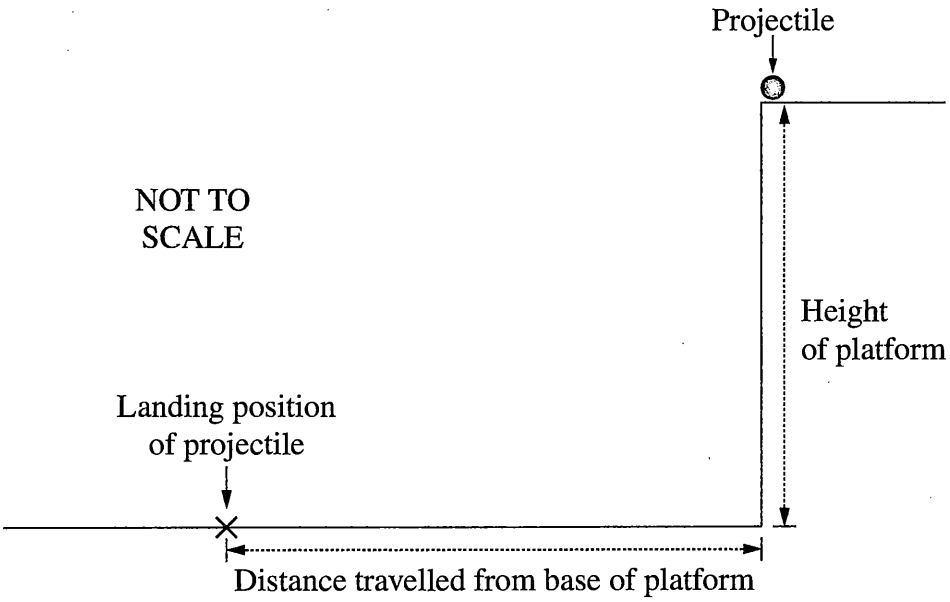
Question 21 (4 marks)

A projectile is fired horizontally from a platform.



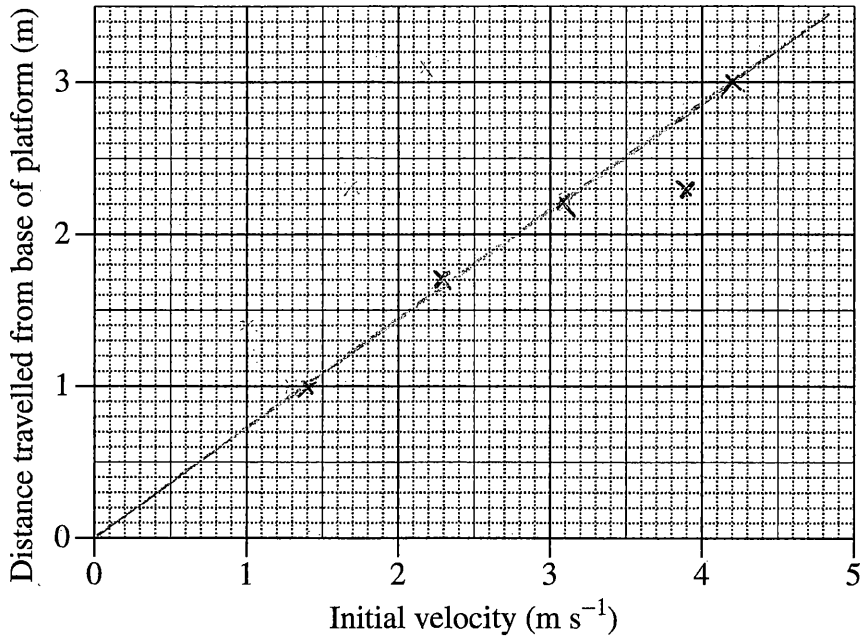
Measurements of the distance travelled by the projectile from the base of the platform are made for a range of initial velocities.

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**

falling time $= \frac{2.2-1}{3.1-1.4}$

$= 0.705$

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

$u_y = 0 \quad a_y = 9.8$

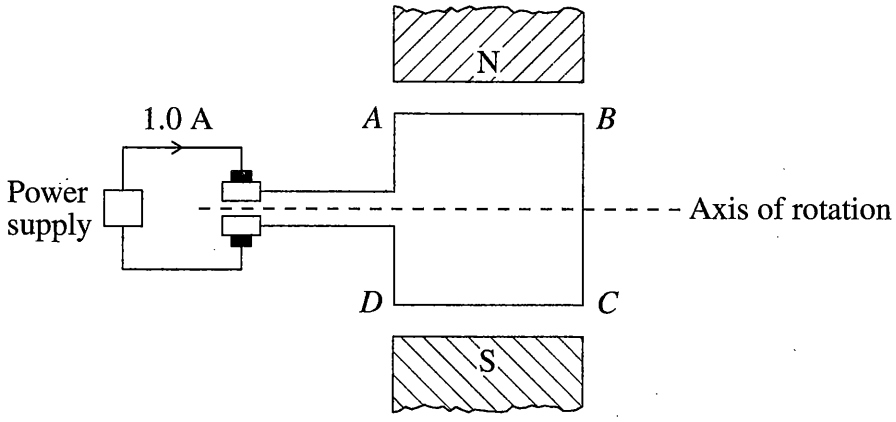
$\therefore \Delta y = 0.5 \times 9.8 \times (0.705)^2$

$= 2.44$ 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**

$T = nBIA\cos\theta$

$= 1 \times 0.01 \times 1 \times (0.05 \times 0.05) \times \cos 0$

$= 0.0000025$ N

~~Side AB = 2.5×10^{-5} N downwards~~

Side AB

$F = BIL\sin\theta$

Side AB

$F = 0.01 \times 1 \times 0.05 \times \sin 90°$

$= 5 \times 10^{-4}$ N downwards

Side BC

$F = 0.01 \times 1 \times 0.05 \times \sin 0°$

$= 0$ N

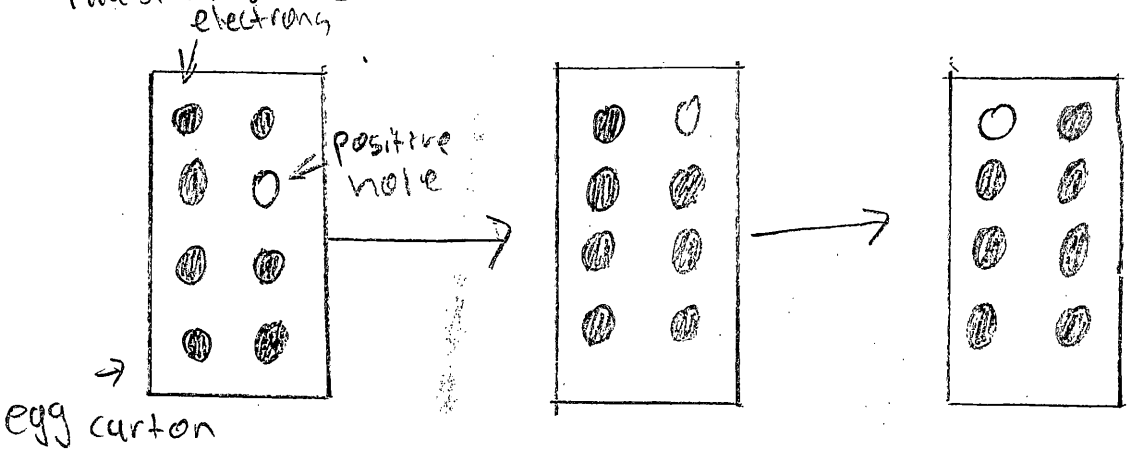
(b) How is the direction of the torque maintained as the loop rotates 360° from the position shown? **2**

the direction of torque is maintained using a split ring commutator which reverse the current every half cycle inorder to keep the motor spinning in one direction.

Question 23 (5 marks)

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

A p-type semi-conductor can be modeled using an egg carton and styrofoam balls. The balls are the electron and holes in the carton ~~are~~ + valence shell. Since in ~~the~~ a p-type semi-conductor there is one less electron and thus a positive hole is formed. The movement of the positive hole is illustrated below.

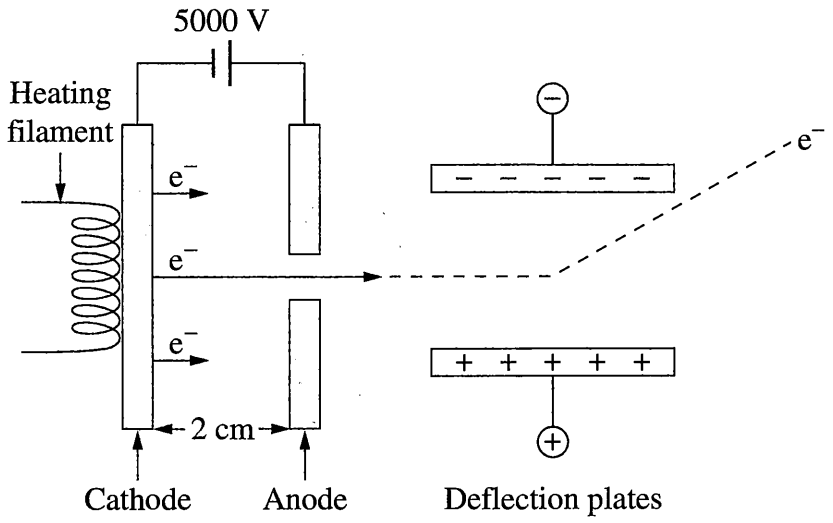


(b) Explain a limitation of the model outlined in part (a). **2**

The limitation of the model is not a true representation of the cause of the movement of positive holes since there is no ~~way to demonstrat~~ indication that an electric field was applied which is needed inorder to cause the movement of positive holes. Also positive holes are circles they are ~~regions of the~~ just positive regions thus this representation is also inaccurate.

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**

When an electron experiences a force caused by an electric field it is ~~not to be~~ does not cause its ~~to be~~ ~~bent~~ path to be bent at a sharp angle rather the electron will follow a curved path. ~~This is because when the~~ Also the electron experiences a force as soon as it enters the electric field not ~~at~~ just in the ~~middle~~ later half. thus the representation is inaccurate.

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**

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

$E = \frac{5000}{0.02}$

$= 250000$

$E = \frac{F}{q}$

$\therefore F = qE$

$\therefore N = 250000 \times 1.602 \times 10^{-19}$

$= 4.005 \times 10^{-14}$ N

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

$E_k = \frac{1}{2}mv^2$

$v^2 = \frac{2E_k}{m}$

$= \frac{250000 \times 2}{9.109 \times 10^{-31}}$

~~$\therefore V = 5.24 \times 10^{17}$ m/s~~

$V = 5.48 \times 10^{35}$ m/s

End of Question 24

Question 25 (6 marks)

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

~~One~~ electrical energy can be converted into useful forms of energy through devices. One device is a television which converts electrical energy into light, sound and heat energy. Another device that converts electrical energy is a radio which converts electrical in sound, an heat and also light if there is a light source present on the radio.

(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.

~~According to the equation~~ The law of conservation of energy states that energy cannot be created nor destroyed. Using the formula)

$\frac{V_P}{V_S} = \frac{I_S}{I_P}$ ← The current flowing in the out voltage should be 0.024 A

$\frac{240V}{2000} = \frac{I_S}{5}$ ~~This means that extra~~ ~~is~~ not 1 A therefore extra energy has been created

$\therefore I_S = \frac{240V \times 5}{2000}$ and thus is a violation of the law of conservation of energy and the label is incorrect.

$= 0.024\ A$

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: $G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$ $r_{\text{Earth}} = 6.38 \times 10^6 \text{ m}$ $r_{\text{orbit}} = 6.58 \times 10^6 \text{ m}$ $M = 6.0 \times 10^{24} \text{ kg}$ $m = 300 \text{ kg}$ $W = \Delta E_P$ $\Delta E_p = E_{p\,\text{final}} - E_{p\,\text{initial}}$ $= -\frac{GMm}{r_{\text{orbit}}} - \left(\frac{GMm}{r_{\text{Earth}}}\right)$ $= -1.824 \times 10^{10} - \left(-1.881 \times 10^{10}\right)$ $= 5.7 \times 10^8 \text{ J}$

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

In model X the gravitational acceleration is assumed to be constant even as altitude increases whereas in model Y the equation takes into consideration the changing values of gravitational acceleration as altitude increases, a decrease in value as altitude increases.

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

Since the altitude is not that high the change in the value of ~~gravitation~~ gravitational acceleration has not change significantly thus the results are very close.

Question 26 continues on page 22

Question 26 (continued)

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

equate centripetal and universal gravitation equation

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

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

$v = \sqrt{\frac{GM}{r}}$

$v = \sqrt{\frac{6.67\times10^{-11} \times 6.0\times10^{24}}{(6.38\times10^{6}+200)}}$

~~$= 7919.93$ m/s~~

$= 7798.76$ m/s

End of Question 26

Question 27 (6 marks)

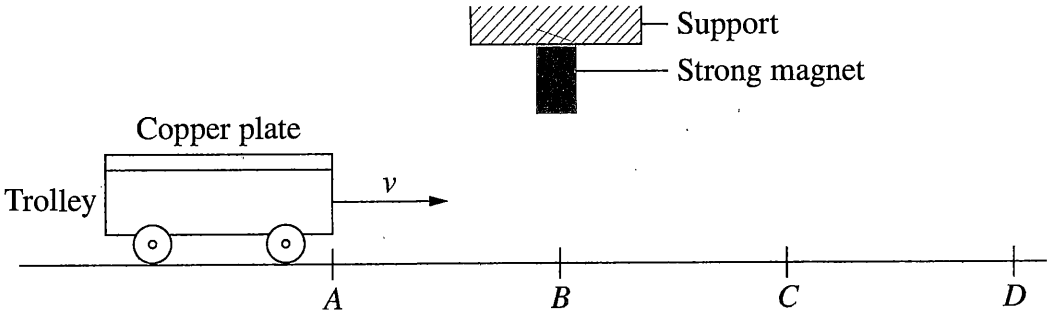
In 1865, James Clerk Maxwell developed the theory of electromagnetism. This theory explained the nature of light. It also predicted the existence of other electromagnetic waves. **6**

How did Hertz test and validate Maxwell's theory?

Hertz connected a primary loop with spherical electrodes to an induction coil which resulted in sparks being produced between the electrodes. Hertz then ~~got~~ held a secondary loop with spherical electrodes near the primary loop and a spark was also created in the secondary loop. Hertz concluded that since the secondary wasn't connected to an external circuit the spark was created by the detection of an EMR produced by the ~~first spa~~ primary loop. The EMR that was produced ~~was~~ were radio waves. Hertz was able to measure the speed of the radio waves by ~~using t~~ calculating the frequency and wavelength $V = f\lambda$. The frequency could be predetermined since it was the same as the frequency of the supplied AC current. The wavelength was calculated ~~that~~ by sending the EMR to follow to ~~dif~~ slightly different pathways creating an interference pattern. Thus using the frequency and wavelength Hertz found that the Radio waves travelled at the same speed as light which validated Maxwell's theory that other electromagnetic waves had the same speed as light. Also Hertz demonstrated that the Radio waves also shared other similar properties with light including reflection, retraction and polarisation further supporting Maxwell's theory of the existence of other electromagnetic waves that shared certain properties with light.

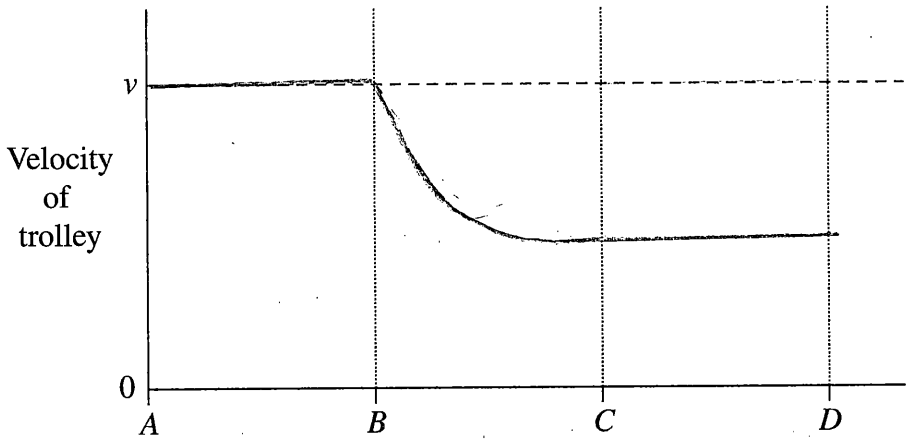
Question 28 (5 marks)

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.



The ~~cop~~ trolley at ~~plate~~ point B experiences a changing magnetic flux due to the relative movement between the trolley and the magnet. According to lenz's law this results in the production of eddy currents that create a magnetic field to oppose the change in magnetic flux, thus slowing down the movement at the train. ~~the~~ As the trolley slows down between B and C the eddy currents also become proportionally smaller so the decrease at decreasing rate. Between C and D if there is no magnetic field so the velocity is not affected and continues.

Velocity

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**

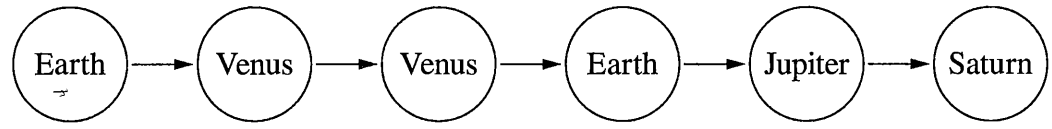
Superconductors have zero resistance ~~that~~ this means that electrical energy is not converted into heat energy and is used fully to produce a magnetic field resulting ~~a~~ in a much stronger magnetic field that can accelerate protons around LHC to greater speeds.

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

~~Since the~~ Since the particle is approaching the speed of light, mass dialation will occur. Since the speed of the electron cannot exceed the speed of light according the Einstein's equation $E=mc^2$, the extra energy that is applied to accelerate the object to the speed of light will be converted into mass. thus the electrons mass will increase rapidly approaching infinity.

Question 30 (6 marks)

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



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.

Law of Universal gravitation States that any two objects with mass will exert an attractive force on each other. ~~This~~ Thus the ~~planets~~ slingshot effect can be exploited to gain a boost in velocity for the ~~rocket~~ space probe the rocket approaches a planet such as Venus which occured on the 26/4/1998 and is ~~attracted~~ experiences a force ~~that p~~ due to gravity that pulls the spacecraft towards the planet which results in an increase in velocity. As the ~~rocket~~ space probe leaves it loses the velocity relative to the planet but gains velocity relative to the sun due to the dragging effect of the planets orbit around the sun. When the space probe arrived at saturn ~~inorder~~ inorder to ~~orbit~~ maintain a circular orbit a force is need according to Newton's third law where objects travel with uniform motion in straight lines unless acted upon by a force. Thus the force that is needed is provided by gravity, ~~which acts~~ centripetal force thus allowing the space probe to orbit ~~the~~ Saturn.