2020

HIGHER SCHOOL CERTIFICATE **EXAMINATION**

Physics – HSC Prep I

General Instructions

- Reading time – 5 minutes
- Working time – 2 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper

Total marks: 80

Section I – 15 marks

- Attempt Questions 1–15
- Allow about 25 minutes for this part

Section II – 65 marks

- Attempt Questions 16-27
- Allow about 1 hour 35 minutes for this section

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word correct and drawing an arrow as follows.

Start Here →

1.	A ○	B ○	C ○	D ○		**11.**	A ○	B ○	C ○	D ○
2.	A ○	B ○	C ○	D ○		**12.**	A ○	B ○	C ○	D ○
3.	A ○	B ○	C ○	D ○		**13.**	A ○	B ○	C ○	D ○
4.	A ○	B ○	C ○	D ○		**14.**	A ○	B ○	C ○	D ○
5.	A ○	B ○	C ○	D ○		**15.**	A ○	B ○	C ○	D ○
6.	A ○	B ○	C ○	D ○						
7.	A ○	B ○	C ○	D ○						
8.	A ○	B ○	C ○	D ○						
9.	A ○	B ○	C ○	D ○						
10.	A ○	B ○	C ○	D ○						

Section I

15 marks
Attempt Questions 1-15
Allow about 25 minutes for this part

Use the multiple-choice answer sheet for Questions 1-15

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1. A student throws a ball vertically downwards from the roof of a building at 7.5 ms^{-1}. The ball strikes the ground 3.5s later, what is the height of the building?

(A) 34 m
(B) 42 m
(C) 60 m
(D) 86 m

2. What is the speed of a 1000kg satellite in a Low Earth Orbit of 500km in altitude above the Earth's surface?

(A) $7.92x10^{3}\ ms^{-1}$
(B) $7.63x10^{3}\ ms^{-1}$
(C) $9.85x10^{-8}\ ms^{-1}$
(D) $1.02x10^{-7}\ ms^{-1}$

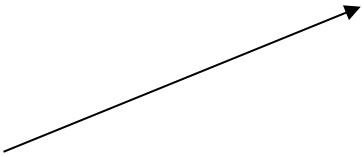
3. A space probe orbits the planet Saturn with a period of 12 hours at an orbital radius of 121,511km. The mass of Saturn is:

(A) $5.7x10^{17}\ kg$
(B) $1.8x10^{15}\ kg$
(C) $1.8x10^{24}\ kg$
(D) $5.7x10^{26}\ kg$

4. Which of the following arrows correctly indicates the direction of force acting a ball after it is projected at an angle of 30° to the horizontal from the top of a high cliff?

(A)

(B) 

(C) 

(D) 

5. Two planets, Jialoumma and Geyise, have equal diameters, but planet Jialoumma has twice the density of Geyise. The acceleration due to gravity on the surface of Jialoumma is $30 ms^{-2}$.
What is the value of acceleration due to gravity on Geyise?

(A) $15\ ms^{-2}$

(B) $7.5\ ms^{-2}$

(C) $60\ ms^{-2}$

(D) $120\ ms^{-2}$

6. A transformer is 85% efficient and has a primary coil with 2000turns and a secondary coil with 200 turns. If the primary input power of the transformer is 100W and the secondary current is 10A, what is the secondary voltage closest to?

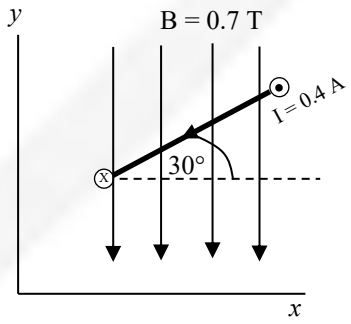
(A) 7.3 V

(B) 8.5 V

(C) 10.0 V

(D) 11.8 V

7. A single, circular loop of wire of radius R = 0.24m carries a current of I = 0.4A, and is oriented as shown in the diagram. A constant magnetic field points along the negative y-direction, having a magnitude B = 0.7 T.
What is the magnitude of the torque acting on the loop?



(A) 0.025 Nm

(B) 0.044 Nm

(C) 0.21 Nm

(D) 0.37 Nm

8. What is the role of a laminated soft iron core in transformers?

(A) To maximise the flux leakage between the primary and the secondary coil

(B) To reduce the resistance of the soft iron core

(C) To reduce the size of the eddy currents within the transformer core

(D) Both (A) and (C)

9. A proton is moving around a ring inside a synchrotron. The proton follows a circular path length of 1.2km and has a velocity of 2×10^8 ms^{-1}.

The magnitude of the magnetic field required to keep the proton in this circular path is closest to:

(A) 0.00174 T

(B) 0.00234 T

(C) 0.0109 T

(D) 0.0147 T

10. The maximum speed of a stationary electron accelerated through a potential difference of 1000V is closest to:

(A) 1.6×10^{-16} m s^{-1}

(B) 9.4×10^6 m s^{-1}

(C) 1.3×10^7 m s^{-1}

(D) 1.8×10^7 m s^{-1}

11. A 2W laser emits light of wavelength 600nm, the number of photons emitted from the laser per minute will be closest to:

(A) 2.5×10^{12}

(B) 6×10^{18}

(C) 3.6×10^{20}

(D) 8.2×10^{24}

12. Spectroscopy is used in many different ways to analyse various characteristics of stars. When we use spectroscopy to analyse light from the Sun, which type of spectrum do we see?

(A) Continuous black body spectrum

(B) Emission spectra

(C) Absorption spectra

(D) Broad spectra

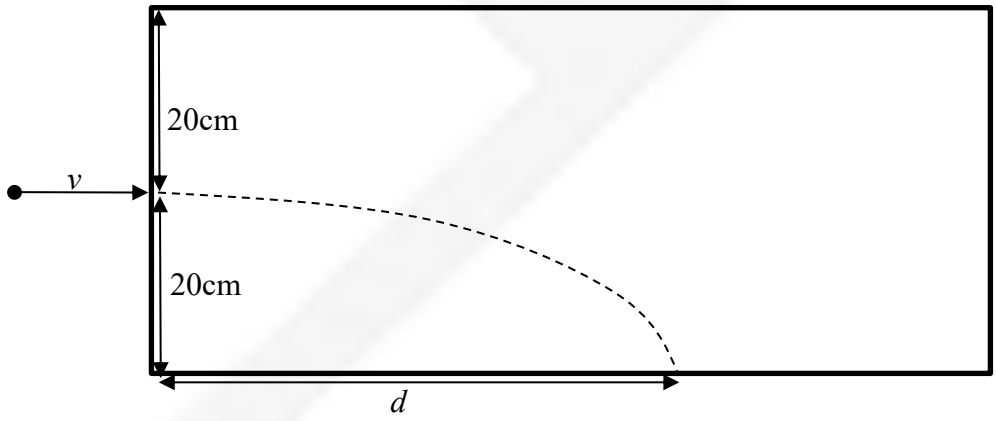
13. Which of the following is the highest possible energy of a photon emitted when an electron undergoes a transition in the Balmer series of Hydrogen?

(A) 3.03eV
(B) 3.40eV
(C) 10.2eV
(D) 13.6eV

14. Which experiment showed that neutrons are not fundamental particles?

(A) Neutron diffraction
(B) Deep Inelastic Scattering
(C) Alpha particles incident on Be foil
(D) Compact muon solenoid and toroidal LHC apparatus experiment

15. The diagram below shows the trajectory of a particle with a charge q and a mass m when fired horizontally into a vacuum chamber at a speed v, where it falls under the influence of gravity.



An electric field is then applied and the experiment is repeated with the same particle fired in from the same position at a speed of $2v$ and striking the upper surface of the chamber at a distance of $\frac{3d}{2}$.

What is the magnitude of the force due to the electric field?

(A) $\frac{2mg}{3}$

(B) $\frac{4mg}{3}$

(C) $\frac{16mg}{9}$

(D) $\frac{25mg}{9}$

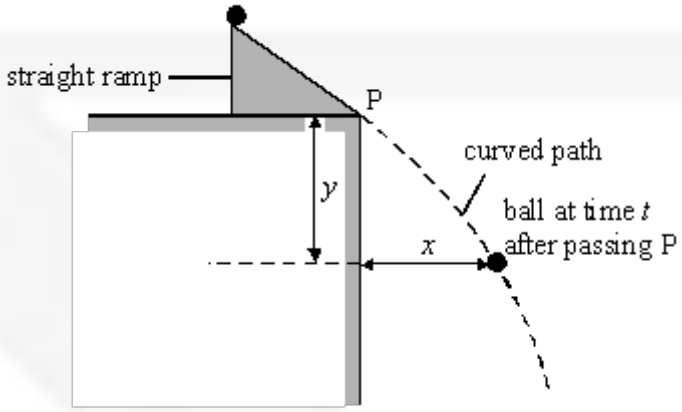
Question 16 (4 marks)

Choose **ONE** of the following pieces of evidence and explain how the results from the experiment validate Einstein's predictions.

- Atomic clocks (Hafele-Keating experiment)
- Observations of cosmic-origin muons at the Earth's surface

Question 17 (5 marks)

While investigating projectile motion, a student used stroboscopic photography to determine the position of a steel ball at regular intervals as it fell under gravity. With the stroboscope flashing 20 times per second, the ball was released from rest at the top of an inclined track, and left the foot of the track at P, as shown in the diagram below.



For each of the images on the photograph, the student calculated the horizontal distance, x, and the vertical distance, y, covered by the ball at time t after passing P. Both distances were measured from point P. He recorded his results for the distances x and y in the table.

image	x/cm	y/cm	t/s	(y/t)/cm s^{-1}
1	11.6	9.3	0.05	
2	22.0	21.0	0.10	
3	32.4	35.0	0.15	
4	44.2	51.8	0.20	
5	54.8	71.0	0.25	
6	66.0	92.2	0.30	

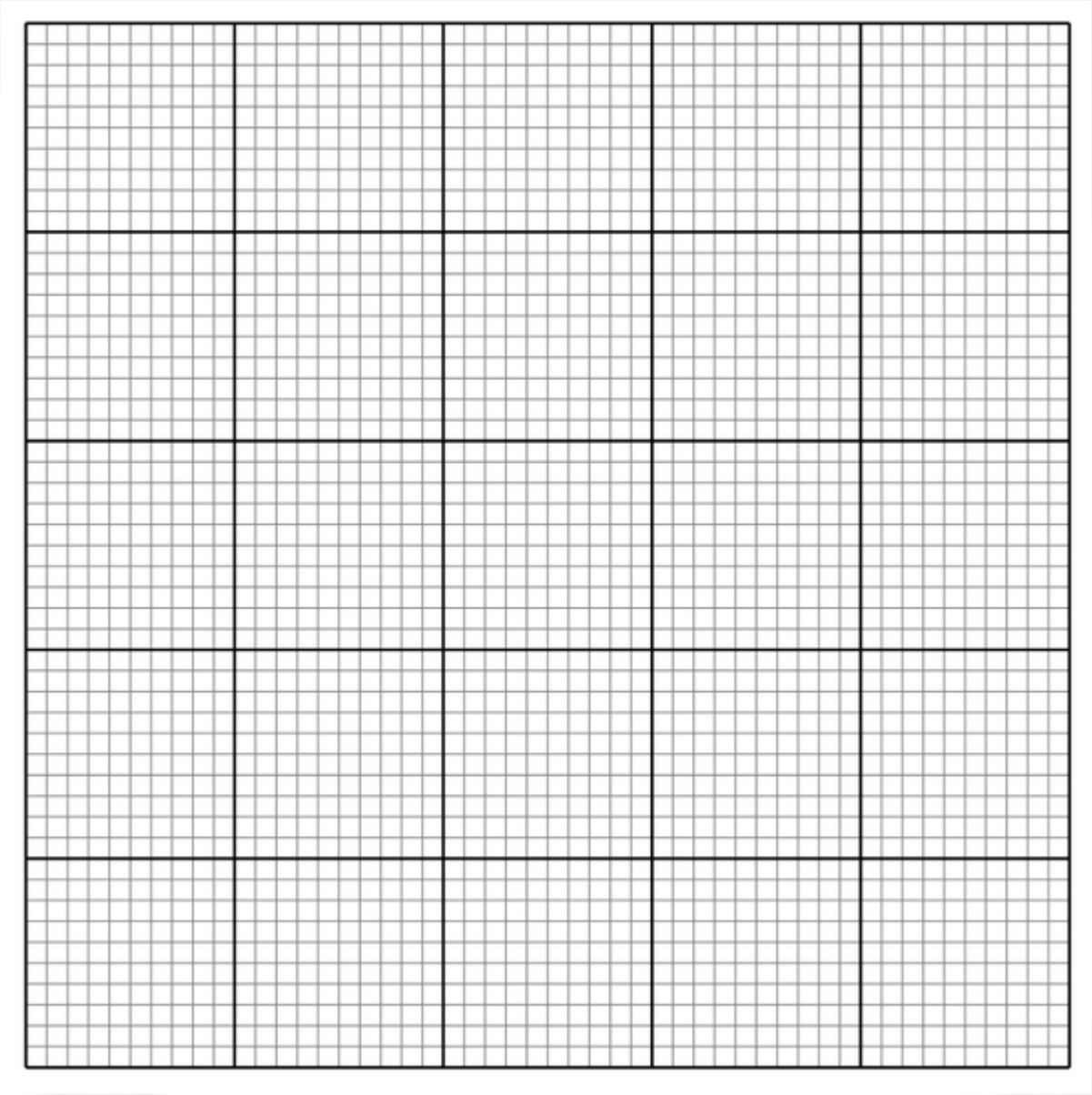
(a) The student worked out that the variables y and t in the experiment could be represented by

$$\frac{y}{t} = u + kt$$

where u and k are constants.

(i) Complete the table on the previous page. **1**

(ii) Use the data in the table to plot a suitable linear relationship to confirm the equation. **2**



(iii) Use your graph to find the values of u and k. **2**

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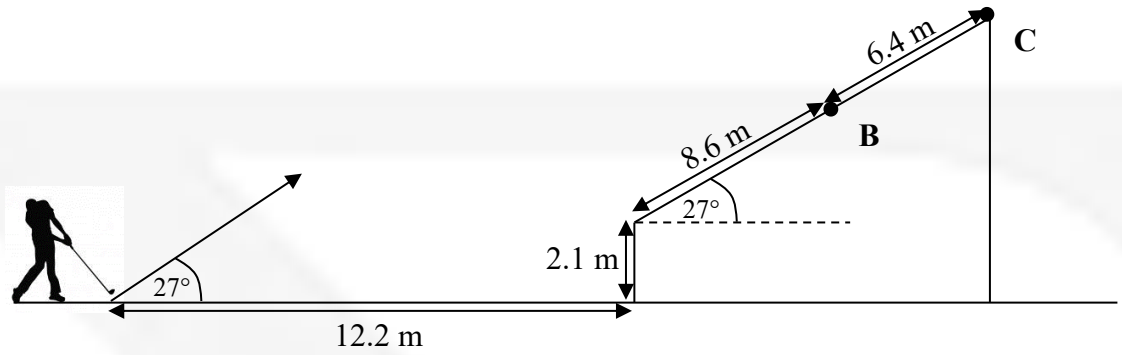
Question 18 (6 marks)

A golf-ball is chipped onto a hill with a velocity v_0.



(a) Find the value of v_0 if it reaches the point on the hill marked with B. **3**

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(b) If the ball is chipped at the same speed, find the angle(s) at which the ball can strike point C. **3**

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Question 19 (6 marks)

A satellite of mass 1250kg is placed in a low Earth orbit of 350km altitude.

(a) Find the required orbital velocity at this altitude. **1**

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(b) State a possible use of a low earth orbit satellite. **1**

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(c) This satellite is then manoeuvred to a medium earth orbit of period 12 hours. Find the work required to be done on the satellite to allow this manoeuvre. **4**

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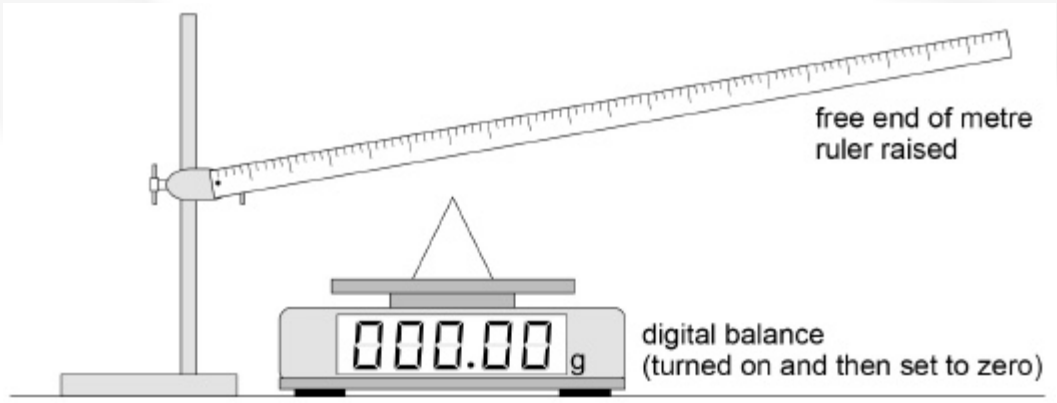
Question 20 (6 marks)

This question is about using a digital balance to investigate the force on a wire placed in a magnetic field when there is an electric current in the wire.

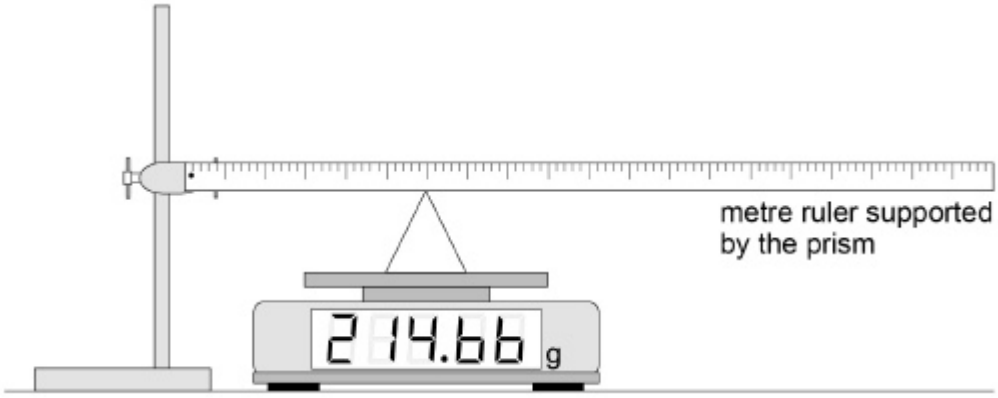
A student carries out the procedure shown in **Figure 1** and **Figure 2**.
A metre ruler is pivoted at the 1.0 cm mark and a prism is placed on a digital balance. The free end of the ruler is raised and the balance is turned on and then set to zero, as shown in **Figure 1**.

Figure 1



The ruler is then supported by the prism with the apex of the prism at the 30.0 cm mark as shown in **Figure 2**. The height of the pivot is adjusted so that the ruler is horizontal.

Figure 2



(a) Using the concept of applied torque, deduce the mass of the ruler. **2**
State **one** assumption you make.

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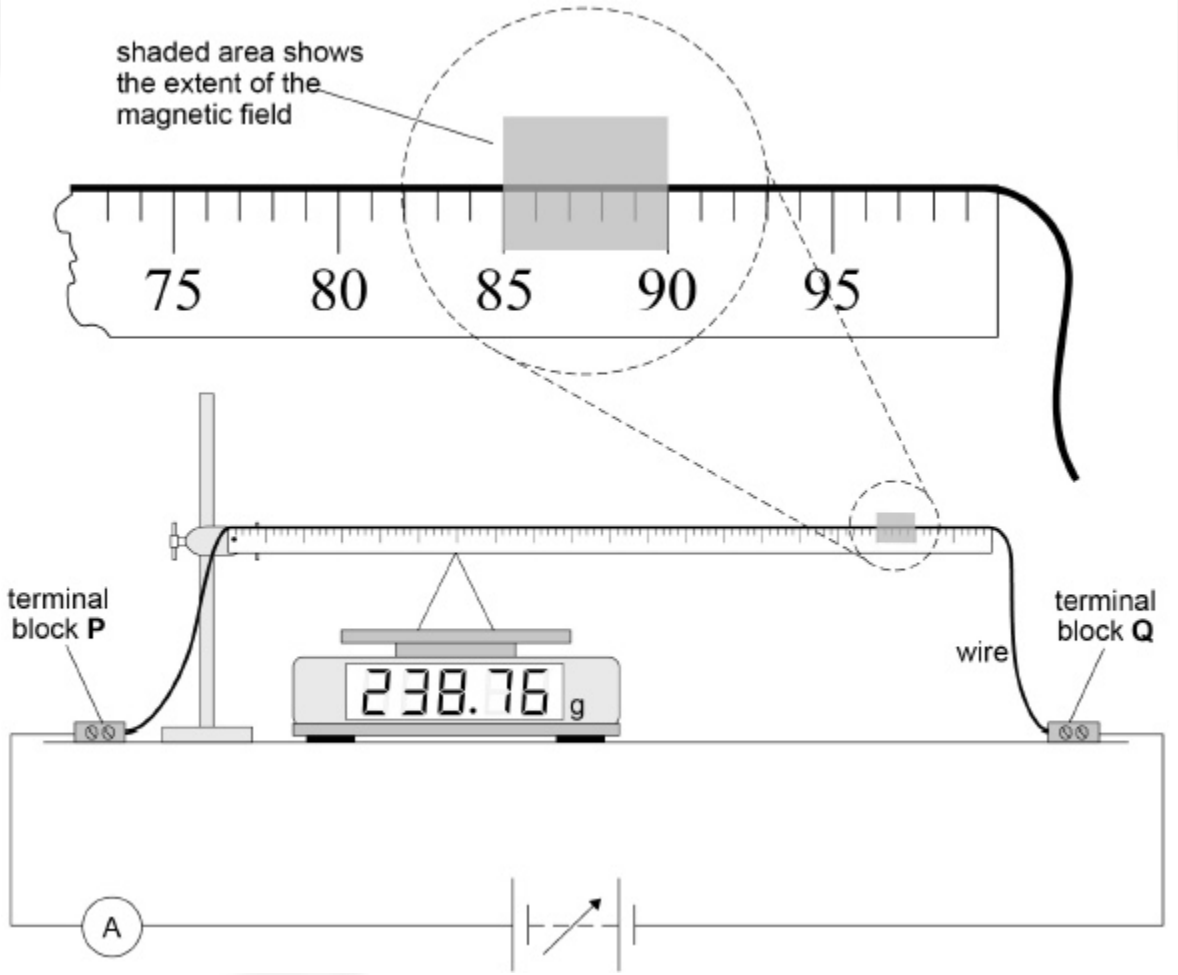
(b) The student attaches a uniform wire to the upper edge of the ruler, as shown in **Figure 3**.

The ends of the wire are connected to terminal blocks **P** and **Q** which are fixed firmly to the bench. A power supply and an ammeter are connected between **P** and **Q**.

These modifications cause the balance reading to increase slightly.

A horizontal uniform magnetic field is applied, perpendicular to the wire, between the 85 cm and 90 cm marks, as shown in the close-up diagram in **Figure 3**.

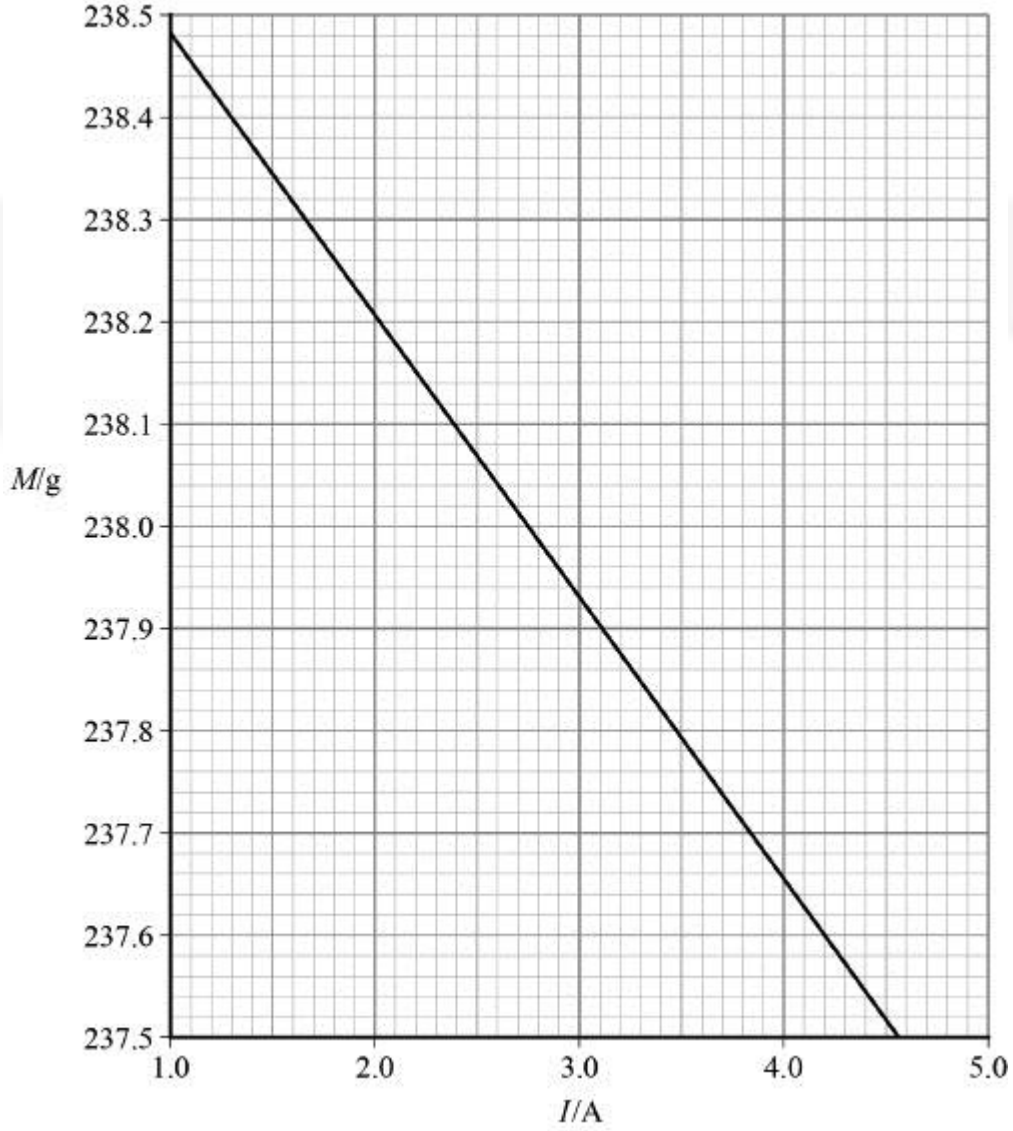
Figure 3



The balance reading M is recorded for increasing values of current I.
A graph of these data is shown in **Figure 4 on the <u>next page</u>**.

Question 20 (cont…)

Figure 4



(b) State the direction of the horizontal uniform magnetic field, justify your answer. **2**

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(c) It can be shown that B, the magnitude of the magnetic flux density of the horizontal uniform magnetic field, is given by

$$B = \frac{\sigma}{3L}$$

where

σ = change in force acting on the prism per unit current in the wire
L = length of the region where the magnetic field cuts through the wire.

Determine B. **2**

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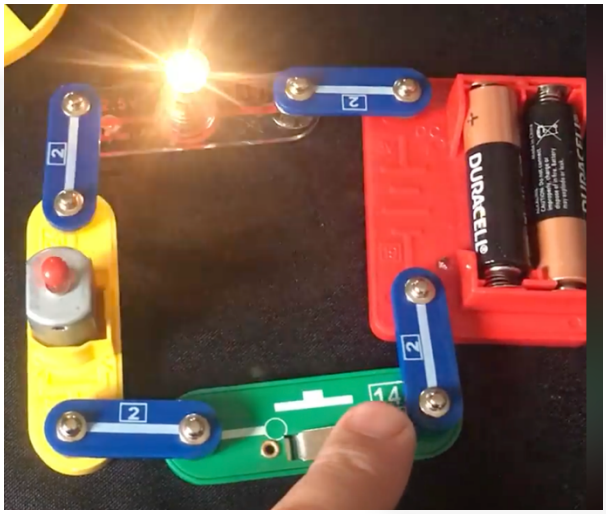
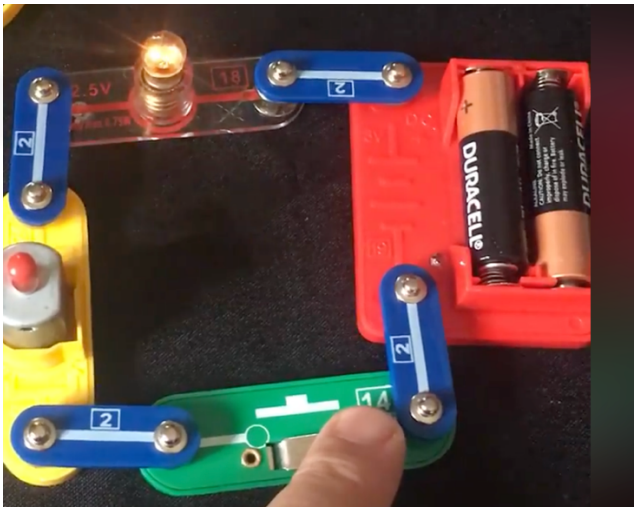
Question 21 (5 marks)

The 3 photos below show a small DC motor (the grey/silver box with red knob on the left hand side) operating off 2 x 1.5V batteries. A small light is placed in series with the DC motor.



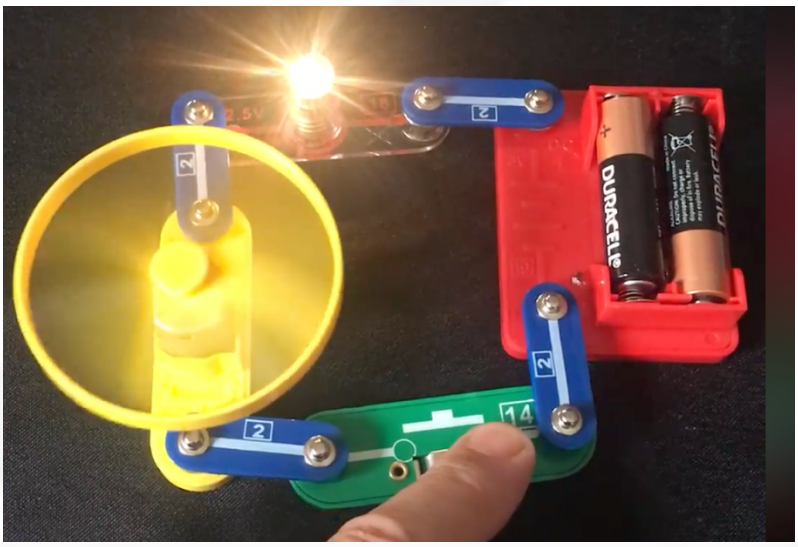
Picture 1

Photo of the circuit immediately after the circuit is turned on.



Picture 2

Photo of the circuit 2 seconds after the circuit is turned on.



Picture 3

Photo of the circuit 2 seconds after the circuit is turned on after a small fan is added to the motor.

(a) Identify the energy conversion taking place in the motor. **1**

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(b) Explain the differences in the brightness of the bulbs in the three photos. **4**

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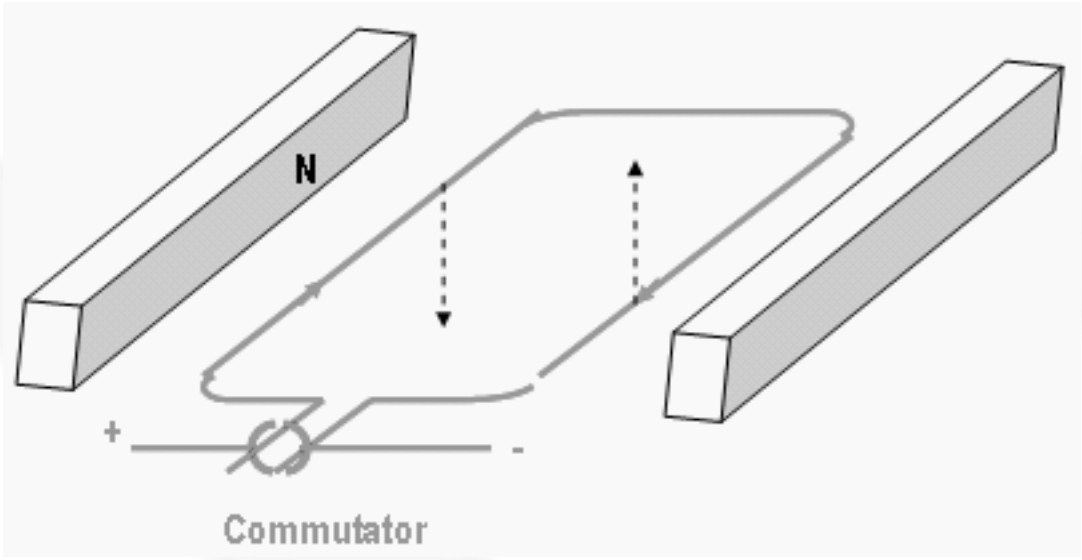
Question 22 (5 marks)

A simple DC motor is placed parallel to the magnetic field lines as shown below.



The motor rotates with a constant angular velocity of $\pi\ rads^{-1}$.

(a) Sketch a graph of the torque due to the supply current acting on the motor as it rotates through TWO FULL revolutions. Include appropriate labels and scales on your axes **3**

(b) Account for 2 features of your graph. **2**

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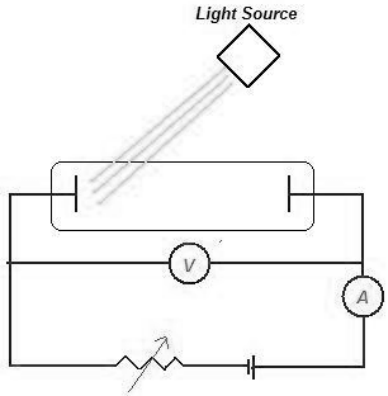
Question 23 (6 marks)

White light of equal intensity at all visible wavelengths is incident on sodium metal, which has a work function of 2.36eV. This is set up as in the diagram below:



(a) If a potential difference of 5V is applied between the electrodes, determine the range of speeds at which electrons strike the anode. **3**

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(b) If the distance between the two electrodes is 15cm, determine the wavelength of incoming light which liberates an electron that takes 200ns to move between the electrodes. **3**

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Question 24 (6 marks)

The decay of a radioactive substance can be represented by the equation

$$A = A_0 e^{-\lambda t}$$

where A = the activity of the sample at time t
A_0 = the initial activity at time $t = 0$
λ = the decay constant

The half life, $T_{½}$ of the radioactive substance is given by

$$T_{½} = \frac{ln(2)}{\lambda}$$

An experiment was performed to determine the half-life of a radioactive substance which was a beta emitter. The radioactive source was placed close to a detector. The total count for exactly 5 minutes was recorded. This was repeated at 20 minute intervals. The results are shown in the table below.

time, t / minutes	**total count, C, recorded in 5 minutes**	**count rate, R / counts minute^{-1}**	**corrected count rate, R_C / counts minute^{-1}**	**ln (R_C / minute^{-1})**
0	1016	203	183	5.21
20	892	178	158	5.06
40	774	155	135	4.90
60	665	133	113	4.73
80	608	122	102	4.62
100	546	109	89	4.49

(a) A correction has been made to the count rate, R, to give the corrected count rate, R_C. Explain why this correction has been made and deduce its value from the table. **2**

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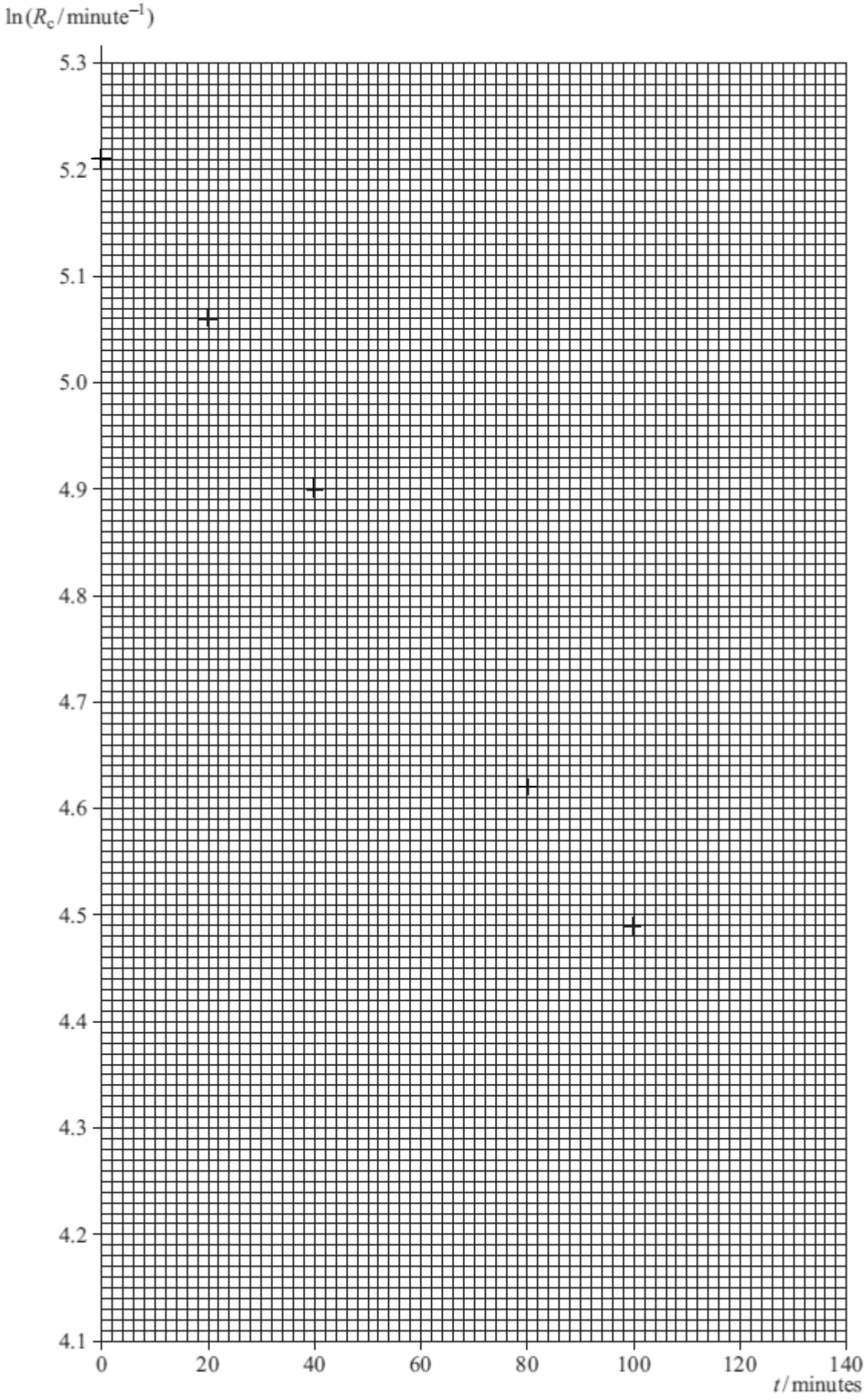

(b) Draw an appropriate straight line through the plotted points. **1**

Question 24 continues on the next page

Question 24 (*cont…)*

(c) Determine the gradient *G* of your graph. **2**

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(d) Use your graph to determine the half-life in minutes of the radioactive substance used in this experiment. **1**

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Question 25 (3 marks)

Nickel-62 has an observed mass of 61.9283449u.

Find the binding energy per nucleon of the Ni-62 isotope.

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Question 26 (5 marks)

The model of the atom has been changed significantly since Dalton proposed the 'Billiard Ball' model of the atom in 1803.

With reference to Rutherford, Bohr and de Broglie, explain how specific experimental observations led to the refinement of the atomic model.

Question 27 (8 marks)

Analyse how our understanding of the nature of light has changed over time.

SCIENCE DUCATION

HSC PHYSICS. SUMMED UP.