EXAM NUMBER

Shore School

Year 12

Physics

Practical Skills Test

Term 2 2021

General Instructions

- Working time – 90 minutes
- Read the theory section carefully before attempting the questions.
- All work should be done in the spaces provided. The back of pages may be used if required.
- Values should be measured and calculated to 1 decimal place or 2 significant figures.
- Values > 1000 and values < 0.01 should be quoted in scientific notation.

Total marks – 45

- Attempt all questions
- After completing all questions, any time remaining should be spent revising your answers.

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

BLANK

PAGE

1. Charge in B Field to determine Mass

(a) A proton is accelerated from rest in a vacuum through a potential difference of 1.2×10^4 V. Show that the final speed of the proton is 1.5×10^6 m s^{-1}. **[2]**

____

____

____

____

____

____

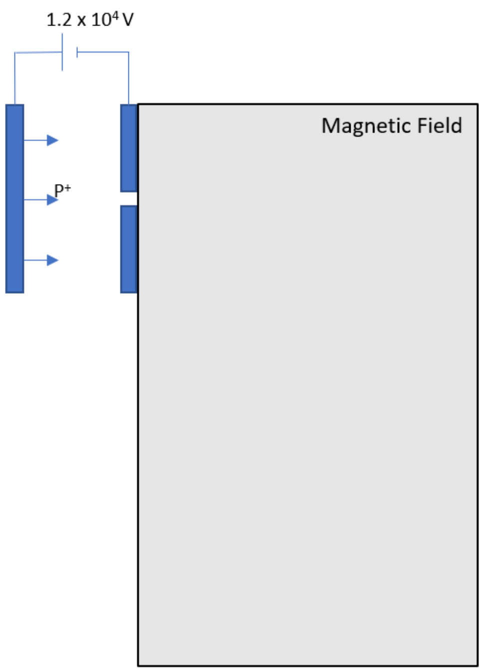
(b) The accelerated proton now enters a region of uniform magnetic field acting out of the plane of the paper, as illustrated below. Describe the path of the proton as it passes through the region of the magnetic field. **[2]**

____

____

____

____



Question 1 continues next page…

(c) Explain the effect on the magnitude of the deflection of the proton in the magnetic field if;

i. the potential difference accelerating the proton is reduced. **[1]**

____

____

____

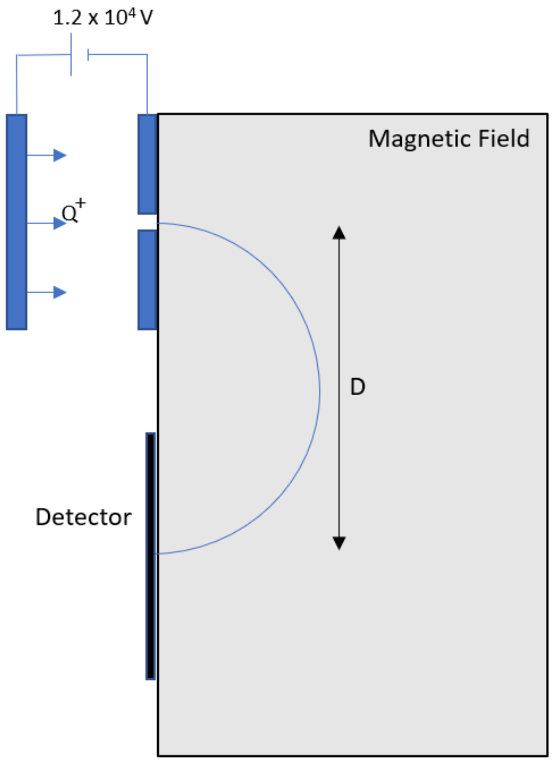
ii. the magnetic field strength is increased. **[1]**

____

____

____

The proton is now replaced with a particle of positive charge, 3.2×10^{-19} C, as shown in the diagram below.



Question 1 continues next page…

(d) An investigation is conducted to determine the mass of the positive particle. A positive particle is accelerated from rest in a vacuum through the potential difference of 1.2×10^4 V. The final speed of the positive particle is 1.1×10^6 m s^{-1}.

i) Show the relationship between magnetic field strength, B, and radius, r, is given by:

$$B = \frac{mv}{q} x \frac{1}{r}$$

[2]

___

___

___

___

___

ii) In the investigation, magnetic field strength, *B*, was varied and the diameter, *D*, was measured. Data collected can be found in the table below. Complete the third column for $\frac{1}{r}$. **[2]**

Magnetic Field Strength (T)	**Diameter (m)**	
0.1	0.456	
0.2	0.221	
0.3	0.152	
0.4	0.110	
0.5	0.091	
0.6	0.073	

Question 1 continues next page…

iii) Graph these results on the grid provided below. Using a graphical method, determine the mass of the positive particle. Show full working. **[4]**

iv) Use a graphical method to determine the mass of the positive particle. Show full working. **[3]**

2. Geostationary Orbits and Gravitational Potential Energy

The Earth may be considered to be a sphere of radius 6.4×10^6 m with its mass of 6.0×10^{24} kg concentrated at its centre.

A satellite of mass 650 kg is to be launched from the Equator and put into geostationary orbit with a period of 24 hours.

a. Show that the radius of the geostationary orbit is 4.2×10^7 m. **[2]**

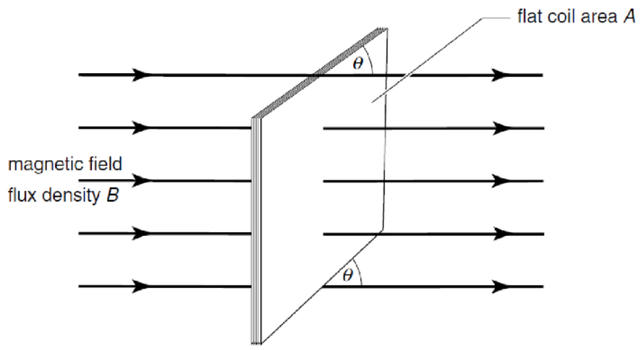
b. Determine the increase in gravitational potential energy of the satellite during its launch from the Earth's surface to the geostationary orbit. **[3]**

BLANK PAGE

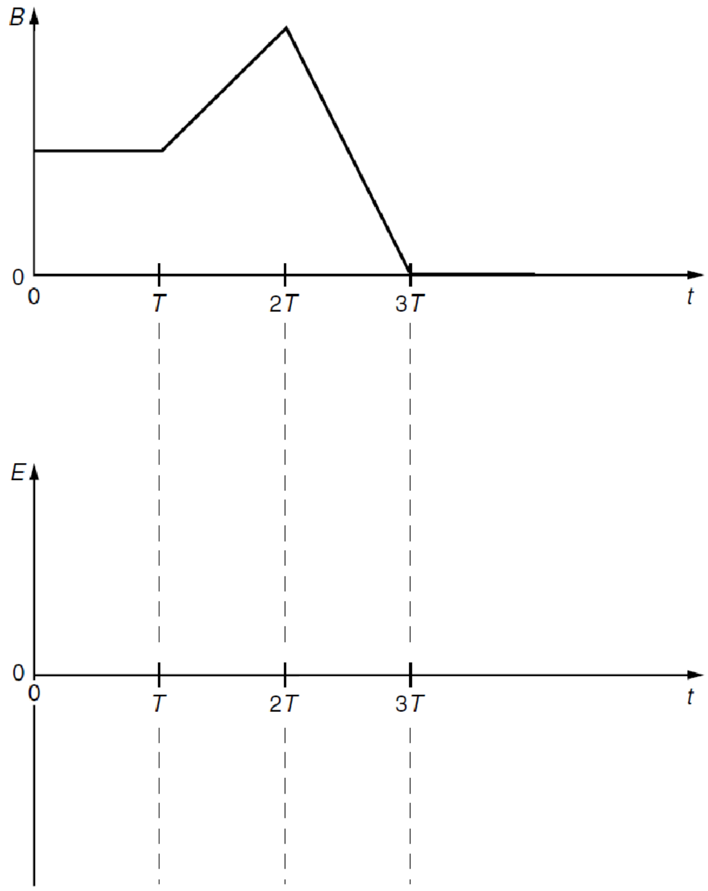
3. Faraday's Law

a. State Faraday's law of electromagnetic induction. **[2]**

b. A flat coil consists of N turns of wire and has area A. The coil is placed so that its plane is at an angle θ to a uniform magnetic field of flux density B, as shown in the diagram right.



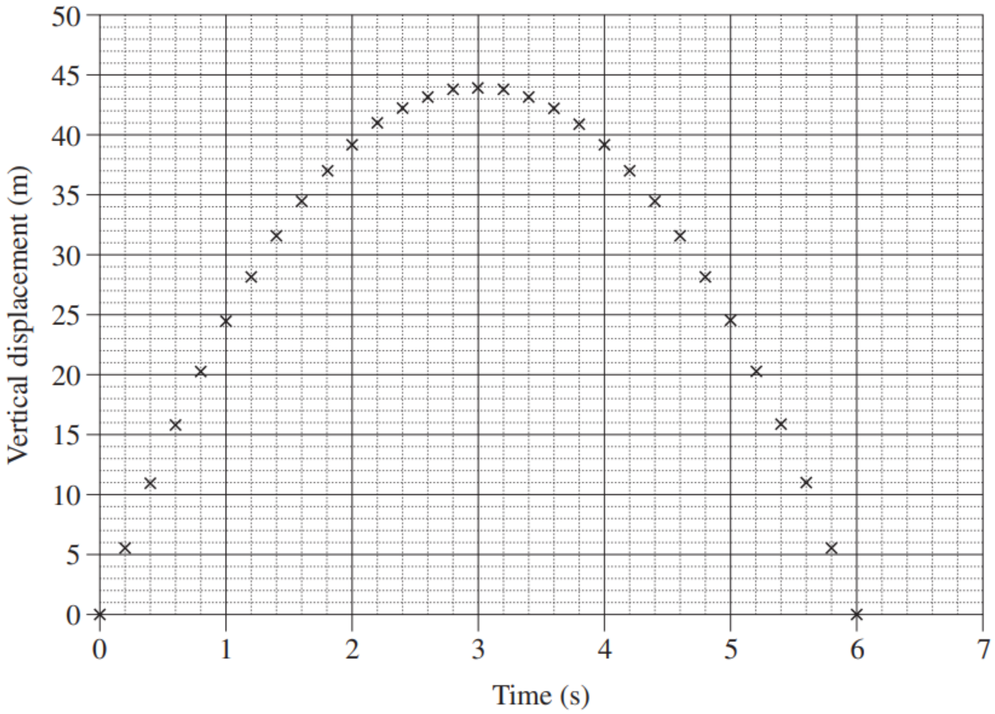
The magnetic flux density B in the coil is now made to vary with time t as shown in below. On figure below, sketch the variation with time t of the e.m.f. E induced in the coil. **[2]**



4. Projectile Motion

The graph shows the vertical displacement of a projectile throughout its trajectory.

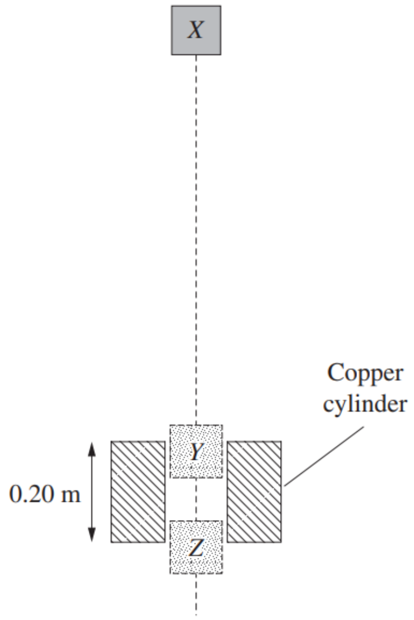
The range of the projectile is 130 m.



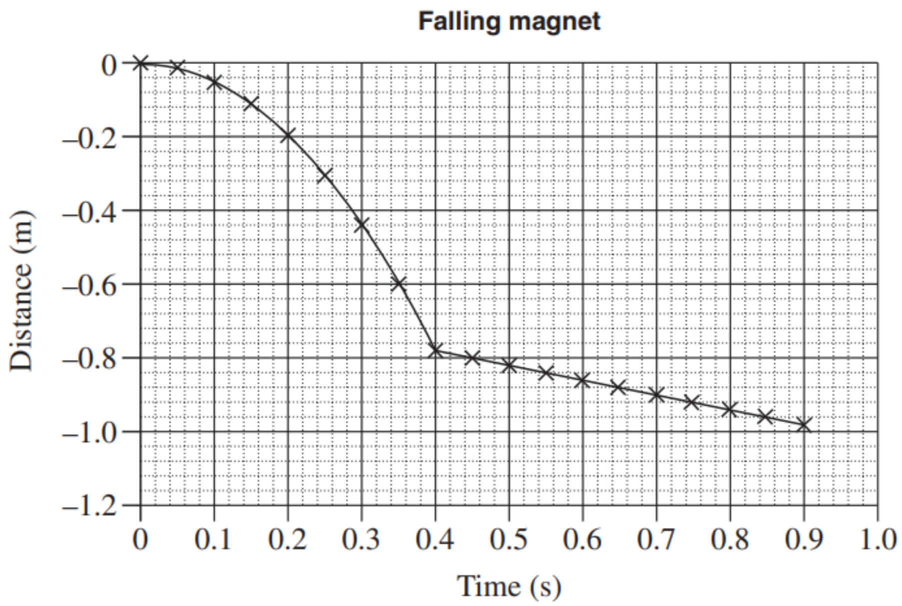
Calculate the initial velocity of the projectile. **[4]**

5. Magnetic Braking

A strong magnet of mass 0.06 kg falls 0.78 m under the action of gravity from position X above a hollow copper cylinder. It then travels a distance of 0.20 m through the cylinder from Y to Z before falling freely again.



The magnet takes 0.5 seconds to pass through the cylinder. The displacement–time graph of the magnet is shown.



Question 5 continues next page…

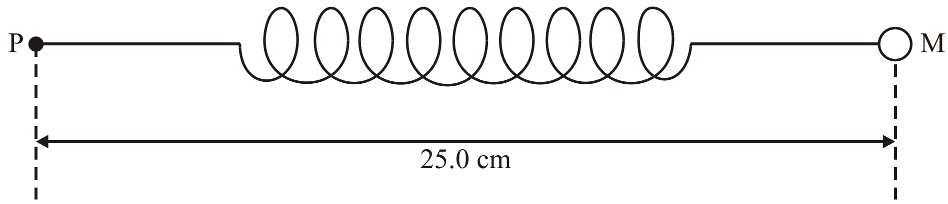
Question 5 continued

Analyse the motion of the magnet by applying the law of conservation of energy. Your analysis should refer to gravity and the copper cylinder, and include both qualitative and quantitative information. **[9]**

6. Circular Motion

A linear spring of negligible mass requires a force of 18.0 N to cause its length to increase by 1.0 cm.

A sphere of mass 75.0 g is attached to one end of the spring. The distance between the centre of the sphere M and the other end P of the unstretched spring is 25.0 cm, as shown below.



The sphere is rotated at constant speed in a horizontal circle with centre P. The distance PM increases to 26.5 cm.

a. Explain why the spring increases in length when the sphere is moving in a circle. **[2]**

____

____

____

____

b. Determine the speed of the sphere. **[4]**

____

____

____

____

____

____

____

____

____

END OF SKILLS TEST

2021 Year 12 Physics Skills Test Solutions

Question 1a

Criteria	Marks
• Correctly calculates final speed of proton	2
• Calculates the final speed of the proton with ONE error	1

Sample answer:

ΔKE = Work done

$$^{1}/_{2}\, mv^2 = qV$$

$$v = \sqrt{\frac{2qv}{m}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 1.2 \times 10^{4}}{1.673 \times 10^{-27}}} = 1.52 \times 10^{6} ms^{-1}$$

Question 1b

Criteria	Marks
• Proton undergoes circular motion while in the magnetic field AND moves in a clockwise direction • Correctly calculates the radius of motion	2
• Proton undergoes circular motion while in the magnetic field OR • Proton moves in a clockwise direction OR • Correctly calculates the radius of motion	1

Sample answer:

While in the magnetic field the proton undergoes circular motion in a clockwise direction of radius 0.16 m.

$$qvB = \frac{mv^2}{r}$$

$$r = \frac{mv}{Bq} = \frac{1.673 \times 10^{-27} \times 1.5 \times 10^{6}}{0.1 \times 1.6 \times 10^{-19}} = 0.16\, m$$

Question 1c i

Criteria	Marks
• Correctly states radius will decrease	1

Sample answer:

Radius of the circular motion will decrease.

Question 1c ii

Criteria	Marks
• Correctly states radius will decrease	1

Sample answer:

Radius of the circular motion will decrease.

Question 1d i

Criteria	Marks
• Correctly equates forces due to magnetic field and centripetal force • Correctly derives mathematical relationship	2
• Correctly equates forces due to magnetic field and centripetal force AND/OR • Derives mathematical relationship with ONE error	1

$$F_B = F_C$$

$$qvB = \frac{mv^2}{r}$$

$$B = \frac{mv}{qr} = \frac{mv}{q} \times \frac{1}{r}$$

Question 1d ii

Criteria	Marks
• Correctly labels column heading including units • Correctly calculates radius^{-1}	2
• Correctly labels column heading including units AND/OR • Correctly calculates radius^{-1}	1

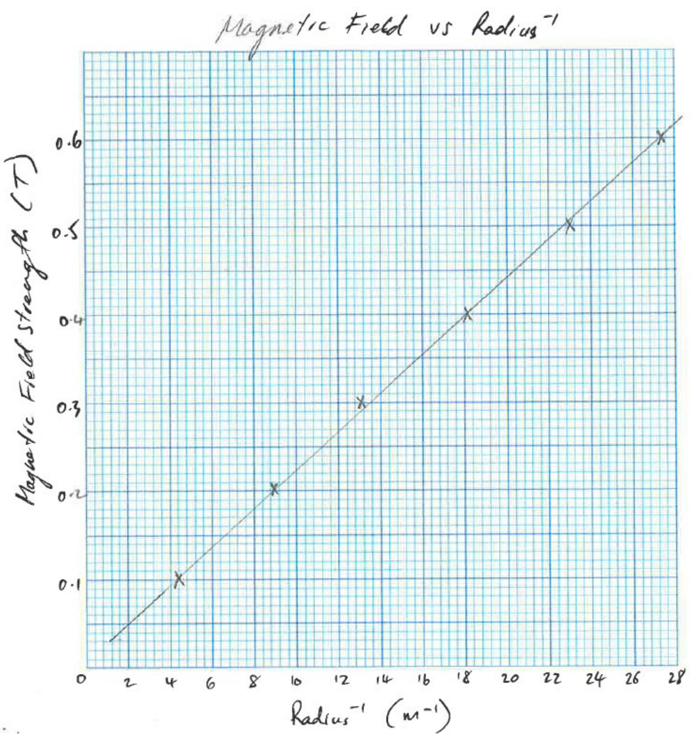
Sample answer:

Magnetic Field Strength (T)	Diameter (m)	Radius $^{-1}$ (m^{-1})
0.1	0.456	4.39
0.2	0.221	9.05
0.3	0.152	13.16
0.4	0.110	18.18
0.5	0.091	21.99
0.6	0.073	27.40

Question 1d iii

Criteria	Marks
Any of the following for 4 marks: • Correctly labels axes including units • Correct scales • Correctly plotted data points • Line of best fit	4

Sample answer:



Question 1d iv

Criteria	Marks
• Correctly calculates gradient of the graph • Correctly calculates mass using the gradient of the graph	3
• Correctly calculates gradient of the graph AND/OR • Correctly calculates mass using the gradient of graph (error carried forward from gradient)	2
• Calculates gradient of the graph with ONE error OR • Calculates mass using the gradient of graph with ONE error	1

Sample answer:

Data: $v = 1.1 \times 10^6$ ms^{-1}

$q = 3.2 \times 10^{-19}$ C

$$Grad = \frac{0.61 - 0}{28 - 0} = 0.022\ Tm$$

$$Grad = \frac{mv}{q}$$

$$m = \frac{Grad \times q}{v} = \frac{0.22 \times 3.2 \times 10^{-19}}{1.1 \times 10^6} = 6.4 \times 10^{-27} kg$$

Question 2a

Criteria	Marks
• Correctly calculates geostationary orbit	2
• Calculates geostationary orbit with ONE error	1

Sample answer:

Data: $m_E = 6.0 \times 10^{24}$ kg

T = 24 hrs = 86400 s

$$r^3 = \frac{GMT^2}{4\pi^2}$$

$$r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24} x (86400)^2}{4\pi^2}} = 4.23 \times 10^7 m$$

Question 2b

Criteria	Marks
• Correctly calculates change in gravitational potential energy	3
• Provides main steps for calculating the change in gravitational potential energy	2
• Provides some relevant information	1

Sample answer:

Data: $r_i = 6.4 \times 10^6$ m

$r_f = 4.2 \times 10^7$ m

$m_E = 6.0 \times 10^{24}$ kg

$m_S = 650$ kg

$$\Delta U = U_f - U_i = -\frac{GM_E m_s}{r_f} - \left(-\frac{GM_E m_s}{r_i}\right) = GM_E m_s \left(\frac{1}{r_i} - \frac{1}{r_f}\right)$$

$$\Delta U = 6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 650 \times \left(\frac{1}{6.4 \times 10^6} - \frac{1}{4.2 \times 10^7}\right) = 3.45 \times 10^{10}\ J$$

Question 3a

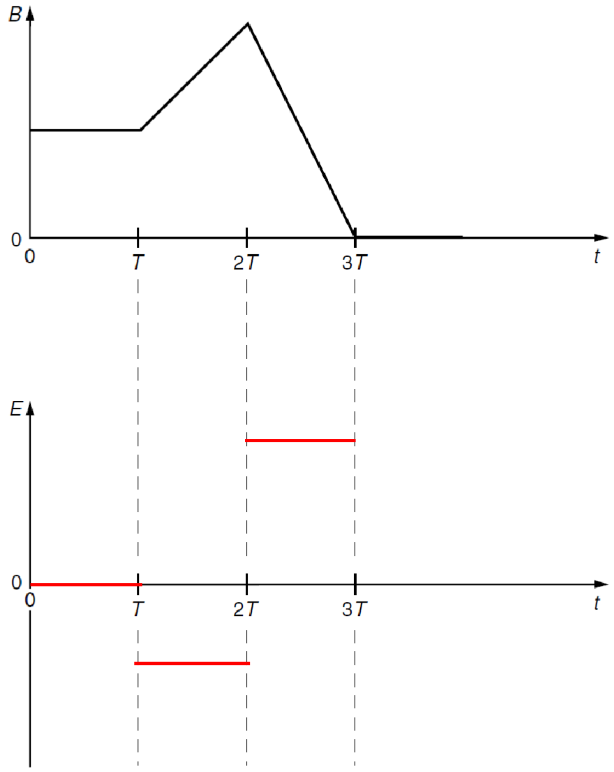
Criteria	Marks
• Correctly states Faraday's law	2
• Refers to change in magnetic flux	1

Sample answer:

An emf is induced in a coil whenever there is a change in magnetic flux with time.

Question 3b

Criteria	Marks
• Correctly sketches emf induced	2
• Sketched emf induce with ONE error.	1



Question 4

Criteria	Marks
• Correctly calculates the magnitude and direction of the initial velocity	4
• Provides the main steps for calculating the initial velocity	3
• Provides some steps for calculating the initial velocity	2
• Provides some relevant information	1

Sample answer:

From the graph, max height is 44 m and $v_y = 0$ at max height. Therefore:

$v_y{}^2 = u_y{}^2 + 2a_y s_y$

$0 = u_y{}^2 + 2 \times (-9.8) \times 44$

$u_y = 29.4 \text{ m s}^{-1}$

From the graph, time of flight is 6s and horizontal range is 130m. Therefore:

$u_x = R / t = 130/6 = 21.7$ m s^{-1}

Pythagoras' relationship:

$u^2 = 21.7^2 + 29.4^2 = 36.5$ m s^{-1}

$\theta = \tan^{-1} (29.4/21.7) = 54°$

Therefore u = 36.5 m s^{-1}, 54° above the horizontal.

Questions 5

Criteria	Marks
• Provides a comprehensive analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	9
• Provides a thorough analysis of the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and the copper cylinder • Includes quantitative information	8
• Describes the motion of the magnet • Applies the law of conservation of energy • Refers to gravity and/or the copper cylinder • Includes quantitative information	6-7
• Describes the motion of the magnet AND/OR • Relates the law of conservation of energy AND/OR • Refers to gravity and/or the copper cylinder AND/OR • Includes quantitative information	4-5
• Shows some understanding of the motion of the magnet and/or gravity and/or the copper cylinder	2-3
• Provides some relevant information	1

Sample answer:

During the first 0.4 s, the magnet is free-falling due to gravitational force, falling a distance of 0.78 m, and accelerating at 9.8 m s^{-2} ($\frac{2s}{t^2}$). Here, gravitational potential energy is being converted to kinetic energy as the magnet accelerates downward. This is shown by the nonlinear line on the distance vs time graph.

At position Y, the induced currents in the cylinder produce a magnetic field that causes the magnet to decelerate to a constant velocity of 0.4 m s^{-1} for a period of 0.5 seconds as it passes through the copper cylinder. There is zero net force on the magnet as it passes through the cylinder, as shown by the straight line in the distance vs time graph.

The magnet's kinetic energy is converted to heat energy during the deceleration.

As the magnet passes through the cylinder, the gravitational potential energy decreases and there is a corresponding increase in the heat energy in the cylinder. This is consistent with the law of conservation of energy.

Question 6a

Criteria	Marks
• Describes the net force on M to maintain circular motion • Applies the Newton's 3rd law to describe the spring extension	2
• Provides some relevant information to justify the increase in spring length	1

Sample answer:

A net force is required to pull M from a straight-line path and maintain circular motion. The spring must apply a force on M and, from Newton's 3rd Law, M must also apply an equal and opposite force on the spring. Therefore, the spring increases in length.

Question 6b

Criteria	Marks
• Correctly calculates the magnitude of speed of M	4
• Provides the main steps for calculating the speed of M	3
• Provides some steps for calculating the speed of M	2
• Provides some relevant information	1

Sample answer:

Force required to extent spring per unit cm = 18 N

Force to extend spring = (26.5 – 25.0) × 18 = 27 N

$$F = \frac{mv^2}{r}$$

$$v = \sqrt{\frac{Fr}{m}} = \sqrt{\frac{27x\,0.265}{0.075}} = 9.8\ ms^{-1}$$