2023 HSC Physics Examination

NSW Education Standards Authority

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Exam Overview

Year	2023
Total Marks	100
Section I	20 marks (Questions 1-20, Multiple Choice)
Section II	80 marks (Questions 21-34, Extended Response)

Section I: Multiple Choice

20 marks - Questions 1-20

Allow about 35 minutes for this section

Question 1

1 The gravitational field strength acting on a spacecraft decreases as its altitude increases.

This is due to a change in the

A. mass of Earth.

B. mass of the spacecraft.

C. density of the atmosphere.

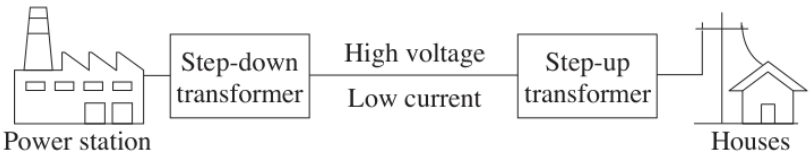
D. distance of the spacecraft from Earth's centre.

Figure 1: Q1

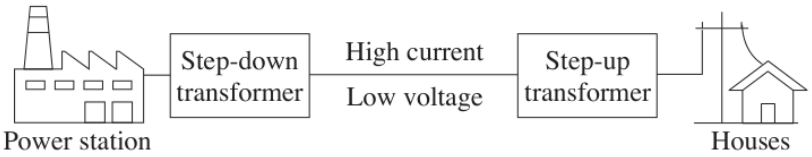
Question 2

2 Which diagram best represents the transmission of energy from a power station to people's houses?

A.



B.



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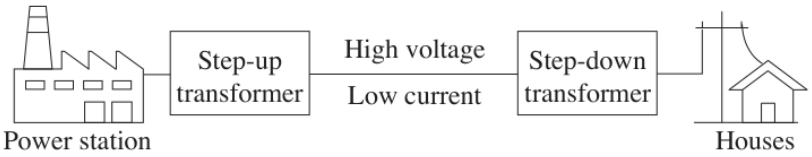


D.

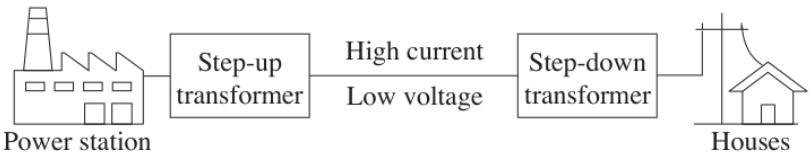
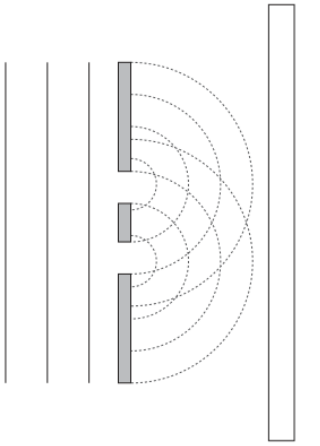


Figure 2: Q2

Question 3

3 A diagram representing a double slit experiment using light is shown.



Which of the following best represents the expected pattern on the screen?

A. 

B. 

C. 

D. 

Figure 3: Q3

Question 4

4 Caesium-137 has a half-life of 30 years.

What mass of caesium-137 will remain after 90 years, if the initial mass was 120 g?

A. 4 g

B. 15 g

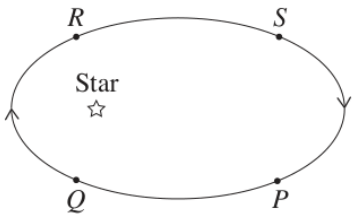
C. 40 g

D. 60 g

Figure 4: Q4

Question 5

5 An exoplanet is in an elliptical orbit, moving in the direction shown. The distances between consecutive positions P, Q, R and S are equal.



Between which two points is the exoplanet's travel time the greatest?

A. P and Q

B. Q and R

C. R and S

D. S and P

Figure 5: Q5

Question 6

6 An electron would produce an electromagnetic wave when it is

A. stationary.

B. in a stable hydrogen atom.

C. moving at a constant velocity.

D. moving at a constant speed in a circular path.

Figure 6: Q6

Question 7

7 A proton and a neutron travel at the same speed.

Which statement correctly explains the difference between their de Broglie wavelengths?

A. The proton has a longer wavelength because its mass is greater.

B. The proton has a shorter wavelength because its mass is smaller.

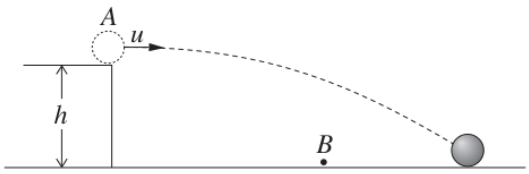
C. The neutron has a shorter wavelength because its mass is greater.

D. The neutron has a longer wavelength because its mass is smaller.

Figure 7: Q7

Question 8

8 A ball is launched from a platform at position A with velocity u. It lands in the position shown.



The ball could be made to land at position B by increasing the

A. velocity u.

B. launch angle.

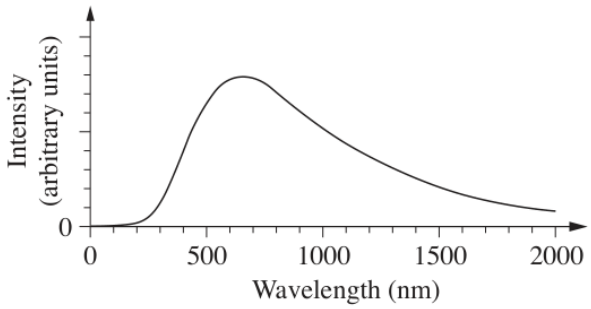
C. mass of the ball.

D. height of the platform.

Figure 8: Q8

Question 9

9 The graph shows the relationship between radiation intensity and wavelength for a black body at 4500 K.



Which statement describes the expected difference in the graph for a black body at 4000 K?

A. Intensity at all wavelengths will be less.

B. Intensity at all wavelengths will be greater.

C. The peak intensity will occur at a higher frequency.

D. The peak intensity will occur at a shorter wavelength.

Figure 9: Q9

Question 10

10 Figure I shows a current flowing through a loop of wire that is in a uniform magnetic field.

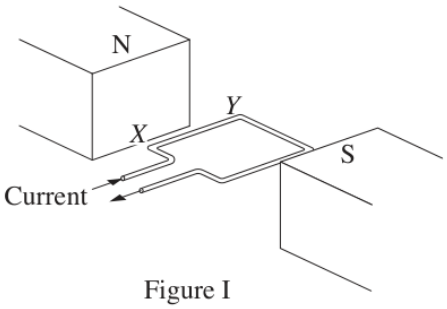


Figure I

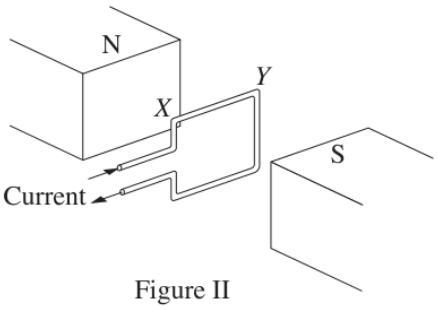


Figure II

The loop is then rotated to the position shown in Figure II.

The magnitude of the force on the side *XY* and the magnitude of the torque on the loop in Figure II are compared to those in Figure I.

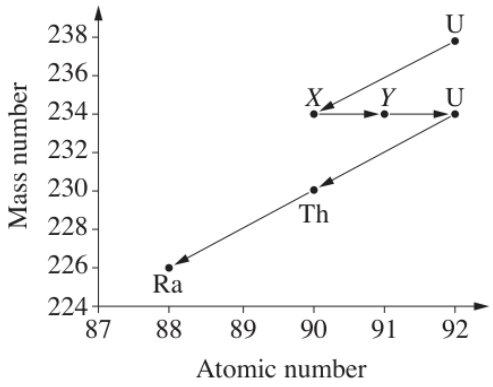
Which row of the table correctly describes the comparison?

	Force	*Torque*
A.	I > II	I = II
B.	I > II	I > II
C.	I = II	I = II
D.	I = II	I > II

Figure 10: Q10

Question 11

11 The chart shows part of a nuclear decay series beginning with uranium.



Which option correctly identifies *X* and *Y* and the process by which each was produced?

	X	*Y*
A.	$^{234}_{90}$Th alpha decay	$^{234}_{91}$Pa beta decay
B.	$^{234}_{90}$Th alpha decay	$^{234}_{91}$Pa alpha decay
C.	$^{234}_{91}$Pa beta decay	$^{234}_{90}$Th beta decay
D.	$^{234}_{91}$Pa beta decay	$^{234}_{90}$Th alpha decay

Figure 11: Q11

Question 12

12 Figure I shows a positively charged particle accelerating freely from X to Y, between oppositely charged plates. The change in the particle's kinetic energy is W.

The distance between the plates is then doubled as shown in Figure II. The same charge accelerates from rest over the same distance from X to Y.

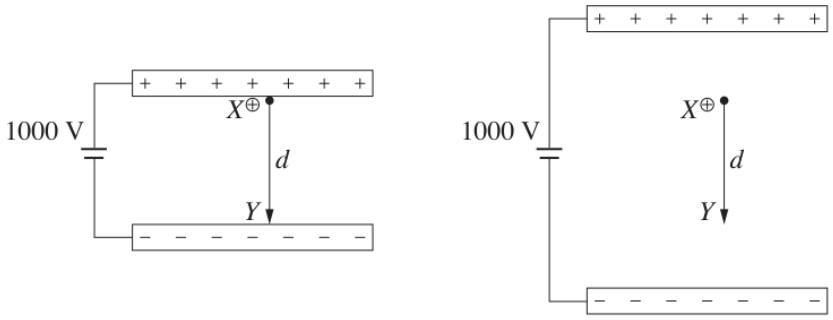


Figure I Figure II

What is the change in kinetic energy of the positively charged particle shown in Figure II?

A. W

B. $\frac{W}{2}$

C. $\sqrt{W}$

D. $2W$

Figure 12: Q12

Question 13

13 Nucleus X has a greater binding energy than nucleus Y.

What can be deduced about X and Y?

A. X is more stable than Y.

B. Y is more stable than X.

C. X has a greater mass defect than Y.

D. Y has a greater mass defect than X.

Figure 13: Q13

Question 14

14 Planet X has a mass 4 times that of Earth and a radius 3 times that of Earth. The escape velocity at the surface of Earth is $11.2\ \text{km s}^{-1}$.

What is the escape velocity at the surface of planet X?

A. $8.40\ \text{km s}^{-1}$

B. $9.70\ \text{km s}^{-1}$

C. $12.9\ \text{km s}^{-1}$

D. $14.9\ \text{km s}^{-1}$

Figure 14: Q14

Question 15

15 What evidence resulting from investigations into the photoelectric effect is consistent with the model of light subsequently proposed by Einstein?

A. Photoelectrons were only ejected from a metal if the light was less than a specific wavelength.

B. Increasing the intensity of light on a metal increased the maximum kinetic energy of the photoelectrons.

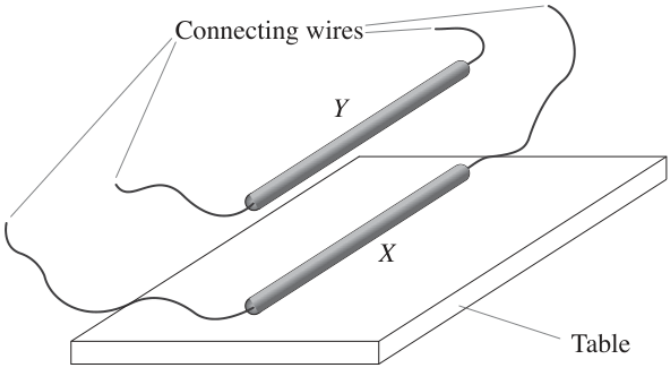
C. If photons had sufficient energy to eject photoelectrons from a metal, the maximum kinetic energy was independent of the type of metal used.

D. The probability of photoelectrons being emitted from a metal was proportional to the duration of exposure to light for any given wavelength used.

Figure 15: Q15

Question 16

16 In a thought experiment, two identical parallel aluminium rods, X and Y, are carrying electric currents of equal magnitude. Rod X rests on a table. Rod Y remains stationary, vertically above X, as a result of the magnetic interaction. The masses of the connecting wires are negligible.



Which statement must be correct if rod Y is stationary?

A. The magnetic force acting on X is upward.

B. The currents through X and Y are in the same direction.

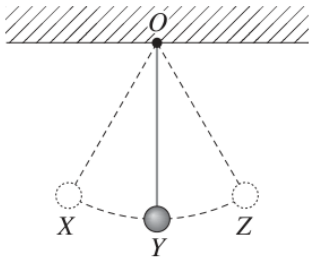
C. The force the table exerts on X is equal and opposite to the total weight of X and Y.

D. The force the table exerts on X is equal and opposite to the force of gravity acting on Y.

Figure 16: Q16

Question 17

17 A mass attached to a lightweight, rigid arm hanging from point O, oscillates freely between X and Z.



Which statement best describes the torque acting on the arm as it oscillates?

A. It is constant in magnitude and direction.

B. It is zero at Y and a maximum at X and Z.

C. It is zero at X and Z and a maximum at Y.

D. It is constant in magnitude but its direction changes.

Figure 17: Q17

Question 18

18 The diagrams show the trajectories of two particles with the same mass and charge and which initially have the same velocity u, as shown. The subsequent motion of each particle is determined by its properties and by its interaction with the field in which it is moving.

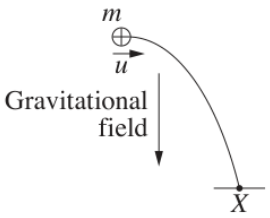


Figure I

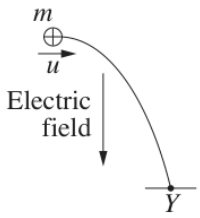


Figure II

X and Y represent the landing points in Figures I and II.

Which row of the table shows the correct paths of the particles if the mass of each is increased by the same amount and they are given the same initial velocity u?

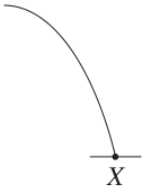
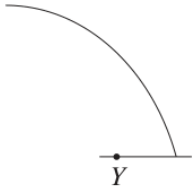
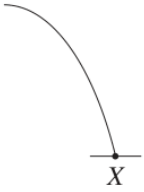
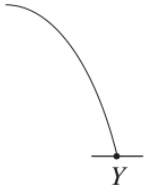
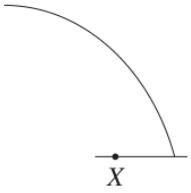
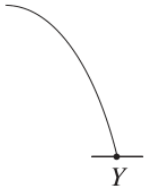
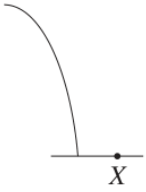
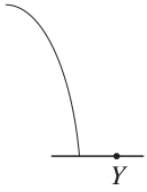
	Gravitational field	Electric field
A.		
B.		
C.		
D.		

Figure 18: Q18

Question 19

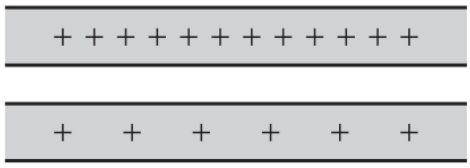
19 The diagram represents the distribution of positive charges in identical wires when no current is flowing.

Equal currents then flow in each wire, but in opposite directions. These currents are considered conventionally as the flow of positive charge.

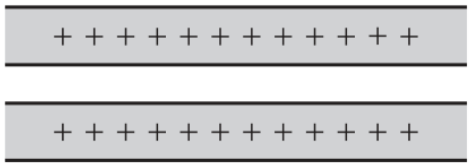
Which diagram represents the charge distribution in the wires, from the frame of reference of a positive charge in wire *Y*?

A.

B.



C.



D.

Figure 19: Q19

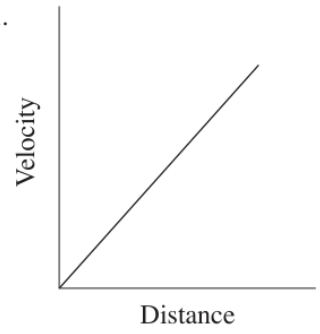
Question 20

20 In 1995, observational evidence showed that Hubble's description of the expansion of the universe was inaccurate.

It was discovered that the expansion of the universe was accelerating. This discovery was based on observations of light from galaxies whose distances from Earth could be accurately measured, and were significantly more distant than any observed by Hubble.

Which graph relating velocities of galaxies to their distances from Earth is consistent with an accelerating rate of expansion of the universe?

A.



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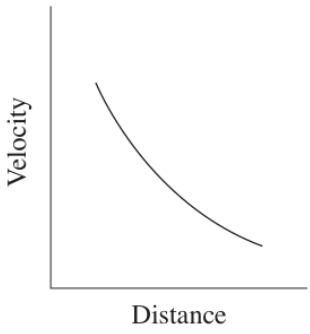

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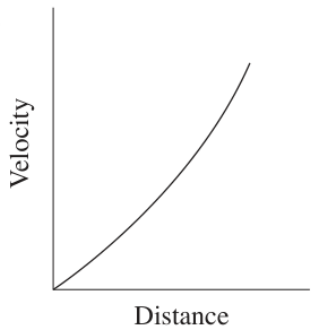


D.

Figure 20: Q20

Section II: Extended Response

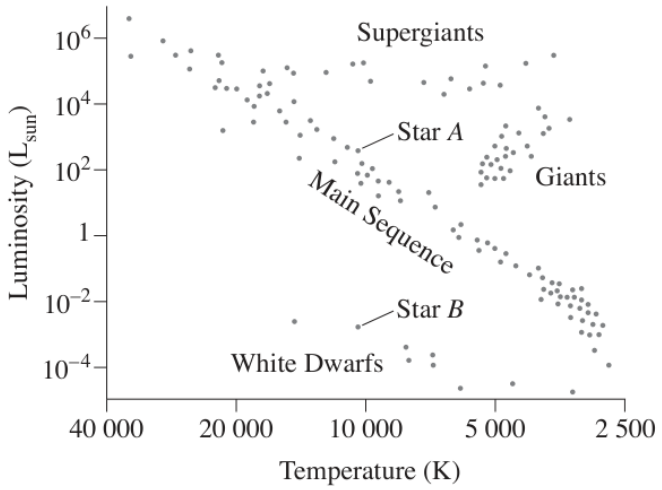
80 marks - Questions 21-34

Allow about 2 hours and 25 minutes for this section

Question 21 (5 marks)

Question 21 (5 marks)

A Hertzsprung–Russell diagram is shown.



(a) Identify TWO variables that determine the luminosity of a star. **2**

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(b) Describe differences between stars *A* and *B*. **3**

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Figure 21: Q21

Part (a)

(a) Identify TWO variables that determine the luminosity of a star. **2**

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Figure 22: Q21a

Part (b)

(b) Describe differences between stars *A* and *B*. **3**

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Figure 23: Q21b

Question 22 (3 marks)

Question 22 (3 marks)

A spacecraft passes Earth at a speed of $0.9c$. The spacecraft emits a light pulse every 3.1×10^{-9} s, as measured by the crew on the spacecraft. **3**

What is the time between the pulses, as measured by an observer on Earth?

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Figure 24: Q22

Question 23 (7 marks)

Question 23 (7 marks)

The James Webb Space Telescope (JWST) has a mass of 6.1×10^3 kg and orbits the Sun at a distance of approximately 1.52×10^{11} m.

(a) The Sun has a mass of 1.99×10^{30} kg. **2**

Calculate the magnitude of gravitational force the Sun exerts on the JWST.

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(b) The telescope is sensitive to wavelengths from 6.0×10^{-7} m to 2.8×10^{-5} m. **3**

What is the minimum photon energy that it can detect?

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(c) The JWST observed an exoplanet emitting a peak wavelength of 1.14×10^{-5} m. **2**

Calculate the temperature of the exoplanet.

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Figure 25: Q23

Part (a)

(a) The Sun has a mass of 1.99×10^{30} kg. **2**

Calculate the magnitude of gravitational force the Sun exerts on the JWST.

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Figure 26: Q23a

Part (b)

(b) The telescope is sensitive to wavelengths from 6.0×10^{-7} m to 2.8×10^{-5} m. **3**

What is the minimum photon energy that it can detect?

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Figure 27: Q23b

Part (c)

(c) The JWST observed an exoplanet emitting a peak wavelength of 1.14×10^{-5} m. **2**

Calculate the temperature of the exoplanet.

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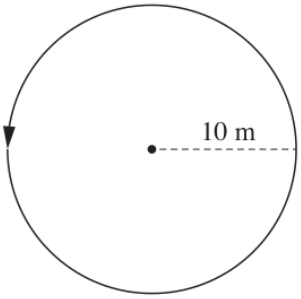
Figure 28: Q23c

Question 24 (3 marks)

Question 24 (3 marks)

An electron is travelling at 3.0×10^6 m s^{-1} in the path shown. **3**



Calculate the magnetic field required to keep the electron in the path.

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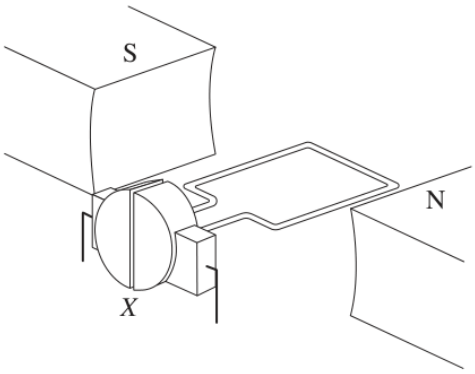
Figure 29: Q24

Question 25 (4 marks)

Question 25 (4 marks)

(a) The diagram represents one type of electric motor. **2**



Describe the function of part *X*.

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(b) Explain why the torque of a DC motor decreases as its rotational speed increases. **2**

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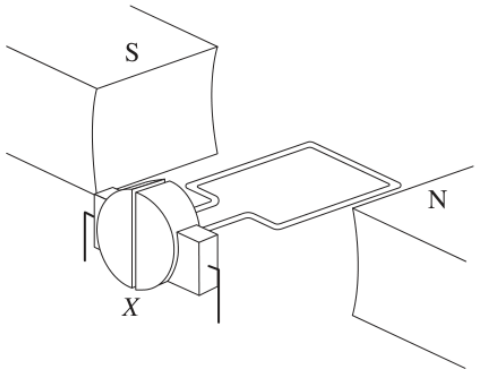
Figure 30: Q25

Part (a)

(a) The diagram represents one type of electric motor. **2**



Describe the function of part *X*.

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Figure 31: Q25a

Part (b)

(b) Explain why the torque of a DC motor decreases as its rotational speed increases. **2**

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Figure 32: Q25b

Question 26 (3 marks)

Question 26 (3 marks)

Consider the following nuclear reaction. **3**

$$^{12}_{6}\text{C} + ^{1}_{1}\text{H} \rightarrow ^{9}_{5}\text{B} + ^{4}_{2}\text{He}$$

The masses of the isotopes in this process are shown in the table.

Isotope	*Mass* (*u*)
$^{12}_{6}\text{C}$	12.064
$^{9}_{5}\text{B}$	9.013
$^{4}_{2}\text{He}$	4.003
$^{1}_{1}\text{H}$	1.008

Calculate the energy released in this reaction.

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Figure 33: Q26

Question 27 (8 marks)

Question 27 (8 marks)

(a) Explain how the composition and temperature of a star can be determined from its spectrum. **4**

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Question 27 continues on page 25

Figure 34: Q27

Part (a)

(a) Explain how the composition and temperature of a star can be determined from its spectrum. **4**

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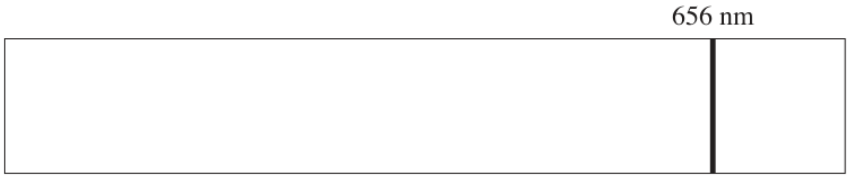
Question 27 continues on page 25

Figure 35: Q27a

Part (b)

(b) The diagram represents one hydrogen emission line from the spectrum of a star. **4**



Explain the changes to this spectral line that would be observed as a result of the star's rotational velocity. Modify the diagram to support your answer.

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End of Question 27

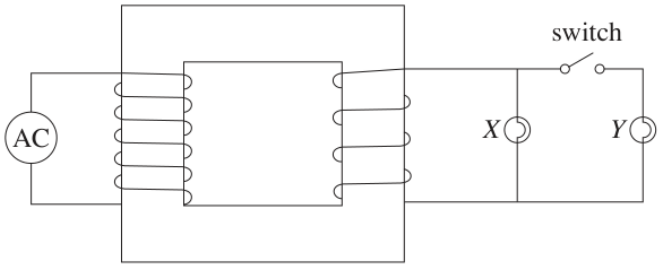
Figure 36: Q27b

Question 28 (5 marks)

Question 28 (5 marks)

An ideal transformer is connected to a 240 V AC supply. It has 300 turns on the primary coil and 50 turns on the secondary coil.

It is connected in the circuit with two identical light globes, *X* and *Y*, as shown.



(a) Calculate the voltage across light globe *X* when the switch is open. **2**

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(b) Explain why, after the switch has been closed, the current in the primary coil is different from when the switch is open. **3**

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Figure 37: Q28

Part (a)

(a) Calculate the voltage across light globe *X* when the switch is open. **2**

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Figure 38: Q28a

Part (b)

(b) Explain why, after the switch has been closed, the current in the primary coil is different from when the switch is open. **3**

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Figure 39: Q28b

Question 29 (4 marks)

Question 29 (4 marks)

When light from an incandescent lamp is passed through a plane polarising filter, the intensity of the light is reduced. **4**

Explain this phenomenon.

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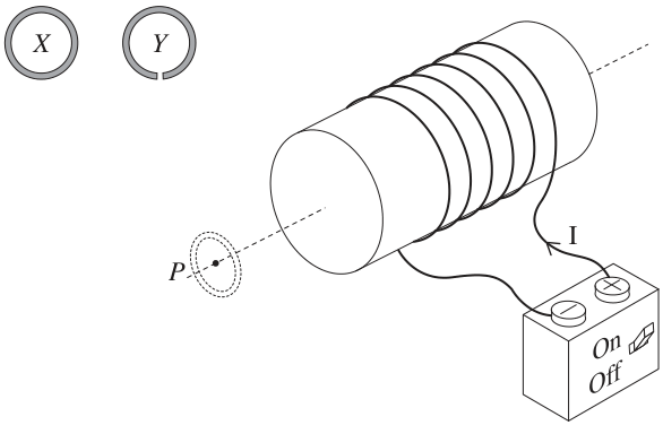
Figure 40: Q29

Question 30 (8 marks)

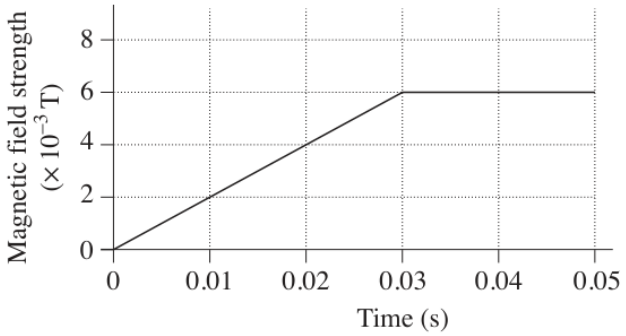
Question 30 (8 marks)

The diagram shows apparatus that is used to investigate the interaction between the magnetic field produced by a coil and two copper rings *X* and *Y*, when each is placed at position *P*, as shown.



Ring *X* is a complete circular ring, and a small gap has been cut in ring *Y*. Each of the rings has a cross-sectional area of 4×10^{-4} m^2.

The power supply connected to the coil produces an increasing current through the coil in the direction shown, when the switch is turned on. This produces a magnetic field at *P* that varies as shown in the graph.



Question 30 continues on page 29

Figure 41: Q30

Part (a)

(a) In the first part of the investigation, ring X is held near the end of the electromagnet at position P. **4**

Account for the force acting on the ring from 0 to 0.05 seconds after the power supply is turned on.

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Figure 42: Q30a

Part (b)

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(b) (i) In the second part of the investigation, ring Y is placed at P, and the power supply is turned on. **2**

Explain the behaviour of the ring.

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(ii) Calculate the maximum induced emf in ring Y. **2**

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End of Question 30

Figure 43: Q30b

(i)

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(b) (i) In the second part of the investigation, ring Y is placed at P, and the power supply is turned on. **2**

Explain the behaviour of the ring.

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Figure 44: Q30b_i

(ii)

(ii) Calculate the maximum induced emf in ring *Y*. **2**

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End of Question 30

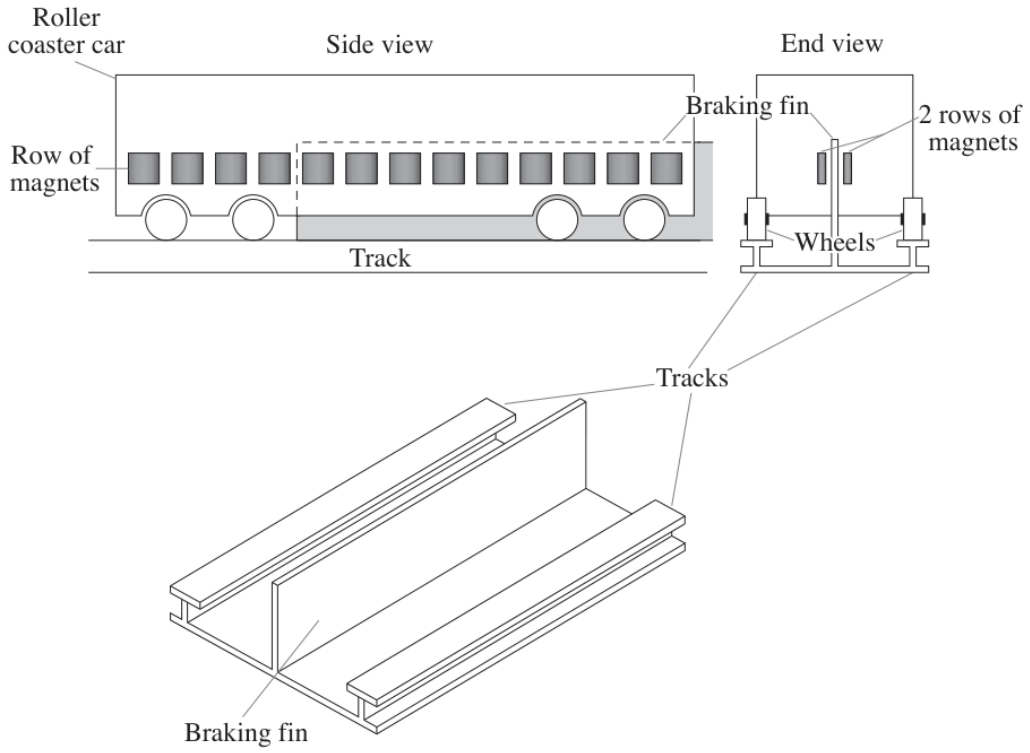
– 29 –

Figure 45: Q30b_ii

Question 31 (5 marks)

Question 31 (5 marks)

A roller coaster uses a braking system represented by the diagrams. **5**



When the roller coaster car reaches the end of the ride, the two rows of permanent magnets on the car pass on either side of a thick aluminium conductor called a braking fin.

Question 31 continues on page 31

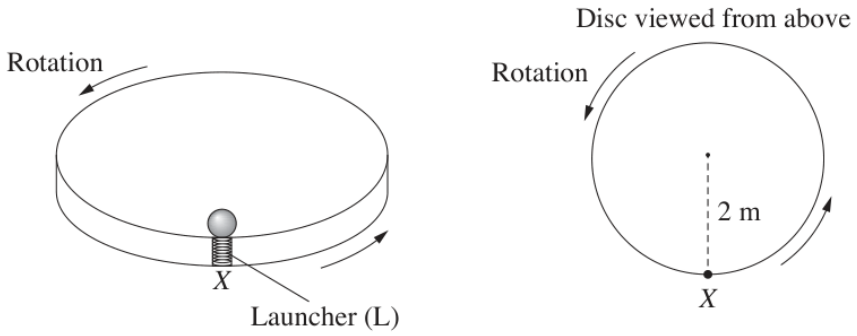
Figure 46: Q31

Question 32 (7 marks)

Question 32 (7 marks)

A horizontal disc rotates at 3 revolutions per second around its centre, with the top of the disc at ground level. **7**

At 2 m from the centre of the disc, a ball is held in place at ground level on the top of the disc by a spring-loaded projectile launcher. At position X, the launcher fires the ball vertically upward with a velocity of 5.72 m s^{-1}.



Calculate the ball's position relative to the launcher's new position, at the instant the ball hits the ground.

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Figure 47: Q32

Question 33 (9 marks)

Question 33 (9 marks)

Consider the following statement. **9**

> The interaction of subatomic particles with fields, as well as with other types of particles and matter, has increased our understanding of processes that occur in the physical world and of the properties of the subatomic particles themselves.

Justify this statement with reference to observations that have been made and experiments that scientists have carried out.

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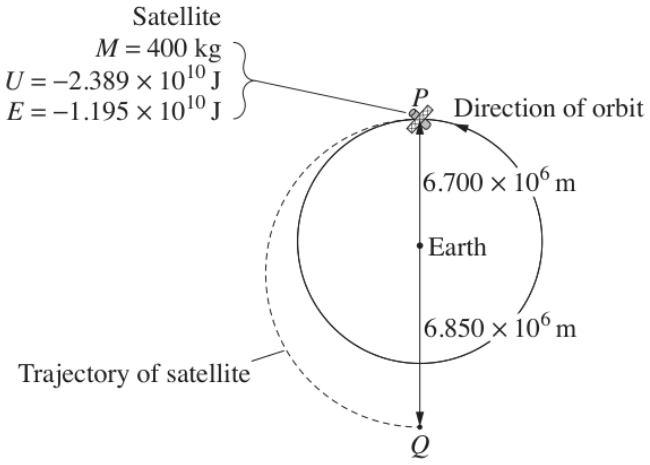
Figure 48: Q33

Question 34 (9 marks)

Question 34 (9 marks)

A 400 kg satellite is travelling in a circular orbit of radius 6.700×10^6 m around Earth. Its potential energy is -2.389×10^{10} J and its total energy is -1.195×10^{10} J.



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At point P, the satellite's engines are fired, increasing the satellite's velocity in the direction of travel and causing its kinetic energy to increase by 5.232×10^8 J. Assume that this happens instantaneously and that the engine is then shut down.

The satellite follows the trajectory shown, which passes through Q, 6.850×10^6 m from Earth's centre.

(a) Analyse qualitatively the energy changes as the satellite moves from P to Q. **2**

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Question 34 continues on page 35

Figure 49: Q34

Part (a)

(a) Analyse qualitatively the energy changes as the satellite moves from P to Q. **2**

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Question 34 continues on page 35

Figure 50: Q34a

Part (b)

(b) Show that the kinetic energy of the satellite at Q is 1.194×10^{10} J. **4**

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Figure 51: Q34b

Part (c)

(c) Explain the motion of the satellite after it passes through Q. **3**

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Figure 52: Q34c