EXAM NUMBER

Shore

Year 12
Physics
General Skills Test
2020

General Instructions

- Working time – 1 hour
- Write using black or blue pen
- Draw diagrams using pencil
- Calculators may be used
- Answer to 2 significant figures unless otherwise stated

Total marks – 35

Part A – 7 marks

- Attempt Questions 1 – 7
- Allow about 12 minutes for this part

Part B – 28 marks

- Attempt Questions 8 – 15
- Allow about 48 minutes for this part

Note: Any time you have remaining should be spent revising your answers.

DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

Part A – 7 marks

Attempt Questions 1 – 7
Allow about 12 minutes for this part

Select the best answer.
Write the letter of your answer in the box provided.

1 A satellite in circular orbit of radius r around the Earth has an orbital velocity v.

What would be the orbital radius of a satellite with orbital velocity $2v$?

(A) $\frac{r}{4}$

(B) $\frac{r}{2}$

(C) $2r$

(D) $4r$

Answer

2 A rock is thrown horizontally from a high cliff with an initial velocity of $15 ms^{-1}$.

After what time interval will the rock have a velocity vector directed at 45^{o} to the horizontal?

(A) 1.0s

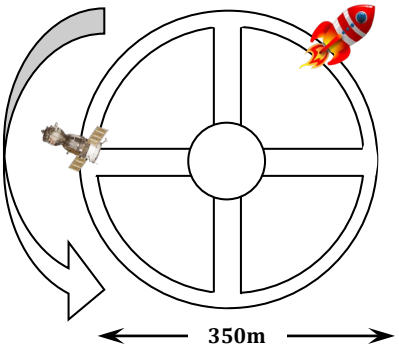
(B) 1.2s

(C) 1.5s

(D) 2.0s

Answer

3 The futuristic space station shown in the diagram at right spins on its central axis to create artificial gravity for astronauts living in the rim. It spins at a speed of rotation that produces an acceleration of g. Which of the following would result in the astronauts experiencing an acceleration more than g?



(A) Increasing the mass of the astronauts

(B) Increasing the mass of the space station

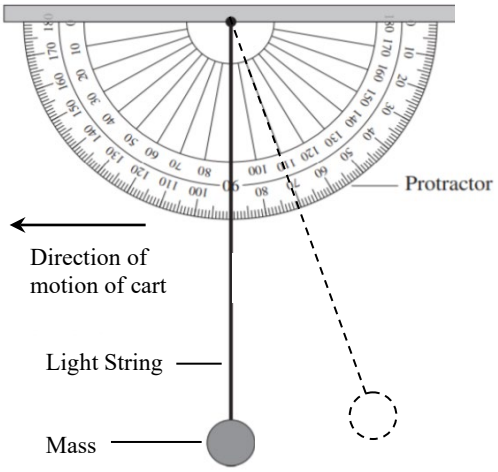
(C) Increasing the radius of the space station

(D) Increasing the speed of rotation of the space station

Answer

4 The device shown in the diagram at right was set up on a motion cart such that the plane of the protractor was parallel to the direction of travel. The cart was then accelerated at a rate of a ms^{-2}, causing the mass to swing backwards through an angle of 20^{o} as shown.

What acceleration will cause the mass to swing backwards through an angle of 40^{o}?



(A) $\frac{a}{2.3} ms^{-2}$

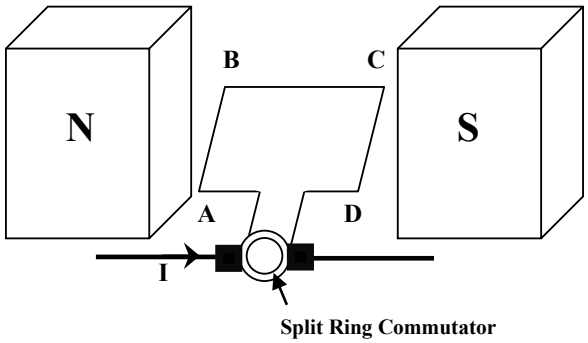
(B) $\frac{a}{2} ms^{-2}$

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

(D) $2.3a\ ms^{-2}$

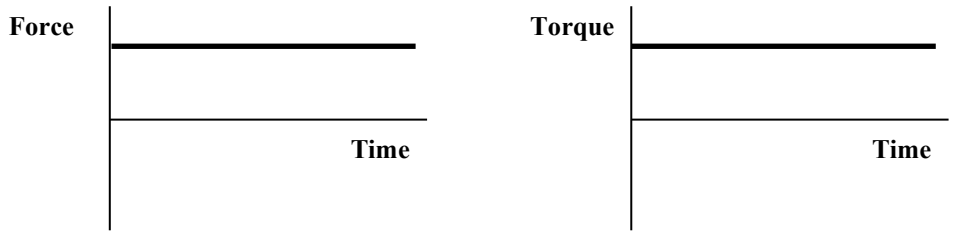
Answer

5 A small simple DC motor is shown in the diagram below. When current flows the armature rotates completely within the uniform magnetic field.

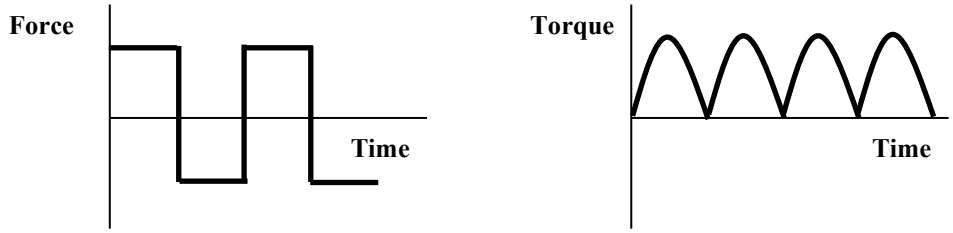


Which set of graphs best shows the change in force and torque on wire AB as it rotates.

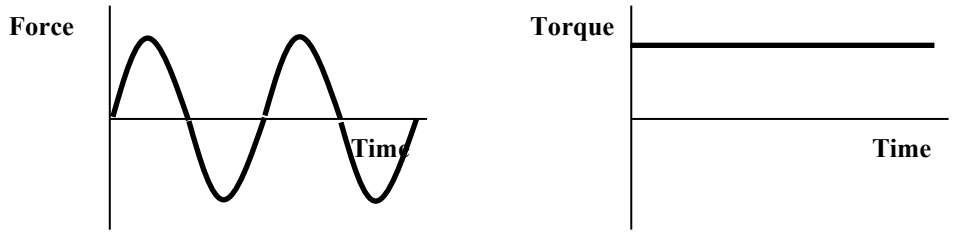
(A)



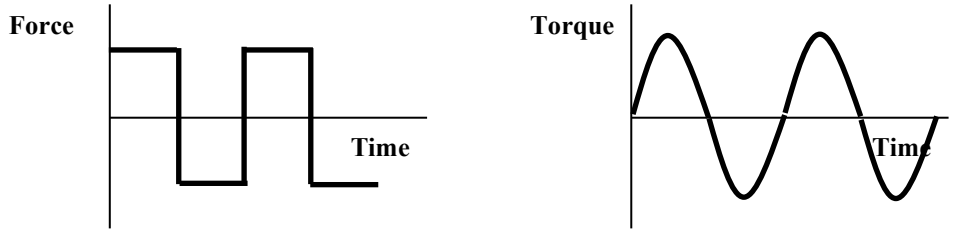
(B)



(C)

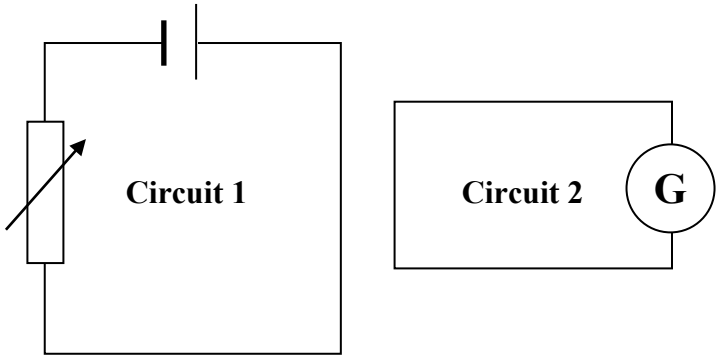


(D)



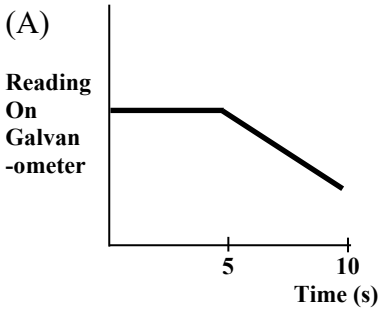
Answer

6 Two separate circuits are set up as shown below. Initially a current of 5A flows in Circuit 1. After 5 seconds the rheostat is gradually adjusted so that the resistance of Circuit 1 increases at a constant rate over the next 5 seconds.

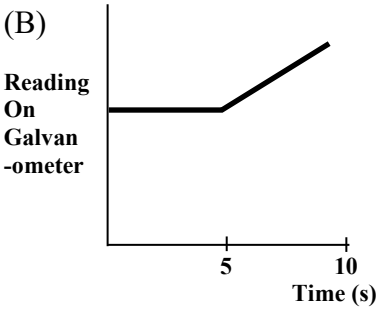


Which graph best shows the reading on the galvanometer in Circuit 2 during the 10 seconds?

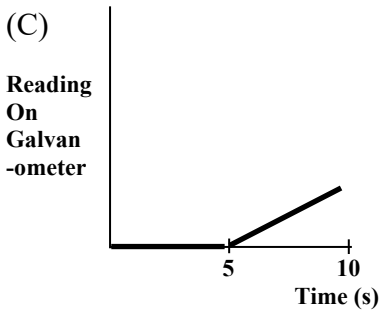
(A)



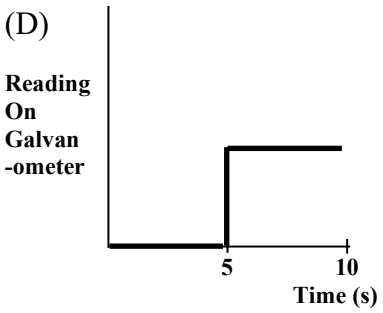
(B)



(C)



(D)



Answer

7 The unit for flux is Weber (Wb). Which of the following is also a valid unit for flux?

(A) Tm

(B) Tm^2

(C) mT^{-1}

(D) m^2T^{-1}

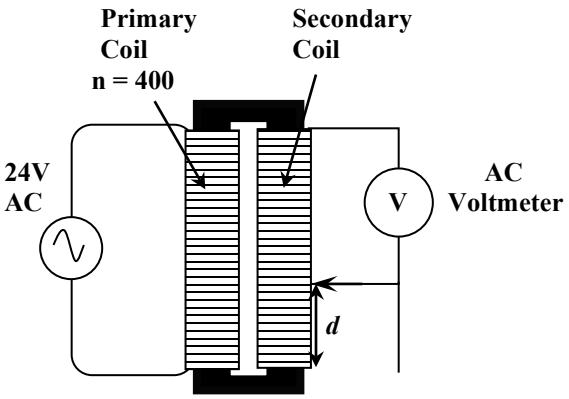
Answer

Part B – 28 marks
Attempt Questions 8 – 15
Allow about 48 minutes for this part
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

Show all relevant working in questions involving calculations.

Question 8 (4 marks) **Marks**

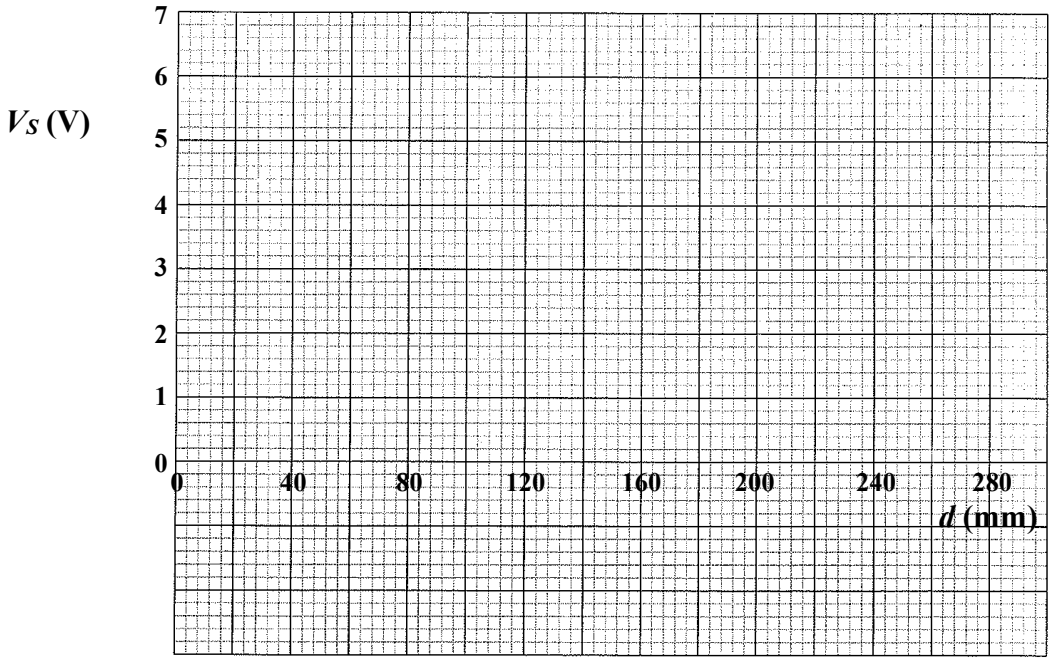
An experiment is set up as shown at right using the principles of a transformer.
The connection into the secondary coil can be adjusted, thereby adjusting the number of turns in the secondary coil. (You can assume the secondary coil is wound such that there is a constant number of turns per cm.)



A student measures the voltage output of the secondary coil for various distances *d* as shown. The results are shown in the table below.

d (mm)	40	80	120	160	200
Secondary voltage, V_S (V)	4.9	4.0	2.9	1.9	1.0

a) Plot the data from the table on the graph below and construct a line of best fit. **2**



Question 8 (continued) **Marks**

b) From the graph, determine the voltage output from the secondary coil when it is connected for its full length. **1**

_____

c) Calculate the number of turns in the secondary coil (assume it is an ideal transformer). **1**

_____

_____

_____

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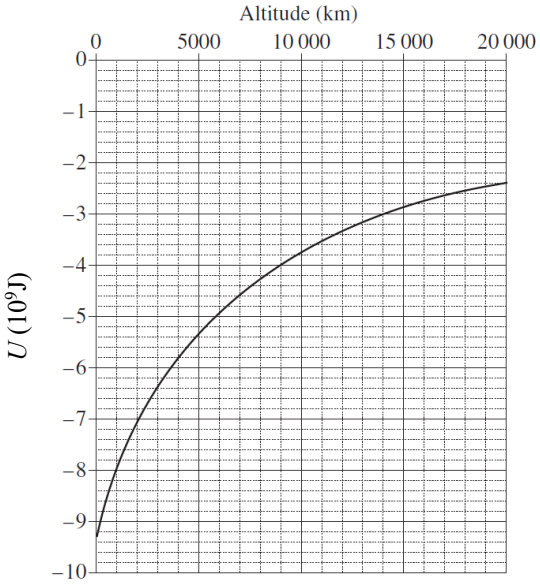
Question 9 (3 marks) **Marks**

The graph shows how the gravitational potential energy (U) of a small probe changes with its altitude above Venus.
The mass of Venus is 4.9×10^{24}kg and its radius is 6100km.



a) Use the graph to determine the potential energy of the probe at 4000km altitude and use that value to calculate the mass of the probe. **2**

b) Use the graph to determine the change in U for the probe if it is moved from an orbit of 4000km altitude to an orbit of 14000km altitude. **1**

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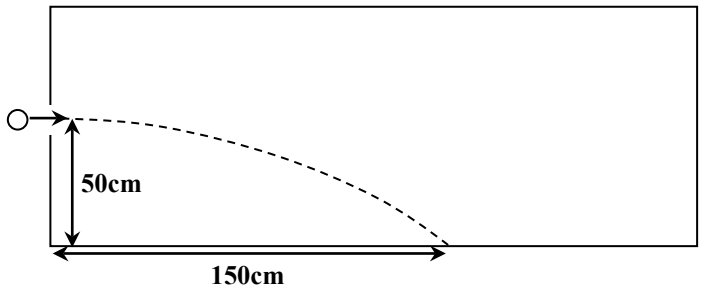
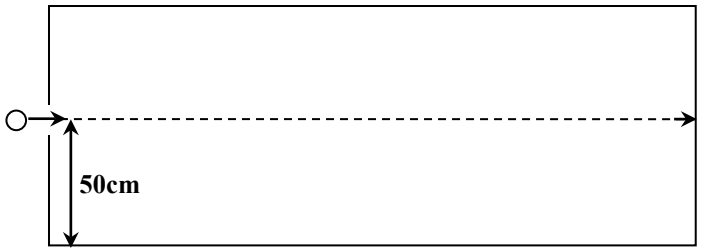
Question 10 (6 marks) **Marks**

A ball of mass 160g is launched horizontally into a vacuum chamber where it falls under the influence of gravity causing it to take the parabolic trajectory shown.



a) Calculate the velocity of the ball when it impacts the bottom of the chamber. **3**

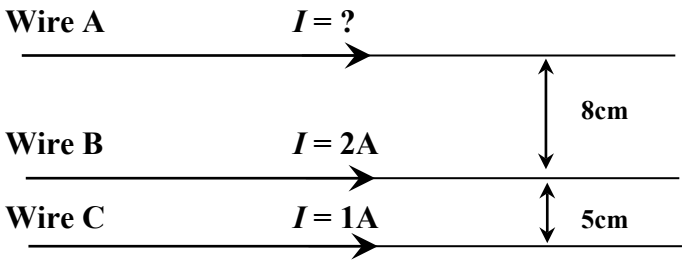
The experiment is repeated with the ball launched in an identical manner into the chamber. But this time the ball carries a charge of +0.2C and a uniform magnetic field is applied to the chamber. The ball is observed to travel the length of the chamber without deviating from its initial path.



b) Calculate the strength and direction of the magnetic field applied. **3**

Question 11 (3 marks) **Marks**

The nett force on wire B is zero (you can assume the weight of the wire is negligible). Calculate the size of the current in wire A. **3**



Question 12 (2 marks)

The Earth orbits the Sun with an average radius of approximately 150 million km. Halley's comet orbits the Sun with a period of 75 years.

Calculate the average radius of the orbit of Halley's comet. **2**

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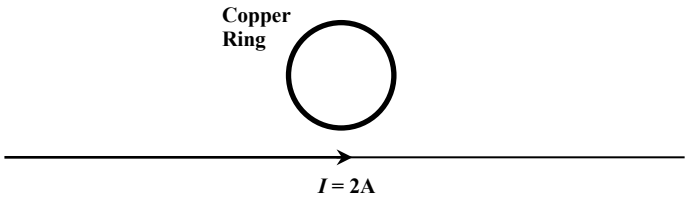
Question 13 (3 marks) **Marks**

A current carrying wire is positioned close to a conducting copper ring of radius 5cm as shown in the diagram below.



When the current through the wire is 2A, the magnetic field strength through the coil is an average of 2.5×10^{-4}T. A rheostat is used to steadily increase the current in the wire to 6A over a period of 0.5s.

a) On the diagram indicate the direction of current that would be induced in the copper ring. **1**

b) Calculate the magnitude of the emf produced in the copper ring during the time interval when the current in the wire is changing. **2**

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Question 14 (4 marks) **Marks**

A DC electric motor has a resistance of 10Ω and is powered by a 120V battery. It has a square armature of sides 30cm containing 300 turns of wire that rotates in a radial magnetic field of strength 0.5T.

a) Calculate the maximum torque produced by the motor on start. **2**

b) When at operating speed, the current through the armature is 2.0A. Calculate the back emf at operating speed. **2**

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Question 15 (3 marks) **Marks**

Two small meteors are drifting with identical velocities in deep space. One has a mass of 250g and the other a mass of 70g. They are 1km apart.

a) Calculate the gravitational force of attraction between the two meteors. **1**

b) The two meteors will gradually come together due to the gravitational force between them.

Explain differences and changes in the acceleration of the two meteors as they come together. Support your answer using mathematics. **2**

END OF TEST

Year 12 Physics

General Skills Test 2020

Marking Guidelines

Part A

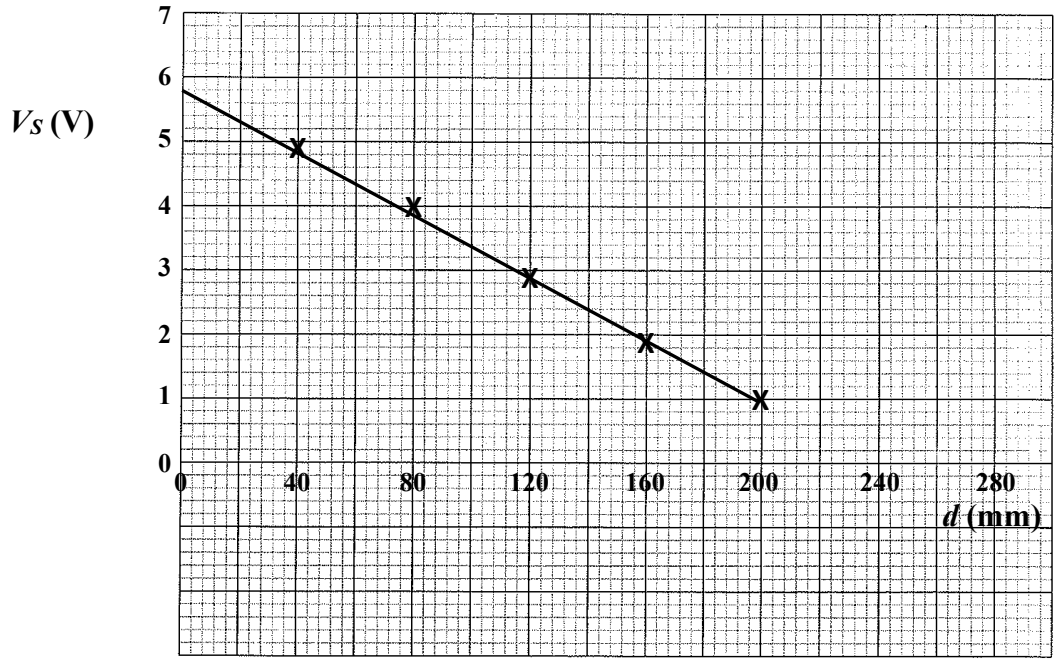
Question #	1	2	3	4	5	6	7
Answer	A	C	D	D	B	D	B

Part B

Question 8 a)

Criteria	*Mark*
All plots correct within ½ small division AND a line of best fit that represents the plotted data with similar numbers of plots on each side of the line.	**2**
All plots correct within ½ small division **OR** A line of best fit that represents the plotted data with similar numbers of plots on each side of the line.	**1**

Sample Answer



Question 8 b)

Criteria	*Mark*
Correct y-intercept from student's graph (+/-0.1V)	**1**

Sample Answer
5.8 V

Question 8 c)

Criteria	*Mark*
Valid method with correct substitution of values from student's answer to part b)	**1**

Sample Answer

$$\frac{V_P}{V_S}=\frac{n_P}{n_S},\quad \frac{24}{5.8}=\frac{400}{n_S},\quad n_S=97 turns$$

Question 9 a)

Criteria	*Mark*
Correct value for U AND correct equation with substitutions	**2**
Correct value for U **OR** Correct equation with one error of substitution	**1**

Sample Answer
From the graph, U at 4000km altitude = – 5.8 x 10^9J.

$$U=\frac{-GMm}{r},\ m=\frac{-Ur}{GM}=\frac{5.8\times10^9\times(6100+4000)\times10^3}{6.67\times10^{-11}\times4.9\times10^{24}}=180kg$$

Question 9 b)

Criteria	*Mark*
Correct value with correct sign +/- and correct units (given student's answer to part a)	**1**

Sample Answer

$$\Delta U=-3\times10^9-(-5.8\times10^9)=2.8\times10^9 J$$

Question 10 a)

Criteria	*Mark*
A valid method with correct substitutions. Answer must include a direction	**3**
Correct working to find either final horizontal OR vertical velocity **OR** A valid method with one error of logic or substitution	**2**
Correctly working for any of final vertical velocity, time to impact or horizontal velocity	**1**

Sample Answer

Final vertical velocity, $v^2 = u^2 + 2as = 0 + 2 \times 9.8 \times 0.5 = 9.8$, $v = 3.1ms^{-1}$.

The time to impact is given by $v = u + at$, $3.1 = 0 + 9.8t$, $t = 0.32s$.

Horizontal velocity is given by $s = ut$, $u = \frac{s}{t} = \frac{1.5}{0.32} = 4.7ms^{-1}$

Final velocity is $v = \sqrt{4.7^2 + 3.1^2} = 5.6ms^{-1}$, the angle of impact is $\theta = \tan^{-1}\left(\frac{3.1}{4.7}\right) = 33^o$ below the horizontal

Question 10 b)

Criteria	*Mark*
A valid method with correct substitutions AND correct field direction	**3**
A valid method with correct substitutions for the strength of the magnetic field **OR** One error of logic or substitution in calculating the strength of the magnetic field AND correct field direction	**2**
Identifies equivalence of forces acting **OR** Identifies correct field direction	**1**

Sample Answer

For a straight path, $F_B = F_g$, $qvB = mg$, $B = \frac{mg}{qv} = \frac{0.16 \times 9.8}{0.2 \times 4.7} = 1.7T$.

The force due to the magnetic field must be directed upwards. By the right hand rule, the magnetic field must be directed into the page.

Question 11

Criteria	*Mark*
A valid method with correct substitutions (Note – allow valid "shortcuts" such as not showing "*k*" or showing "*r*" in cm).	**3**
One error of logic or substitution **OR** Identifies correct equation AND that the forces are equal in size	**2**
Identifies correct equation	**1**

Sample Answer

There is no nett force on wire B. Therefore, $F_{AB} = F_{BC}$ where $\frac{F}{\ell} = \frac{\mu_0}{2\pi} \times \frac{I_1 I_2}{r}$.

So $\frac{\mu_0}{2\pi} \times \frac{I_A \times 2}{0.08} = \frac{\mu_0}{2\pi} \times \frac{2 \times 1}{0.05}$, $I_A = 1.6A$

Question 12

Criteria	*Mark*
Valid method with correct substitutions. The answer is presented with correct units to two significant figures.	**2**
One error of logic or substitution	**1**

Sample Answer

For any orbital system, $\frac{r^3}{T^2}$ is constant.

As both the Earth and Halley's Comet orbit the Sun, $\frac{{r_E}^3}{{T_E}^2} = \frac{{r_{HC}}^3}{{T_{HC}}^2}$.

Working in millions of km and years, $\frac{150^3}{1^2} = \frac{{r_{HC}}^3}{75^2}$, $r_{HC} = 2700$ million *km*.

Question 13 a)

Criteria	*Mark*
Clearly shows clockwise direction of current	**1**

Sample Answer

Clearly shows clockwise direction of current

Question 13 b)

Criteria	*Mark*
Valid method with correct substitutions.	**2**
One error of logic or substitution	**1**

Sample Answer

$$\varepsilon = n\frac{\Delta\phi}{\Delta t} = n\frac{\Delta BA}{\Delta t} = 1 \times \frac{\left(7.5 \times 10^{-4} - 2.5 \times 10^{-4}\right) \times \pi \times 0.05^2}{0.5} = 7.9 \times 10^{-6} V$$

Question 14 a)

Criteria	*Mark*
Valid method with correct substitutions.	**2**
One error of logic or substitution	**1**

Sample Answer

At start, current through the armature $I = \frac{V}{R} = \frac{120}{10} = 12A$.

$\tau = nIAB = 300 \times 12 \times 0.3^2 \times 0.5 = 160Nm$.

Question 14 b)

Criteria	*Mark*
Valid method with correct substitutions.	**2**
One error of logic or substitution	**1**

Sample Answer

At operating speed, the voltage across the armature will be $V = IR = 2.0 \times 10 = 20V$.
Therefore back emf $= 120 - 20 = 100V$

Question 15 a)

Criteria	*Mark*
Valid method with correct substitutions.	**1**

Sample Answer

$$F = \frac{GMm}{r^2} = \frac{6.67 \times 10^{-11} \times 0.25 \times 0.07}{1000^2} = 1.2 \times 10^{-18} N$$

Question 15 b)

Criteria	*Mark*
Explains TWO differences in the acceleration of the meteors using equations to support their answers.	**2**
Explains ONE difference OR Outlines two differences	**1**

Sample Answer

The accelerations acting on the two meteors will be different as they have the same force acting on them but different masses, acceleration being given by $a = \frac{F}{m}$.

As they drift together the distance between them will decrease. Hence their accelerations will increase as $a = \frac{GM}{r^2}$ and r is decreasing.