2016

TRIAL HSC

EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Write your Student Number at the top of the response sheet on page 14 and on the Elective answer booklet.
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided.

.

Total Marks – 100

Section I Pages 2 – 27

75 marks

This section has two parts, Part A and Part B

Part A –20 marks

•Attempt Questions 1- 20

•Allow about 35 minutes for this part

Part B – 55 marks

•Attempt Questions 21 – 31

•Allow about 1 hour and 40 minutes for this part

Section II Pages 30-31

25 marks

•Attempt Question 32

•Allow about 45 minutes for this section

Mark your answers on the ANSWER grid on page 14

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

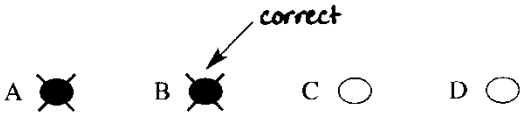
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

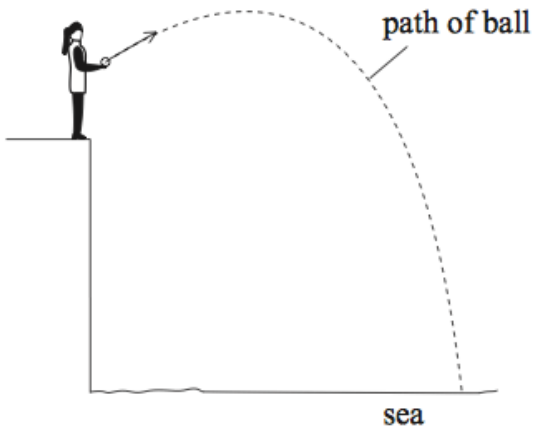
If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

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.

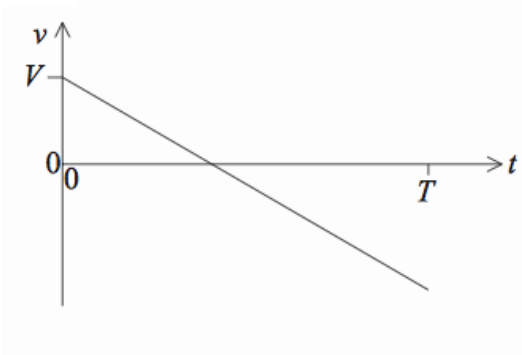


1. A ball is thrown from the top of a cliff. The initial magnitude of the velocity of the ball at time 0 is *V*. Air resistance is negligible.

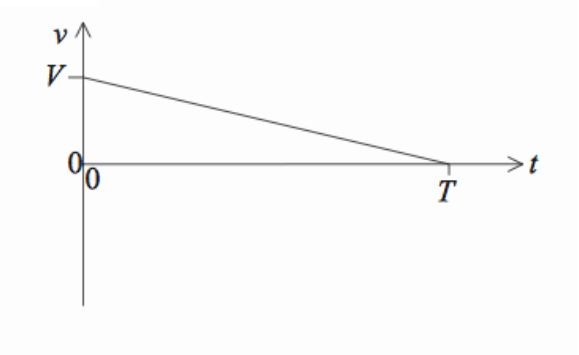


Which graph shows how the vertical component of the velocity *v* of the ball varies with *t* as it falls to the sea?

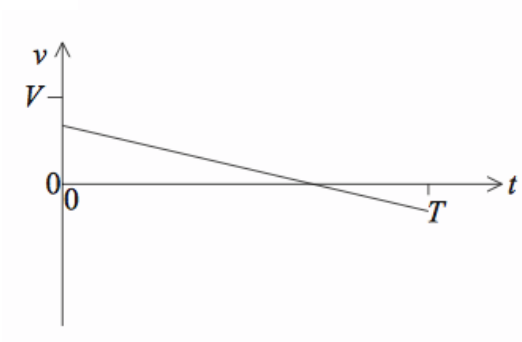
(A)



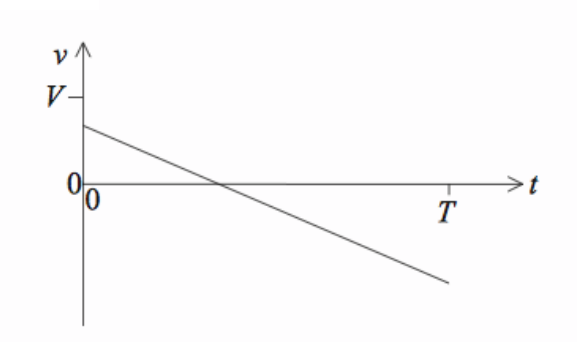
(B)



(C)



(D)



2. The mass of a planet is twice that of Earth. Its radius is half that of the radius of Earth. The gravitational field strength at the surface of Earth is *g*.

What is the gravitational field strength at the surface of the planet?

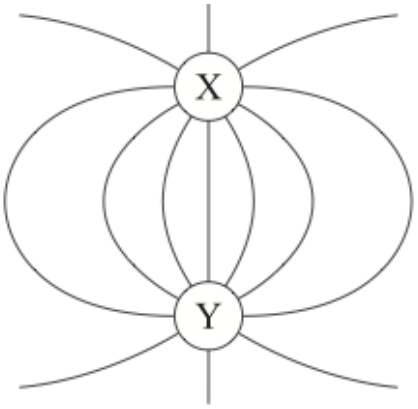
(A) 0.5 g

(B) g

(C) 2 g

(D) 8 g

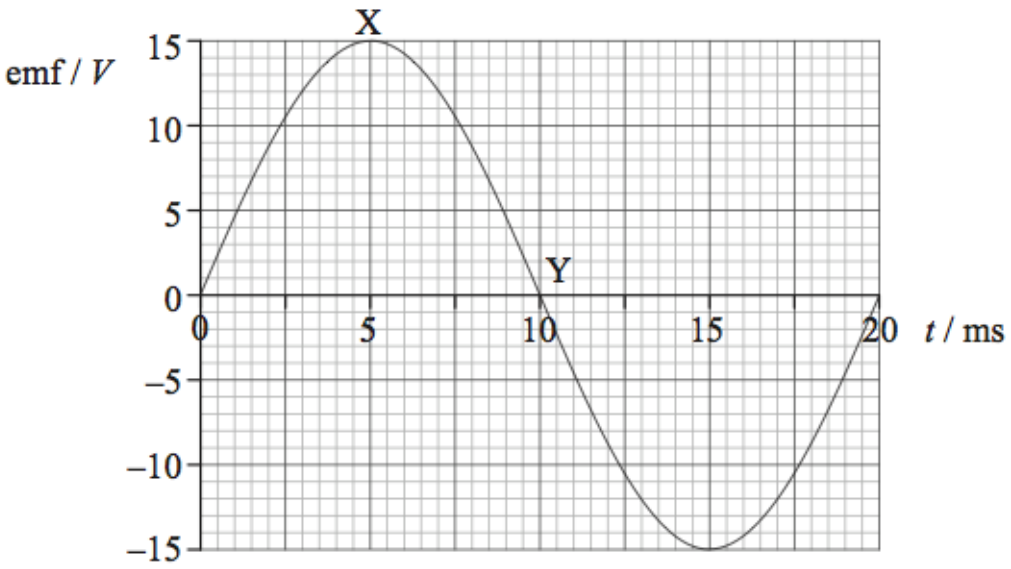
3. The diagram shows the electric field pattern due to two point charges X and Y.
Y is a negative charge.



Which of the following correctly identifies the charge X and the direction of the electric field?

	Sign of charge X	*Direction of electric field*
(A)	positive	Y to X
(B)	positive	X to Y
(C)	negative	X to Y
(D)	negative	Y to X

4. A rectangular loop of conducting wire rotates in a region of magnetic field. The graph shows the variation with time *t* of the induced emf in the loop during one cycle.



Which of the following gives the correct times at which the magnitude of the magnetic flux linkage and the current in the loop are maximum?

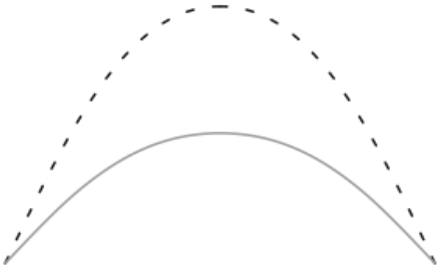
	Flux linkage	*Current*
(A)	Y	Y
(B)	Y	X
(C)	X	Y
(D)	X	X

5. The diagram shows the path of a projectile that is launched with velocity *v*. Air resistance is negligible.

A second projectile has double the mass of the first projectile and is launched with the same velocity. Air resistance is still negligible.

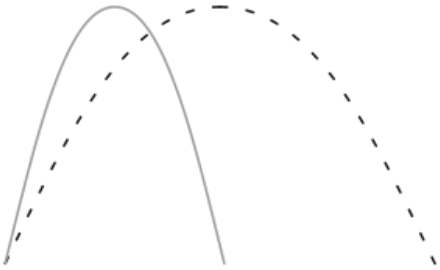
Which of the following paths best represents the path of the projectile? (The original path is shown as a dotted line)

(A)



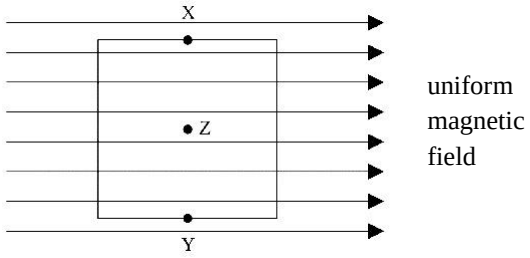
(B)

(C)



(D)

6. The diagram shows a square coil with its plane parallel to the magnetic field.



Which one of the following will induce an emf in the coil?

(A) movement of the coil slightly to the left

(B) movement of the coil slightly downwards

(C) rotation of the coil about an axis through XY

(D) rotation of the coil about an axis perpendicular to the plane of the coil through Z

7. Electric power stations step up the voltage for the transmission to distant consumers.

This is done because

(A) there is less danger of fire if the wire breaks

(B) the wires can be thinner and therefore less expense is involved

(C) less insulation is needed

(D) transmission is faster at higher voltages

8. Which of the following includes only the elements capable of being used as impurities to produce n-type semiconductors?

(A) boron; nitrogen; gallium

(B) gallium; aluminium; boron

(C) carbon; arsenic; phosphorus

(D) arsenic; antimony; phosphorus

9. The diagram shows striation patterns in a discharge tube under certain conditions.

What is the main cause of these striation patterns?

(A) High voltages across low pressure gases

(B) Photoelectric effect

(C) Interference of radio waves

(D) Black body radiation

10. A satellite is orbiting the Earth in a circular path at constant speed. Four students are discussing its motion.

Who is giving the best account of the forces acting on the satellite?

(A) Albert: The satellite is kept up by an outward force (mv^2/r) which counteracts the force due to gravity (mg)

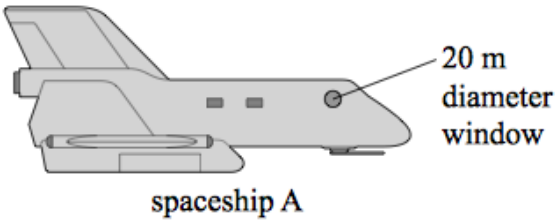
(B) Betty: There is one force, that of gravity, acting on the satellite and this results in an inward acceleration of v^2/r.

(C) Caren: The satellite has escaped from the earth's gravitational field, so that gravity is negligible. It is kept in orbit by its momentum, equal to mv. The net force on the satellite is zero.

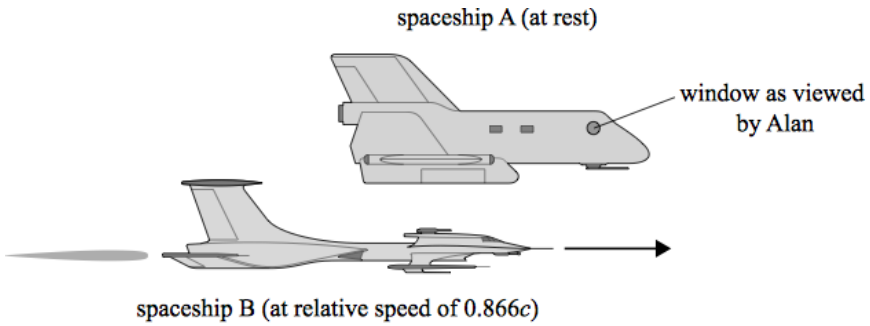
(D) David: I agree with Caren about the negligible effect of gravity, but there is an inward force equal to mv^2/r which holds the satellite in orbit.

Use the following information to answer Questions 11 and 12.

Spaceship A has a circular window in its side. Alan, a crew member of spaceship A, measures the diameter of the window as 20 m. The figure below shows spaceship A at rest.

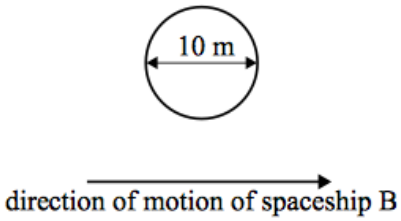


Briony is a crew member of spaceship B. She measures the dimensions of the window as spaceship B moves past spaceship A at a relative speed of 0.866 *c*.

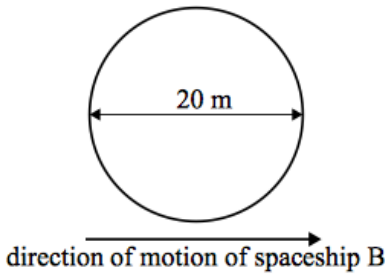


11. Which of the following diagrams best shows the dimensions of the circular window on spaceship A as measured by Briony on spaceship B?

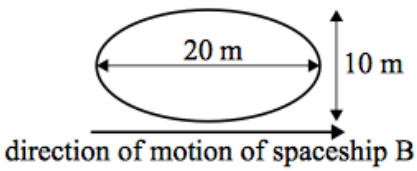
(A)



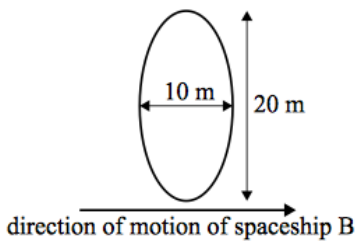
(B)



(C)



(D)



12. Briony (on spaceship B) also measures the time that she takes to pass the window.

Which of the following is the best estimate of the time that she measures?

(A) 1.92×10^{-8} s

(B) 3.33×10^{-8} s

(C) 3.85×10^{-8} s

(D) 7.70×10^{-8} s

13. An electrician drills a hole into a wall using an electric drill. As he makes the hole, friction on the end of the drill causes the armature of the motor within the drill to slow down.

How will the back emf and the current through the armature change as the drill slows down?

	Back emf	*Current*
(A)	Increase	Increase
(B)	Increase	Decrease
(C)	Decrease	Increase
(D)	Decrease	Decrease

14. In an experiment to demonstrate the photoelectric effect, light of intensity L and frequency f is incident on a metal surface. The maximum photoelectric current is I and the stopping potential is V_s.

What happens to the maximum photoelectric current and stopping voltage when the frequency of the incident light is doubled?

	Maximum photoelectric current (I)	*Stopping potential* (V_s)
(A)	I is unchanged	Greater than V_s
(B)	less than I	Greater than V_s
(C)	I *is* unchanged	Less than V_s
(D)	less than I	Less than V_s

15. A cathode beam passes undeflected through crossed electric and magnetic fields. When the electric field is switched off, the beam splits up into several beams.

Which of the following will cause the beam to split?

(i) different masses
(ii) different velocities
(iii) different charges

(A) (ii) only

(B) (i) and (ii) only

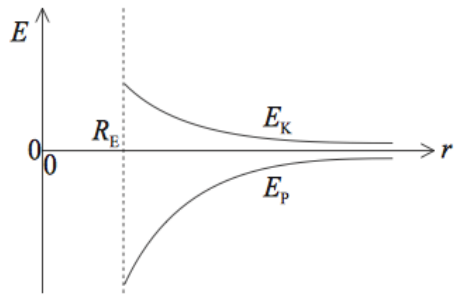
(C) (ii) and (iii) only

(D) (i), (ii) and (iii)

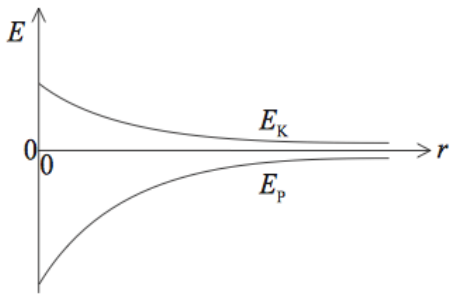
16. A satellite is in orbit about Earth at a distance r from the centre of Earth. The gravitational potential energy of the satellite is E_p and its kinetic energy is E_k. The radius of Earth is R_E.

Which graph shows how E_p and E_k vary with r ?

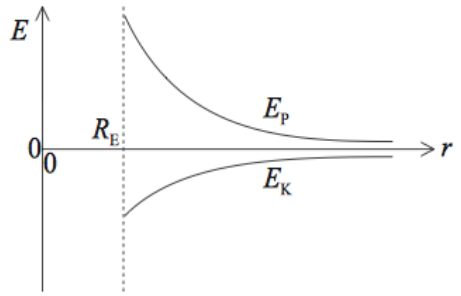
(A)



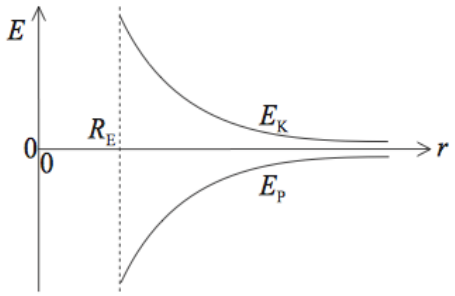
(B)



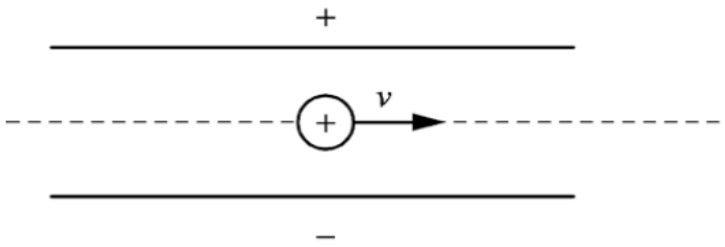
(C)



(D)



17. A proton enters the space between two oppositely charged parallel metal plates.



A magnetic field acts between the plates at right angles to the electric field and the direction of motion of the proton. The magnetic field strength is 20 mT and the electric field strength is 100 V m^{-1}. The proton moves in a straight line between the plates.

What is the speed of the proton?

(A) 2 m s^{-1}

(B) 5 m s^{-1}

(C) 2 000 m s^{-1}

(D) 5 000 m s^{-1}

18. Why are X-rays useful for investigating crystal structure?

(A) They carry enough energy to break the crystal into its component parts for analysis.

(B) Their frequency is close to the resonant frequency of the crystal lattice.

(C) Their wavelength is similar in size to the gaps between atoms in a crystal lattice.

(D) They are absorbed by some atoms but can pass through others, generating an image.

19. How does the conductivity of copper and silicon change as their temperatures are increased?

(A) copper decreases and silicon decreases

(B) copper decreases and silicon increases

(C) copper increases and silicon increases

(D) copper increases and silicon decreases

20. Which of the following statements is true regarding the band structure theory of solids?

(A) In semiconductors, the forbidden energy gap is smaller than for insulators.

(B) In insulators, the valence and conduction bands overlap.

(C) In conductors, there is a large forbidden energy gap between the valence and conduction bands.

(D) In insulators, the conduction band is full at 0 K.

Student Number	
Mark / 100	

Section I 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 ○

Mark: /20

Part B 55 marks

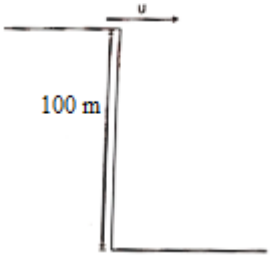
Attempt questions 21 - 31
Allow about 1 hour and 40 minutes for this part

- *Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response*
- *Show all relevant working in questions involving calculations*

Question 21 (4 marks) **Marks**

A stone is projected horizontally from the top of a cliff 100 m high. After 2 seconds the stone has a velocity of 31.8 m s^{-1} at an angle of 38.1^o below the horizontal.

initially



(a) Determine the vertical velocity of the stone after 2 seconds. **2**

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(b) Determine the horizontal velocity of the stone after 2 seconds. **1**

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(c) Determine horizontal range of the stone after 2 seconds. **1**

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Question 22 (5 marks) **Marks**

The escape velocity for planet Earth is 11.2 km s^{-1}. However, a spaceship travelling with its engines on and at a lower speed, near the planet's surface, can escape the planet's gravitational field.

(a) With a clear reference to Newton's concept of escape velocity, explain how this is possible. **3**

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(b) Explain why the direction given to any projectile with escape velocity will not matter (as long as it does not collide with anything). **2**

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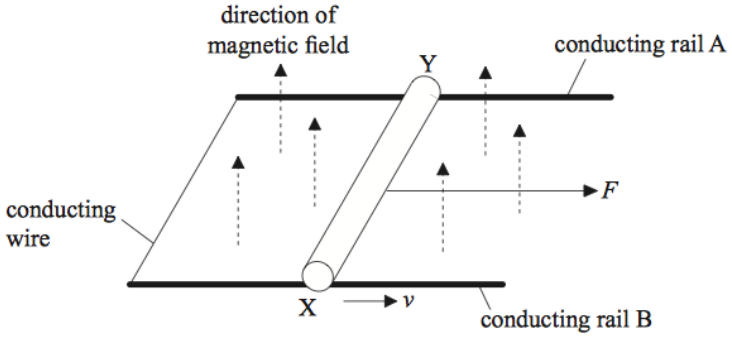
Question 23 (4 marks) **Marks**

A copper rod XY is able to move freely along two horizontal, parallel conducting rails A and B. The conducting rails are in a region of uniform magnetic field that is in a direction perpendicular to the plane of the rails. The rails are connected together at one end by a conducting wire. **4**



In the situation shown, the rod is moved along the rails at a constant speed *v* by a constant horizontal force of magnitude *F*.

Explain using physics principles why a force is required to move the rod at constant speed.

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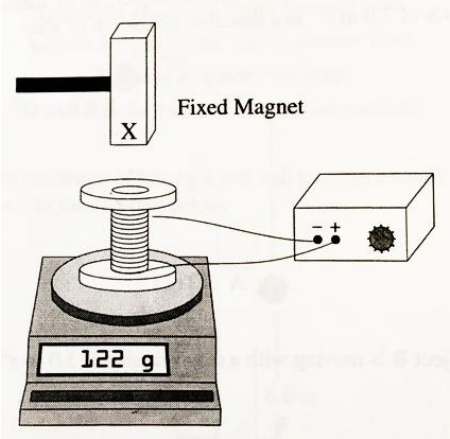
Question 24 (6 marks) **Marks**

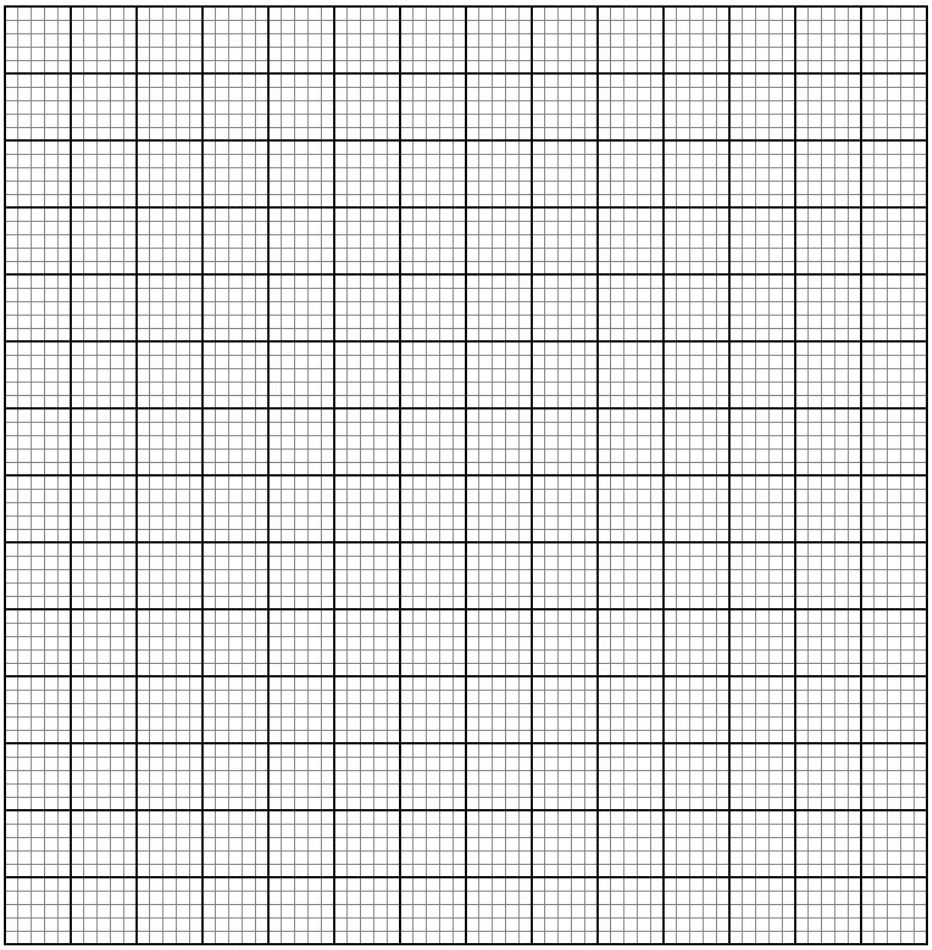
A student performed an investigation involving a magnet and a current carrying solenoid. The solenoid is resting on an electronic balance.

The current through the solenoid is varied and the reading on the electronic balance recorded



Current (A)	*Reading on balance (g)*
1	122
2	111
3	100
4	89
8	45

(a) Plot and draw a graph showing how the current varied against the balance reading. **2**



Question 24 continues on the next page

(b) Use the graph to determine the mass of the solenoid. **1**

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(c) Was the magnetic pole at X a north or a south pole? Explain your answer. **2**

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(d) Ignoring the mass of the connecting wires, find the minimum current required to suspend the solenoid in mid-air. **1**

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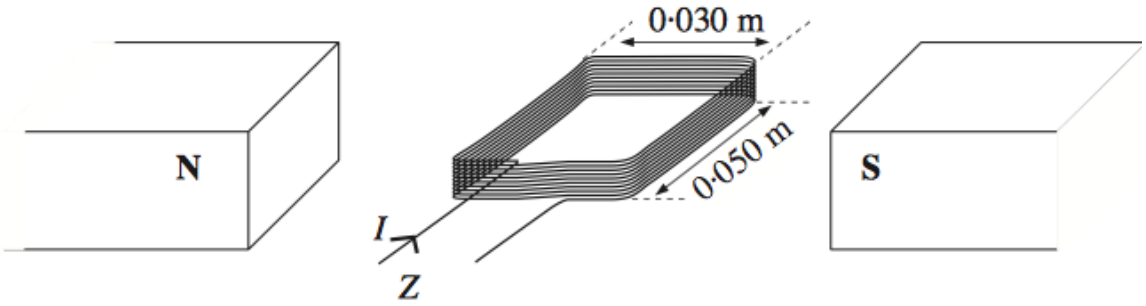
Question 25 (5 marks) **Marks**

A coil consists of 10 turns of insulated copper wire. It is placed between the poles of magnets as shown in the diagram. These magnets may be assumed to create a uniform magnetic field of flux density 0·15 T.



A current of 2·0 A is passed through the coil in the direction shown.

(a) Calculate the magnitude of the torque that acts on the coil when it is in the position shown in the diagram. **2**

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(b) In what direction will the coil start to turn as seen from position *Z*? **1**

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(c) A device is placed at *Z* to allow current to be supplied to the coil so that the coil rotates continuously.

Name the device and explain how it works. **2**

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Question 26 (6 marks) **Marks**

The theory of relativity discusses the physical consequences of the absence of a universal frame of reference. The special theory of relativity, published in 1905 by Einstein, is concerned with problems involving inertial frames of reference. Its fundamental principles, however, caused apparent discrepancies in measurements.

(a) State TWO fundamental principles upon which the special theory of relativity is based. **2**

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(b) State TWO apparent discrepancies caused by these fundamental principles and outline how Einstein was able to explain them. **4**

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Question 27 (7 marks) **Marks**

Alongside the growth in our understanding of the natural world, perhaps the more obvious and relevant result of physics is our ability to change the world. This is the technological side of physics, in which physical principles have been applied to construct and alter the material world to suit our needs, and have had a profound influence on the daily lives of all human beings. **7**

From your study of the core topics: *Space*, *Motors and Generators* and *From Ideas to Implementation*, identify and assess TWO technologies that have been developed as a result of increased knowledge and understanding of physics principles and laws.

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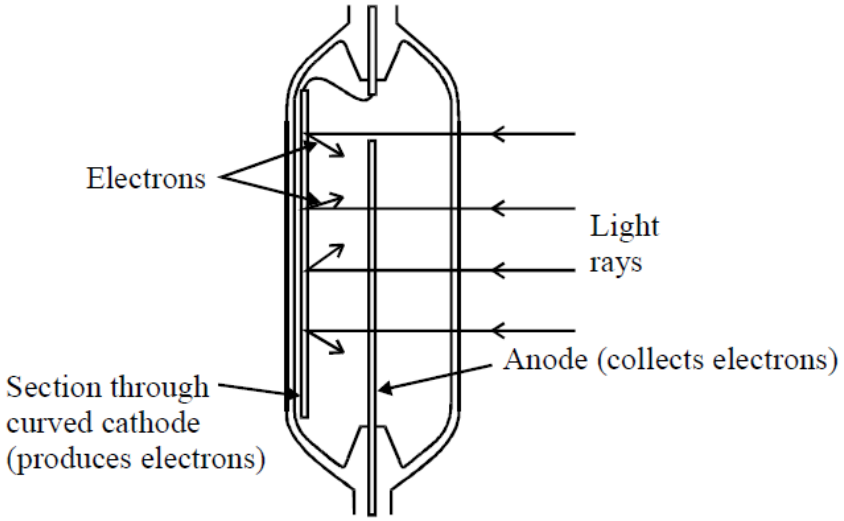
Question 28 (7 marks) **Marks**

The figure below shows a photocell.



(a) Describe how an electron escapes from the surface of the cathode. **2**

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(b) Potassium has a work function of 2.90×10^{-19} J. **1**

Calculate the lowest frequency of radiation that will produce photoelectrons from the surface of a potassium cathode.

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Question 28 continues on the next page

(c) The photocell will produce the best results if it responds to light over most of the visible spectrum. This has a range of wavelengths from 400 nm to 700 nm.

Explain with the aid of an appropriate calculation whether potassium is a suitable material for use in this photocell. **2**

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(d) A potassium cathode is exposed to visible light, with a complete range of wavelengths.

Determine the maximum kinetic energy of an emitted photoelectron. **2**

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Question 29 (4 marks) **Marks**

You performed a first-hand investigation to demonstrate the production and reception of radio waves. **4**

Describe how this demonstration was conducted.

Include in your answer the following:

- a labelled diagram of the investigation carried out
- the observations made
- identification of any risk(s) and how this was minimised

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Question 30 (3 marks) **Marks**

Transmission of electrical energy is usually accomplished by alternating currents operating At high voltage. **3**

Justify the use of AC as the preferred form for the efficient transmission of electrical energy.

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Question 31 (4 marks) **Marks**

(a) Using Newtonian physics, calculate the kinetic energy (in eV) of a proton if it were to travel at 3×10^8 m s^{-1}. **2**

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(b) A student makes the statement that "the maximum kinetic energy a proton can have is 4.7×10^8 eV because it cannot travel faster than the speed of light". **2**

Assess the statement on the basis of your answer to part (a).

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End of Part B

Part B extra writing space

If you use this space, clearly indicate which question you are answering.

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

Complete ALL answers to this question in the ANSWER BOOKLET provided.

(a) Complete the table below to successfully link conclusions drawn from the experimental observations made by Rutherford and his co-workers. **2**

Experimental observation	*Conclusion drawn*
Most alpha particles pass through the gold foil with little or no deviation	
Some alpha particles were deflected through very large angles (>90°)	

(b) Bohr's model of the hydrogen atom was an attempt to improve on the Rutherford model of the atom. However, it also had limitations such as its inability to completely explain the relative intensity of spectral lines and the Zeeman effect.

Discuss these TWO limitations. **2**

(c) Justify the need for Pauli's hypothesis of the existence of the neutrino. **4**

(d) The following is a typical fission reaction of a Uranium-235 nucleus by a neutron.

$$^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{88}_{38}Sr + {}^{136}_{54}Xe + 12{}^{1}_{0}n$$

Given the following masses:

$^{235}_{92}U : 235.0439\ u \quad ^{88}_{38}Sr : 87.9056\ u \quad ^{136}_{54}Xe : 135.9072u \quad ^{1}_{0}n : 1.0087\ u$

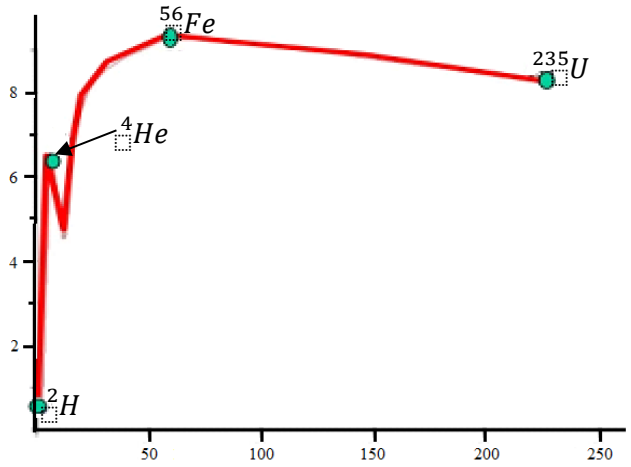
Calculate the energy released in this fission reaction, in MeV. **2**

(e) Describe the role of moderators and control rods in a nuclear fission reactor. **4**

(f) Describe the key features and components of the Standard Model of Matter and analyse the role of particle accelerators in developing this model. **7**

Question 32 continues on the next page

(g) Below is a graph that appears in nuclear physics.



(i) Identify the correct label for the vertical axis of the graph (units not required). **1**

(ii) What information is this graph used to indicate. **1**

(h) The energy-level diagram for the hydrogen atom is shown below.

Photons of wavelength 103 nm are emitted by excited hydrogen gas in a discharge tube.

On the diagram in the answer booklet, use an arrow to draw in the transition that could lead to this emission line. Show ALL necessary working. **2**

End of exam

2016
TRIAL HSC EXAMINATION
Physics

Section I 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 ○

Mark: /20

Part B. 55 marks

Question 21 (4 marks) **Marks**

(a) **2**

Marking Criteria	*Marks*
Correct calculation showing vertical velocity and direction	2
Correct calculation showing vertical velocity (no direction)	1

$v_y = 31.8 \times (\sin 38.1)$ $v_y = 19.6$ ms^{-1} downwards

(b) **1**

Marking Criteria	*Marks*
Correct calculation showing horizontal velocity	1

v_x after 2 seconds is $31.8 \times (\cos 38.1) = 25.0$ m s^{-1} right

(c) **1**

Marking Criteria	*Marks*
Correct calculation showing range and correct units	1

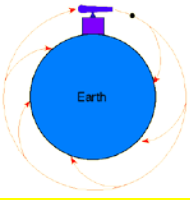
Range = 25 x 2 = 50.0 ms^{-1}

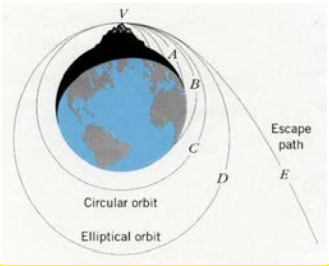
Question 22

(a) **3**

Marking Criteria	*Marks*
Define escape velocity, correct equation, describe Newton's concept of escape velocity (better with a diagram) **and** role of engines on the spaceship	3
Describe Newton's concept of escape velocity and equation	2
Describe Newton's concept of escape velocity or equation or role of engines	1

Newton conceived escape velocity using his force equation. If an object moves fast enough it can escape a massive object's gravity and not be drawn back toward the massive object. The critical speed needed to do this is the **escape velocity**. If the projectile's initial velocity is high enough, the $1/d^2$ term in the gravity equation will cause the acceleration g to decrease with height too rapidly to bring the projectile to a stop so it will never fall back.





This is because the engines continue to provide the thrust and hence the low velocity is sufficient.

Escape velocity is how fast an object has to be moving away from its position near a body such as a planet (star/galaxy) in order to escape the effect of its gravitational field. [The value decreases as the distance of the starting position from the centre of that body increases]

$\frac{1}{2} mv^2 = -GMm/r$ Hence $v = \sqrt{\frac{2GM}{r}}$

Marks

However, because G is a constant, its effect on escape velocity is fixed by this constant and is only dependent on the mass of the central body and the distance from its centre.

Newton realised that the faster a projectile was launched horizontally, the further it fell from its starting point. (Paths A, B in the image). A projectile launched with sufficient velocity would orbit the Earth in a circular orbit. At a faster velocity, the orbit would be elliptical.

Given a sufficient velocity, the projectile would continue to move away from the Earth and the minimum velocity required to cause it to move indefinitely away from the Earth was called the escape velocity. This analysis was first proposed by Newton.

(b) **2**

Marking Criteria	*Marks*
Refer to escape velocity equation and explain why direction is not relevant	2
Equation (if not mentioned in (a) or suggestion of KE being a scalar quantity	1

A projectile with escape velocity given will have total energy of (KE = ½ mv^2_{esc} and GPE = -GMm/r)
Since ½ mv^2_{esc} - -GMm/r = 0, the projectile has a net mechanical energy of zero.
It is really a speed, because the initial direction of the projectile isn't critical.

Question 23 **4**

Marking Criteria	*Marks*
Using the principles of physics: Change of flux (Faraday's law) induces emf Direction of current Description of direction of magnetic force Lenz's law induction of magnetic force (at constant speed) forces are balanced	4
4 of above	3
Any 3 of above	2
Any 2 of above	1

As the rod is moved to the right, flux is changed within the loop, and emf is induced in the rod (Faraday's law). With a complete circuit, current is induced and flows from Y to X in the rod. This creates a magnetic field around the rod which opposes the change that caused it (Lenz's law). The rod experiences an opposing magnetic force to the left (motor effect). In this situation the induced current (in the rod) is in such a direction that the magnetic force on the rod opposes the force *F*. Hence in order for the rod to be pulled along at constant speed, a force F needs to be applied as shown to overcome the opposing force and all forces are balanced.

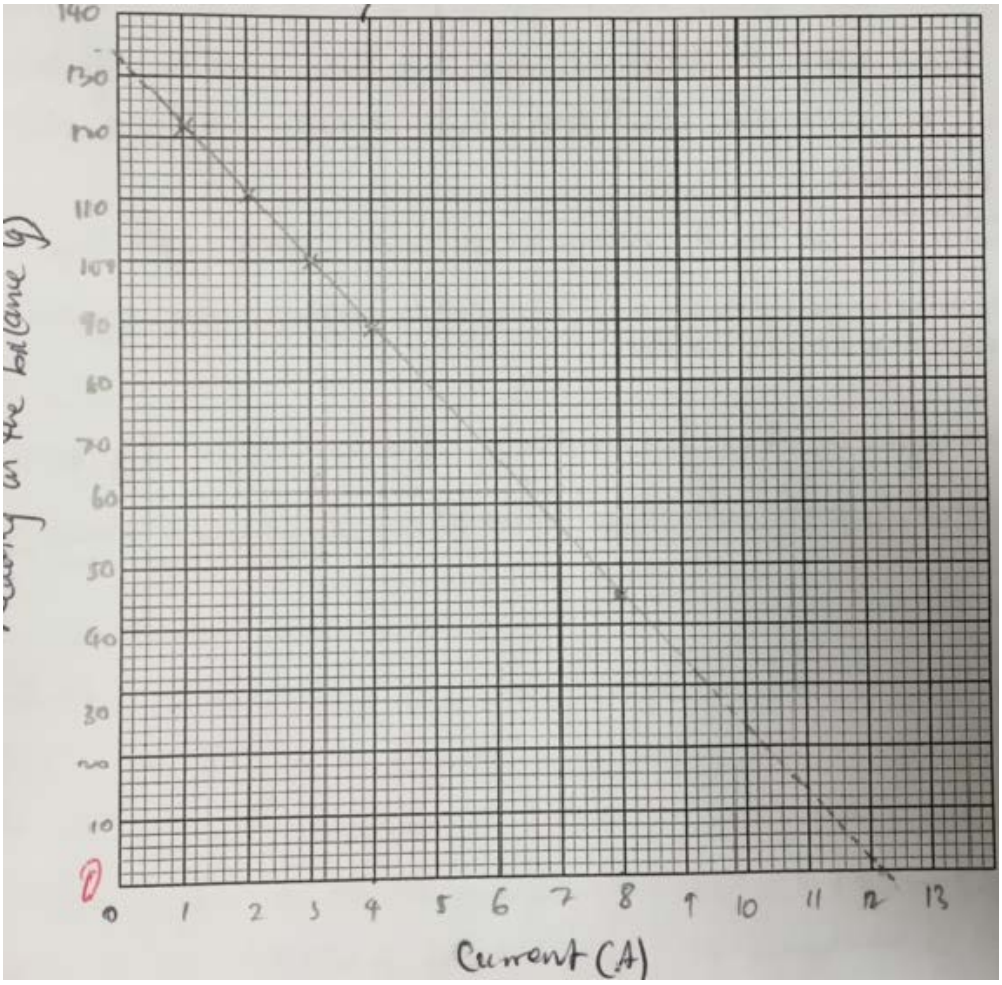
Marks

Question 24

(a) **2**

Marking Criteria	*Marks*
Correctly label axes and plot points correctly and draw a line graph	2
Correctly label axes and plot some points correctly and draw a line graph OR Incorrect choice of axes	1

Relationship between current and reading on balance



(b) **1**

Marking Criteria	*Marks*
Correct answer from graph and correct units	1

133 g: the y-intercept on the graph

(c) **2**

Marking Criteria	*Marks*
Correctly identify polarity of X and give a complete correct reason for the choice	2
Correctly identify polarity of X and give a partially correct reason for the choice	1

The mass appears to be decreasing as current increases. This indicates solenoid is attracted to the magnet. Hence the top of the solenoid is a S pole so the bottom of the magnet (X) must be a **N pole**.

Marks

(d) **1**

Marking Criteria	*Marks*
Correct answer from x-intercept graph and correct units	1

This would be when the magnet has an apparent mass of 0.
At the x-intercept on the graph at **12.0 A**.

Question 25

(a) **2**

Marking Criteria	*Marks*
Correct calculation showing mag of torque and correct units	2
Correct calculation showing mag of torque	1

T = nBIA = 10 x 0.15 x 2 x 0.03 x 0.05

$= 4.5 \times 10^{-3}$ Nm or (0.0045 Nm)

(b) Anticlockwise **1**

(c) **2**

Marking Criteria	*Marks*
Correct device name and clear explanation of how it works	2
Correct device name OR clear explanation of how it works	1

Device: Split ring commutator

Function: to reverse the direction of current in the coil every half cycle so that torque continues in same direction always.

Question 26

(a) **2**

Marking Criteria	*Marks*
Correct account of two principles	2
Correct account of one principle	1

1. The special theory of relativity is based on the assumption that the laws of physics are the same in all inertial frames of reference and
2. that the speed of light is the same for all observers, regardless of their state of motion.

Marks

(b) **4**

Marking Criteria	*Marks*
A clear statement of two apparent discrepancies and outline of Einstein's explanation of each of them (including speed of light is constant)	3-4
A statement of one apparent discrepancy and a basic account of time dilation or of Einstein's use of thought experiments	2
A response that states that time or length are relative and mentions time dilation	1

Time dilation, length contraction and the relativity of simultaneity are among the strange conclusions of special relativity.

If the speed of light is to be a constant then time and length must be relative concepts. i.e. time and length must change as velocity increases.

Einstein explained that the factor by which time dilates and length contracts a result of relative motion is given by the expressions:

$$t' = t\sqrt{1 - V^2 / c^2}$$

Where: t' = dilated time
t = stationary time
V = velocity
c = speed of light

$$\ell = \ell_0 \sqrt{\left(1 - \frac{V^2}{c^2}\right)}$$

He conducted thought experiments to help understand and explain his theory of special relativity and these consequences.

Having clocks that run at different rates leads to other strange effects: **simultaneity is relative**. Whether or not two things are simultaneous depends upon your frame of reference.

Question 27 **7**

Marking Criteria	*Marks*
Identifies two current technologies (2) and links the appropriate and relevant physics principles/laws (3) makes an assessment in a coherent, concise, unambiguous and appropriate manner (1+1)	7
Any 6 of the above	6
Any 5 of the above	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

- Semiconductors – solar cells, photocells, transistors
- Superconductors – maglev trains
- Transformers – transmission of power
- Electric motors – transport, industry
- CRT – discharge tubes, Thomson's Expt.
- AC generators – production of electricity
- Rocketry – rocket/projectile motion, Newton's laws, g-forces, orbital motion, re-entry issues
- Particle accelerators – production of radionuclides

Marks

Question 28

(a) **2**

Marking Criteria	*Marks*
• Provides a correct description of how electrons are ejected from the surface of the cathode, including concepts of work function and kinetic energy	2
• Provides a brief description of how electrons are ejected from the surface of the cathode, including one the following concepts: work function or kinetic energy	1

When light with frequency above the threshold for photoemission, falls on the cathode, electrons are ejected. This occurs when energy of the incident radiation is greater than the work function of the cathode, with the difference in energies providing the kinetic energy to these photoelectrons to escape from the surface of the cathode.

(b) **1**

Marking Criteria	*Marks*
• Correctly calculates the minimum frequency, including units	1

$$f = \frac{E}{h}$$
$$= \frac{2.90 \times 10^{-19}}{6.626 \times 10^{-34}}$$
$$= 4.38 \times 10^{14} \text{ Hz}$$

(c) **2**

Marking Criteria	*Marks*
• Correctly calculates the cut-off wavelength AND correctly locates this wavelength as being within the visible spectrum and accordingly indicates the suitability of potassium in the photocell	2
• Calculates the energy of the 400 nm incident light or the 700 nm light, and mentions the suitability of potassium, by comparing this with the work function.	1

The cut-off wavelength is given by:

$$\lambda_c = \frac{c}{f_0}$$
$$= \frac{3 \times 10^8}{4.38 \times 10^{14}}$$
$$\sim 685 \text{ nm},$$ which is clearly within the range of the visible spectrum (400 nm – 700 nm). Hence Potassium is a suitable material for the photocell.

(d) **Marks 2**

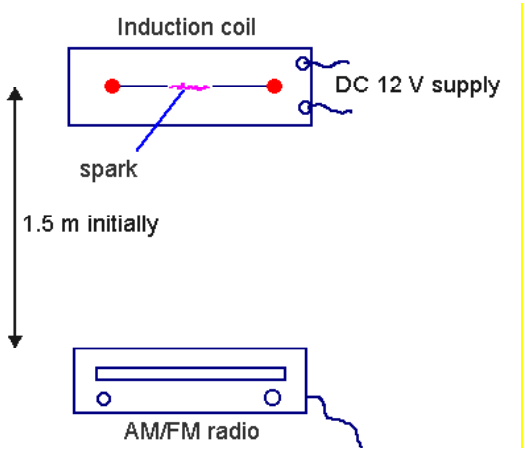
Marking Criteria	*Marks*
• Correctly determines the kinetic energy; and with appropriate working	2
• Any one of the above	1

$$E_k = \frac{hc}{\lambda} - W$$
$$= \frac{6.626 \times 10^{-34} . 3 \times 10^{8}}{400 \times 10^{-9}} - 2.90 \times 10^{-19}$$
$$= 2.07 \times 10^{-19} \text{ J}$$

Question 29 **4**

Marking Criteria	*Marks*
• Provides a fully labelled diagram of the equipment (induction coil and power pack and FM/AM radio) (1); describes an observation made (1) and includes a risk assessment (1 each for risk identified and 1 for the mitigation)	4
• Any three of the above	3
• Any two of the above	2
• Any one of the above	1

An induction coil was used to create a continuous spark about 2 cm long between its terminals. A radio receiver was placed approximately 1.5 m from the spark.



Before the spark was turned on, the radio receiver was tuned so that is was between stations (no sound heard) using the AM band. The spark was then turned on and loud static noise was heard on the radio. This was repeated, tuning the radio between two FM stations, and MUCH less static was heard. The radio was then moved 10 m away from the spark and the two experiments were repeated. The static noise on the radio was less in each case than what was heard on the corresponding AM/FM band when the distance was less.

The distance between the spark and the AM/FM radio was changed.The band on which the radio waves were received was changed from AM to FM.

Marks

The production of x-rays by the induction coil while operating at high voltage was identified as the main risk. To minimise this risk, the observers were positioned at least 3 m away from the spark generation, and the operator was expected to operate the coil/power supply for short durations and adhere to the 3 m exclusion zone during operation.

Question 30 **3**

Marking Criteria	*Marks*
• A clear statement justifying at least 3 relevant points	**3**
• A clear statement justifying at least 2 relevant points	**2**
• A clear statement justifying at least 1 relevant point	**1**

AC is used in preference to DC for transmission because:

- AC power is easily transformed and can be used in transformers to step-up or step down voltages
- AC power is easily generated in large quantities
- AC power is cheaper to generate than DC power
- AC power enables lower energy loss during transmission due to the alternating nature of as the current, power loss is = I^2R
- AC power is safer than DC power for humans
- AC power is suitable for devices such as clocks and motors that require precise timing
- AC voltage varies sinusoidally with time

Question 31

(a) **2**

Marking Criteria	*Marks*
Correct equation and calculation including units	2
Correct equation and calculation	1

$KE = ½ mv^2$

$= 0.5 \times 1.673 \times 10^{-27} \times (3 \times 10^8)^2$

$= 7.5285 \times 10^{-11}$ J

$= 4.7 \times 10^8$ eV

(b) **2**

Marking Criteria	*Marks*
• Assessment of statement based on correct reasoning	**2**
• Assessment of statement based on partly correct reasoning	**1**

Marks

As speed increases closer to the speed of light, mass dilation occurs (mass approaches infinity). So the force required to accelerate an object to the speed of light becomes infinite. This is why the speed of light cannot be reached. The KE formula does not apply at relativistic speeds, even if M_v is substituted into formula. In relativity, mass and energy are regarded as the same thing.

$KE = mc^2 - m_0c^2$

In fact, as v approaches c, the kinetic energy goes to infinity. This means that the rise in v gets smaller as we approach c: no matter how much energy we put in, the speed never gets to c.

Hence statement is not correct.

End of Part B

Section II

Question 32

(a) **2**

Marking Criteria	*Marks*
• 1 mark for each correct response	**2**

Experimental observation	*Conclusion drawn*
Most alpha particles pass through the gold foil with little or no deviation	Atoms are mostly made up of empty space
Some alpha particles were deflected through very large angles (>90°)	Atoms have a small, dense, positive nucleus making up almost all of its mass

(b) **2**

Marking Criteria	*Marks*
• 1 mark for each detailed discussion	**2**

Relative Intensity of Spectral Lines – some emission lines were brighter than others implying that some electron transitions occurred more often than others

Zeeman effect – when excited hydrogen gas was placed in an external magnetic field, any one emission line split into 3 (or more) lines. This was later explained by Pauli using a 4^{th} quantum no. "m_s – spin"

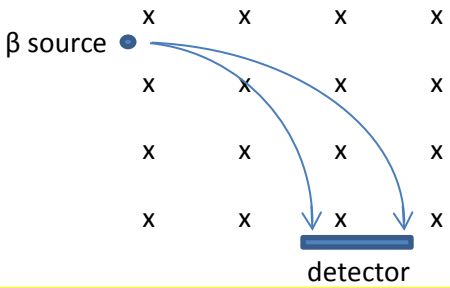
Bohr's model had no (incomplete) explanations for either of these phenomenon

Marks

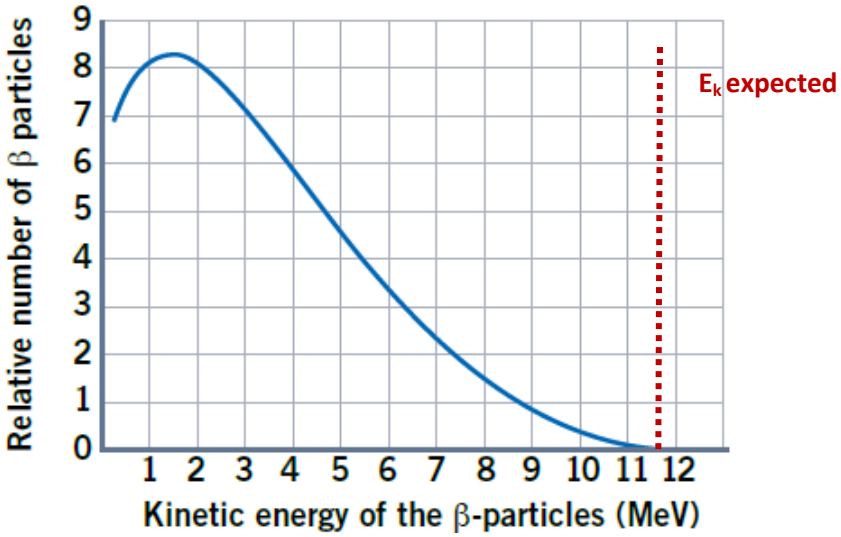
(c) **4**

Marking Criteria	*Marks*
• 4 of experimental background, properties of the neutrino, missing KE in beta decay, conservation laws intact, appropriate graph (alpha decay comparison and "random sharing" may also have been credited)	**4**
• 3 of the above	**3**
• 2 of the above	**2**
• 1 of the above	**1**

When a magnetic spectrometer was used to analyse the KE carried by electrons in beta decay, a spectrum of KEs were detected, evidenced by varying radii of curvature in the magnetic field (see diagram). Some energy seemed to go missing.



The neutrino is a small, fast moving (or high energy) neutral particle that carried away this missing energy and was hypothesised by Pauli to account for the variation of kinetic energy carried by electrons in beta decay. (in contrast, in alpa decay, all helium nuclei were emitted with the same energy).



Pauli hypothesised that the "missing" KE was carried away by the neutrino(s) in order for the conservation laws (energy and momentum) to remain applicable during beta decay.

Marks

(d) **2**

Marking Criteria	*Marks*
• Correctly calculate mass difference AND energy released	**2**
• Correctly calculate mass difference OR energy released	**1**

$$mass\ difference = \Delta m = mass\ of\ reactants - mass of\ products$$

$$\Delta m = (1.0087 + 235.0439) - (87.9056 + 135.9072 + 12(1.0087))$$

$$\Delta m = 0.1354\ u$$

$$\therefore E = (0.1354)(931.5) \approx 126\ MeV$$

(e) **4**

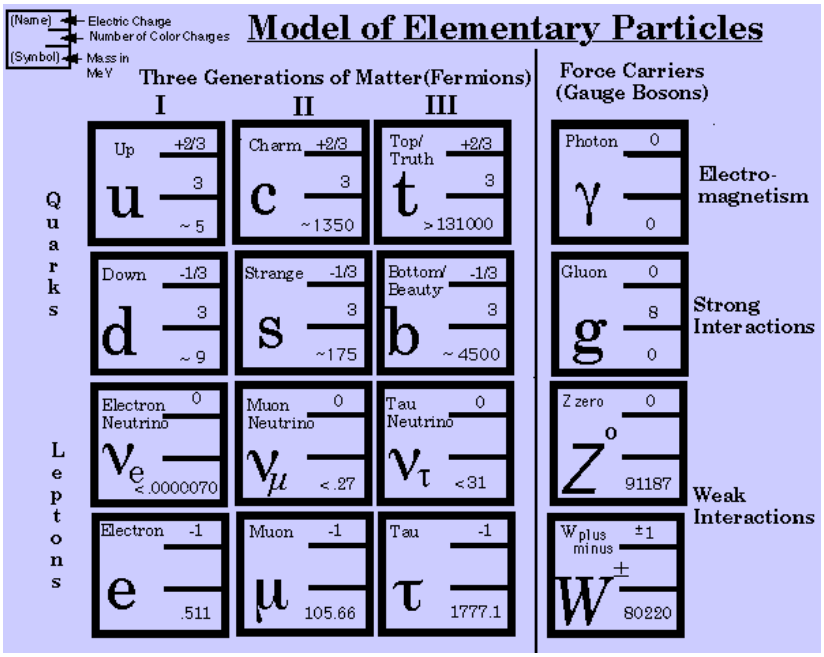
Marking Criteria	*Marks*
• detailed description of the role of each reactor component	**2**
• brief description/outline of the role of the reactor component	**1**

Moderators (eg: heavy water, graphite) are used to slow neutrons down to thermal speeds in order to make their capture by a U-235 nucleus more likely and hence make the fission process more efficient.

Control rods (eg: cadmium, boron) are used to absorb excess neutrons released in the fission process in order to keep the fission chain reaction controlled (i.e: 1neutron fissions a U-235 nucleus and only 1neutron is released to continue the chain reaction).

(f) **7**

Marking Criteria	*Marks*
• detailed description of: quarks and leptons • detailed description of bosons and their role AND correctly linked to force mediated • detailed analysis of the role of particle accelerators	**2** **2** **2**
• brief description/outline of quarks and leptons • brief description of bosons and their role OR correctly linked to force mediated • brief analysis of the role of particle accelerators	**1** **1** **1**
• answer is concise, mostly correct, legible with a logical sequence and flow	**1**



The Standard Model is a theory which attempts to give order to the over 200 particles discovered (mainly through particle accelerator collisions) in the second half of the 20th century, often referred to as a particle zoo.

Matter is made up of two types of fundamental particles – 6 quarks and 6 leptons.

The 6 quarks are made up of 3 generations: the up(u) and down(d) quarks with charges of +2/3e and -1/3e respectively make up the first generation and are the constituents of protons (uud) and neutrons (udd). Respective quarks in 2nd and 3rd generations are charm(c) and strange(s)/ top(t) and bottom(b) respectively.

The 6 leptons also are grouped into 3 generations. The electron is the first generation lepton, the 2nd and 3rd being the muon and tau. All 3 have a charge of –e. All 3 also have an associated neutrino (charge =- 0) making a total of six leptons

The four fundamental forces of nature are mediated by 4 bosons-force carrier particles.
Electromagnetic force – photon
Strong force – gluon
Weak force (responsible for beta decay) - Intermediate vector bosons (w^+, w^- and Z^0)
Gravitational force – graviton (yet to be discovered)

Particle accelerators are complex machines that use electric and/or magnetic fields to accelerate charged particles to extremely high speeds (very close to the speed of light).
An example is the Large Hadron Collider (LHC) which uses both a linear accelerator and a synchrotron to achieve this.

Particle accelerators have been crucial in the development of the Standard Model as it is only through the high energy collisions made possible using particle accelerators such as the LHC that experimental evidence supporting the existence of 2nd and 3rd generation quarks and leptons (and many of the unstable members of the particle zoo) have been confirmed (due to their very large masses-especially 3rd generation).

Marks

Marks

(g) (i) Binding Energy per nucleon **1**

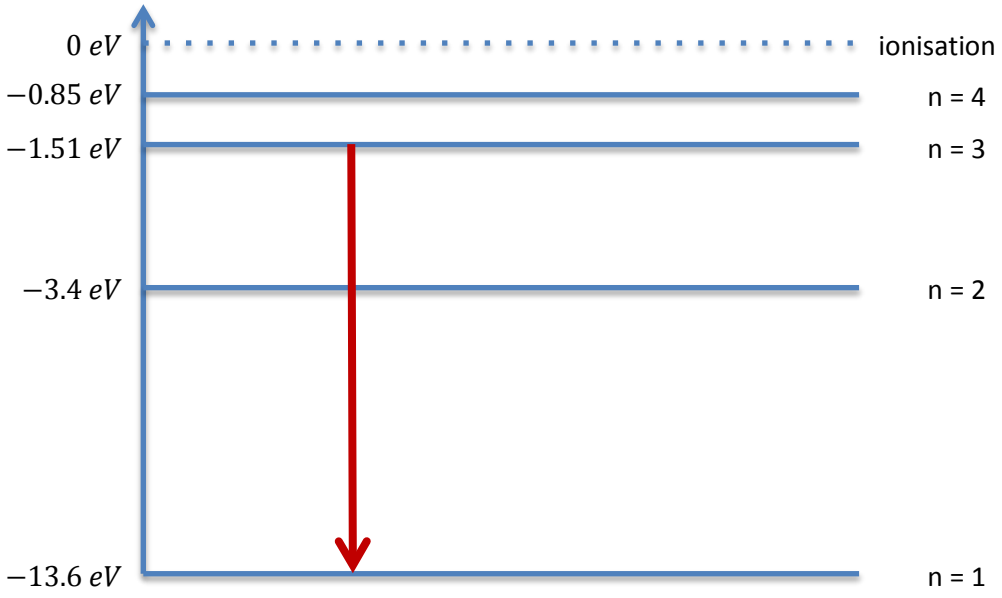
(ii) Graph is a measure of the relative stability of all nuclei **1**

(h) **2**

Marking Criteria	*Marks*
• Correct photon energy calculation AND correct energy transition predicted and arrow drawn	**2**
• Correct photon energy calculation OR correct energy transition predicted and arrow drawn	**1**

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{(103 \times 10^{-9})} = 1.93 \times 10^{-18}\ J \approx 12.06\ eV$$

$$\therefore n = 3 \rightarrow n = 1\ (12.09\ eV)\ is\ the\ correct\ transition)$$



End of exam