **3**

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Figure 46: Q32a

Part (b)

(b) The bike rider wants to increase the opposing torque on the flywheel. Justify an adjustment that could be made to the magnets to achieve this. **3**

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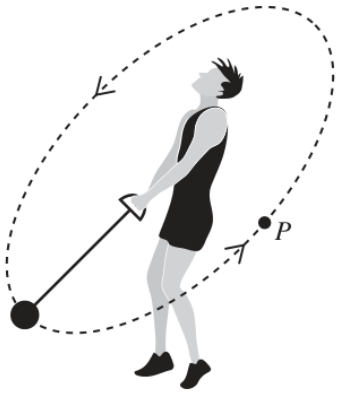
Figure 47: Q32b

Question 33 (6 marks)

Question 33 (6 marks)

In a hammer throw sport event, a 7.0 kg projectile rotates in a circle of radius 1.6 m, with a period of 0.50 s. It is released at point P, which is 1.2 m above the ground, where its velocity is at 45° to the horizontal.



(a) Show that the vertical component of the projectile's velocity at P is 14.2 m s^{-1}. **2**

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(b) Calculate the horizontal range of the projectile from point P. **4**

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Figure 48: Q33

Part (a)

(a) Show that the vertical component of the projectile's velocity at P is 14.2 $m\,s^{-1}$. **2**

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Figure 49: Q33a

Part (b)

(b) Calculate the horizontal range of the projectile from point P. **4**

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Figure 50: Q33b

Question 34 (7 marks)

Question 34 (7 marks)

Three charged particles, X, Y and Z, travelling along straight, parallel trajectories at the same speed, enter a region in which there is a uniform magnetic field which causes them to follow the paths shown. Assume that the particles do not exert any significant force on each other. **7**

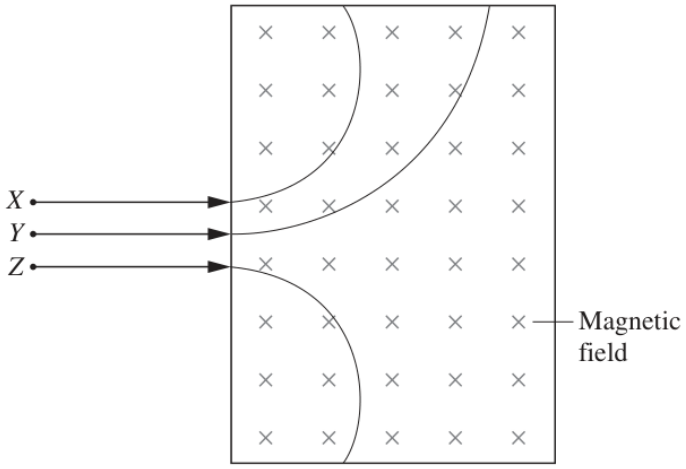

Figure 51: Q34

Explain the different paths that the particles follow through the magnetic field.

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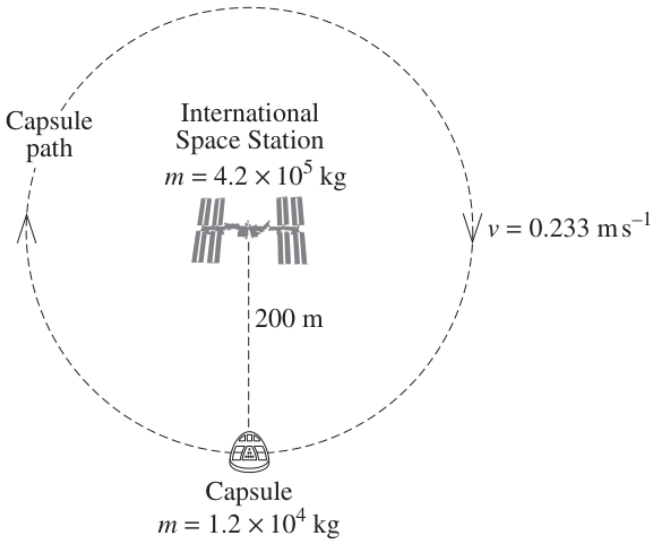
Question 35 (5 marks)

Question 35 (5 marks)

A capsule travels around the International Space Station (ISS) in a circular path of radius 200 m as shown. **5**



Analyse this system to test the hypothesis below.

The uniform circular motion of the capsule around the ISS can be accounted for in terms of the gravitational force between the capsule and the ISS.

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Figure 52: Q35