Name: ________________

Class: ________________

Practice exam

Year 12 Physics exam

Time permitted: 180 minutes

	Section	Number of questions	Marks available	Marks achieved
I	Multiple choice	20	20	
II	Short answer	34	80	
	Total	54	100	

Grade: ______________

Scale:

A+	66–70	**A**	60–65	**B**	50–59	**C**	40–49	**D**	35–39	**E**	21–34	**UG**	0–20

Comments:

Section I: Multiple choice (20 marks)

Section A consists of 20 questions, each worth one mark. Each question has only one correct answer. Circle the correct answer. Attempt all questions. Marks will not be deducted for incorrect answers. You are advised to spend no more than 30 minutes on this section.

1 A projectile is launched at a speed of 750 m s^{-1} at an angle of elevation 40.0°. How long does it take before the angle of elevation of the projectile's motion is 0°?

A. 24.6 s

B. 29.3 s

C. 49.2 s

D. 58.6 s

2 A ball is thrown from a height of 2.50 m above the ground with initial velocity of 15.0 m s^{-1} at an angle of 41.0°. The angle at which the ball hits the ground is:

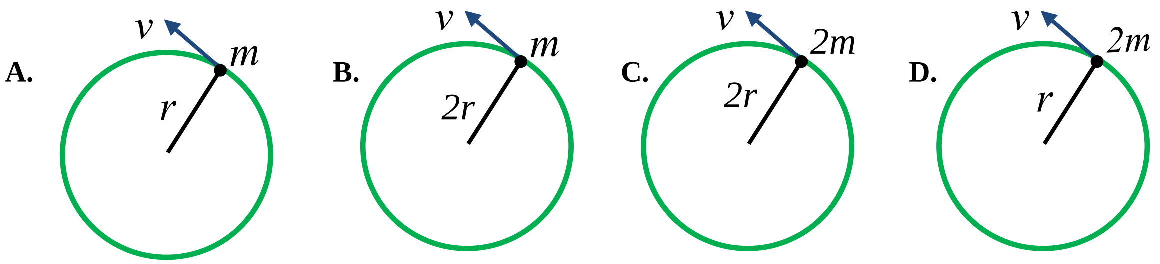
A. 42.2°

B. 43.2°

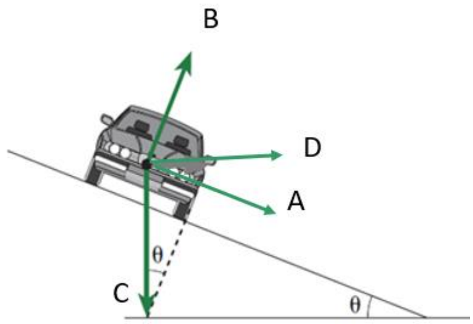
C. 46.8°

D. 47.8°

3 Each image below **A**, **B**, **C**, **D**, shows an object moving at the same constant speed in horizontal circles. In which of the following situations is the tension force in the string greatest?



4 The figure below shows a vehicle travelling in a horizontal circle at constant speed on a frictionless banked track. **Circle** the arrow, **A**, **B**, **C**, **D,** that represents the direction of the net force on the vehicle?



5 An ion of mass 3.0×10^{-27} kg is subjected to a net force of 9.0×10^{-18} N, which causes it to move continuously on a circular path of radius 10 cm. Calculate the frequency of the ion's motion.

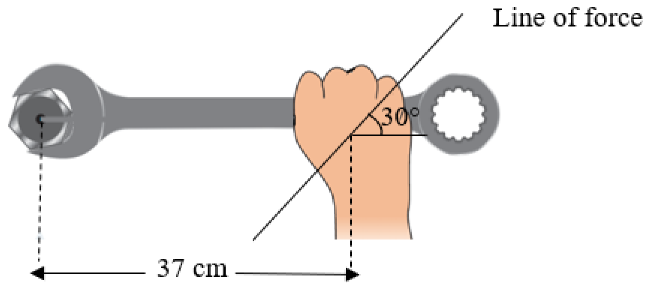
A. $3.6 \times 10^{-5}\,s^{-1}$

B. $2.9 \times 10^{4}\,s$

C. $5.9 \times 10^{-7}\,s^{-1}$

D. $1.7 \times 10^{6}\,s$

6 The figure below shows a spanner being used to undo a bolt on a child's swing. The person applies a force of 81 N at 37 cm from the centre of the bolt. The force is applied at an angle of 30° to the long axis of the spanner.



A. $3.6 \times 10^{-5}\,s^{-1}$

B. $2.9 \times 10^{4}\,s$

C. $5.9 \times 10^{-7}\,s^{-1}$

D. $1.7 \times 10^{6}\,s$

7 A planet of mass 4.21×10^{16} kg revolves around a star of mass 1.87×10^{25} kg at 2.78×10^{13} km. The gravitational field due to the star at the planet is:

A. 1.61×10^{-18} N kg^{-1}.

B. 1.61×10^{-12} m s^{-2}.

C. 3.63×10^{-27} N kg^{-1}.

D. 3.63×10^{-21} m s^{-2}.

8 The speed of a 44-tonne rocket and payload changes from 13.1 km h^{-1} to 12.8 km h^{-1} while it travels 2000 km directly away from the Earth. Which of the following statements **A**–**D** is correct?

A. The increase of kinetic energy is equal to the decrease of potential energy of the rocket.

B. The decrease of kinetic energy in the Earth-rocket system is equal to the increase of potential energy of the Earth-rocket system.

C. The decrease of kinetic energy in the Earth-rocket system is equal to the increase of potential energy of the rocket.

D. Both the potential energy of the rocket and the kinetic energy of the Earth-rocket system are the same.

9 The total energy associated with an Earth satellite of mass 1.5 tonne, which has an orbital radius of 5.34×10^4 km is -7.31×10^9 J. The kinetic energy of the satellite is:

A. 3.66×10^9 J

B. -3.66×10^9 J

C. 7.31×10^9 J

D. -7.31×10^9 J

10 A moving negatively charged mass enters horizontally into a constant field, which is pointing vertically downwards. The motion of the mass will be most obviously:

A. parabolic, upwards in an electric field; horizontal and circular in a magnetic field.

B. parabolic, downwards in an electric field; vertical and circular in a magnetic field.

C. parabolic, upwards in a magnetic field; parabolic downwards in a gravitational field.

D. parabolic, downwards in a gravitational field; horizontal and circular in an electric field.

11 A point charge of 3.0 μC is responsible for an electric field of 5.1 kN C^{-1} at a point 2.3 m from the charge. The force on a –5.0 μC point charge, which is 4.6 m from the original charge is:

A. 0.26 kN C^{-1}

B. 2.10 kN C^{-1}

C. 2.60 kN C^{-1}

D. 4.30 kN C^{-1}

12 An electron of mass 9.11×10^{-31} kg moves horizontally at a speed of 1.1×10^{4} m s^{-1} directly towards the west. At this location, the magnitude of Earth's magnetic field, which is horizontal and points north, is 55μT. The force applied to the electron by the magnetic field is:

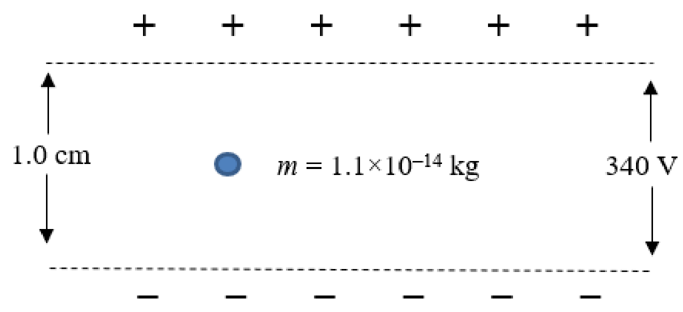
A. 5.5×10^{-25} N

B. 9.7×10^{-20} N

C. 9.7×10^{-19} N

D. 1.1×10^{11} N

13 An oil drop of mass 1.1×10^{-14} kg falls vertically into the evacuated space between two parallel charged plates, which are 1.5 cm apart. See figure below.



When the potential difference between the plates is 340 V, the oil drop stops moving. How many excess electrons are on the oil drop?

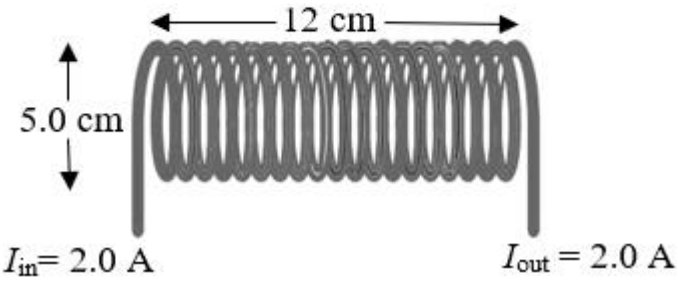
A. 1

B. 2

C. 3

D. 4

14 The figure below shows a 12-cm long solenoid of diameter 5.0 cm with 600 turns. The current in the solenoid is 2.0 A.



The magnitude of the magnetic field near the centre of the solenoid is:

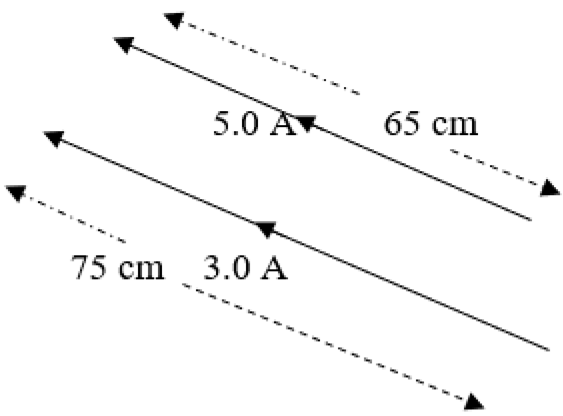
A. 16 μT.

B. 1.5 mT.

C. 13 mT.

D. 80 mT.

15 A straight wire, 75 cm in length and carrying a current of 3.0 A, is parallel to and 15 cm from a 65-cm long straight wire, carrying a 5.0 A current. See the figure below.



The magnitude of the magnetic force applied to the 75-cm wire is:

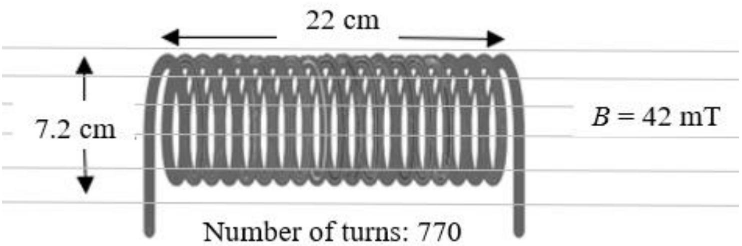
A. 20 μN.

B. 15 μN.

C. 13 μN.

D. 3.0 μN.

16 Figure 7 shows a 7.2-cm diameter, 22-cm long solenoid comprising 770 turns. It is placed in a 42 mT magnetic field.



The flux threading the coil is:

A. 17 mWB.

B. 68 mWB.

C. 13 mWB.

D. 53 mWB.

17 A transformer comprises a primary coil of 40 turns and a secondary coil of 60 turns. The primary is connected to a 15 V DC power source. Which of the following, **A–D**, is correct for the secondary coil?

	Secondary coil	
	Potential difference (V)	Flux
A.	22.5	1.5 × primary flux
B.	22.5	same as primary flux
C.	0	1.5 × primary flux
D.	0	same as primary flux

18 Muons are subatomic particles, which are created high in the Earth's atmosphere. They have a lifetime of 2.2μs and travel at a speed of 0.95*c*. According to an observer on the ground, muons travel a distance of:

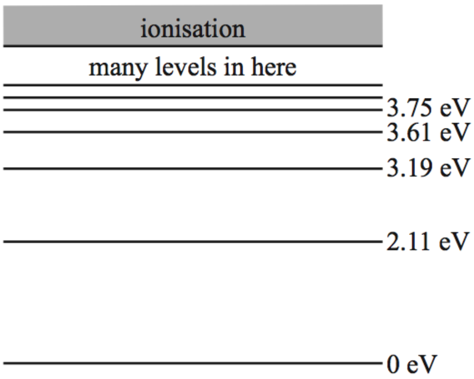
A. 0.21 km.

B 0.64 km.

C. 0.66 km.

D. 2.0 km.

19 The figure below shows the energy levels for sodium.



If an atom returns to the ground state from the 3.61 eV state, the transition that produces the longest wavelength emitted by the atom is:

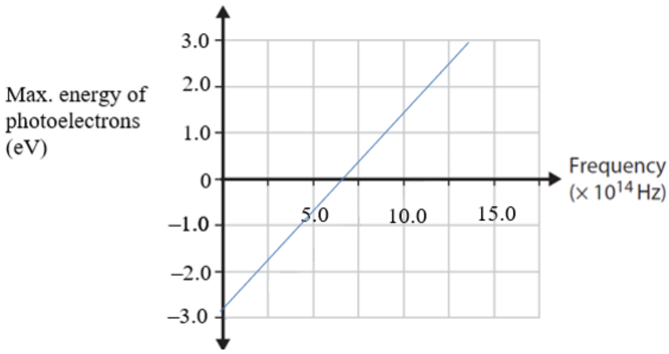
A. 3.61 eV to ground.

B. 3.61 eV to 3.19 eV.

C. 3.61 eV to 2.11 eV.

D. 3.19 eV to 2.11 eV.

20 Different wavelengths of light are shone onto a metallic surface. The maximum energy of photoelectrons emitted is shown as a function of the frequency of the incident light on the graph below.



What potential difference is required to measure the maximum energy emitted by light of wavelength 3.0 μm.

A. 0 V

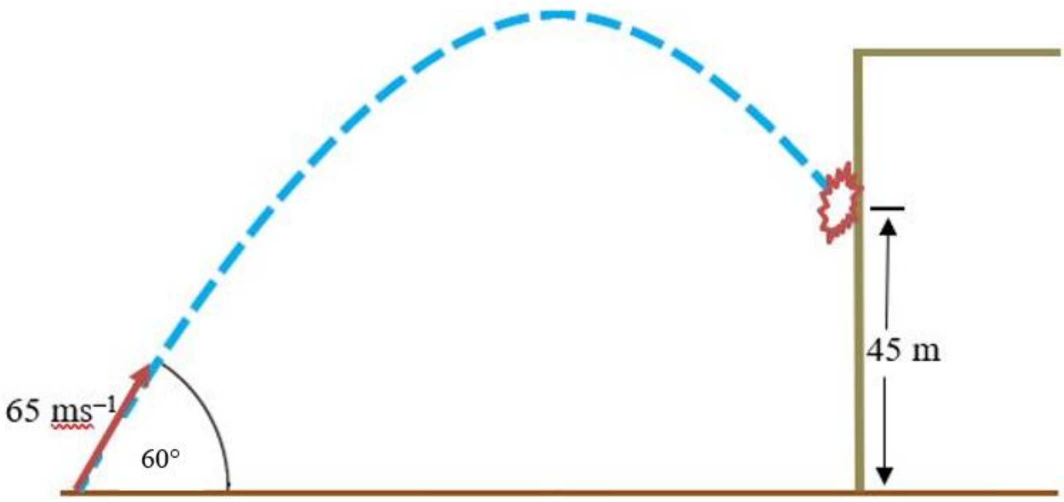
B. 1.2 V

C. 1.2 eV

D. 3.0 V

Section II Short answer (80 marks)

21 The figure below shows the path of a rocket, which is propelled upwards towards a cliff at 65.0 ms^{-1} at an angle of $60°$. It strikes the cliff 45 m above the launch position.



Find:

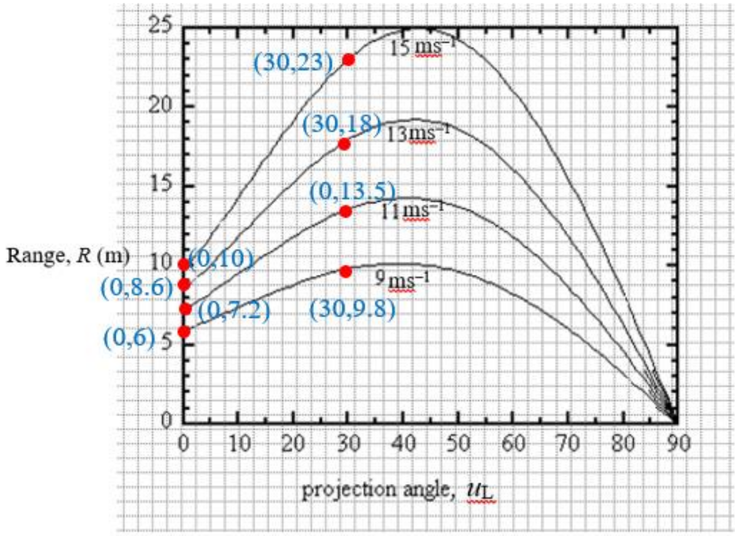
a the maximum height attained.

b the time taken to strike the cliff.

c the distance to the cliff.

[2 + 2 + 1 = 5 marks]

22 The graph below shows the predicted range of a 7.26-kg shot put launched at different angles and speeds.



a Construct a graph to show how, at a projection angle of 30° the range varies with launch speed by:

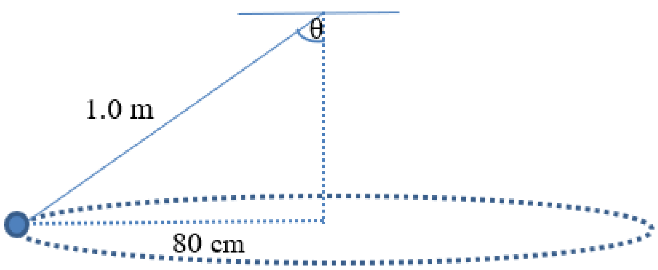
i constructing a suitable data table.

ii plotting a graph from the data table.

b Determine whether the assumed launch height is reasonable for all angles of launch.

[3 + 3 = 6]

23 The figure below shows a small ball of mass 25 g, which is attached to a light, inextensible string of length 1.0 m. It is swung in a horizontal circle of radius 80 cm at a rate of 0.45 Hz.



Calculate:

a the angular velocity of the ball.

b the tension in the string.

[1 + 3 = 4 marks]

24 The radius of the orbit of the Moon ($m = 7.35 \times 10^{22}$ kg) around the Earth is 3.85×10^{5} km. The period of the Moon's orbit is 27.3 days and the radius of the Moon is 1740 km.

Calculate:

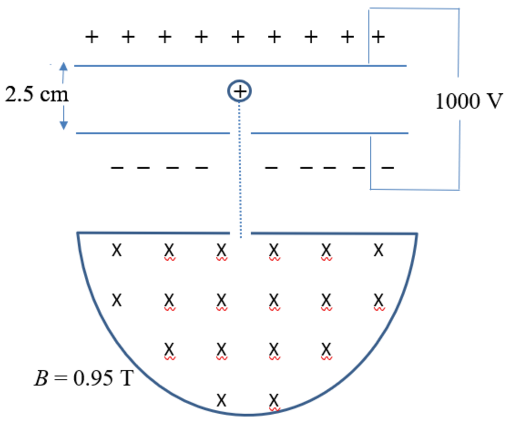
a the magnitude of the gravitational field due to the Earth at the Moon.

b the orbital speed of the Moon.

c the minimum speed required for the Moon to leave the Earth's gravitational field completely.

[3 + 2 + 2 = 7 marks]

25 In a mass spectrometer, positive ions are accelerated across a potential difference of 1.0 kV between two charged plates 2.5 cm apart and then injected at right angles into a magnetic field of 0.95 T. (See Figure below.)



Copper ions have very similar masses. Consider a doubly charged Cu^{2+} copper ion of mass 1.02×10^{-22} kg.

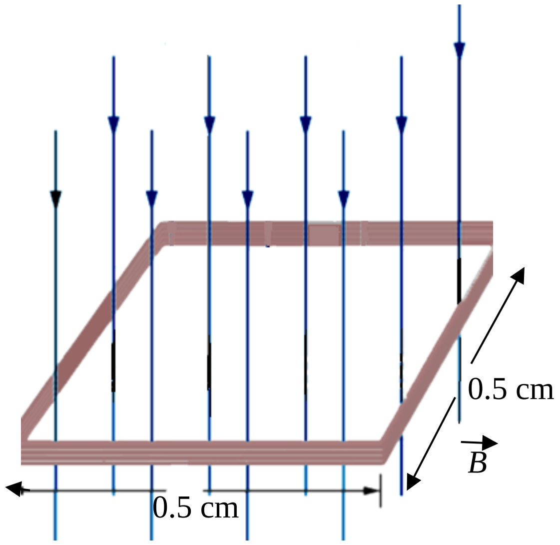
a Calculate the speed of the ion when it enters the magnetic field.

b Calculate the radius of the circle in which the Cu^{2+} ion moves in the magnetic field.

c Explain how a mass spectrometer can be used to distinguish between Cu^{+}, Cu^{2+} and Cu^{3+} ions.

[2 + 2 + 2 = 6 marks]

26 The figure below shows a 100-loop square coil of side length 5.0 cm in a constant magnetic field of 0.60 T. The coil is positioned so that its leading edge is at the position where the magnetic field changes abruptly to zero. It takes 0.10 s for the coil to be drawn at constant speed completely out of the field in the direction shown.



a Calculate the flux through the coil.

The coil has a total resistance of $100\,\Omega$.

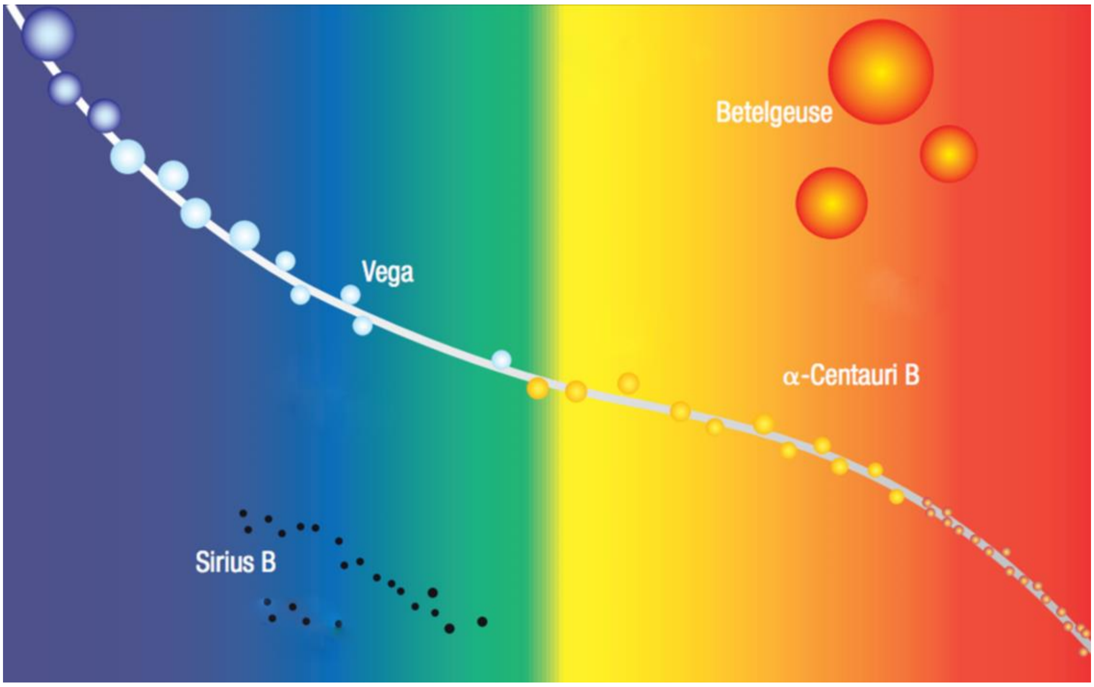
b What average force is required in order to pull the coil out of the field?

[2 + 3 = 5 marks]

27 Use energy and field considerations to compare and contrast an electric motor, an AC generator and a DC generator.

[3 marks]

28 The figure below shows a Hertzprung–Russell diagram.



a Making use of the diagram and your knowledge, complete the following table.

Star	Region of H–R diagram	Typical nucleosynthesis reactions
Vega		
Sirius B		

b Explain how the H–R diagram can be used to determine the characteristics and evolutionary stage of a star.

[2 + 2 = 4 marks]

29 A thermal neutron causes U-235 to undergo fission. In one such event, the fission fragments are Rb-93 and Cs-141.

particle	${}^{1}_{0}n$	U - 235	Rb - 93	Cs - 141
mass (u)	1.01	235.04	92.92	140.92

$u = 1.660 \times 10^{-27}$

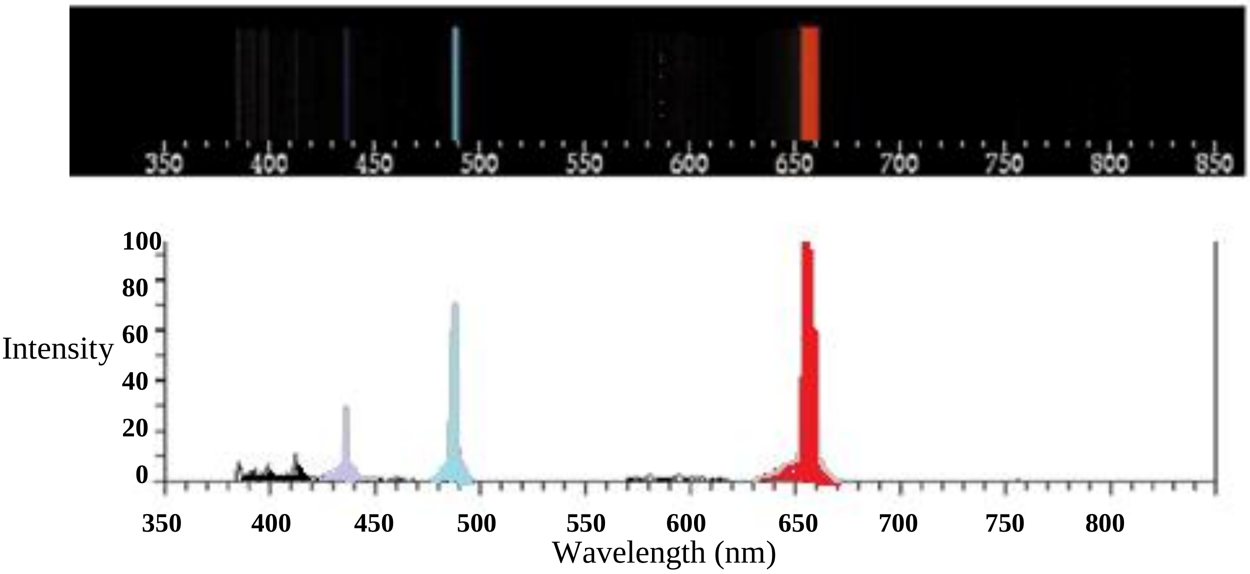
a Calculate the energy released as a result of this reaction. Give your answer in joule, J.

b Cs-141 radiodecays by β^{-} emission with a half-life of 24.85s. If 50 kg of Cs - 141 is released in a cloud of vapour from a nuclear accident, what mass of Cs-141 would remain 10 minutes later?

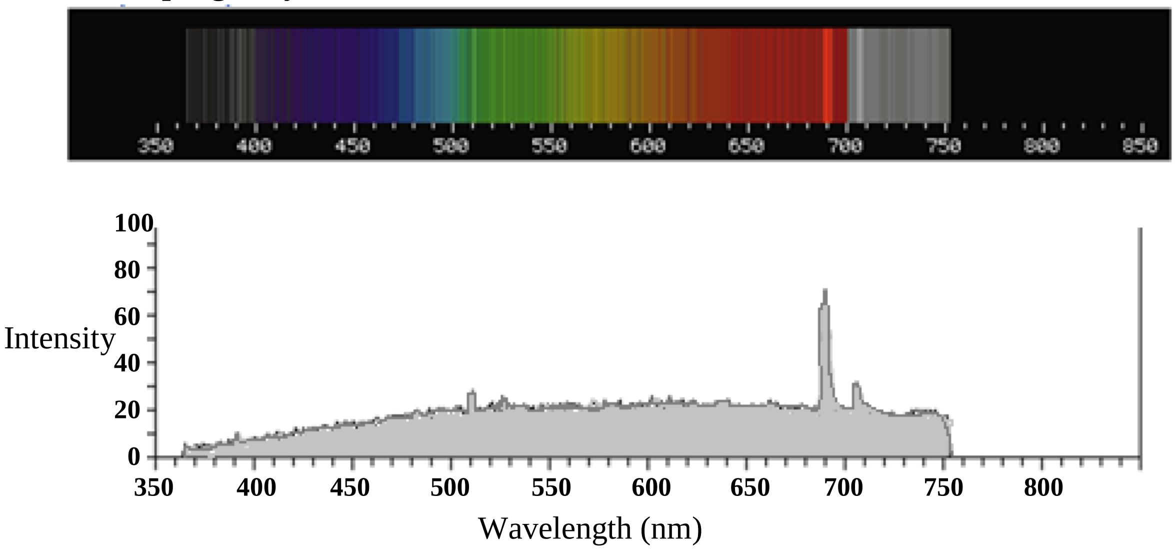
[3 + 3 = 6 marks]

30 The graphs below show data from a hydrogen discharge tube and from a hydrogen-rich galaxy. The frequency of the main line from the hydrogen discharge tube is $f_{lab} = 4.58 \times 10^{14}$ Hz.

Hydrogen gas



Sample galaxy



a Find the frequency of the main hydrogen line from the galaxy.

b Calculate the recession speed of the galaxy.

[2 + 4 = 6 marks]

31 A solid diffraction grating is made of aluminium. It has 6250 lines per cm printed onto its surface. A ray of light of wavelength 800 nm is directed at the grating.

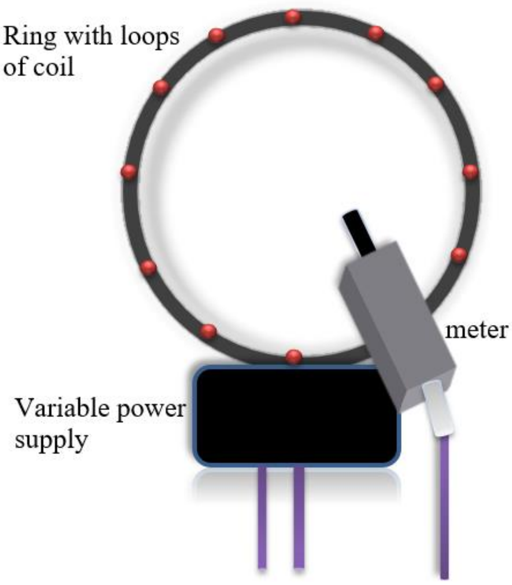
a How many lines are there in the diffraction pattern produced?

b If the source was changed to ultraviolet light, would the number of lines in the pattern increase, decrease or remain the same? Justify your answer.

[2 + 2 = 4 marks]

32 The figure (**Figure A**) below shows a magnetic field meter arranged to measure the magnetic field at the centre of a coil of insulated conducting wire. The coil is supported by a ring that is made of insulated, non-magnetic material. The ring is designed so that different numbers of loops of insulated conducting wire can be coiled around the ring.

The side view (**Figure B**) shows that the support ring comprises two annular wafers held together by pins at a distance, *d* from each other. The ends of the conducting coil are connected to a variable power supply.



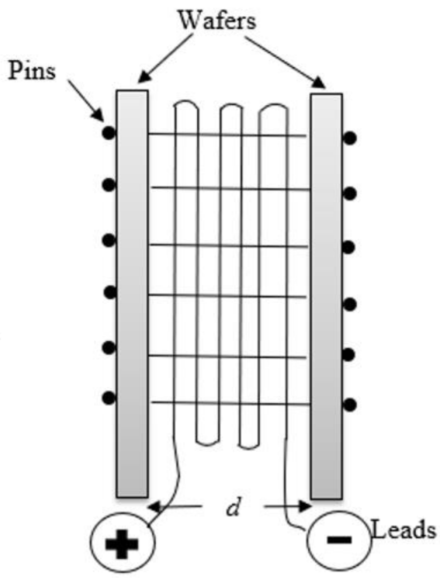


Figure A **Figure B**

The apparatus is used in an attempt to find the variables that affect the magnitude of the coil's magnetic field. The experimenter collected the following data:

No. of turns	Current (A)	Magnetic field (mT)
5	1.0	0.52
10	1.0	1.28
15	1.0	1.80
20	1.0	2.63
25	1	2.92
10	2	2.41
10	3	4.10
10	4	4.91
10	5	6.15
10	6	8.05

Use a graphical method to show, quantitatively, how the magnetic field depends on the current and the number of turns in the coil; hence, find a reasonable estimate of the width, d, between the wafers of the support ring.

[8 marks]

33 Identify the purpose of the Geiger-Marsden experiment and outline, qualitatively, the significant features of the data. Ensure you explain the importance of the experiment for the development of the model of the atom.

[8 marks]

34 The measurement of the speed of light in air and in water around 1850 was important for the acceptance of the wave model of light. In 1905, the explanation of the photoelectric effect in metals was important for the re-introduction of a particle model of light. Discuss with reference to Newton, Huygens and Einstein.

[8 marks]

End of paper

Practice exam answers

Year 12 Physics exam

Section A: Multiple choice (20 marks)

1	C
2	C
3	D
4	D
5	B
6	B
7	A
8	B
9	C
10	A
11	B
12	D
13	C
14	C
15	B
16	A
17	D
18	D
19	B
20	A

Short answer (80 marks)

21 a

$$u_y = u\sin\theta$$

$$\Rightarrow u_y = 65.0\ \text{m s}^{-1} \times \sin 60°$$

$$\Rightarrow u_y = 56.3\ \text{m s}^{-1}$$

$$s_y = ?\quad u_y = 56.3\ \text{m s}^{-1}\quad v_y = 0\quad g = {}^{-}9.8\ \text{m s}^{-2}\quad t = ?$$

$$v_y^2 = 2gs_y + u^2{}_y$$

$$\Rightarrow s_y = \frac{v_y^2 - u^2{}_y}{2g}$$

$$\Rightarrow s_y = \frac{0^2 - (56.3\ \text{m s}^{-1})^2}{2 \times -9.8\ \text{m s}^{-2}}$$

$$\Rightarrow s_y = 162\ \text{m}$$

b

$$s_y = 45.0\text{ m}\quad u_y = 56.3\text{ m s}^{-1}\quad v_y = ?\quad g = -9.8\text{ m s}^{-2}\quad t = ?$$

$$s_y = \frac{1}{2}gt^2 + u_y t$$

$$\frac{1}{2}gt^2 + u_y t - s_y = 0$$

$$\Rightarrow \frac{1}{2}({}^-9.8\text{ m s}^{-2})t^2 + (56.3\text{ m s}^{-1})t + 45.0\text{ m} = 0$$

$$\Rightarrow 4.9t^2 - 56.3t + 45 = 0$$

$$\Rightarrow t = \frac{-(-56.3) \pm \sqrt{(56.3)^2 - 4\times 4.9\times 45}}{2\times 4.9}$$

$$\Rightarrow t = 0.86\text{ s } or\ t = 10.6\text{ s}$$

$$\Rightarrow t = 10.6\text{ s (after maximum height)}$$

c The distance to the cliff:

$$u_x = \frac{s_x}{t}$$

$$s_x = u_x t$$

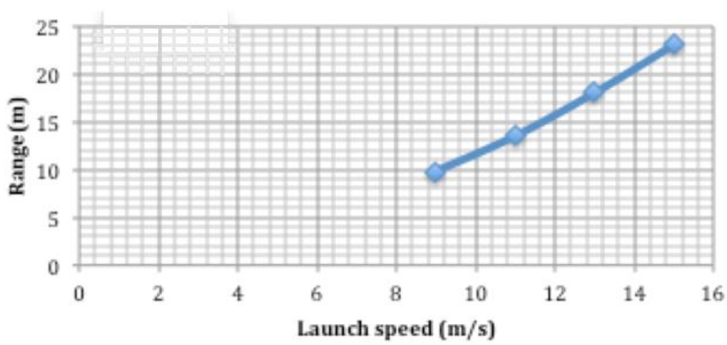
$$s_x = 32.5\text{ m s}^{-1} \times 10.6\ s$$

$$s_x = 340\text{ m}$$

22 a i

speed (m s^{-1})	9.0	11	13	15
range (m)	9.8	13.5	18.0	23.0

ii **Range versus Launch speed for a 7.26 kg shot put**



b For launch angle $\theta = 0°$ and launch speed, $u_L = u_x = 9.0 \text{ m s}^{-1}$ the range is $R = 6.1 \text{ m}$

Time of flight:

$$v_x = \frac{s_x}{t}$$

$$t = \frac{v_x}{s_x}$$

$$t = \frac{6.0\ m}{9.0\ m\ s^{-1}}$$

$$t = 0.67\ s$$

Height from launch to ground, s_y:

$$s_y = \frac{1}{2}gt^2 + u_y t$$

$$s_y = \frac{1}{2} \times -9.8 \text{ m s}^{-2} \times (0.67)^2$$

$$s_y = -2.2 \text{ m}$$

For launch angle $\theta = 0°$, the shot is put with the arm stretched out from the shoulder horizontally at release. Most people are under 2.0 m in height, so the assumed ground to shoulder height is monumentally unreasonable.

23 a

$$\omega = \frac{2\pi}{T}$$

$$\omega = 2\pi f$$

$$\omega = 2\pi \times 0.45\ Hz$$

$$\omega = 2.8 \text{ rad s}^{-1}$$

b

$$\Sigma F = T \sin\theta = m \times 4\pi r f^2$$

$$\sin\theta = \frac{r}{\ell} = \frac{0.80\ m}{1.0\ m} = 0.80$$

$$T \times 0.80 = 2.5 \times 10^{-2} \text{ kg} \times 4\pi \times 0.80 \text{ m} \times (0.45 \text{ s}^{-1})^2$$

$$T = 6.3 \text{ N}$$

24 The radius of the orbit of the Moon $(mass = 7.35 \times 10^{22}\ \text{kg})$ around the Earth $(mass = 5.97 \times 10^{24}\ \text{kg})$ is $3.85 \times 10^{5}\ \text{km}$. The period of the Moon's orbit is 27.3 days.

a

$$g_{\text{by Earth}} = G\frac{M_{\text{E}}}{r^2}$$

$$g_{\text{by Earth}} = 6.67 \times 10^{-11}\ \text{m}^3\ \text{kg}^{-1}\ \text{s}^{-2} \times \frac{6.0 \times 10^{24}\ \text{kg}}{(3.85 \times 10^{8}\ \text{m})^2}$$

$$g_{\text{by Earth}} = 2.7 \times 10^{-3}\ N\ \text{kg}^{-1}$$

b

$$v_{\text{orbit}} = \frac{2\pi r}{T}$$

$$v_{\text{orbit}} = \frac{2\pi \times 3.85 \times 10^{8}\ \text{m}}{27.3\ d \times 24\ h\ d^{-1} \times 3600\ \text{s h}^{-1}}$$

$$v_{\text{orbit}} = 1.03\ \text{km s}^{-1}$$

c

$$v_{\text{esc}} = \sqrt{\frac{GM_{\text{E}}}{r}}$$

$$v_{\text{esc}} = \sqrt{\frac{6.67 \times 10^{-11}\ N\ m^2\ kg^{-2} \times 6.0 \times 10^{24}\ \text{kg}}{3.85 \times 10^{8}\ \text{m}}}$$

$$v_{\text{esc}} = 3.67\ \text{km s}^{-1}$$

25 **a**

$$qV = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2qV}{m}}$$

$$v = \sqrt{\frac{2 \times (2 \times 1.602 \times 10^{-19}\ \text{C}) \times 1.0 \times 10^{3}\ V}{1.06 \times 10^{-22}\text{kg}}}$$

$$v = 2.46 \times 10^{3}\ \text{m s}^{-1}$$

b

$$F = qvB\sin\theta = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB};\ \sin 90° = 1$$

$$r = \frac{1.06\times10^{-22}\ \text{kg}\times4.26\times10^{3}\ \text{m s}^{-1}}{2\times1.602\times10^{-19}\ C\times0.95\ \text{T}}$$

$$r = 0.86\ \text{m}$$

c $r \mu \frac{1}{q}$ because the ionic masses are almost identical. Singly charged Cu^{1+} ions will have a greater radius and triply charged Cu^{3+} ions a lesser radius of curvature than the doubly charged Cu^{2+} ions.

26 **a**

$$\phi = BA$$

$$\phi = 0.60\ \text{T}\times(0.050\ \text{m})^2$$

$$\phi = 1.5\ \text{mWb}$$

b

$$W = Pt$$

$$W = 2.3\times10^{-3}\ \text{J}\times0.10\ \text{s}$$

$$W = 2.3\times10^{-4}\ \text{W}$$

$$W = Fd$$

$$F = \frac{W}{d}$$

$$F = \frac{2.3\times10^{-4}\ \text{W}}{0.050\ \text{m}}$$

$$F = 4.5\times10^{-3}\ \text{N}$$

27

- In electric motors, work is done on charge by the electrical field in a circuit in order to produce a torque in a conducting loop in a magnetic field. (1)
- Generators transform energy from an external source to produce energy of movement, which is used to cause flux change in a magnetic field. (1)
- The flux change generates an electric potential difference that enables an electric field to do work on charge and drive a current. (1)

28 a

Star	Regionof H–R diagram	Typical nucleosynthesis reactions
Vega	main sequence	fusion of hydrogen to helium
Sirius B	white dwarfs	none

b

- Temperature:
  - Horizontal axis – surface temperature (Wien's law); hence, spectral classification (read axis from right to left for increasing temperature) and luminosity
- Luminosity-mass:
  - On the main sequence, there is a linear log-log relationship between luminosity and mass.
- Nuclear reactions:
  - Main sequence – fusion of light elements from hydrogen
  - Red giants – fusion to carbon from helium; super red giants produce elements up to Fe.
  - White dwarfs – no fusion.
- Star evolution:
  - Starting on the main sequence, evolution depends on mass – up to 8 × M_{Sun}, red giant to white dwarf; < 8 × M_{Sun}, super red giants to neutron star or black hole.

1 mark each for any two different characteristics.

[2 + 2 = 4 marks]

29 a

mass defect:

$$\Delta m = m_i - m_f$$

$$\Delta m = (1.01\,u + 235.05) - (92.92\,u + 140.92\,u + 2\times 1.01u)$$

$$\Delta m = 0.20\,u$$

$$\Delta m = 0.20\,u \times 1.660\times 10^{-27}\ \text{kg}$$

$$\Delta m = 3.32\times 10^{-28}\ \text{kg}$$

Einstein's energy equation:

$$\Delta E = \Delta mc^2$$

$$\Delta E = 3.32\times 10^{-28}\ \text{kg}\times (3.0\times 10^{8}\ \text{m s}^{-1})^2$$

$$\Delta E = 3.00\times 10^{-9}\ \text{J}$$

b

$$N_t = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{1/2}}$$

$$N_t = N_0 e^{-(\ln 2 \times \frac{t}{t_{1/2}})}$$

$$N \propto m$$

$$m_t = m_0 e^{-(\ln 2 \times \frac{t}{t_{1/2}})}$$

$$m_t = 50\ \text{kg} \times e^{-(\ln 2 \times \frac{600\ s}{24.84\ s})}$$

$$m_t = 2.7\ \mu g$$

30 a

$$f_{\text{galaxy}} = \frac{3.00 \times 10^8\ \text{m s}^{-1}}{685 \times 10^{-9}\ \text{m}}$$

$$f_{\text{galaxy}} = 4.38 \times 10^{14}\ \text{s}^{-1}$$

b

Doppler for a stationary observer and a galaxy moving away:

$$f_{\text{galaxy}} = f_{\text{lab}} \left(\frac{c}{c + v_{\text{galaxy}}}\right)$$

$$\frac{c}{c + v_{\text{galaxy}}} = \frac{f_{\text{galaxy}}}{f_{\text{lab}}}$$

$$\frac{c}{c + v_{\text{galaxy}}} = \frac{4.38 \times 10^{14}\ \text{Hz}}{4.58 \times 10^{14}\ \text{Hz}}$$

$$\frac{c}{c + v_{\text{galaxy}}} = 0.956$$

$$c = 0.956 \times (c + v_{\text{galaxy}})$$

$$v_{\text{galaxy}} = \frac{c \times (1 - 0.956)}{0.956}$$

$$v_{\text{galaxy}} = \frac{3.00 \times 10^8\ \text{m s}^{-1} \times (1 - 0.956)}{0.956}$$

$$v_{\text{galaxy}} = 1.4 \times 10^7\ \text{m s}^{-1}$$

31 a

$$d \sin\theta = m\lambda$$

$$\textit{for } \sin\theta = 1 \; (\theta = 90°)$$

$$m = \frac{d}{\lambda}$$

$$d = \frac{1\,\text{cm}}{6250\ \text{lines}}$$

$$d = 1.6 \times 10^{-6}\ \text{m}$$

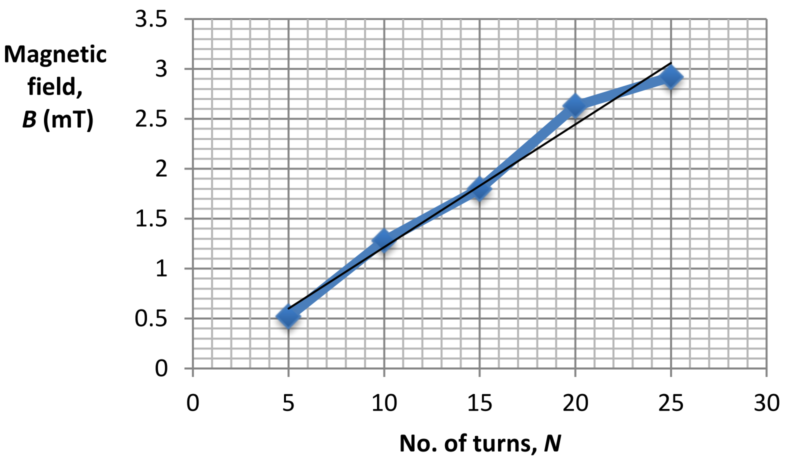
$$m = \frac{1.6 \times 10^{-6}\ \text{m}}{800\ \text{nm}}$$

$$m = 2$$

b Ultraviolet light has shorter wavelengths; hence '*m*' will increase ($m\,\mu\,\frac{1}{l}$).

32

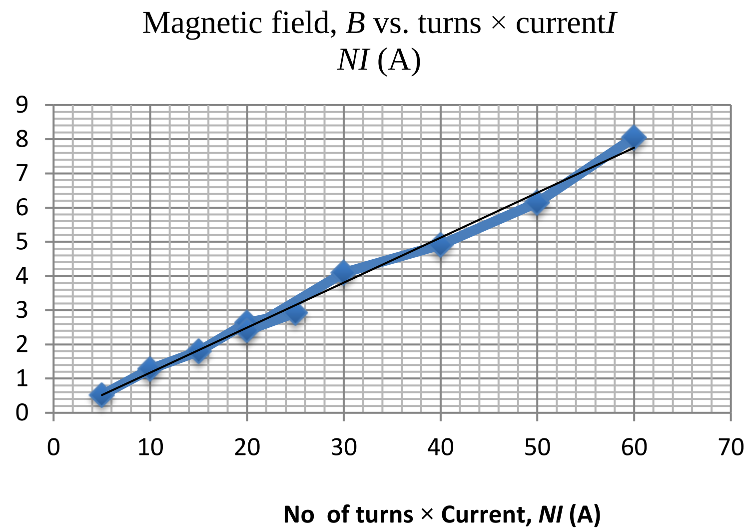
Solenoid: Magnetic field, *B* vs No. of turns, *N*
(Current, *I* = 1.0 A)



$$\text{gradient, } m = \frac{3.1\,\text{mT} - 0.6\,\text{mT}}{25 - 5}$$

$$m = 0.125\ \text{mT turn}^{-1}$$

$$\text{equation}: B = 0.125\text{N}$$



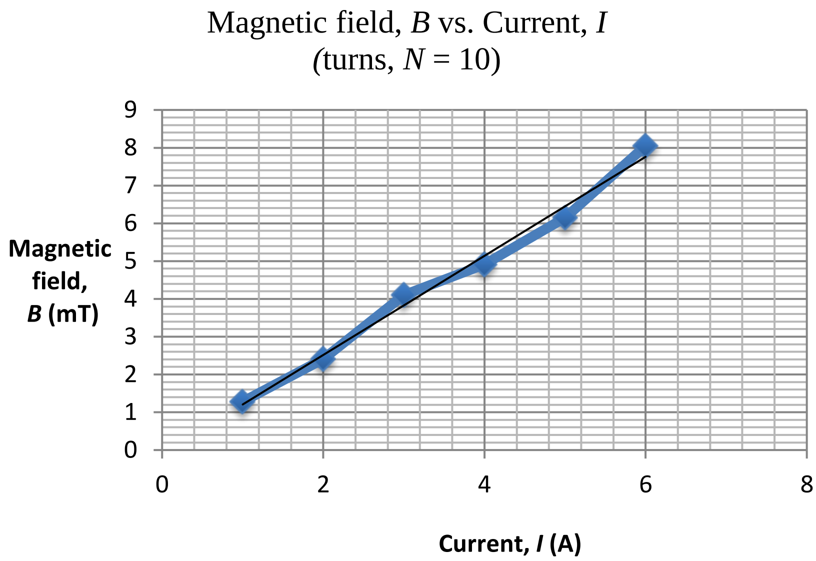
$$\text{gradient, } m = \frac{7.8\text{ mT} - 1.2\text{ mT}}{6\text{ A} - 1\text{ A}}$$

$$m = 1.32\text{ mT A}^{-1}$$

$$B = 1.32I$$

Alternatively, produce a new data table.

No. of turns	Current (A)	Magnetic field (mT)	NI (A)
5	1.0	0.52	5
10	1.0	1.28	10
15	1.0	1.80	15
20	1.0	2.63	20
25	1	2.92	25
10	2	2.41	20
10	3	4.10	30
10	4	4.91	40
10	5	6.15	50
10	6	8.05	60



$$\text{gradient, } m = \frac{7.8\ mT - 1.2\ \text{mT}}{60\ A - 10\ \text{A}}$$

$$m = 0.132\ \text{mT A}^{-1}$$

$$\text{equation} : B = 0.132 NI$$

Graphs (4) Gradient (2) Equation (2)

[8 marks]

33

- Purpose: to test the hypothesis that alpha particles will travel straight through an atom based on Thomson's 'plum pudding' model. (2)
- Data: There were significantly more numbers of forward and back scattered alpha particles than expected. (2)
- Explanation: The deflections, especially the 1800 back-scattered alpha particles could be explained by positing a small, positive nucleus with relatively large spaces between, around which electrons could be supposed to move. (2)
- Challenge: the immediate challenge to this 'solar system' model was that the model violated Maxwell's electromagnetic equations, which required energy to be radiated away from a circulating, hence accelerating, electrons so that the model would collapse almost instantly. (1)
- Bohr model: The Bohr quantised atom arose from this debate and subsequent interrogation and explanation of spectroscopic data. (1)

[8 marks]

34

- Newton: light refraction towards normal meant corpuscles gained speed (particle model). (1)
- Huygens: light refraction towards normal meant waves gained speed (wave model) (1)
- 1850: Light, which refracts towards the normal when it travels from water to air, was shown to slow down in water compared to air. (1)
- Huygens' wave model supersedes Newton's particle model. (1)
- 1905: Photoelectric effect, where electrons are emitted from metal surfaces, showed some results that were not consistent with waves; that is, waves carry their energy in the amplitude so larger amplitude waves should cause the effect but for particular waves up to a threshold frequency, no matter the intensity, no effect occurred. (1)
- However, if the effect occurred with particular waves beyond the threshold, the intensity could be extremely low and the effect would still occur. (1)
- Einstein explained the effect by proposing that light comprised particles that carried their energy in an associated wave: $E = hf$. (1)
- This satisfactorily explained the data for all metals, which showed that $E = hf = hf_0$. For light of energy less than $E = hf_0$ there was insufficient energy to provoke the photoelectric effect. (1)

[8 marks]