Physics

Trial Examination

HSC Course

2011

General Instructions

Reading time - *5 minutes*

Working time - *135 minutes*

Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

Formulae sheets and a Periodic Table are provided with this question paper.

Answer all questions in the spaces provided.

This paper has two sections:

Total marks (75)

Part A

15 marks – attempt questions 1 -15

Part B

60 marks – attempt questions 16 - 28

Part A

Multiple Choice Answers

For questions 1 - 15 place a cross (X) in the column which matches your choice.

Question	A	B	C	D
1				
2				
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15				

Marking Summary

Space	1 – 5	……. / 5	
	16 – 21	…… / 20	*Space Total* …… / 25
Motors	6 – 10	……. / 5	
	22 – 26	…… / 20	*Motors Total* …… / 25
Ideas	11 – 15	……. / 5	
	27 – 32	…… / 20	*Ideas Total* …… / 25
			Final Mark …… / 75

Part A – 15 marks

Attempt Questions 1 – 15

Allow about 25 minutes for this part

1 Why do all objects at any particular point on the Earth's surface accelerate at the same rate in free fall?

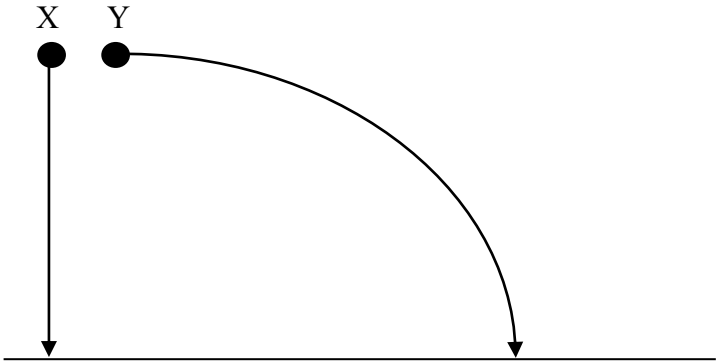
(A) The gravitational force acting on each object is the same.

(B) The gravitational force on each object is proportional to its mass.

(C) The acceleration is directly proportional to the gravitational force acting on each mass.

(D) The acceleration is directly proportional to the mass of each object.

2 Two identical metal balls, X and Y, are released at the same time from the same height above horizontal ground. Ball X falls vertically from rest. Ball Y is projected horizontally as shown below. (Air resistance is negligible.)



Which of the following statements is correct?

(A) Ball X hits the ground before ball Y because it travels a shorter distance.

(B) Ball Y hits the ground before ball X because its initial velocity is greater.

(C) The balls hit the ground at the same time because horizontal motion does not affect vertical motion.

(D) The balls hit the ground at the same time because they have equal weights.

3 Which choice correctly describes *escape velocity*?

(A) The velocity an object needs to be given at the Earth's surface, to escape completely from the gravitational field of the planet

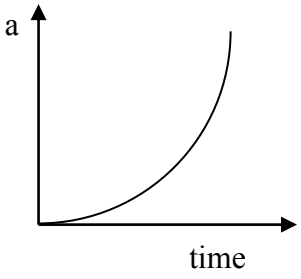
(B) The velocity an object needs to be given at launch from the Earth's surface, to enter a geostationary orbit about the planet

(C) The velocity an object needs to be given to escape from the atmosphere of the planet

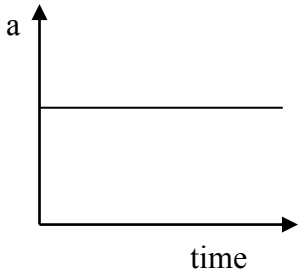
(D) The velocity an object needs to be given to cancel the effects of gravity

4 Which of the following *acceleration versus time* graphs best describes the acceleration of a rocket, which is launched with constant thrust motors?

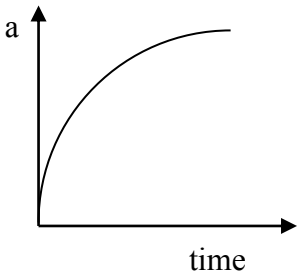
(A)



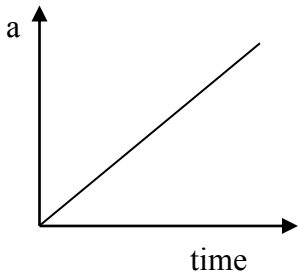
(B)



(C)



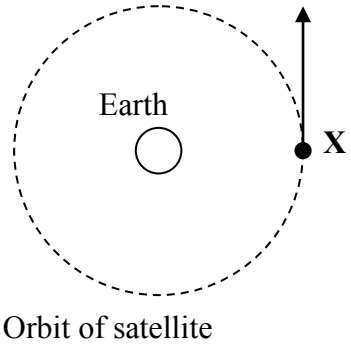
(D)



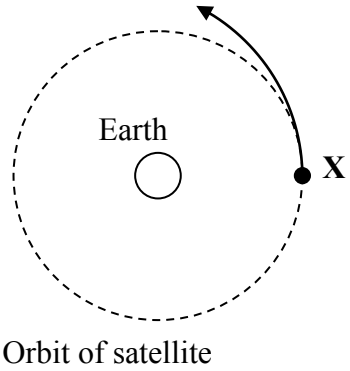
5 *A satellite is in a stable geostationary orbit around the Earth.*

Which choice best shows the satellite's path (solid arrow), if the gravitational force acting on it was somehow "switched off" when it was at point X?

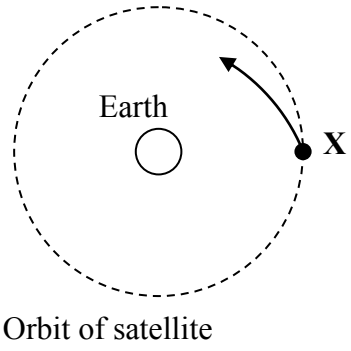
(A)



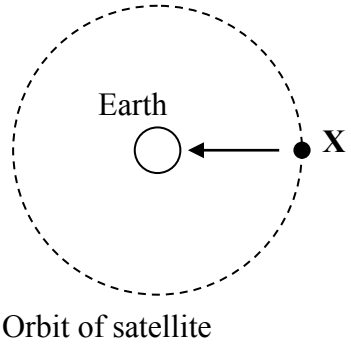
(B)



(C)



(D)



6 Which of the following is **NOT** due to the motor effect?

(A) Rotation of a coil in a generator

(B) Movement of a needle in a galvanometer

(C) Movement of the voice coil in a loud speaker

(D) Electromagnetic brakes

7 A direct current (dc) simple motor is connected to a battery by means of two leads. What is the role of the motor's commutator?

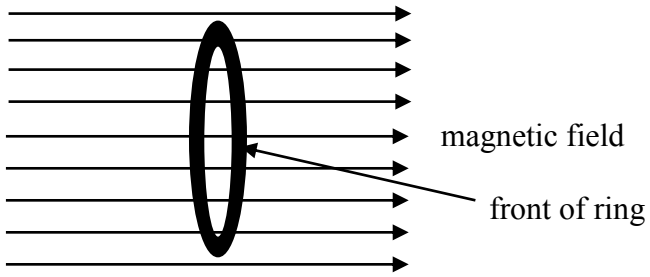
(A) To allow the motor to produce a uniform torque in a constant direction

(B) To prevent overheating due to too large a current in the coil of the motor

(C) To reverse the direction of current in the leads from the power supply to the commutator

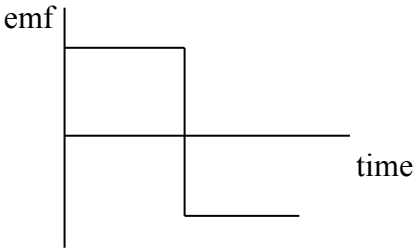
(D) To ensure the direction of current in the coil of the motor is constant relative to the magnetic field

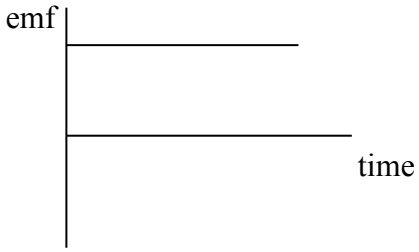
8 A metal ring has its plane perpendicular to a magnetic field as shown.

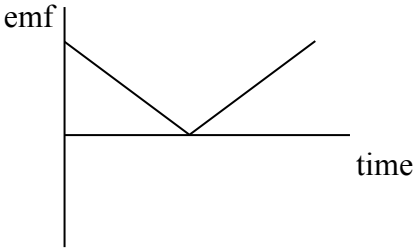


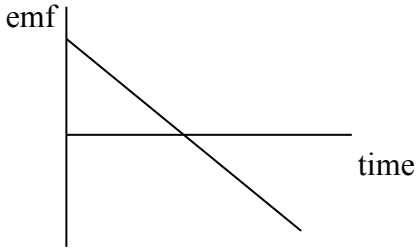
Over a period of time, the strength of the magnetic field is reduced at a uniform rate from 0.5 T to zero. Then its direction is reversed and the strength increased, at the same uniform rate, back up to 0.5T.

Which graph shows a possible emf induced in the ring during this time?

(A)


(B)


(C)


(D)


9 Why are high voltages used to transmit electrical energy from power stations over large distances?

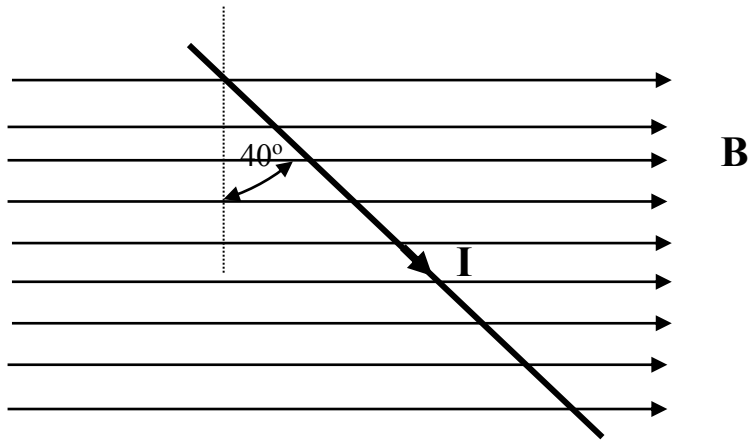
(A) High voltages can be transformed down to any required value.

(B) Energy losses in the transmission lines are minimised.

(C) Transformers operate with less heat production if high voltages are used.

(D) High voltages provide the large currents needed to be efficient over large distances.

10 A straight current-carrying conductor has 15 cm of its length in a uniform magnetic field of strength 0.4 T. The current in the conductor is 3 A and it makes an angle of 40º to the normal of the magnetic field.



What is the magnitude of force on the conductor?

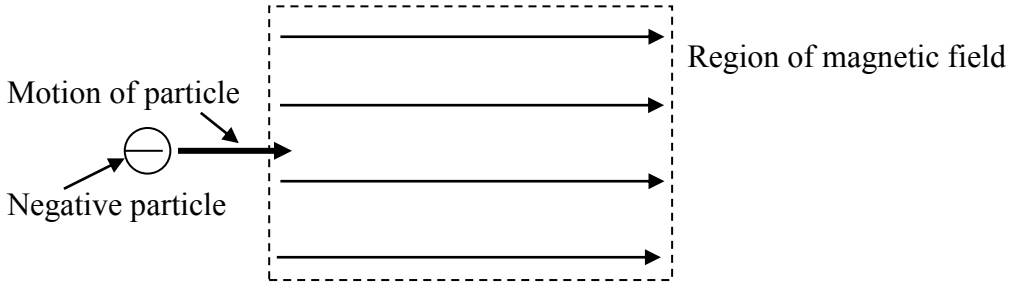
(A) 0.12 N

(B) 0.14 N

(C) 0.77 N

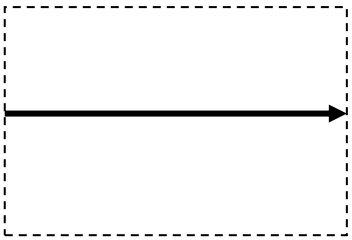
(D) 0.92 N

11 A negatively charged particle enters a region of uniform magnetic field. The direction of the particle's velocity is parallel to the field as shown in the diagram.

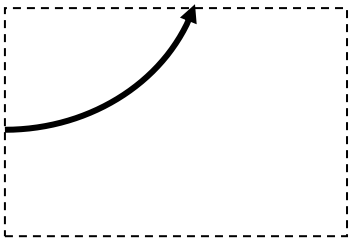


Which choice best describes what happens to this particle while it is in the field?

(A)



(B)



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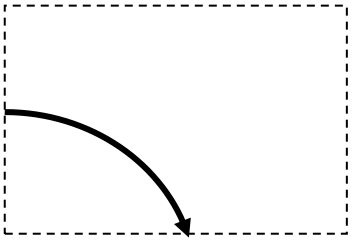
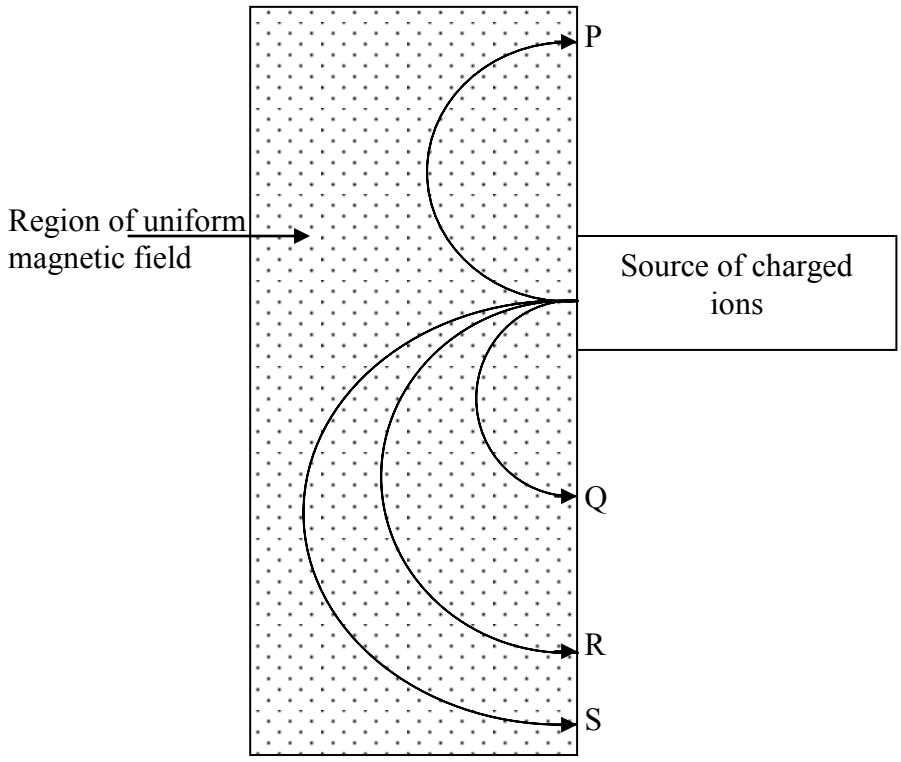


(D)

Particle curves up out of the page.

12 The diagram shows the paths taken by four charged particles, (P, Q, R and S), fired with identical speeds into a region of uniform magnetic field directed normally to the page.



Which statement about these particles could account for these paths?

(A) P and Q carry opposite and equal charges and Q has more mass than P.

(B) Q and R have the same mass, carry opposite charges and R has a larger charge than Q.

(C) R and P have the same mass, carry opposite charges and R has a smaller charge than P.

(D) R and S carry identical charges and R has a larger mass than S.

13 Which of the following groups of substances conducts electricity by the free movement of individual electrons through a crystal lattice?

(A) low pressure gases

(B) metallic conductors

(C) semiconductors

(D) superconductors

14 Photons of wavelength λ are incident on a metallic surface in a vacuum. The number of photons incident on the surface per second is N. No electrons are emitted from the surface.

Which of the following actions is most likely to cause electrons to be emitted from the surface?

(A) Decrease the frequency of the incident light

(B) Decrease the wavelength of the incident light

(C) Increase the number of photons per second incident on the surface

(D) Change to a different metallic surface

15 Which of the following correctly describes the most commonly used semiconductor material, in which conduction involves the movement of holes when an electric field is applied across the semiconductor?

(A) Silicon doped with phosphorus

(B) Germanium doped with phosphorus

(C) Silicon doped with boron

(D) Germanium doped with boron

Part B

Total Marks (60)

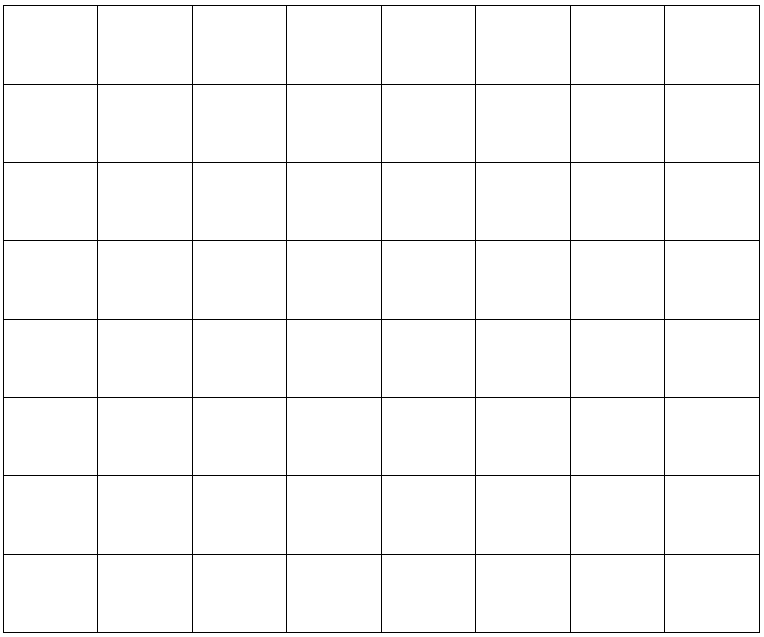
Attempt questions 16 – 28

Allow about 1 hour and 50 minutes for this part

Question 16 (4 marks)

A projectile is fired from the ground at an angle of 30^o to the horizontal at time t = 0. It lands back on the ground at t = T.

(a) On the same axes, sketch graphs on the grid below to show the variation with time of both the vertical and horizontal velocities of the projectile. Label each graph. **2**



(b) If the launch speed of the projectile was 80 m s^{-1}, calculate its maximum height. **2**

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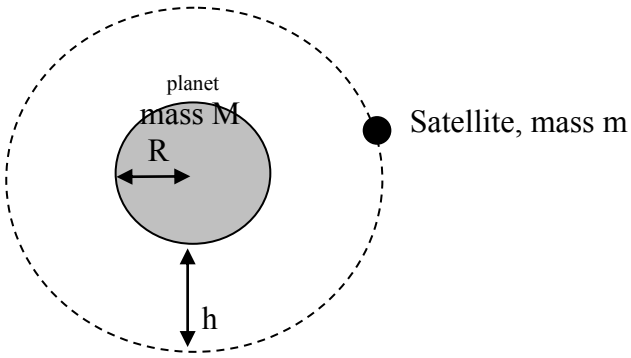
Question 17 (5 marks)

A spherical planet has radius *R* and mass *M*. A satellite of mass *m* orbits the planet with constant orbital speed *v* at a height *h* above the planet's surface, as shown below (not to scale).



(a) Outline why, although the satellite is moving with constant speed, the net force on it is not zero. **1**

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(b) Why does a person experience weight on the Earth but feel weightless orbiting the Earth in a satellite? **2**

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(c) A second satellite, mass 2M is placed into the same orbit. What will be its orbital speed compared to the first satellite? Justify your answer using Physics equations. **2**

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Question 18 (3 marks)

(a) State the hypothesis of the Michelson-Morley experiment. **2**

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(b) The Michelson-Morley experiment failed to achieve its purpose.
Does this mean that the experiment was valid or invalid? Justify your answer. **1**

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Question 19 (3 marks)

(a) State the meaning of the phrase "the relativity of simultaneity". **1**

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(b) Describe a thought experiment that is an example of the relativity of simultaneity. **2**

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Question 20 (3 marks)

(a) In an experiment in1971, four caesium atomic clocks were flown twice around the world in commercial airliners. The times on the clocks were synchronised before takeoff with four identical clocks at the US Naval Observatory and compared when the planes landed after the journey. **1**

Why were four clocks used in the planes?

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(b) An observer on Earth is watching electronic displays of his own time and time on board a spaceship moving away from Earth at 0.6c. **2**

The observer falls asleep when the two displays read exactly the same time. When he wakes up he observes that the times differ by 10 minutes. How long was he asleep?

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Question 21 (2 marks)

In his book "Dialogues Concerning Two New Sciences", Galileo Galilei presented his classic analysis of the motion of a projectile.

Outline Galileo's contribution to our understanding of projectile motion. **2**

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Question 22 (4 marks)

(a) Outline how electrical transmission lines are protected from lightning strikes. **2**

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(b) Outline how the production of an alternating current may be demonstrated in the school laboratory. **2**

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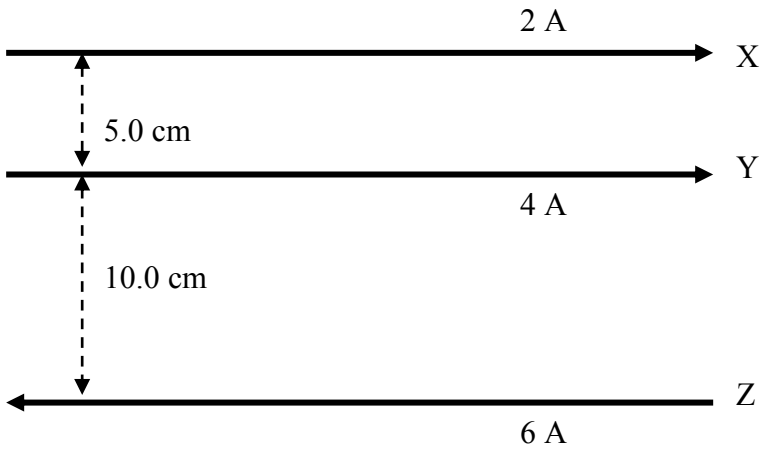
Question 23 (3 marks)

Three long, straight, parallel wires; X, Y and Z are 5.0 cm and 10.0 cm apart respectively and carry currents of 2 A, 4 A and 6 A. The currents in wires X and Y are in the opposite direction to the current in wire Z.



Calculate the magnitude AND direction of the force per unit length on wire Y, due to the other two wires. **3**

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Question 24 (6 marks)

(a) Outline the basic principle of induction motors. **2**

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(b) Galvanometers and loudspeakers are both applications of the motor effect and a moveable coil is a central part of each device.

Analyse how the motor effect is used to produce rotation of the coil in one device and vibration in the other. **4**

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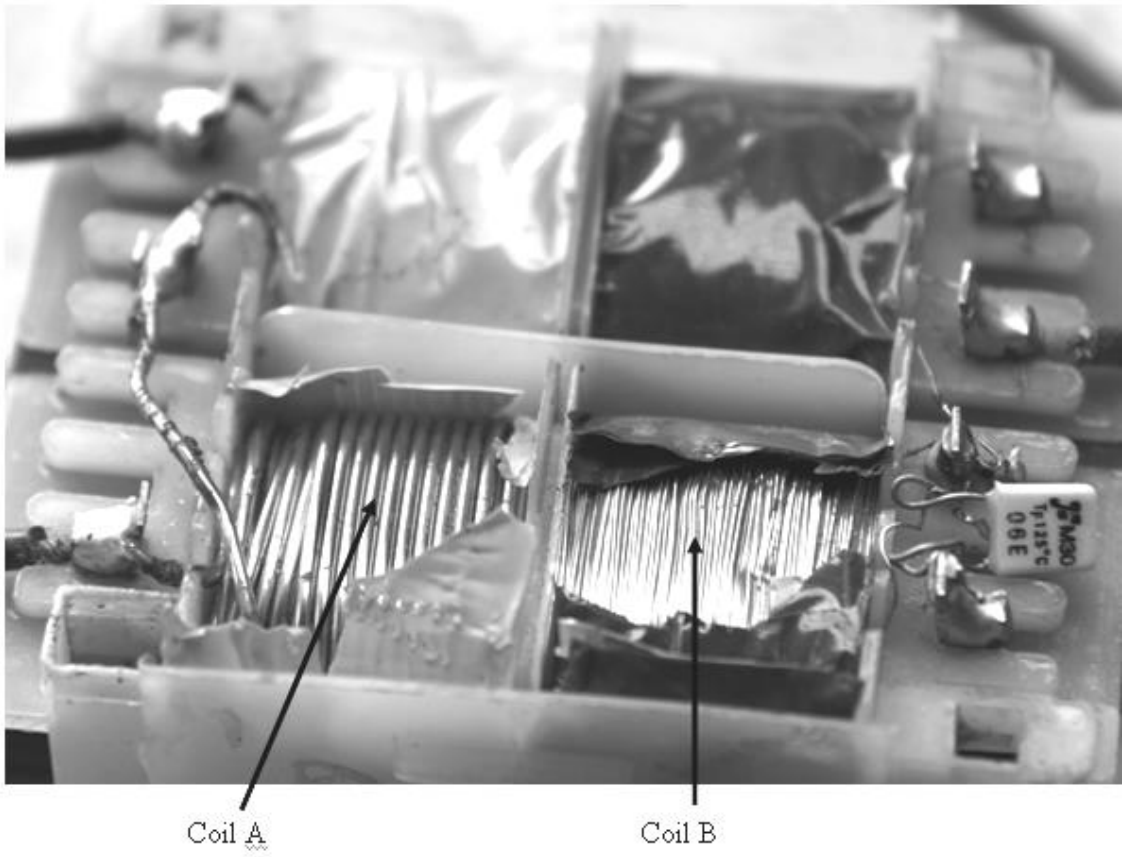
Question 25 (4 marks)

The photograph shows the wires inside a step-up transformer. The wires are wound on a soft iron core of uniform thickness.



(a) Account for the differing thicknesses of the wires used in coils A and B. **2**

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(b) The transformer is from a bedside lamp. Its input voltage is 240 V and its output is 12 V. If the current through the globe in the lamp is 5 A, what is the input current? **2**

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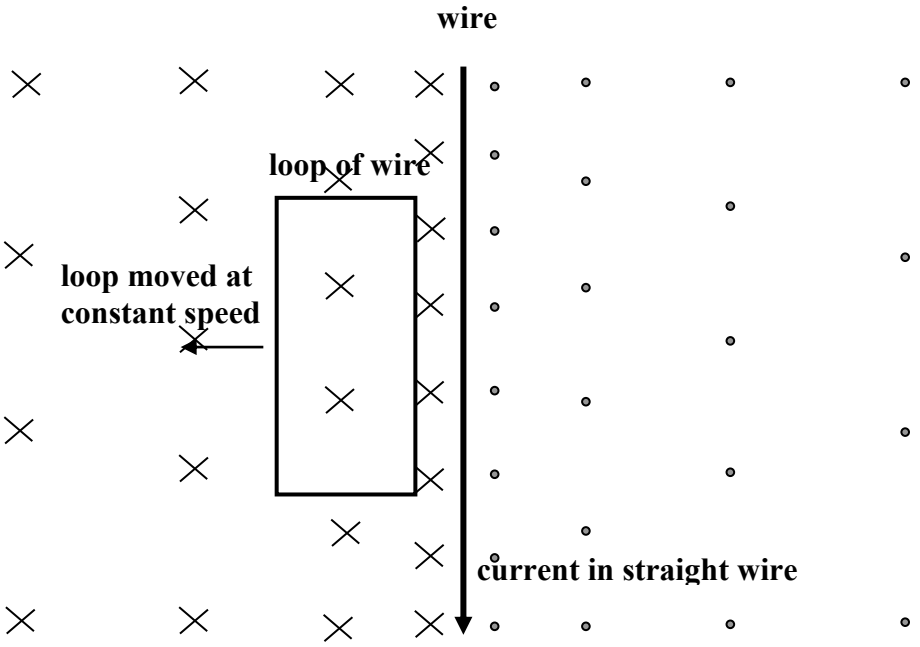
Question 26 (3 marks)

A long straight wire carries a constant current. The magnetic field around the wire is shown, using crosses to represent the field directed into the page.
A rectangular loop of conducting wire is placed near the wire and lies totally within the magnetic field due to the current in the wire.
The loop is then moved to the left at a constant speed.



(a) Explain why an emf will be induced in the loop. **2**

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(b) Determine the direction of the induced current in the loop. State it as clockwise or anticlockwise. **1**

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Question 27 (3 marks)

Identify AND discuss one impact of the invention of transistors on our society. **3**

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Question 28 (4 marks)

(a) A strong disc magnet is lowered above a superconducting material which has been cooled below its critical temperature. It is then released from the tongs used to hold it. It hovers in the air above the superconducting material.

(i) Define critical temperature. **1**

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(ii) Explain how electromagnetic induction can account for this hovering. **2**

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(b) A magnet is placed on a superconductor at room temperature. The superconductor is cooled and the magnet rises. Describe the property of superconductors that causes this to happen. **1**

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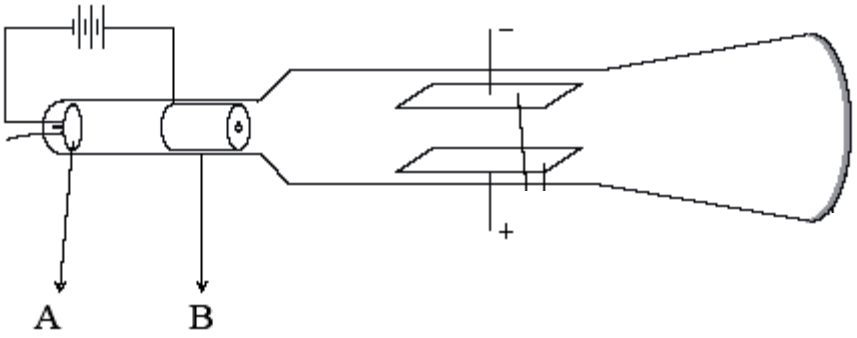
Question 29 (3 marks)

J. J. Thomson was the first to deflect cathode rays in electric fields, providing evidence for the theory that they were negative particles. He also measured the charge to mass ratio for cathode ray particles. The diagram illustrates a modern version of part of the apparatus he used.



(a) Why did Thomson's results lead him to believe that he had discovered a new particle? **1**

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(b) If the potential difference between the plates is 500 V and the distance between them is 20 mm, calculate the magnitude of the acceleration of each cathode ray particle as it passes between the plates. **2**

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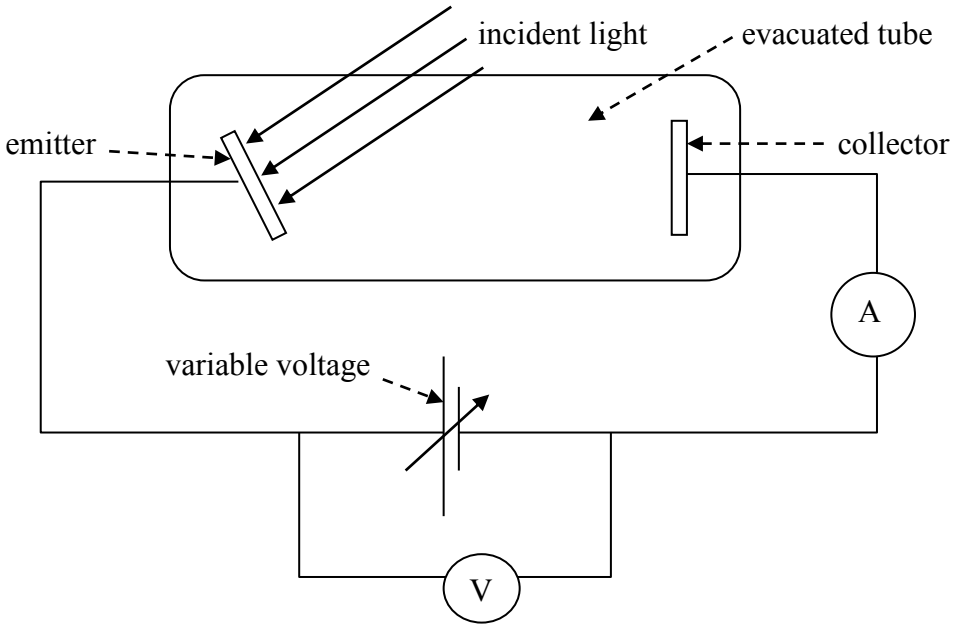
Question 30 (5 marks)

The diagram shows apparatus used to investigate the photoelectric effect.



In experiments using this apparatus to determine the work function of different materials, photoelectrons are stopped from reaching the collector.

(a) A photon of frequency 5 x 10^{14} Hz, emits electrons from the emitter which are just stopped from reaching the collector when the applied voltage is 1.5 V.

Calculate the work function of the emitter material. **3**

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Question 30 continues on the next page

(b) On the axes below, sketch graphs for two different metals to show the relationship between the frequency of the incident light and the maximum kinetic energy of electrons emitted by the photoelectric effect. (Values are not required). **2**

Question 31 (3 marks)

In the nineteenth century scientists used a variety of tubes to investigate the nature of cathode rays. One of these tubes was the "Maltese Cross" tube.

(a) What was the observation made using the cathode ray tube with a Maltese cross? **1**

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(b) What property of cathode rays did this observation imply? **1**

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(c) How helpful was the observation in determining whether cathode rays were particles or waves? Justify your answer. **1**

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Question 32 (2 marks)

A student carried out an experiment on the photoelectric effect. The frequency of the incident radiations and the energy of the photoelectrons were both determined from measurements taken during the experiment.

The results obtained are shown in the table:

Energy of photoelectrons $(x\ 10^{-19}\ J)$	*Frequency of incident radiation* $(x\ 10^{14}\ Hz)$
1.22	6.9
1.70	8.2
3.70	9.1
3.05	9.9
3.38	10.6
3.91	11.8

When these data pairs are plotted on a graph, a straight line with a positive gradient results.

Comment on the key features of the graph i.e. describe the significance of the gradient, y-intercept, x-intercept, etc. **2**

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Physics

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HSC Course

2011

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Board-approved calculators may be used.

Write using blue or black pen.

Draw diagrams using pencil.

Formulae sheets and a Periodic Table are provided with this question paper.

Answer all questions in the spaces provided.

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Total marks (75)

Part A

15 marks – attempt questions 1 -15

Part B

60 marks – attempt questions 16 - 28

Part A

Multiple Choice Answers

For questions 1 - 15 place a cross (X) in the column which matches your choice.

Question	A	B	C	D
1		X		
2			X	
3		X		
4		X		
5		X		
6	X			
7				X
8		X		
9		X		
10		X		
11	X			
12			X	
13		X		
14		X		
15			X	

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			Final Mark …… / 75

Part B

Total Marks (60)

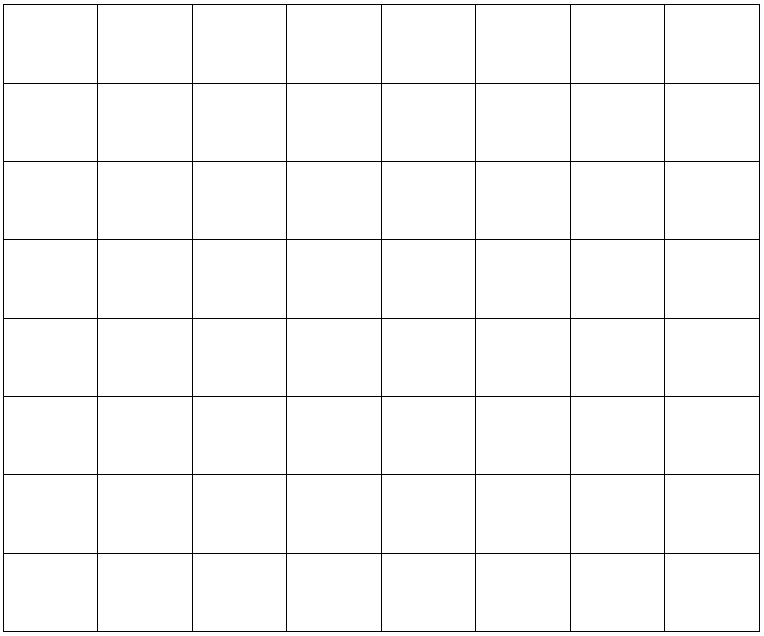
Attempt questions 16 – 28

Allow about 1 hour and 50 minutes for this part

Question 16 (4 marks)

A projectile is fired from the ground at an angle of 30^o to the horizontal at time t = 0. It lands back on the ground at t = T.

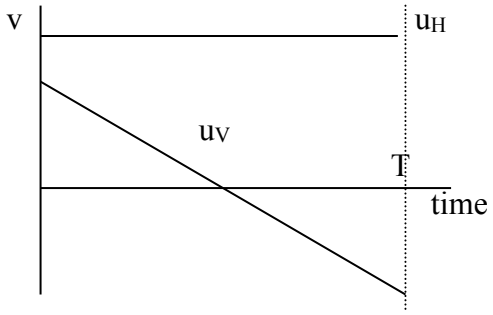
(a) On the same axes, sketch graphs on the grid below to show the variation with time of both the vertical and horizontal velocities of the projectile. Label each graph. **2**



16(a)

Criteria	Marks
Draws line for u_h parallel to and above time axis and line for u_v with negative slope from above to below time axis, with labels.	**2**
Draws line for u_h parallel to and above time axis with label OR line for u_v with negative slope from above to below time axis with label.	**1**

Sample Answer:



(b) If the launch speed of the projectile was 80 m s^{-1}, calculate its maximum height. **2**

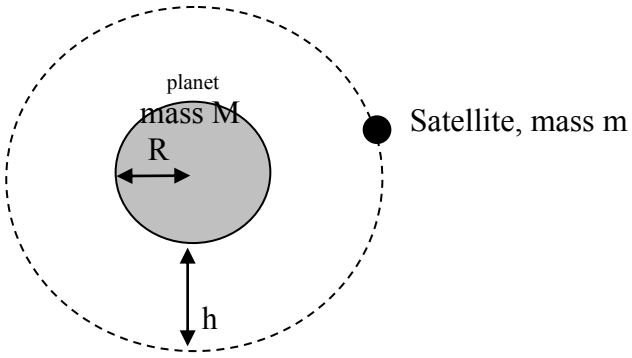
16(b)

Criteria	Marks
Provides correctly substituted equation and calculates correct answer.	2
Provides correctly substituted equation OR correct answer.	1

Sample Answer: $v_y^2 = u_y^2 + 2a\Delta y$ $O = (80\cos 60°)^2 - 2 \times 9.8 \times \Delta y$ $\Delta y = 81.6$ m

Question 17 (5 marks)

A spherical planet has radius *R* and mass *M*. A satellite of mass *m* orbits the planet with constant orbital speed *v* at a height *h* above the planet's surface, as shown below (not to scale).



(a) Outline why, although the satellite is moving with constant speed, the net force on it is not zero. **1**

17(a)

Criteria	Marks
States direction of gravitational force or acceleration in relation to its velocity.	1

Sample Answer: Satellite is accelerating towards the centre, it has gravitational force acting on it at 90° to its direction of motion, therefore undergoes uniform circular motion.

(b) Why does a person experience weight on the Earth but feel weightless orbiting the Earth in a satellite? **2**

17(b)

Criteria	Marks
Explains sensation of weight and lack of weight in satellite due to common acceleration.	2
Explains sensation of weight OR lack of weight in satellite due to common acceleration.	1

Sample Answer: Weight is experienced when our body is in contact with the ground (or other surface) which pushes on us in the opposite direction to the gravitational force. In space circling the Earth or in 'freefall' all parts of our body accelerate at the same rate as the satellite towards Earth due to the gravitational force and no contact forces are exerted on us, hence no sensation of weight.

(c) A second satellite, mass 2M is placed into the same orbit. What will be its orbital speed compared to the first satellite? Justify your answer using Physics equations. **2**

17(c)

Criteria	Marks
Provides correct answer and provides equation to justify same orbital speed.	2
Provides correct answer OR provides equation to justify same orbital speed.	1

Sample Answer: Same orbital speed. $GMm/r^2 = mv^2/r$ Since mass of satellite m cancels, orbital speed is independent of mass. Therefore speed will be the same for all satellites at the same radius; OR use Kepler's law of periods.

Question 18 (3 marks)

(a) State the hypothesis of the Michelson-Morley experiment. **2**

18(a)

Criteria	Marks
Provides statement about expected difference in speed of light and reason.	2
Provides statement about expected difference in speed of light.	1

Sample Answer: The speed of light measured relative to the Earth will be different when light is measured travelling in different directions due to the effects of the Earth's motion through the aether.

(b) The Michelson-Morley experiment failed to achieve its purpose.
Does this mean that the experiment was valid or invalid? Justify your answer. **1**

18(b)

Criteria	Marks
States that valid and provides reason.	1

Sample Answer: The experimental design was valid. If there had been a difference in the speed of light from the different direction, their apparatus would have detected that. The fact that a null result was achieved was due to theory not known at that time.

Question 19 (3 marks)

(a) State the meaning of the phrase "the relativity of simultaneity". **1**

19(a)

Criteria	Marks
Defines *relativity of simultaneity*.	1

Sample Answer: Two events seen to be simultaneous in one frame of reference may not be seen to be simultaneous in another frame of reference.

(b) Describe a thought experiment that is an example of the relativity of simultaneity. **2**

19(b)

Criteria	Marks
Outlines the event and observations by two observers in different frames.	2
Outlines the event OR observations by two observers in different frames.	1

Sample Answer: Beams of light are directed backwards and forwards from a source in the middle of a train carriage moving at a significant speed. An observer is standing on the ground level with the middle of the carriage when the light is emitted. He will see the light beam reaching the rear wall of the carriage before forwards beam hits the front wall of the carriage. The observer on the train in the middle of the carriage sees the beams hit at the same time.

Question 20 (3 marks)

(a) In an experiment in1971, four caesium atomic clocks were flown twice around the world in commercial airliners. The times on the clocks were synchronised before take-off with four identical clocks at the US Naval Observatory and compared when the planes landed after the journey. **1**

Why were four clocks used in the planes?

20(a)

Criteria	Marks
Identifies reliability as the reason.	1

Sample Answer: Four clocks were used to increase the reliability of the experimental results.

(b) An observer on Earth is watching electronic displays of his own time and time on board a spaceship moving away from Earth at 0.6c. **2**

The observer falls asleep when the two displays read exactly the same time. When he wakes up he observes that the times differ by 10 minutes. How long was he asleep?

20(b)

Criteria	Marks
Calculates correct answer.	2
States that time measured in spaceship is greater than time observed on Earth.	1

Sample Answer: The observer on Earth will observe the ship time to be passing more slowly, so will read the spaceship time to be 10 minutes less than his time. $t_{ship} = t_{earth} - 10$

$t_{earth} = t_{ship}/\sqrt{(1 - v^2/c^2)}$ $t_{earth} = (t_{earth} - 10)/\sqrt{(1 - 0.6^2)}$ **therefore** t_{earth} = 50 minutes = time asleep

Question 21 (2 marks)

In his book "Dialogues Concerning Two New Sciences", Galileo Galilei presented his classic analysis of the motion of a projectile.

Outline Galileo's contribution to our understanding of projectile motion. **2**

Galileo suggested that the motion of the projectile could be broken down into two separate components i.e. horizontal and vertical. In the absence of air resistance, the horizontal motion remains constant while the vertical motion is subjected to the weight force of the body and thus it accelerates towards the centre of the Earth. The resulting trajectory is a parabola.

Question 22 (4 marks)

(a) Outline how electrical transmission lines are protected from lightning strikes. **2**

22(a)

Criteria	Marks
Describes the continuous earth cable and its role.	2
States that towers are grounded by earth wires.	1

Sample Answer: Transmission lines are protected from lightning strikes by shield conductors (continuous earth lines) which are fixed on the towers well above the transmission lines and connected to earth cables to carry electrical energy from the strikes to earth.

(b) Outline how the production of an alternating current may be demonstrated in the school laboratory. **2**

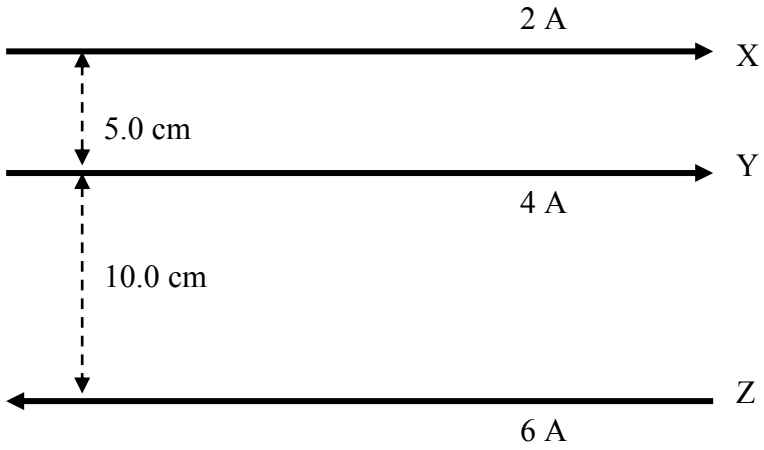
22(b)

Criteria	Marks
Describes a suitable laboratory method to produce AC and how AC production is confirmed.	2
Describes a suitable laboratory method to produce AC OR how AC production is confirmed.	1

Sample Answer: A coil is connected to a sensitive galvanometer. The end of a bar magnet is moved quickly in and out of the end of the coil. The galvanometer needle moves to right and left of zero position, demonstrating that AC current is produced OR slow turning of dynamo connected to galvanometer.

Question 23 (3 marks)

Three long, straight, parallel wires; X, Y and Z are 5.0 cm and 10.0 cm apart respectively and carry currents of 2 A, 4 A and 6 A. The currents in wires X and Y are in the opposite direction to the current in wire Z.



Calculate the magnitude AND direction of the force per unit length on wire Y, due to the other two wires. **3**

23

Criteria	Marks
Calculates the correct sum of the forces and states correct direction.	3
Calculates correct the sum of the forces OR makes one error and states correct direction.	2
Provides a calculation based on correct formula with two errors OR states correct direction.	1

Sample Answer: $F/l = kI_1I_2/d$ F/l on wire Y = F_x upwards + F_z upwards

$= 2.0\times10^{-7}(2\times4/0.05 + 4\times6/0.1)$

$F/l = 8.0\times10^{-5}$ Nm^{-1} towards the top of the page (towards wire X)

Question 24 (6 marks)

(a) Outline the basic principle of induction motors. **2**

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(b) Galvanometers and loudspeakers are both applications of the motor effect and a moveable coil is a central part of each device.

Analyse how the motor effect is used to produce rotation of the coil in one device and vibration in the other. **4**

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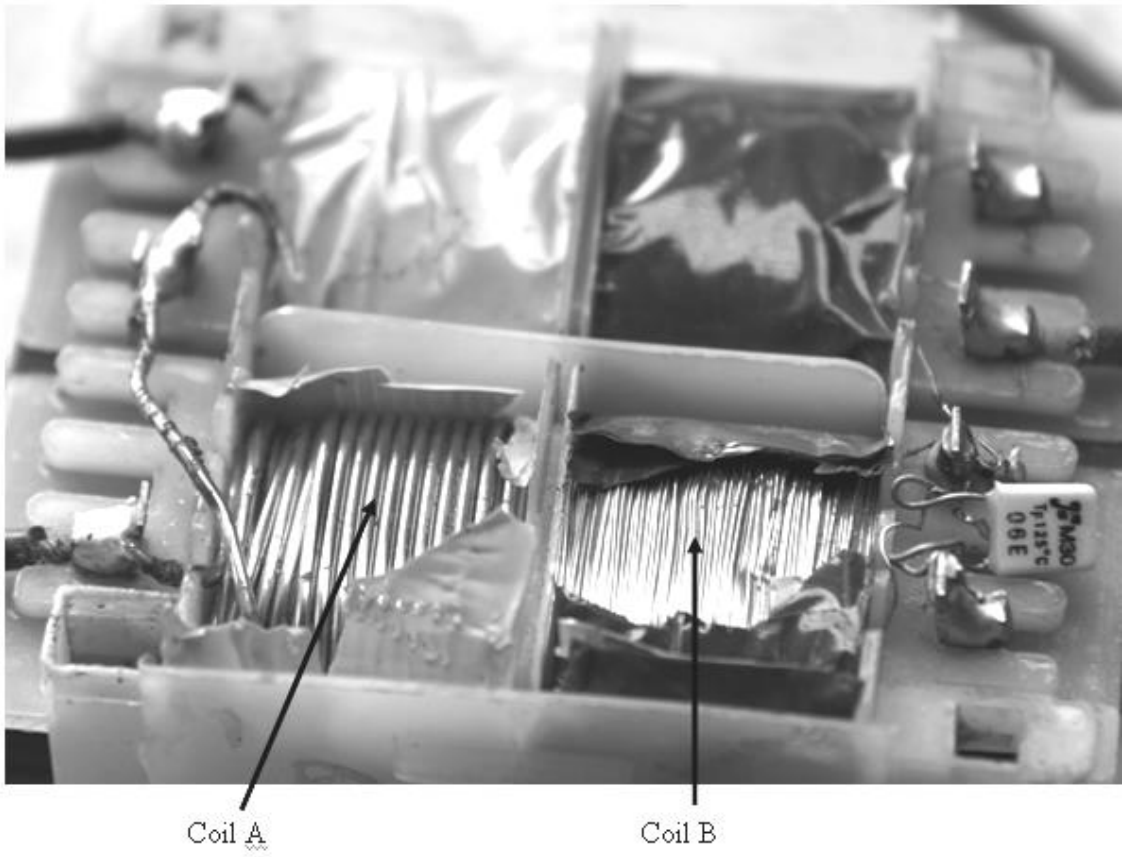
Question 25 (4 marks)

The photograph shows the wires inside a step-up transformer. The wires are wound on a soft iron core of uniform thickness.



(a) Account for the differing thicknesses of the wires used in coils A and B. **2**

25(a)

Criteria	Marks
Compares resistance of wires and states need to reduce heating.	**2**
Compares resistance of wires OR states need to reduce heating.	**1**

Sample Answer: Coil A, being the lower voltage coil will carry a higher current than coil B. Its resistance therefore needs to be lower to minimise energy losses by heating effects. Thicker wire has a lower resistance than thinner wire.

(b) The transformer is from a bedside lamp. Its input voltage is 240 V and its output is 12 V. If the current through the globe in the lamp is 5 A, what is the input current? **2**

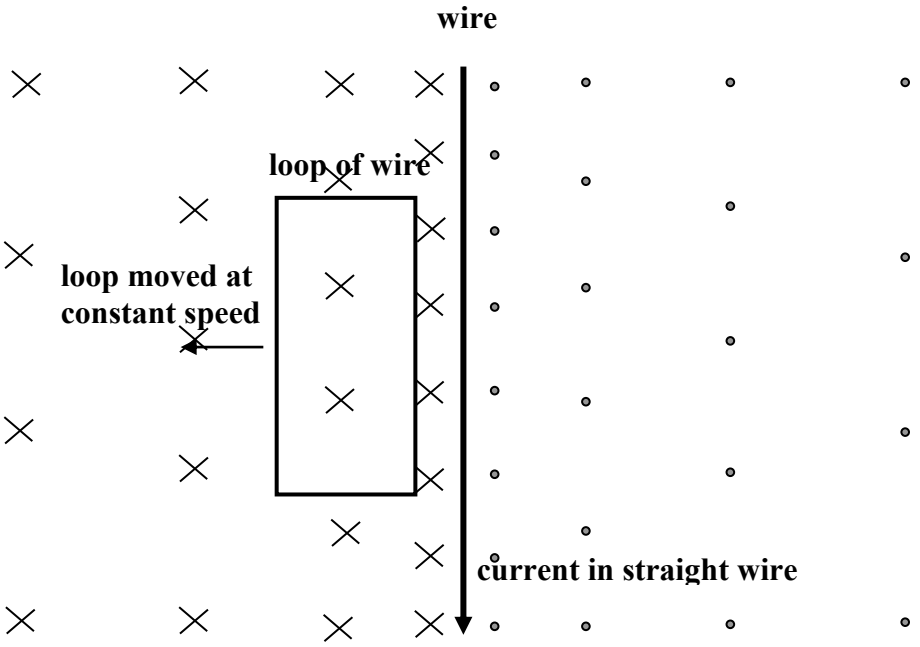
25(b)

Criteria	Marks
Provides correct answer and reason.	**2**
Provides correct answer OR reason for incorrect answer.	**1**

Sample Answer: power in = power out $V_{in}I_{in} = V_{out}I_{out}$ $240\ I_{in} = 12 \times 5$
input current $I = 60/240 = 2.5 \times 10^{-1}$ A

Question 26 (3 marks)

A long straight wire carries a constant current. The magnetic field around the wire is shown, using crosses to represent the field directed into the page.
A rectangular loop of conducting wire is placed near the wire and lies totally within the magnetic field due to the current in the wire.
The loop is then moved to the left at a constant speed.



(a) Explain why an emf will be induced in the loop. **2**

26(a)

Criteria	Marks
Identifies that a change in flux results in an emf and reason for change of flux.	**2**
Identifies that a change in flux results in an emf.	**1**

Sample Answer: While the loop is totally enclosed in the field, the field is weaker further away from the wire. When the loop moves, there will be a change of flux through the loop, so an emf will be induced; OR the right side of loop has a greater emf induced than left side as field at right is stronger.

(b) Determine the direction of the induced current in the loop. State it as clockwise or anticlockwise. **1**

26(b)

Criteria	Marks
Correct direction.	**1**

Sample Answer: Clockwise.

Question 27 (3 marks)

Identify AND discuss one impact of the invention of transistors on our society. **3**

27

Criteria	Marks
Identifies one impact and discusses at least two points.	**3**
Identifies one impact and discusses one point.	**2**
Identifies one impact with no discussion.	**1**

Answers will vary, for example: Transistors made possible the use of integrated circuits and the consequent miniaturisation of components in electrical circuits resulted in the miniaturisation of electrical devices. As a result, devices such as computers and phones have become portable devices with their functions greatly increased as more and more chips have been enclosed. Also, leisure activities for people (picnics, jogging) are more enjoyable as they can more easily take their music with them.

Question 28 (4 marks)

(a) A strong disc magnet is lowered above a superconducting material which has been cooled below its critical temperature. It is then released from the tongs used to hold it. It hovers in the air above the superconducting material.

(i) Define critical temperature. **1**

28(a)(i)

Criteria	Marks
Defines *critical temperature*.	**1**

Sample Answer: Critical temperature is the temperature below which a superconducting material has zero resistance.

(ii) Explain how electromagnetic induction can account for this hovering. **2**

28(a)(ii)

Criteria	Marks
Provides clear explanation of repulsion based on surface eddy currents.	**2**
States involvement of eddy currents OR production of opposing magnetic field.	**1**

Sample Answer: The motion of the magnet towards the superconductor induces surface eddy currents in the superconductor (Faraday's law) in such a direction that their magnetic field opposes the motion of the magnet (Lenz's Law). The magnet "hovers" due to repulsion between the magnetic field of magnet and eddy currents. (These eddy currents remain as negligible energy is lost because there is no resistance.)

(b) A magnet is placed on a superconductor at room temperature. The superconductor is cooled and the magnet rises. Describe the property of superconductors that causes this to happen. **1**

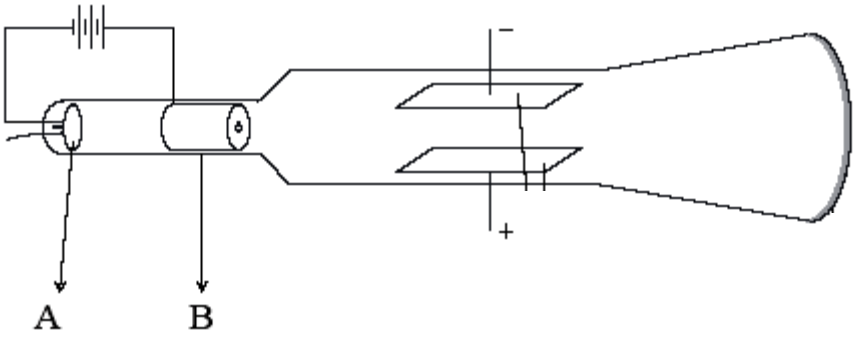
28(b)

Criteria	Marks
Identifies superconductors expel all magnetic flux.	**1**

Sample Answer: A magnetic field cannot penetrate a superconducting material below its critical temperature.

Question 29 (3 marks)

J. J. Thomson was the first to deflect cathode rays in electric fields, providing evidence for the theory that they were negative particles. He also measured the charge to mass ratio for cathode ray particles. The diagram illustrates a modern version of part of the apparatus he used.



(a) Why did Thomson's results lead him to believe that he had discovered a new particle? **1**

29(a)

Criteria	Marks
Identifies the large size of q/m ratio as the reason.	1

Sample Answer: The value he obtained for q/m for the cathode ray was larger than the value for any known particle. It therefore represented a previously unidentified particle.

(b) If the potential difference between the plates is 500 V and the distance between them is 20 mm, calculate the magnitude of the acceleration of each cathode ray particle as it passes between the plates. **2**

29(b)

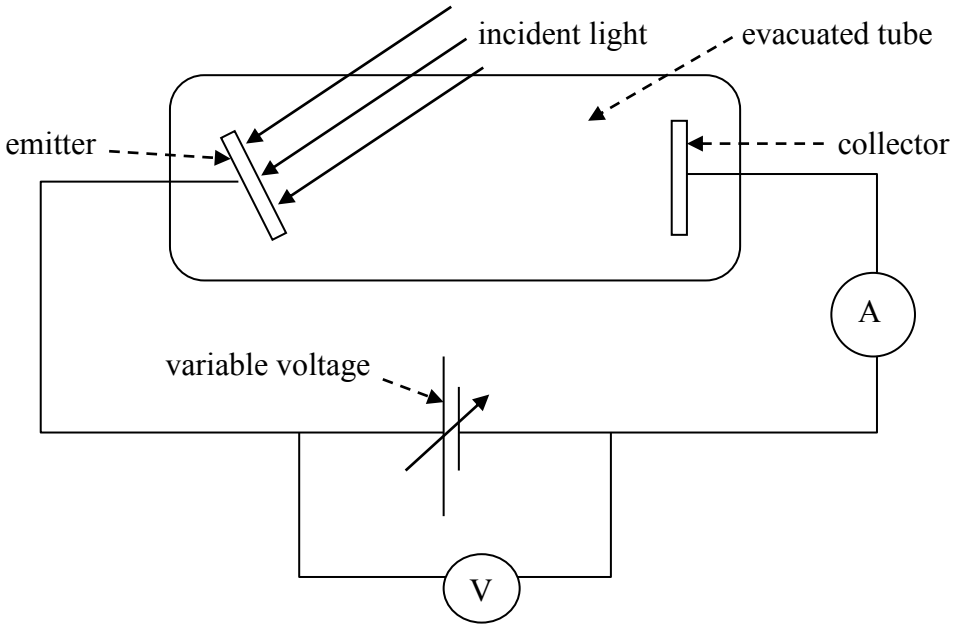
Criteria	Marks
Identifies correct formulae and substitutes correctly to calculate acceleration	2
Identifies formulae and substitutes, making one error	1

Sample Answer: From $F = qV/d = ma$

$a = 1.602 \times 10^{-19} \times 500/(9.109 \times 10^{-31} \times 20 \times 10^{-3}) \quad = 4.4 \times 10^{15}$ m s^{-2}

Question 30 (5 marks)

The diagram shows apparatus used to investigate the photoelectric effect.



In experiments using this apparatus to determine the work function of different materials, photoelectrons are stopped from reaching the collector.

(a) A photon of frequency 5 x 10^{14} Hz, emits electrons from the emitter which are just stopped from reaching the collector when the applied voltage is 1.5 V.

Calculate the work function of the emitter material. **3**

30(a)

Criteria	Marks
Identifies correct formula, calculates photon energy and subtracts kinetic energy in same units	**3**
Makes one error in the steps above	**2**
Makes two errors in the steps above	**1**

Sample Answer: From data, kinetic energy of emitted electrons = qV = 1.5 eV

From E = hf, energy of incident photon is = 5 x 10^{14} x 6.626 x 10^{-34} / (1.602 x 10^{-19} eV) = 2.07 eV

Therefore, work function of emitter = 2.07 – 1.5 = 5.7 x10^{-1} eV

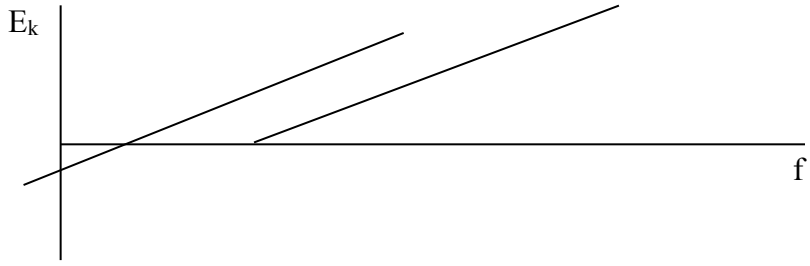
Question 30 continues on the next page

(b) On the axes below, sketch graphs for two different metals to show the relationship between the frequency of the incident light and the maximum kinetic energy of electrons emitted by the photoelectric effect. (Values are not required). **2**

30(b)

Criteria	Marks
Draws two parallel lines above axis only, with same positive gradient.	2
Draws one line above axis with positive gradient OR draws two parallel lines crossing frequency axis.	1

Sample Answer:



Question 31 (3 marks)

In the nineteenth century scientists used a variety of tubes to investigate the nature of cathode rays. One of these tubes was the "Maltese Cross" tube.

(a) What was the observation made using the cathode ray tube with a Maltese cross? **1**

31(a)

Criteria	Marks
Provides correct observation.	1

Sample Answer: A sharp shadow was formed on the glass behind the cross.

(b) What property of cathode rays did this observation imply? **1**

31(b)

Criteria	Marks
States correct property.	1

Sample Answer: Cathode rays travel in straight lines.

(c) How helpful was the observation in determining whether cathode rays were particles or waves? Justify your answer. **1**

31(c)

Criteria	Marks
States that not helpful, with appropriate justification.	1

Sample Answer: Not helpful, as observation supports both particle and wave nature of cathode rays.

Question 32 (2 marks)

A student carried out an experiment on the photoelectric effect. The frequency of the incident radiations and the energy of the photoelectrons were both determined from measurements taken during the experiment.

The results obtained are shown in the table:

Energy of photoelectrons $(x\ 10^{-19}\ J)$	*Frequency of incident radiation* $(x\ 10^{14}\ Hz)$
1.22	6.9
1.70	8.2
3.70	9.1
3.05	9.9
3.38	10.6
3.91	11.8

When these data pairs are plotted on a graph, a straight line with a positive gradient results.

Comment on the key features of the graph i.e. describe the significance of the gradient, y-intercept, x-intercept, etc. **2**

The gradient of the graph is equal to Planck's constant i.e. 6.626 x 10-34. The x-intercept is equal to the threshold frequency of the metal being tested. The y-intercept is equal to the work function of the metal being tested.

These values are consistent with the equation which describes the photoelectric effect i.e. $KE_{max} = hf - \varphi$

which is in the form $y = mx + b$

A simple comparison makes it obvious that
when $f = 0$, $KE_{max} = \varphi$ and
$h = m$ = gradient