| | |
|---|---|
| **Student Number** | |
| **Mark / 100** | |

# 2010

## TRIAL HSC EXAMINATION

# Physics

## General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of this page and on the response sheets on page 21
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided

**Total Marks – 100**

**Section I** Pages 2 - 28

**75 marks**

This section has two parts, Part A and Part B

**Part A** – 20 marks
•Attempt Questions 1- 20
•Allow about 30 minutes for this part

**Part B** – 60 marks
•Attempt Questions 21 - 30
•Allow about 1 hour and 45 minutes for this part

**Section II** Pages 29 - 31

**25 marks**

•Attempt Question 31.
•Allow about 45 minutes for this section

## Section I
**75 marks**

**Part A – 20 marks**
**Attempt Questions 1-20**
**Allow about 30 minutes for this part**

**Use the multiple choice answer sheet on page 17.**

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

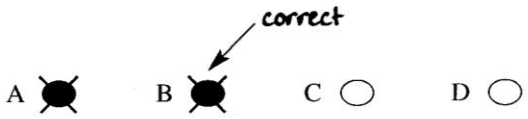
**Sample:** $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



**1.** Which of the following must hold in order for a satellite to remain in orbit around the Earth?

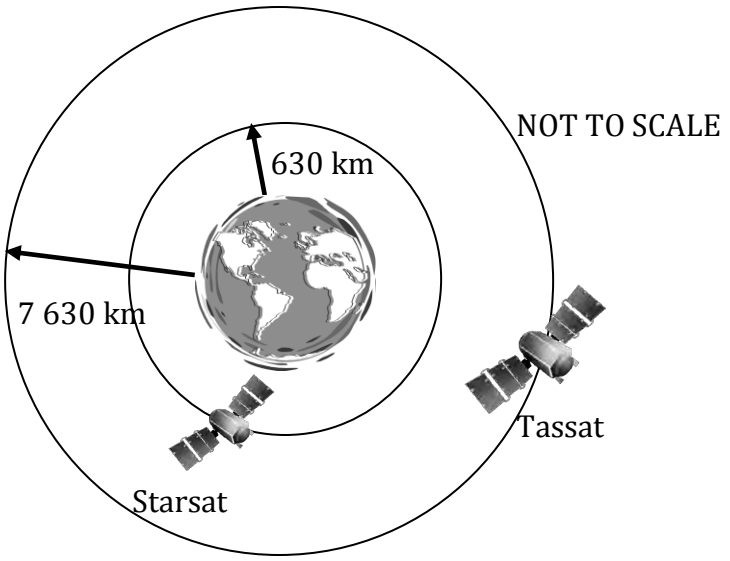
(A) The period of the satellite must equal the period of the Earth's rotation.

(B) The centripetal force must equal the gravitational forces acting on the satellite.

(C) There must not be any forces acting on the satellite.

(D) The satellite must remain outside the gravitational influences of the Earth.

**2.** Starsat is a satellite orbiting with an altitude of 630 km. Tassat is another satellite orbiting with an altitude of 7 630 km.




What would be the centripetal acceleration of Starsat?

(A) Four times greater than that of Tassat.

(B) Half that of Tassat.

(C) About the same as Tassat.

(D) Not be able to be compared to Tassat without knowing the satellites' speeds.

**3.** Which of the following factors affect the escape velocity from the planet?

I. the mass of the planet.
II. the mass of the object trying to escape.
III. the distance from the centre of the planet to the centre of the escaping object.
IV. the speed of light.

(A) I, II, III, & IV

(B) I, II & II

(C) I & III

(D) I, II, & IV

**4.** Two satellites move in circular orbits around the earth. The radius of orbit of the outer satellite is three times the radius of the orbit of the inner satellite as measured from the Earth's centre. If the orbital speed of the inner satellite is v, then what is the speed of the outer satellite?

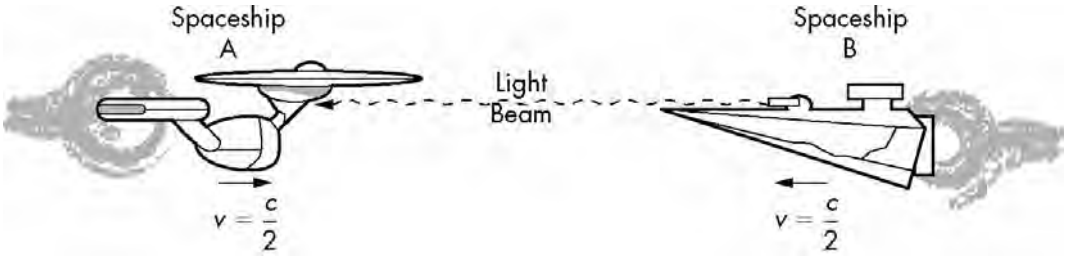
(A) $v/3$

(B) $v/\sqrt{3}$

(C) $\sqrt{3} \times v$

(D) $\sqrt{3}$

**5.** An observer in spaceship A travelling at half the speed of light (c/2) measures the speed of a light beam that was sent from spaceship B that was travelling at half the speed of light in the opposite direction.




What value would an observer in spaceship A measure for the speed of the light beam sent from spaceship B?

(A) c/2

(B) 2c

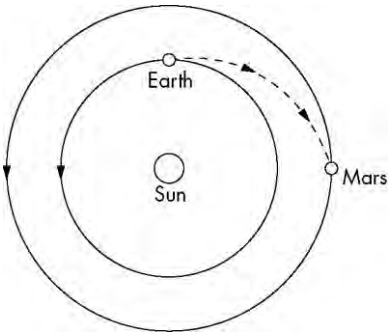
(C) 3c/2

(D) c

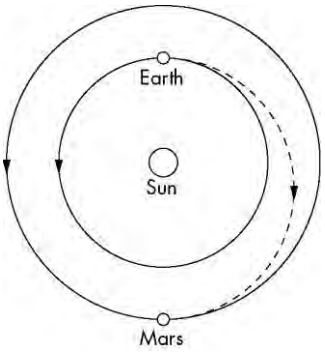
**6.** It is very expensive to send interplanetary probes to other planets and for this reason trajectories are chosen to minimise the energy required.

The diagrams below show the position of the Earth when the probe was launched and the position of Mars when the probe reaches Mars. The direction of the orbital rotation of both planets is also shown. Which of the trajectories would minimise the energy required to travel from the Earth to Mars?

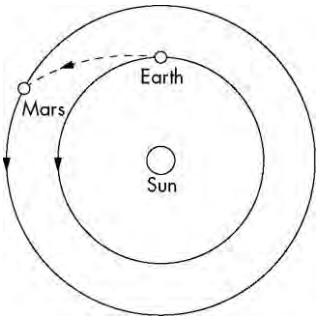
(A)



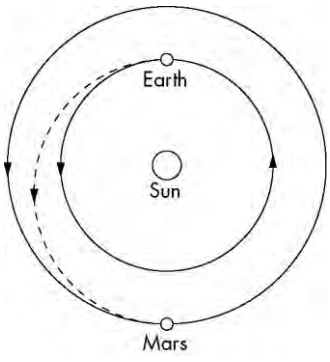

(B)




(C)

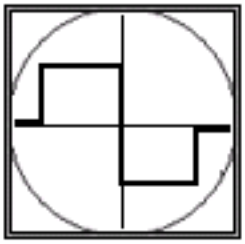


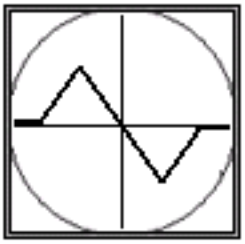

(D)

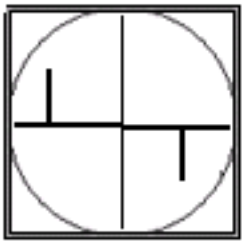


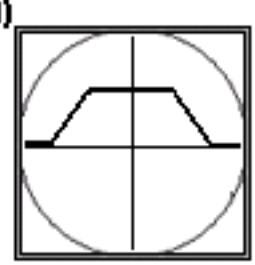
**7.** During a physics experiment a student connects an oscilloscope to a solenoid held in the vertical position. He then holds a strong bar magnet above the solenoid and drops it through the solenoid.

Which one of the following diagrams most closely represents the waveform produced on the oscilloscope as the magnet falls through the solenoid?

A) 

B) 

C) 

D) 

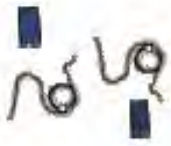
**8.** The picture below shows a small electric motor that has been taken apart.

Which part of this motor is known as the rotor coil or armature?

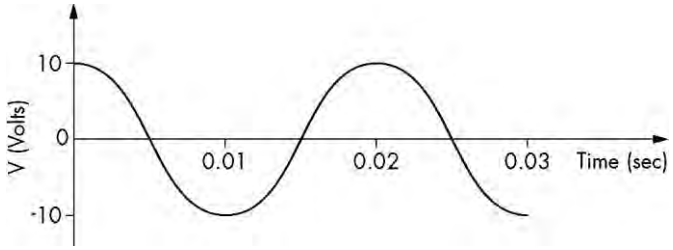
A) 

B) 

C) 

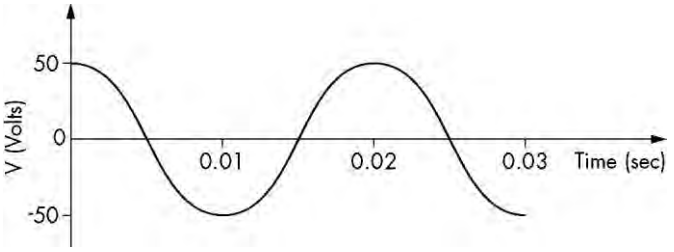
D) 

**9.** A transformer is made up of a primary coil with 200 turns and a secondary coil with 1000 turns. Assume that this transformer is 100% efficient. The input voltage applied to the transformer is shown in the diagram below.

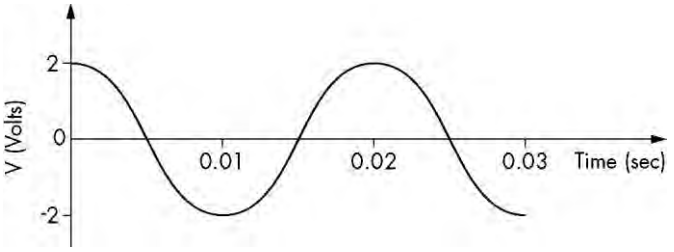



Which of the following sketches best represents the output voltage that would be produced by this transformer?

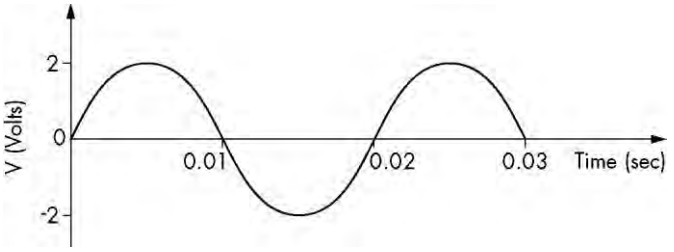
(A)



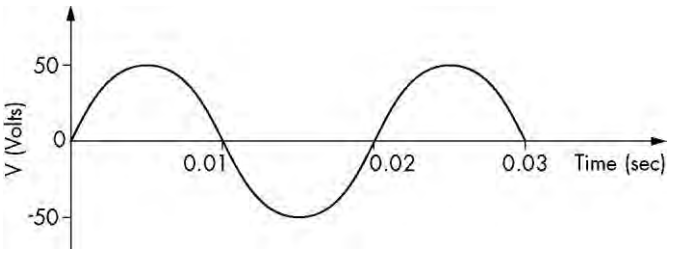

(B)



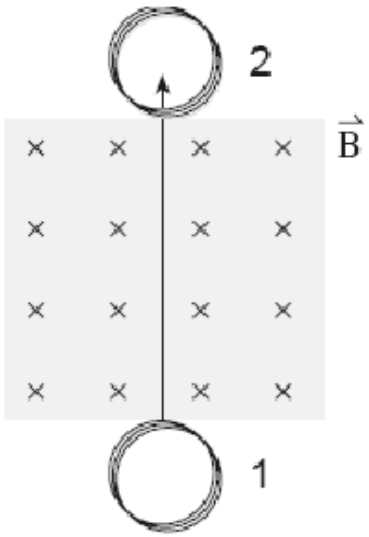

(C)



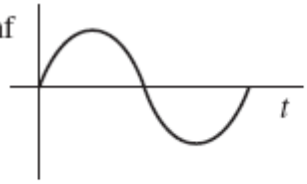

(D)



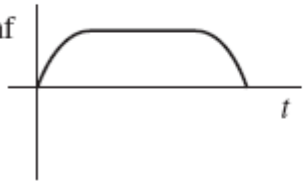
**10.** A coil moves at a constant velocity across a region of magnetic field as shown.

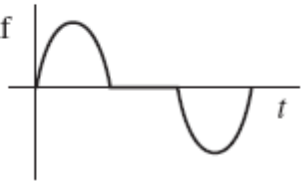



Which of the following best shows the emf vs. time graph for the emf induced in the coil as it moves from 1 to 2?

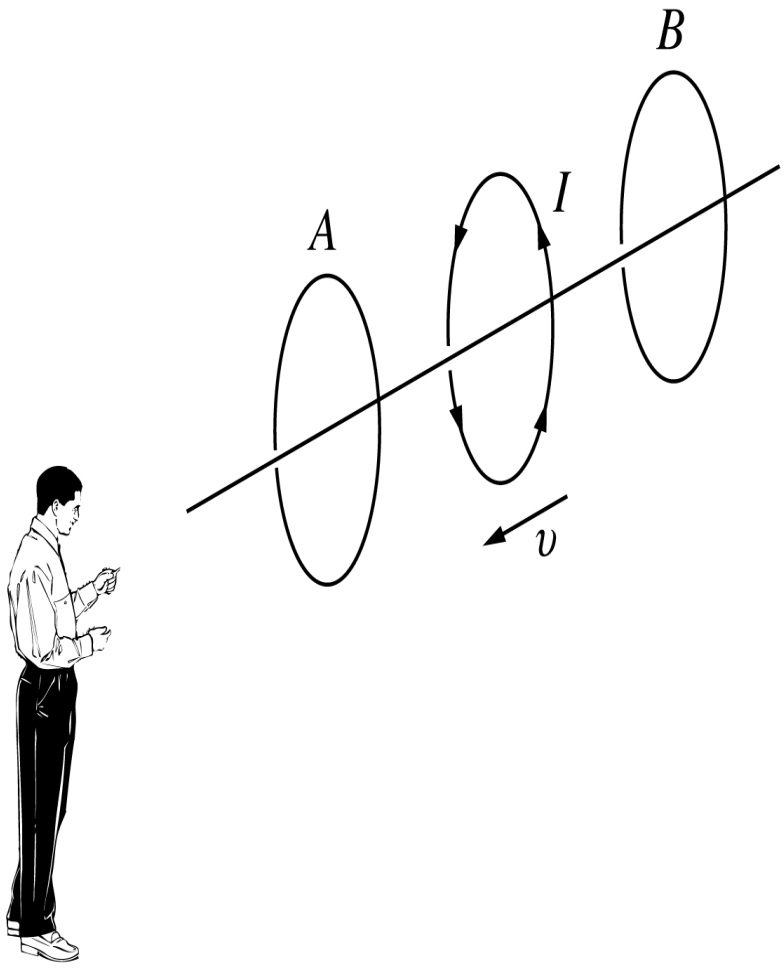
A. 


B. 


C. 


D. 

**11.** Three wire loops and an observer are positioned as shown in the figure below:




From the observer's point of view, a current *I* flows anticlockwise in the middle loop, which is moving towards the observer with a velocity $v$ .
Loops *A* and *B* are stationary.

What would this same observer notice?

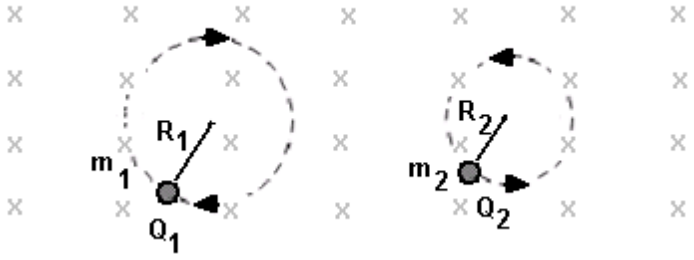
(A) clockwise currents are induced in loops *A* and *B.*

(B) anticlockwise currents are induced in loops *A* and *B.*

(C) a clockwise current is induced in loop *A*, but a anticlockwise current is induced in loop *B.*

(D) an anticlockwise current is induced in loop *A*, but a clockwise current is induced in loop *B.*

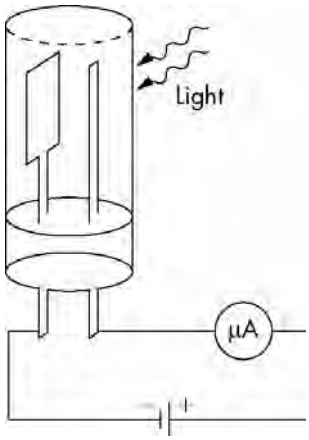
**12.** Two charged particles are travelling in circular orbits with the same speed in a region of uniform magnetic field that is directed into the page, as shown. The magnitude of the charge on each particle is identical, but the signs of the charges are unequal.




Which one of the entries in the table below is correct?

| | Mass Relationship | Sign of charge $Q_1$ | Sign of charge $Q_2$ |
|---|---|---|---|
| (A) | $m_1 > m_2$ | - | + |
| (B) | $m_1 < m_2$ | - | + |
| (C) | $m_1 > m_2$ | + | - |
| (D) | $m_1 < m_2$ | + | - |

**13.** A simple photocell is shown in the diagram below.




Why is the current in the circuit proportional to the intensity of the light incident upon the cell?

(A) The current is proportional to the number of electrons that are ejected per second from the negative cathode by the incident light photons.

(B) The current is proportional to the total number of electrons that are ejected from the negative cathode by the incident light photons.

(C) The current is proportional to the number of electrons per second that are ejected from the positive anode by the incident light photons.

(D) The current is proportional to the number of electrons per second that are ejected from the positiv e cathode by the incident light photons.

**14.** 'Doping' intrinsic semiconductors with impurity atoms produces the more commercially important extrinsic semiconductors.

If silicon is doped with one gallium atom per million silicon atoms, what characteristics will the new extrinsic semiconductor have?

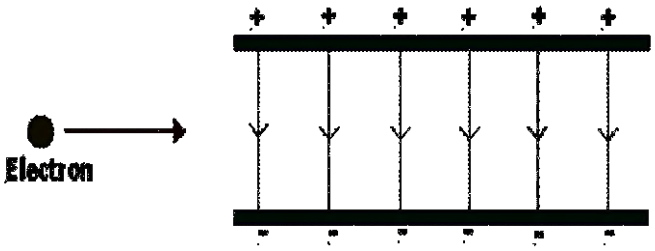
(A) An increased number of free electrons per unit volume, but no change in the net charge of the semiconductor.

(B) An increased number of free holes per unit volume, but no change in the net charge of the semiconductor.

(C ) An increased number of free electrons per unit volume that would give the semiconductor a small net negative charge.

(D ) An increase in the number of holes per unit volume that would give the semiconductor a small net positive charge.

**15.** The diagram below show the path of an electron moving into an electric field




Given that the potential difference between the two plates is 500 V and the distance between the plates is 2.0 cm.

What is the force acting on the electron as it enters the electric field?

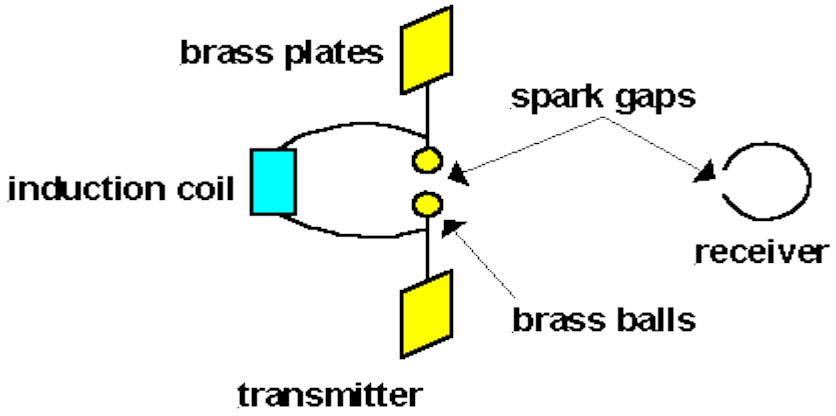
(A) $2.5 \times 10^{4}$ N

(B) $4.0 \times 10^{4}$ N

(C) $4.0 \times 10^{-15}$ N

(D) $2.5 \times 10^{-15}$ N

**16.** The diagram is a representation of Hertz's radio wave apparatus.




As sparks jumped across the gap between the balls, sparks were also observed jumping the gap in the receiver.

Which wave properties did Hertz use to determine the speed of light?

(A) Reflection and refraction

(B) Reflection and interference

(C) Refraction and interference

(D) Interference and polarisation

**17.** Braggs used X-ray diffraction to probe the crystal structure of matter.
What is the best definition of diffraction?

(A) The change in direction of propagation of a wave when it moves from one medium to another.

(B) The superposition of waves emitted from two or more independent sources.

(C) The spreading out of waves when they encounter objects or gaps comparable in size to the wavelength.

(D) The intensity pattern formed when waves emerge from a transparent crystalline solid.

**18.** Black body radiation is the electromagnetic radiation that is emitted from a body due to its temperature alone. How does the black body radiation emitted from a body change as the temperature of the body is increased?

(A) The power radiated increases and the frequency at which most of the radiation is emitted also increases.

(B) The power radiated remains constant but the frequency at which most of the radiation is emitted increases.

(C) The power radiated increases, but the frequency at which most of the radiation is emitted decreases.

(D) The power radiated remains constant but the frequency at which most of the radiation is emitted decreases.

**19.** Superconductors lose their superconductivity when they are heated to a temperature above their critical temperature. Why is this?

(A) The lattice vibrations increase the number of collisions with electrons.

(B) The electrons now travel in pairs.

(C) They can no longer exclude magnetic fields.

(D) The electrons can no longer behave like waves.

**20.** The household 240 volt ventilation fan is an example of a low power, constant speed application for electric motors.

The type of electric motor best suited to this application is:

(A) DC motor

(B) AC motor

(C) Induction motor

(D) DC/AC brushless hybrid motor

**Student Number ……**

**Section I** **Mark ----- /20**

**Part A**

**Multiple Choice Answer Sheet**

| | | | | |
|---|---|---|---|---|
| **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 ○ |

**Part B 55 marks** **Student No. ……**

**Attempt questions 21 - 30**

**Allow about 1 hour and 45 minutes for this part**

▸ *Show all relevant working in questions involving calculations*

**Question 21** (6 Marks) **Marks**

It was proposed to investigate the surface of the planet Mars by putting a spacecraft (the command module) into orbit around the planet and sending an exploration module down to the surface of the planet and subsequently recovering it.

mass of planet Mars = $6.42 \times 10^{23}$ kg

radius of planet Mars = $3.39 \times 10^{6}$ m

(a) The command module is positioned in circular orbit at a height of $5.0 \times 10^{5}$ m above the surface of the planet. **2**
Show that the period of the orbit is just over 2 hours.

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(b) Calculate the magnitude of gravitational field strength at a point on the orbit of the command module. **1**

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**Question 21 continued on page 18**

**Marks**

(c) Sketch a graph showing how the gravitational field strength, $g_M$, due to the planet Mars varies with distance from the planet along a line through the centre of the planet. Consider points external to the planet only. **1**

(d) Calculate the change in gravitational potential energy in moving the exploration module of mass $1.0 \times 10^{23}$ kg from the surface of Mars to a point on the orbit of the command module. **2**

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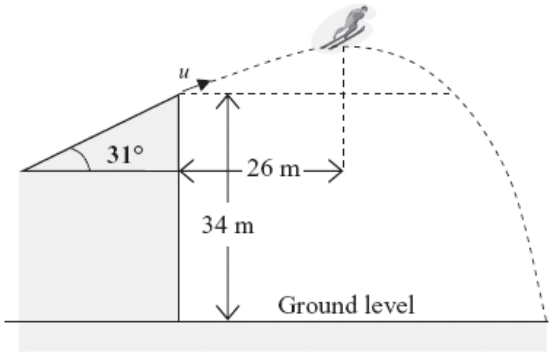
**Question 22** (5 marks) **Marks**

A ski jumper makes a ski jump and is in the position shown below, 2.0 s after leaving the 31° jump ramp. He has travelled 26 m horizontally in this time.




(a) Calculate the magnitude of the skier's horizontal velocity at the instant shown in the diagram. Ignore air resistance. **1**

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(b) Calculate the magnitude of the skier's launch velocity from the end of the ramp. **1**

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(c) What is the magnitude and direction of the skier's acceleration at the instant shown in the diagram? Justify your answer. **3**

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**Question 23** (3 marks) **Marks**

Two identical spacecrafts are launched from the Earth. They eventually reach a speed of 0.600 c travelling in opposite directions to each other in space.


The person on the spacecraft says to the captain that he will see the other spacecraft travelling at a speed of 0.600 c + 0.600 c = 1.20 c relative to himself. The captain says that this is not possible. Who is correct and why?

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**Question 24** (6 marks) **Marks**

(a) With the aid of a diagram, explain how rotating a coil within a magnetic field can cause emf to be induced within the wires of the coil while an external magnetic field remains stationary and constant. **2**

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(b) Identify two changes that could be made to the coil in (a) that would increase the induced emf as it was being rotated in the external magnetic field. **2**

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(c) Besides rotating the coil within a magnetic field, describe two other actions which can be performed to induce an emf in a coil or solenoid. **2**

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**Question 25** (6 marks) **Marks**

Explain how induction is used in electromagnetic braking and identify it's applications.

**Question 26** (6 marks) **Marks**

During your physics course you have carried out an investigation to demonstrate the motor effect.

(a) Clearly describe how the experiment was carried out. Include a diagram. **4**

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(b) Analyse the findings from this investigation. **2**

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**Question 27** (6 marks) **Marks**

"A controversy between competing scientific theories can sometimes be resolved by a single experiment".

Evaluate this statement with reference to J. J. Thomson's experiment to determine the charge to mass ratio of the electron and the experiment conducted by Michelson and Morley to detect the motion of the Earth through the aether.

**Question 28** (3 Marks) **Marks**

Describe an experiment that could demonstrate magnetic levitation using the Meissner effect.

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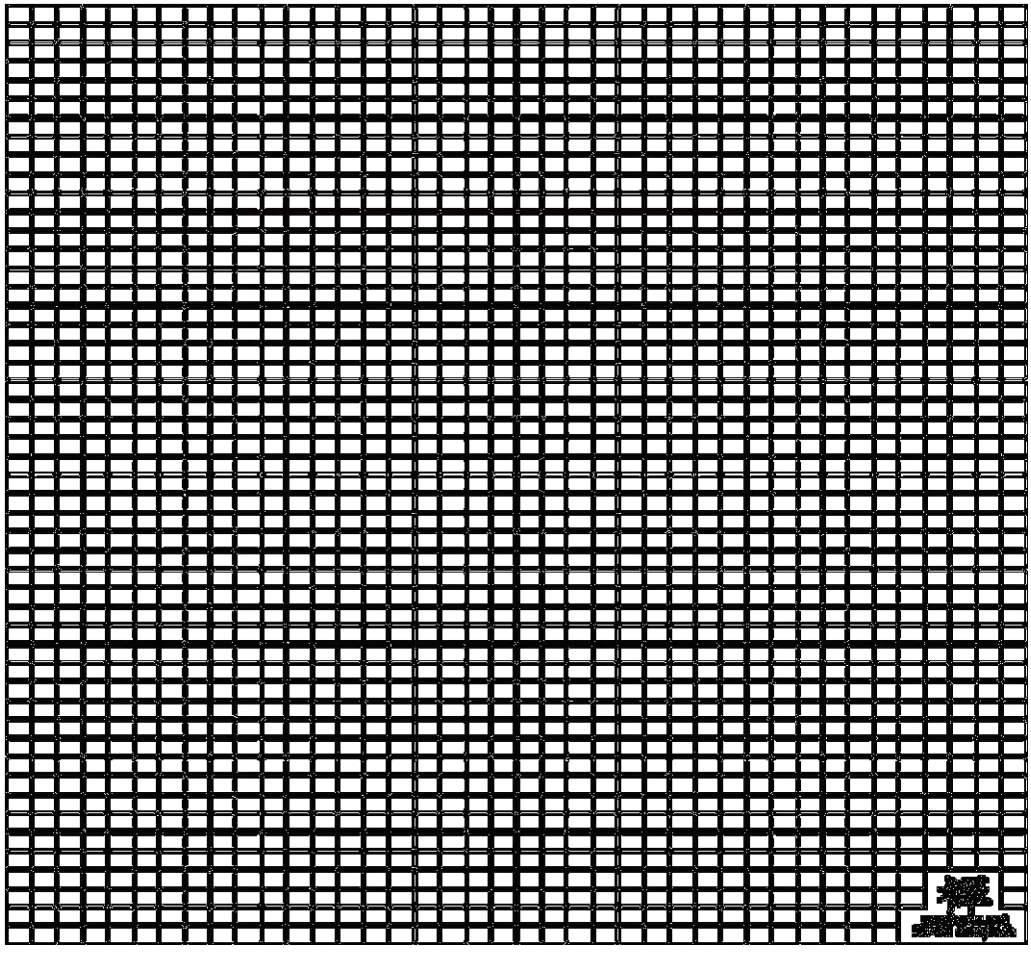
**Question 29** (7 marks) **Marks**

A student carried out an experiment on the photoelectric effect. The frequency of incident radiation and the energy of the photoelectrons were both determined from measurements taken during the experiment.
The results are shown below in the table.

| Frequency of incident radiation ($\times 10^{14}$ Hz) | Energy of photons ($\times 10^{-19}$ J) |
|---|---|
| 7.0 | 1.22 |
| 8.3 | 1.90 |
| 9.0 | 2.70 |
| 10.0 | 3.00 |
| 10.7 | 3.32 |
| 12.5 | 3.85 |

(a) Plot the data from the table and draw a curve of best fit. Use energy of photons on the *y* axis. **3**



**Question 29 continued on page 27**

**Marks**

(b) Determine the gradient of the graph. **1**

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(c) What does the gradient represent? **1**

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(d) Use the particle nature of electromagnetic radiation to explain how light can cause the photoelectric effect. **2**

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**Question 30** (6 marks) **Marks**

Semiconductors are used in the construction of solar cells. Explain with the aid of a diagram, how a solar cell operates.

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**2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION**

# PHYSICS

**Section II**

**25 marks**
**Attempt Question 31**
**Allow about 45 minutes for this section**

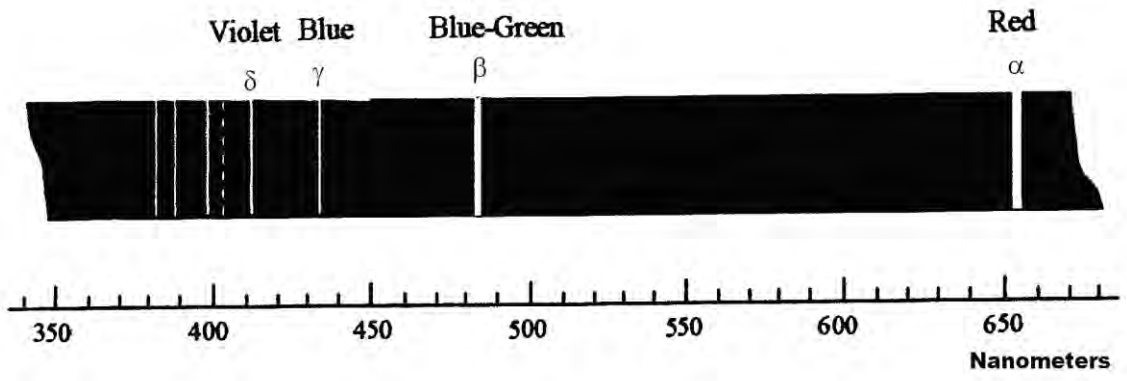
Answer the questions in a writing booklet.
- Show all relevant working in questions involving calculations.

---

**Question 31 -- FROM QUANTA TO QUARKS** (25 Marks)

**Marks**

(a) The diagram below represents the visible spectrum of the hydrogen atom.




i. Calculate the wavelength of the blue/green line. **1**

ii. Calculate the energy of a photon emitted by the blue/green line **2**

**Marks**

(b) Carbon-14 undergoes $\beta^-$ decay.

(i) Write the complete nuclear equation for this transmutation. **1**

(ii) Calculate the energy released during the decay of carbon-14, in MeV per atom, using the information in the table given below. **2**

| Atom/Particle | Mass (u) |
|---|---|
| boron-10 | 10.012 937 |
| boron-11 | 11.009 305 |
| carbon-12 | 12.000 000 |
| carbon-13 | 13.003 354 |
| carbon-14 | 14.003 241 |
| nitrogen-14 | 14.003 074 |
| nitrogen-15 | 15.000 108 |
| electron | 0.00055 |

(c) The electron and positron both have a rest mass of $9.109 \times 10^{-31}$ kg. In the annihilation of a positron with an electron, all the mass is converted to gamma rays carrying energy. Calculate the amount of energy released as gamma rays, in Joules, when a positron and electron undergo annihilation. **1**

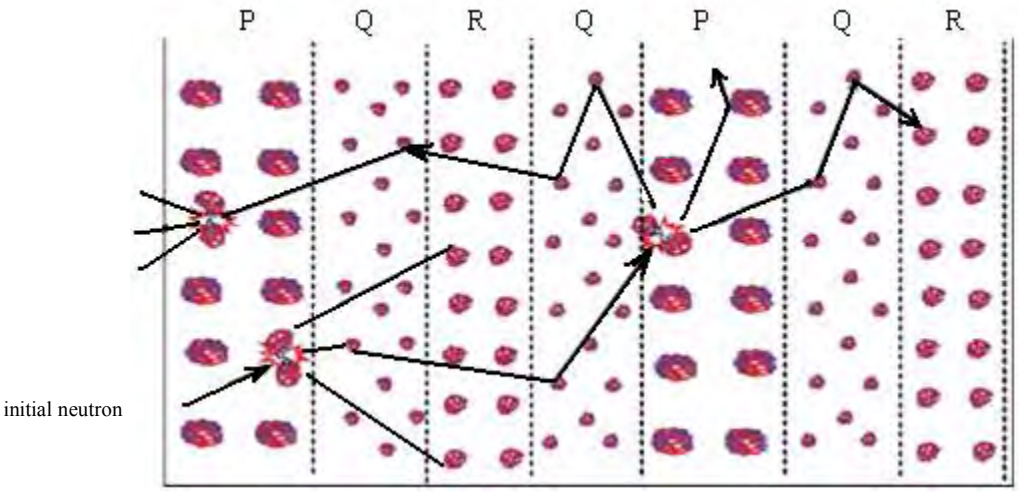
(d) Outline the role that nuclear fission reactors play to benefit Science. **6**

**Question 31 continues on page 31**

**Marks**

(d) The simplified diagram shows the nuclei of different components in a nuclear fission reactor core. **3**

Identify the moderator, fuel rod, and control rod, using the letters P, Q or R




(e) Until the 1960s, matter was considered to compose of the fundamental particles of protons, neutrons and electrons. **6**
Describe the recent developments in understanding the structure of matter and how particle accelerators have contributed to this increased understanding.

(g) The physicist Wolfgang Pauli had a significant impact on our understanding of the structure of the atom. Outline his contribution to the current theory of atomic structure. **3**

**End of paper**

| | |
|---|---|
| **Student Number** | |
| **Mark / 100** | |

# 2010

## TRIAL HSC EXAMINATION

# Physics

### General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of this page and on the response sheets on page 21
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided

**Total Marks – 100**

**Section I** Pages 2 - 20

**75 marks**

This section has two parts, Part A and Part B

**Part A** – 20 marks
•Attempt Questions 1- 20
•Allow about 30 minutes for this part

**Part B** – 60 marks
•Attempt Questions 21 - 30
•Allow about 1 hour and 45 minutes for this part

**Section II** Pages 29 - 31

**25 marks**

•Attempt Question 31.
•Allow about 45 minutes for this section

## Section I
**75 marks**

**Part A – 20 marks**
**Attempt Questions 1-20**
**Allow about 30 minutes for this part**

**Use the multiple choice answer sheet on page 17.**

Select the alternative A, B, C or D that best answers the question. Fill in the response oval completely.

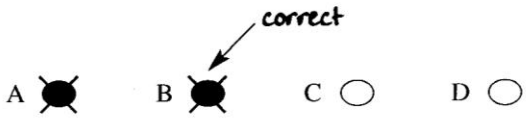
**Sample:** $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



1. Which of the following must hold in order for a satellite to remain in orbit around the Earth?

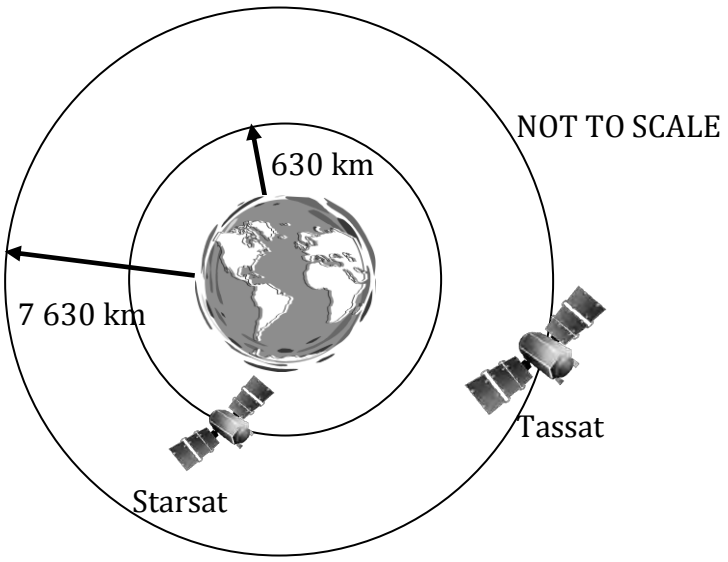
(A) The period of the satellite must equal the period of the Earth's rotation.

(B) The centripetal force must equal the gravitational forces acting on the satellite.

(C) There must not be any forces acting on the satellite.

(D) The satellite must remain outside the gravitational influences of the Earth.

2. Starsat is a satellite orbiting with an altitude of 630 km. Tassat is another satellite orbiting with an altitude of 7 630 km.




What would be the centripetal acceleration of Starsat?

(A) Four times greater than that of Tassat.

(B) Half that of Tassat.

(C) About the same as Tassat.

(D) Not be able to be compared to Tassat without knowing the satellites' speeds.

**3.** Which of the following factors affect the escape velocity from the planet?

I. the mass of the planet.
II. the mass of the object trying to escape.
III. the distance from the centre of the planet to the centre of the escaping object.
IV. the speed of light.

(A) I, II, III, & IV

(B) I, II & II

(C) I & III

(D) I, II, & IV

**4.** Two satellites move in circular orbits around the earth. The radius of orbit of the outer satellite is three times the radius of the orbit of the inner satellite as measured from the Earth's centre. If the orbital speed of the inner satellite is v, then what is the speed of the outer satellite?

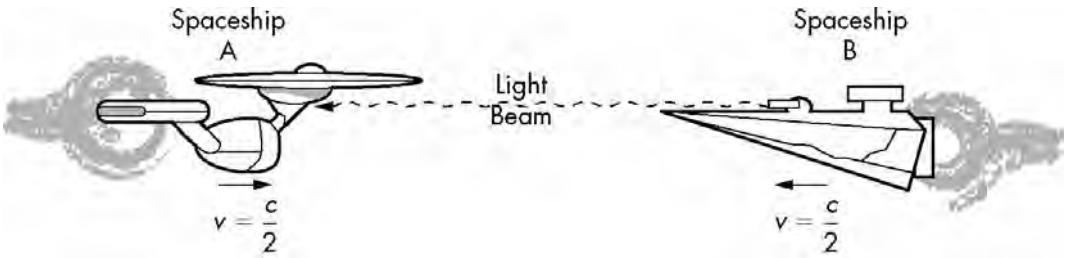
(A) $v/3$

(B) $v/\sqrt{3}$

(C) $\sqrt{3} \times v$

(D) $\sqrt{3}$

**5.** An observer in spaceship A travelling at half the speed of light (c/2) measures the speed of a light beam that was sent from spaceship B that was travelling at half the speed of light in the opposite direction.




What value would an observer in spaceship A measure for the speed of the light beam sent from spaceship B?

(A) c/2

(B) 2c

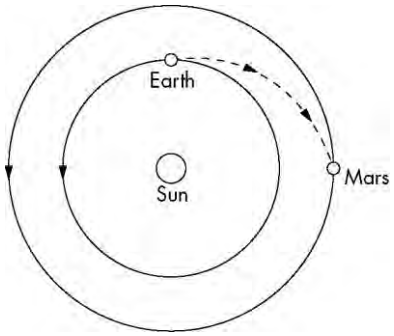
(C) 3c/2

(D) c

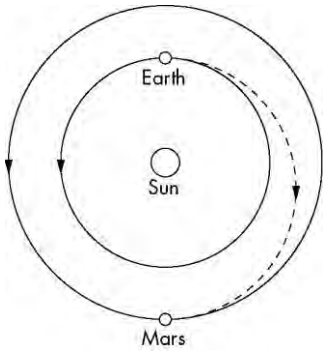
**6.** It is very expensive to send interplanetary probes to other planets and for this reason trajectories are chosen to minimise the energy required.

The diagrams below show the position of the Earth when the probe was launched and the position of Mars when the probe reaches Mars. The direction of the orbital rotation of both planets is also shown. Which of the trajectories would minimise the energy required to travel from the Earth to Mars?

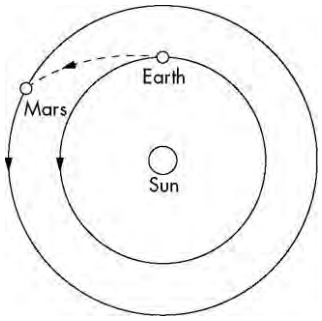
(A)



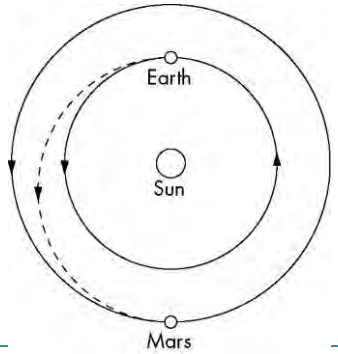

(B)




(C)



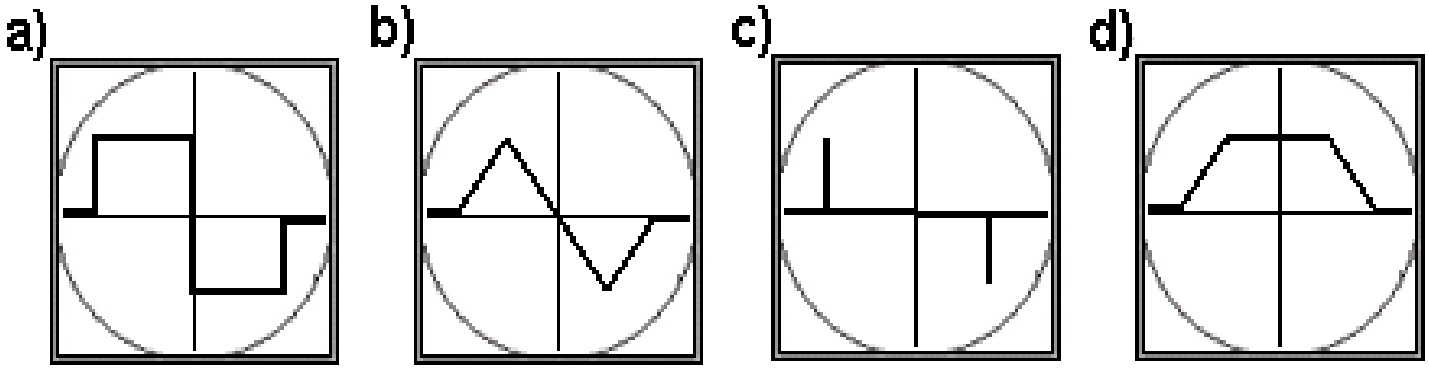

(D)



**7.** During a physics experiment a student connects a solenoid to an oscilloscope as shown in the figure. He then holds a strong bar magnet above the solenoid and drops it through the solenoid.

Which one of the following diagrams most closely represents the waveform produced on the oscilloscope as the magnet falls through the solenoid?

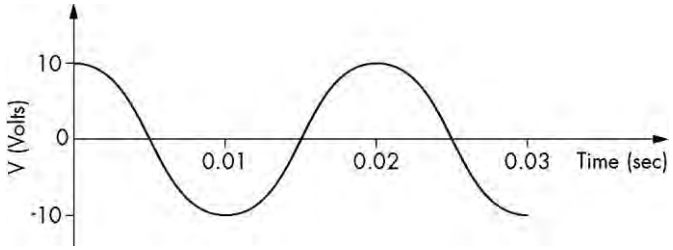
B




**8.** The picture below shows a small electric motor that has been taken apart.
Which part of this motor is known as the rotor coil or armature?

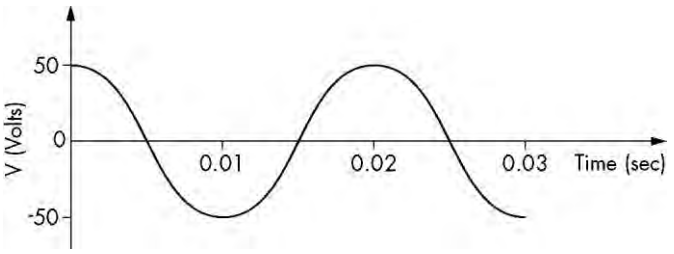
A

**9.** A transformer is made up of a primary coil with 200 turns and a secondary coil with 1000 turns. Assume that this transformer is 100% efficient. The input voltage applied to the transformer is shown in the diagram below.

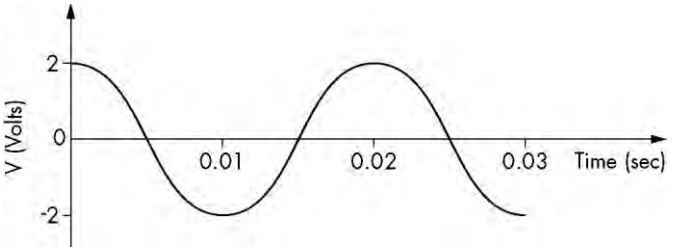



Which of the following sketches best represents the output voltage that would be produced by this transformer?

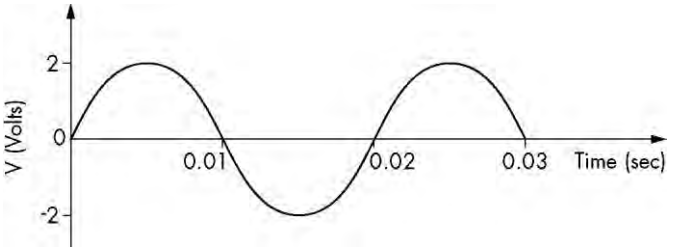
(A)



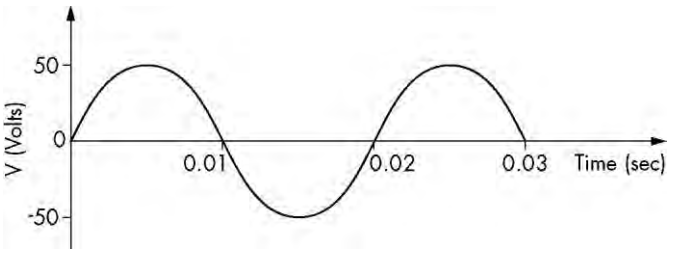

(B)



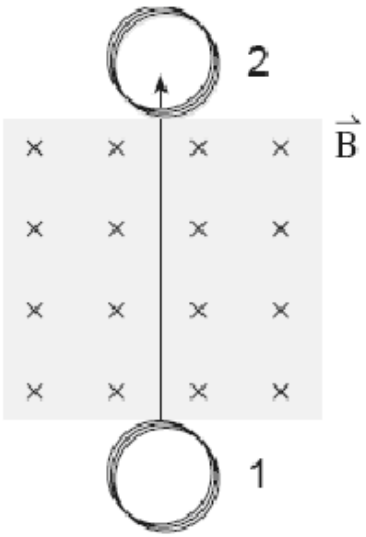

(C)



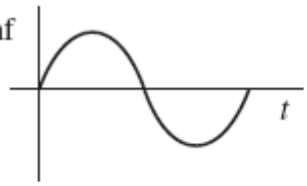

(D)



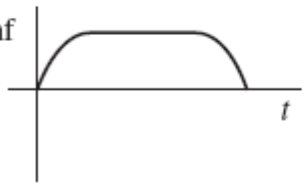
**10.** A coil moves at a constant velocity across a region of magnetic field as shown.

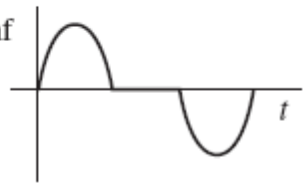



Which of the following best shows the emf vs. time graph for the emf induced in the coil as it moves from 1 to 2?

A. 

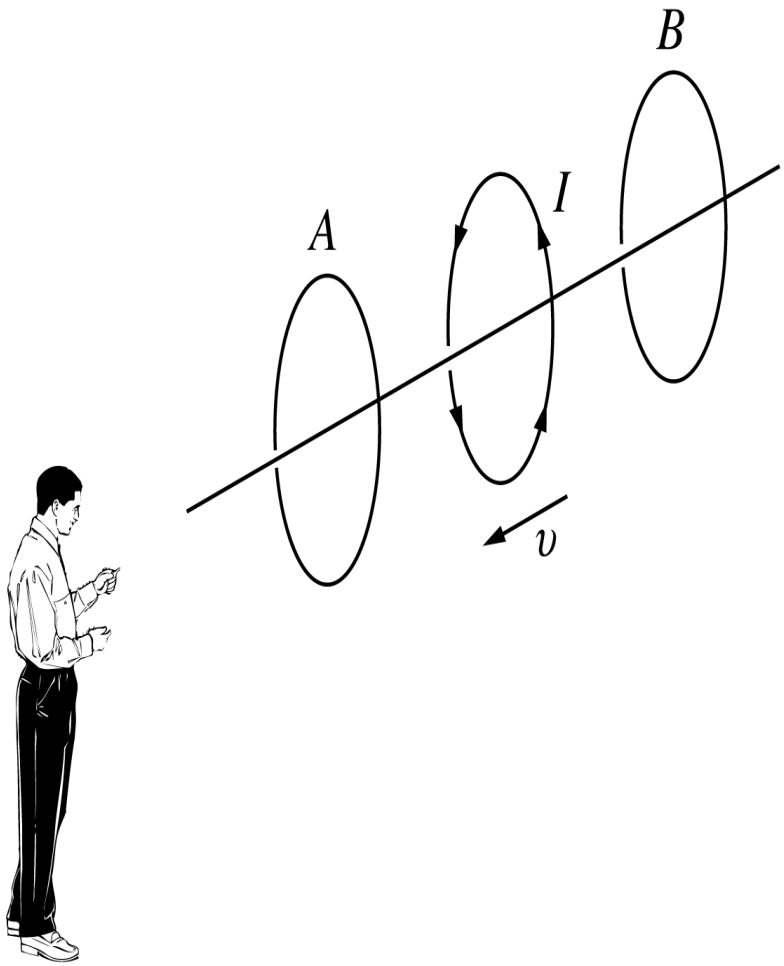

B. 


C. 


D. 


D

**11.** Three wire loops and an observer are positioned as shown in the figure below:




From the observer's point of view, a current *I* flows anticlockwise in the middle loop, which is moving towards the observer with a velocity *v* .
Loops *A* and *B* are stationary.

What would this same observer notice?

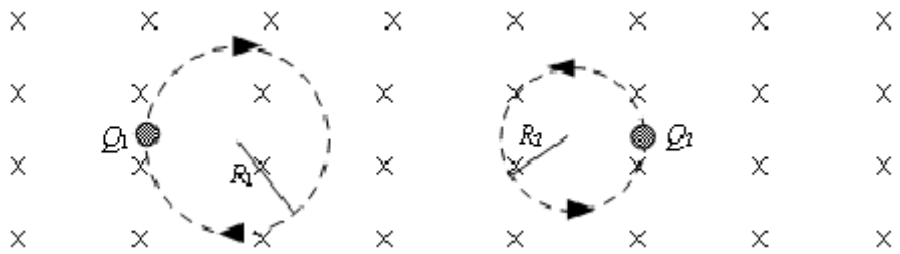
(A) clockwise currents are induced in loops *A* and *B.*

(B) anticlockwise currents are induced in loops *A* and *B.*

(C) a clockwise current is induced in loop *A*, but a anticlockwise current is induced in loop *B.*

(D) an anticlockwise current is induced in loop *A*, but a clockwise current is induced in loop *B.*

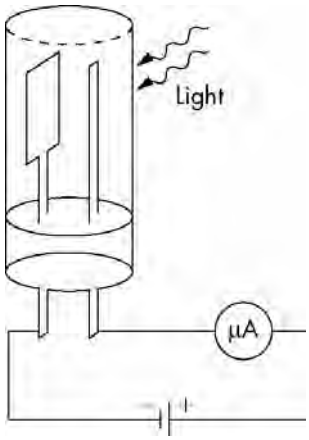
**12.** Two charged particles are travelling in circular orbits with the same speed in a region of uniform magnetic field that is directed into the page, as shown. The magnitude of the charge on each particle is identical, but the signs of the charges are unequal.




Which one of the entries in the table below is correct?

| | Mass Relationship | Sign of charge $Q_1$ | Sign of charge $Q_2$ |
|---|---|---|---|
| (A) | $m_1 > m_2$ | - | + |
| (B) | $m_1 < m_2$ | - | + |
| (C) | $m_1 > m_2$ | + | - |
| (D) | $m_1 < m_2$ | + | - |

**13.** A simple photocell is shown in the diagram below.




Why is the current in the circuit proportional to the intensity of the light incident upon the cell?

(A) The current is proportional to the number of electrons that are ejected per second from the negative cathode by the incident light photons.

(B) The current is proportional to the total number of electrons that are ejected from the negative cathode by the incident light photons.

(C) The current is proportional to the number of electrons per second that are ejected from the positive anode by the incident light photons.

(D) The current is proportional to the number of electrons per second that are ejected from the positive cathode by the incident light photons.

**14.** 'Doping' intrinsic semiconductors with impurity atoms produces the more commercially important extrinsic semiconductors.

If silicon is doped with one gallium atom per million silicon atoms, what characteristics will the new extrinsic semiconductor have?

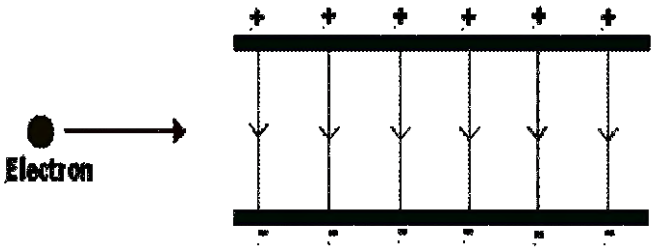
(A) An increased number of free electrons per unit volume, but no change in the net charge of the semiconductor.

(B) An increased number of free holes per unit volume, but no change in the net charge of the semiconductor.

(C ) An increased number of free electrons per unit volume that would give the semiconductor a small net negative charge.

(D ) An increase in the number of holes per unit volume that would give the semiconductor a small net positive charge.

**15.** The diagram below show the path of an electron moving into an electric field




Given that the potential difference between the two plates is 500 V and the distance between the plates is 2 cm .

What is the force acting on the electron as it enters the electric field?

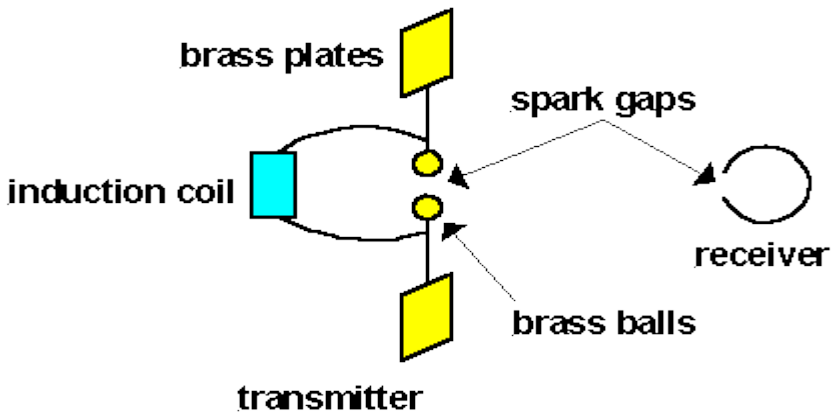
(A) $2.5 \times 10^{4}$ N

(B) $4.0 \times 10^{4}$ N

(C) $4.0 \times 10^{-15}$ N

(D) $2.5 \times 10^{-15}$ N

**16.** The diagram is a representation of Hertz's radio wave apparatus.




As sparks jumped across the gap between the balls, sparks were also observed jumping the gap in the receiver.

Which wave properties did Hertz use to determine the speed of light?

(A) Reflection and refraction

(B) Reflection and interference

(C) Refraction and interference

(D) Interference and polarisation

**17.** Braggs used X-ray diffraction to probe the crystal structure of matter.
What is the best definition of diffraction?

(A) The change in direction of propagation of a wave when it moves from one medium to another.

(B) The superposition of waves emitted from two or more independent sources.

(C) The spreading out of waves when they encounter objects or gaps comparable in size to the wavelength.

(D) The intensity pattern formed when waves emerge from a transparent crystalline solid.

**18.** Black body radiation is the electromagnetic radiation that is emitted from a body due to its temperature alone. How does the black body radiation emitted from a body change as the temperature of the body is increased?

(A) The power radiated increases and the frequency at which most of the radiation is emitted also increases.

(B) The power radiated remains constant but the frequency at which most of the radiation is emitted increases.

(C) The power radiated increases, but the frequency at which most of the radiation is emitted decreases.

(D) The power radiated remains constant but the frequency at which most of the radiation is emitted decreases.

**19.** Superconductors lose their superconductivity when they are heated to a temperature above their critical temperature. Why is this?

(A) The lattice vibrations increase the number of collisions with electrons.

(B) The electrons now travel in pairs.

(C) They can no longer exclude magnetic fields.

(D) The electrons can no longer behave like waves.

**20.** The household 240 volt ventilation fan is an example of a low power, constant speed application for electric motors.

The type of electric motor best suited to this application is:

(A) DC motor

(B) AC motor

(C) Induction motor

(D) DC/AC brushless hybrid motor

**Student Number ……**

**Section I** **Mark ----- /20**

**Part A**

**Multiple Choice Answer Sheet**

| | | | | |
|---|---|---|---|---|
| **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 ○ |

**Part B 55 marks** **Student No. ……**

**Attempt questions 21 - 30**

**Allow about 1 hour and 45 minutes for this part**

▸ *Show all relevant working in questions involving calculations*

---

**Question 21** (6 Marks) **Marks**

It was proposed to investigate the surface of the planet Mars by putting a spacecraft (the command module) into orbit around the planet and sending an exploration module down to the surface of the planet and subsequently recovering it.

mass of planet Mars = $6.42 \times 10^{23}$ kg

radius of planet Mars = $3.39 \times 10^{6}$ m

(a) The command module is positioned in circular orbit at a height of $5.0 \times 10^{5}$ m above the surface of the planet. **2**

Show that the period of the orbit is just over 2 hours.

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

$T = \sqrt{R^3 . 4\pi^2 / GM}$ $R = 3.39 \times 10^6 + 5 \times 10^5 = 38.9 \times 10^5$ m

$$= \sqrt{\frac{(3.89 \times 10^6)^3 \times 4\pi^2}{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}}$$

$= 7366.714$ s

$= 2.04$ hours

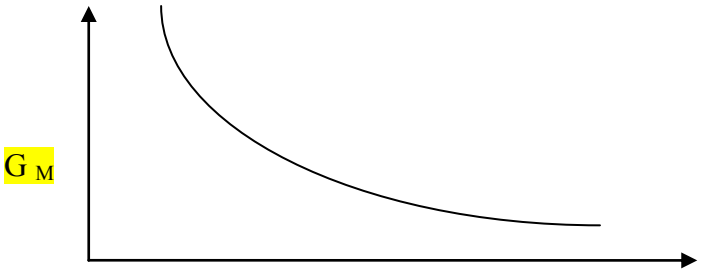
(b) Calculate the magnitude of gravitational field strength at a point on the orbit of the command module. **1**

$g = GM / r^2$

$$= \frac{6.67 \times 10^{-11} \times 6.42 \times 10^{23}}{(38.9 \times 10^5)^2}$$

$= 2.829$ ms$^{-2}$

(c) Sketch a graph showing how the gravitational field strength, $g_M$, due to the planet Mars varies with distance from the planet along a line through the centre of the planet. Consider points external to the planet only. **1**




(d) Calculate the change in gravitational potential energy in moving the exploration module of mass $1.0 \times 10^{23}$ kg from the surface of Mars to a point on the orbit of the command module. **2**

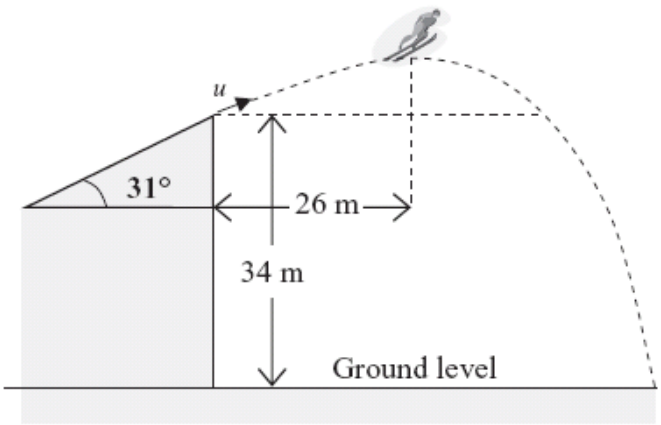
$\Delta E_p = m g \times h$
$= 1.0 \times 10^{23} \times 2.829 \times 5.0 \times 10^{5}$
$= 1.625 \times 10^{29}$ J

Or

$\Delta E_p = Gm_1m_2 / \left( \frac{1}{Ri} - \frac{1}{Rf} \right)$ $Ri = 3.39 \times 10^{6}$ $Rf = (3.39 + .5) \times 10^{6}$
$= \mathbf{1.625 \times 10^{29}}$ **Joules**

**Question 22** (5 marks) **Marks**

A ski jumper makes a ski jump and is in the position shown below, 2 s after leaving the 31° jump ramp. He has travelled 26 m horizontally in this time.




(a) Calculate the magnitude of the skier's horizontal velocity at the instant shown in the diagram. Ignore air resistance. **1**

$v = s/t \quad = \quad 26 / 2 = 13\ ms^{-1}$

(b) Calculate the magnitude of the skier's launch velocity from the end of the ramp. **1**

$u_h = u \cos 31°$

$\cos 31° = 13 \div u$

$u = 13 \div \cos 31°$

$= 15.2 \text{ or } 15\ ms^{-1}$

(c) What is the magnitude and direction of the skier's acceleration at the instant shown in the diagram? Justify your answer. **3**

$a = 9.8\ ms^{-2}$

Direction: downwards

Gravity acts continuously during the skier's motion and is always downwards.

**Question 23** (3 marks) **Marks**

Two identical spacecrafts are launched from the Earth. They eventually reach a speed of 0.600c travelling in opposite directions to each other in space.

0.600c ← 0.600c →

The person on the spacecraft says to the captain that he will see the other spacecraft travelling at a speed of 0.600 c + 0.600 c = 1.20 c relative to himself. The captain says that this is not possible. Who is correct and why?

The captain is correct.
Nothing can travel faster than the speed of light.
Newton's laws apply only at non-relativitsic speeds.
At relativisitc speeds length contracts and time dilate and therefore the speed of light remains constant because speed = distance / time

**Question 24** (6 marks) **Marks**

(a) With the aid of a diagram, explain how rotating a coil within a magnetic field can cause emf to be induced within the wires of the coil while an external magnetic field remains stationary and constant. **2**

A changing magnetic flux through the coil is needed for an induced emf to be produced. Rotating the coil changes the flux until it reaches zero (when the plane of coil lies in plane of mag field). The flux then reverses direction as the coil continues to rotate and reaches a (negative) max again. This repeats over again and again.

(b) Identify two changes that could be made to the coil in (a) that would increase the induced emf as it was being rotated in the external magnetic field. **2**

To increase induced emf, increase rate of change of flux: rotate coil faster of external mag field or increase no. of turns of wire in the coil.

(c) Besides rotating the coil within a magnetic field, describe two other actions which can be performed to induce an emf in a coil or solenoid. **2**

Vary the strength of the mag field, change the size (cross sectional area) of the coil

**Question 25** (6 marks) **Marks**

Explain how induction is used in electromagnetic braking.

Eddy current brakes slow an object by creating eddy currents through em induction which creates resistance. During braking, metal wheels are exposed to mag field from an em which produces eddy currents in wheels. The mag interaction between applied fields and eddy current act to show the wheels down. Faster the wheels are spinning, the stronger the effect, increasing braking force and therefore smooth braking.

**Question 26** (6 marks) **Marks**

During your physics course you have carried out an investigation to demonstrate the motor effect.

(a) Clearly describe how the experiment was carried out. Include a diagram. **4**

- Appropriate experiment for motor effect, 1 mark,
- Diagram, 1 mark,

- Clear description of how expt was conducted, 1 mark
- Student actually did it, 1 mark,

b)

List of equipment: Al foil, magnets, Dc power supply, rheostat

Description o f set up or diagram

Current-carrying conductor, external magnetic field, position of angle,

Variables tested: varying the current, the strength of the mag field, the direction of the current and mag field

(b) Analyse the findings from this investigation . **2**

Force on conductor depends on I, B and l

**Question 27** (6 marks) **Marks**

"A controversy between competing scientific theories can sometimes be resolved by a single experiment".

Evaluate this statement with reference to J. J. Thomson's experiment to determine the charge to mass ratio of the electron and the experiment conducted by Michelson and Morley to detect the motion of the Earth through the aether.

**Question 28** (3 Marks) **Marks**

Describe an experiment that could demonstrate magnetic levitation using the Meissner effect.

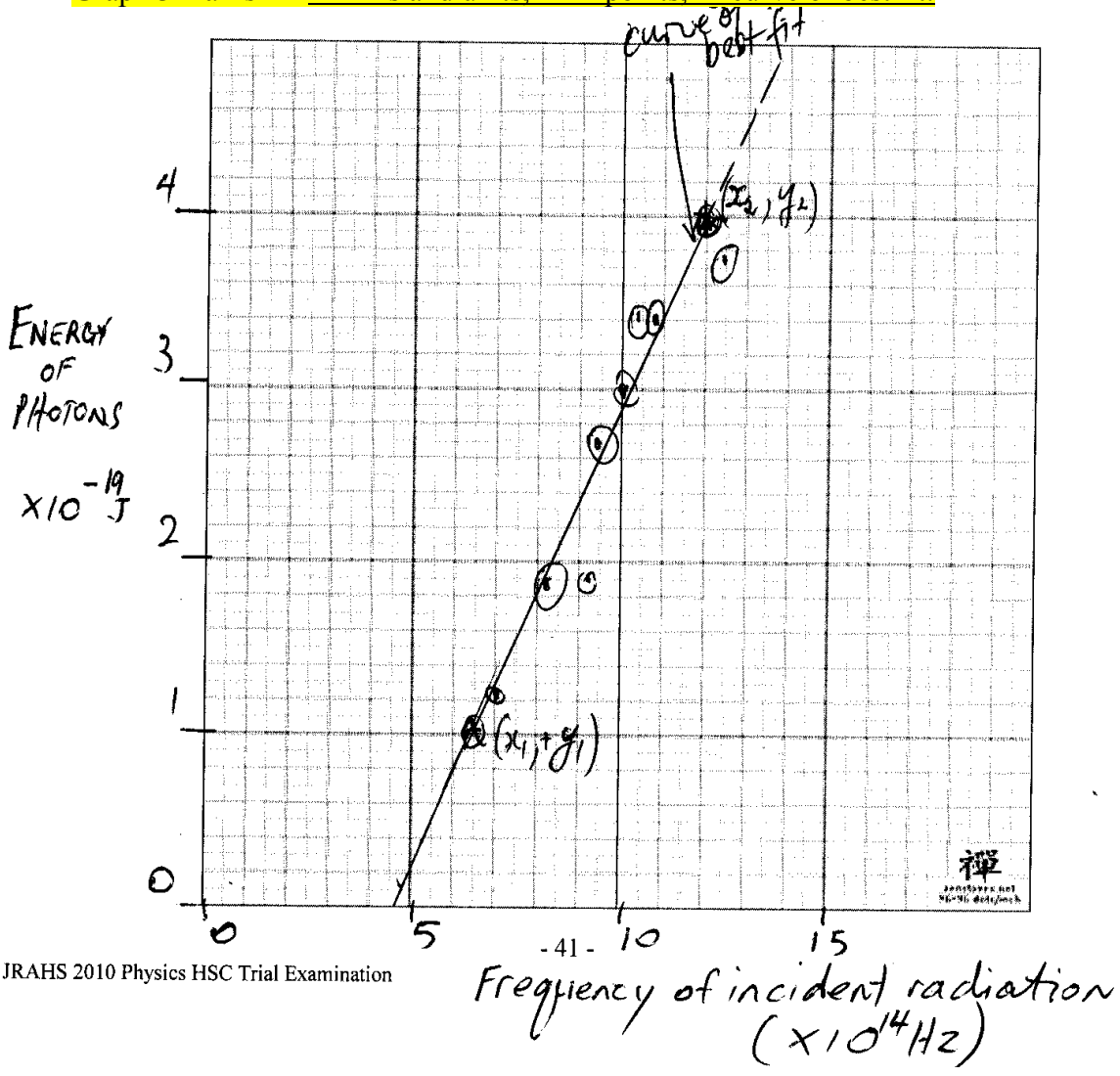
Superconductor held below its critical temp. with the use of liquid nitrogen. Drop a magnet onto the superconductor and observe it levitate. Superconductors expel mag field.

**Question 29** (7 marks) **Marks**

A student carried out an experiment on the photoelectric effect. The frequency of incident radiation and the energy of the photoelectrons were both determined from measurements taken during the experiment.
The results are shown below in the table.

| Frequency of incident radiation ($\times 10^{14}$ Hz) | Energy of photons ($\times 10^{-19}$ J) |
|---|---|
| 7.0 | 1.22 |
| 8.3 | 1.90 |
| 9.0 | 2.70 |
| 10.0 | 3.00 |
| 10.7 | 3.32 |
| 12.5 | 3.85 |

(a) Plot the data from the table and draw a curve of best fit. Use energy of photons on the *y* axis. **3**
Graph 3 marks => 1- Axis and units, 1 - points, 1- curve of best fit.



**Marks**

(a) Determine the gradient of the graph.

Slope = Rise/Run = $y_2 - y_1 / x_2 - x_1$ rs
$(x_1, y_1)$ = (6.5, 1) plus powers
$(x_2, y_2)$ = (12, 4) plus powers

(b) Using the graph calculate the slope. **1**

Slope = Rise/Run = $\frac{y_2 - y_1}{x_2 - x_1} = \frac{(4-1)\times 10^{-14}}{(12-6.5)\times 10^{14}}$

$= \frac{3}{5.5} \times 10^{-33}$

$= 5.45 \times 10^{-34}$

(c) What is the significance of the slope? **1**

Accepted = $6.626 \times 10^{-34}$ Js

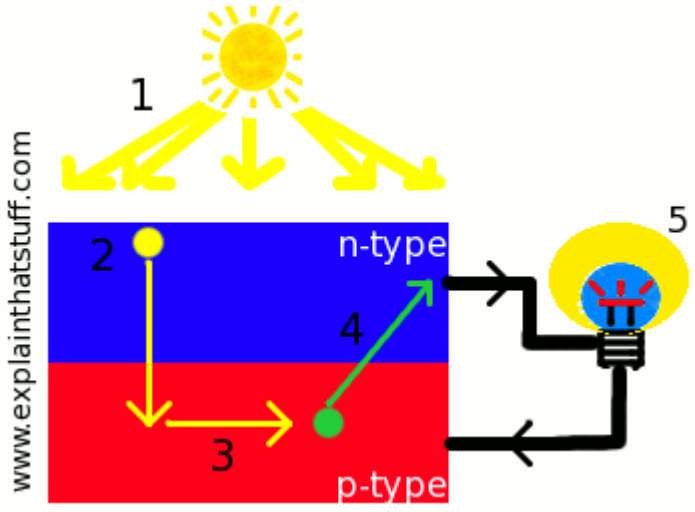
So the slope is Planck constant

(d) Use the particle nature of electromagnetic radiation to explain how light can cause the photoelectric effect. **2**

Light travels in the form of discrete particle-like packets of energy called photons. If the incident quantum of energy has a frequency above the threshold frequency photoemission will occur. E = hf An electron is emitted when a photon collides with it on the surface of the metal and it absorbs its entire quantum of energy.

**Question 30** (6 marks) **Marks**

Semiconductors are used in the construction of solar cells. Explain with the aid of a diagram, how a solar cell operates.




Solar cells use the p-n junction to convert light directly into electricity.

A solar cell is a sandwich of n-type silicon (blue) and p-type silicon (red).

In the photoelectric effect light hits a material and electrons are released and are then able to produce a current. When light hits the *n*-type semiconductor photons hit electrons the light energy is transformed into energy for the electron. This energy frees the electrons by bridging the gap between the donor level and conduction band and also gives kinetic energy to the electrons, which produces a current in the solar cell.

When a junction is formed between the *n*-type and *p*-type semi conductor there is a potential difference set up between the n-type and p-type semiconductors at the junction. The electrons that move from *n*-type to *p*-type set up a positive potential in the *n*-type at the junction and a negative potential in the *p*-type. This potential can accelerate electrons across the field from the *p*- to *n*-type and prevents electrons from flowing from the *n*-type to *p*-type. This forces freed electrons from the *n*-type semiconductor to travel around the external circuit creating a current in the external circuit.

**2010 TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION**

PHYSICS

**Section II**

**25 marks**
**Attempt Question 31**
**Allow about 45 minutes for this section**

Answer the questions in a writing booklet.
- Show all relevant working in questions involving calculations.

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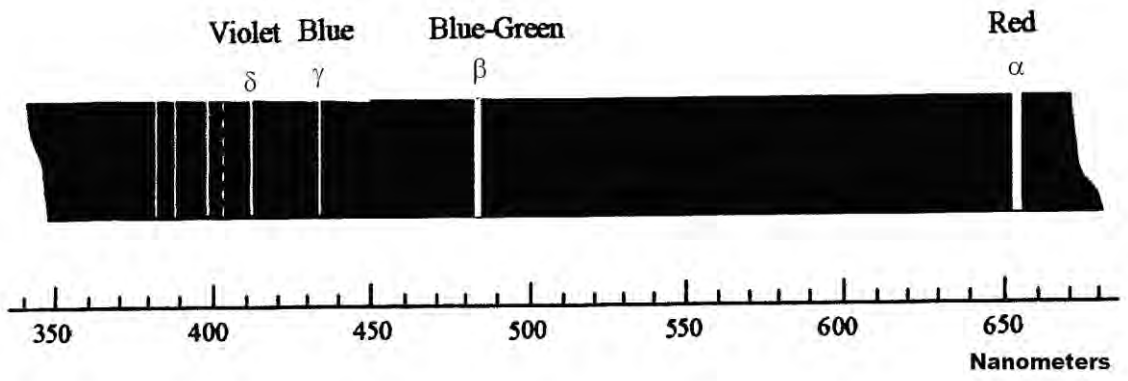
**Question 31 -- FROM QUANTA TO QUARKS** (25 Marks)

**Marks**

(a) The diagram below represents the visible spectrum of the hydrogen atom.




i. Determine the wavelength of the blue/green line. 485 nm **1**

ii. Calculate the energy of a photon emitted by the blue/green line **2**

$E = hf = \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{485 \times 10^{-9}}$

$= 4.099 \times 10^{-19}$ J

**Marks**

(b) Carbon-14 undergoes $\beta^-$ decay.

(i) Write the complete nuclear equation for this transmutation. **1**

(ii) Calculate the energy released during the decay of carbon-14, in MeV per atom, using the information in the table given below. **2**

| Atom/Particle | Mass (u) |
|---|---|
| boron-10 | 10.012 937 |
| boron-11 | 11.009 305 |
| carbon-12 | 12.000 000 |
| carbon-13 | 13.003 354 |
| carbon-14 | 14.003 241 |
| nitrogen-14 | 14.003 074 |
| nitrogen-15 | 15.000 108 |
| electron | 0.00055 |

$$^{14}_{6}C \rightarrow ^{14}_{7}N + ^{0}_{-1}e + \bar{\nu}$$

$\Delta m$ = (14.003074 + 0.00055) - 14.003241
= 0.000383 amu

Convert to MeV ..... as 1amu = 931.5 MeV (from data)

E = 0.000383 x 931.5
E = 0.357 MeV

(c) The electron and positron both have a rest mass of $9.109 \times 10^{-31}$ kg. In the annihilation of a positron with an electron, all the mass is converted to gamma rays carrying energy. Calculate the amount of energy released as gamma rays, in Joules, when a positron and electron undergo annihilation. **1**

$E = mc^2$
$= (9.109 \times 10^{-31}) \times 2 \times (3 \times 10^8)^2$
$= 1.639 \times 10^{-13}$ J

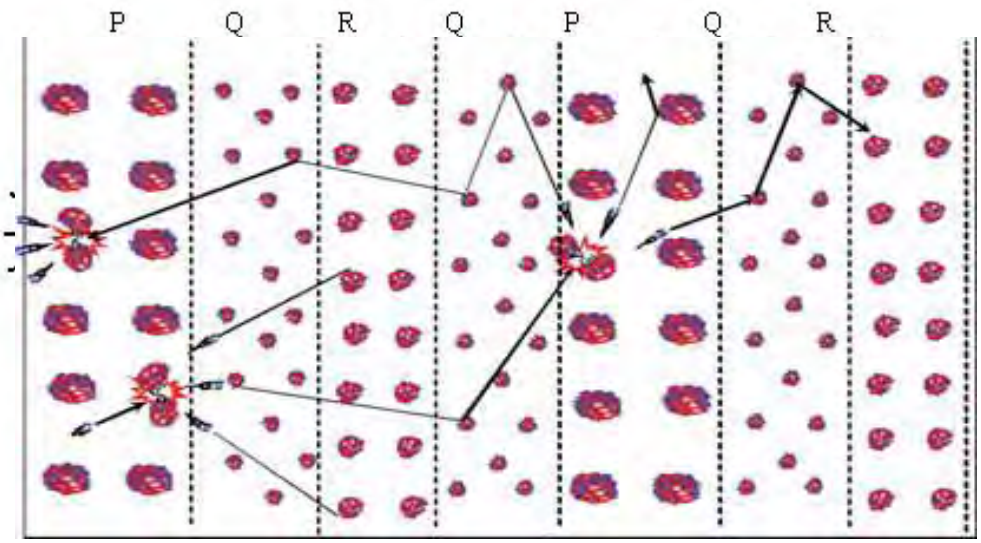
**(d)** Outline the role that nuclear fission reactors play to benefit Science. **6**

Describe the role of nuclear fission reactors used to

- Generate electricity
- Power ships
- Generate neutrons for research
- Generate neutrons for radioisotopes
- Medical industry – diagnosis and treatment
- Agriculture
- Industry

**Marks**

(e) The simplified diagram shows the nuclei of different components in a nuclear fission reactor core. **3**
Identify the moderator, fuel rod, and control rod, using the letters P, Q or R




P = fuel rod
Q = moderator
R = control rod

(f) Until the 1960s, matter was considered to compose of the fundamental particles of protons, neutrons and electrons. **6**
Describe the recent developments in understanding the structure of matter and how particle accelerators have contributed to this increased understanding.

**Marking Guidelines**

| *Criteria* | *Mark* |
|---|---|
| Correct outline of standard model of matter with key features including quarks and leptons and describe the role particle accelerators played in helping develop the model | 6 |

The standard model of matter describes the composition of matter. It states that 12 matter particles and 4 force-carrying particles can explain how matter is composed and behaves. Of the matter particles, there are 6 quarks and 6 leptons. Hadrons, baryons, mesons and prions represent the force carrying particles. 3 forces act between particles and act by the exchange of force-carrying particles called bosons. The standard model has developed out of both research and theorising about the structure and properties of matter.

Particle accelerators have provided scientists with the tools to probe and investigate the structure of matter. The high-energy charged particles can either be fired at a stationary target or collided with other high-energy particles travelling in the opposite direction. Whilst linear accelerators and cyclotrons were once very important tools in studying the composition and property of matter, today synchrotrons and particle accelerators, such as the LHC, have become the major tools. Many of the newly discovered particles can only be made in a particle accelerator. Whilst the SM of M is a great achievement and many experiments, using the accelerators listed above, have confirmed its predictions, the model has some serious flaws and continues to generate even more questions.

(g) The physicist Wolfgang Pauli had a significant impact on our understanding of the structure of the atom. Outline his contribution to the current theory of atomic structure. **3**

| *Criteria* | *Mark* |
|---|---|
| Describe the details of the exclusion principle and what its impact has been on the understanding of the periodic table; and the proposal of the existence of the neutrino | 3 |

Pauli mad e several contributions to atomic theory:

- Proposed that each electron in an atom would be described by 4 quantum numbers
- Proposed the exclusion principle, that no 2 electrons in an atom could have a set of 4 identical quantum numbers
- His exclusion principle and rules provide an explanation for the structure of the periodic table
- Proposed the existence of the neutrino which is emitted during beta decay.

**End of paper**