

## Section I

Total marks – 75

### Part A

15 marks

Attempt Questions 1-15

Allow about 30 minutes for this part

Use the Multiple Choice Answer Sheet provided

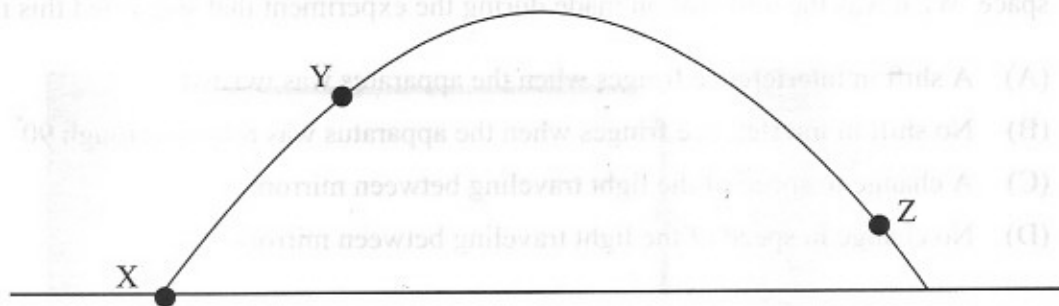
- 1 Using the data in the table below answer the following question.

Planet	Acceleration of Gravity
Earth	$9.8 \text{ m/s}^2$
Mars	$3.7 \text{ m/s}^2$

A person stood on scales that were designed for the Earth whilst on Mars. The scale gave a reading of 50 Kg. What is the actual mass of the person?

- (A) 132.4 Kg  
(B) 50 Kg  
(C) 18.9 Kg  
(D) 490 N
- 2 A projectile is fired horizontally at  $10 \text{ ms}^{-1}$  from the top of a cliff, 55m high, into the water. What is the magnitude of its velocity as it impacts with the water?
- (A)  $32.8 \text{ ms}^{-1}$   
(B)  $1078 \text{ ms}^{-1}$   
(C)  $1175.8 \text{ ms}^{-1}$   
(D)  $34.3 \text{ ms}^{-1}$

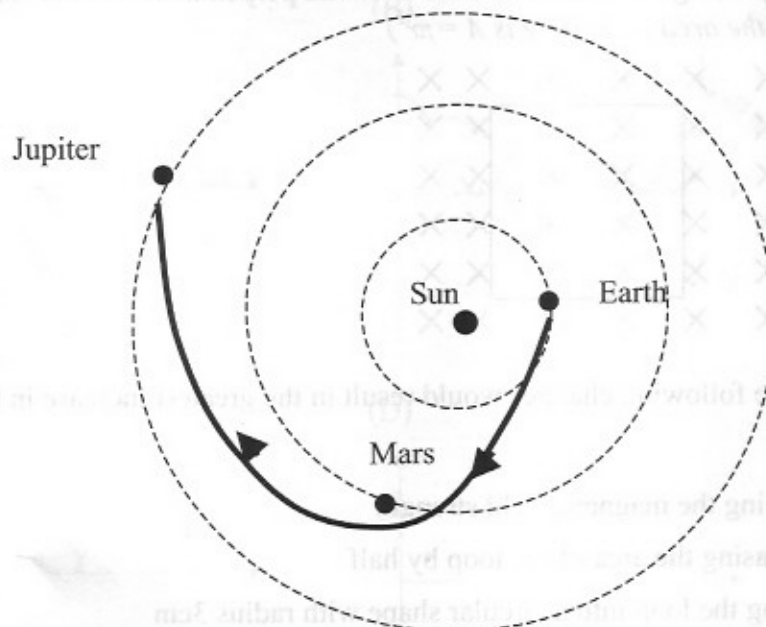
3



A projectile is fired from point X and travels in a parabolic path returning to ground after passing through points Y and Z. Which of the following statements is correct?

- (A) By the conservation of momentum, the momentum at Y equals the momentum at Z
- (B) The energy at Z will be greater than the energy at Y because the earth's gravity force has acted on the projectile for a greater time
- (C) By gravitational field theory, the force acting on the projectile at Y is less than the force acting on the projectile at Z
- (D) The horizontal velocity of the projectile remains constant throughout the entire motion

4 The following diagram shows the trajectory of a spacecraft on a mission to Jupiter from Earth:



What can be said about the spacecraft as it passes Mars?

- (A) It is slowed down due to atmospheric friction
- (B) It is slowed down by Martian gravity
- (C) It is sped up by the slingshot effect
- (D) It wastes fuel to escape the gravity of Mars

5 The Michelson-Morley experiment failed to support the idea that there is an aether in space. What was the observation made during the experiment that suggested this result?

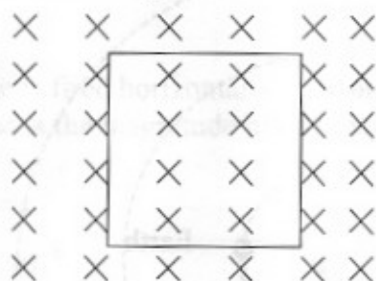
- (A) A shift in interference fringes when the apparatus was twisted
- (B) No shift in interference fringes when the apparatus was rotated through  $90^\circ$
- (C) A change in speed of the light traveling between mirrors
- (D) No change in speed of the light traveling between mirrors

6 A simple motor has  $n$  turns in the armature, and has an area of  $A \text{ m}^2$ . A current of  $I$  amps is passed through the armature which sits at  $0^\circ$  in a magnetic field of strength  $B \text{ T}$ .

Determine the torque if the area and the current is doubled, and the armature now makes an angle of  $60^\circ$ .

- (A) 2 x original torque
- (B) 4 x original torque
- (C) Original torque
- (D)  $1/2$  x original torque

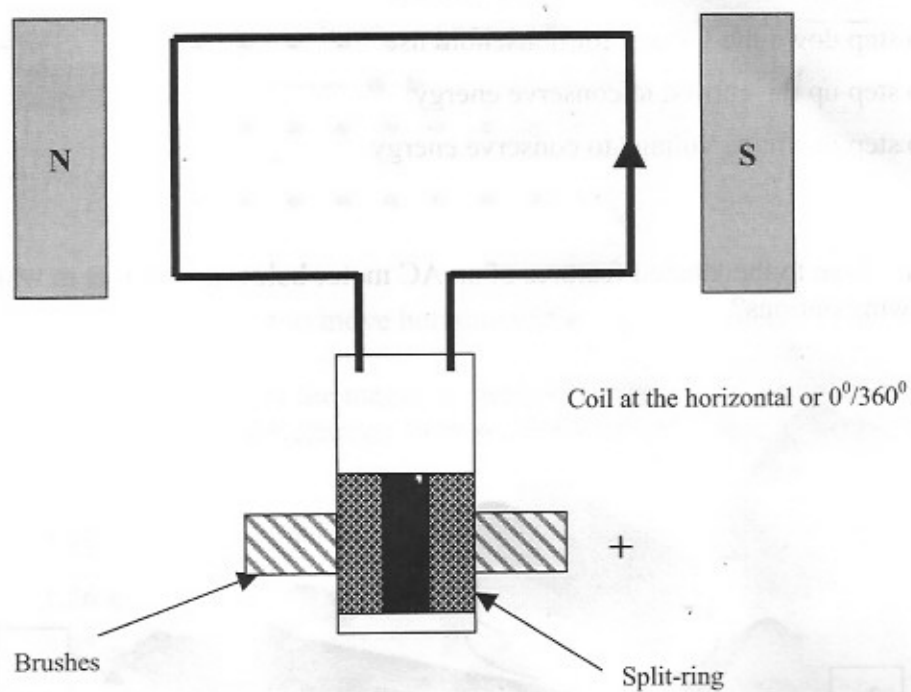
7 The following diagram shows a loop of wire (side lengths =  $5\text{cm}$ ) that has a magnetic field cutting through it so that the field lines run perpendicular to the surface of the loop. (Given that the area of a circle is  $A = \pi r^2$ )



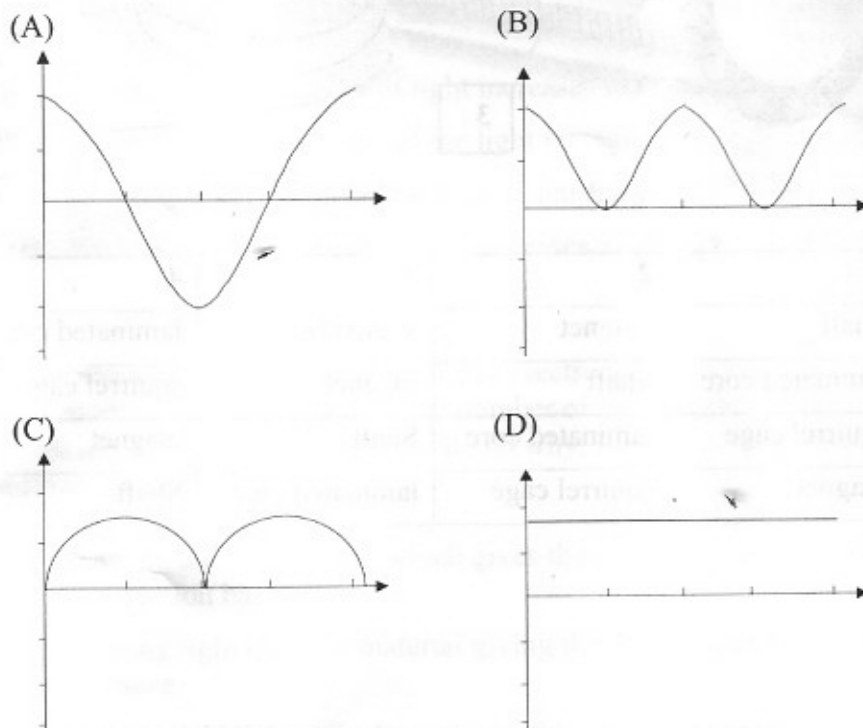
Which of the following changes would result in the greatest increase in the magnetic flux?

- (A) Doubling the magnetic field strength
- (B) Decreasing the area of the loop by half
- (C) Making the loop into a circular shape with radius  $3\text{cm}$
- (D) Making the loop circular with a radius of  $2\text{cm}$

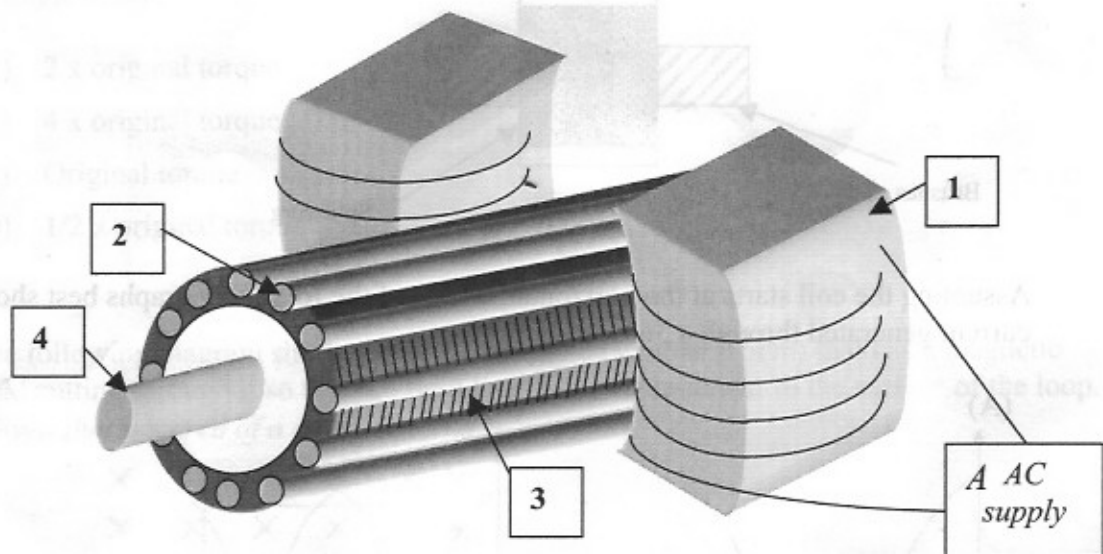
- 8 The following set up was used to generate electric current.



Assuming the coil starts at the horizontal, which of the following graphs best shows the current generated through a  $360^\circ$  rotation.

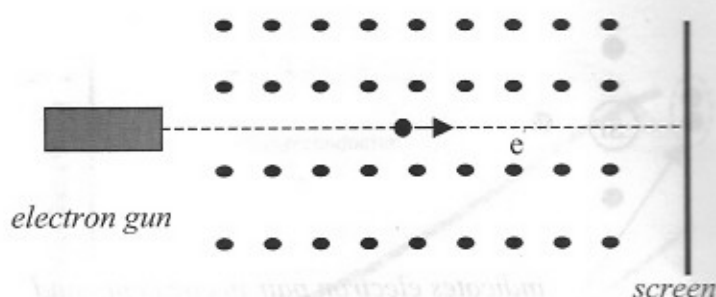


- 9 What is the role of a transformer in an electricity sub station?
- (A) To step down the current for household use  
 (B) To step down the voltage for household use  
 (C) To step up the current to conserve energy  
 (D) To step down the voltage to conserve energy
- 10 The name given to the labeled features of an AC motor below are correct in which of the following options?



	1	2	3	4
(A)	Shaft	magnet	squirrel cage	laminated core
(B)	laminated core	Shaft	magnet	squirrel cage
(C)	squirrel cage	laminated core	Shaft	magnet
(D)	magnet	squirrel cage	laminated core	Shaft

- 11 An electron is fired from an electron gun towards a screen as shown:

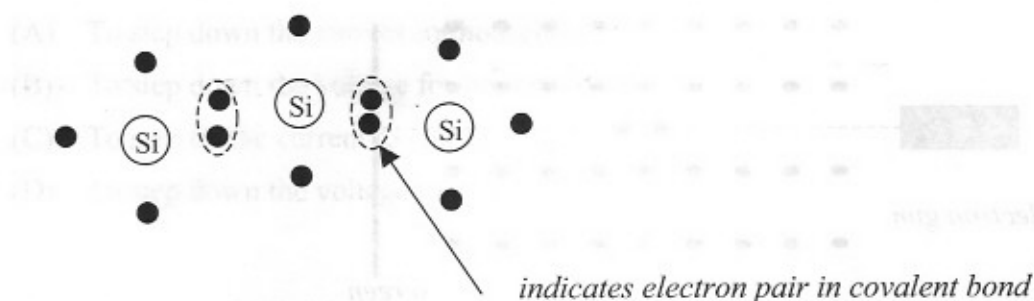


The electron is observed to move horizontally in a straight line at a speed of  $6.2 \times 10^{18}$  m/s.

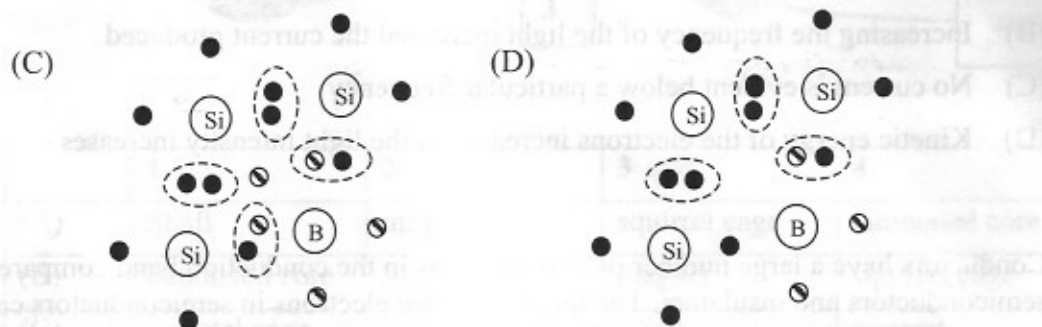
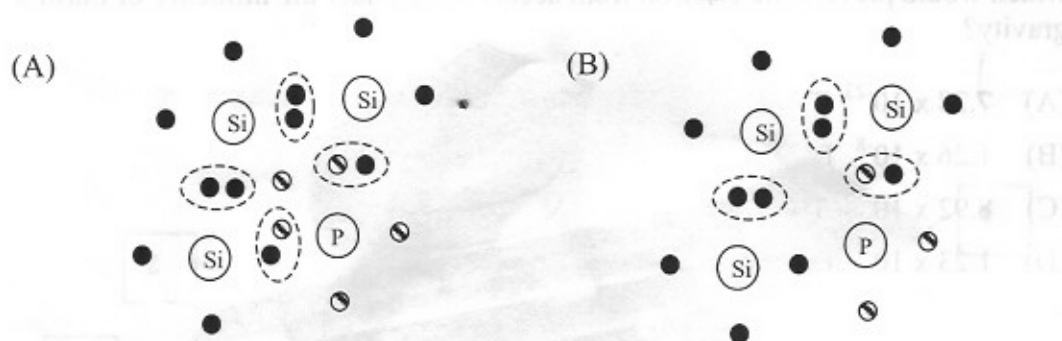
What is the magnitude of the magnetic field perpendicular to the velocity of the electron which would prevent the electron from accelerating under the influence of Earth's gravity?

- (A)  $7.28 \times 10^{-23}$  T  
(B)  $1.26 \times 10^{-8}$  T  
(C)  $8.92 \times 10^{-30}$  T  
(D)  $1.23 \times 10^{-7}$  T
- 12 Einstein explained the phenomenon of the photoelectric effect using the idea that light is quantised. Which behaviour of solar cells backs up this idea?
- (A) Increasing the intensity of light increases the emf produced  
(B) Increasing the frequency of the light increased the current produced  
(C) No current is evident below a particular frequency  
(D) Kinetic energy of the electrons increases as the light intensity increases
- 13 Conductors have a large number of free electrons in the conduction band compared to semiconductors and insulators. The number of free electrons in semiconductors can be increased. How this can be achieved and why, is best described by which of the following alternatives?
- (A) Raising the temperature which gives the electrons enough energy to jump into the conduction band  
(B) Shining light onto the material giving the electrons a higher frequency and ability to move  
(C) Shining UV light onto the surface of the material giving the electrons the ability to jump the forbidden gap into the valence band  
(D) Applying a potential difference to the material in order to move the electrons to the valence band

- 14 Below is a diagram showing the electrons in the outer shell of three silicon atoms.

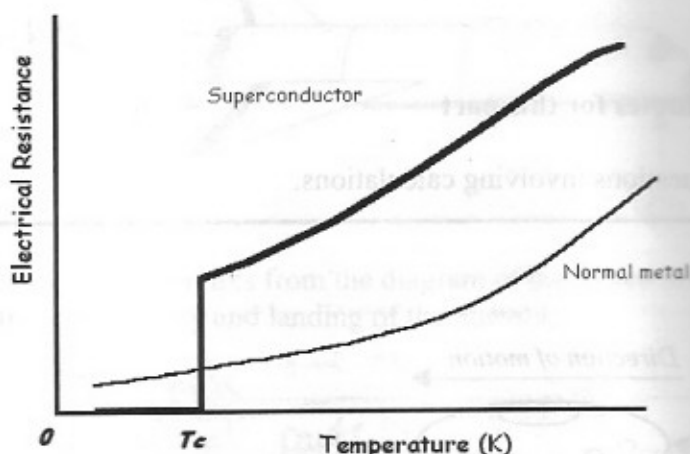


When silicon is with other atoms, it bonds covalently. Which of the following diagrams best shows how silicon would bond when it is doped to form an n-type semiconductor?





15 Use the graph to answer the following question.



$T_c$  = Critical temperature

Which of the following statements best describes what is occurring in the superconductor when temperature  $< T_c$ .

- (A) Resistance is reduced to zero because of the eddy currents being produced in a magnetic field that is generated by the superconductor
- (B) Pairs of electrons, known as Cooper pairs, are able to move through the lattice of positive particles distorting the shape of the lattice and therefore decreasing resistance to zero
- (C) Electrons are forced to jump from the atomic lattice structure and induce a current in nearby materials
- (D) A junction diode can be created using the superconductor to stop the flow of current in one direction, but not effecting the flow of current in the other



## Section I

### Part B

60 marks

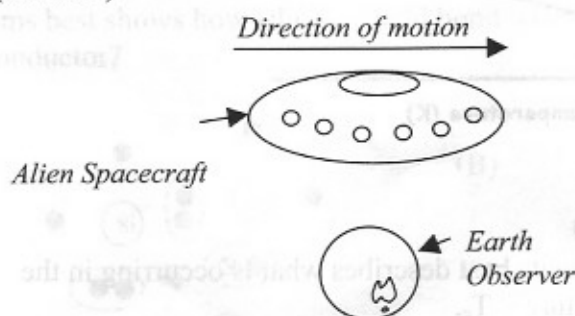
Attempt Questions 16–28

Allow about 1 hour and 45 minutes for this part

Show all relevant working in questions involving calculations.

#### Question 16 (5 marks)

Marks



An observer on Earth observed an alien spacecraft passing by as shown in the diagram above. The observer photographed it then made measurements and found it to be 25 m long and 10 m high. NASA tracked the vehicle on their radar and found that it had a speed of  $0.8c$ .

- (a) Calculate the length of the space craft as measured by the observer on Earth.

2

$$L = L_0 \sqrt{1 - \frac{v^2}{c^2}} \quad L_0 = 41.667 \text{ m}$$

The aliens observe it at 41.667 m

$$25 = 41.667 \sqrt{1 - \frac{(0.8c)^2}{c^2}}$$

$$25 = 41.667 \sqrt{0.36}$$

- (b) What was the height of the spacecraft as measured by the aliens on board?

1

10 m. Height doesn't change

- (c) The spacecraft took some Earthlings, did some experiments and then returned them to Earth. One of those captured reported he was on the craft for 10 hours. For how long did his family experience him missing? (Assume it continued at the same speed and did not need to stop.)

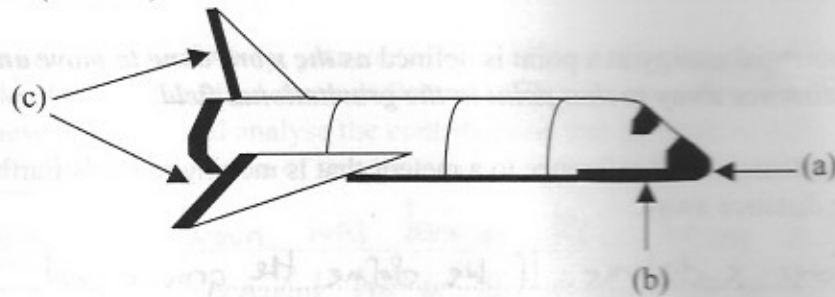
2

$$t_{\text{family}} = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{10}{\sqrt{1 - 0.8^2}} = 16.667$$

His family experienced him missing for 16.667 hours.

Question 17 (6 marks)

Marks



- (a) Identify TWO features from the diagram of the Space Shuttle above that aid in the safe re-entry and landing of the humans.

2

(a) Blunt nose cone

(b) Sacrificial parts

Name: it

- (b) Discuss how the features identified in part (a), in conjunction with others built into the Space Shuttle will make re-entry safer.

4

A Blunt nose was used to create a shockwave of air that absorbs much of the frictional heat. It is also used to slow the space shuttle down. The Sacrificial parts were used to absorb the heat energy as a result of re-entry. The parts were made usually of fibreglass or heat-resistant ceramic tiles. These ~~parts~~ parts would vaporise as they absorb the heat. In conjunction with other safety features to make re-entry ~~safer~~ safer, such as wings to allow the pilot to control the direction and thus make the re-entry angle of  $5.6^\circ - 7.6^\circ$  more easily achievable. As a result of these safety measures, re-entry is made much more safer.

Question 18 (5 marks)

Marks

The gravitational potential energy at a point is defined as *the work done to move an object from a very large distance away to that point in the gravitational field.*

- (a) Apply this statement with reference to a meteor that is moving towards Earth from a long distance away.

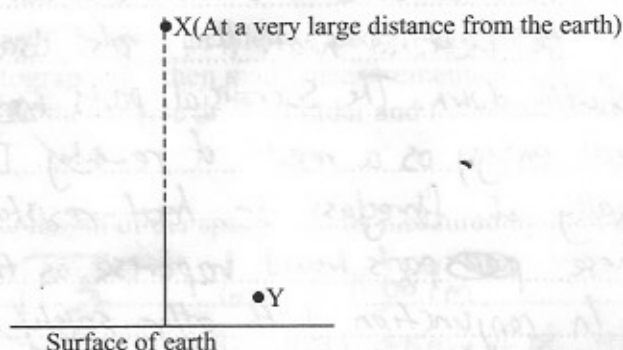
3

Work = force  $\times$  distance. If we define the gravitational potential ~~energy~~ at a point as infinity, then a ~~meteor~~ meteor that is moving towards Earth from a long distance away requires work to be done. As a result of defining ~~infinity~~ the gravitational potential energy as infinity, the result will be a negative number as shown by

$$E_p = -\frac{Gm_1m_2}{r}$$

- (b) X is a point at a very large distance from the Earth's surface. Y is a point 1 kilometre above the Earth's surface.

2



Calculate the potential energy of the meteor that is moving from point X to Y if the mass of the meteor is 300kg.

$$E_p = -\frac{Gm_1m_2}{r}$$

$$= \frac{-6.67 \times 10^{-11} \times 300 \times 6 \times 10^{24}}{1000}$$

$$= -1.2 \times 10^{14} \text{ J}$$

Question 19 (4 marks)

Marks

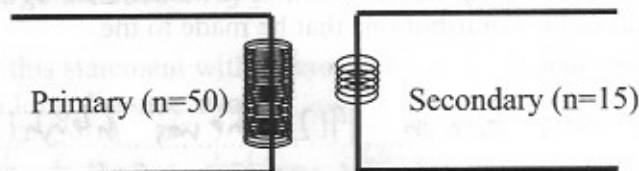
During the course of your study, you studied one of the following scientists, Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun. Choose ONE of these scientists and analyse the contributions that he made to the development of the exploration of space.

Von Braun Von Braun was born in 1912, he was interested in rockets and played a crucial role in the development of the exploration of space. In ~~1948~~ <sup>1956</sup> he made the ~~3 stage~~ 3 stage Jupiter C rocket and 3 months later he ~~was~~ launched another Jupiter C into space. The Jupiter C was then modified and later became known as Juno 2 which with the Jupiter C combined made the first rocket that would predict to bring man into space known as the Saturn V. And in 1967 it was launched and began a new world of exploration. Von Braun's contribution was mainly in the making of rockets. He worked for Hitler to help the war effort and made the powerful V2 rocket. After a while, ~~he~~ von Braun ~~at~~ surrendered and worked for the United States, which was where ~~the~~ space exploration became very exciting to him. He was considered the father of rockets which not only led America into space but produced weapons of mass destruction. He ~~was~~ worked in NASA in 1960 and his contributions of creating the Saturn rocket was crucial.

**Question 20 (7 marks)**

**Marks**

In the picture below, the transformer has 50 turns in its primary coil and 15 in the secondary coil.



- (a) If the initial primary voltage is 240V, calculate the output voltage of this transformer.

1

$$\frac{V_p}{V_s} = \frac{n_p}{n_s} \quad \frac{240}{V_s} = \frac{50}{15}$$

$$50V_s = 3600$$

$$V_s = 72V$$

The output voltage is 72V.

- (b) Explain why it is necessary to transmit electricity at high voltages.

3

It is necessary to transmit electricity at high voltages to reduce power loss. According to Ohm's law,  $P = I^2 R$  and thus

$$\text{Power}_{in} = \text{Power}_{out} + \text{power loss}$$

$$IV = IV + I^2 R$$

As you can see if the current was doubled, power loss will be increased by 4 times, which is why a high voltage is required to avoid power loss.

- (c) Outline where and how a transformer similar to the one above could be used to assist in the transmission of high voltages (approximately 35KV) to home requiring only a 240V supply.

2

A transformer similar to the one above could be used in substations. In the outskirts of a city, substations are there to step down the high voltages to the 240V ones we use at home. In comparison, the substation will have less turns in the secondary coil than in the primary.

- (d) Identify ONE other location in which this type of transformer is commonly used within a household.

1

Mobile phone chargers.



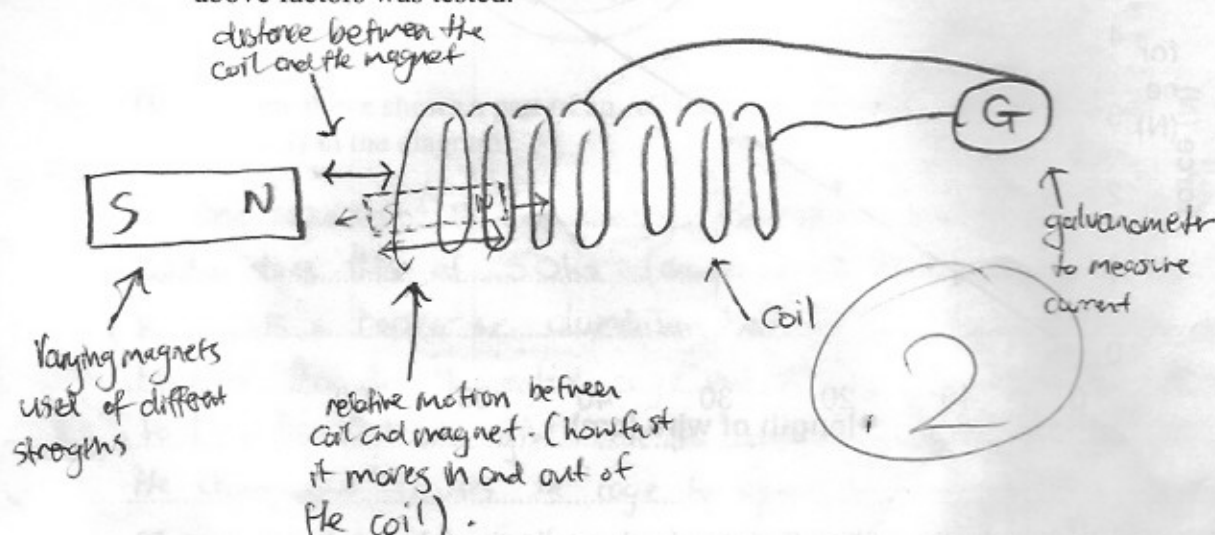
**Question 21 (4 marks)****Marks**

In the course of your studies, you were required to plan and perform a first hand investigation to predict and verify the effect of a number of factors that effect the generation of electric current.

These factors included:

- (i) the distance between the coil and the magnet
- (ii) the strength of the magnet and
- (iii) the relative motion between the coil and magnet.

- (a) Draw a labelled diagram of your equipment with notes to show how each of the above factors was tested. 2



- (b) Describe the effect that you found that each factor has on the generation of current. 2

- i) distance - further away, less current | closer = more current
  - ii) Strength of magnet - the stronger the magnet, the more current, the weaker the magnet, less current.
  - iii) Relative motion - faster it moves in and out of the coil, more current, slower = less.
- 2

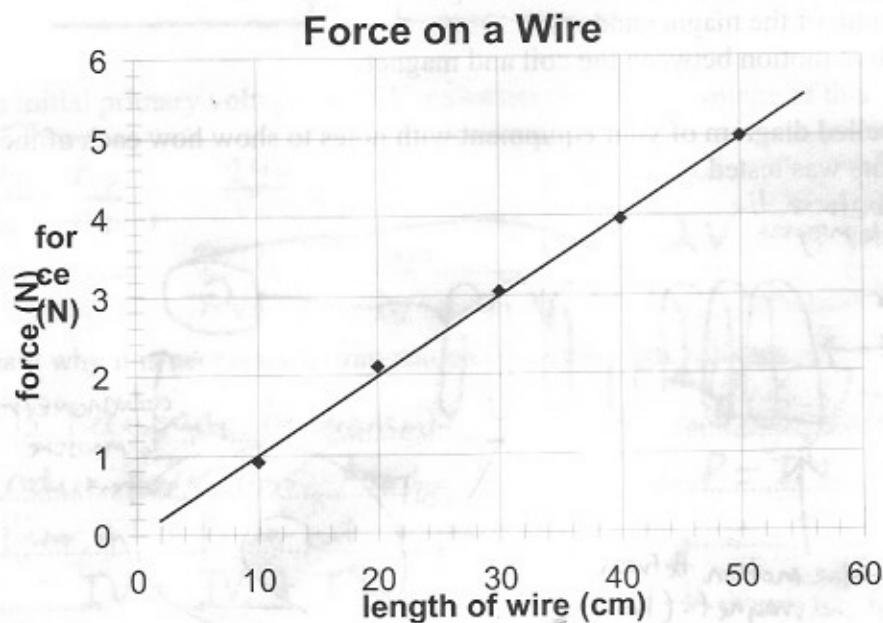


**Question 22 (4 marks)**

**Marks**

A student performed an experiment to measure the force on a wire within a magnetic field (**B**). The student varied the length (**l**) of the wire and graphed the results, which are shown below.

The magnetic field was at an angle of  $90^\circ$  to the wire. The current through the wire was 2.5A.



- (a) Use the gradient of the line of best fit drawn by the student to calculate the value of **B**, the magnetic field intensity.

**3**

$$F = BIL \sin \theta$$

$$1 = B \times 2.5 \times 0.1 \sin 90$$

$$B = \frac{1}{0.25}$$

$$= 4$$

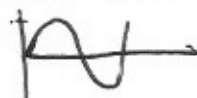
The magnetic field intensity of **B** is 4 T.

3

- (b) Describe the effect on the force on the wire of turning the wire slowly until the wire is parallel to the direction of the magnetic field.

**1**

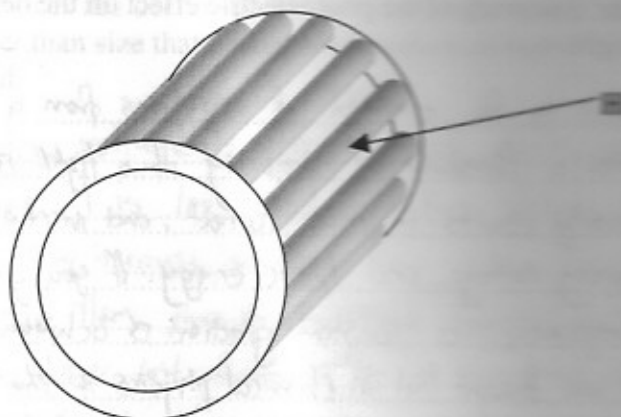
Maximum force when wire is perpendicular to the magnetic field. as the angle slowly reaches parallel ( $0^\circ$ ) the force becomes zero as shown by the sine curve.



1

Question 23 (3 marks)

Marks



The diagram above shows a part of an AC induction motor. Explain the function of the part labeled H in the diagram.

3

- (a) one requirement is a <sup>not sufficient</sup> constantly changing magnetic field. The AC supply does this at 50Hz. (changes direction 50 times a second)
- (b) H is a copper or aluminium bar. The function is to allow current to pass through the entire cage and sets up a magnetic field. According to Lenz law, it will give rise to another magnetic field that opposes the change and causes the cage to spin. As a result its like the cage is 'chasing' itself.

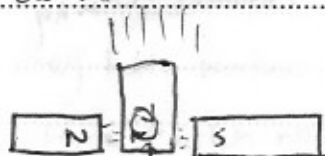
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Question 24 (2 marks)

Explain how induction electric brakes work.

2

Induction electric brakes work through the concept of eddy currents. When a metal falls into a magnetic field (e.g. the space probe 7 in wonderland) circular eddy currents are induced that oppose the change and thus slow it down.



circular eddy currents.

2

Question 27 (3 marks)

Marks

The size of electronic devices has decreased due to the introduction of semiconductors. Discuss ONE factor other than size that makes semiconductors better than the technology they replaced.

One factor is the low voltage requirements in electronic devices. They make it better as it is less hazardous to electric shock as low voltages are used. Also because of their low voltage requirements, batteries can be used to run them thus allowing many devices to be portable. Another reason is the lower cost of electricity to consumers as most things in the house make use of these low voltage requirements and thus reduce electricity costs.

3

3

24

Question 28 (5 marks)

Outline how Einstein and Planck's views of Science differed in relation to Science research being influenced by society and politics.

5

Einstein and Planck were very good friends. However their views had significantly changed as the war approached. Einstein was a man of peace, he believed that his discoveries should not be used for war. Planck on the other hand was a patriot. He worked for Hitler and helped the war effort. As a result, Einstein and Planck became rivals in their social and political views. This is shown when Einstein had developed his idea of relativity. This idea did not sit well with the Nazi party as they were against Einstein's views simply because he hated the Nazis. As a result, it shows that because of rivaling societies, the facts become impeded for the sole reason that they didn't like each other and that just because a rivaling society discovered something, the other rivaling society won't believe it because they hate each other. Because of this

WWI

2

End of Section I

Planck was reluctant to accept Einstein's ideas as they both worked for different reasons, Planck was to help the war effort while Einstein was to keep the peace. This is shown as quoted by Einstein that "I only want to know God's thoughts, anything else is trivial".

Einstein could never forgive Planck for his help in causing destruction in helping the war effort and as a result their views of Science differed in relation to Science research being influenced by society and politics.

**Question 29 – Geophysics (25 marks)****Marks**

- (a) (i) Describe the function of a gravimeter. 1
- (ii) Give TWO reasons why Earth's gravity may vary between two points on its surface. 2
- (b) (i) Define the term *palaeomagnetic*. 1
- (ii) Describe the type of information obtained from any ONE of the following principle methods used in geophysics: seismic, gravitational, magnetic, palaeomagnetic, electrical, electromagnetic, radiometric or geothermal. Clearly identify which method you refer to. 3
- (c) (i) Explain the benefits of geophysical methods in mineral exploration and environmental monitoring. 8
- (ii) Contrast ONE property of P waves and S waves. 1
- (d) Explain the role of remote sensing techniques in monitoring climatic conditions on Earth. 4
- (e) Summarise the geophysical evidence that supports the theory of plate tectonics. 5

**End of Question 29**

**Question 30 – Medical Physics (25 marks)****Marks**

- (a) Describe why gel is rubbed onto the skin before an ultrasound transducer is used. 1
- (b) The table below contains information that relates to the questions that follow:

Material	Density ( $\text{kgm}^{-3} \times 10^3$ )	Acoustic Impedance ( $10^6$ rayls)
Air	0.001	0.0004
Water	1.00	1.54
Bone	1.85	7.80
Muscle	1.06	1.70
Fat	0.93	1.38
Blood	1.00	1.61

- (i) Calculate the percentage of an ultrasound beam that is reflected when it passes from the muscle of the stomach to the fat that surrounds it. 2
- (ii) Calculate the speed of sound in bone. 1
- (c) Crystals are located within an ultrasound transducer. Describe the piezoelectric effect and how ultrasound is produced. 3

**Question 30 continues on page 23**

- (d) Image A and B have been produced using different imaging techniques.

**A****B**

Compare the images in the scans above.

8

- (e) PET scans are produced by introducing radioisotopes into the body. Discuss what happens when a positron collides with an electron within the tissues of the body. 1
- (f) Discuss the difference in structure and function of the coherent and incoherent bundles of an endoscope. 4
- (g) MRI and CT both produce images showing 'slices' through the body. Compare these two imaging techniques. 5

**End of Question 30**



**Question 31 – Astrophysics (25 marks)****Marks**

- (a) (i) Define the term 'binary star'. 1
- (ii) Describe the observations of an astronomer on Earth to identify an astrometric binary star. 2
- (b)
- | Star       | Apparent Magnitude | Distance (parsecs) |
|------------|--------------------|--------------------|
| Vega       | +0.04              | 8.1                |
| Canopus    | -0.72              | 29.9               |
| Betelgeuse | +0.41              | 184                |
- (i) Identify which star is the brightest as seen from Earth. 1
- (ii) Calculate the absolute magnitude of Vega. 3
- (c) Outline the key stages in a stars life in terms of the physical processes involved and identify the nuclear reactions that occur at each stage. 8
- (d) A plot is made of the energy released at all wavelengths of a black body of 200K. If the body was heated to a temperature of 1000K identify how the plots would vary. 1
- (e) (i) Discuss some of the problems associated with ground-based Earth astronomy. 4
- (ii) Discuss how the development of interferometry has improved the resolution and sensitivity of ground-based astronomy. 5

**End of Question 31**

**Question 32 – Quanta to Quarks (25 marks)****Marks**

- (a) (i) Cyclotrons and linear accelerators can be used to accelerate many particles but not neutrons. Discuss why is this so? **1**
- (ii) Name the FOUR fundamental forces of nature. **2**
- (b) (i) Define binding energy. **1**
- (ii) Determine the ionisation energy of the hydrogen atom. Give the answer in electron volts (eV). **3**
- (c) (i) Describe how you carried out an investigation to observe radiation emitted from a nucleus with a Wilson Cloud Chamber or similar device, relate your results. **8**
- (ii) State a difference between controlled and uncontrolled nuclear reactions. **1**
- (d) State what are TWO essential properties of radio isotopes and give ONE example of a radio isotope and how it is used. **4**
- (e) Assess the significance of the Manhattan Project to society. **5**

**End of Question 32**

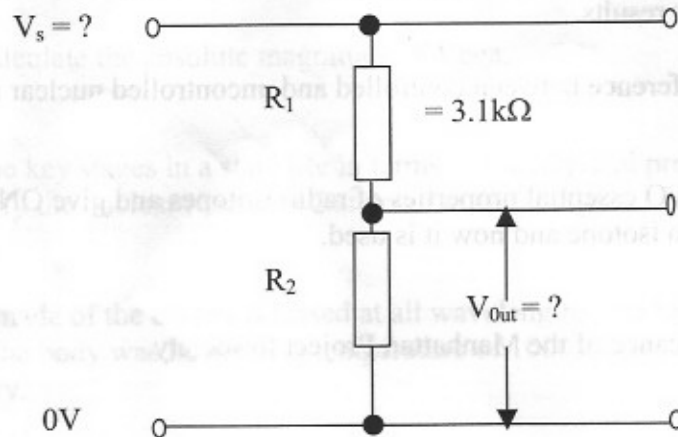
**Question 33 – Age of Silicon (25 marks)**

**Marks**

- (a) State ONE difference between an integrated circuit and a transistor. 1
- (b) Silica is a very commonly used material in electronics because it has properties that are desirable.

Name ONE such property and explain why it is so desirable in electronics. 2

- (c) (i) Define a potential divider. 1
- (ii) Below is a diagram of a potential divider: 3



Total current flowing through the potential divider =  $1.5A$

Total resistance =  $5\Omega$

From the information given, calculate the voltage supplied,  $V_s$  and voltage out  $V_{out}$ .

- (d) Items such as solar cells, switches and light meters in cameras are considered to be input transducers. Explain why this can be said. 8
- (e) Identify the gates that are used to make a half adder. 1

**Question 33 continues on page 27**

Question 33 (continued)

Mark

- (f) A school has decided to install a security system on the computer room. To be able to use the computer the following requirements must be met: 4

A student swipes an ID card or enters a user name and a password. The student must then select their teacher's name from a list, if they are registered in this class, they will then be permitted to use the computer.

Design a logic system that achieves the above security. Draw it and the truth table.

- (g) Describe the function and properties of an ideal amplifier. 5

**End of Question 33**

**End of paper**