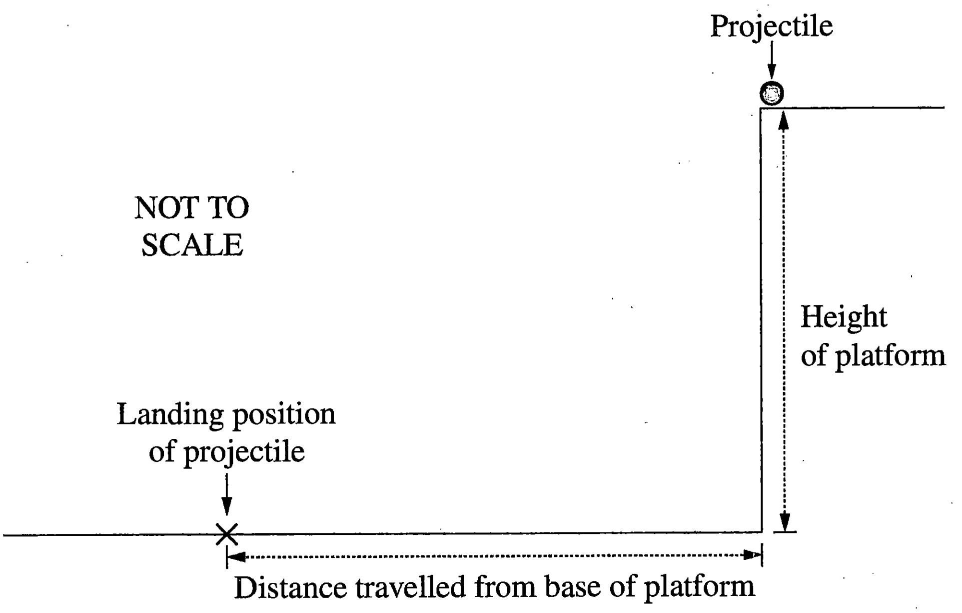
Question 21 (4 marks)

A projectile is fired horizontally from a platform.



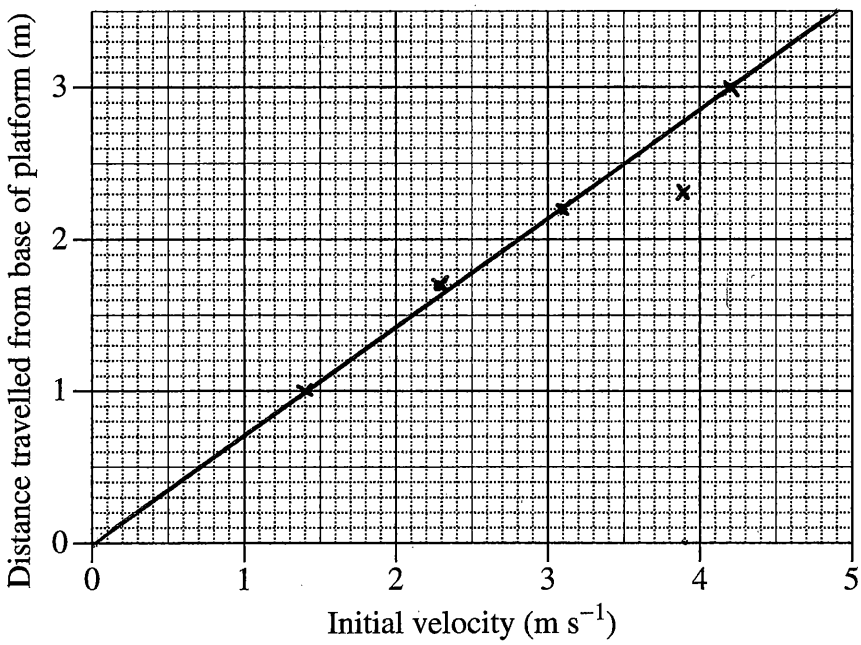
Measurements of the distance travelled by the projectile from the base of the platform are made for a range of initial velocities.

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

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**

$\Delta x = v_x \times t$

$1/1.4 = t = 0.71\,s$

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

$= 0 \times 0.71 + \frac{1}{2} \times -9.8 \times 0.71^2$

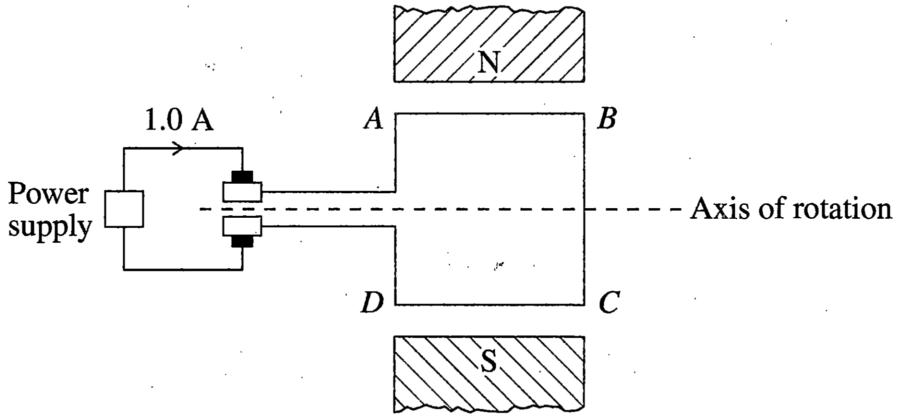
$= -2.47009\,m$

$\therefore$ height of platform $= 2.47009\,m$.

End of Question 21

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**

$0.05 \times 0.05 = 0.025 m^2$

$F/l = 2.0 \times 10^{-7} \times$

$F = 0.01 \times 1 \times 0.025 \times \sin 90$

$= 250 \times 10^{-6}$ Coloumbs

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

Torque direction is maintained by the constant reversal of electron flow at 0°/180°. The reversal of current flow coupled with momentum ensures the torque of the motor never reaches 0NM as it is constantly attempting to reach 180°/0°

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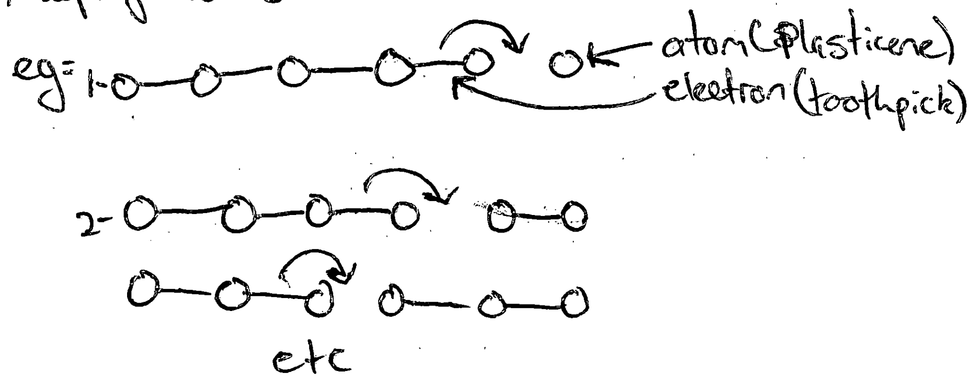
Question 23 (5 marks)

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

1- Set up a lattice structure using ~~styrene~~ Plasticene balls as atoms & toothpicks as electrons, leaving one part of lattice without a toothpick.
2- move toothpick (electron) to fill hole, just as what happens in semi-conductor when current is applied at right temperature.
3- keep moving toothpick into hole ~~to~~ which is made by each electron movement to show how semi-conductors w/ doping works



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

Part a will only show what happens when a semi-conductor doped w/ group 3 atoms behaves like under optimal conditions. It will not show how a group 5 type doping will affect the electrical conductivity, nor will it demonstrate the conditions needed to ~~create~~ cause conductivity in a semi conductor

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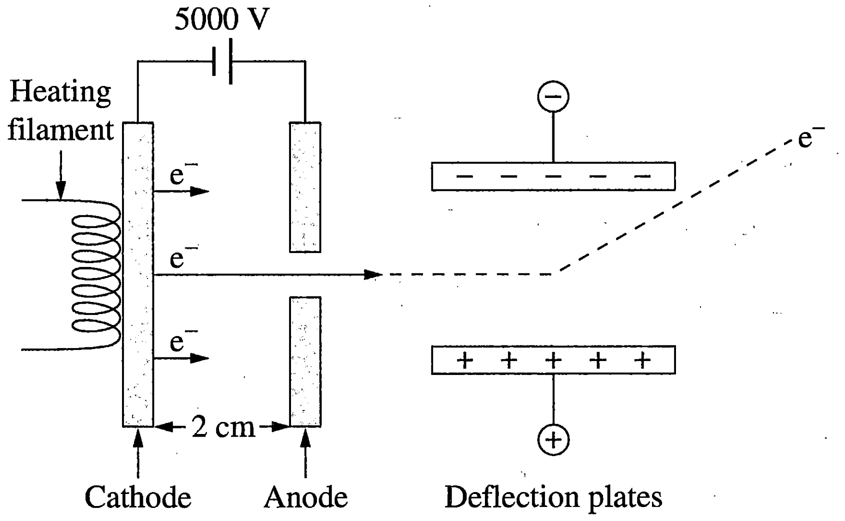
Question 24 (7 marks)

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**

The diagram is inaccurate as it shows the electrons deflecting towards the negative plate. Electrons being negative particles, are attracted to positively charged objects, meaning they should be deflecting towards the positively charged plate. The diagram also shows the electron path as being straight & angular, when in fact it should show a curved path as an electrons path around positively charged plate is circular & has a radius.

Question 24 continues on page 19

Question 24 (continued)

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

~~F/l = k × I₁ × I₂ / d~~ ~~P = m × v~~

$\frac{2 \times 10^{-7} \times 5000}{0.02}$ =

= 250 N

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

3×10^{8} ms

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**

Light bulb: Electricity travels in circuit with resistance, said circuit then heats up which turn electrical energy to heat & light energy

Loudspeaker: Electrical energy causes an electric field to be induced ~~at~~ in a coil around a magnet in a magnetic field. This causes the coil to vibrate in accordance to the frequency of talking & amplitude is increased as loudness increases. The vibrations cause the cone of the speaker to vibrate creating sound energy. Electrical energy → Sound energy

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

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.

~~input = 240V / 5 a~~
~~Output = 2000 V / 1 amp~~
~~$\frac{V_p}{V_s} = \frac{n_p}{n_s} = \frac{2000}{240}$~~

$P = V \times I$

input = $240 \times 5 = 1200$ W

$2000 \times 1 = 2000$ W

The transformer label is suggesting that it is somehow creating energy from raising the voltage & lowering current, due to the laws of conservation of energy this is impossible

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: $g = 9.8\ \text{m s}^{-2}$ $m = 300\ \text{kg}$ $\Delta h = 200\ \text{km}$ $W = Fs$ $= mg\Delta h$ $= 3\times10^2 \times 9.8 \times 2.0 \times 10^5$ $= 5.9\times10^8\ \text{J}$	Data: $G = 6.67\times10^{-11}\ \text{N m}^2\ \text{kg}^{-2}$ $r_{\text{Earth}} = 6.38\times10^6\ \text{m}$ $r_{\text{orbit}} = 6.58\times10^6\ \text{m}$ $M = 6.0\times10^{24}\ \text{kg}$ $m = 300\ \text{kg}$ $W = \Delta E_p$ $\Delta E_p = E_{p\ \text{final}} - E_{p\ \text{initial}}$ $= -\frac{GMm}{r_{\text{orbit}}} - \left(-\frac{GMm}{r_{\text{Earth}}}\right)$ $= -1.824\times10^{10} - (-1.881\times10^{10})$ $= 5.7\times10^8\ \text{J}$

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

The radius of the Earth & Earth's gravitational acceleration are both accepted values which may vary in real world application. Because the two models use different accepted values which have slight variation on true value the results from each calculation are slightly different

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

This is because the accepted values of Earth's radius & gravitation acceleration are very close to their actual values, leading to the similar results of the calculations

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**

$F = \frac{mv^2}{r}$ | $F = G\frac{m_1 m_2}{d^2}$

$= \frac{6.67\times10^{-11} \times 300 \times 6\times10^{24}}{200\,000^2} = 3.0015\times10^6$

$\frac{F \times r}{m} = v^2$

$\frac{3.0015\times10^6 \times 6.58\times10^6}{300} = v^2$

$= 6.58\times10^{10}$

$\therefore V = 256.58\times10^3$ m/s

End of Question 26

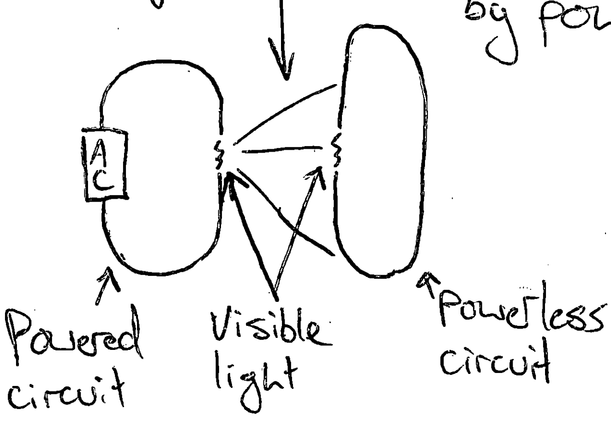
Question 27 (6 marks)

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 the theory by setting up two ~~conduction~~ current carrying conductors, one with a power source the other without each with gaps in the circuit. When the circuit w/ the power source had a current passed through it it created sparks across the gap in the coil. The other coil was also shown to spark across the gap in its circuit, denoting the fact that another invisible wave was being emitted from the gap in powered conductors sparks. Hertz had discovered the x-ray. Hertz was also able to calculate the speed of which this wave travelled & concluded that it travelled a 3×10^8 m/s, the speed of light. From this he was able to calculate the wavelength of the new wave by firing the waves at a mirrored surface & inspecting the interference pattern. Hertz concluded that the new wave had a higher frequency & longer wave length than visible light

Diagram: x-rays being emitted from powered circuit & absorbed by powerless circuit.



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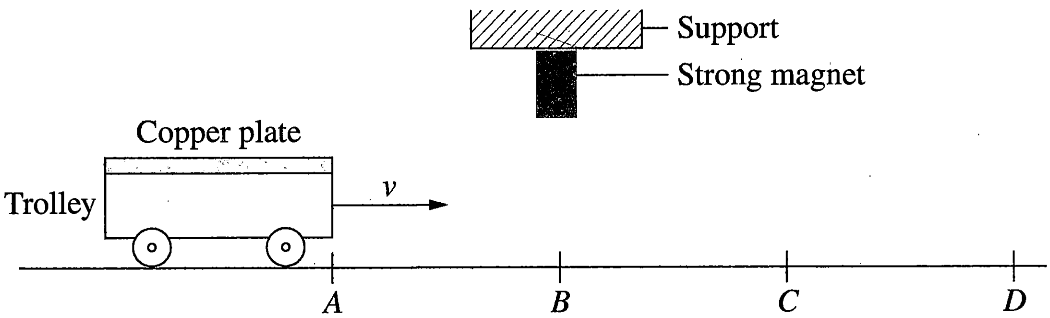
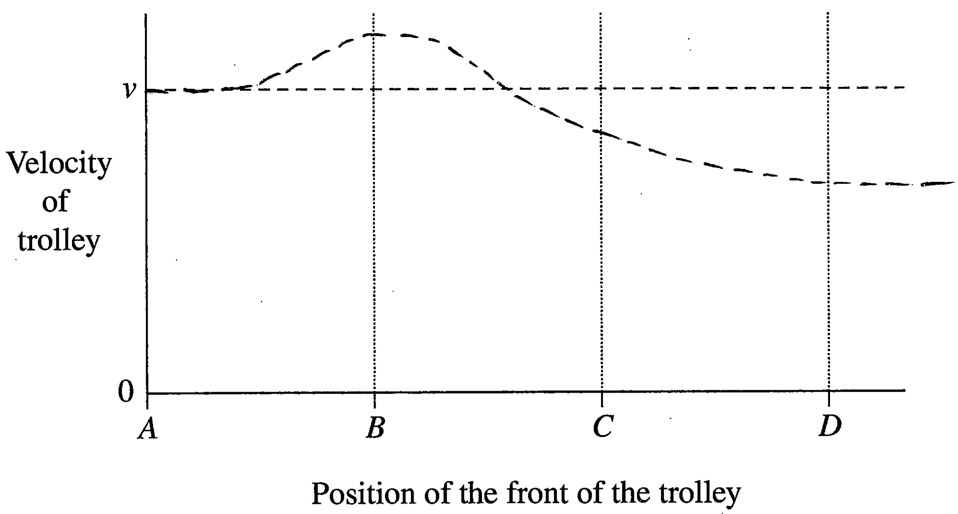
Question 28 (5 marks)

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 travels from A to B, the strong magnet pulls the trolley closer to it, increasing its velocity for a small amount of time. As the magnet draws closer to the trolley the trolley starts to speed up but this then causes the magnet to be insuccesful in stopping the trolley, instead allowing it to pass under ~~the~~ it. After the trolley passes the magnet the magnet is still trying to attract the copper plate pulling it back towards the magnet, creating a pulling force acting against the trolleys velocity, thereby decreasing its velocity until the magnet is too weak.

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**

Superconductors have zero electrical resistance, meaning that they can create are extremely strong electromagnets without resistance

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

Special relativity is applied to the protons in the LHC as they travel at speeds almost reaching c. Because of this their mass & length drastically change as does their subatomic particles. Because of this the theory of special relativity is required to be applied to these protons of the Large hadron Collider.

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	Slingshot	Slingshot	Slingshot	Slingshot	Orbit
15/10/1997	26/4/1998	24/6/1999	18/8/1999	30/12/2000	1/7/2004

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

Each planet gives off some of it's energy to the Cassini to keep it in orbit, but this energy is not strong enough to keep it in orbit, instead allowing the cassini to slingshot around the planets atmosphere, losing no energy in the process. This allowed the cassini to reach Saturn without total reliance on fuel which would've made the journey impossible. Newton's law state that energy cannot be created nor destroyed only transformed & that every reaction has an equal & opposite reaction, these two laws combined helped scientists to determine whether the space probes mission was possible.