Physics

Trial Examination

HSC Course

2009

General Instructions

Reading time - *5 minutes*

Working time - *2 hours 15 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.

Total Marks (75)

This paper has one section with two parts:

Section I

Total marks (75)

Part A

15 marks – attempt questions 1 - 15

Part B

60 marks – attempt questions 16 - 29

Candidate Number: ……

Section I

Total Marks (75)

Part A

Total Marks (15)

Attempt Questions 1 – 15

Allow about 30 minutes for this part

For each question place a cross (X) in the column which matches your choice.

Question	A	B	C	D
1				
2				
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Marking Summary

Space	1 – 5	……. / 5		
	16 – 20	…… / 19	*Space Total*	…… / 24
Motors	6 – 10	……. / 5		
	26 – 29	…… / 20	*Motors Total*	…… / 25
Ideas	11 – 15	……. / 5		
	21 – 25	…… / 21	*Ideas Total*	…… / 26
			Final Mark	…… / 75

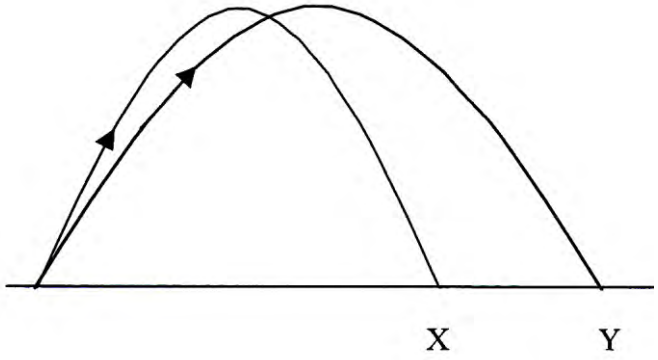
1. Which statement about the weight of an object is correct?

   A. If gravitational acceleration is zero, then weight is zero.
   B. The weight of a particular object is constant on a particular planet.
   C. The weight of an object will not change when it is taken to a different planet.
   D. Weight is independent of the acceleration due to gravity.

2. Which choice bets describes the relationship between the work done on an object and its gravitational potential energy?

   A. The work done on an object equals its gravitational potential energy.
   B. The work done on an object equals the change in its gravitational potential energy.
   C. The work done on an object equals the increase in its gravitational potential energy.
   D. The work done on an object equals the decrease in its gravitational potential energy.

3. The diagram below shows the paths of flight of two projectiles, X and Y.



   Which statement is the same for X and Y?

   A. horizontal velocity
   B. time of flight
   C. range
   D. initial velocity

4. The escape velocity of a particular planet is 4 500 ms^{-1}.

   Which of the following statements is correct?

   A. An object fired at 4 000 ms^{-1} would always return to the planet's surface.
   B. An object fired vertically at 4 000 ms^{-1} would be unable to go into orbit.
   C. An object with an initial vertical speed of 4 500 ms^{-1} would escape the planet.
   D. An object travelling at 5 000 ms^{-1} would not escape the planet.

5. The purpose of the Michelson-Morley experiment was to

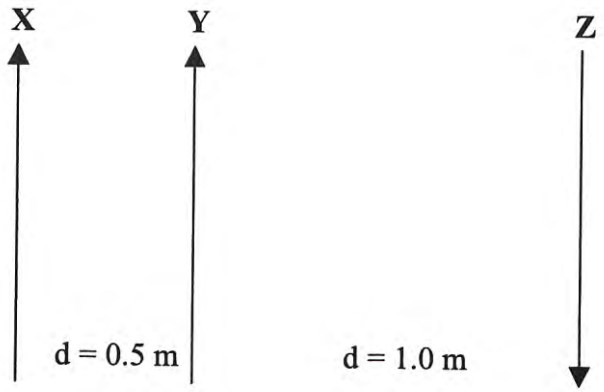
   A. discover the aether.
   B. measure the speed of light relative to the aether.
   C. measure the speed of light relative to the Earth.
   D. measure the speed of the Earth relative to the aether.

6. A 20 cm length of wire is suspended horizontally from a spring balance. The wire is hanging in a horizontal magnetic field that is perpendicular to the wire. A current flow of 25 A through the wire results in a reading of 0.12 N and when the current is reversed, the reading on the balance is 0.08 N.

What is the magnitude of the magnetic field?

A. 4×10^{-3} T
B. 8×10^{-3} T
C. 4×10^{-1} T
D. 8×10^{-1} T

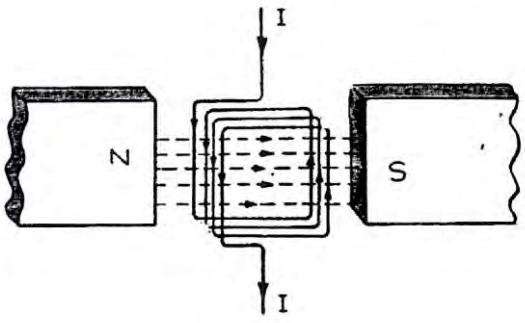
7. Three long parallel wires X, Y and Z are positioned in the same plane and conduct identical currents as shown. Wires X and Y are separated by 0.5 m and conduct current in the same direction. Wire Z is separated from the middle wire by 1.0 m and its current is in the opposite direction. The force between wires X and Y is F newtons.



What is the magnitude of the force (in N) on wire Y due to the three currents?

A. 5F/4 B. 3F/4 C. 3F/2 D. F/2

8. A coil is carrying a direct current is suspended in a magnetic field as shown.



How does the coil move when the current is first switched on?

A. The coil rotates continuously.
B. The coil moves to the vertical position and stops.
C. The coil oscillates about the vertical axis before coming to rest.
D. The coil will not rotate as there is no commutator.

9. A transmission line of 5 ohm is to be used to transmit at 1 000 W of power.

What is the ratio of the energy loss in the line for a current of 1 A compared to a current of 10 A?

A. 1 : 1 B. 1 : 10 C. 1 : 20 D. 1 : 100

10. Which alternative correctly identifies the features of the galvanometer and the loudspeaker?

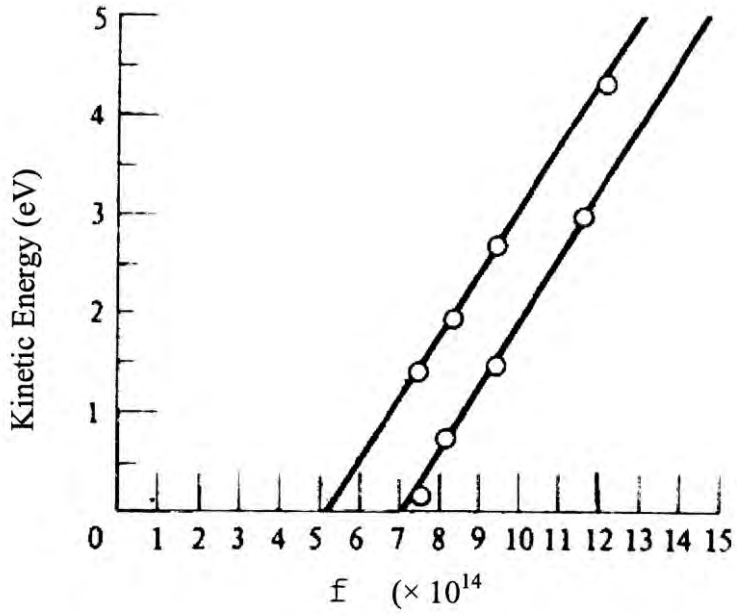
	Galvanometer	**Loudspeaker**
A.	Curved magnetic pole surfaces	Counterbalancing spring
B.	Counterbalancing spring	Plane of coil parallel to magnetic field
C.	Plane of coil perpendicular to magnetic field	Curved magnetic pole surfaces
D.	Alternating current	Direct current

11. The discovery of cathode rays resulted in new technology and many developments in experimental physics work.

Which of the following was NOT a consequence of the research stimulated by cathode rays?

A. The development of television.
B. The manipulation of streams of charged particles.
C. The use of oscilloscopes.
D. Direct measurement of the charge on the electron.

12. The figure below relates the kinetic energy of ejected photoelectrons to the frequency of incident light on two different metals.



Which statement is the best explanation for the two lines being parallel?

A. The threshold frequency of the two metals used is the same.
B. The gradient of both lines is equal to Planck's constant.
C. The metals used are both doped semiconductors.
D. Both metals behave as black body radiators.

13. For which reason were thermionic devices replaced by solid state devices in electronic circuits?

A. Solid state electronic circuits are more reliable than circuits using thermionic devices.
B. Solid state audio equipment always produces superior sound.
C. Solid state devices operate at higher temperatures than thermionic ones.
D. The material used to manufacture thermionic devices was in short supply.

14. The force experienced by an electron in a uniform electric field is 1.54×10^{-15} N.

The magnitude of the electric field is

A. 2.47×10^{-34} Vm^{-1}
B. 1.04×10^{-4} Vm^{-1}
C. 9.61×10^{3} Vm^{-1}
D. 1.69×10^{15} Vm^{-1}

15. In semiconductors, electrons and holes both help to carry current. Holes are understood to

A. be positively charged particles
B. be neutral particles
C. move in the direction of the applied electric field lines
D. move in the same direction as the electrons

Section I continued

Part B

Total Marks (60)

Attempt Questions 16 – 29

Allow about 1 hour and 45 minutes for this part

Question 16 (4 marks)

A projectile is launched at 60 ms^{-1} at an elevation of 30^o.

(a) Calculate the vertical component of its velocity. **1**

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(b) Calculate the time of flight of the projectile. **1**

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(c) Calculate the maximum height of the projectile above its launch position. **1**

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(d) Calculate the range of the projectile **1**

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Question 17 (4 marks)

Three identical moons, X, Y and Z are in orbit around the same planet. The moons have identical orbital speeds and masses of M, 9M and 25M respectively.

(a) If the moons have the same orbital speeds, calculate the ratio of their orbital radii and justify your answer. **2**

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(b) Explain how the characteristics of a geostationary orbit relate to the main purposes of the satellites placed in them. **2**

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Question 18 (4 marks)

(a) Explain the role of gravitational attraction in the slingshot effect. **2**

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(b) How would our exploration of the solar system be different if the slingshot effect did not exist? **2**

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Question 19 (4 marks)

(a) Recall the principle of relativity. **1**

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(b) Explain how the principle of relativity was essential to Einstein's developing ideas on special relativity. **3**

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Question 20 (3 marks)

Using appropriate examples to support your answer, comment on the statement that "a theory is useless unless it has supporting evidence".

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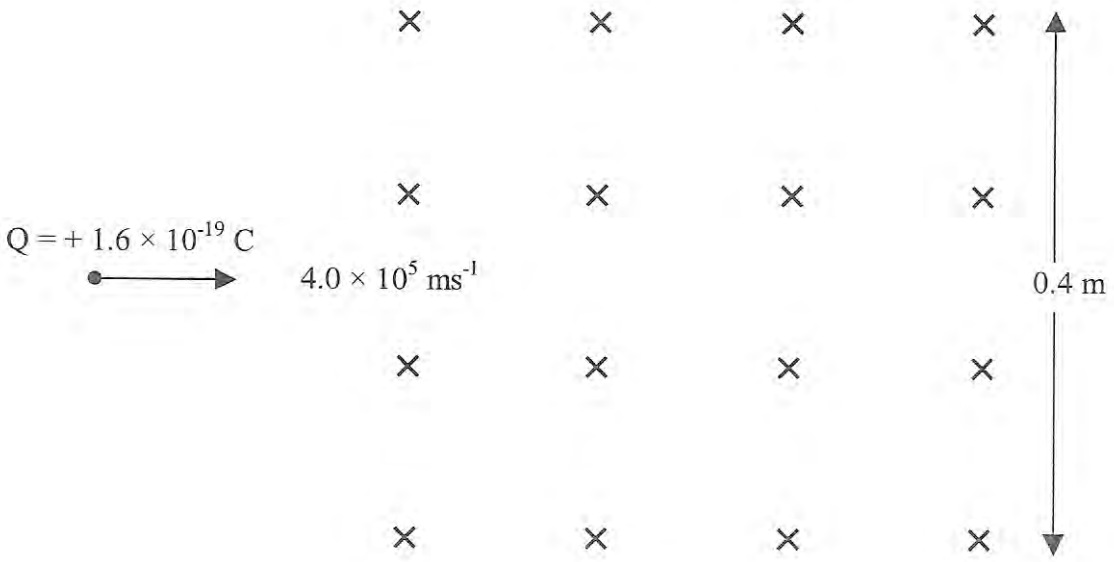
Question 21 (4 marks)

A proton of charge $+1.6 \times 10^{-19}$ C moves in the plane of the page with a speed of 4.0×10^{5} ms^{-1} into a uniform magnetic field of 6.0×10^{-2} T. The magnetic field is directed into the page. The magnetic field covers a square area with sides 0.4 m and the proton enters the field midway as shown.



(a) Predict the direction of the force on the proton as it enters the magnetic field. **1**

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(b) Calculate the magnitude of the force on the proton. **1**

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(c) On the diagram above, draw as accurately as possible the path of the proton while it is in the magnetic field. **2**

Question 22 (4 marks)

The threshold frequency for a metal is 3.7×10^{15} Hz.

(a) Determine whether light with a wavelength of 5.8×10^{-7} m will cause the emission of photoelectrons. Show your working. **1**

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(b) Calculate the maximum speed of the emitted photoelectrons if light with a frequency of 9.1×10^{15} Hz is incident on the metal. **3**

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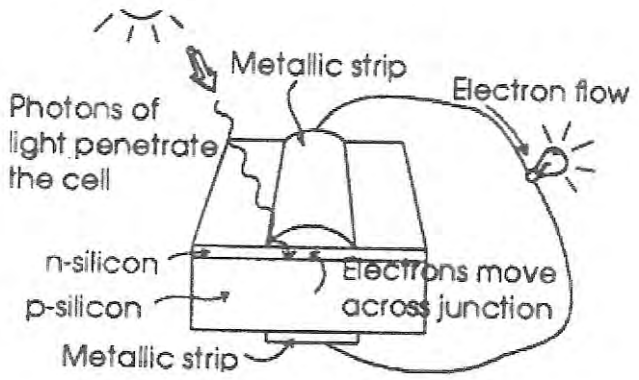
Question 23 (4 marks)

The diagram below shows the structure of a solar cell.



Explain the difference between the silicon layers and how this results in the electron flow shown. **4**

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Question 24 (5 marks)

(a) Draw a labelled diagram to compare the band structure for conductors, insulators and semiconductors.

3

(b) State the reasons for the early use of germanium for semiconductors and why silicon is currently preferred. **2**

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Question 25 (4 marks)

In the 19th century, soon after cathode rays were discovered, a debate arose as to whether they were made up of electromagnetic radiation or streams of particles.

(a) Identify TWO contradicting pieces of evidence regarding the nature of cathode rays. **2**

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(b) Identify ONE significant hazard encountered in using cathode ray tubes in the school laboratory and ONE precaution to minimise this hazard. **2**

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Question 26 (6 marks)

(a) Compare the main components of AC and DC generators. **3**

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(b) Assess the effect of the development of AC generators on society and the environment. **3**

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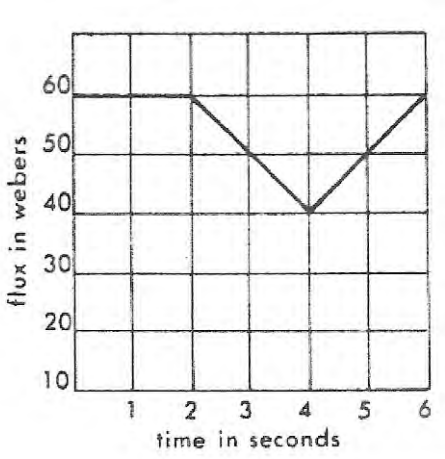
Question 27 (4 marks)

The graph below shows the change in flux experienced by a conductor in a closed circuit.



(a) State one way in which the flux experienced by a conductor can be changed. **1**

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(b) Compare the current induced in the conductor during the time intervals 0 – 2 seconds, 2 – 4 seconds and 4 – 6 seconds. Explain your reasoning. **3**

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Question 28 (5 marks)

(a) Discuss reasons for the need for transformers by certain electrical appliances used in households. **3**

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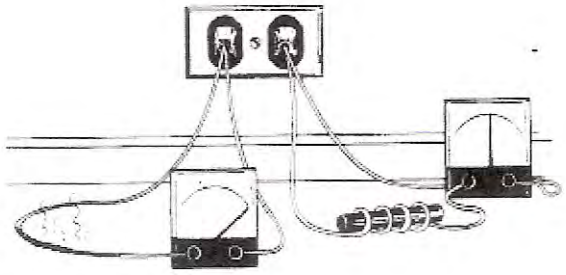
(b) In the figure below the wire on the left is plugged directly into a 240 volt alternating current source and has a very large current which may blow the fuse.



Explain why the same wire, if coiled around a soft iron core, will have a lower current and is less likely to blow the fuse. **2**

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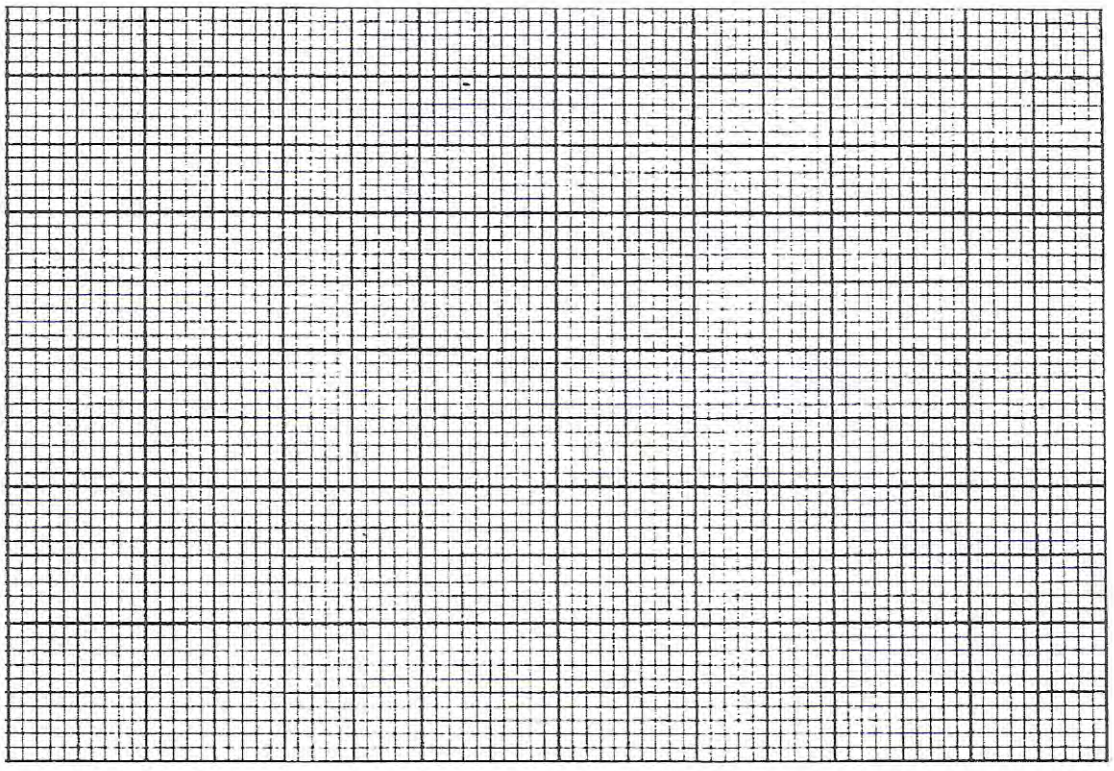
Question 29 (5 marks)

A student set out to measure the magnetic field at the centre of a single coil of wire. She passed different currents through the coil and measured the strength of the magnetic field at its centre.

The student recorded her results in a table, as shown below.

Current (A)	Magnetic field (T)
0	0
1	1.2×10^{-5}
2	error
3	4.9×10^{-5}
4	6.3×10^{-5}
5	7.2×10^{-5}



(a) Graph the student's results on the grid provided above. **3**

(b) What value should she have obtained when applying a current of 2 A? **1**

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Question 29 (continued)

(c) From a fellow student she obtained two formulae for calculating the magnetic field at the centre of a coil of wire:

$B = u_o I / 2r$ and $B = u_o I^2 / 2r$ where r is the radius of the coil

Use the graph to determine which is the correct formula and justify your answer. **1**

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Physics Solutions

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2009

General Instructions

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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.

Total Marks (75)

This paper has one section with two parts:

Section I

Total marks (75)

Part A

15 marks – attempt questions 1 - 15

Part B

60 marks – attempt questions 16 - 29

Section I

Total Marks (75)

Part A

Total Marks (15)

Attempt Questions 1 – 15

Allow about 30 minutes for this part

For each question 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	

Section I continued

Part B

Total Marks (60)

Attempt Questions 16 – 29

Allow about 1 hour and 45 minutes for this part

Question 16 (4 marks)

A projectile is launched at 60 ms^{-1} at an elevation of 30°.

(a) Calculate the vertical component of its velocity. **1**

$u_v = v\sin\varphi = 60 \times \sin 30 = 30\ ms^{-1}$

(b) Calculate the time of flight of the projectile. **1**

Time to reach maximum height = 30 / 9.8 = 3.06 s

Therefore total time of flight = 2 x 3.06 = 6.12 s

(c) Calculate the maximum height of the projectile above its launch position. **1**

Maximum height = $s = ut + \frac{1}{2} at^2 = 30 \times 3.06 - \frac{1}{2} \times 9.8 \times (3.06)^2 = 45.9\ m$

(d) Calculate the range of the projectile **1**

Range = horizontal velocity x time of flight = $u\cos\varphi \times 6.12 = 318\ m$

Question 17 (4 marks)

Three identical moons, X, Y and Z are in orbit around the same planet. The moons have identical orbital speeds and masses of M, 9M and 25M respectively.

(a) If the moons have the same orbital speeds, calculate the ratio of their orbital radii and justify your answer. **2**

Orbital radii will be identical for all three moons as neither orbital speed nor orbital radii depend on mass. The formula for orbital speed is $v = \sqrt{(GM_p / R)}$ where M_p is the mass of the planet being orbited

(b) Explain how the characteristics of a geostationary orbit relate to the main purposes of the satellites placed in them. **2**

Geostationary satellites orbit at an altitude that gives them the same rotational period as that of the Earth. This makes their use simpler as they always remain in the same position relative to the surface. The high altitude (37 000 km) also enables them to be accessed from a large area of the Earth's surface below them. Their main purpose as communications satellites is thus enhanced.

Question 18 (4 marks)

(a) Explain the role of gravitational attraction in the slingshot effect. **2**

The gravitational force accelerates the spacecraft towards the planet but it also slows the spacecraft as it moves away from the planet. Because of the faster speed of the spacecraft as it moves away from the planet deceleration is much less than the acceleration on approach and so gravitational attraction results in an increase in speed for the spacecraft.

(b) How would our exploration of the solar system be different if the slingshot effect did not exist? **2**

The slingshot effect is repeatedly used to increase the speed of space probes. The extraordinarily large distances in space mean that any increase in speed is welcome. The time taken to travel these vast distances is reduced by making use of the slingshot effect.

Question 19 (4 marks)

(a) Recall the principle of relativity. **1**

The physical laws should all be the same in all inertial frames of reference.

(b) Explain how the principle of relativity was essential to Einstein's developing ideas on special relativity. **3**

The consequence of the principle of relativity was that in order for the speed of light to remain constant regardless of the motion of the observer, measurements of previously held constants (mass, time and length) between frames of reference in constant relative motion, had to vary depending on that motion.

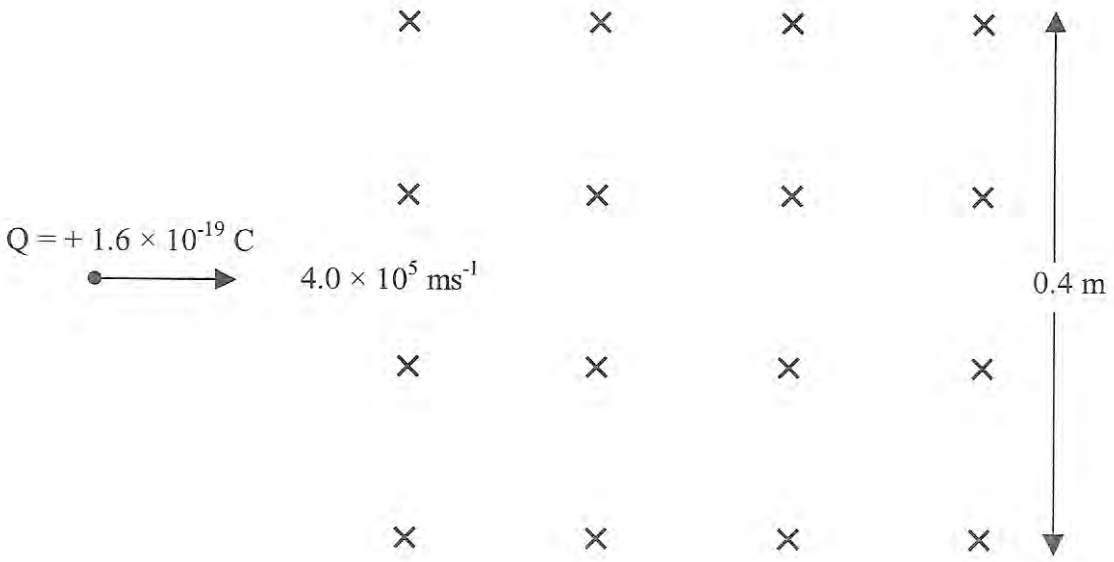
Question 20 (3 marks)

Using appropriate examples to support your answer, comment on the statement that "a theory is useless unless it has supporting evidence".

Einstein's theory of special relativity initially had no experimental evidence to support it. Einstein used "thought experiments" to establish his theories. While the mathematical theory was revolutionary, experimental evidence to validate it was essential. Such ideas have value in that they stimulate the minds of other scientists and often are the stimulus for the search for experimental evidence. In this way they contribute greatly to scientific discovery and therefore are far from useless.

Question 21 (4 marks)

A proton of charge +1.6 x 10^{-19} C moves in the plane of the page with a speed of 4.0 x 10^{5} ms^{-1} into a uniform magnetic field of 6.0 x 10^{-2} T. The magnetic field is directed into the page. The magnetic field covers a square area with sides 0.4 m and the proton enters the field midway as shown.



(a) Predict the direction of the force on the proton as it enters the magnetic field. **1**

Towards the top of the page

(b) Calculate the magnitude of the force on the proton. **1**

$F = Bqv = 6.0 \times 10^{-2} \times 1.6 \times 10^{-19} \times 4.0 \times 10^{5} = 3.8 \times 10^{-15}$ *N*

(c) On the diagram above, draw as accurately as possible the path of the proton while it is in the magnetic field. **2**

Semicircle (curving anticlockwise i.e. initially towards top of page)

Question 22 (4 marks)

The threshold frequency for a metal is 3.7×10^{15} Hz.

(a) Determine whether light with a wavelength of 5.8×10^{-7} m will cause the emission of photoelectrons. Show your working. **1**

$f = c / \lambda = 3.0 \times 10^{8} / 5.8 \times 10^{-7} = 0.5 \times 10^{15}$ Hz (less than threshold so no emission)

(b) Calculate the maximum speed of the emitted photoelectrons if light with a frequency of 9.1×10^{15} Hz is incident on the metal. **3**

Energy of incident photon $= hf = 6.63 \times 10^{-34} \times 9.1 \times 10^{15} = 6.2 \times 10^{-18}$ J

Work function of surface $= hf_o = 6.63 \times 10^{-34} \times 3.7 \times 10^{15} = 2.0 \times 10^{-18}$ J

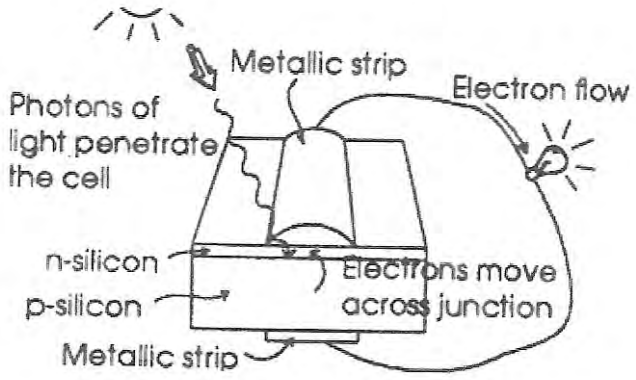
Kinetic energy of photoelectrons $= hf - hf_o = 4.2 \times 10^{-18}$ J

Therefore speed of photoelectrons

$v = \sqrt{(2 \times KE / m)} = \sqrt{(2 \times 4.2 \times 10^{-18} / 9.11 \times 10^{-31})} = 2.8 \times 10^{6}$ ms^{-1}

Question 23 (4 marks)

The diagram below shows the structure of a solar cell.



Explain the difference between the silicon layers and how this results in the electron flow shown. **4**

N-type silicon has group V atoms added (doped) as impurities so that it has unbonded electrons while p-type silicon has group III atoms added so that there are spaces (holes) where electrons are now absent. At the junction electrons diffuse from the n-type into the p-type leaving holes and setting up an electric field at the junction. The electric field causes separation of the pairs, moving the electron into the n-type layer and then to the external circuit as shown in the diagram.

Question 24 (5 marks)

(a) Draw a labelled diagram to compare the band structure for conductors, insulators and semiconductors. **3**

Diagrams need to show the overlap of the valence bands and conduction bands in a metallic crystal (i.e. no energy gap present); small energy gap between the bands in a semiconductor and significant energy gap for the insulator.

(b) State the reasons for the early use of germanium for semiconductors and why silicon is currently preferred. **2**

The technique to purify germanium to the high level required for transistors was developed during the World War II while silicon was first purified and used in transistors in 1957. Silicon retains its properties at higher temperatures and is therefore preferred and is also more abundant than germanium.

Question 25 (4 marks)

In the 19th century, soon after cathode rays were discovered, a debate arose as to whether they were made up of electromagnetic radiation or streams of particles.

(a) Identify TWO contradicting pieces of evidence regarding the nature of cathode rays. **2**

Cathode rays can create a shadow when a barrier (e.g. maltese cross) is placed in their path. This is consistent with wave behaviour.

Cathode rays can make a paddle wheel spin, thus imparting momentum to the wheel. This behaviour is indicative of particle behaviour.

(b) Identify ONE significant hazard encountered in using cathode ray tubes in the school laboratory and ONE precaution to minimise this hazard. **2**

Cathode rays are generated by a high voltage. The high voltage is generated by an induction coil. Induction coils produce X-rays as a result of the acceleration of charges across a spark gap. X-rays can be harmful to human tissue, so the experiment is done as a teacher demonstration with no students within 3 m of the apparatus.

Question 26 (6 marks)

(a) Compare the main components of AC and DC generators. **3**

Both types of generators have one or more coils of wire and a permanent magnet or electromagnet. Either the coil of the magnet field is rotated. In AC generators, each end of the coil is attached to a separate ring that moves against carbon brushes. In DC generators, each end of the coil is attached to one half of a split ring commutator moving against a brush.

(b) Assess the effect of the development of AC generators on society and the environment. **3**

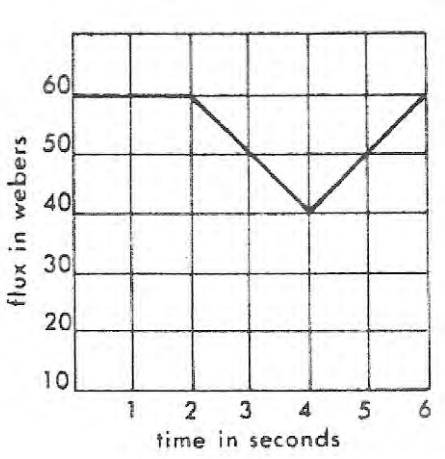
AC generators are able to supply electricity in a form which may transmitted over large distances so that people can live near their work and not necessarily near the power station. On the downside the invention of electrical lighting meant that factories could operate 24 hours a day and this lead to the concept of shift work.

Electrical machines have freed people from many tasks and improved living standards but have not increased leisure time as people work to earn the necessary money to purchase the wide range of devices available.

Electricity generation has also increased the environmental pollution problems such as acid rain, heat, oxides of nitrogen and sulphur, as well as using up coal reserves which will not then be available to supply other carbon compounds.

Question 27 (4 marks)

The graph below shows the change in flux experienced by a conductor in a closed circuit.



(a) State one way in which the flux experienced by a conductor can be changed. **1**

The flux can be changed by changing the strength or direction of the magnetic field or moving the conductor within the field.

(b) Compare the current induced in the conductor during the time intervals 0 – 2 seconds, 2 – 4 seconds and 4 – 6 seconds. Explain your reasoning. **3**

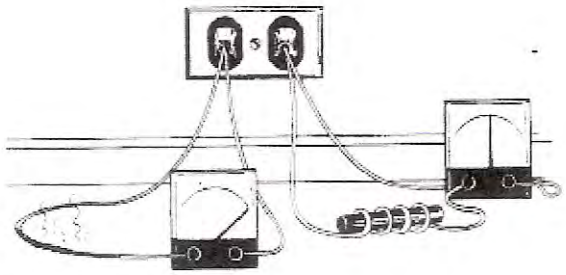
During the first two seconds, the flux does not change and hence zero current is induced. During the next two intervals, the flux changes at the same rate (as shown by the gradients) so the induced currents are equal in size but in opposite direction. During one interval the flux is increasing and during the other interval the flux is decreasing.

Question 28 (5 marks)

(a) Discuss reasons for the need for transformers by certain electrical appliances used in households. **3**

Many household appliances require low voltages between 3 and 12 volts to suit modern semiconductor circuits. So the supply of 240 volts must be reduced. Cathode ray tube TV sets require very high voltages (of the order of 25 000 V) so in this case the voltage must be increased. Thus there is a need for both step-down and step-up transformers within a household.

(b) In the figure below the wire on the left is plugged directly into a 240 volt alternating current source and has a very large current which may blow the fuse.



Explain why the same wire, if coiled around a soft iron core, will have a lower current and is less likely to blow the fuse. **2**

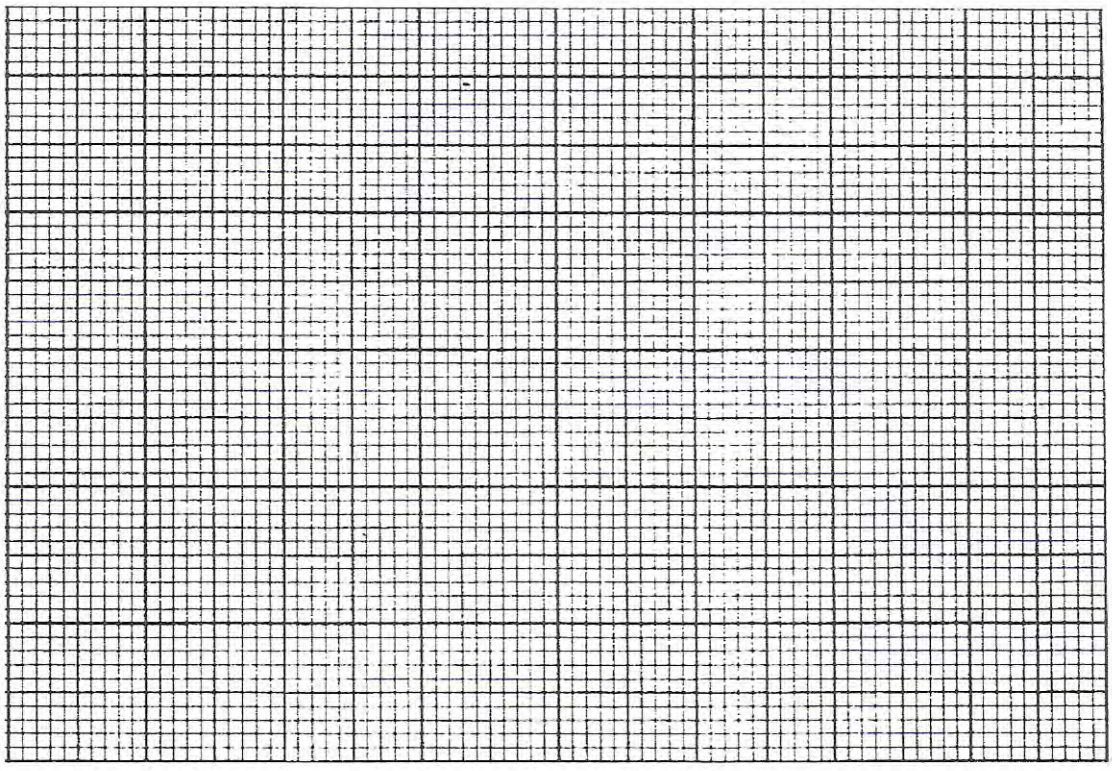
The coil induces an emf in the soft iron core. This in turn induces currents. These currents add to the back emf generated in the coil by its own changing magnetic field. The net effect is therefore a lower current in the coil and the circuit is less likely to blow the fuse.

Question 29 (5 marks)

A student set out to measure the magnetic field at the centre of a single coil of wire. She passed different currents through the coil and measured the strength of the magnetic field at its centre.

The student recorded her results in a table, as shown below.

Current (A)	Magnetic field (T)
0	0
1	1.2×10^{-5}
2	error
3	4.9×10^{-5}
4	6.3×10^{-5}
5	7.2×10^{-5}



(a) Graph the student's results on the grid provided above. **3**

Graph should show a line of best fit with positive gradient. (This reflects B α I.) Current is independent variable and should therefore be on the horizontal axis.

(b) What value should she have obtained when applying a current of 2 A? **1**

3×10^{-5} T (by inspection)

Question 29 (continued)

(c) From a fellow student she obtained two formulae for calculating the magnetic field at the centre of a coil of wire:

$B = u_o I / 2r$ and $B = u_o I^2 / 2r$ where r is the radius of the coil

Use the graph to determine which is the correct formula and justify your answer. **1**

Graph is linear [see part (a)] so the relationship suggests a direct proportionality. Thus the first formula is correct as the second formula is a quadratic i.e. has I^2 rather than I.