Candidate Number: .....

P12 Trial

P 12 Trial

**BAULKHAM HILLS HIGH SCHOOL**

**Higher School Certificate**

**2010**

# Trial Examination

# Physics

## General Instructions

- Reading time - 5 minutes
- Working time - 3 hours
- Board approved calculators may be used
- Write using black or blue pens, only
- Draw diagrams using pencil
- A Data Sheet, Formulae Sheets and Periodic Table are provided at the back of this paper
- Write your student number at the top of each page, where indicated
- Students should show all working

## Total Marks: 100

**Section I (75 marks)**
This section has two parts, Part A and Part B

**Part A - Multiple Choice (20 marks)**
Attempt Questions 1-20
Allow about 30 mins for this section

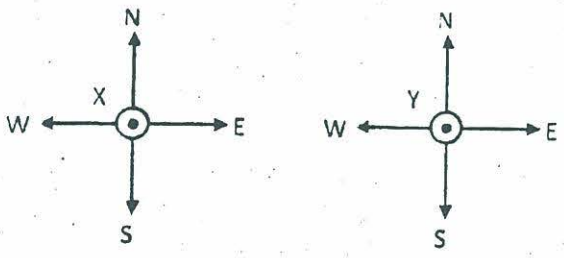
**Part B - Short Response (55 marks)**
Attempt Questions
Allow about 2 hours for this section

**Section II (25 marks)**
**Elective - Astrophysics**
Allow about 30 mins for this section

**Section I (75 marks)**

**Part A – Multiple Choice**
**Attempt all 20 questions**
**Select the most correct response, A, B, C or D on the Multiple Choice Answer Sheet provided.**

1. In the diagram below, X and Y are two long, straight, parallel conductors carrying current perpendicularly to and out of the plane of the paper.

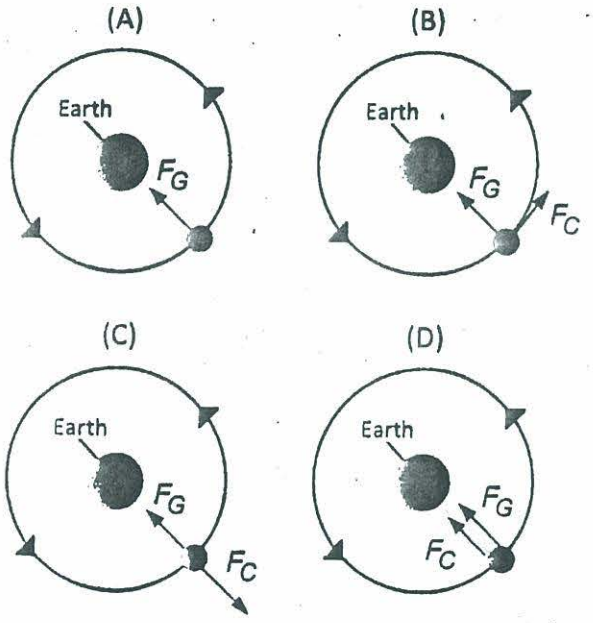



Which of the following pairs show the correct directions of the forces on X and Y?

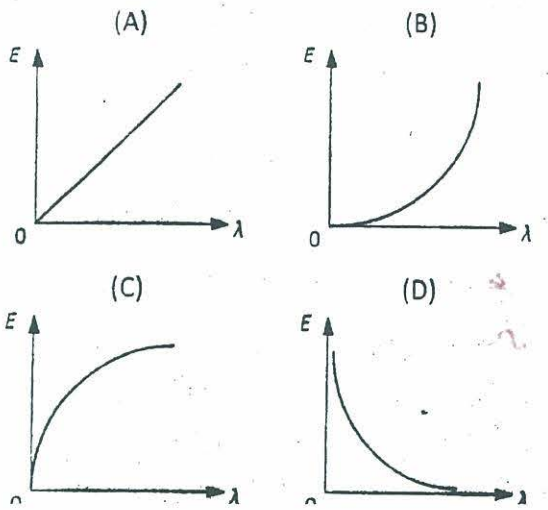
| | **Directions of force on X** | **Directions of force on Y** |
|---|---|---|
| a) | N | S |
| b) | S | N |
| c) | E | W |
| d) | W | E |

2. A satellite is orbiting the Earth. The gravitational force on the satellite is $F_G$ and the centripetal force to maintain satellite in orbit is $F_C$.

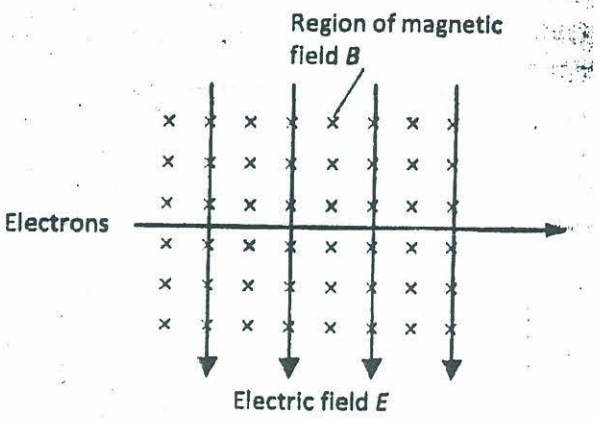
Which of the following, A, B, C or D correctly shows the forces acting on the satellite?



3. Which of the following graphs, A, B, C or D correctly shows how the energy $E$ of a photon of light is related to its wavelength $\lambda$ ?




4. A beam of electron enters a region in which there are magnetic and electric fields directed at right angles to each other. The beam remains undeflected.




A second beam of electrons travelling twice as fast as the first beam is then directed along the same line.

How would this second beam deviate from its initial path?

a) downwards in the plane of the paper
b) upwards in the plane of the paper
c) out of the plane of the paper
d) into the plane of the paper

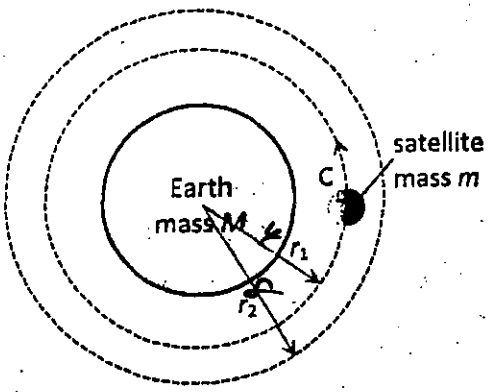
5. A satellite of mass 50kg moves from Point A where the gravitational potential due to Earth is -20MJkg $^{-1}$ to another Point B where the gravitational potential is -60MJkg $^{-1}$

What is the direction when the satellite moves from A to B and the change in potential energy?

a) closer to the Earth and a loss of 2000 MJ of potential energy
b) closer to the Earth and a loss of 40 MJ of potential energy
c) further from the Earth and a gain of 2000 MJ of potential energy
d) further from the Earth and a gain of 40 MJ of potential energy

6. A satellite of mass $m$, initially orbiting at radius $r_1$ around the Earth, moved to a new circular orbit of radius $r_2$ as shown in the figure below.

The Earth has a mass of $M$ and the gravitational constant is $G$.




What is the increase in the potential energy of the satellite?

a) $GM\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$

b) $GM\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$

c) $GMm\left(\frac{1}{r_2}-\frac{1}{r_1}\right)$

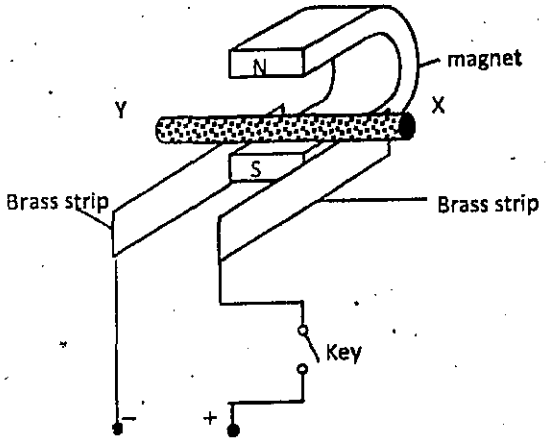
d) $GMm\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$

$\Delta E_p = -G\frac{M\cdot m_2}{r_2} - -G\frac{Mm}{r_1}$

$= GMm\left(\frac{1}{r_1}-\frac{1}{r_2}\right)$

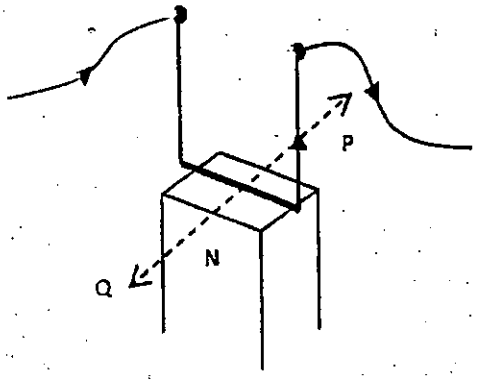
$= GMm\left(\frac{1}{4}-\frac{1}{8}\right)$

7. In the diagram below, when the key in the circuit shown is closed, the bare wire $XY$ will




a) rise up off the brass strip
b) press down more strongly
c) move backward
d) move forward

8. A current is made to pass through a swing mounted to the ceiling such that it can swing freely.



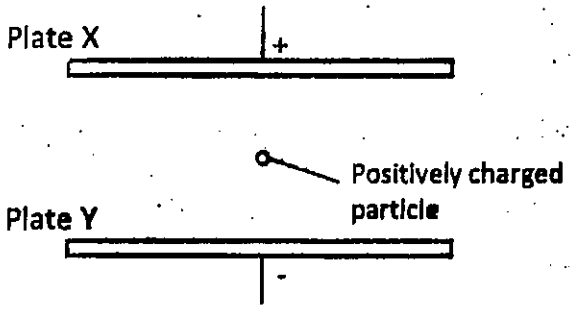

The swing will

a) deflect in the direction $P$ and stay there
b) oscillate back and forth along $P$
c) deflect in the direction $Q$ and stay there
d) oscillate back and forth along $Q$

9. An oil drop of mass $m$ and charge $q$ is between two horizontal plates.
When the potential difference between the upper and lower plates is $V$, the drop is stationary.
What would be the initial upward acceleration of the drop when the potential difference is increased to $2V$?

a) $g$
b) $2g$
c) $\frac{2qV}{m} - g$
d) $\frac{2qV}{m}$

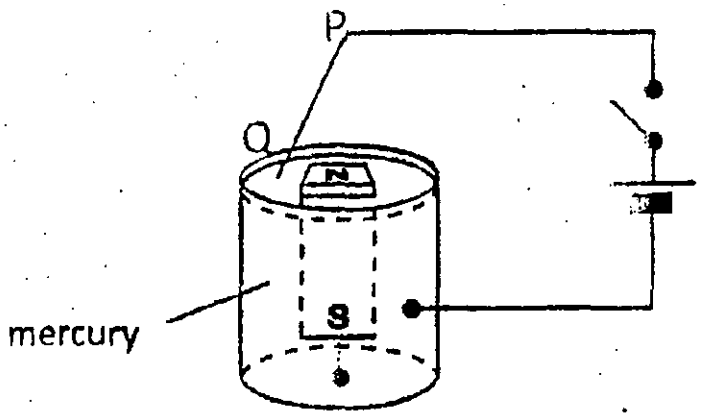
10. Two large parallel metal plates $X$ and $Y$ carrying equal and opposite charges are situated in a vacuum.




Which of the following is correct about what happens to the force on a positively charged particle as it moves from $X$ to $Y$?

a) It decreases because the positively charged particle is moving away from the positively charged plate
b) It decreases because the positively charged particle is moving in the direction of the electric field between the plates
c) It increases because the positively charged particle is moving closer to a negatively charged plate
d) It remains constant because the positively charged particle is in the uniform electric field between the plates

11. A bar magnet is fixed in a container of mercury as shown. A copper wire $PQ$ is connected to a cell and freely suspended at $P$.




What will happen to the end $Q$ as seen by the observer when the switch is closed and remains closed?

a) kick out the page
b) kick into the page
c) rotate clockwise
d) rotate anticlockwise

12. Electrical power was first transmitted by Edison in 1882 and soon afterwards a competition developed between Edison and Westinghouse to supply electricity to cities.

What is the main reason that Westinghouse was successful?

a) He was able to use transformers to change the transmission voltage
b) He spent more money on advertising
c) He developed a safer system of electricity supply
d) The Westinghouse company was better known

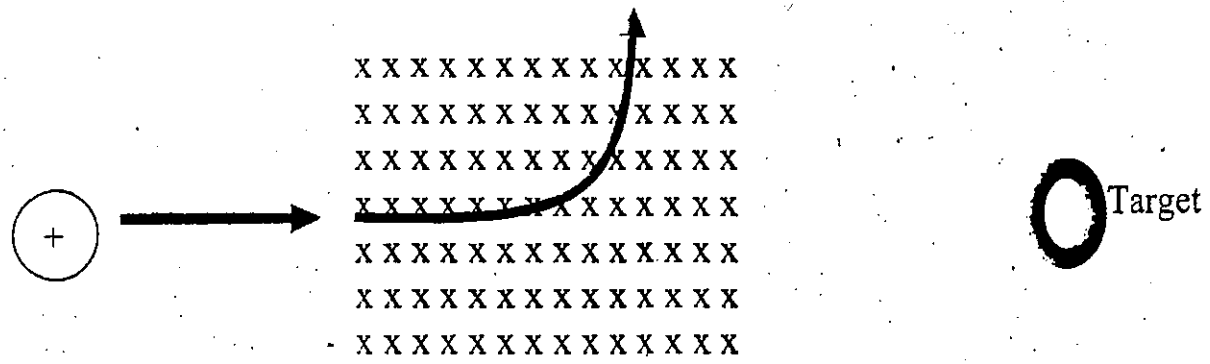
13. Semiconductors have

a) empty valence bands and a small energy gap to the conduction band
b) completely filled valence bands and a large energy gap to the conduction band
c) partially filled valence bands and very small (or zero) energy gap to the conduction band
d) partially filled valence bands and a very large energy gap to the conduction band

14. Two astronauts landed on a very small asteroid orbiting the Sun between Mars and Jupiter. They experienced almost negligible weight force. Which statement explains this?

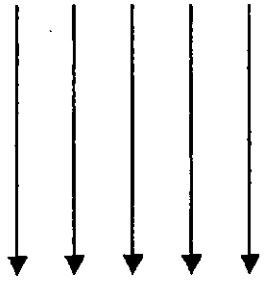
a) Because the asteroid is in a stable orbit around the Sun it will have zero mass
b) Because the asteroid is in a stable orbit around the Sun, the astronauts will apparently be weightless
c) Because the asteroid is very small it will have very small gravitational force
d) The gravitational force on the asteroid is balanced by an equal and opposite gravitational force on the astronauts

15. The diagram below shows how a proton curves as it passes through a magnetic field and does not hit the target.

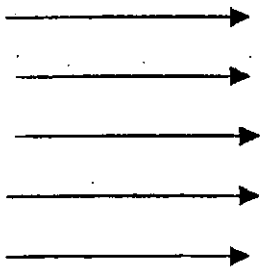



If an electric field were now applied (in the same region as the magnetic field) and the proton hit the target, what must have been its direction?

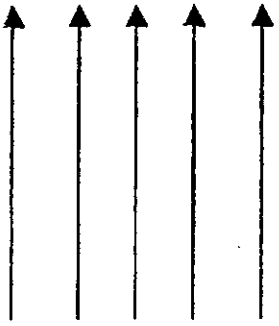
a)



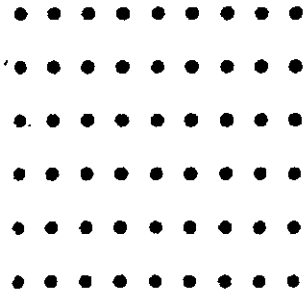
b)



c)



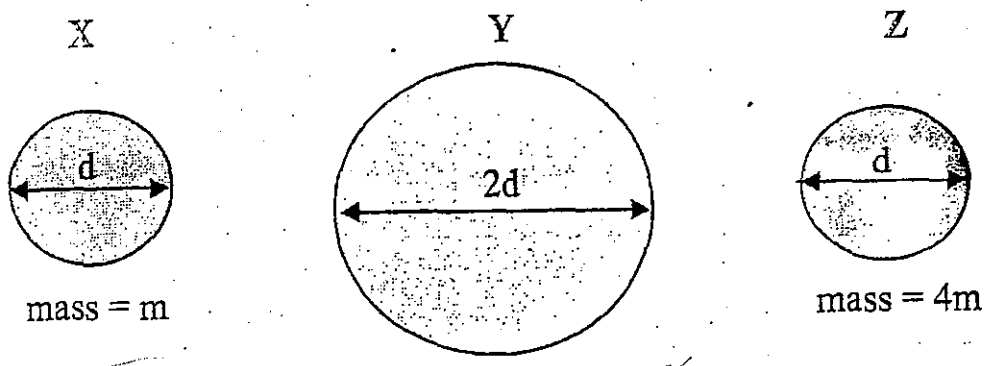
d)



16. Which of the following devices could best be used to demonstrate the motor effect in its normal operation?

a) Transformer
b) Induction cook top
c) Generator
d) Loudspeaker

17. Consider the following planets, X, Y and Z.



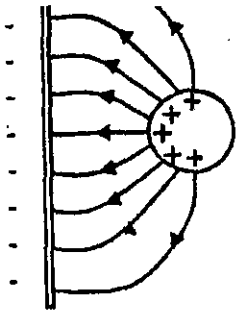

What is the correct ratio of the escape velocity of these planets?

**Note:** $v_e = \sqrt{\frac{2GM}{r}}$

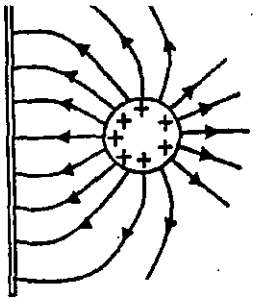
a) X : Y : Z = 1 : 1 : 2
b) X : Y : Z = 1 : 2 : 4
c) X : Y : Z = 2 : 1 : 4
d) X : Y : Z = 2 : 1 : 2

18. What is the pattern of the electric field between a positively charged conducting sphere and a metal plate near to it?

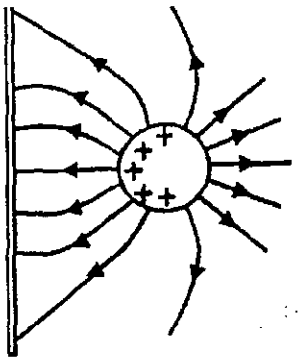
a)



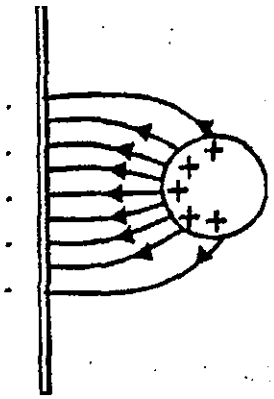
b)



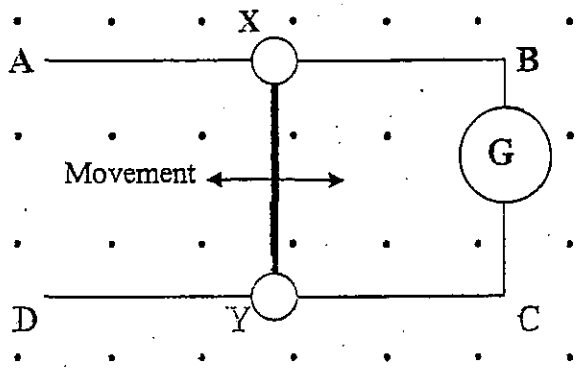
c)



d)

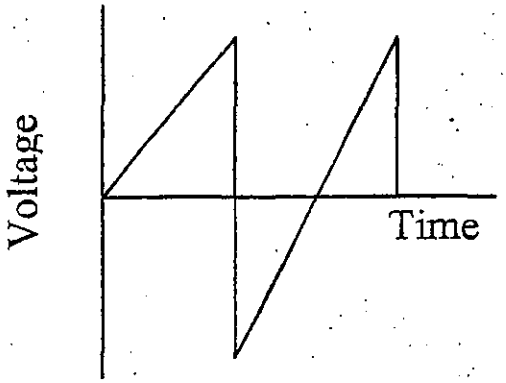


19. A conductor, ABCD is situated in a magnetic field directed out of the page. The conductor has a galvanometer inserted in side BC and a conducting rod XY connects the sides AB and CD as shown. The rod XY is able to slide and is moved 5cm to the left, then 10cm to the right and back to its original position.

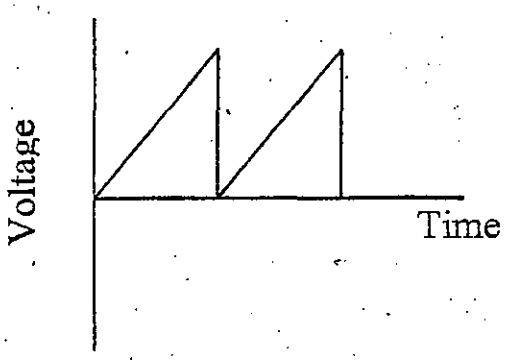



Which graph shows the possible voltage changes that could be observed on the galvanometer?

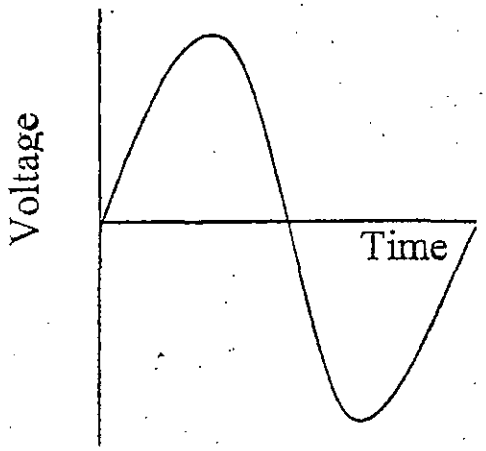
a)



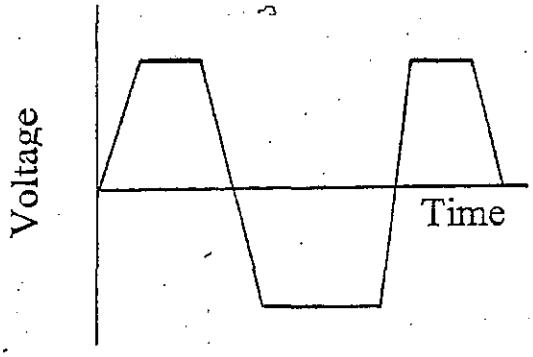

b)



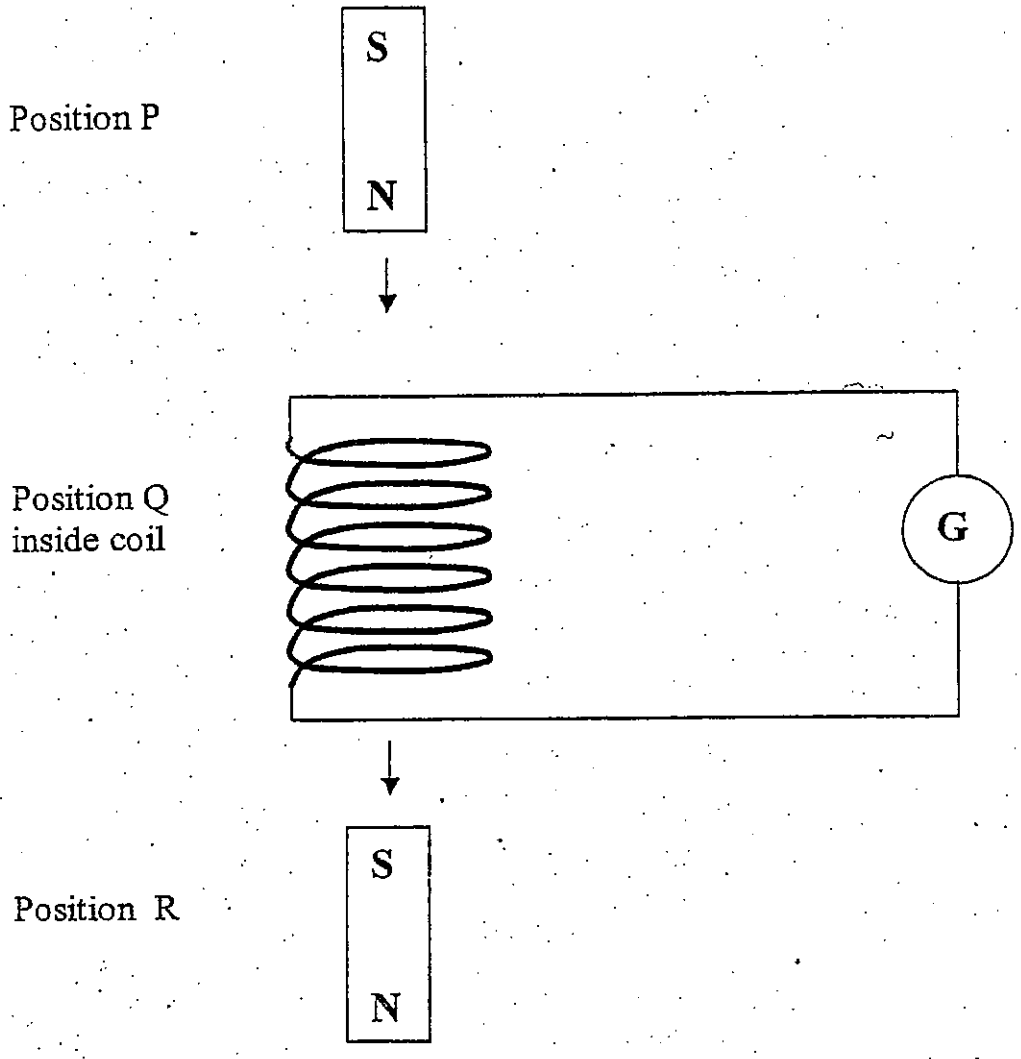

c)




d)



20. A magnet is dropped so that it moves through a coil that is suspended vertically. The coil is connected to a galvanometer.




Which alternative could describe the galvanometer needle deflection as the magnet moves from Position P through Q to R?

| | Position P | Position Q | Position R |
|---|---|---|---|
| a) | to the right | no deflection | to the right |
| b) | to the right | to the right | no deflection |
| c) | to the right | no deflection | to the left |
| d) | to the right | to the right | to the right |

**End of Section I – Part A**

**Section I (continued)**
**Part B – Short Response**
**55 marks**

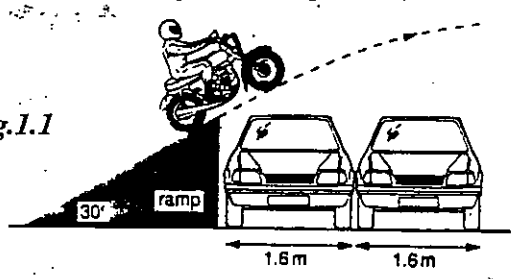
**Write your answers in the spaces provided.**

**Question 21 (7 marks)**

**Marks**

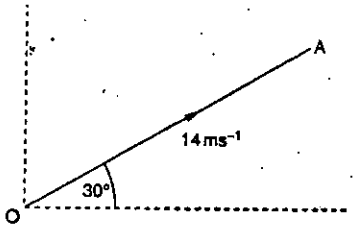
In *Fig1.1* below, a stuntman on a motorcycle plans to ride up a ramp in order to jump over a number of cars. The speed of the motorcycle as it leaves the ramp is 14 $ms^{-1}$ (Neglect air resistance throughout this question)

*Fig.1.1*




a) In *Fig.1.2* below, the line OA represents the velocity of the motorcycle just as it leaves the ramp.

*Fig.1.2*




i) Explain why OA represents the velocity of the motorcycle and not just its speed 1

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ii) What is the scale used in *Fig.1.2*? 1

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b) Calculate the time interval between leaving the end of the ramp and reaching maximum height. 2

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c) The cars are each of width 1.6m and the same height as the ramp. Estimate the maximum number of cars which the motorcyclist can jump for the take-off speed of 14 $ms^{-1}$ 3

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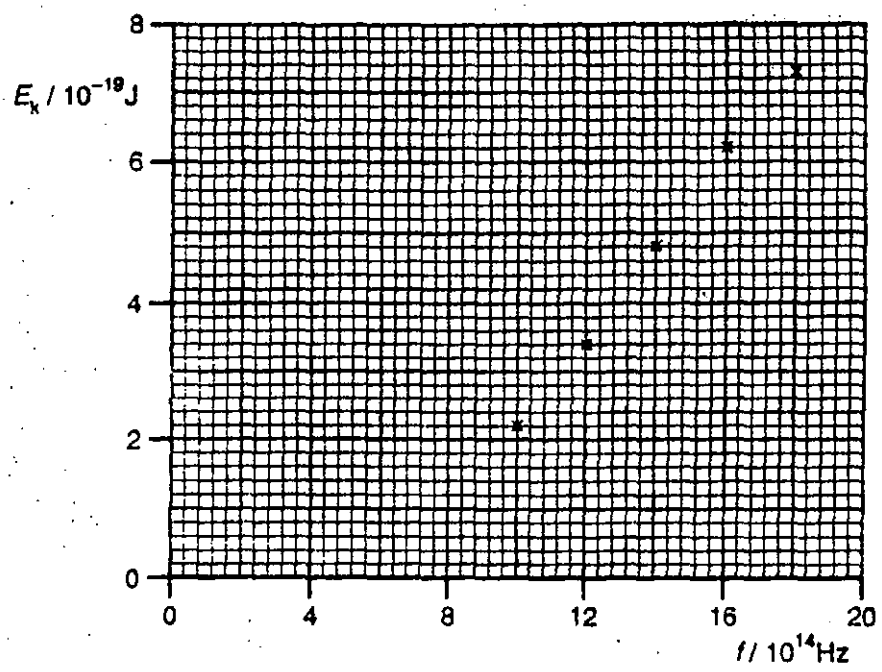
Marks

**Question 22 (8 marks)**

Electrons are emitted from a metal surface when it is illuminated with suitable electromagnetic radiation.

*Fig. 7.1*




The variation with frequency $f$ of the maximum kinetic energy $E_k$ of the emitted electrons is shown in Fig.7.1.

a) Use Fig.7.1 to determine

i) the threshold frequency of the radiation **2**

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ii) a value for the Planck constant **2**

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b) On Fig.7.1 draw a line to show the variation with frequency $f$ of the maximum kinetic energy $E$ of the emitted electrons for a second metal which has a lower work function than that in (b). **2**

c) The kinetic energy of the electrons is described as the maximum. **2**
Suggest why emitted electrons are likely to have a range of kinetic energy for any one frequency of the electromagnetic radiation.

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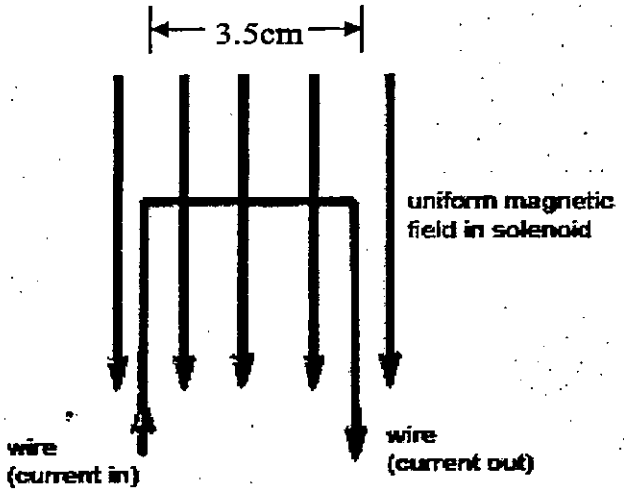
Marks

**Question 23 (6 marks)**

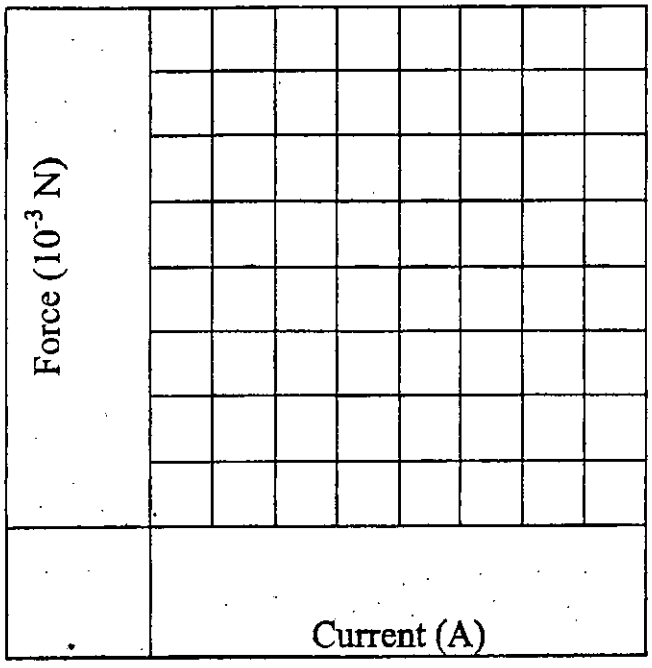
A current carrying wire of length 3.5cm is placed deep inside a solenoid where the magnetic field is uniform. The wire is kept perpendicular to the magnetic field. Looking down, this is shown below.




As the current in the wire is increased, the downward force on the wire is measured. The results are shown in the table below.

| Current in wire (A) | Downward Force ($x10^{-3}$ N) |
|---|---|
| 0.00 | 0.000 |
| 0.50 | 2.5 |
| 1.0 | 6.0 |
| 1.5 | 9.5 |
| 2.0 | 12.0 |

a) Draw a line graph of these results on the grid below. **2**



Marks

**Question 23 (continued)**

b) Calculate the gradient of your line graph. 1

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c) Using these results, a student claims that they can calculate the magnitude of the magnetic field inside the solenoid. 2

Justify this claim.

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d) Without performing another experiment, describe how you would predict the downward force on the wire when it carries a current of 3.5 A. 1

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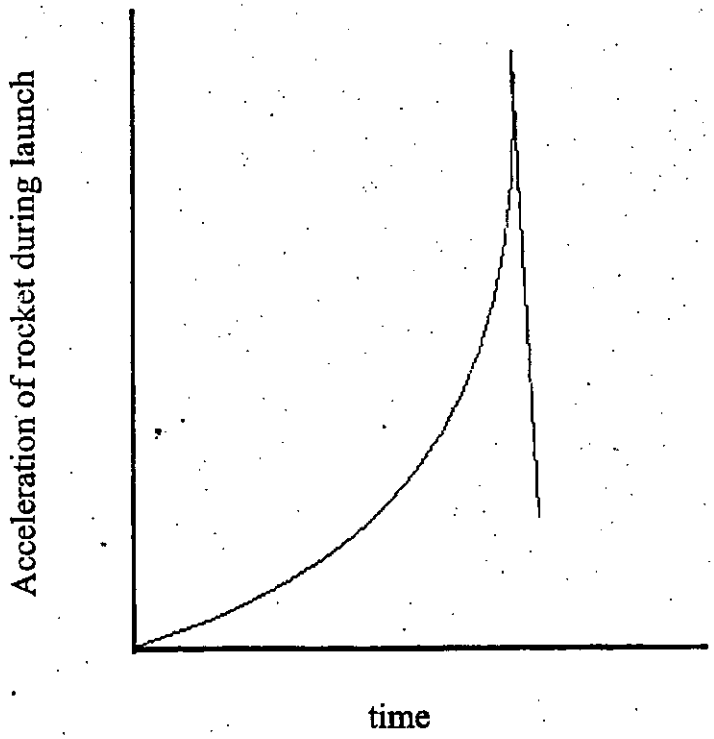
Marks

**Question 24 (4 marks)**

The sketch below shows how the acceleration of a rocket changes during the first stage of the launch of a rocket.




Explain why the acceleration changes as shown in the graph. **4**

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Marks

**Question 25 (4 marks)**

Superconductors have the potential to revolutionise electricity production and use.

a) Identify ONE other use of superconductors. 1

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b) Identify ONE advantage of using superconductors. 1

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c) Explain why magnetic levitation has not been widely used in the transport industry. 2

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**Question 26 (3 marks)**

The impact of the development of transformers on society has been enormous. Electrical energy from coal fired power stations is distributed to homes and industries at great distances from its point of generation using transformers.

Transformers are also a point of energy losses.

Explain how these energy losses occur in transformers and how they can be reduced. 3

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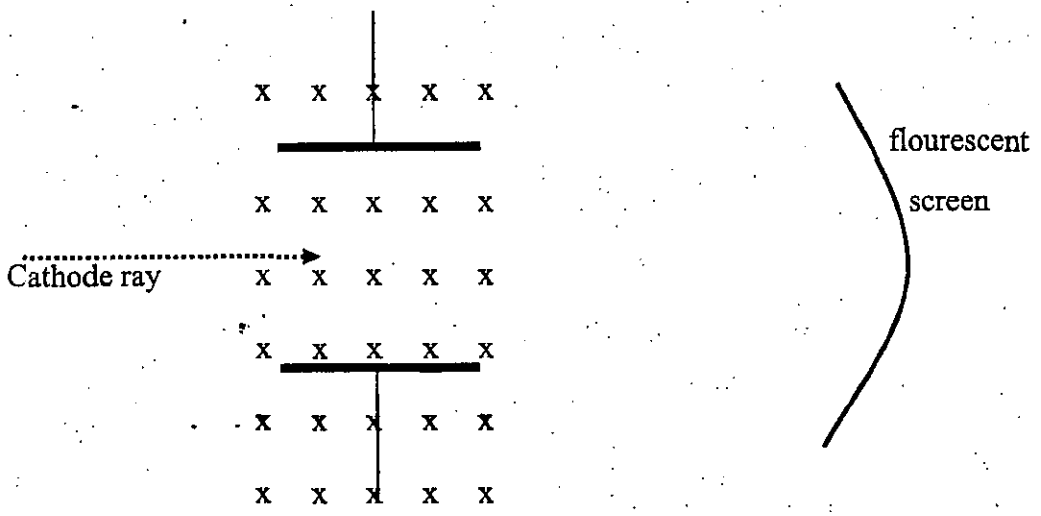
**Question 27 (7 marks)**

The diagram below is of the apparatus used by J.J. Thomson to measure some of the properties of cathode rays. The cathode ray is fired at a high velocity across both magnetic and electric fields and the deflection is measured on a fluorescent screen.




a) On the diagram above, indicate the direction of the force experienced by the cathode rays when only the magnetic field is applied. 1

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b) In one of his experiments, J.J. Thomson deflected a cathode travelling at 0.01c by passing it through a magnetic field of 0.01T. Calculate the force acting on the cathode ray due to the magnetic field. 2

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c) In his next experiment, J.J. Thomson also applied an electric field of 300V across the parallel plates, 1cm apart. Calculate the net force on the cathode ray. 2

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d) In 1897, why was J.J. Thomson's experiment and results regarded as a "scientific breakthrough?" 2

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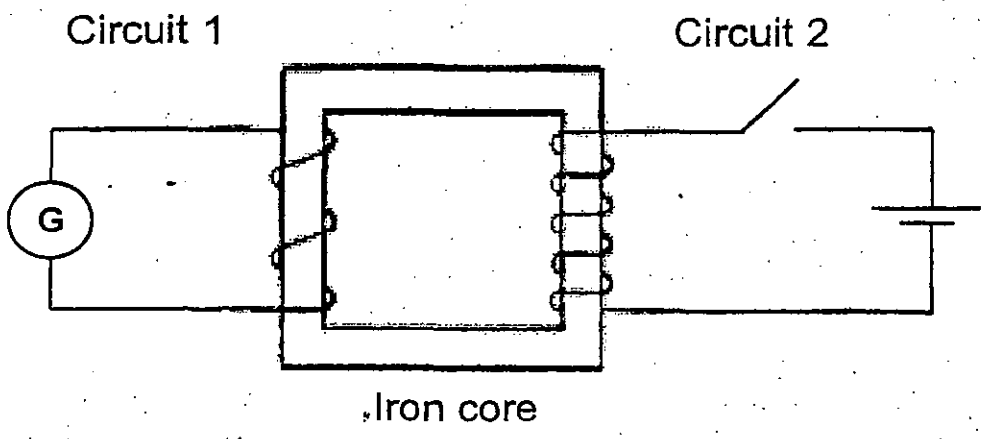
Marks

**Question 28 (5 marks)**

Two coils are wrapped around the opposite sides of an iron core, as shown.
Circuit 1 has a galvanometer and Circuit 2 has a switch and a battery.




When the switch is first closed, the galvanometer needle moves, and then returns to zero.

a) Explain the cause of the current flow in Circuit 1. **2**

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b) Justify TWO changes to the apparatus that would increase the magnitude of the momentary current flow. **2**

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c) Propose ONE change to the apparatus that would produce a continuous current in Circuit 1 while the switch is held closed. **1**

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Marks

**Question 29 (5 marks)**

a) What is the orbital velocity of a shuttle in circular orbit at an altitude of 260km (radius of earth 6400km)? **3**

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b) On one such future mission an observation satellite may be launched from orbit. **2**

What is the radius of the satellite orbit if its period is 14 hours?

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Marks

**Question 30 (6 marks)**

Justify the use of AC generators to provide large scale power production and distribution. 6

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**End of Section I**

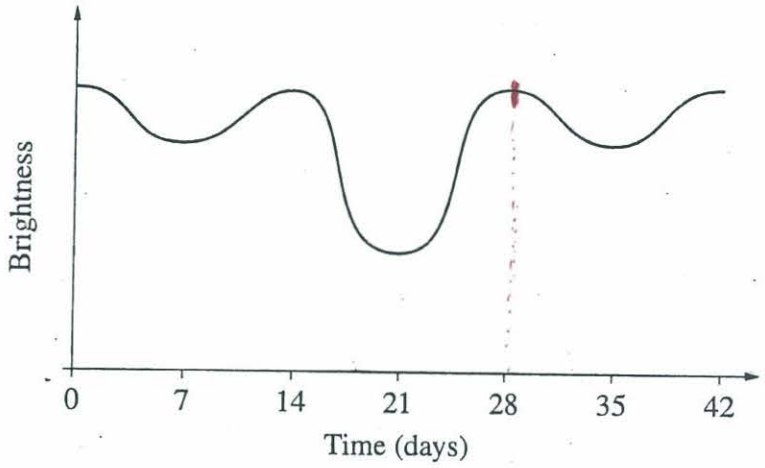
**Section II**
**Elective - Astrophysics**
**25 marks**

**Write your answers to Section II in the spaces provided.**

**Marks**

**Question 31 (25 marks)**

a) The graph represents the variation in brightness of a binary star system.




Given that the mass of the system is determined to be $6 \times 10^{32}$ kg, calculate the average distance between the stars within the system. **2**

b) The following information is available on three main sequence stars.

| Star | Absolute Magnitude | Apparent Magnitude | Parallax Angle (arc sec) |
|---|---|---|---|
| X | 7.2 | 3.6 | - |
| Y | 0.7 | 0.9 | - |
| Z | -2.8 | - | 0.003 |

i) List the stars from the hottest surface temperature to coolest surface temperature **1**

ii) Determine the apparent magnitude of Z. **2**

**Question 31 (continued)**

c) Calculate the distance to a star that has an annual parallax of 0.25 arcseconds. **2**

d) i) Name the two main wavebands from space which are most easily detected on Earth. **1**

ii) Account for the difficulty in detecting two other wavebands on Earth. **2**

iii) Define the term ***parallax*** **1**

e) Data on two nearby stars are given in the table below:

| Star | Parallax (arcsec) | Absolute Magnitude |
|---|---|---|
| Procyon B | 0.286 | +13.0 |
| Ross 154 | 0.336 | +13.0 |

Which star would appear brighter from Earth? **2**
Justify your response.

f) The telescope was first used by Galileo to observe objects in the night sky.

i) Outline ONE feature of the Moon identified by Galileo using the telescope. **1**

Marks

**Question 31 (continued)**

ii) Define the terms ***resolution*** and ***sensitivity***. **2**

iii) Compare the relative limits of trigonometric parallax distance determinations using ground-based and space-based telescopes. **3**

g) Binary stars are classed as visual, eclipsing, spectroscopic or astrometric binaries.

Discuss the techniques used to identify binary stars and a limitation for EACH technique that makes it unable to be used to identify some stars as binaries.

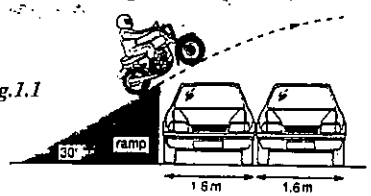
**Section I (continued)** 1C 2D 3D 4A 5B 6D 7D 8C 9A 10D 11C 12A
**Part B – Short Response** 13C 14C 15A 16D 17A 18B 19D 20C
**55 marks**

**Write your answers in the spaces provided.**

**Question 21 (7 marks)** Marks

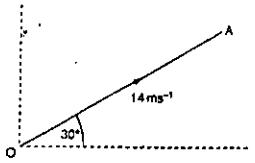
In *Fig1.1* below, a stuntman on a motorcycle plans to ride up a ramp in order to jump over a number of cars. The speed of the motorcycle as it leaves the ramp is 14 $ms^{-1}$ (Neglect air resistance throughout this question)

*Fig.1.1*




a) In *Fig.1.2* below, the line OA represents the velocity of the motorcycle just as it leaves the ramp.

*Fig.1.2*




i) Explain why OA represents the velocity of the motorcycle and not just its speed 1

OA has size and direction and so is a vector

ii) What is the scale used in *Fig.1.2*? 1

1 cm = 3·3 m/s (approx)

b) Calculate the time interval between leaving the end of the ramp and reaching maximum height. 2

$\sin 30 = \frac{v}{14}$ ∴ vert comp = $14 \sin 30 = 7$ m/s ..... 1 mk

$v = u + at$ $\quad 0 = 7 + -9.8t$ ..... 1 mk

$t = \frac{7}{9.8} = 0.7$ sec

c) The cars are each of width 1.6m and the same height as the ramp. Estimate the maximum number of cars which the motorcyclist can jump for the take-off speed of 14 $ms^{-1}$ 3

Total time = 1.4 sec

Horiz component = $14 \cos 30 = 12.1$ m/s

" dist = $12.1 \times 1.4 = 16.94$ m ..... 1 mk

No cars cleared = $\frac{16.94}{1.6} = 10.6$ ..... 1 mk

∴ will clear 10 cars ..... 1 mk

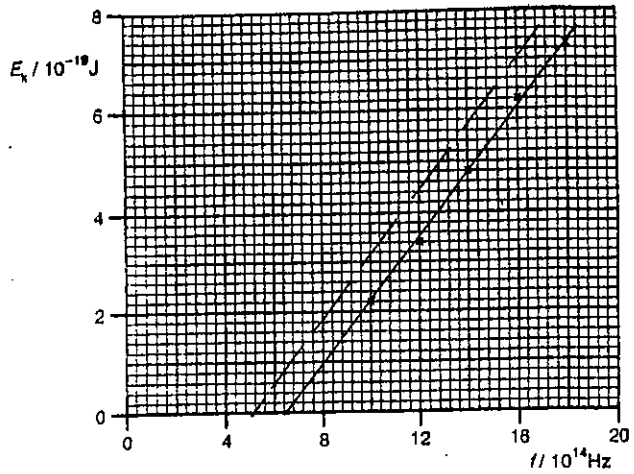


Marks

**Question 22 (8 marks)**

Electrons are emitted from a metal surface when it is illuminated with suitable electromagnetic radiation.

*Fig. 7.1*




The variation with frequency $f$ of the maximum kinetic energy $E_k$ of the emitted electrons is shown in Fig.7.1.

a) Use Fig.7.1 to determine

i) the threshold frequency of the radiation 2

$6.4 \times 10^{14}$ Hz (approx) ..... 2 mks

ii) a value for the Planck constant 2

Planck's const = gradient = $\frac{7.6 \times 10^{-19}}{(18.4 - 6.6) \times 10^{14}}$ ..... 1 mk

MUST HAVE UNITS

$= 6.4 \times 10^{-34}$ J/Hz (or Js) ..... 1 mk

b) On Fig.7.1 draw a line to show the variation with frequency $f$ of the maximum kinetic energy $E$ of the emitted electrons for a second metal which has a lower work function than that in (b). 2

Parallel to first ..... 1 mk

To left of first ..... 1 mk

c) The kinetic energy of the electrons is described as the maximum. Suggest why emitted electrons are likely to have a range of kinetic energy for any one frequency of the electromagnetic radiation. 2

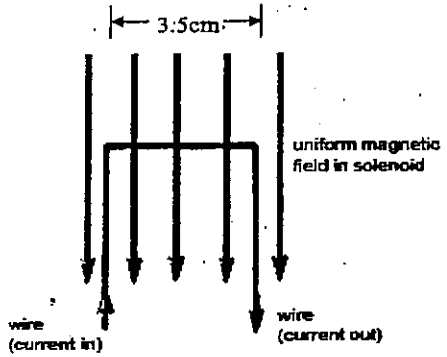
Electrons on surface most easily dislodged ∴ to have max KE ..... 1 mk

More work to free electrons deeper under surface OR electrons lose energy through collisions on way out ..... 1 mk

Marks

**Question 23 (6 marks)**

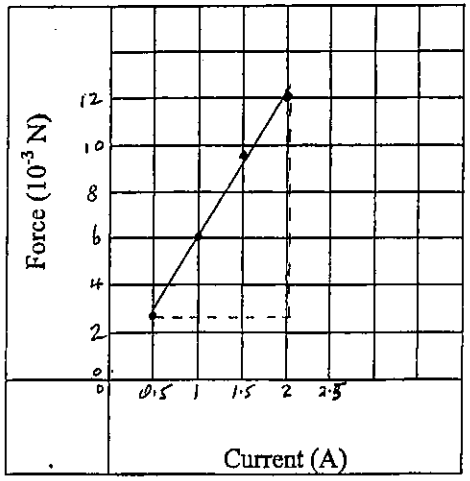
A current carrying wire of length 3.5cm is placed deep inside a solenoid where the magnetic field is uniform. The wire is kept perpendicular to the magnetic field. Looking down, this is shown below.




As the current in the wire is increased, the downward force on the wire is measured. The results are shown in the table below.

| Current in wire (A) | Downward Force ($x10^{-3}$ N) |
|---|---|
| 0.00 | 0.000 |
| 0.50 | 2.5 |
| 1.0 | 6.0 |
| 1.5 | 9.5 |
| 2.0 | 12.0 |

a) Draw a line graph of these results on the grid below. 2




Points correct ... 1 mk
Line of best fit ... 1 mk



Marks

**Question 23 (continued)**

b) Calculate the gradient of your line graph. 1

grad = rise / run = (12.2 − 2.5) / (2 − 0.5) = 6.5 × 10^−3 N/A ... 1

NEED UNITS

c) Using these results, a student claims that they can calculate the magnitude of the magnetic field inside the solenoid. 2

Justify this claim.

gradient = F/I = B.L (From F = BIL) ... 1 mk
and L is known so can find B ... 1 mk
so student is correct.

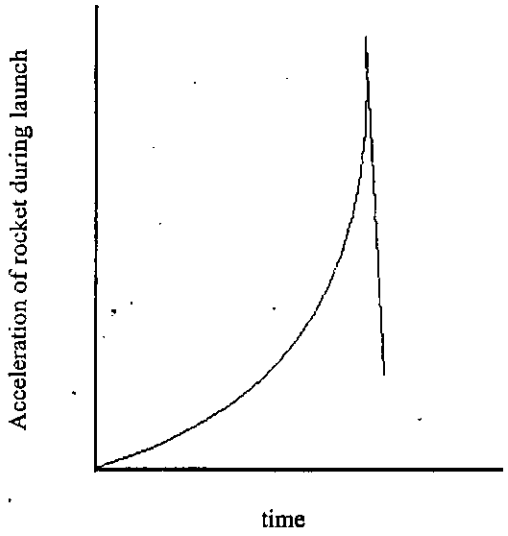
d) Without performing another experiment, describe how you would predict the downward force on the wire when it carries a current of 3.5 A. 1

Extend graph to I = 3.5 and read force ... 1 mk

Marks

**Question 24 (4 marks)**

The sketch below shows how the acceleration of a rocket changes during the first stage of the launch of a rocket.




Explain why the acceleration changes as shown in the graph. 4

Thrust is constant ..... 1 mk
but mass decreases as fuel is consumed .... 1 mk
From F = ma this means increasing acceleration ... 1 mk
At end of first stage boosters ejected when
fuel is all used and acceleration immediately
decreases ... 1 mk



Marks

**Question 25 (4 marks)**

Superconductors have the potential to revolutionise electricity production and use.

a) Identify ONE other use of superconductors. 1

Maglev train, MRI, etc

b) Identify ONE advantage of using superconductors. 1

Due to zero resistance motors can be much smaller and/or more efficient.

c) Explain why magnetic levitation has not been widely used in the transport industry. 2

Large amount of electricity needed
Difficult keeping temp < $T_c$
Brittle nature of ~~ceramic~~ superconductors
Dedicated tracks
High infrastructure cost

any 2

**Question 26 (3 marks)**

The impact of the development of transformers on society has been enormous. Electrical energy from coal fired power stations is distributed to homes and industries at great distances from its point of generation using transformers.

Transformers are also a point of energy losses.

Explain how these energy losses occur in transformers and how they can be reduced. 3

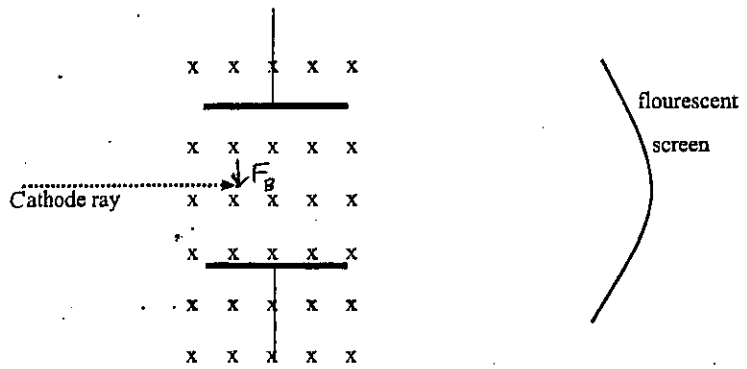
Energy losses occur through the occurrence of eddy currents in the core (producing heat and reducing efficiency). ..... 1 mk

Reduce by:
* laminating core
* which reduces size of eddy currents
* cross section of layers perpendicular to direction of flux
* use ferrites to reduce eddy currents

any 1 mk each

**Question 27 (7 marks)**

The diagram below is of the apparatus used by J.J. Thomson to measure some of the properties of cathode rays. The cathode ray is fired at a high velocity across both magnetic and electric fields and the deflection is measured on a fluorescent screen.




a) On the diagram above, indicate the direction of the force experienced by the cathode rays when only the magnetic field is applied. 1

b) In one of his experiments, J.J. Thomson deflected a cathode travelling at 0.01c by passing it through a magnetic field of 0.01T. Calculate the force acting on the cathode ray due to the magnetic field. 2

$F_B = qvB$ • correct numerical value

$= (1.6\times10^{-19} \times 0.01 \times 3\times10^{8} \times 0.01)$ • correct unit

$= 4.8\times10^{-15}$ N down

c) In his next experiment, J.J. Thomson also applied an electric field of 300V across the parallel plates, 1cm apart. Calculate the net force on the cathode ray. 2

$F_E = qE = qV/d$ • correct $F_E$ calculation (1mk)

$= 1.6\times10^{-19} \times 300/10^{-2}$ • correct $F_{net}$ (1mk)

$F_E = 4.8\times10^{-15}$ N

$F_{net} = F_E + F_B$; $F_{net} = 0$ if upper plate is positive

$F_{net} = 9.6\times10^{-15}$ N down if the lower plate is negative

d) In 1897, why was J.J. Thomson's experiment and results regarded as a "scientific breakthrough?" 2

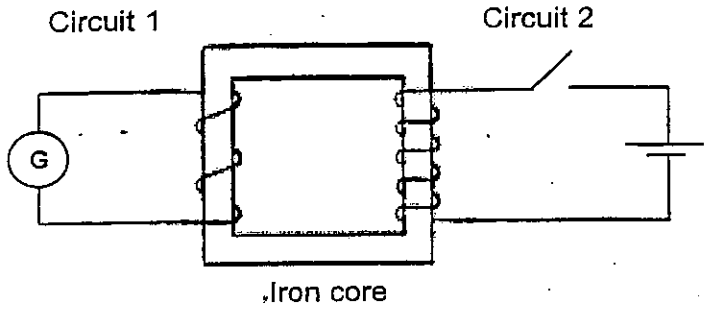
- proved that cathode rays are negatively charged particles
- measured charge/mass ratio for electrons





**Question 28 (5 marks)**

Two coils are wrapped around the opposite sides of an iron core, as shown. Circuit 1 has a galvanometer and Circuit 2 has a switch and a battery.




When the switch is first closed, the galvanometer needle moves, and then returns to zero.

a) Explain the cause of the current flow in Circuit 1. 2

when the switch in circuit 2 is closed, a current flows through it and produces a magnetic field that is strengthened/confined by the iron core, which then induces a current in circuit 1. This induced current is due to the coil in circuit 1 responding to a change in the magnetic field caused by switching the coil in circuit 2 on.

b) Justify TWO changes to the apparatus that would increase the magnitude of the momentary current flow. $V_1/V_2 = n_1/n_2 = I_2/I_1$ 2

- increase voltage in circuit 2 will increase its magnetic field
- increase the number of turns of coil in circuit 2 to increase its magnetic field
- laminate the iron core to reduce eddy current

c) Propose ONE change to the apparatus that would produce a continuous current in Circuit 1 while the switch is held closed. 1

Use an AC source instead of battery

Marks

**Question 29 (5 marks)**

a) What is the orbital velocity of a shuttle in circular orbit at an altitude of 260km (radius of earth 6400km)? 3

$v = \sqrt{\frac{GM}{R}}$ * use the correct equation (1mk)

$= \sqrt{\frac{6.67\times10^{-11} \times 6.0\times10^{24}}{(6400+260)\times10^{3}}}$ * correct numerical value and unit (1mk)

$= 7751.78 ms^{-1}$ * 3 sig. fig (1mk)

$= 7.75 km/s$ or $7800 m/s$

b) On one such future mission an observation satellite may be launched from orbit. 2

What is the radius of the satellite orbit if its period is 14 hours?

$R^3/T^2 = GM/4\pi^2$

$R = \sqrt[3]{\frac{6.67\times10^{-11} \times 6\times10^{24} \times (14\times60\times60)^2}{4\pi^2}}$

$= 29529.73 km$

$= 29.5\times10^{3} km$

- correct equation (1mk)
- correct numerical value + unit (1mk)



Marks

**Question 30 (6 marks)**

Justify the use of AC generators to provide large scale power production and distribution. 6

Justify: support an argument or conclusion

Large scale production

Is easier/cheaper to construct/maintain as AC generator has continuous slip rings with much less sparking and less wear due to friction

Is more reliable than equivalently power rated DC generator as AC generator generally use a rotating central electromagnet (rotor) to induce currents in stationary coils (stator) placed around the rotor.

Distribution:

- AC can be transformed and be transmitted over long distances at high voltage and low current to minimise energy loss by heating effects
- Power stations are built near the source of energy (eg. coal)/located at great distances away from cities.
- Transformers are used to step up the voltage of AC power to 500kV before transmission and then finally step down to 240V for domestic use and 415V for industrial use.

* clear, well constructed presentation of your answer

**End of Section I**

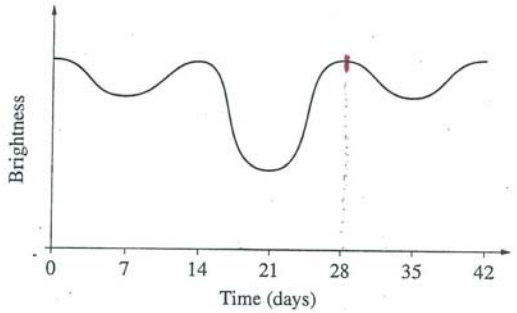
**Section II** TRIAL ASTROPHYSICS 2010 BHHS
**Elective - Astrophysics** ANSWERS
**25 marks**

**Write your answers to Section II in the spaces provided.**

Marks

**Question 31 (25 marks)**

a) The graph represents the variation in brightness of a binary star system.




Given that the mass of the system is determined to be $6 \times 10^{32}$ kg, calculate the average distance between the stars within the system. 2

$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$

$6\times10^{32} = \frac{4\pi^2 \times r^3}{6.67\times10^{-11}(28\times24\times3600)^2}$

$r^3 = 5.9328 \times 10^{33}$

$= 1.81 \times 10^{11}$ m

OR

$2 \times 10^{11}$ m to 1 sig fig

b) The following information is available on three main sequence stars.

| Star | Absolute Magnitude | Apparent Magnitude | Parallax Angle (arc sec) |
|---|---|---|---|
| X | 7.2 | 3.6 | - |
| Y | 0.7 | 0.9 | - |
| Z | -2.8 | - | 0.003 |

i) List the stars from the hottest surface temperature to coolest surface temperature 1

Z Y X

ii) Determine the apparent magnitude of Z. 2

$M = m - 5\log\left(\frac{d}{10}\right)$

$-2.8 = m - 5\log\left(\frac{333.3}{10}\right)$

$m = 4.81$

$d = \frac{1}{p} = \frac{1}{0.003} = 333.3$ pc



Marks

**Question 31 (continued)**

c) Calculate the distance to a star that has an annual parallax of 0.25 arcseconds. 2

$d = \frac{1}{p} = 1/0.25 = 4$ pc

d) i) Name the two main wavebands from space which are most easily detected on Earth. 1

visible, radio (both correct for the one mark)

ii) Account for the difficulty in detecting two other wavebands on Earth. 2

2 Wavebands must be named.

& Must not make wrong/misleading statements.

eg. "UV & IR are absorbed by the atmosphere & can't be detected"
THEY ARE NOT COMPLETELY ABSORBED.

iii) Define the term ***parallax*** 1

The apparent movement of an object relative to its background when viewed from 2 different positions.

e) Data on two nearby stars are given in the table below:

| Star | Parallax (arcsec) | Absolute Magnitude |
|---|---|---|
| Procyon B | 0.286 | +13.0 |
| Ross 154 | 0.336 | +13.0 |

Which star would appear brighter from Earth? 2
Justify your response.

Procyon B $M = m - 5\log\left(\frac{d}{10}\right)$ $13 = m - 5\log\left(\frac{1/0.286}{10}\right)$

$m = 10.72$

Ross 154 $13 = m - 5\log\left(\frac{1/0.336}{10}\right)$

$m = 10.37$

OR Same M, but parallax data indicates that Ross is closer. ∴ Ross will appear brighter

Ross 154 has a lower apparent magnitude than Procyon
∴ Ross 154 appears brighter

f) The telescope was first used by Galileo to observe objects in the night sky.

i) Outline ONE feature of the Moon identified by Galileo using the telescope. 1

mountains, valleys, "seas", rough features

Not sufficient to say not smooth/not spherical.

**Question 31 (continued)**

Marks

ii) Define the terms ***resolution*** and ***sensitivity***. 2

(R) clearly distinguish between 2 very close objects

If you use the word "resolve", it needs to be explained (derived from "resolution")

(S) light gathering power ← essential

It is related to (not synonymous with) The minimum amount of light for a clear image.

iii) Compare the relative limits of trigonometric parallax distance determinations using ground-based and space-based telescopes. 3

Marks

Correct numerical data required

Distance limitations compared

eg. Ground ($p = 0.01$ arcsec) Space ($p = 0.001$ arcsec)

eg. ~30pc →100pc to much greater ~1000pc + (1)

linked to number of suitable stars

e.g. ~700 only to much greater ~100,000 + (1)

S/ Statements comparing conditions causing limitations:

e.g. Ground based limitted by "seeing" effects of atmosphere

∴ Space telescopes have better resolution.

Space telescopes have size limitations (lower sensitivity) because of difficulty & cost of getting into orbit (1)

3 marks can also be awarded for an answer that links parallax limits to distance limits, fully and accurately, with an excellent coverage of condition causing limitations.

{NB} Hipparcos orbits the earth, so its base line is nearly the same (sometimes smaller) than ground telescopes.

g) Binary stars are classed as visual, eclipsing, spectroscopic or astrometric binaries.

Discuss the techniques used to identify binary stars and a limitation for EACH technique that makes it unable to be used to identify some stars as binaries. 6

define eclipse

4

4 points: Detection techniques for each technique clearly, correctly & comprehensively stated.

4 points: A limitation for each technique clearly and correctly outlined.

All statements must be clearly linked to each class of binaries. 5, 6

2 or 3 of the above 8 points missing or not adequately outlined. The others need to be clearly linked. 3, 4

More than 2 of the above 8 points missing or not adequately outlined/linked 1, 2

**Notes:**

Most students outlined the 4 techniques very well, however the limitations that were linked to each, varied from trivial to precise and unique. The quality of your choice and description of limitation were very important when deciding if your answer was in the 5, 6 category

Visual technique: need to include "powerful telescope"

lim: Best answers talked about "resolution" problems. Answers like "too far" "seeing" "long period" unless they (use the term) related to "resolution" were not as strong, not as unique to Visual.

Eclipsing technique: concept of "periodic" should be clear

lim: best answers: (define plane of orbit) // to line of sight

OR sufficient luminosity of both stars to detect changes

End of Paper

Spectroscopic: "periodic" concept, outlining red, blue no shift & when occur.

lim: "plane of orbit" problems described but more acceptable angles than Eclip above.

: fast enough relative movement must be fully explained.

Astrometric: good description incl. concept of gravity.

lim: (best answers fully describe): can't detect wobble because its too small because

→ comparable small mass of other object. (Answers like "too far" "seeing" not unique enough)

→ maybe a planet, not a second star.