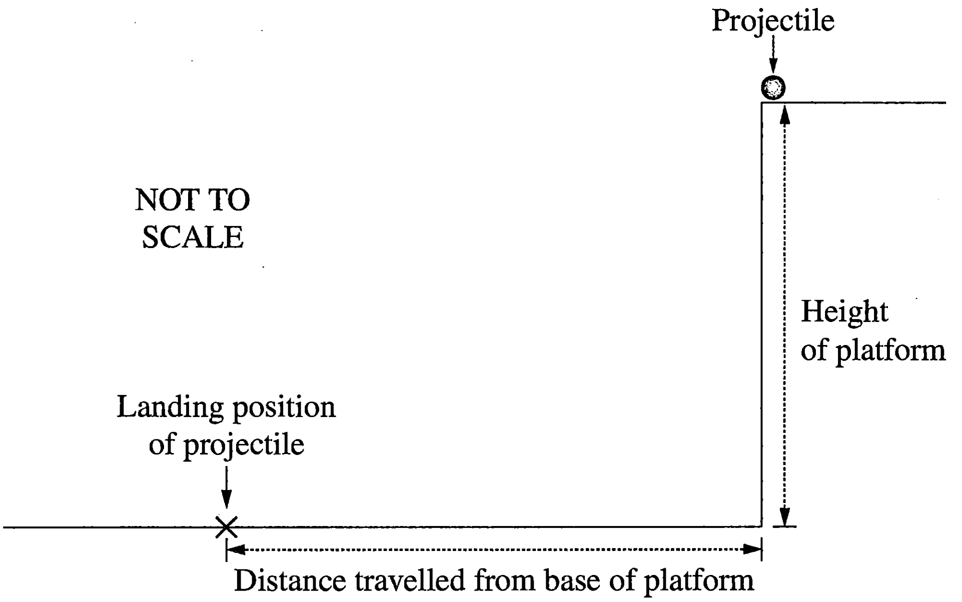
Question 21 (4 marks)

A projectile is fired horizontally from a platform.



Measurements of the distance travelled by the projectile from the base of the platform are made for a range of initial velocities.

u , Δx , Δy

Initial velocity of projectile (m s^{-1})	*Distance travelled from base of platform* (m)
1.4	1.0
2.3	1.7
3.1	2.2
3.9	2.3
4.2	3.0

Question 21 continues on page 15

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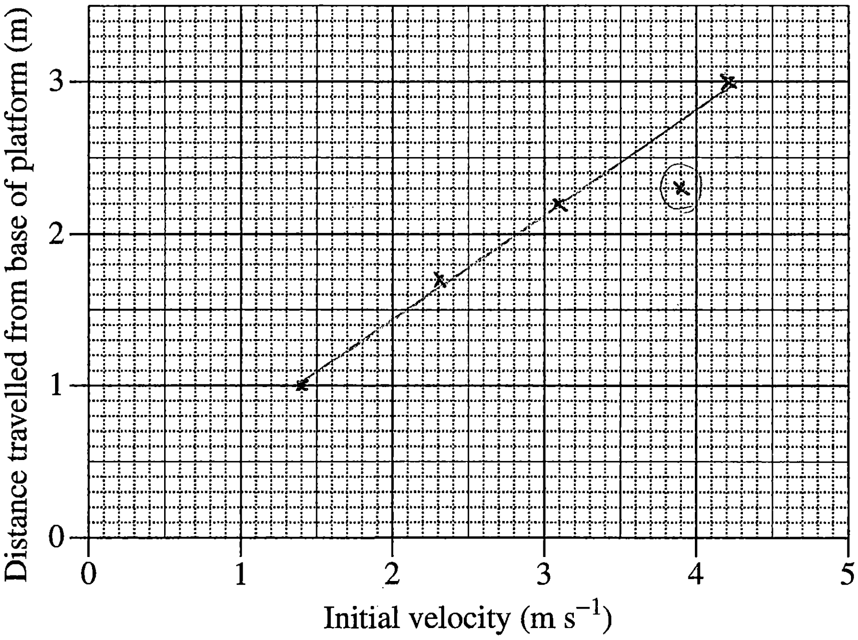
Question 21 (continued)

(a) Graph the data on the grid provided and draw the line of best fit. **2**



(b) Calculate the height of the platform. **2**

$y = mx$

from graph $m = t$ $\quad \Delta x = u_x t$

$m = \frac{3-1}{4.2-1.4} = 5/7$ $\quad \therefore t = \frac{5}{7}$ s.

$\Delta y = u_y t + \frac{1}{2} a_y t^2$ $\quad$ gravity

where $\Delta y = h$, $t = 5/7$, $a = -9.8$, $u_y = 0$ (fired horizontally)

$\Delta y = 0(\frac{5}{7}) + \frac{1}{2}(-9.8)(\frac{5}{7})^2$

$= -25/2$

$h = 2.5$ m.

End of Question 21

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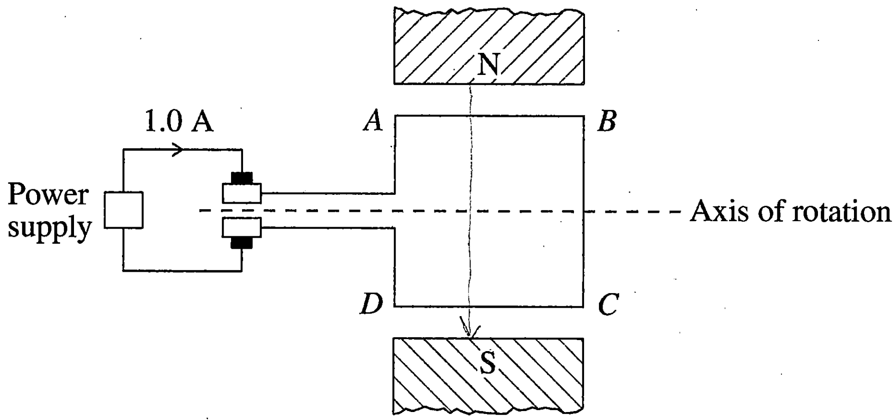
Question 22 (5 marks)

The diagram represents a simple DC motor. A current of 1.0 A flows through a square loop *ABCD* with 5 cm sides in a magnetic field of 0.01 T.



(a) Determine the force acting on section *AB* and the force acting on section *BC* due to the magnetic field, when the loop is in the position shown. **3**

No force acting on BC as it is parallel to field, $\sin 0 = 0$
AB = $F = BIl\sin\theta$ $\theta = 90$
$= 0.01 \times 1 \times 0.05 \times \sin 90$ $l = 0.05$
$= 5 \times 10^{-4}$ N $I = 1$
(into the page) $B = 0.01$

(b) How is the direction of the torque maintained as the loop rotates 360° from the position shown? **2**

As the loop rotates, it changes its contact with the brushes via a split ring commutator. This changes the direction of the current every half turn & this coupled w momentum will see the loop continue to rotate in the same direction, allowing torque to be maintained.

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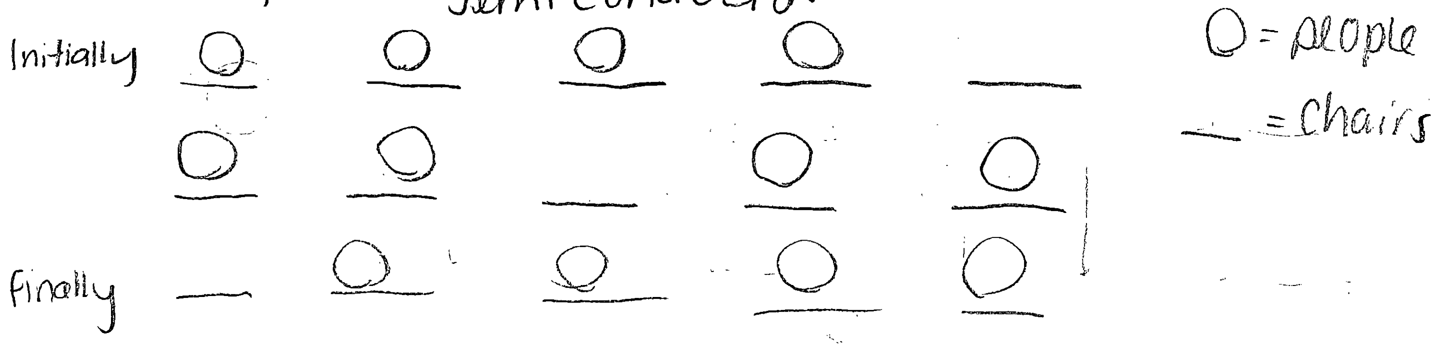
Question 23 (5 marks)

(a) Outline a procedure that could be used to model electrical conduction in a semiconductor. **3**

'Chair Experiment'. ~~As in a semi conductor~~, line up 5 chairs, ~~there a f~~ with only four people representing the positive hole in the semiconductor. Starting from the right, each person moves along one seat, (representing electrons). Whilst the people are moving to the right, the positive hole, whilst not moving at all, appears to be moving to the left, mirroring conduction in a semiconductor.



(b) Explain a limitation of the model outlined in part (a). **2**

A limitation of this model is that it is only available on a small scale, and does not represent a lattice like structure (ie only 1 dimension).

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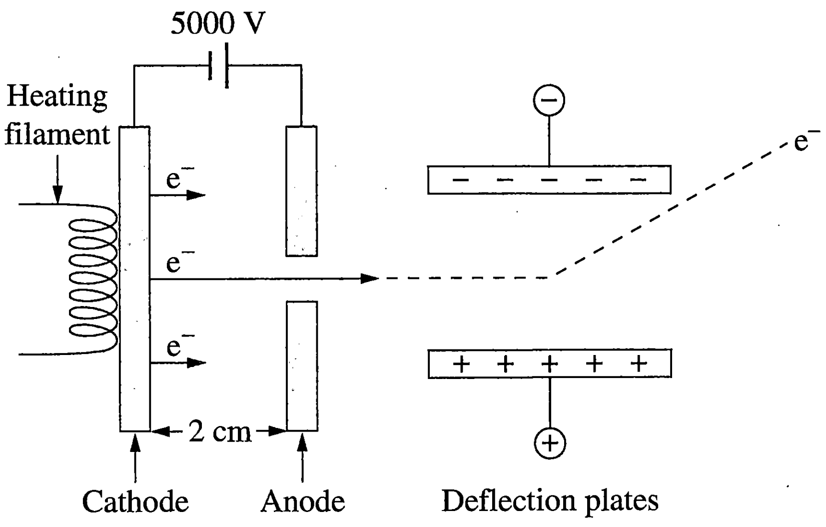
Question 24 (7 marks)

A part of a cathode ray oscilloscope was represented on a website as shown.



Electrons leave the cathode and are accelerated towards the anode.

(a) Explain why the representation of the path of the electron between the deflection plates is inaccurate. **3**

It will move the other way - as an electron is negatively charged, it will be attracted towards the positive plates & move downwards.
It will move straight away - as soon as the electron enters the electric field, it will feel a force attracting it down, not halfway through as shown
It will follow a circular path - the electron will inscribe a circular path whilst in the electric field, rather than the straight line shown.

Question 24 continues on page 19

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Question 24 (continued)

(b) Calculate the force on an electron due to the electric field between the cathode and the anode. **2**

$E = \frac{V}{d}$

$= \frac{5000}{0.02}$

$E = 250\ 000\ j$

$F = Eq$

$= 250\ 000\ j \times -1.602 \times 10^{-19}$

$= 4.005 \times 10^{-14}$ N towards the anode.

(c) Calculate the velocity of an electron as it reaches the anode. **2**

$E = hf$

$250\ 000 = 6.626 \times 10^{-34}\ f$

$f = 3.773 \times 10^{38}$ $\quad f = \frac{1}{\lambda}$

$\lambda = 2.6504 \times 10^{-39}$

$\lambda = \frac{h}{mv}$ $\quad m = 9.109 \times 10^{-31}$

$V = \frac{h}{m\lambda}$ $\quad h = 6.626 \times 10^{-34}$

$= 2.74 \times 10^{15}$ m/s

End of Question 24

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Question 25 (6 marks)

(a) Outline the conversion of electrical energy by devices in the home into TWO other forms of energy. **3**

Electrical energy is ~~certain~~ not always useful in all devices and is often converted to energy that can serve a greater purpose. For instance, in speakers, electrical energy is converted into sound energy through the motor effect. And electrical energy is converted into heat energy in induction cooktops through eddy currents

(b) The diagram shows a label on a transformer used in an appliance. **3**

$R = \frac{I}{V}$ $\quad \frac{V_p}{V_s} = \frac{I_s}{I_p}$

$V = IR$

$\frac{1}{48}$

Input:	240 V AC	5.0 A
Output:	2 kV AC	1.0 A

Explain why the information provided on the label is not correct. Support your answer with calculations.

~~The resistance is different~~ It does not fit in with the formula for transformers $\frac{V_p}{V_s} = \frac{I_s}{I_p}$

$\frac{240}{2000} = \frac{1}{5}$

$0.12 \neq 0.2$

Since the voltages & currents are not in the same ratio, then it is not acting as a step up transformer correctly

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Question 26 (6 marks)

Consider the following two models used to calculate the work done when a 300 kg satellite is taken from Earth's surface to an altitude of 200 km.

You may assume that the calculations are correct.

Model X	*Model Y*
Data: $g = 9.8\ \text{m s}^{-2}$ $m = 300\ \text{kg}$ $\Delta h = 200\ \text{km}$ $W = Fs$ $= mg\Delta h$ $= 3 \times 10^2 \times 9.8 \times 2.0 \times 10^5$ $= 5.9 \times 10^8\ \text{J}$	Data: $G = 6.67 \times 10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$ $r_{\text{Earth}} = 6.38 \times 10^6\ \text{m}$ $r_{\text{orbit}} = 6.58 \times 10^6\ \text{m}$ $M = 6.0 \times 10^{24}\ \text{kg}$ $m = 300\ \text{kg}$ $W = \Delta E_P$ $\Delta E_p = E_{p\ \text{final}} - E_{p\ \text{initial}}$ $= -\frac{GMm}{r_{\text{orbit}}} - \left(-\frac{GMm}{r_{\text{Earth}}}\right)$ $= -1.824 \times 10^{10} - (-1.881 \times 10^{10})$ $= 5.7 \times 10^8\ \text{J}$

(a) What assumptions are made about Earth's gravitational field in models *X* and *Y* that lead to the different results shown? **2**

That the Earths gravitational field is constant up to 200km, which is untrue. and that the earths ~~[illegible]~~ gravity is exactly 9.8 at the surface & does not vary.

(b) Why do models *X* and *Y* produce results that, although different, are close in value? **1**

Because 200km is not relatively high & variations in g are small.

Question 26 continues on page 22

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Question 26 (continued)

(c) Calculate the orbital velocity of the satellite in a circular orbit at the altitude of 200 km. **3**

$F_g = F_c$ where $d = r$

$\frac{G m_1 m_2}{d^2} = \frac{m v^2}{r}$

$\frac{Gm}{r} = v^2$

$v = \sqrt{\frac{Gm}{r}}$ [ignore neg.]

$G = 6.67 \times 10^{-11}$

$= \sqrt{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24}}{200\ 000}}$

$m = 6 \times 10^{24}$

$r = 200\ 000$

$= 44732$ m/s

End of Question 26

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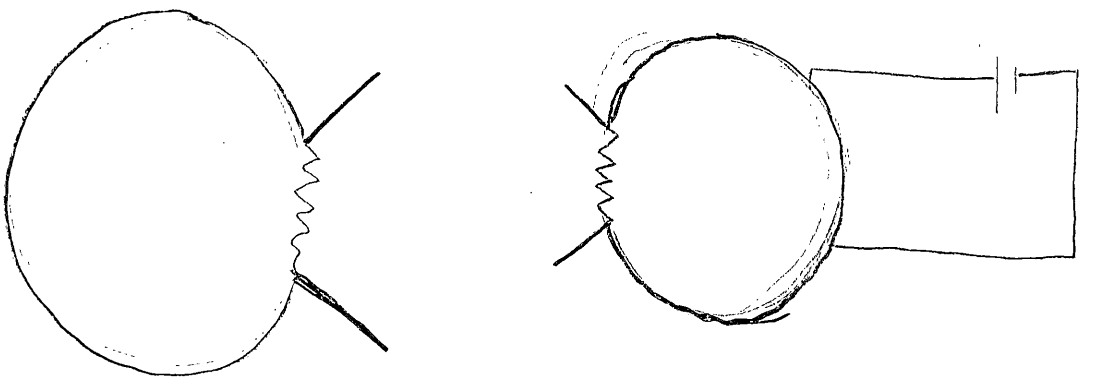
Question 27 (6 marks)

In 1865, James Clerk Maxwell developed the theory of electromagnetism. This theory explained the nature of light. It also predicted the existence of other electromagnetic waves. **6**

How did Hertz test and validate Maxwell's theory?

Hertz tested this theory through experimenting with ~~X-rays~~ Radio waves. By ~~[illegible]~~ running a current through a metal ring, a spark was produced in the gap. Directed by parabolic plates (as shown below), Hertz was able to produce a spark in the recieving coil. Although the waves could not be seen, Hertz had proved that they existed. He went on to examine some of their properties ~~to~~ by finding where there where areas of maxima & minima, proving that the radio waves were in fact waves as they had constructive & destructive interference. Hertz was also able to validate the equation $\lambda = \frac{h}{mv}$ that Maxwell had proposed showing that there were other forms of EMRs they behaved as Maxwell had described



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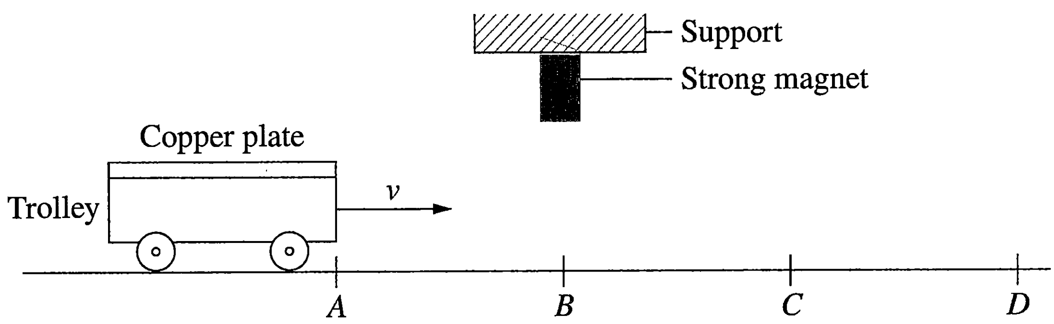
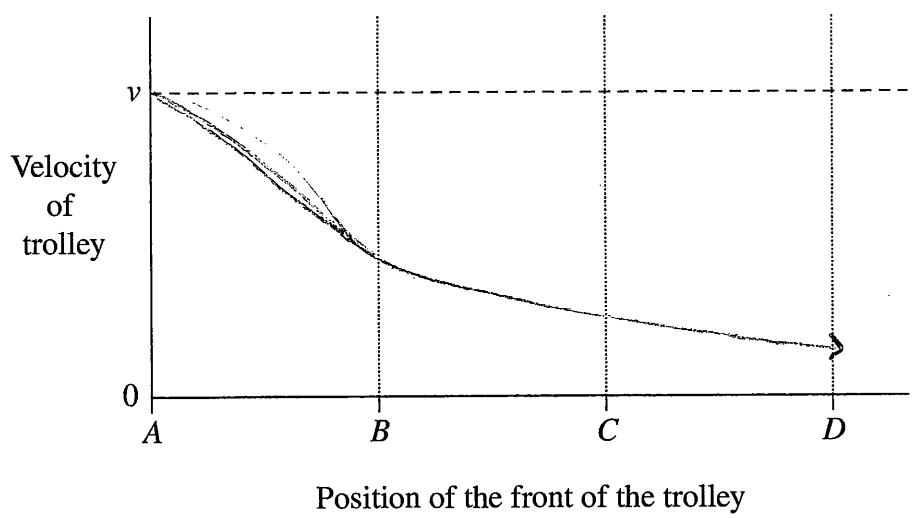
Question 28 (5 marks)

A copper plate is attached to a lightweight trolley. The trolley moves at an initial velocity, v, towards a strong magnet fixed to a support. **5**



The dashed line on the graph shows the velocity of the trolley when the magnet is not present.

On the axes, sketch the graph of the velocity of the trolley as it travels from A to D under the magnet, and justify your graph.



As the trolley moves towards (B), it sees a change in flux. This will cause eddy currents to flow (solid device) in a way that opposes the changing flux. This will cause the repel from the magnet & slow down. Due to its momentum however, it will move past (B) where the magnetic flux is now becoming smaller (thus changing) and the eddy currents will move in a way to

continued →

Section I Part B extra writing space

If you use this space, clearly indicate which question you are answering.

Q26. attract the magnet, further slowing the trolley, The trolley will continue to slow as it moves out of the magnetic field.

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Question 29 (5 marks)

In the Large Hadron Collider (LHC), protons travel in a circular path at a speed greater than 0.9999 *c*.

(a) What are the advantages of using superconductors to produce the magnetic fields used to guide protons around the LHC? **2**

By using superconductors to produce magnetic fields, ~~little~~ no energy is lost in conduction, and they can be switched on & off unlike permanent magnetic. They are also very strong whilst not being overly large.

(b) Discuss the application of special relativity to the protons in the LHC. **3**

The theory of special realativity has many implications on protons travelling at relativistic speeds. Firstly, they will appear heavier, ~~and~~ ~~[illegible]~~ & thus when collided with a target, will have larger impacts. Also, the effect of time dialation & length contraction will mean that calculations must be adjusted to account for this. ~~By~~ Through appearing smaller, heavier & slower, protons can have a larger impact on their targets.

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Question 30 (6 marks)

The following is a timeline for the Cassini space probe mission to Saturn. **6**

Earth	→	Venus	→	Venus	→	Earth	→	Jupiter	→	Saturn
Launch 15/10/1997		Slingshot 26/4/1998		Slingshot 24/6/1999		Slingshot 18/8/1999		Slingshot 30/12/2000		Orbit 1/7/2004

Explain how Newton's Laws of Motion and Universal Gravitation were applied to the Cassini mission.

As it it is shown, the Cassini mission utilised the slingshot effect on its way to Saturn. As the journey took just under 7yrs, it is impractice to carry that much fuel for the hole journey, so they use the slingshot effect. This involves going near a planet as to be taken in by its gravity, ie accelerated, and exit, and by logic decelerated. But as the planet is also moving in its orbit around the sun, the space craft gains extra momentum from the planet, & will keep it without using fuel, Newton's Law of Inertia. The Law of Universal Gravitation shows that no extra momentum will be gained as a result of the planets gravitational field, but rather takes some from the planets orbital speed [illegible] which due to the ~~sont~~ space ships small mass, is almost negligable.

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