Student Number	
Mark / 100	

2013

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 10 and 11
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided

Total Marks – 100

Section I Pages 2 - 22

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 – 55 marks
•Attempt Questions 21 - 31
•Allow about 1 hour and 45 minutes for this part

Section II Page 23

25 marks

•Attempt Question 32
•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 10.

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

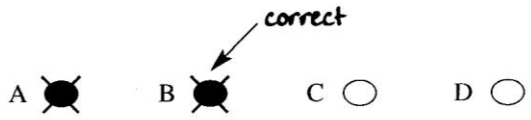
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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. A person stands on a scale in an elevator. He notices that the scale reading is lower than his normal 'weight'.

Which of the following could possibly describe the motion of the elevator?

(A) It is moving up and slowing down.

(B) It is moving up and speeding up.

(C) It is moving down at constant speed.

(D) It is moving down and slowing down.

2. A ball is projected horizontally with a speed of 40 ms^{-1} from the top of a cliff on the surface of the Earth.

What will be its approximate speed 3.0 s later if there were no air resistance?

(A) 30 ms^{-1}

(B) 40 ms^{-1}

(C) 50 ms^{-1}

(D) 60 ms^{-1}

3. A moon of a planet Rusean has an orbital period of 5 days and is at a distance of 5 units from the centre of the planet. Another moon is discovered at a distance of 20 units from the centre of Rusean.

Which of the following will be closest to the orbital period of the newly discovered moon?

(A) 40 days

(B) 20 days

(C) 13 days

(D) 5 days

4. The Space Shuttle orbits 300 km above the Earth's surface. If the Earth's radius is 6400 km, what is the gravitational acceleration experienced by the Space Shuttle while in this orbit?

(A) 4.9 ms^{-2}

(B) 8.9 ms^{-2}

(C) 9.8 ms^{-2}

(D) 10.8 ms^{-2}

5. The minimum initial velocity required by a space probe to just escape the gravitational pull of a planet is called escape velocity.

Which of the following quantities does NOT affect the magnitude of the escape velocity?

(A) mass of the planet

(B) mass of the space probe

(C) radius of the planet

(D) universal gravitational constant

6. The gravitational potential energy of two masses at a distance 2.0 m apart is - 8.0 J.

What external work must be done on this system to separate the masses to a distance of 4.0 m?

(A) - 4.0 J

(B) - 2.0 J

(C) + 2.0 J

(D) + 4.0 J

7. Astronauts on a long space journey are playing golf inside their spaceship, which is travelling away from the Earth with speed 0.6 c . One of the astronauts hits a drive exactly along the length of the spaceship (in its direction of travel) at speed 0.1 c in the frame of the spaceship.

What is the speed of the golf ball as observed from Earth?

(A) 0. 74 c

(B) 0.7 c

(C) 0.66 c

(D) 0.5 c

8. How does a moving coil galvanometer operate?

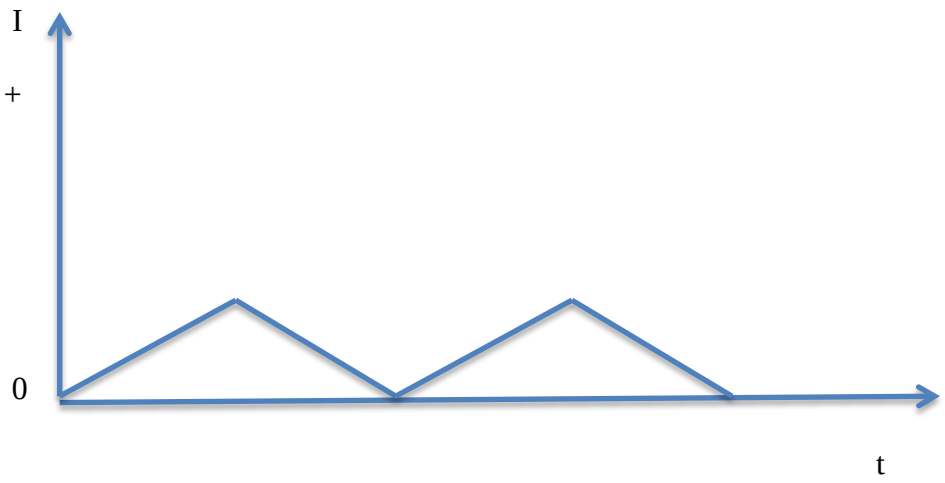
(A) by balancing the torque on a current-carrying coil with the torque on a coil spring

(B) by balancing the current induced in a coil with the applied current

(C) by producing a magnetic field that is balanced by a coil spring

(D) by inducing a current in the coil that is placed in a magnetic field

9. A current flows in a straight wire placed perpendicular to a uniform magnetic field. The current varies with time as shown on the diagram below.



Which statement best describes the magnetic force acting on the wire?

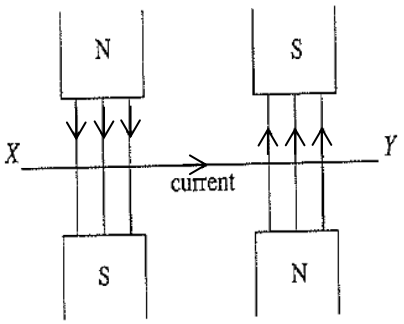
(A) It has a constant magnitude but changing direction.

(B) It has both a constant magnitude and direction.

(C) It has both a changing magnitude and direction.

(D) It has a changing magnitude but constant direction.

10. The figure below shows a straight wire carrying a steady current from X to Y. The wire is suspended between the poles of two similar permanent magnets, each of which produces a uniform magnetic field between the N and S poles.



What will the wire experience?

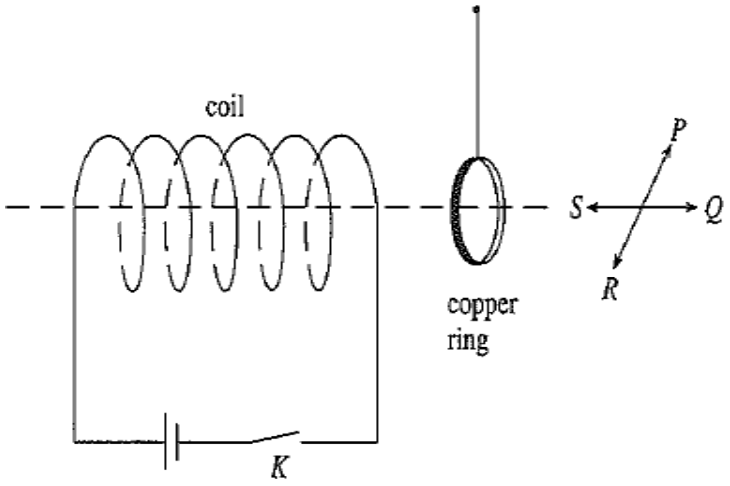
(A) a force in the direction XY

(B) a force in the upward direction

(C) a torque tending to rotate the wire about an axis parallel to the magnetic field

(D) no resultant force

11. A copper ring hangs vertically from a thread with its axis along the axis of a coil as shown in the diagram.



What is the initial direction of motion of the copper ring when the switch K is closed?

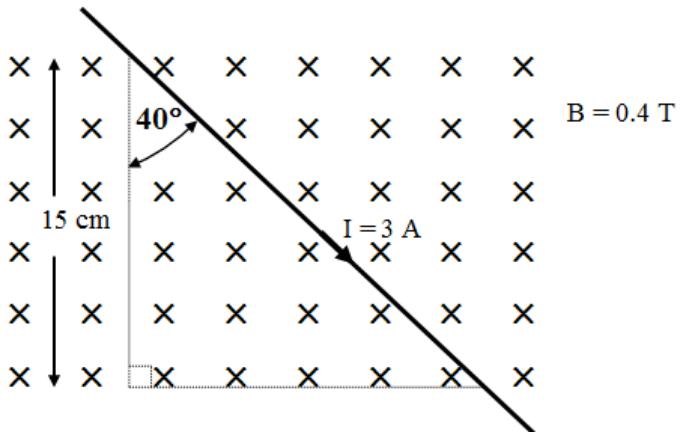
(A) P

(B) Q

(C) R

(D) S

12. A straight current-carrying conductor is placed within an external magnetic field as shown below.



What is the magnitude of the force on the conductor carrying a current of 3 A?

(A) 0.12 N

(B) 0.15 N

(C) 0.18 N

(D) 0.24 N

13. A simple DC motor has n turns of wire in the armature and has an area of A m^2. A current of I amperes passes through the armature. The plane of the armature is at 0^o to the direction of the magnetic field of strength B Teslas.

What is the torque on the armature if the area and the current are doubled and the armature is at an angle of 60^o to the magnetic field direction?

(A) twice the original torque

(B) four times the original torque

(C) equal to the original torque

(D) half the original torque

14. AC induction motors are commonly used in small power tools around the home.
Which of the following statements correctly describes the working of an AC induction motor?

(A) A changing magnetic flux from the stator induces a current in the rotor causing it to spin in the same direction as the changing field.

(B) A constant magnetic flux from the stator induces a current in the rotor causing it to spin in the same direction as the field.

(C) A changing magnetic flux from the stator induces a current in the rotor causing it to spin in the opposite direction to the changing field.

(D) A constant magnetic flux from the stator induces a current in the rotor causing it to spin in the opposite direction as the field.

15. At room temperature, what is the current in an intrinsic semiconductor due to?

(A) movement of holes

(B) movement of electrons

(C) movement of holes and electrons

(D) none of the above

16. Which of the following correctly describes a photon?

(A) It is a unit of energy,

(B) It is an electron emitted from a metal surface by the action of light.

(C) It is an electron emitted from a metal surface by the action of heat.

(D) It is a quantum of electromagnetic radiation.

17. William Bragg and his son Lawrence studied crystals and Lawrence determined the mathematical formula:

$$n\lambda = d \sin\theta$$

Which of the following did this formula allow them to determine?

(A) the number of electrons in an atom

(B) the mass of atoms

(C) the charge on an electron

(D) the internal arrangement of atoms in crystals

18. Which statement, according to the BCS theory of superconductivity, is correct?

(A) Superconductivity occurs because the crystal lattice causes electron pairs to break up.

(B) Distortions of the crystal lattice by electron movement cause superconductivity to cease.

(C) Distortions of the crystal lattice allow electrons to pair up and flow unimpeded.

(D) Superconductivity occurs because low temperatures cause the crystal lattice to stop vibrating and remain free from distortion.

19. The following is a list of some possible properties of high temperature superconductors. Some may be incorrect.

1. Relatively hard to produce
2. Only made from metals
3. Not very ductile
4. Can be brittle

Which of the above would be considered as correct limitations to modern high temperature superconductors?

(A) 2 and 3

(B) 1, 3 and 4

(C) 2, 3 and 4

(D) 1, 2, 3 and 4

20. Inside a discharge tube producing cathode rays, a freely rotatable wheel is mounted. When cathode rays fall on it the wheel starts rotating.

What does this experiment indicate about cathode rays?

(A) Cathode rays are charged particles.

(B) Cathode rays are energetic rays.

(C) Cathode rays are particles having momentum.

(D) Cathode rays are electromagnetic waves.

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. ……**

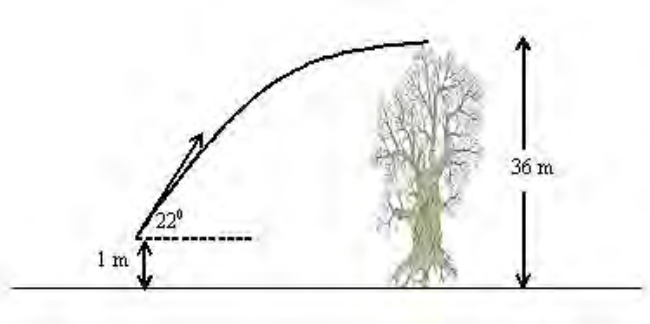
Attempt questions 21 - 31

Allow about 1 hour and 45 minutes for this part

▸ *Show all relevant working in questions involving calculations*

Question 21 (6 Marks) **Marks**

An archer shoots an arrow at a 22^o angle to the horizontal. At the top of its motion, the arrow just clears a 36 m high gum tree.



(a) Determine the speed of the arrow when it left the bow. **3**
Assume it was shot from 1 m above the ground.

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(b) How far away is the archer from the foot of the tree? **3**

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Question 22 (5 marks) **Marks**

The following information applies to the Space Shuttle during the first 120 seconds of its launch.

Mass of space shuttle at 0 s	2 051 113 kg
Thrust force from the rocket engines is constant by first-stage burn	3.0×10^7 N
Mass loss per second due to rocket discharge of fuel	1.3×10^4 kg
Frictional forces due to the atmosphere decrease with height	

(a) Describe qualitatively and quantitatively how the *g* forces acting on the astronauts vary during the first 120 seconds. **4**

Compare them to the *g* forces on the astronaut while the rocket is at rest.

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(b) Sketch two graphs, on the same axes, to show how the velocity and kinetic energy of the shuttle varies during the first 120 seconds. (No numerical values are required). **1**

Use different labelled lines to show velocity and kinetic energy.

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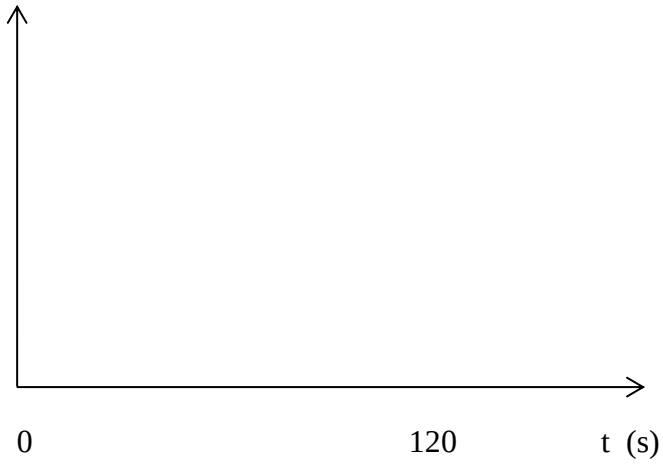
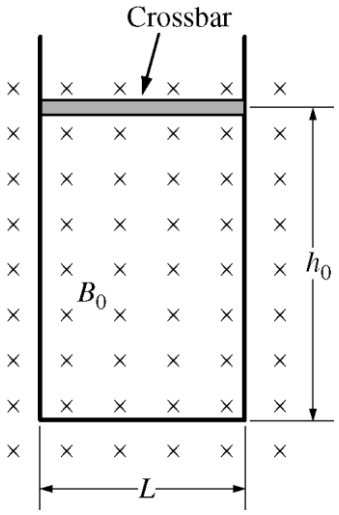


Question 23 (5 marks) **Marks**

Assess the use of thought experiments in the development of our current understanding of time.

Question 24 (7 marks) **Marks**



A closed loop is made of a U-shaped metal wire of negligible resistance and a movable metal crossbar of resistance R. The crossbar has mass m and length L. It is initially located a distance h_0 from the other end of the loop. The loop is placed vertically in a uniform horizontal magnetic field of magnitude B_0 in the direction shown in the figure above.

Express all algebraic answers to the questions below in terms of B_0, L, m, h_0, R, and fundamental constants, as appropriate.

(a) Determine the magnitude of the magnetic flux through the loop when the crossbar is in the position shown. **1**

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The crossbar is released from rest and slides with negligible friction down the U-shaped wire without losing electrical contact.

(b) On the figure below, indicate the direction of the current in the crossbar as it falls. Justify your answer. **3**

crossbar 

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Question 24 continues on the next page

(c) If the resistance, *R*, of the crossbar now is increased, will the initial speed of the crossbar increase, decrease, or remain the same as before? **1**

Circle the correct answer below.

Increases Decreases Remains the same

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(d) Justify your answer in (c) in terms of the forces on the crossbar. **2**

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Question 25 (4 marks) **Marks**

A student conducts two investigations with a bar magnet. First, a bar magnet is suspended horizontally by a piece of thread and allowed to oscillate about a vertical axis through its centre,

(i) above a piece of glass plate, and then

(ii) above a piece of copper plate.

Describe and explain what the student will observe in each investigation.

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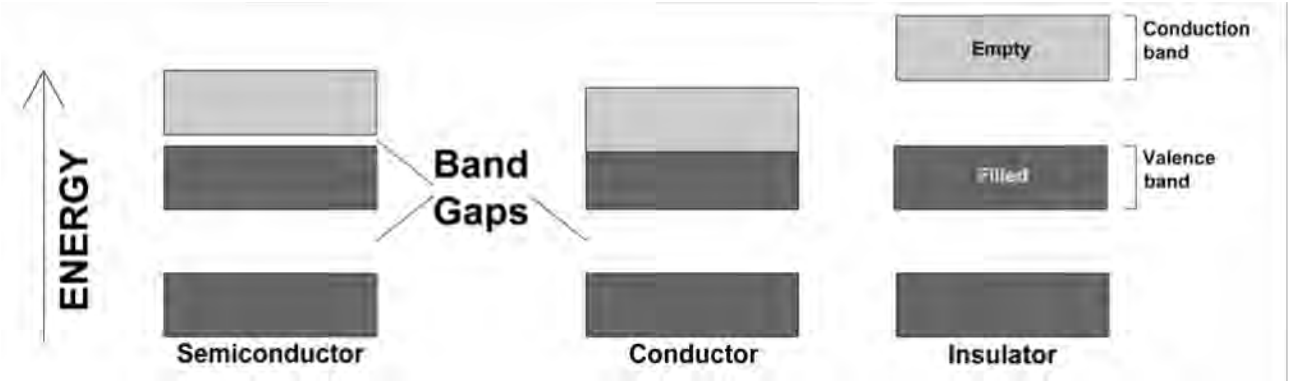
Question 26 (2 marks) **Marks**

Models are often used in Science to explain phenomena. The model below is found in a textbook and is used to explain conduction in semi-conductors, conductors and insulators.



The model correctly explains semi-conductors and insulator behaviour.

In conductors, with reference to the diagram, what aspect of metal conductivity behaviour does the model not explain?

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Question 27 (4 marks) **Marks**

(a) An ideal transformer has a primary coil with 36 loops, a current of 0.900 A and a voltage of 7.0 V. **1**

What is the voltage of the secondary coil if it's current is 0.675 A?

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(b) With the same primary coil described in (a), how many loops will need to be in the secondary coil to have a current of 2.7 A? **1**

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(c) Why are transformers dependent on AC current? **2**

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Question 28 (5 Marks) **Marks**

Assess the impact on society and the environment of the potential applications of superconductors in motors and generators, and in power transmission.

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Question 29 **(**4 marks) **Marks**

(a) With the aid of a labelled diagram, explain briefly how electrons are produced in a Cathode Ray Oscilloscope. **2**

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(b) Outline how these electrons are given a high velocity. **1**

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(c) Outline how the beam of electrons can be made to move vertically. **1**

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Question 30 (8 Marks) **Marks**

In a photoelectric emission experiment, a metal surface in an evacuated tube is illuminated with monochromatic light and a current is detected. If the experiment is repeated with light of the same wavelength but of twice the intensity, explain how it would affect the following:

(a) the energy of the photon,

(b) the maximum kinetic energy of the photoelectrons,

(c) the work function of the metal,

(d) the photoelectric current.

(a) **2**

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(b) **2**

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(c)..... **2**

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(d) **2**

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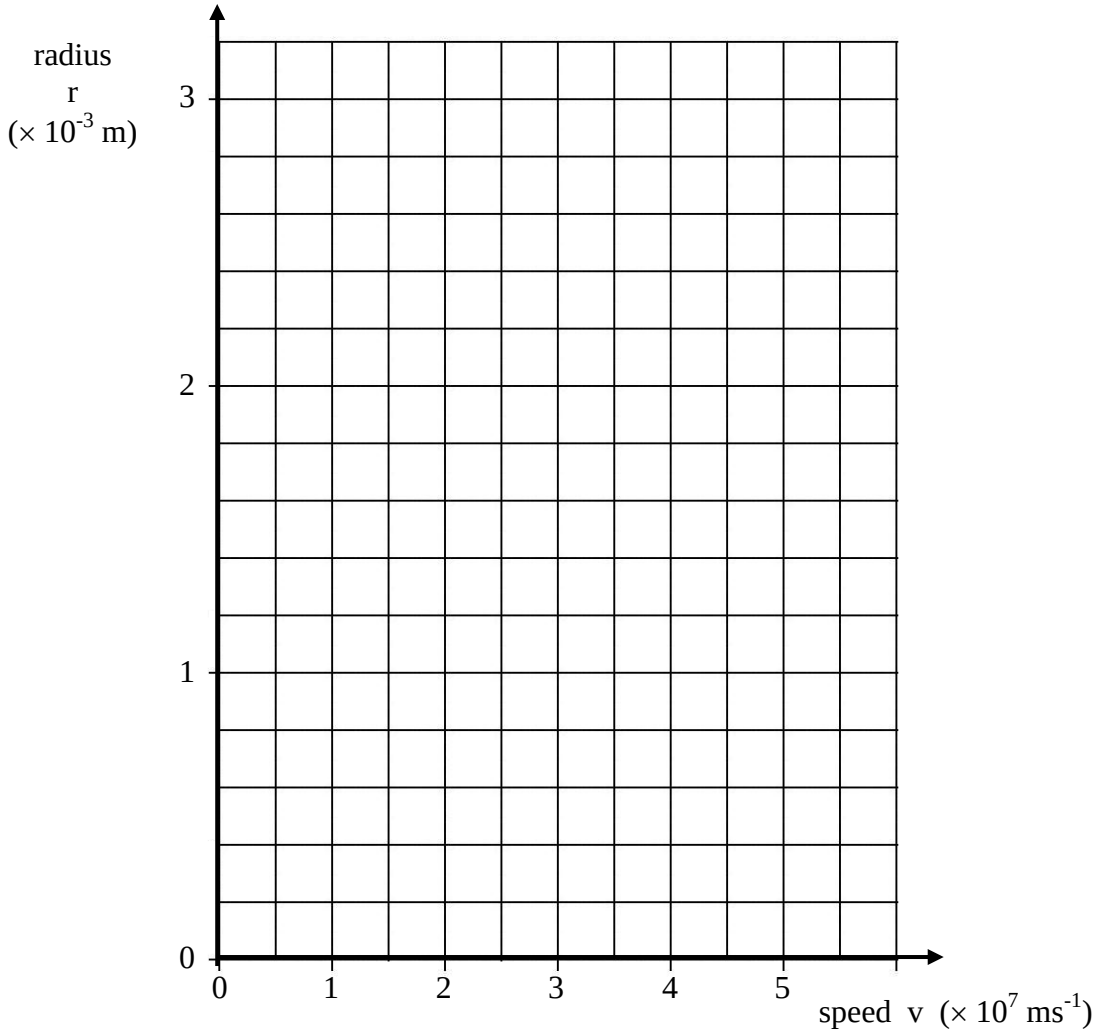
Question 31 (5 marks) **Marks**

A student performed an experiment to determine the strength of a constant, uniform magnetic field by measuring the radius of the path of a beam of electrons moving at various speeds in a this magnetic field.

The student's data is presented below.

$v\ (\times 10^{7}\ ms^{-1})$	$r\ (\times 10^{-3}\ m)$
1.0	0.6
2.0	1.1
3.0	1.7
4.0	2.3
5.0	2.8

(a) Plot the data from the table and draw a graph. **1**



Question 31 continues on the next page

(b) Use the gradient of the graph to determine the magnitude of the magnetic field as electrons move in their circular paths. Show all working. **4**

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Section II

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

Allow about 45 minutes for this section

(a) When hot hydrogen vapour is viewed through a spectrometer, four distinct bright lines of the Balmer series can be seen. The wavelengths of these lines are given in the table below.

Balmer series
6.562×10^{-7} m
4.861×10^{-7} m
4.340×10^{-7} m
4.102×10^{-7} m

(i) By referring to the Bohr model of the atom, describe how these lines are formed. **2**

(ii) Apply the Rydberg equation to show how any ONE of the lines can be predicted. **2**

(b) (i) The nuclide $^{210}_{81}X$ decays to the nuclide $^{A}_{82}Y$ in 4 successive radioactive decays. Each decay involves the emission of either an alpha or a beta particle. **1**

What is the value of A ?

(ii) The actual mass of the $^{120}_{52}X$ atom is 119.9045 u. Calculate its mass defect, given the following data: **1**

Proton mass	1.0073 u
Neutron mass	1.0087 u
Electron mass	0.00055 u

(iii) What is the energy equivalent of this mass defect? **1**

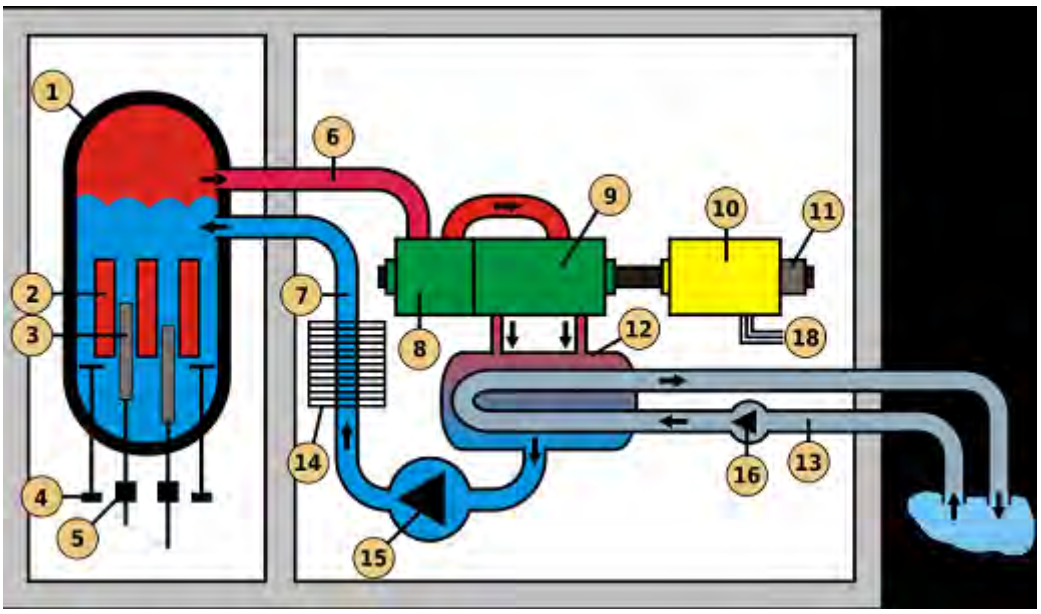
(c) (i) Using a labelled diagram outline ONE way in which physicists obtain particles with the appropriate energy to investigate the structure of matter. **5**

(ii) Give ONE other application of the technology outlined above. **1**

(d) Describe how de Broglie's proposal was confirmed by Davisson and Germer. **4**

(e) The diagram shows a fission nuclear reactor.

(i) Identify the parts labelled (2) and (3) in the diagram. **2**



(ii) State the function of the parts labelled (1) and (3) in the diagram. **2**

(f) Until the second half of the twentieth century, the proton, neutron and electron were thought to be fundamental particles of matter. **4**

Justify how the introduction of quarks and leptons, and strong and weak forces in the standard model, has changed our understanding of particle physics.

End of examination

Student Number	
Mark / 100	

2013

TRIAL HSC EXAMINATION

Physics
(Marking Criteria)

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 10 and 11
- 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 – 55 marks
•Attempt Questions 21 - 32
•Allow about 1 hour and 45 minutes for this part

Section II Page 21

25 marks

•Attempt Question 32
•Allow about 45 minutes for this section

Multiple Choice Answers

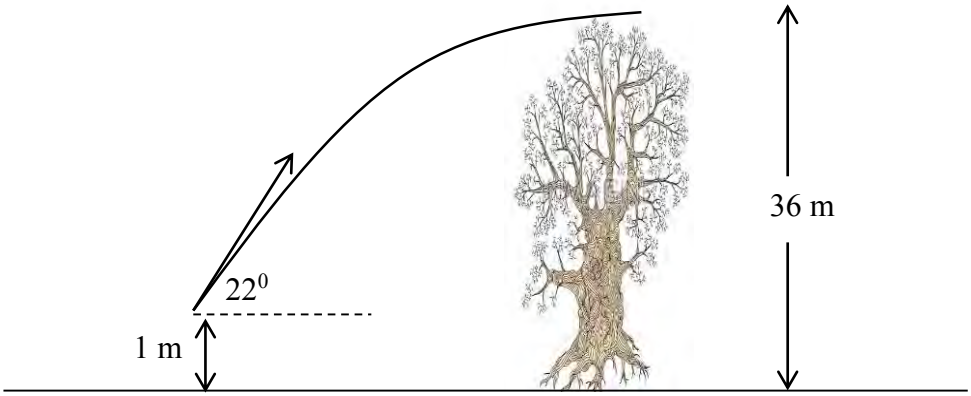
1	2	3	4	5	6	7	8	9	10
A	C	A	B	B	D	C	A	D	C

11	12	13	14	15	16	17	18	19	20
B	D	A	A	C	D	D	C	B	C

Part B Answers

Question 21 (6 Marks)

An archer shoots an arrow at a 22° angle to the horizontal. At the top of its motion, the arrow just clears a 36 m high gum tree.



(a) How fast was the arrow going when it left the bow?
(Assume it was shot from 1 m above the ground.)

Marking Criteria	Marks
• Correct substitution into formula to correctly calculate u_y and correct units	**3**
• Correct formula, and partly correct substitution but wrong calculation	**2**
• Correct calculation of u_y	**1**

$v_y^2 = u_y^2 + 2a_y s_y$

But $v_y = 0$ at the maximum height

Hence $0 = (u \sin 22)^2 + 2(-9.8)(35)$

From which, $u = +\sqrt{2 \times 9.8 \times 35} / \sin 22^0 = 69.9\ ms^{-1}$ (speed of arrow)

(b) How far away is the archer from the foot of the tree?

Marking Criteria	Marks
• Correct substitution into formula to correctly calculate u_x and correct time and then range	**3**
• Correct substitution into formula to correctly calculate u_x and incorrect time and then range	**2**
• Correct substitution into formula to correctly calculate range	**1**

Time to reach maximum height:

$t = (v_y - u_y)/a_y$

$= \frac{0-69.9\times\sin 22}{-9.8}$

$= 2.67\ s$

Distance archer is from foot of tree:

$s_x = u_x t$

$= 69.9 \times \cos 22 \times 2.67$

$= 173.5\ m$

Question 22 (5 marks)

The following information applies to the Space Shuttle during the first 120 seconds of its launch.

Mass of space shuttle at 0 s	2,051,113 kg
Thrust force from the rocket engines is constant by first-stage burn	3.0×10^7 N
Mass loss per second due to rocket discharge of fuel	1.3×10^4 kg
Frictional forces due to the atmosphere decrease with height	

(a) Describe qualitatively and quantitatively how the g forces acting on the astronauts vary during the first 120 seconds. Compare them to the g forces while the rocket is at rest.

When $t = 0$, the acceleration is zero, and hence the g-force is 0, from $g - force = 1 + \frac{a}{g}$

However, as the rocket takes off, fuel is being consumed, and the overall mass of the rocket decreases, and hence by Newton's 2nd law, its acceleration increases sharply,
from $a = (T - m_{left}g)/m_{left}$

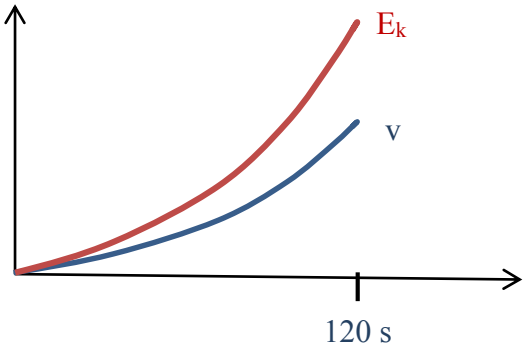
At $t = 120\ s$, the mass remaining is $2\,051\,113 - 3.0 \times 10^4 \times 120 = 491\,113\ kg$

Hence the acceleration when $t = 120\ s$ is $a = 3.0 \times \frac{10^7}{491113} - 9.8 = 51.3\ ms^{-2}$

Thus the $g - force = 1 + \frac{51.3}{9.8} = 6.23$

Marking Criteria	Marks
• Description of g forces on astronaut increasing from 1g with time up to 120 s • Stating g force = 1 when t = 0, • Calculation of thrust by end of first stage burn • Correct calculation of g force by the end of the 120 s after launch	**4**
• Any 3 of the above	**3**
• Any 2 of the above	**2**
• Any 1 of the above	**1**

(b) Sketch two graphs, on the same set of axes, to show how the velocity and kinetic energy of the shuttle vary during the first 120 seconds. (No numerical values are required). Use different labelled lines to show velocity and kinetic energy.



E_k line curved before v line

Question 23 (5 marks)

Assess the use of thought experiments in the development of our current understanding of time.

Marking Criteria	Marks
• Gives a detailed analysis of the concept of time at relativistic speeds, including a description of a thought experiment (1 mark), constancy of the speed of light (1 mark), frames of reference (1 mark), time dilation (1 mark) and makes and justifies (assessment) its use on the basis of experimental evidence (1 mark)	**5**
• Any four of the above, with a brief description of a thought experiment	**4**
• Any three of the above, with a brief description of a thought experiment	**3**
• Any two of the above with a brief description of a thought experiment	**2**
• A superficial assessment of thought experiments	**1**

At low speeds ($v \ll c$), time is absolute and invariant in all frames of reference, and as such the use of thought experiments are unnecessary. Judgements based on observation reveals the exactness of time that event/s occur.

However, at relativistic speeds ($v \sim 0.1\ c$), the use of thought experiments are profoundly useful as the ability/technology to attain such large speeds is not easily achievable. Thought experiments in Physics helps to overcome such problems.

One typical thought experiment that shows that time and space are not invariant , when the speed of light is taken as the absolute constant , in a particular inertial frame of reference is the following:

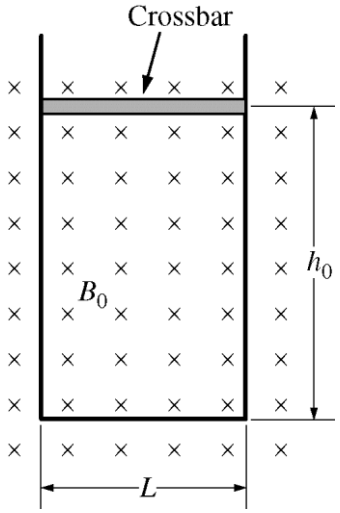
A traveller in a high speed train observes a light beam travelling vertically from the ceiling to a mirror on the floor. An observer at rest outside the train also makes an observation of the same event. Clearly the time taken for the light beam to travel to the mirror, bounce off and and return to the ceiling is different as measured from the two different frame of reference.

This perception that time measured from different frames of references is different is known as time dilation. This thought experiment is useful to establish that moving clocks run slower, and this result would not have been achieved had this thought experiment not been used.

Current evidence to support this perception of times measured by different observers in different frames being different are (i) synchronised atomic clocks on high speed rockets (ii) detection of muons, produced in cosmic rays, on earth

Hence thought experiments are extremely useful in understanding the notion of time.

Question 24 (7 marks)



A closed loop is made of a U-shaped metal wire of negligible resistance and a movable metal crossbar of resistance R. The crossbar has mass m and length L. It is initially located a distance h_0 from the other end of the loop. The loop is placed vertically in a uniform horizontal magnetic field of magnitude B_0 in the direction shown in the figure above.

Express all algebraic answers to the questions below in terms of B_o, L, m, h_o, R, and fundamental constants, as appropriate.

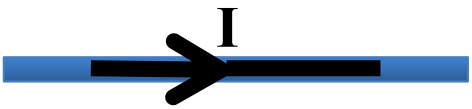
(a) Determine the magnitude of the magnetic flux through the loop when the crossbar is in the position shown. **1**

$$\Phi = BA = B_o h_o L$$

Marking Criteria	Marks
• Correct substitution into $\Phi = BA$	**1**

The crossbar is released from rest and slides with negligible friction down the U-shaped wire without losing electrical contact.

(b) On the figure below, indicate the direction of the current in the crossbar as it falls. Justify your answer.

crossbar 

As the crossbar falls the magnetic flux enclosed by the loop is decreasing (as the area is decreasing). This change(decrease) in magnetic flux induces an emf in the loop (Faraday's Law), which causes a current to flow in a direction so that its magnetic field opposes this change in flux (into the page) (Lenz's law). This means that the induced current must flow from left to right (clockwise).

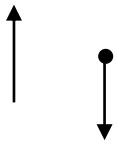
Marking Criteria	Marks
• Correct direction of current • Change in mag flux induces emf +current (Faraday's law) • Direction of current will oppose change (Lenz's law)	**3**
• Any 2 of the above	**2**
• Any 1 of the above	**1**

(c) If the resistance *R* of the crossbar is increased, does the terminal speed increase, decrease, or remain the same? Circle the correct answer.

Increases Decreases Remains the same

(d) Give a physical justification for your answer to (c) in terms of the forces on the crossbar.

Marking Criteria	Marks
• Correctly predicts $F_B \downarrow$ and $\therefore F_{net} \uparrow$causing u $\uparrow$	**2**
• Correctly predicts F_B decreases	**1**



There are two forces, the gravitational force and the magnetic force. The F_{grav} does not change but the F_{mag} changes in response to R, with more resistance but with still the same amount of emf induced, the current decreases and with that a weaker force , which leads to an increased acceleration and initial speed.

Question 25 (4 marks)

A student conducts two investigation with a bar magnet. First, a piece of bar magnet is suspended horizontally by a piece of thread and allowed to oscillate about a vertical axis through its centre,
(i) above a piece of glass plate, and then
(ii) above a piece of copper plate.

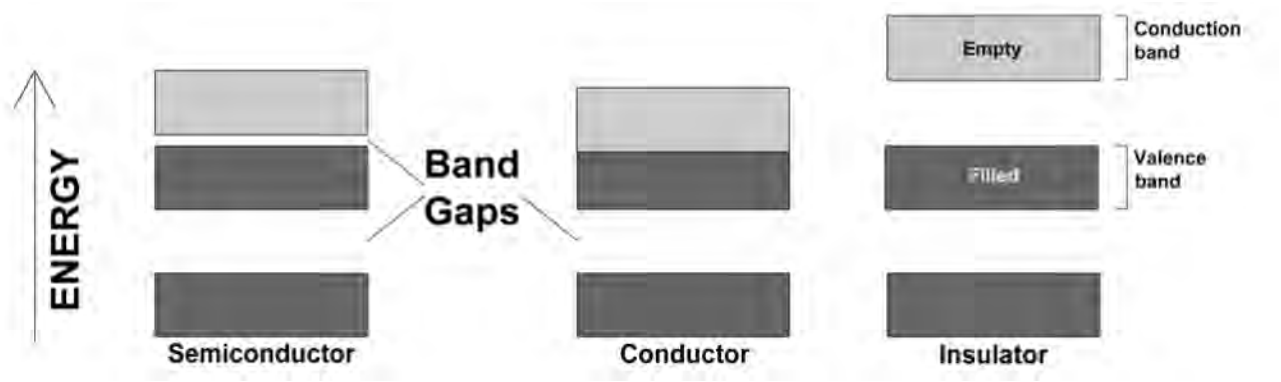
Describe and explain what the student will observe in each investigation.

Marking Criteria	Marks
• Description of observation above glass plate • Description of observation above copper plate • Explanation of observation above glass plate • Explanation of observation above copper plate (change in flux, eddy currents, Lenz's/Faraday's law	**4**
• Any 3 of the above	**3**
• Any 2 of the above	**2**
• Any 1 of the above	**1**

(i) Suspended above the glass plate, the oscillation is lightly damped due to its resistance of the air. No eddy currents because glass is an insulator.
(ii) Suspended above the copper plate, the oscillation is highly damped (electromagnetic braking). When the magnet oscillates above the copper plate, there is a change in magnetic flux and by Faraday's law, an emf is induced in the copper plate. By Lenz's law the flow of the induced eddy currents is such that the induced force field opposes the change in flux, and hence slows down the oscillation of the bar magnet.

Question 26 (2 marks)

Models are often used in Science to explain phenomena. The model below is often found in textbooks and is used to explain conduction in semi-conductors, conductors and insulators.



The model correctly explains semi-conductors and insulator behaviour.
With reference to the diagram, in conductors, explain what aspect of metal conductivity behaviour does the model not explain?

Marking Criteria	Marks
• Model does not explain why as temperature of conductor increases the conductivity of conductors does not increase.	**2**
• Partly correct explanation of the model for conductors	**1**

As temperature decreases electrons, lose energy. In this model electrons would drop from the conduction into the valence band. This would decrease conduction. This is not what happens in practice. In practice conduction increases as temp decreases. This is because at lower temperatures there is less electron scattering from the lattices.

Question 27 (4 marks)

(a) A transformer has a primary coil with 36 loops, a current of 0.900 A and a voltage of 7.0 V. What is the voltage of the secondary coil it its current is 0.675 A?

Marking Criteria	Marks
• Correct substitution into formula	**1**

Using Ns/Np = Ip/Is,
0.900/0.675 = 36/Np
Np = 48 loops

Using Np/Ns = Vp/Vs
Vs/7 = 48/36
Vs = 9.33 V

(b) With the same primary coil described in (a), how many loops will have to be in the secondary coil to have a current of 2.7 A?

Using Ns/Np = Ip/Is,
0.900/0.675 = 36/Np
Np = 48 loops

Using Is/Ip = Np / Ns
2.7/0.900 = 36 / Ns
Ns = 12 loops

(c) Why are transformers dependent on AC current?

Transformers require ac current because the alternation of the current's direction in the primary coil gives rise to an induced current in the secondary coil. A change in flux is needed for electromagnetic induction. DC would not induce a current in the secondary loop because the flux through the secondary coil would remain constant.

Question 28 (5 Marks)

Assess the impact on society and the environment of the potential applications of superconductors in motors and generators, and in power transmission.

Marking Criteria	Marks
• Thorough discussion of impact of superconductors on society and environment on motors and generators and on transmission of power together with a statement of judgement	**5**
• Brief discussion of impact of superconductors on society and environment on motors and generators and on transmission of power together with a statement of judgement	**4**
• Undeveloped discussion of impact of superconductors on motors and generators and on transmission of power together with a statement of judgement	**3**
• Brief discussion of impact of superconductors on motors and generators and on transmission of power together with a statement of judgement	**2**
• Limited discussion without judgement	**1**

Judgement: Superconductors could have a significant impact on the design of motors and generators and on the transmission of electricity if the limitations are overcome.

Electricity generation: Electricity is currently sent along Co or Al wires that may lose much of the energy due to heating of the wires, and also requires the use of expensive transformer infrastructure to help minimise these losses. Superconductors mean that el can be generated and then transmitted over vast distances without loss. The transmission wires can be made from SC rather than ordinary metals. This will improve efficiency and reduce costs to consumers. For the environment it will mean that resources are used more efficiently, conserving valuable non-renewable resources such as coal or oil. This also means that in the case of coal-fired power stations, there is less coal burnt (less CO_2 emission and less global warming impacts) as far more of each tonne of coal used actually results in el. reaching the consumer rather than being lost along the transmission wires. Relatively thin wires can carry large currents.

Limitations: The technology to use SC cables in a large scale is currently not available. The energy required to achieve the low temps of SC may be very high and could offset energy savings in other areas. So while more research is needed, SC have the potential to save energy, lower consumer costs, and help the environmental through less pollution and conservation of resources. There is a max current that sc can carry (critical current density), the substance reverts to being a normal conductor regardless of temp.

Motors and generators: Both would be lighter and smaller (no soft iron cores would be needed, and the coil would be much smaller). Less energy input would be needed to sustain their operation, thus saving environmental effects from using fossil fuels.

Question 29 (4 marks) **Marks**

(a) With the aid of a labelled diagram, explain briefly how the electrons are produced in a Cathode Ray Oscilloscope.

Marking Criteria	Marks
• Correctly labelled diagram showing source of electrons being thermionically emitted	**2**
• Either a diagram or a heated filament	**1**

In a cathode tube the heater heats up the cathode and the electron is emitted from the hot metal surface by thermionic emission.

(b) Explain how these electrons are given a high velocity.

Marking Criteria	Marks
• Inclusion of an high voltage source or electric field exerting a force	**1**

The anode is set to a positive potential with respect to the cathode. This sets up an electric field and the resultant force on the electrons causes the electrons to accelerate giving them a high velocity.

(c) Outline how the beam of electrons can be made to move vertically.

Marking Criteria	Marks
• Electric fields set up perpendicular to cathode beam	**1**

Electric fields are set up between the Y deflecting plates that will cause the electrons to be deflected vertically.

Question 30 (8 Marks)

In a photoelectric emission experiment, a metal surface in an evacuated tube is illuminated with monochromatic light and a current is detected. If the experiment is repeated with light of the same wavelength but of twice the intensity, explain how it would affect the following:

(a) the energy of the photon,
(b) the maximum kinetic energy of the photoelectrons,
(c) the work function of the metal,
(d) the photoelectric current.

(a)

Marking Criteria	Marks
• description of energy increase and correct reason	**2**
• description of energy increase without correct reason	**1**

The energy of the photon = hv, v = frequency and is independent of the intensity. Hence the energy of the photon remains unchanged.

(b)

Marking Criteria	Marks
• description of max KE remaining unchanged correct reason	**2**
• description of max KE energy unchanged with incorrect reason	**1**

Emax = hv – W, W = work function of the metal and is independent of the intensity. Hence max KE remains unchanged.

(c)

Marking Criteria	Marks
• description of work function remaining unchanged with correct reason	**2**
• description of work function unchanged with incorrect reason	**1**

Work function of metal is characteristic of the metal and does not depend on intensity of incident light. Hence it remains unchanged.

(d)

Marking Criteria	Marks
• description of photocurrent doubling with correct reason	**2**
• description of photocurrent doubling with incorrect reason	**1**

The photoelectric current is doubled. When the intensity of the incident light is doubled, the number of light photons per second incident on the metal surface i8s doubled. Hence the rate of emission of photoelectrons is doubled and so is the current.

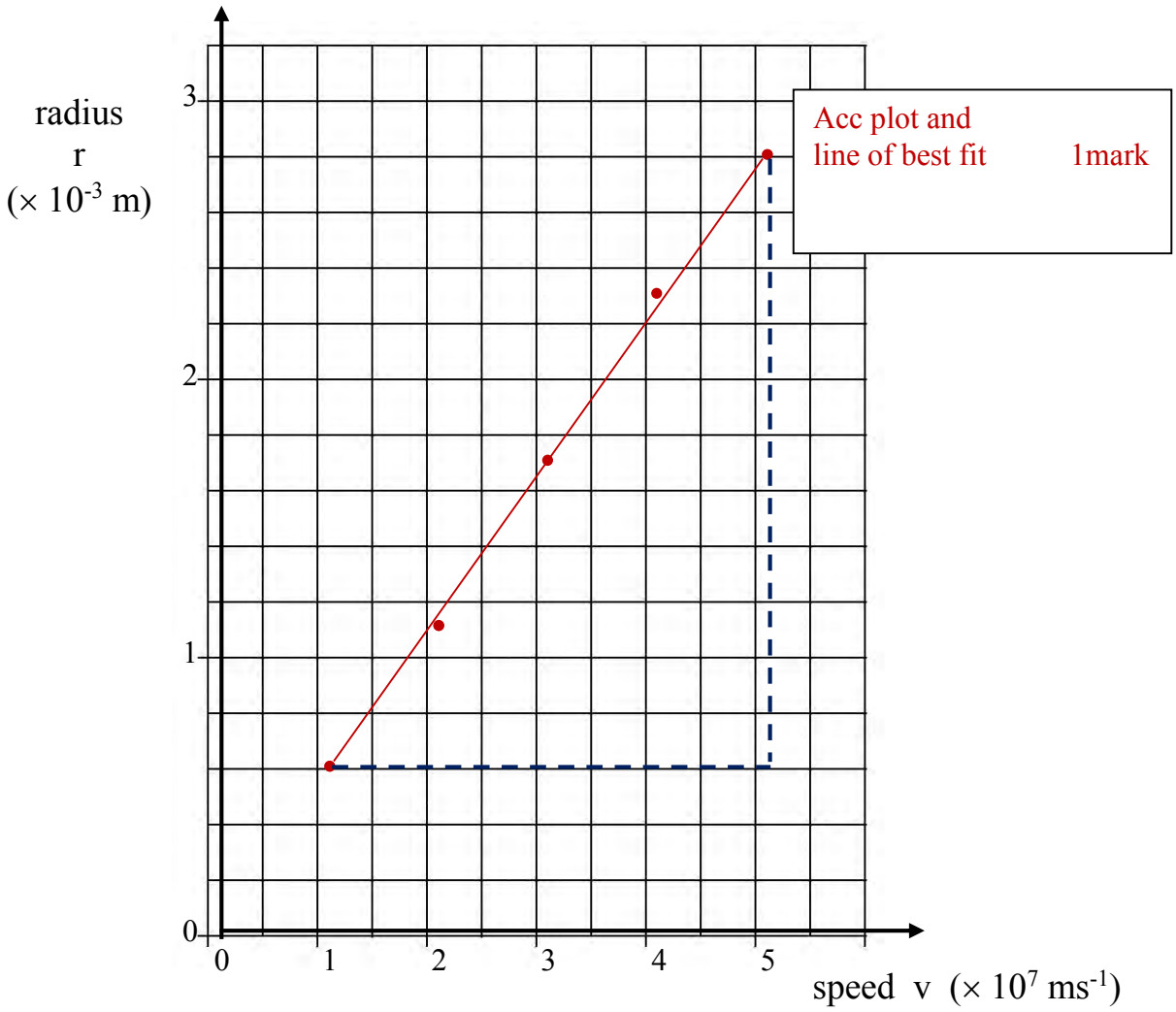
Question 31 (5 marks)

A student performed an experiment to measure the radius of the path of a beam of electrons moving at various speeds in a constant, uniform magnetic field.
The student's data is presented below.

v (ms^{-1} x 10^7)	r (mm)
1.0	0.6
2.0	1.1
3.0	1.7
4.0	2.3
5.0	2.8

(a) Plot the data from the table and draw a graph.

Marking Criteria	Marks
• Correctly plotted graph and line of best fit	**2**



(b) Use the gradient of the graph to determine the magnitude of the magnetic field as the electrons as move in their circular paths. Show all working.

Marking Criteria	Marks
• Determine gradient from graph • Using Fmag = F_c or qvB = mv^2/r to determine relationship between B and gradient • Rearranging equation to get B • Correct substitution and calculation and units	**4**
• Determine gradient from graph • Fmag = F_c or qvB = mv^2/r to determine relationship between B and gradient • Rearranging equation to get B • incorrect substitution and calculation	**3**
• Determine gradient from graph • Fmag = F_c or qvB = mv^2/r to determine relationship between B and gradient	**2**
• Determine gradient from graph	**1**

$$grad \approx \frac{(2.8-0.6)\times 10^{-3}}{(5-1)\times 10^{7}}$$

$$= 5.5 \times 10^{-11}\ s$$ ← 1 mark

$$Since\ F_B = F_C$$

$$\therefore qvB = \frac{mv^2}{r}$$ ← 1 mark

$$\frac{r}{v} = grad = \frac{m}{qB}$$

$$\therefore B = \frac{m}{q \times grad}$$ ← 1 mark

$$\therefore B = \frac{9.1\times 10^{-31}}{(1.6\times 10^{-19})(5.5\times 10^{-11})}$$

$$\therefore B \approx 0.09\ T \quad (0.087)$$ ← 1 mark

Option Questions:

Question 32– From Quanta to Quarks (25 marks)

When hot hydrogen vapour is viewed through a spectrometer, four distinct bright lines of the Balmer series can be seen. The wavelengths of these lines are given in the table below.

Balmer series
6.562×10^{-7} m
4.861×10^{-7} m
4.340×10^{-7} m
4.102×10^{-7} m

(i) By referring to the Bohr model of the atom, describe how these lines are formed.

Marking Criteria	Marks
Description of Bohr atom and electrons dropping from higher to lower energy states emitting photons of energy	**2**
Description of Bohr atom and electrons dropping from higher to the ground state	**1**

(ii) Apply the Rydberg equation to show how anyone of the lines can be predicted.

Marking Criteria	Marks
Correct substitution into formula and correct calculation	**2**
Correct substitution into formula and incorrect calculation	**1**

(b)(i) The nuclide $^{210}_{81}X$ decays to the nuclide $^{A}_{82}Y$ in 4 successive radioactive decays. Each decay involves the emission of either an alpha or a beta particle. What is the value of A?

Marking Criteria	Marks
Correct identification	**1**

$^{210}_{81}X \rightarrow {}^{A}_{82}Y + n\,{}^{4}_{2}He + (4-n)\,{}^{0}_{-1}e$

$81 = 82 + 2n - 4 + n$

$n = 1$

$\therefore A = 206$

(ii) The actual mass of $_{52}Te^{120}$ atom is 119.9045 u.
Calculate its mass defect, given the following data:

Proton mass	1.0073 u
Neutron mass	1.0087 u
Electron mass	0.00055 u

Marking Criteria	Marks
Correct calculation	**1**

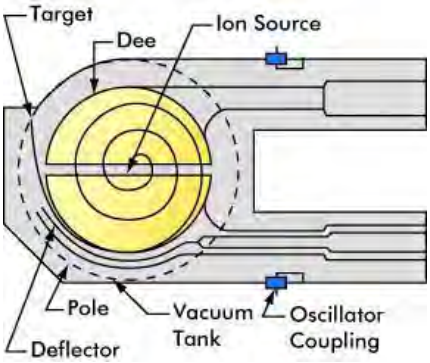
isotope	mass of protons	mass of neutrons	mass of electrons	calc mass of atom	act mass of atom	mass defect
$_{52}Te^{120}$	52 x 1.0073 = 52.380	68 x 1.0087=68.592	52 x 0 .00055 = .029	121.001	119.9045	1.0953 u

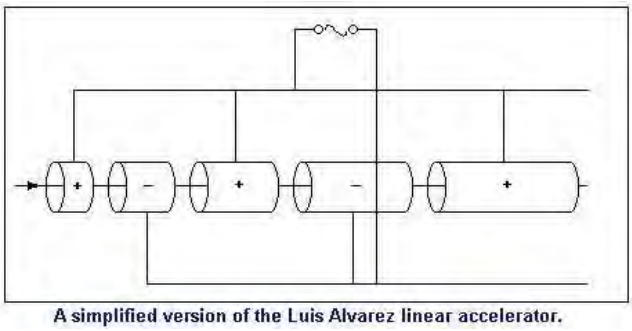
(iii) How much energy is this mass defect equivalent to?

1.953 31.5 = 1020.3 MeV

(c)(i) Using a labelled diagram outline ONE way in which physicists obtain particles with the appropriate energy to investigate the structure of matter.

Marking Criteria	Marks
Diagram Labels Source of ions and target Detailed method used for acceleration	**5**
Any 4 of the above	**4**
Any 3 of the above	**3**
Any 2 of the above	**2**
Any 1 of the above	**1**





A simplified version of the Luis Alvarez linear accelerator.

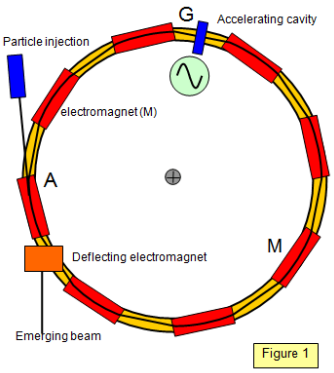
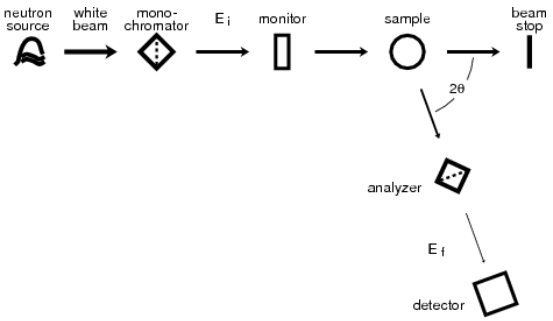


Figure 1



They are devices that are designed to use electric fields and/or magnetic fields to accelerate charged particles to very high speeds before smashing the particles into a target.

This can then produce a transmutation as a result of the smashing. This was how subatomic particles were discovered.

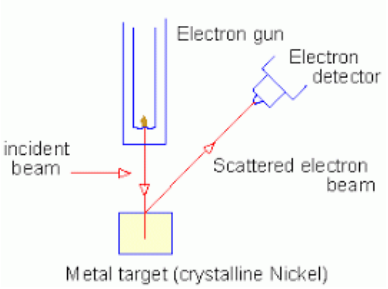
Cyclotron or linear or synchrotron

(ii) Give ONE other application of this technology outlined above.

Marking Criteria	Marks
Correct application	**1**

To produce new elements / bring about transmutation/produce radio-active isotopes used in medicine or ag or industry.

(d) Describe the confirmation of De Broglie's proposal by Davisson and Germer. **4**



De Broglie hypothesised that many particles have both particle and wave properties and have a wavelength of h/mv. Davisson and Germer designed and built a vacuum apparatus for the purpose of measuring the energies of electrons scattered from a metal surface. Electrons from a heated filament were accelerated by a voltage and allowed to strike the surface of nickel metal. The electron beam was directed at the nickel target, which could be rotated to observe angular dependence of the scattered electrons. Their electron detector (called a Faraday box) was mounted on an arc so that it could be rotated to observe electrons at different angles. It was a great surprise to them to find that at certain angles there was a peak in the intensity of the scattered electron beam. This peak indicated wave behaviour for the electrons.

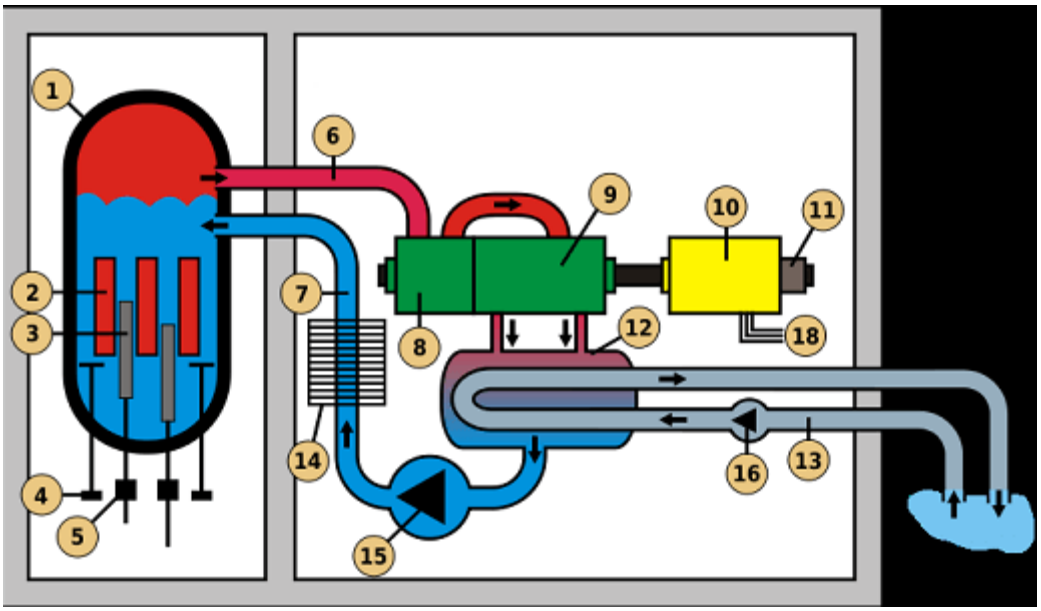
Explain intensities due to diffraction and intereference.

Marking Criteria	Marks
Stating de Broglie's hypothesis, correctly describing the D and G experiment the observations (diffraction, interference)and conclusions drawn.	**4**
any 3 of the above	**3**
any 2 of the above	**2**
Stating de Broglie's hypothesis,	**1**

(e)(i) The diagram shows a fission nuclear reactor. **2**

Identify the parts labelled **(2)** and **(3)** in the diagram.

(2) is fuel rods (3) is control rods



Marking Criteria	
2 correct labels	**2**
1 correct label	**1**

(ii) State the function of parts labelled (1) and (3) in the diagram. **2**

(1) radiation shield to ensure that radiation is contained within the reactor core so that the surrounding env. is not affected.

(3) control to absorb the neutrons to stop or slow the reaction

Marking Criteria	
2 correct functions	**2**
1 correct function	**1**

(f) Until the second half of the twentieth century, the proton, neutron and electron were thought to be fundamental particles of matter. **4**

Justify how the introduction of **quarks** and **leptons,** and **strong** and **weak** forces in the standard model, have changed our understanding of particle physics.

Marking Criteria	Marks
Thorough knowledge of SMM, describing the composition and nature of quarks, leptons, the SNF and the weak force.	**4**
Description of the 4 above with no link to the SMM	**3**
Description of the 3 above with no link to the SMM	**2**
Description of the 2 above with no link to the SMM	**1**

The SMM is a theory that was developed to describe all matter and forces in the Universe. There are 2 families of **fundamental** particles: quarks and leptons, and the force carrier particles: bosons.

Experiments with modern particle accelerators and detectors led to the discovery of sub-atomic particles that had previously been theorised. As scientists discovered more particles, or found that observations did not match previous results (as occurred with the discovery of the muon), it posed new questions about how many more particles were awaiting discovery.

The SMM helped to organise the 12 basic subatomic particles and the forces between them.
Quarks are fundamental particles, 6 flavours (identified through p.a.) are unstable and only exist as composite particles called hadrons. The up and down quarks form protons and neutrons inside the nucleus of the atom.

Leptons, another fundamental particle have very little or no mass. 6 flavours. The discovery of quarks and leptons and their corresponding antiparticles. The electrons orbit the nucleus to complete the whole atom.

The **weak force** is responsible for radioactive decay. It actually makes neutrons turn into protons, amongst other things, and every type of matter particle experiences it. It acts through weakons. The weak nuclear forces explain how leptons interact. This explains how electrons and other types of subatomic particles change into other types of particles.

The **strong force** (so-called because it is stronger than the weak force) is only felt by quarks. It behaves like elastic, because the further apart you pull two quarks, the stronger the strong force gets between them. It is a short range force and it is what keeps the nucleons together in the nucleus. It acts through gluons. The SNF explains how protons and neutrons can bind to form nuclei.

In march 2013, a Higgs boson was detected and found to have just the energy that the SM predicted.

End of examination