Baulkham Hills High School

Half Yearly Examination

2016

Year 12

Physics

General Instructions

- Reading time, 5 minutes
- Working time, 2 hours
- Attempt ALL questions
- Use black or blue pen only (black pen preferred)
- Ensure Data Sheet, Periodic Table and Formulae Sheet are included with this paper
- Before commencing, please check to confirm that all pages are correctly collated.
- Show all working.

Total Marks: 75

This paper consists of TWO sections

Section I (Multiple Choice)
Questions 1-20
20 marks
Pages 1-7

Section II (Extended Response)
Questions 21-34
55 marks
Pages 9-21

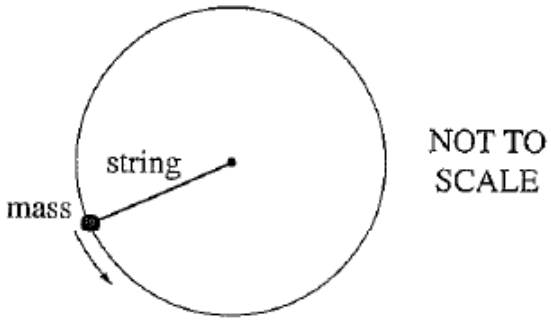
Section I – Multiple Choice
20 marks
Select the response which best answers the question and indicate your choice by placing an 'X' over A, B, C or D on the Multiple Choice answer sheet provided

---

1. A radioactive particle is used in a linear accelerator. Measured at rest relative to the laboratory it has a half life of 2.5μs. When measured at constant speed by an observer in the laboratory, its half life has increased to 10μs.

   What is the speed of the particle relative to the laboratory?
   a) 1.68×10^8 ms $^{-1}$
   b) 2.10×10^8 ms^{-1}
   c) 290 000 000 ms^{-1}
   d) 2.60×10^8 ms^{-1}

2. A 200g mass is swung in a horizontal circle as shown. It completes 5 revolutions in 3 seconds. The Circle has a 2m diameter.



   Which of the following forces is closest to that required to keep the mass moving in this circle?
   a) 0.50 N
   b) 2.5 N
   c) 10 N
   d) 20 N

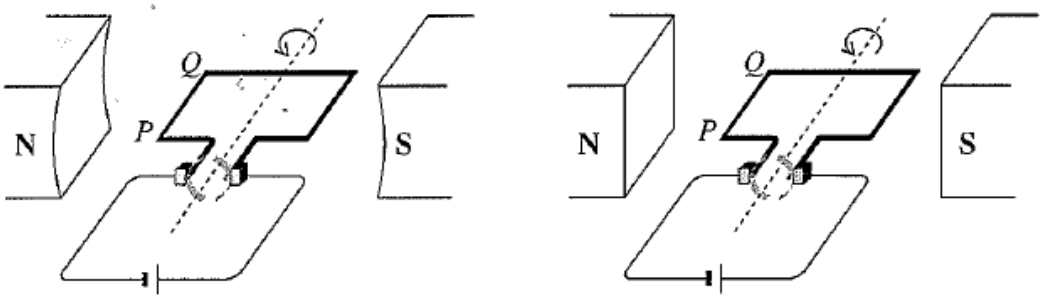
3. The table contains information related to two planets orbiting a distant star.

Planets	Mass (kg)	Orbital Radius (m)	Radius of Planets (m)	Length of day(s)	Orbital period(s)
Ying	1.21×10^{25}	4.00×10^{11}	8.0×10^6	9.5×10^4	8.75×10^7
Yang	1.50×10^{24}	8.00×10^{11}	4.0×10^6	4.7×10^4	-

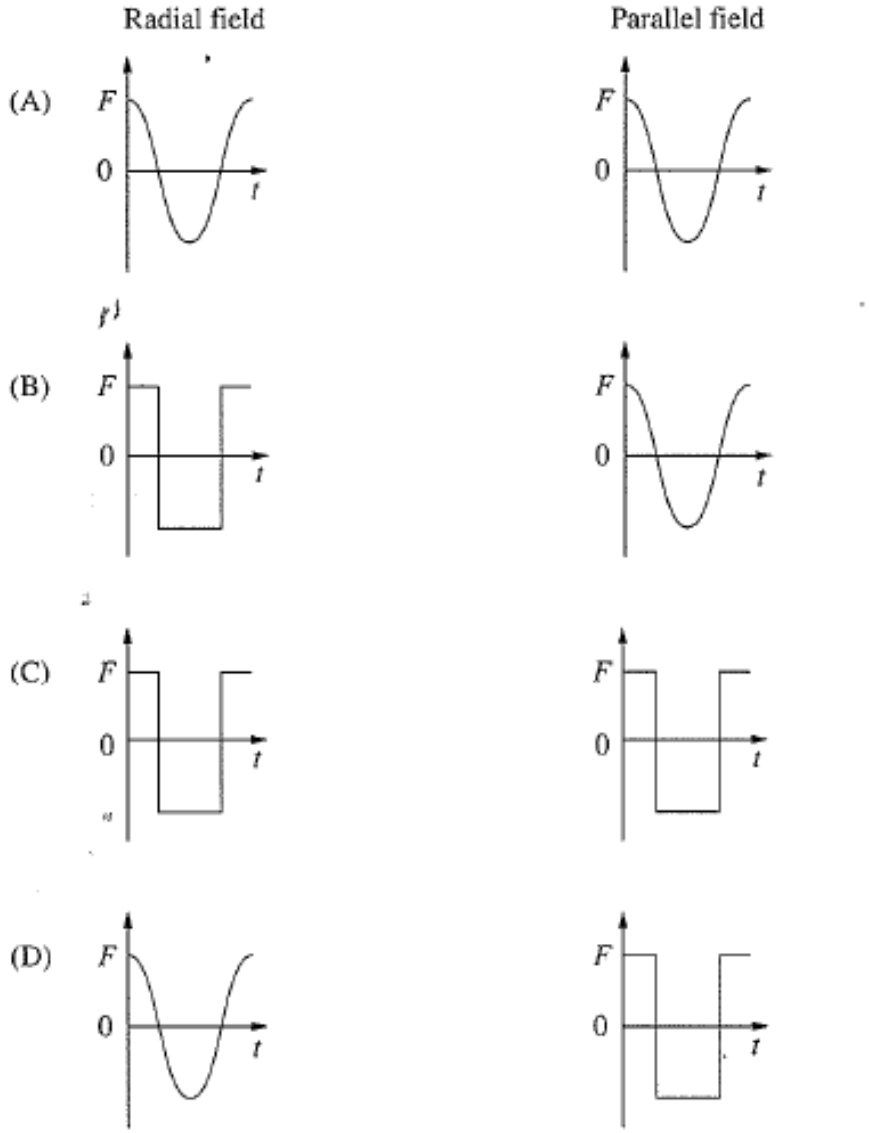
   The orbital period of the planet Ba can be determined by using data selected from this table.

   What is the orbital period of the plant Yang?
   a) 3.10×10^7s
   b) 5.51×10^7s
   c) 1.39×10^8s
   d) 2.47×10^8s

4. The diagrams show a wire loop rotating anticlockwise in a radial magnetic field and in a parallel magnetic field. There is a constant current in the wire loop.



Which pair of graphs best describes the behaviour of the force (F) on the length of wire PQ as a function of time (t) for one revolution of the wire loop?



5. A pendulum is used to determine the value of acceleration due to gravity. The length of the pendulum is varied, and the time taken for the same number of oscillations is recorded.

Which of the following could increase the reliability of the results?

a) Changing the mass of the pendulum
b) Identifying the independent and dependent variables
c) Recording all measurements to at least four significant figures
d) Repeating each measurement several times and recording the average

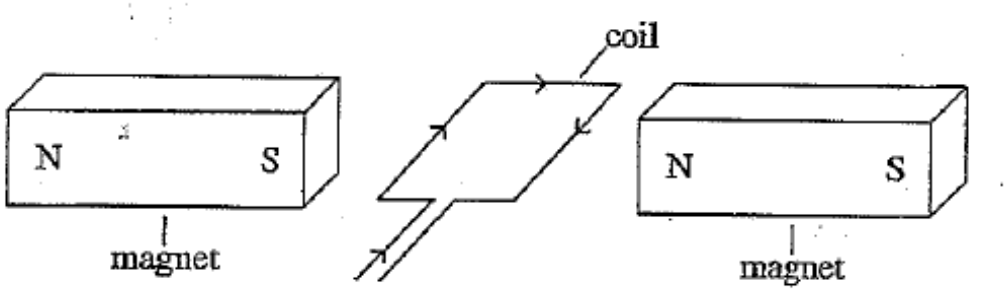
6. Which of the following best describes Galileo's analysis of projectile motion?

a) A projectile launched with a great enough velocity would escape Earth's gravity
b) A projectile would travel in a straight line until it ran out of momentum, then is would fall
c) A projectile launched from the equator towards the east with a great enough velocity would orbit Earth
d) A projectile would travel in a parabolic path because it has constant horizontal velocity and constant vertical acceleration.

7. Which of the following factors does NOT affect the escape velocity of an object from Earth?

a) The mass of the object.
b) The mass of the Earth
c) The radius of the Earth
d) The gravitational constant (G)

8. The following diagram shows a coil of wire between two magnets.



When a current passes through the coil in the direction shown, which is now free to move, the coil will:

a) start rotating clockwise (viewed from the front)
b) not move
c) move vertically
d) start rotating anticlockwise (viewed from front)

9. The Michelson-Morley experiment was unsuccessful in proving the existence of the ether because:

a) the apparatus was not sensitive enough
b) length contraction in the arm perpendicular to the "ether wind" occurred
c) the speed of light is constant and is independent of the motion of the source or observer
d) the ether was "carried along" with the Earth

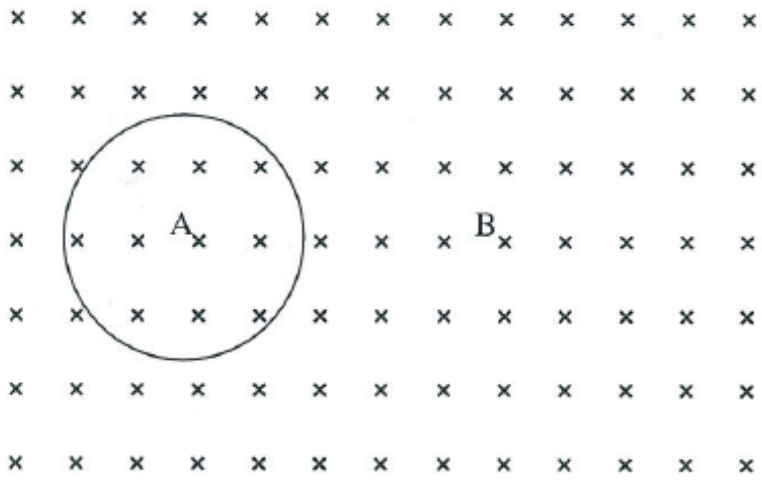
10. A thin copper rod 1.0 m long has a mass of 0.05 kg and is in and perpendicular to a magnetic field of 0.10 T. What minimum current in the rod is needed in order for the magnetic force to cancel the weight of the rod?

a) 1.2 A
b) 2.5 A
c) 4.9 A
d) 9.8 A

11. Why are spacecraft that are placed into orbit around the Earth generally launched in an easterly direction?

a) To gain assistance from the wind
b) To help slow down the spacecraft so it can go into orbit
c) To reduce the interference from the Earth's magnetic field
d) To use the Earth's rotation to increase the spacecraft's speed

12. The diagram below shows a circular loop of conducting wire in a uniform magnetic field directed into the page.



Which of the following actions will not affect the magnetic flux passing through the loop?

a) removing the loop from the field
b) changing the strength of the magnetic field
c) reducing the circle to half of the original radius
d) moving the coil right, from *A* to *B*

13. A transformer is needed to convert an input voltage of 6000V to an output voltage of 240V. The **type of transformer** and the **ratio** of the number of turns in its secondary coil to the number of turns in its primary coil are:

a) step up, 25:1
b) step up, 1:25
c) step down, 25:1
d) step down, 1:25

14. Communications satellites are geostationary. The best description of their motion is that they:

a) Move in a low orbit from pole to pole
b) Move in a high orbit from pole to pole
c) Move in a low orbit parallel to the equator
d) Move in a high orbit parallel to the equator

15. Two long parallel wires are carrying electrical currents. The direction of the current in one of the wires is reversed. How does this affect the force between the wires?

a) The force does not change
b) The force changes direction
c) The force increases
d) The force decreases

16. The Earth, of radius and mass, 6.38×10^6 m and 5.98×10^{24} kg respectively, has an artificial satellite. The satellite orbits at an altitude of 300 km, has a mass of 200 kg and travels with a velocity of 20 000 km h^{-1}. The gravitational force acting on the satellite is:

a) 1.8×10^{-3} N
b) 2.3×10^{-1} N
c) 1.8×10^{3} N
d) 2.3×10^{3} N

17. The maximum torque on a current carrying loop occurs when the angle between the loop's plane and the magnetic field vector is:

a) 0°
b) 45°
c) 90°
d) 180°

18. The acceleration due to gravity on the surface of Titan, the largest moon of Saturn, is 1.4 m s^{-2} A space probe with a weight of 300 N on Earth has what weight on Titan?

a) 30.6 N
b) 42.9 N
c) 214.3 N
d) 420.0 N

19. The purpose of a commutator in a DC electric motor is to:

a) increase the strength of the magnetic field
b) reverse the direction of the current in the coil as it turns
c) apply a torque to the coil
d) increase the length of the coil

20. Why is high voltage used to transmit electrical energy from power station to users?

a) It helps to protect the system from lightning strikes
b) It allows the supporting structures to have smaller insulators
c) It minimises the effects of the electrical resistance of the wires
d) It ensures that, even with voltage losses, 240 V will still reach the user.

Student No: …… Teacher: ……...

Baulkham Hills High School

Half Yearly Examination

2016

Year 12

Physics

Answer Booklet

Section I – Multiple Choice
20 marks

Select the response which best answers the question and indicate your choice by placing an 'X' over A, B, C or D on the grid below

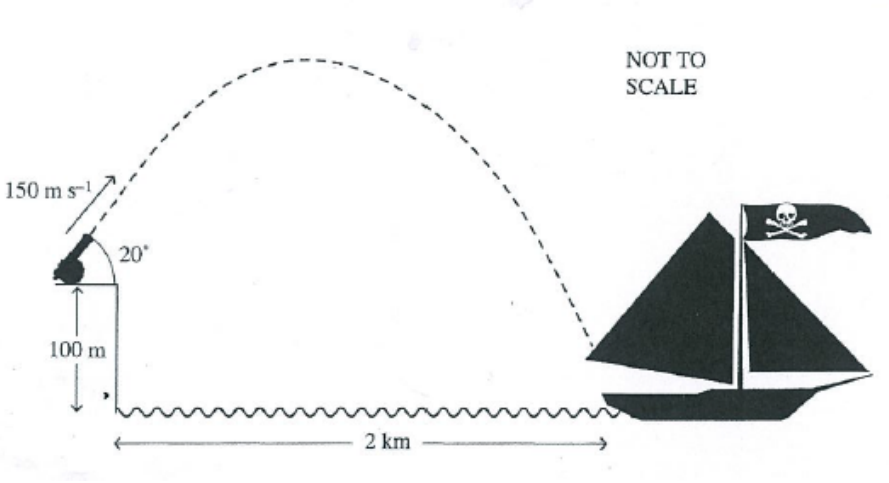
1	**A**	**B**	**C**	**D**
2	**A**	**B**	**C**	**D**
3	**A**	**B**	**C**	**D**
4	**A**	**B**	**C**	**D**
5	**A**	**B**	**C**	**D**
6	**A**	**B**	**C**	**D**
7	**A**	**B**	**C**	**D**
8	**A**	**B**	**C**	**D**
9	**A**	**B**	**C**	**D**
10	**A**	**B**	**C**	**D**

11	**A**	**B**	**C**	**D**
12	**A**	**B**	**C**	**D**
13	**A**	**B**	**C**	**D**
14	**A**	**B**	**C**	**D**
15	**A**	**B**	**C**	**D**
16	**A**	**B**	**C**	**D**
17	**A**	**B**	**C**	**D**
18	**A**	**B**	**C**	**D**
19	**A**	**B**	**C**	**D**
20	**A**	**B**	**C**	**D**

Section II – Extended Response
55 marks
Write your answers to this section in the spaces provided
Individual marks are indicated for each question

Marks

Question 21 (8 marks)



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a projectile at an angle of 20° to the horizontal, at a muzzle speed of 150ms^{-1}

a) Determine the vertical and horizontal components of the initial velocity? **2**

……

……

……

……

b) Calculate the **time** taken for the cannon ball to reach the maximum height **and** the maximum **height** of the cannon ball above the water. **2**

……

……

……

……

……

……

……

……

c) Calculate **2**

(i) the range of the cannon ball

……

……

……

……

……

(ii) how far from the ship the cannon ball landed **1**

……

……

d) Describe an adjustment of the cannon that is necessary for a cannon ball to hit the ship **1**

……

……

Question 22 (2 marks)

Clearly explain why all low earth orbit satellites will eventually fall to the Earth's surface. **2**

……

……

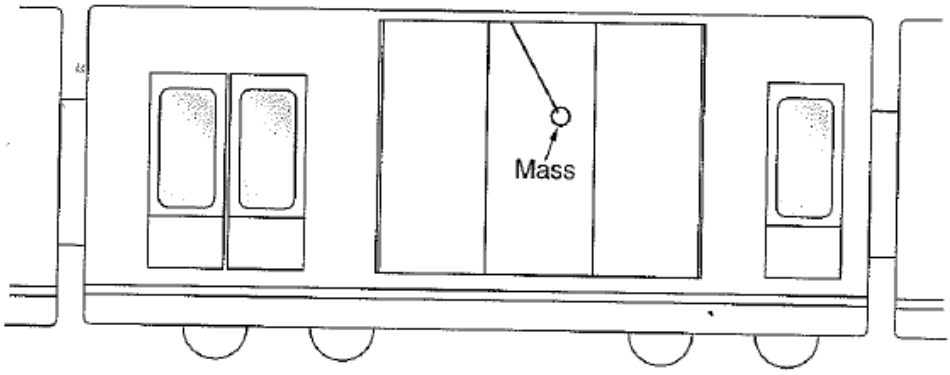
……

……

……

Question 23 (2 marks)

A train is travelling on a straight horizontal track. A student on the train attaches a mass on a string to the ceiling of the train. The student observes that the mass remains in a stationary position.



a) Why does the mass hang with the string at an angle to the vertical? **2**

……

……

Question 24 (3 marks)

Einstein used thought experiments to help explain some of the counter-intuitive aspects of special relativity. With the aid of a diagram, outline a thought experiment that demonstrates the relativity of simultaneity or another counterintuitive prediction of special relativity. **3**

……

……

……

……

……

……

……

……

……

……

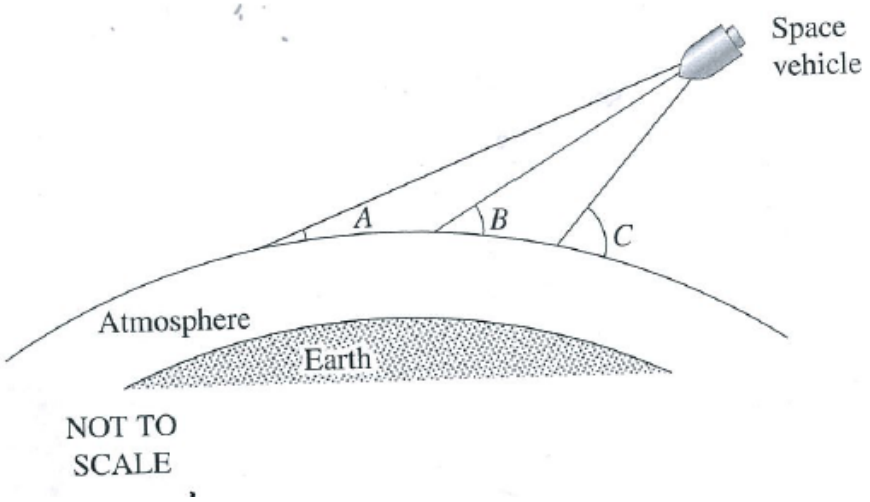
……

……

Question 25 (2 marks)

The optimum angle for safe re-entry of a space vehicle into Earth's atmosphere is angle *B*. **2**

Outline consequences of the space vehicle entering the atmosphere at angle *A* or angle *C*.



……

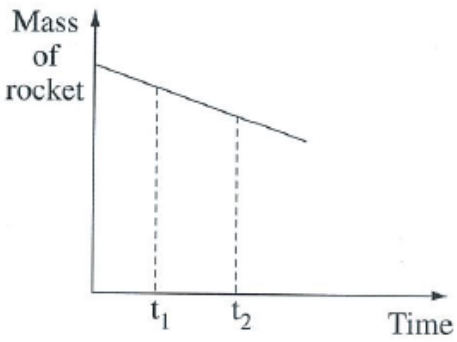
……

……

……

Question 26 (4 marks)

The mass of a rocket decreases during launch as it burns fuel, as shown in the graph.
The rocket engine produces a constant upward force on the rocket.



a) How does the law of conservation of momentum apply to the motion of the rocket? **2**

……

……

……

……

b) Why do the g-forces on an astronaut in the rocket differ at times t_1 and t_2. **2**

……

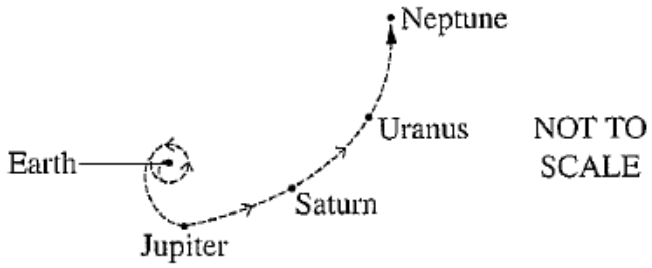
……

……

……

Question 27 (7 marks)

The diagram illustrates the path of a space probe launched from Earth and sent to Neptune.



a) Explain, using physics principles, why the space probe takes this path instead of travelling directly to Neptune. **3**

……

……

……

……

……

……

……

b) The space probe is placed in an orbit at an altitude of 188 km above Earth. Given Earth has a radius of 6380 km, calculate the periods of this orbit **2**

……

……

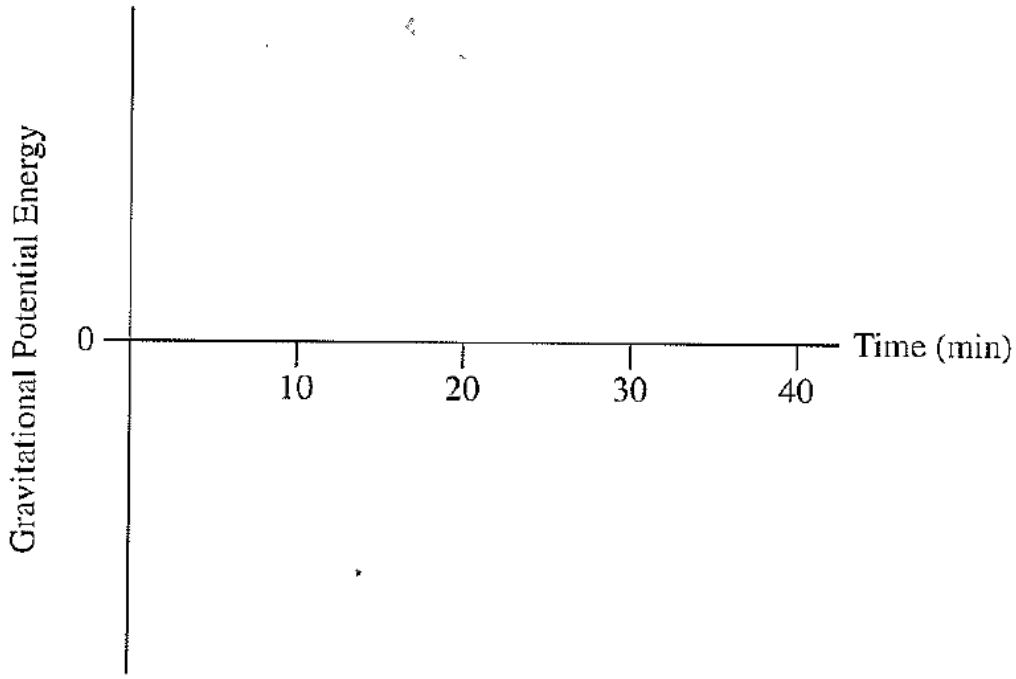
……

……

……

c) It takes 10 minutes for the space probe to reach its orbit around Earth and it remains in orbit for several hours. **2**

Sketch a graph on the axes showing the changes in gravitational potential energy for the first 40 minutes.



Question 28 (2 marks)

Define Lenz's law. **2**

……

……

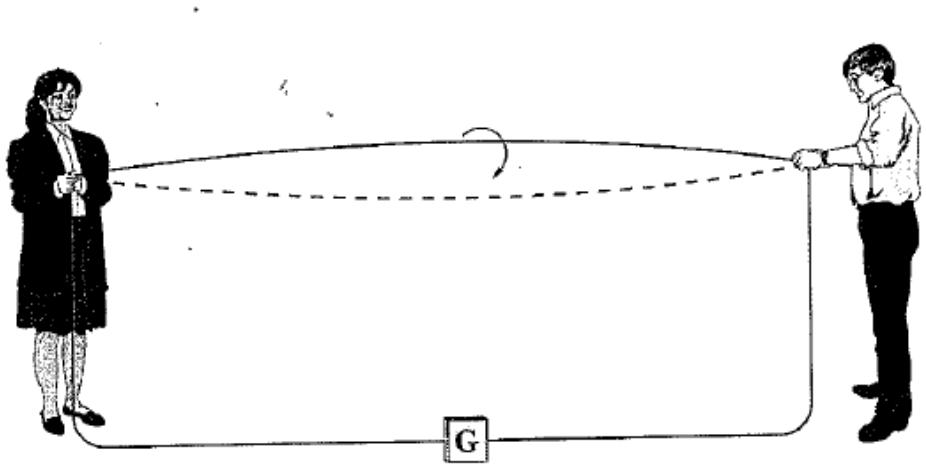
……

……

……

Question 29 (4 marks)

In a particular experiment a long length of copper wire of very resistance is rotated by two students. The ends of the wire are connected to a galvanometer G, and a current is detected.



Explain the effect of increasing the speed of rotation on the current measured by the galvanometer. **4**

……

……

……

……

……

……

……

……

Question 30 (4 marks)

During your study of Physics you used apparatus to produce alternating current. **4**

Explain how the apparatus produced the alternating current.

……

……

……

……

……

……

……

……

……

……

……

……

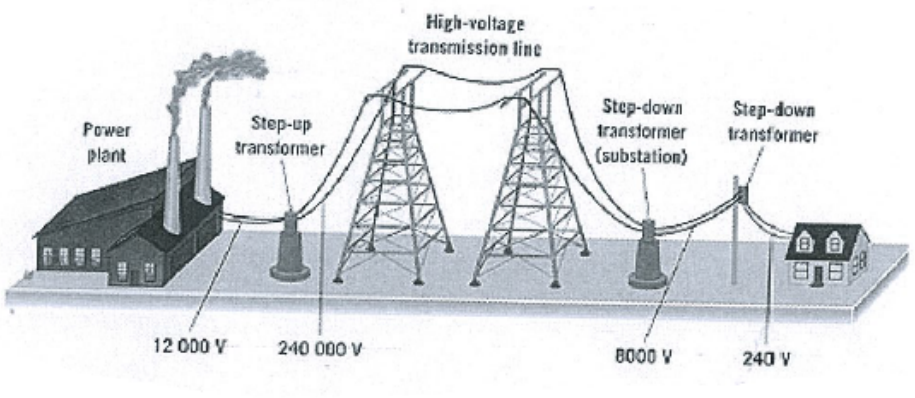
……

……

……

Question 31 (2 marks)

The following diagram shows the distribution of energy from the generator to the home. With reference to the diagram, state the main source of energy loss in the system and how it can be reduced. **2**



……

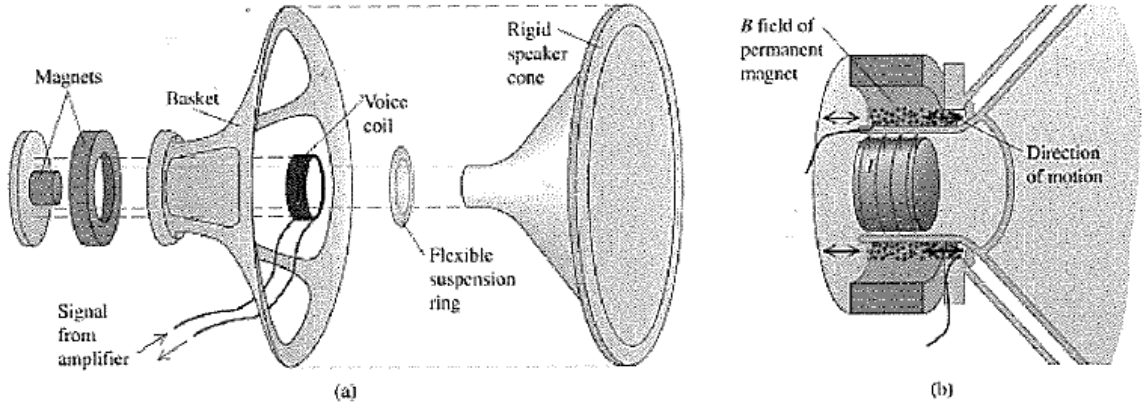
……

……

……

Question 32 (4 marks)

Using the diagram below, explain the application of the motor effect in the design of a loudspeaker. **4**



……

……

……

……

……

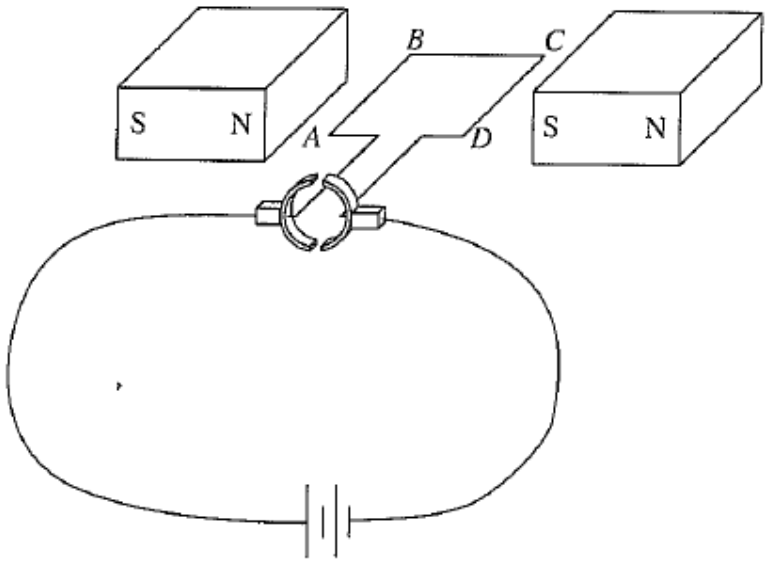
……

……

……

Question 33 (4 marks)

The diagram below shows a single loop of current-carrying wire (*ABCD)* within a uniform magnetic field of strength 0.25 T provided by permanent magnets. The loop is square in shape and 5 cm x 5 cm in size. The current flowing through the loop is 0.45 ampere.



a) Identify an alternative device to the permanent magnets, which could also provide a magnetic field. **1**

……

……

b) Determine the force acting on side *AB*. **2**

……

……

……

……

……

c) Calculate the magnitude of the torque acting on the coil **1**

……

……

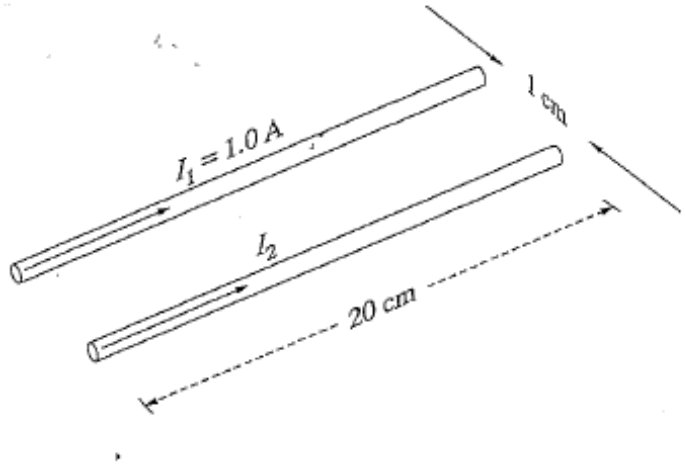
……

……

……

Question 34 (7 marks)

The diagram shows part of an experiment designed to measure the force between two parallel current-carrying conductors.

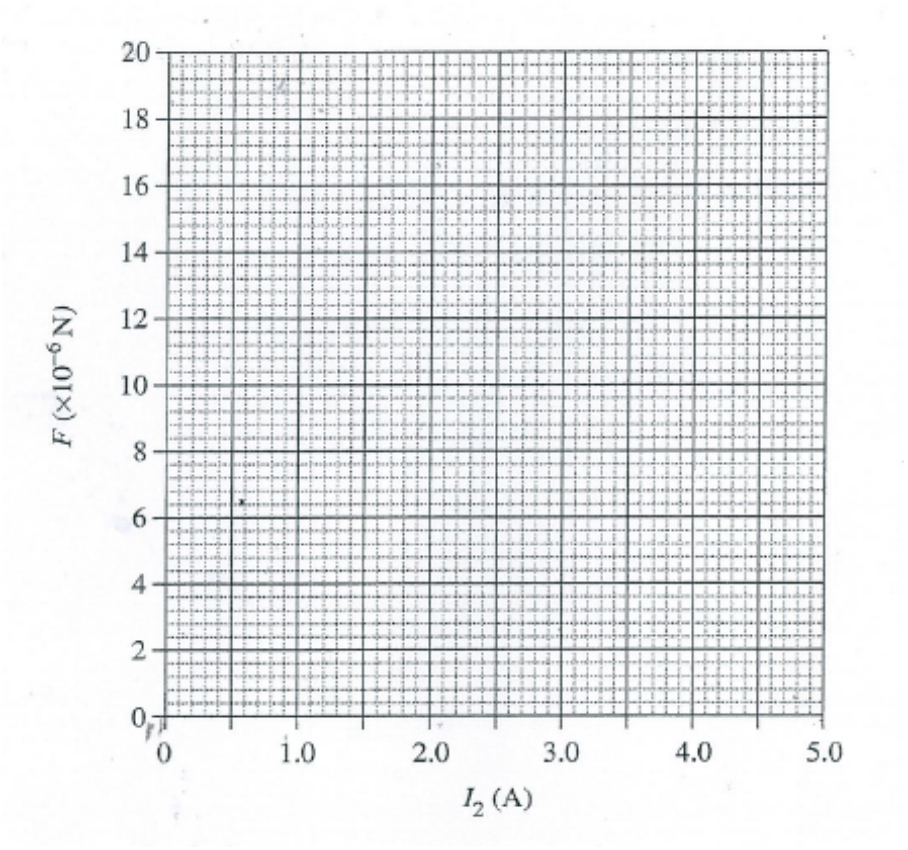


The experimental results are tabulated below.

I_2 (A)	Force ($\times 10^{-6}$ N)
0	0
2.0	7
3.0	11
4.0	14
5.0	18

Question 34 continued

a) Plot the data and draw the line of best fit. **3**



b) Calculate the gradient of the line of best fit for the graph. **2**

……

……

c) Write an expression for the magnetic force constant k in the terms of the gradient and other variables. **1**

……

……

d) Use this expression and the gradient calculated in part b) to determine the value of the magnetic force constant k. **1**

……

……

End of Paper

2016 *2 Yrly.

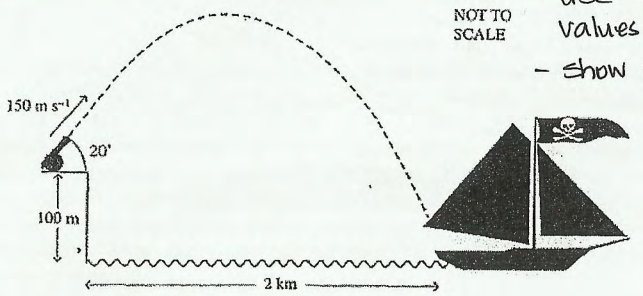
MC
1 C 5 D 9 C 13 D 17 C
2 D 6 D 10 C 14 D 18 B
3 D 7 A 11 D 15 B 19 B
4 C 8 A 12 D 16 B 20 C.

Section II – Extended Response
55 marks
Write your answers to this section in the spaces provided
Individual marks are indicated for each question

Marks

Question 21 (8 marks)

- use unrounded values in calculations
- show working



An enemy ship was sailing 2km from the coast. A cannon on a 100 metre-high cliff fired a projectile at an angle of 20° to the horizontal, at a muzzle speed of 150ms^{-1}

a) Determine the vertical and horizontal components of the initial velocity. **2**

$U_x = 150\cos 20 = 140.95 = 140 ms^{-1}$

$U_y = 150\sin 20 = 51.30 = 51 ms^{-1}$

Both Correct and 2 sig. fig (2)

b) Calculate the **time** taken for the cannon ball to reach the maximum height **and** the maximum **height** of the cannon ball above the water. **2**

(i) $v = u + at$

$t = \frac{v-u}{a}$

$= \frac{0-51.3}{-9.8}$

$= 5.23 s$

$= 5$ seconds.

(ii) $s = ut + \frac{1}{2}at^2$

$= (51.3)(5.23) + \frac{1}{2}(-9.8)(5.23)^2$

$= 134.27 m$

∴ Max height

$= 134.27 + 100$

$= 234.27 m$

$= 230 m.$

c) Calculate **2**

(i) the range of the cannon ball

$R = U_x \times t$

but $t \Rightarrow s = u_y t + \frac{1}{2}at^2$

$-100 = (51.3)(t) + \frac{1}{2}(-9.8)t^2$

$4.9t^2 - 51.3t - 100 = 0$

$t = 12.15 s$ (1)

$R = 140.95(t)$

$= 140.95(12.15)$

$= 1712.54 m$

$= 1700 m.$ (1)

(ii) how far from the ship the cannon ball landed **1**

$(2000 - 1712.54) = 287.46 \Rightarrow 287 m$ short of ship.

= Show working =

d) Describe an adjustment to the cannon that is necessary for a cannon ball to hit the ship. **1**

- Increase angle (to 27° or 61°)
- Increase muzzle velocity

Question 22 (2 marks)

Clearly explain why all low earth orbit satellites will eventually fall to the Earth's surface. **2**

- At the altitude of Low Earth Orbit there is still enough atmosphere to cause the satellite to lose kinetic energy to heat due to friction / drag and so reduce it's tangential velocity. [1 mark]

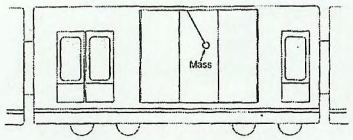
$v = \sqrt{GM/R}$

- As there is only one orbital velocity for a given radius, and so the tangential velocity is now less than the required orbital velocity, the satellite can no longer maintain its orbit. It therefore spirals down ~~directly~~ toward the surface of the Earth. [1 mark]

(note, the satellite cannot "enter" a lower orbit without FYI active "orbital insertion", which means giving the correct tangential velocity and zero vertical velocity)

...on 23 (2 marks)

...ain is travelling on a straight horizontal track. A student on the train attaches a mass on a string to the ceiling of the train. The student observes that the mass remains in a stationary position.



Why does the mass hang with the string at an angle to the vertical?

[1 mark] the train is accelerating to the left (or deaccelerating to the right)

[1 mark] the mass resists the change in its velocity due to its inertia and so the mass is dragged by the accelerating train and hangs at an angle.

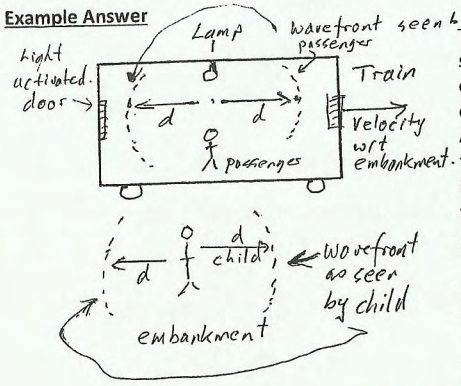
Question 24 (3 marks)

Einstein used thought experiments to help explain some of the counter-intuitive aspects of special relativity. With the aid of a diagram, outline a thought experiment that demonstrates the relativity of simultaneity or another counterintuitive prediction of special relativity.

Notes

- The whole theory of relativity is based on the premise that the speed of light is constant for all observers in all reference frames – so say this CLEARLY in your answer. "the constant speed of light" is not good enough
- Also, your diagram should indicate the constant speed of light
- If you use a paradox, then state that it is a paradox
- If you use the mirror in the train, you should argue from the point of view of the passenger and from point of view of a person on the embankment

Example Answer



This thought experiment demonstrates the relativity of simultaneity, where 2 events which appear simultaneous in one frame of reference do not appear simultaneous to an observer moving relative to the first.

A passenger turns on a bulb just as he is passing the child on the platform. As special relativity posits that the speed of light is the same for all observers independent of their relative velocities, then each sees the same expanding sphere of light - but centred on each of them!!

So the passenger's sphere reaches the front and back of the carriage at the same time and both light activated doors open simultaneously. However the train is moving through the child's light sphere and so the back door reaches the child's sphere first and opens before the front door, the events do not appear simultaneous to the child.

Marking Criteria

A: identifies thought experiment and correctly relates to prediction of special relativity
B: prediction correctly described, includes relative velocity between observers
C: speed of light is the same for all observers, independent of their relative velocity
D: correct & clear explanation of what each observer sees
E: correct, clear and relevant diagram

3 marks	all A, B, C, D, E
2 marks	fair attempt, missing one of A, B, C, D, E
1 mark	some reasonable attempt, missing two of A, B, C, D, E
0 marks	missing 3 or more of A, B, C, D, E
- mark(s)	Inconsistency /contradiction/incorrect
OT	Off Topic
W	Waffle

Question 25 (2 marks)

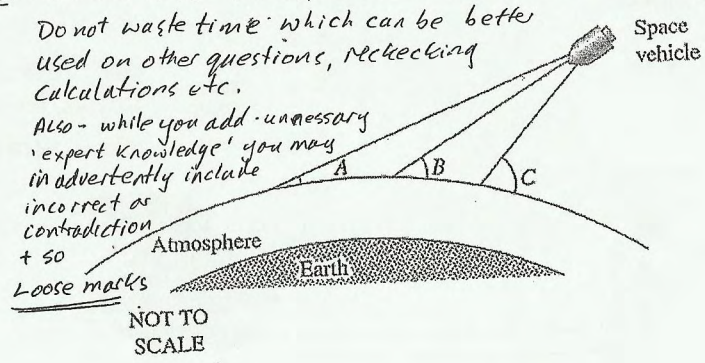
The optimum angle for safe re-entry of a space vehicle into Earth's atmosphere is angle *B*. 2

Outline consequences of the space vehicle entering the atmosphere at angle *A* and angle *C*.

↳ FYI : Outline is not an explanation. You are not asked for the angles.

Do not waste time which can be better used on other questions, rechecking calculations etc.

Also - while you add unnecessary 'expert knowledge' you may inadvertently include incorrect or contradiction + so Loose marks

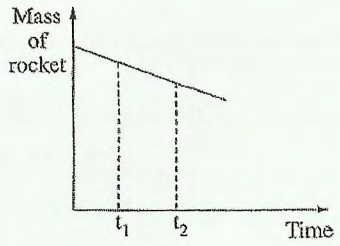


[1 mark] Angle A - Too shallow - will bounce off atmosphere back into space and unless there is enough fuel will not be able to return to Earth.

[1 mark] Angle C - Too steep - vehicle will be subjected to high g-forces (kill astronaut(s)) & friction causes burn up of satellite.

Question 26 (4 marks)

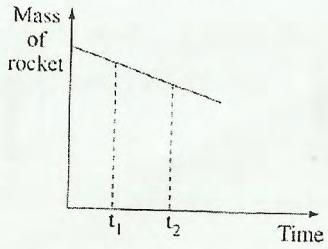
The mass of a rocket decreases during launch as it burns fuel, as shown in the graph below. The rocket engine produces a constant upward force on the rocket.



a) How does the law of conservation of momentum apply to the motion of the rocket? 2

SEE ATTACHED SHEET

The mass of a rocket decreases during launch as it burns fuel, as shown in the graph.
The rocket engine produces a constant upward force on the rocket.



a) How does the law of conservation of momentum apply to the motion of the rocket?

Notes

- The **Law of Conservation of Momentum** states that **total momentum of an isolated (closed) system is constant** - which can be written as $P_{Total} = z$ where z is some constant number $M_{total}V$ that depends on 'the other frame of reference at relative velocity V' you happen to be in. Only if you are in the FoR of the closed system does $z = 0$.
- In other words, the Law of Conservation of Momentum means that the total momentum of an isolated system cannot change, which can be written as $\Delta P_{Total} = 0$ and note that this form is **true from within any inertial FoR.**
- In your answer, you must show that
  - (i) By starting with $\Delta P_{Total} = 0$, the **change in momentum of the rocket over time t** is equal to the negative of the momentum of ejected fuel over time t.
  - (ii) Show that it is ΔP_{rocket} which causes acceleration of the rocket. E.g., you could recognise that the change in momentum of the rocket is an impulse acting on the rocket given by Ft; and from Newton's 2nd law, a = F/M
- This question was not well done, most students confused momentum with change of momentum, and so ended up with a statement such as "the momentum of the rocket $M_rV_r = -m_ev_e$" – which is wrong!! Subsequently, to get V_r to change and so accelerate the rocket, they had to postulate that M_r decreased – which is incorrect.

Example Answer [1 mark for each dot point]

- The rocket is an isolated system and so the by the Law of Conservation of Momentum, the momentum P cannot change: Using subscripts T, r, e, for total, rocket, exhaust we have $\Delta P_T = \Delta P_r + \Delta P_e = 0$. Thus for a given time t, $\Delta P_r = M_r\Delta V_r = -\Delta P_e = -(P_{e,final} - P_{e,initial}) = -(m_ev_e - o) = -m_ev_e$ where m stands for mass and v for velocity.
- So the **change in momentum** of the rocket is equal to the small mass of ejected fuel times its very high velocity. This means that for a given time t the rocket increases its velocity ΔV_r by exhausting burnt fuel, so the rocket accelerates by $\Delta V_r/t$.

(Note; as the mass of fuel ejected in a short time is very much less than the total mass of the rocket then most of the change in momentum of the rocket will be due to change in velocity of the rocket and so $\Delta P_r = \Delta M_r\Delta V_r$ can be approximated as $\Delta P_r = M_r\Delta V_r$. To illustrate this point, if you push half the mass of the rocket out the back of the rocket, then v_e is really low; even though M_r has dropped to half, the rocket will hardly accelerate)

Marking Criteria

1 mark	**correctly states the law of conservation of momentum with reference to the rocket and then shows that the change in momentum of the rocket over time t equals the negative of the momentum of gas exhausted in that time**
1 mark	**explains that the change in momentum of the rocket causes the rocket to accelerate (acceleration is not due to a decrease in mass of rocket which is a secondary effect - which in any case causes the acceleration to increase - which is the subject of part (b) of question 26)**
- mark(s)	**Inconsistency /contradiction/incorrect**
OT	**Off Topic**
W	**Waffle**

12 (extended)

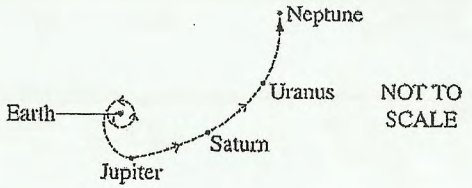
↗ Require $F = ma$ and g-force $= (a+g)/g$ in order to explain

b) Explain why the g-forces on an astronaut in the rocket differ at times t_1 and t_2. **2**

- $a = T/M$, thrust T constant, Mass M rocket decreases as fuel burnt ∴ a increases [1 mark]
- g-force (is apparent weight / Normal Earth weight) $= (a+g)/g$ where $g = 9.8 ms^{-2}$ ∴ as a increases g forces increase [1 mark]

Question 27 (7 marks)

The diagram illustrates the path of a space probe launched from Earth and sent to Neptune.



a) Explain, using physics principles, why the space probe takes this path instead of travelling directly to Neptune. **3**

1 mark - Identify the path taken is due to the slingshot effect.

2 1 mark - Explain that direction and speed (relative to the sun) is changed due to gravitational coupling of the probe and planets and the law of conservation of momentum (angular).

3 1 mark - Identify benefits such as cost and time.

b) The space probe is placed in an orbit at an altitude of 188 km above Earth. Given Earth has a radius of 6380 km, calculate the period of this orbit. **2**

$r = (188 + 6380) \times 10^3$ m
$= 6568000$ m
$M = 6.0 \times 10^{24}$ kg
$T = ?$

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

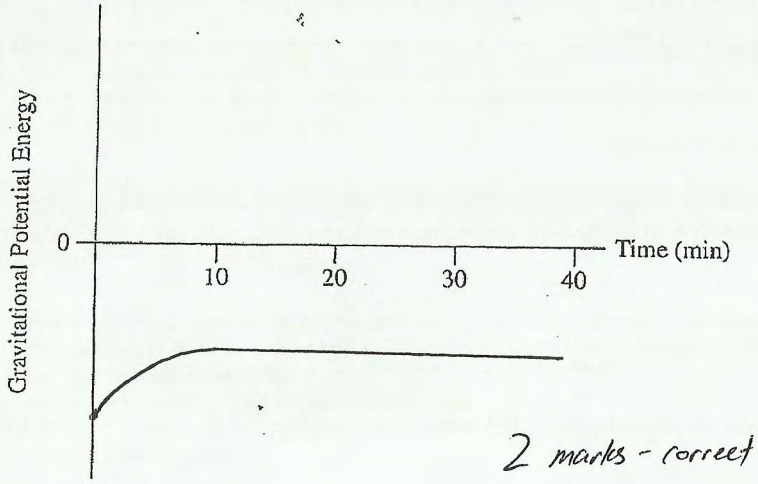
$T = \sqrt{\frac{(r^3)(4\pi^2)}{GM}}$

$= \sqrt{\frac{(6568000)^3 \cdot (4\pi^2)}{(6.67\times10^{-11})(6\times10^{24})}}$

$= 5287$ seconds

c) It takes 10 minutes for the space probe to reach its orbit around Earth and it remains in orbit for several hours. 2

Sketch a graph on the axes showing the changes in gravitational potential energy for the first 40 minutes.



2 marks - correct graph

1 mark - ONE correct feature

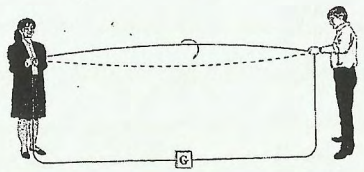
Question 28 (2 marks)

Define Lenz's law. 2

Induced current (1)
gives rise to a magnetic field that opposes the Δ flux that caused it (1)

Question 29 (4 marks)

In a particular experiment a long length of copper wire of very resistance is rotated by two students. The ends of the wire are connected to a galvanometer G, and a current is detected.



Explain the effect of increasing the speed of rotation on the current measured by the galvanometer.

Notes

- The question states that a current is detected by the galvanometer; therefore there must be at least some component of magnetic field perpendicular to the plane of and threading the **closed wire loop**.
- The magnetic field will be the Earth's magnetic field.
- You are expected to answer this question by appealing to Faraday's law (or to the equation for the motor effect)
- Lenz's law is not acceptable. (Many answers confused/muddled this with Faraday's law)
- You need to write the equation for the law in your answer (as it is easier and quicker to demonstrate that you fully understand what is going on)
- When you appeal to an equation such as Faraday's law $\varepsilon = -n\,\Delta\Phi_B/\Delta t$ you must define the terms in your answer.
- Many did not apply Faraday's law correctly, you must reference to the change of flux **threading the loop**. On the other hand, If you want to talk about the relative motion between the wire conductor and the magnetic field you should use the equation $F/L = BqV\sin\theta$ (or $BI\sin\theta$) along with an appropriate diagram, the right hand push rule, and an explanation that the force F is on the conduction electrons, so inducing a current.
- The flux through the loop changes because the area of the loop changes (B is locally constant)
- This is an electrical generator, so there is no 'back emf' which would occur in an electric motor, however, there will be a 'back torque' opposing the torque supplied by the people rotating the wire.
- It would be wise to explain that this generator will produce an AC (alternating current) current.
- You should state the type of flux at least once in your answer (magnetic flux)
- Stay on topic/answer the question. Explanation of the working of the galvanometer is off topic (OT)

Example Answer [4 marks]

As the question states that a current is being measured by the galvanometer then it follows that there must be some component of magnetic field B (the Earth's) perpendicular to the plane of the closed loop of copper wire and also that the system must be an electrical generator.

For a single loop of wire an induced emf ε (voltage) is given by Faraday's law $\varepsilon = -\Delta\Phi_B/\Delta t$ where $\Delta\Phi_B/\Delta t$ is the rate of change of magnetic flux Φ_B threading through the area A of the loop. In this example, as the Earth's magnetic field B is constant, the change of flux is produced by the change of area A of the loop ($\Delta\Phi_B = B\Delta A$) caused by rotation of the top wire, and the induced emf = $B\,\Delta A/\Delta t$ will produce an induced current in the closed conducting loop. When the area is increasing the current will flow in one direction, while a decreasing area will cause a current in the opposite direction. In other words an AC current is induced, the amplitude of which is proportional to the rate of change of flux $\Delta\Phi_B/\Delta t$ and the frequency of which is proportional to the inverse of the period of rotation of the top wire.

Thus the effect of increasing the speed of rotation of the top wire will be to (i) increase the amplitude and (ii) increase the frequency of the AC current measured by the galvanometer.

Marking Criteria

α	1 mark	Some basic explanation based on Faraday's Law
β	1 mark	Further evidence demonstrating deeper/fuller understanding (Φ_B constant, A changes)
A	1 mark	Relates increase of rotation to decrease of period Δt and so to an increase of amplitude of detected current via $\Delta\Phi_B/\Delta t$
B	1 mark	Relates increase of rotation to decrease of period and so to increase in frequency of current
X	- mark(s)	Inconsistency /contradiction/incorrect
OT	Off Topic	
W	Waffle	

Question 30 (4 marks)

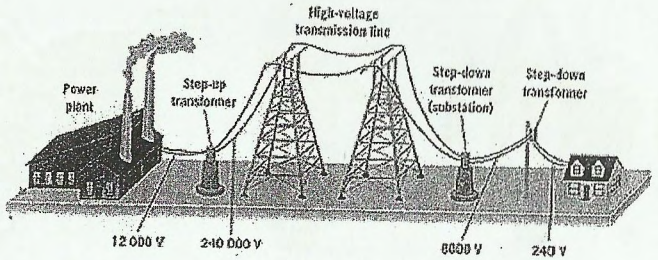
During your study of Physics you used apparatus to produce alternating current. 4

Explain how the apparatus produced the alternating current.

- Description of apparatus (1)
- Faraday's Law described (1)
- Magnet moved (Δ flux) - el. motion (1)
- Lenz's Law - reversal of current (1)

Question 31 (2 marks)

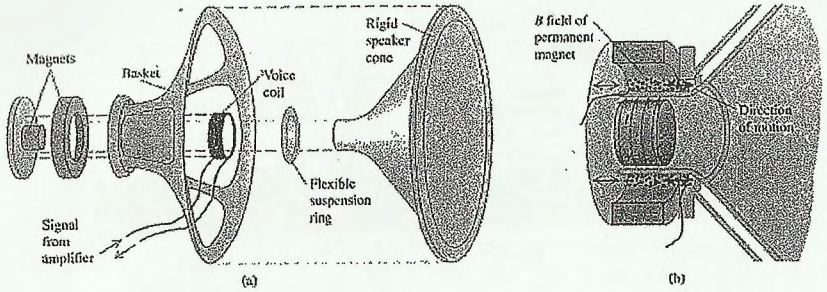
The following diagram shows the distribution of energy from the generator to the home. With reference to the diagram, state the main source of energy loss in the system and how it can be reduced. 2



- energy loss source identified (eg resistive heating) (1)
- how reduced – eg $V \uparrow \rightarrow I \downarrow$ ($P_{loss} = I^2R$) (1)

Question 32 (4 marks)

Using the diagram below, explain the application of the motor effect in the design of a loudspeaker. 4



1 mark - making reference to the motor effect

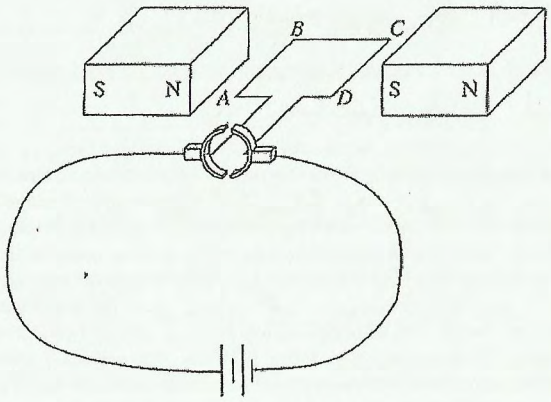
1 mark - explaining the motor effect: as the current flows through the coils, a magnetic field is induced which interacts with the external magnetic field provided by the permanent magnets, producing a force

1 mark - explaining that AC current causes the force on the voice coil to change direction and thus, oscillate.

1 mark - explaining that the speaker cone also oscillates at the same frequency of the voice coil, thus producing sound waves as air particles are disturbed.

Question 33 (4 marks)

Abhisri sets up an experiment as shown below. It consists of a single loop of current-carrying wire *(ABCD)* within a uniform magnetic field of strength 0.25 T provided by permanent magnets. The loop is square in shape and 5 cm x 5 cm in size. The current flowing through the loop is 0.45A.



a) Identify an alternative device to the permanent magnets which could also provide a magnetic field. 1

electromagnets

b) Determine the force acting on side *AB*. 2

$F = BIl \sin\theta$

$= 0.25 \times 0.45 \times 0.05$

$= 0.0056 \rightarrow 5.6 \times 10^{-3}$ N DOWN (1)

(1)

c) Calculate the magnitude of the torque acting on the coil 1

$\tau = nBIA\cos\theta$

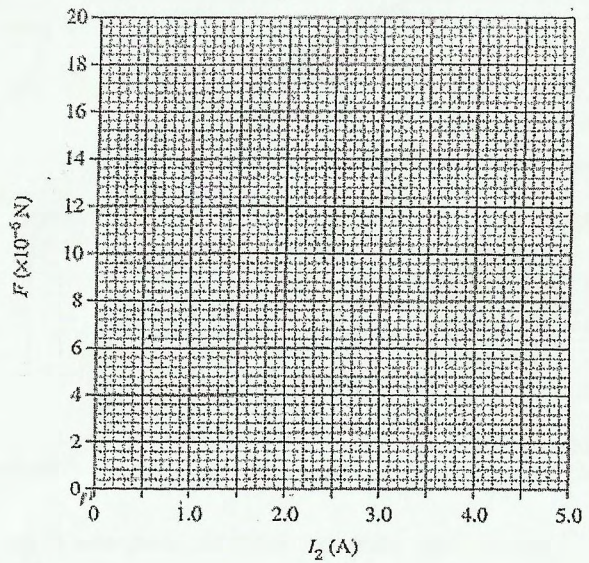
$= 1 \times 0.15 \times 0.45 \times (0.05 \times 0.05)$

$= 2.8 \times 10^{-4}$ Nm

* Not correct unit = 1/2 mark.

Question 34 continued

a) Plot the data and draw the line of best fit. 3



Title (1)
Crosses (1)
Line (1)

b) Calculate the gradient of the line of best fit for the graph. 2

$\frac{18\times10^{-6}}{5}$ (1) $= 3.6\times10^{-6}$ (1)

c) Write an expression for the magnetic force constant k in the terms of the gradient and other variables. 1

m (gradient) $= \frac{F}{I_2}$ | $\frac{F}{l} = k\frac{I_1 I_2}{d} \rightarrow k = \frac{Fd}{I_1 I_2 l}$

$= m \times \frac{d}{I_1 l}$

d) Use this expression and the gradient calculated in part b) to determine the value of the magnetic force constant k. 1

1.8×10^{-7}

End of Paper