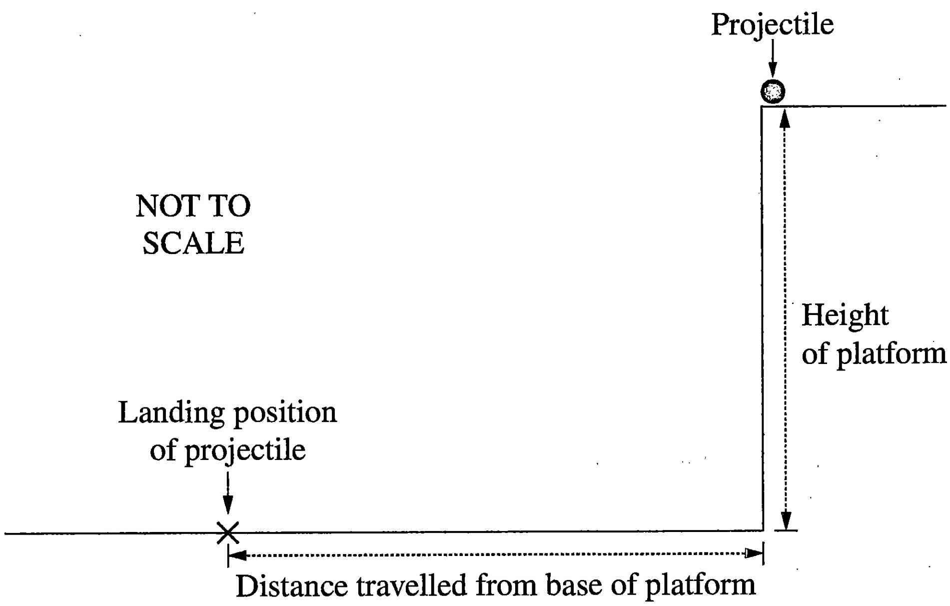
Question 21 (4 marks)

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

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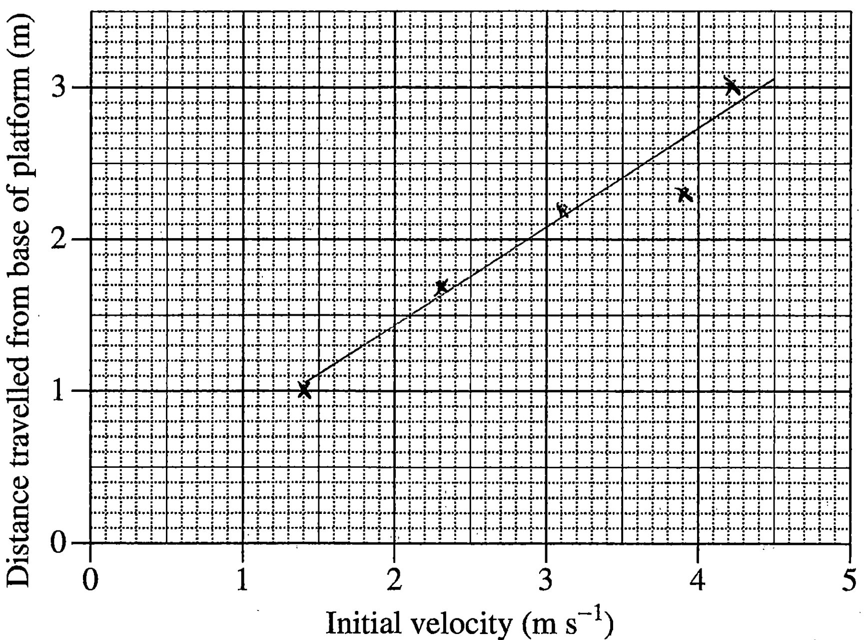
Question 21 (continued)

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



$d =$

$S = \frac{d}{t}$

$\Delta x = u_x t$

$\Delta x = 3,\ u_x = 4.2$

$3 = 4.2t$

$t = 0.78$

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

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

$\Delta y = (0)(t) + \frac{1}{2}(9.8)(0.71)^2$

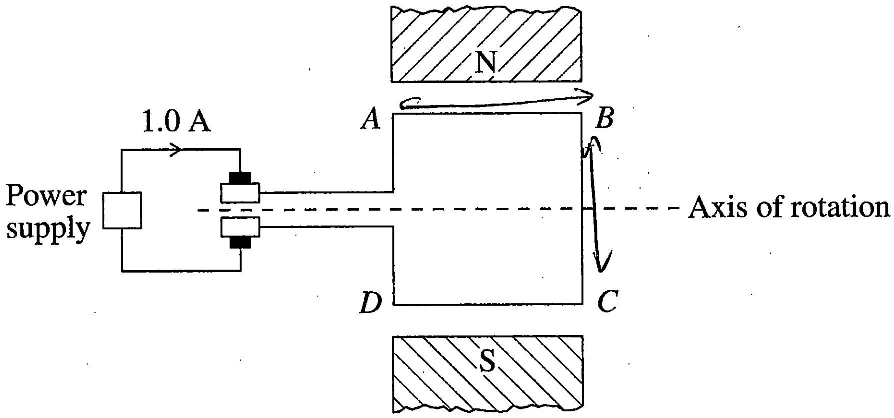
$\Delta y = 2.47009$

$\therefore$ height of platform = 2.5 m (1 dec. place)

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 = 1.0 , B = 0.01 , l = 0.05

(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**

F = BIL sin θ

For (BC) F = (0.01)(1.0)(0.05) sin 90
F = 0.0005
F = 500 × 10⁻⁶ N

~~AB F = (0.01)(1.0)(0.05)~~

AB is parallel to the magnetic field and hence will not experience a force.

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

Torque is defined as the "turning" effect of force, given a magnitude and vector quantity. When rotated the torque will be maintained in a clock wise direction.

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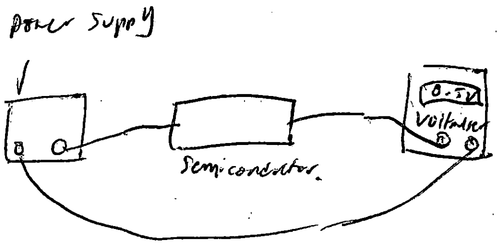
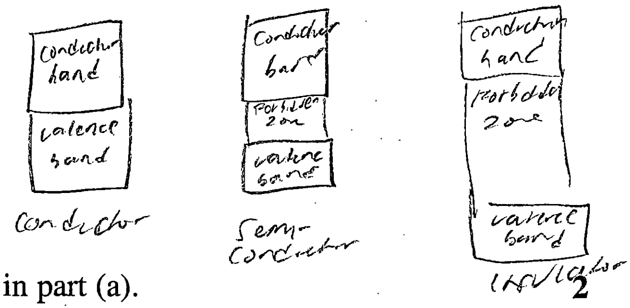
Question 23 (5 marks)

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

Semiconductors can be modelled through the use of doping, and then comparing the electrical conduction to insulators and conductors on the basis of band structure. This is done so using a power source, ~~wiring~~ connecting wires to the semi-conductor and determining the reading on a connected volt meter, which gives a reading of a semiconductors ability as an electrical conductor. [This can then be compared to show electrical conduction.]



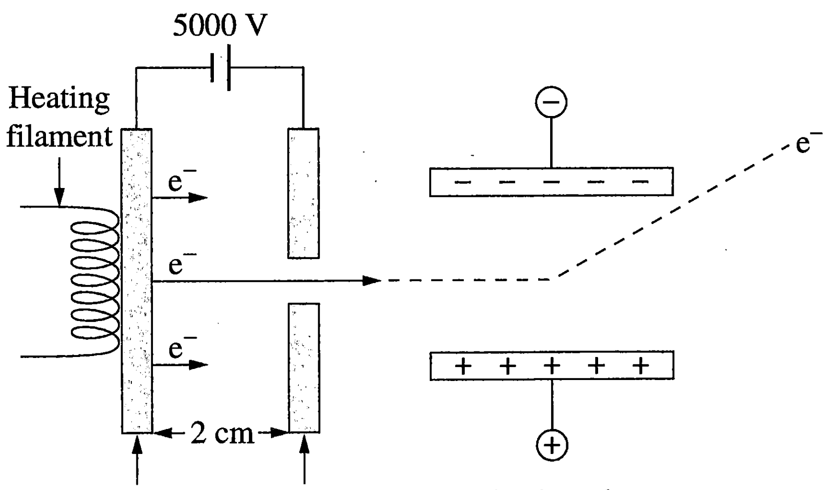


(b) Explain a limitation of the model outlined in part (a). **2**

It requires the use of a power source, and conduction of electricity. Therefore caution needs to be taken as electrocution may occur. Furthermore it only gives a rough estimate of a semi-conductors ability as an electrical insulator, and faulty equipment may result in inaccurate readings, making the experiment null. & so essentially safety and accuracy.

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**

Deflection plates are utilised to affect the ~~elec~~ cathode ray particles. It is evident that the cathode rays are being attracted to the negative plates which ~~is~~ is incorrect as cathode rays are electrons and consequently negatively charged. This means in reality the opposite would occur, the electrons would travel in the direction of the positive plates. This theory was proven by British physicist JJ Thomson.

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**

$V = 5000, \; d = 2cm$

$E = \frac{V}{d}$	$E = \frac{F}{q}$
$E = \frac{5000}{0.02}$	$250000 = \frac{F}{-1.602 \times 10^{-19}}$
$E = 250000 \; V.M$	
	$F = (250000)(-1.602 \times 10^{-19})$
	$F = -4.005 \times 10^{-14} \; N$

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

$F = \frac{mv^2}{r}$, where $r = \frac{2.0}{2} = 1.0$

$4.005 \times 10^{-14} = \frac{(9.109 \times 10^{-31})(v)^2}{1}$

$4.005 \times 10^{-14} = 9.109 \times 10^{-31} \times v^2$

$4.39675046 \times 10^{-46} = v^2$

$v = \sqrt{4.39675067}$

$v = 2.09$

$2.0968429 \times 10^{-23}$

$v =$ (1. dec place.)

2.1×10^{-23}

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**

Toasters : electrical energy → heat energy. used for toasting food.
Speakers: electrical energy → sound energy used to produce sound energy from other sources (eg: TV, computers ..)

(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

$P = VI$, $P = I^2R$, $R = \frac{V}{I}$

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

According to the law of conservation of energy, the amount of power outputted must be equal to the amount of input energy (neglecting energy loss). The output value is seen as being greater than the input which contradicts this law and hence it must be incorrect.
using $P = VI$, the input power is shown to be $P = (240) \times (5.0) = 1200$ W, contradicting the output power $P = (2)(1.0) = 2$ kW. which is greater than input and hence supports the theory that the label is not correct.

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

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

model X assumes that the altitude is 200 km, neglecting radius and orbit of earth. model Y takes this into account and hence gets a different reading of that of model X

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

The difference between r orbit and r earth are very close in value. when subtracted from one another Ep final - Ep initial, the difference is very small, given only a slight variation in answers.

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**

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

$2940 = \frac{(6.0\times10^{24})(v)^2}{6.58\times10^6}$

$1.93452\times10^{10} = 6.0\times10^{24}\times v^2$

$3.2242\times10^{-13} = v^2$

$v = \sqrt{3.2242\times10^{-13}}$

$v = 5.67820539411\times10^{-6}$

$v = 5.7\times10^{-6}\ ms^{-1}$

ignore

End of Question 26

$F = mv^2$ ... $v+$ ... 9.8 ... 2940 N

$F = 3\times10^2\times9.8$

$F = 2940$

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

$2940 = \frac{300\times v^2}{6.58\times10^6 - 20000}$

$300\times v^2 = 2940\times(6.58\times10^6 - 20000)$

$300v^2 = 1.92864\times10^{10}$

$v^2 = 64288000$

$v = \sqrt{64288000}$

$v = 8017.47995$

$v = 8018$ (nearest whole)

∴ orbital velocity of satellite $= 8018\ ms^{-1}$

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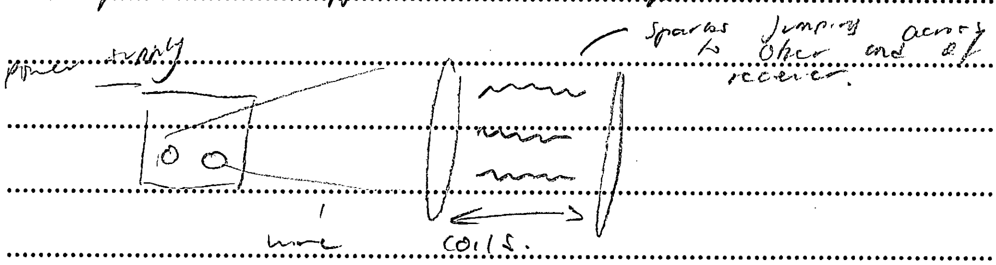
Question 27 (6 marks)

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?

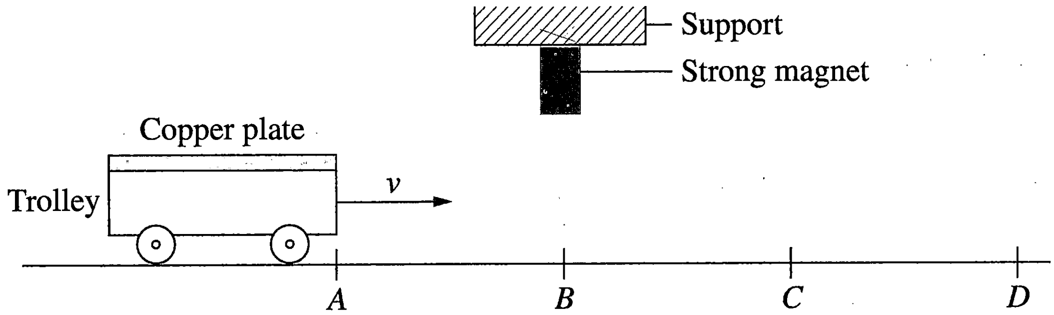
Hertz created an experiment that produces radio waves, another form of electromagnetism, as shown by Maxwell's equations. Hertz's experiment involved a spark jumping across a gap when electricity was applied. ~~sparks~~. The experiment was ~~thus proved the existence of Maxwell's~~ ~~the radio waves~~ shown to produce radio waves ~~truth~~ and hence validated Maxwell's theory of the electromagnetic spectrum. Hertz's experiment relied on the coils induction when a potential difference was applied.



With only visible light being confirmed, Hertz showed that other EM forms did indeed exist and hence provided proof for Maxwell's theories and equations. In terms of validation, ~~it~~ ~~proved that his equations were~~ it only proved some equations, it wasn't until the discovery of a variety of EM waves that ~~it~~ completely validated Maxwell's theory.

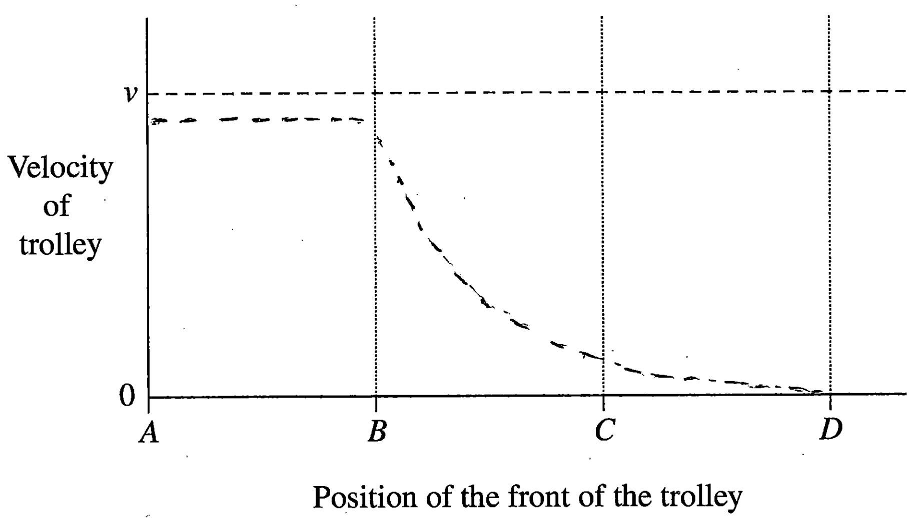
Question 28 (5 marks)

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.



Copper is a metal ~~material~~, so when the lightweight trolley ~~trolley~~ ~~passes~~ reaches point B, the copper plate is attracted to the strong magnet, causing resistance in the trolley. A-B remains ~~for~~ almost constant velocity, however velocity drops at quite significantly when passing through B-C. Points C-D never pick up again as velocity is lost and not ~~regenerated~~ re established.

due to resistance (attraction of metal + magnet)

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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**

Superconductors provide an advantage as they ensure a magnetic field with zero resistance. This means that the protons would be able to travel at speed greater than 0.9999 c, without losing speed due to resistance.

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

The protons are travelling almost at the speed of light, so length contraction and mass dilation come into affect. In terms of the former $l_v = l_0 \sqrt{1 - \frac{v^2}{c^2}}$, as the protons reach the speed of light, the protons reduce in size, this is ideal as it allows less collisions of protons and hence greater speeds. As there is less resistance. The latter however is an issue $m_v = \frac{m_0}{1 - \frac{v^2}{c^2}}$, as it reaches the speed of light, the mass of the protons increase, meaning it will be harder to accelerate as it requires more force to accelerate (F = ma)

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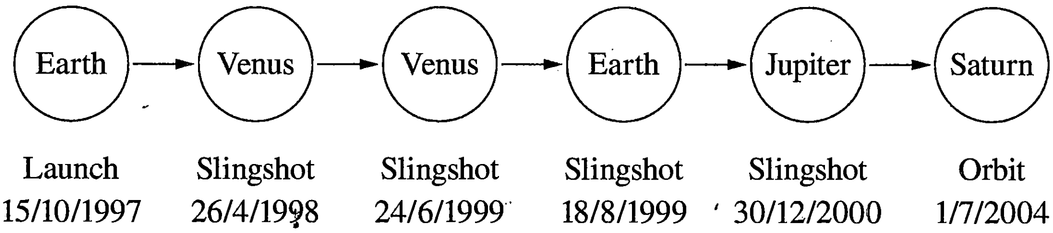
Question 30 (6 marks)

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



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

Universal gravitational was applied ~~throughout~~ multiple ~~[illegible]~~ times during the cassini space probe in mission. This is evident ~~[illegible]~~ from venus-Jupiter the slingshot effect was utilised in order to gain a boost in velocity ~~[illegible]~~ by using the equation and universal ~~gravitat~~ gravitation. This was used in order to save time, however more importantly resources ~~[illegible]~~. By gaining a boost in velocity, less fuel is consumed, hence making the trip reduce in cost. Newton's laws of motion come into effect during flight, as F=ma and g-forces are a significant issue when it flight. On the basis of Newton's Law's, countermeasure are taken such as using contoured seats, ~~or~~ "eye-balls in", or being seated horizontally ~~[illegible]~~ during flight. This is to reduce risks ~~[illegible]~~ such as ~~[illegible]~~ tunnel vision, headaches, or even death, as ~~[illegible]~~ predicted by Newton's Law's of motion. (inertia + equal opposite opp forces)

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