2012

TRIAL HSC EXAMINATION

Physics

Student Number	
Mark / 100	

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

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

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

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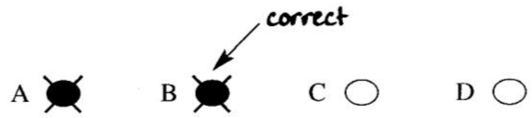


1. The equation $Ep = mgh$, in which g is 9.8 ms^{-2}, cannot be used for calculating the gravitational potential energy of an orbiting Earth satellite.

Which of the following correctly describes the reason for this?

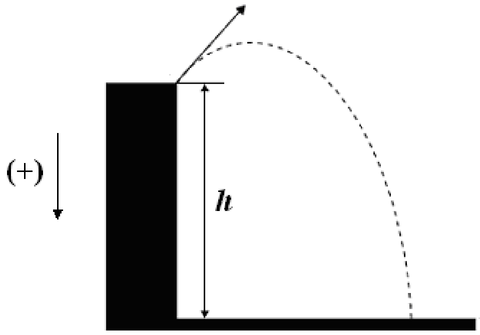
(A) This is because the Earth is rotating

(B) This is because of the influence of other astronomical bodies

(C) This is because the Earth's gravity disappears above the atmosphere

(D) This is because the Earth's gravitational field strength varies with distance

2. A ball is thrown from a cliff as shown.



A student makes the following statements about the ball as it falls down.

I The vertical velocity of the ball increases.
II The vertical acceleration of the ball increases.
III The vertical force on the ball increases.

Which of the statements is/are correct?

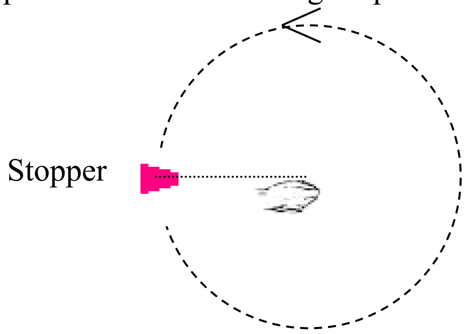
(A) I only

(B) II only

(C) II and III only

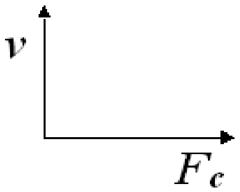
(D) I, II and III

3. In an experiment, a rubber stopper on the end of a string is spun anti-clockwise, as shown below.

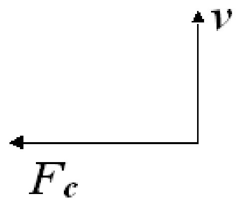


Which diagram below correctly describes the direction of both the stopper's velocity (v) and the centripetal force (F_c) acting on it whilst in the position shown?

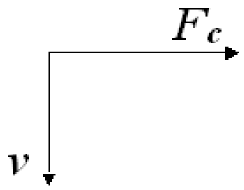
(A)



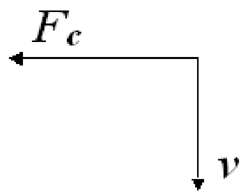
(B)



(C)



(D)



4. Two satellites, X and Y are in orbit at altitudes of 800km and 36000 km respectively.
Which statement about X and Y is correct?

(A) X is in a geostationary orbit

(B) Y is in a low earth orbit.

(C) X will have a smaller orbital speed than Y.

(D) Y will have a smaller orbital speed than X

5. An amount of work, **W**, is expended when a space craft is launched from Earth. The space craft achieves an orbit with kinetic energy **K**.

Which relationship correctly shows the change in the space craft's gravitational potential energy, **P**?

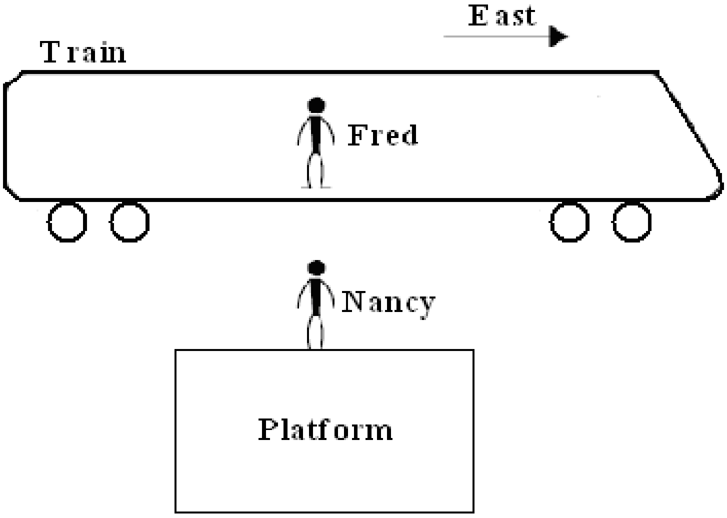
(A) P = W - K

(B) P = W + K

(C) P = K - W

(D) P = - (K + W)

6. The diagram below shows Fred in a futuristic train travelling at constant relativistic velocity in an easterly direction. The train passes a 10 m platform on which Nancy is standing.



Fred measures the carriage he is travelling in to be 20 m long whilst Nancy measures it to be the same length as the platform.

How fast was the train moving, relative to Nancy?

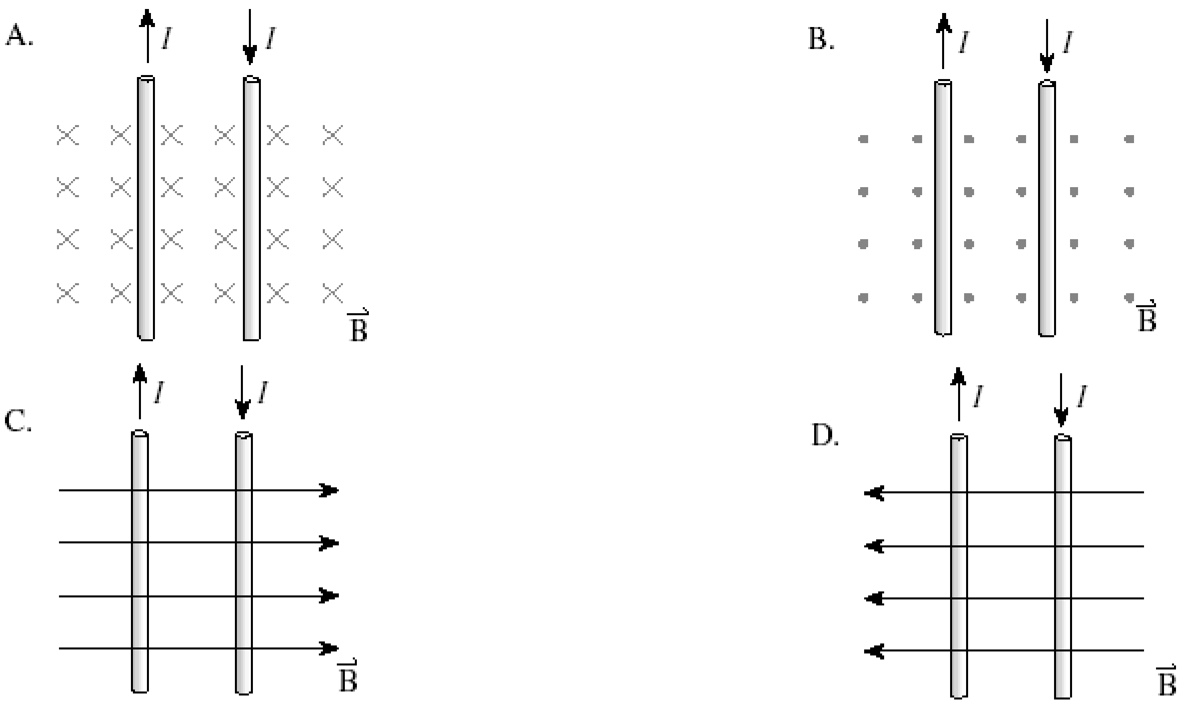
(A) 0.50 c

(B) 0.75 c

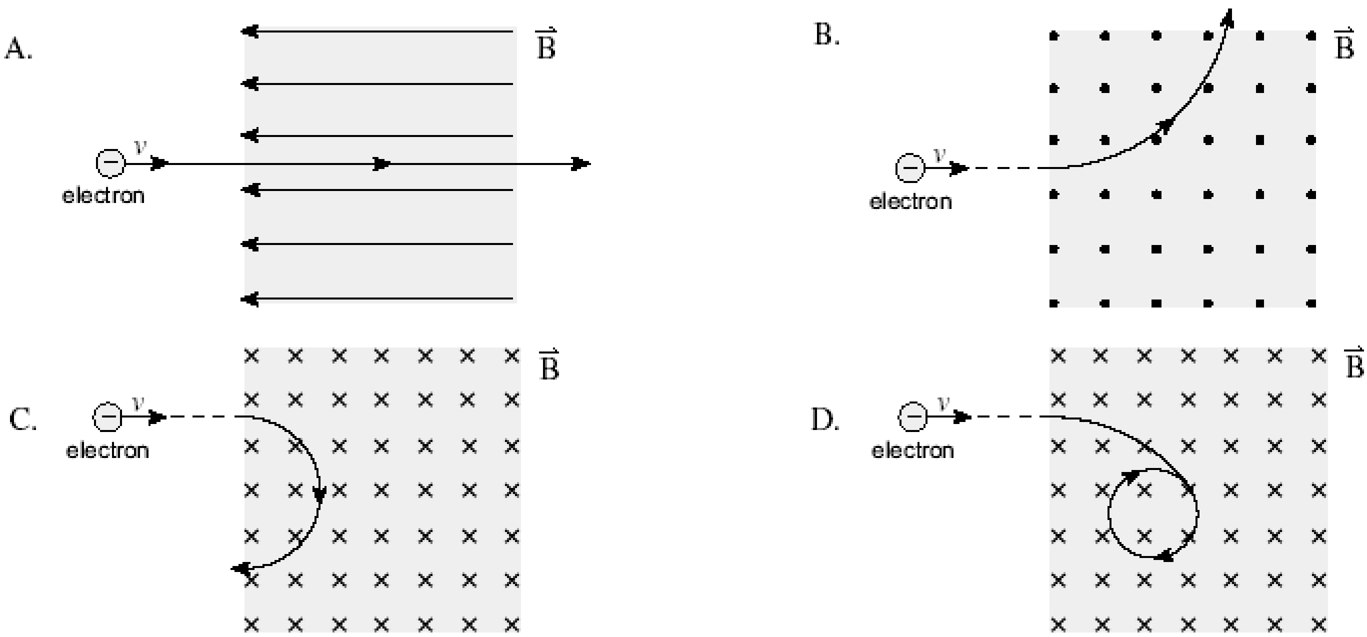
(C) 0.87 c

(D) 0.97 c

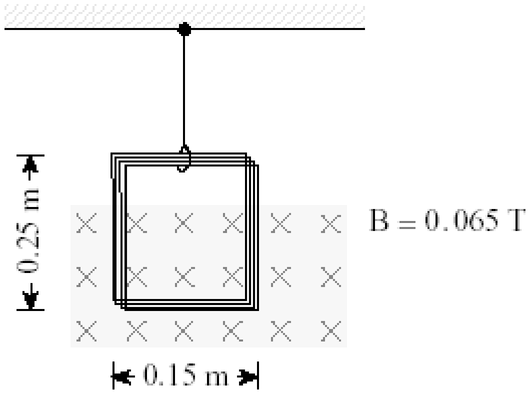
7. In which diagram would an external magnetic field, B , cause two current-carrying wires to move towards one another?



8. An electron, travelling with a constant velocity, enters a region of uniform magnetic field, B. Which of the following is **not** a possible pathway?



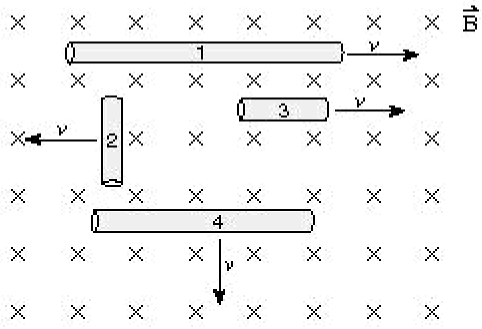
9. A rectangular coil of 25 turns of wire is suspended by a thread. When a current flows through the coil, the tension in the thread is reduced by 4.0×10^{-2} N.



What are the magnitude and direction of the current?

	Magnitude of current	Direction of current
(A)	0.16 A	clockwise
(B)	0.16 A	counter-clockwise
(C)	4.1 A	clockwise
(D)	4.1 A	counter-clockwise

10. Four conductors of different lengths are moved through a uniform magnetic field at the same speed.



Which conductor will induce the greatest emf?

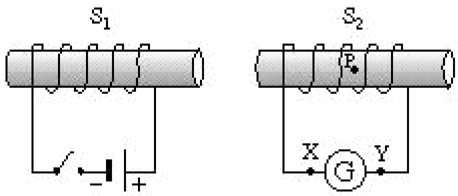
(A) 1

(B) 2

(C) 3

(D) 4

11. Two solenoids S_1 and S_2 are placed close together as shown in the diagram below.



Immediately after the switch is closed, what is the direction of current flow through galvanometer G and what is the direction of the magnetic field produced by this current at position P inside solenoid S_2?

	Direction of current through the galvanometer	Direction of the magnetic field at P
(A)	From X to Y	Left
(B)	From X to Y	Right
(C)	From Y to X	Left
(D)	From Y to X	Right

12. An electric motor is connected to a constant voltage source.
Which of the following observations is correct?

(A) At full speed the applied voltage increases.

(B) At full speed the armature resistance increases.

(C) If the motor is kept from rotating at full speed, the armature heats up.

(D) If the motor is kept from rotating at full speed, the armature temperature decreases.

13. Which of the following statements provides valid reasoning for the transmission of electric energy at high voltage?

(A) At high voltage there will be low current resulting in low power loss.

(B) At high voltage there will be high current resulting in high power loss.

(C) At high voltage there will be low line resistance resulting in low power loss.

(D) At high voltage there will be high line resistance resulting in high power loss.

14. AC induction motors are commonly used in small power tools around the home.
Which of the following alternatives correctly lists an advantage and limitation?

	Advantage	Limitation
(A)	low maintenance on parts	low power
(B)	high power	high maintenance on parts
(C)	low maintenance on parts	high power
(D)	high maintenance on parts	low power

15. Which of the following items was used inside a cathode ray tube to provide evidence for the particle nature of cathode rays?

(A) Parallel charged plates

(B) A Maltese cross

(C) Fluorescent display screen

(D) Glass paddle wheel

16. A particular sample of a semiconductor consists of silicon doped with the group V element, arsenic.
Which of the following properties would apply to this sample?

(A) It would have more protons than electrons.

(B) It would have more electrons than protons.

(C) It would have the same number of electrons and protons.

(D) It would have the same number of electrons and holes.

17. Hertz was the first to produce radio waves and measure their velocity.
What method did he use to determine their velocity?

(A) He measured the time it took them to travel a known distance.

(B) He measured their wavelength by studying interference patterns and then used the formula $v = f\lambda$.

(C) He measured their wavelength by studying resonance in closed pipes and used the formula $v = f\lambda$.

(D) He examined the interference patterns formed between light waves and radio waves.

18. It is found that when an ultra-violet lamp shines onto a metal plate, the plate emits electrons.
What will happen if a second ultra-violet lamp is placed next to the first, so that two ultra-violet lamps shine onto the metal plate?

(A) The number of electrons emitted per unit time will increase.

(B) The maximum kinetic energy of the emitted electrons will increase.

(C) Both the number of electrons per unit time and their maximum kinetic energy will increase.

(D) There will be no change in either the number of electrons emitted per unit time or their maximum kinetic energy

19. What is the main reason that silicon is preferred to germanium in the manufacture of solid-state electronic devices?

(A) Silicon is easier to purify than germanium.

(B) Silicon is more abundant than germanium.

(C) Silicon devices can operate at higher temperatures than germanium devices.

(D) Silicon is a semiconductor whereas germanium is not.

20. How many photons will be emitted from a 60 watt monochromatic light of wavelength 500 nm shining for 1 minute?

(A) 1.5×10^{17}

(B) 9×10^{18}

(C) 1.5×10^{20}

(D) 9×10^{21}

Student Number ……………………

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

Part A

Multiple Choice Answer Sheet

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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 (4 marks) **Marks**

Mars has a mass 0.107358 M_{Earth}. The acceleration due to gravity on Mars is 3.75 ms^{-2}.

(a) Calculate the mass of an astronaut on Mars whose weight is 800 N on Earth. **1**

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(b) Calculate the weight of the astronaut on Mars. **1**

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(c) Determine the radius of Mars relative to the radius of the Earth (R_E). **2**
Express your answer as a ratio.

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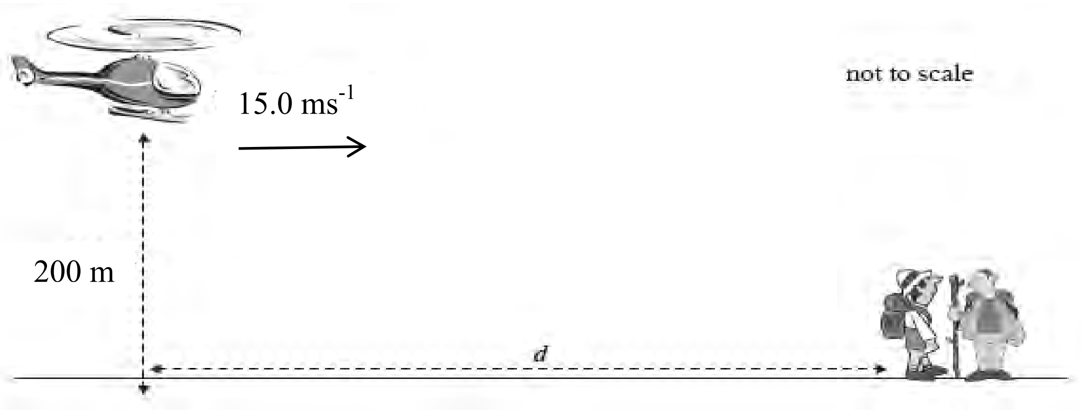
Question 22 (5 Marks) **Marks**

A helicopter is to drop a rescue package to a group of hikers. The helicopter is travelling at a speed of 15.0 ms^{-1} at a constant height of 200 m over the level ground.



(a) The pilot wants to land the package right beside the hikers. At what horizontal distance, *d*, from the hikers must the package be released from the helicopter? **3**

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(b) What is the speed of the package just before it hits the ground? **2**

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Question 23 (6 marks) **Marks**

Information about the Saturn 5 Rocket used in the Apollo Moon Missions is shown in the table below.

Total mass at lift off	2 217 185 kg
Duration of first-stage burn	2.5 minutes
Mass of propellant used in first-stage burn	2 000 000 kg
Height reached after first-stage burn	61 km
Speed at completion of first-stage burn	2.38 kms^{-1}
Thrust produced by first-stage burn	38 000 000 N

With reference to the data in the table above, discuss the change in acceleration and momentum of the rocket and the g-forces experienced by the Apollo astronauts during the first-stage burn of the Saturn 5 Rocket.

Question 24 (3 marks) **Marks**

Nuclear accelerators are used by scientists to accelerate charged subatomic particles to very high speeds. In one accelerator, an electron is accelerated to a speed of 2.8×10^8 ms^{-1}.

(a) If a light beam was sent down the accelerator in the same direction as the moving electron, how fast would the light beam appear to be moving with respect to the electron? **1**

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(b) Calculate the relativistic mass of the moving electron as measured by a scientist in the laboratory frame of reference. **2**

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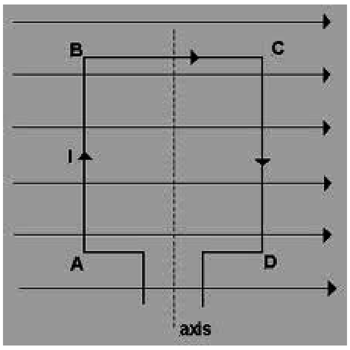
Question 25 (5 marks) **Marks**

A single, square loop of area 20 cm^2 carrying a current of 10 A is placed with the plane of the loop parallel to a magnetic field of strength 0.60 T.



(a) Calculate the magnitude of the torque on this square loop. **1**

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(b) Jo drew the diagram above to demonstrate her understanding of the structure of a DC motor. **4**

With reference to the diagram, assess Jo's understanding of the structure of a DC electric motor consisting of a coil in a single plane.

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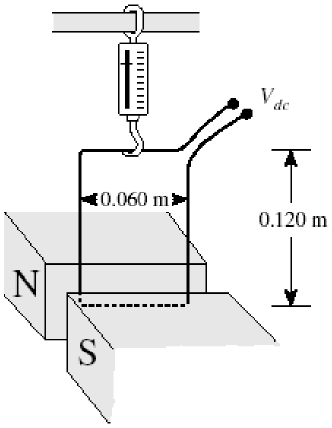
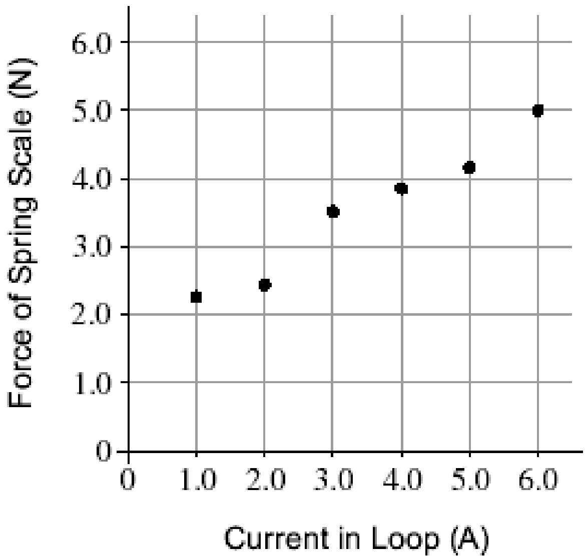
Question 26 (5 marks) **Marks**

A rectangular loop is suspended by a spring scale between magnetic poles. The loop is 0.060 m wide by 0.120 m high.



As the current in the loop is varied, the readings of the spring scale and current are plotted on a graph.



(a) What is the weight, in N, of the loop? **1**

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(b) What is the slope of the line of best fit? **2**

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(c) What is the strength of the magnetic field? **2**

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Question 27 (3 marks) **Marks**

An electric device operates on 9 V AC and has a total resistance of 21 Ω. An ideal transformer is used to change the incoming line voltage of 120 V AC to the operating voltage of 9 V AC.

(a) Is the transformer a step-up or step-down transformer? **1**

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(b) Calculate the current in the primary side? **2**

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Question 28 (3 Marks)

Account for the production of back emf in the coils of a DC electric motor. **3**

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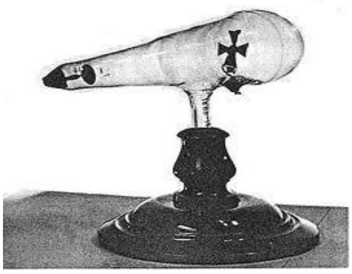
Question 29 (8 marks) **Marks**

The following diagram shows part of the experimental set up for the identification of some properties of cathode rays.



(a) Describe the observations made when the metal target was upright in the path of the cathode rays. **2**

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(b) Identify the properties of cathode rays that are revealed by the observation you have described in part (a). **2**

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(c) Explain why the apparent inconsistent behaviour of cathode rays caused a debate as to whether they were charged particles or electromagnetic waves. **2**

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(d) Identify any risks in this experiment and describe how you will minimise such risks. **2**

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Question 30 (7 Marks) **Marks**

The Hertz experiment was thought, in 1888, to have provided final experimental evidence as to the nature of electromagnetic radiation such as light.

Discuss the methods employed in the Hertz experiment and the model of light that his experimental results clearly supported.

Question 31 (6 marks) **Marks**

(a) Draw labelled diagrams of energy bands to account for the electrical properties of n-type and p-type semiconductors. **2**

(b) Describe how doping can be used to produce n-type and p-type semiconductors and the resulting electrical properties of these materials. **4**

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

(a) Evaluate the Bohr model of the atom. **4**

(b) (i) Write an equation for the natural transmutation of uranium -238 by alpha decay. **1**

(ii) A cobalt-59 nuclide captures a neutron to become cobalt-60 with a half-life of 5.3 years. The nuclear masses and other data are given: **2**

Cobalt - 59 = 58.9332 u
Cobalt - 60 = 59.9338 u
Neutron = 1.00867 u

Calculate the mass defect and the energy released per cobalt-60 nucleus.

(b) Neutron scattering and particle accelerators are both used as probes to study the structure of matter. **6**

Outline these two very different techniques and give one application of each.

(d) Assess the significance of Davisson and Germer's experiment. **3**

(e) The work of Chadwick led to many practical applications of nuclear physics.

(i) Draw a labelled sketch of the experiment that Chadwick performed in the discovery of the neutron. **3**

(ii) When Chadwick discovered the neutron he estimated it's mass. **2**
State how he applied the laws of physics to make this estimate.

(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.

End of examination

2012

TRIAL HSC
EXAMINATION

Physics

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Section II Page 21

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Section I
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Part A – 20 marks
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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

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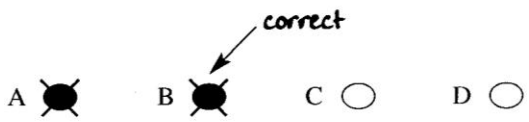


1. The equation $Ep = mgh$, in which g is 9.8 ms^{-2}, cannot be used for calculating the gravitational potential energy of an orbiting Earth satellite.

Which of the following correctly describes the reason for this?

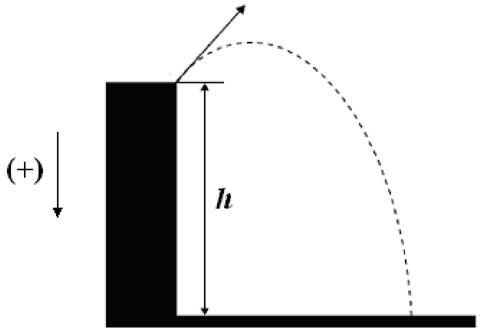
(A) This is because the Earth is rotating

(B) This is because of the influence of other astronomical bodies

(C) This is because the Earth's gravity disappears above the atmosphere

(D) This is because the Earth's gravitational field strength varies with distance

2. A ball is thrown from a cliff as shown.



A student makes the following statements about the ball as it falls down.

I The vertical velocity of the ball increases.
II The vertical acceleration of the ball increases.
III The vertical force on the ball increases.

Which of the statements is/are correct?

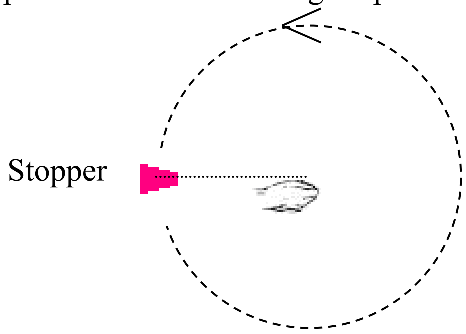
(A) I only

(B) II only

(C) II and III only

(D) I, II and III

3. In an experiment, a rubber stopper on the end of a string is spun anti-clockwise, as shown below.



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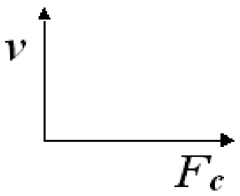

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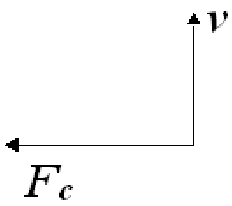

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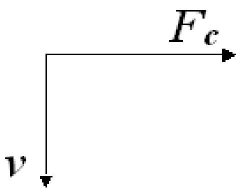
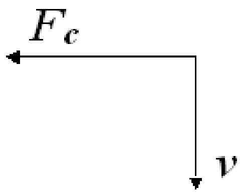


(D)


4. Two satellites, X and Y are in orbit at altitudes of 800km and 36000 km respectively. Which statement about X and Y is correct?

(A) X is in a geostationary orbit

(B) Y is in a low earth orbit.

(C) X will have a smaller orbital speed than Y.

(D) Y will have a smaller orbital speed than X

5. An amount of work, **W**, is expended when a space craft is launched from Earth. The space craft achieves an orbit with kinetic energy **K**.

Which relationship correctly shows the change in the space craft's gravitational potential energy, **P**?

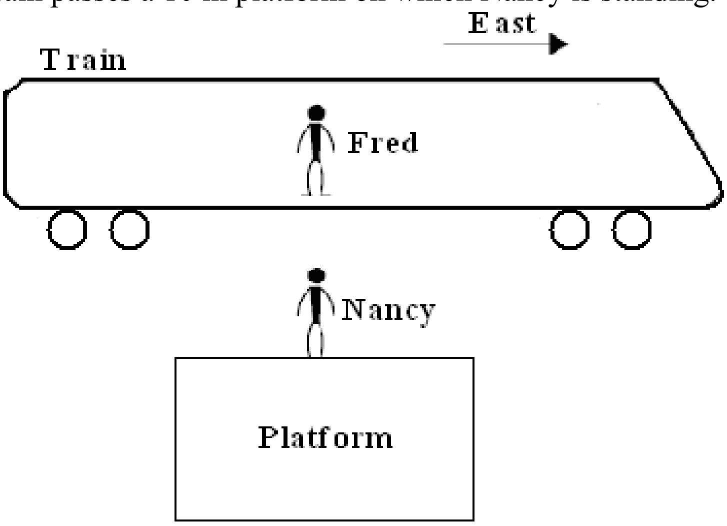
(A) P = W - K

(B) P = W + K

(C) P = K - W

(D) P = - (K + W)

6. The diagram below shows Fred in a futuristic train travelling at constant relativistic velocity in an easterly direction. The train passes a 10 m platform on which Nancy is standing.



Fred measures the carriage he is travelling in to be 20 m long whilst Nancy measures it to be the same length as the platform.

How fast was the train moving, relative to Nancy?

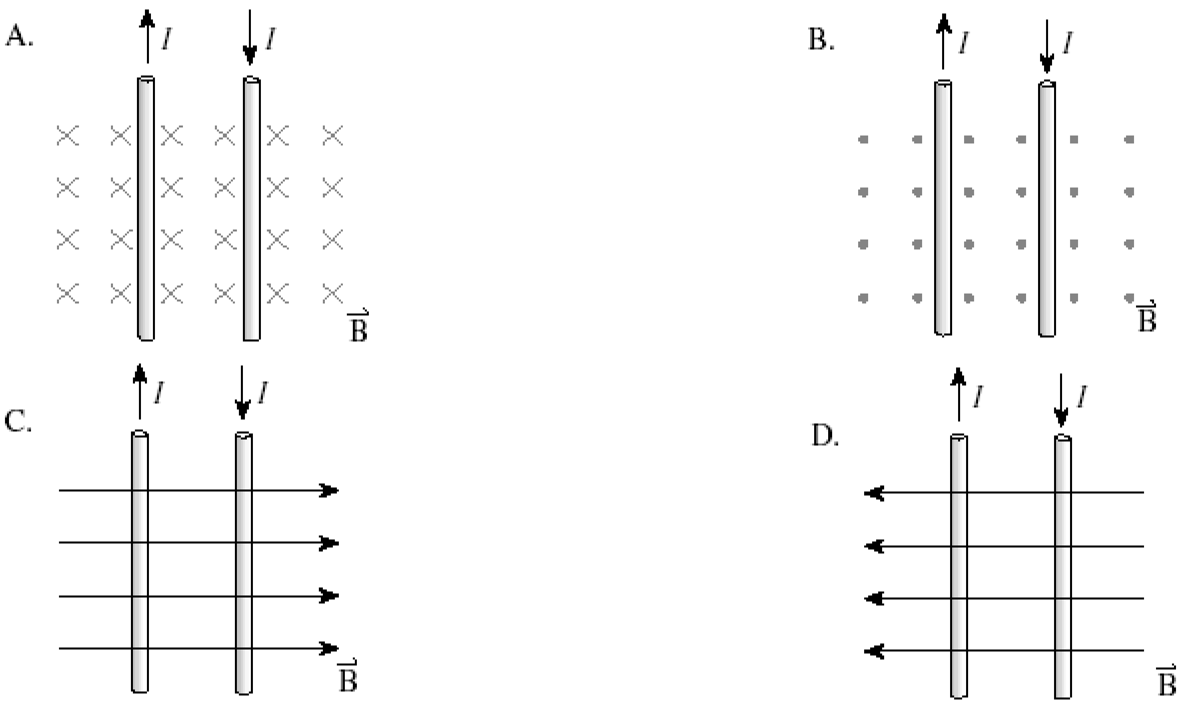
(A) 0.50 c

(B) 0.75 c

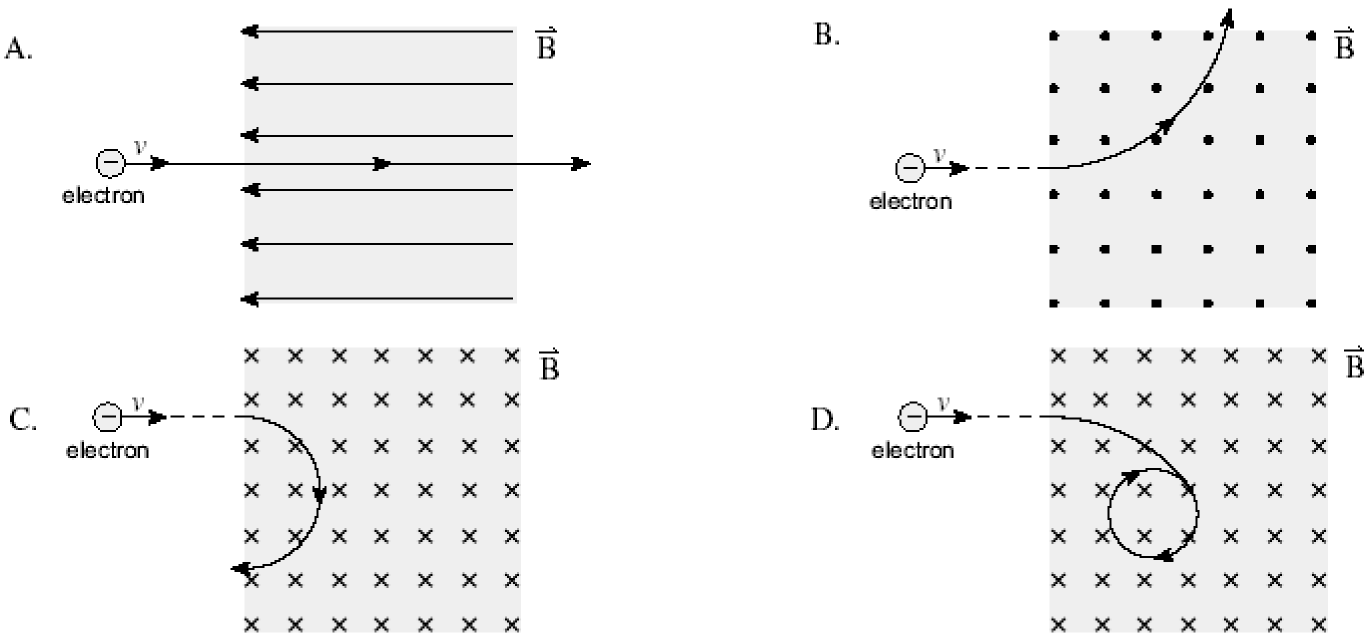
(C) 0.87 c

(D) 0.97 c

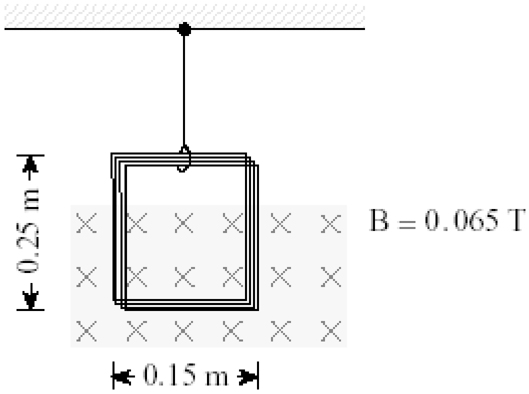
7. In which diagram would an external magnetic field, B , cause two current-carrying wires to move towards one another? B



8. An electron, travelling with a constant velocity, enters a region of uniform magnetic field, B. Which of the following is **not** a possible pathway? D



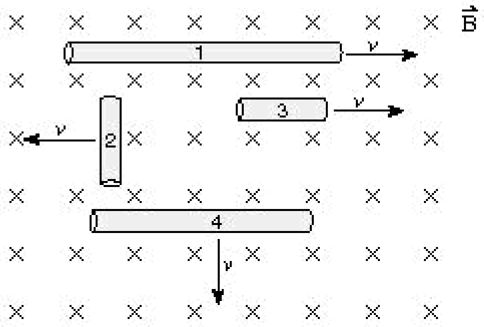
9. A rectangular coil of 25 turns of wire is suspended by a thread. When a current flows through the coil, the tension in the thread is reduced by 4.0×10^{-2} N.



What are the magnitude and direction of the current?

	Magnitude of current	Direction of current
(A)	0.16 A	clockwise
(B)	0.16 A	counter-clockwise
(C)	4.1 A	clockwise
(D)	4.1 A	counter-clockwise

10. Four conductors of different lengths are moved through a uniform magnetic field at the same speed.



Which conductor will induce the greatest emf?

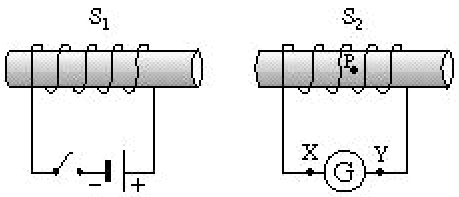
(A) 1

(B) 2

(C) 3

(D) 4

11. Two solenoids S_1 and S_2 are placed close together as shown in the diagram below.



Immediately after the switch is closed, what is the direction of current flow through galvanometer G and what is the direction of the magnetic field produced by this current at position P inside solenoid S_2?

	Direction of current through the galvanometer	Direction of the magnetic field at P
(A)	From X to Y	Left
(B)	From X to Y	Right
(C)	From Y to X	Left
(D)	From Y to X	Right

12. An electric motor is connected to a constant voltage source.
Which of the following observations is correct?

(A) At full speed the applied voltage increases.

(B) At full speed the armature resistance increases.

(C) If the motor is kept from rotating at full speed, the armature heats up.

(D) If the motor is kept from rotating at full speed, the armature temperature decreases.

13. Which of the following statements provides valid reasoning for the transmission of electric energy at high voltage?

(A) At high voltage there will be low current resulting in low power loss.

(B) At high voltage there will be high current resulting in high power loss.

(C) At high voltage there will be low line resistance resulting in low power loss.

(D) At high voltage there will be high line resistance resulting in high power loss.

14. AC induction motors are commonly used in small power tools around the home.
Which of the following alternatives correctly lists an advantage and limitation?

	Advantage	Limitation
(A)	low maintenance on parts	low power
(B)	high power	high maintenance on parts
(C)	low maintenance on parts	high power
(D)	high maintenance on parts	low power

15. Which of the following items was used inside a cathode ray tube to provide evidence for the particle nature of cathode rays?

(A) Parallel charged plates

(B) A Maltese cross

(C) Fluorescent display screen

(D) Glass paddle wheel

16. A particular sample of a semiconductor consists of silicon doped with the group V element, arsenic.
Which of the following properties would apply to this sample?

(A) It would have more protons than electrons.

(B) It would have more electrons than protons.

(C) It would have the same number of electrons and protons.

(D) It would have the same number of electrons and holes.

17. Hertz was the first to produce radio waves and measure their velocity.
What method did he use to determine their velocity?

(A) He measured the time it took them to travel a known distance.

(B) He measured their wavelength by studying interference patterns and then used the formula $v = f\lambda$.

(C) He measured their wavelength by studying resonance in closed pipes and used the formula $v = f\lambda$.

(D) He examined the interference patterns formed between light waves and radio waves.

18. It is found that when an ultra-violet lamp shines onto a metal plate, the plate emits electrons.
What will happen if a second ultra-violet lamp is placed next to the first, so that two ultra-violet lamps shine onto the metal plate?

(A) The number of electrons emitted per unit time will increase.

(B) The maximum kinetic energy of the emitted electrons will increase.

(C) Both the number of electrons per unit time and their maximum kinetic energy will increase.

(D) There will be no change in either the number of electrons emitted per unit time or their maximum kinetic energy

19. What is the main reason that silicon is preferred to germanium in the manufacture of solid-state electronic devices?

(A) Silicon is easier to purify than germanium.

(B) Silicon is more abundant than germanium.

(C) Silicon devices can operate at higher temperatures than germanium devices.

(D) Silicon is a semiconductor whereas germanium is not.

20. How many photons will be emitted from a 60 watt monochromatic light of wavelength 500 nm shining for 1 minute?

(A) 1.5×10^{17}

(B) 9×10^{18}

(C) 1.5×10^{20}

(D) 9×10^{21}

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 (4 marks) **Marks**

Mars has a mass 0.107358 M_{Earth}. The acceleration due to gravity on Mars is 3.75 ms^{-2}.

(a) Calculate the mass of an astronaut on Mars whose weight is 800 N on Earth. **1**

Marking Criteria	Marks
• Correct answer with units	1

Mass will be the same on Alpha as it is on Earth i.e. 800 / 9.8 = 80 kg (approx.)

(b) Calculate the weight of the astronaut on Mars. **1**

Marking Criteria	Marks
• Correct answer	1

Weight will be (3.75/9.8) × 800 = 306 N

(c) Calculate the radius of Mars compared to the radius of the Earth (R_E). **2**

Marking Criteria	Marks
• Correct working and answer	2
• Partially correct working and answer	1

Use $g = GM / r^2$ *for both Mars and Earth, then compare.*

$r = \sqrt{GM/g}$

$r_{mars}/r_{earth} = \sqrt{\{GM_{mars}/g_{mars} \div GM_{earth}/g_{earth}}$

$= \sqrt{\ g_{earth}/g_{mars} \times M_{mars}/)}$

$= \sqrt{\ (9.8/3.75) \times\ 0.107358M_{earth}/M_{earth}}$

$= \sqrt{\ (0.107358)/(3.75/9.8)}$

$\therefore\ r_{Mars} = 0.53\ r_{Earth}$

OR

Use $r_{mars} = \sqrt{GM_{mars}/g_{mars}}$

$= \sqrt{\ (6.67\times10^{-11})(0.107358\ M_{earth})\ /\ 3.75}$

$\approx 3.38\times10^{6}$ m

$r_{earth} = \sqrt{GM_{earth}/g_{earth}}$

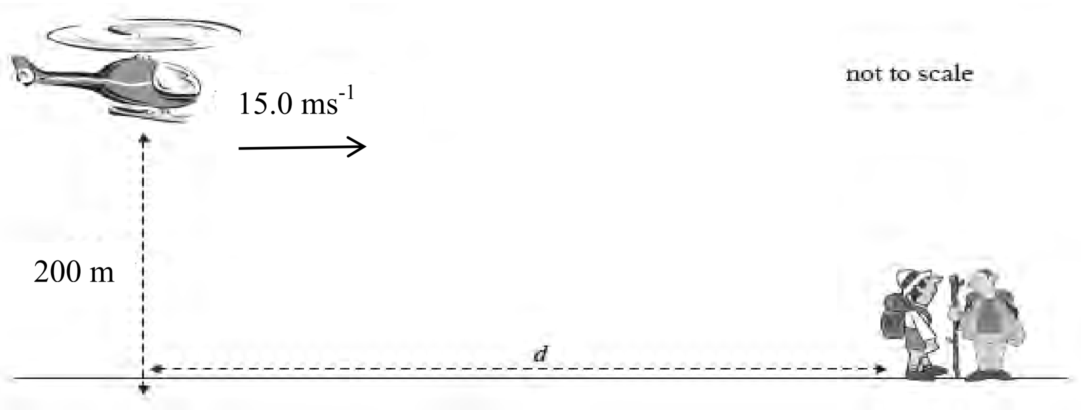
$= \sqrt{\ (6.67\times10^{-11})(M_{earth})\ /\ 9.8}$

$\approx 6.38\times10^{6}$ m

$\therefore\ r_{Mars} = 0.53\ r_{Earth}$

Question 22 (5 Marks) **Marks**

A helicopter is to drop a rescue package to a group of hikers. The helicopter is travelling at a speed of 15.0 ms^{-1} at a constant height of 200 m over the level ground.



(a) The pilot wants to land the package right beside the hikers. At what horizontal distance, *d*, from the hikers must the package be released from the helicopter? **3**

Marking Criteria	Marks
• Correct working and answer for time **AND** correct working and answer for distance	3
• Partially correct working and answer for time **AND** correct working and answer for distance OR correct working and answer for time only	2
• Partially correct working and answer for time **OR** correct working and answer for distance	1

$u_y = 0$

$\therefore s_y = \frac{1}{2} at^2$

$t = \sqrt{2s/a}$

≈ 6.39 s

$d = u_x t$

$= 15 \times 6.39$

≈ 95.8 (or 96) m

(b) What is the speed of the package just before it hits the ground? **2**

Marking Criteria	Marks
Correct working and answer for vertical component of speed **AND** correct final speed by vector addition	2
Correct working and answer for vertical component of speed **OR** correct final speed by vector addition	1

$v_y = a_y t$

$\approx 9.8 \times 6.38$

$\approx 62.6\ ms^{-1}$

$v = \sqrt{v_x^2 + v_y^2}$

$\approx \sqrt{62.6^2 + 15^2}$

$\approx 64.4\ ms^{-1}$

Question 23 (6 marks) **Marks**

Information about the Saturn 5 Rocket used in the Apollo Moon Missions is shown in the table below.

Total mass at lift off	2 217 185 kg
Duration of first-stage burn	2.5 minutes
Mass of propellant used in first-stage burn	2 000 000 kg
Height reached after first-stage burn	61 km
Speed at completion of first-stage burn	2.38 kms^{-1}
Thrust produced by first-stage burn	38 000 000 N

With reference to the data in the table above, discuss the **change in acceleration and momentum** of the rocket and the **g-forces experienced by the Apollo astronauts** during the first-stage burn of the Saturn 5 Rocket.

Marking Criteria	Marks
The discussion should include: • 2 accurate statements about the acceleration of the rocket giving reason(s), including laws of physics • 2 accurate statements about the momentum of the rocket giving reason(s), including laws of physics • 2 accurate statements about the g-forces experienced by the astronauts in the rocket giving reason(s), including laws of physics.	**6**
• Any 5 of the above	**5**
• Any 4 of the above	**4**
• Any 3 of the above	**3**
• Identifies 3 changes but gives no correct reasons	**2**
• Identifies 2 changes but gives no correct reasons	**1**

Acceleration:

1. Fuel is being consumed, resulting in a decrease in the mass **m** of the rocket. The upward thrust **T** remains constant.

$\therefore$ **a = T –mg / m**, (Newton's 2nd Law) and **a** gradually increases.

2. Direction of velocity changes from being vertical to horizontal as rocket goes into orbit, thus a is no longer reduced by g

3. As rocket moves further from planet, the weight of the rocket **mg** decreases.

g forces:

As acceleration increases, g force increases from 1 g (according to g-force = 1 + a/g) before launch to ≈ 3 – 4*g* during the first 2.5 minutes.

Momentum of the rocket:

$\Delta p_{rocket} = -\Delta p_{fuel}$ (Newton's 3rd Law) and $\therefore$ the rocket is continually gaining momentum as Δp_{rocket} is positive (upwards).

Question 24 (3 marks) **Marks**

Nuclear accelerators are used by scientists to accelerate charged subatomic particles to very high speeds. In one accelerator, an electron is accelerated to a speed of 2.8×10^8 ms^{-1}.

(a) If a light beam was sent down the accelerator in the same direction as the moving electron, how fast would the light beam appear to be moving with respect to the electron? **1**

Marking Criteria	Marks
• Correct answer	1

$c = 3 \times 10^8$ ms^{-1}

(b) Calculate the relativistic mass of the moving electron as measured by a scientist in the laboratory frame of reference. **2**

Marking Criteria	Marks
• Correct working and answer	2
• Partially correct working and answer	1

$m = \gamma m_o$ where $\gamma = 1 / \sqrt{1 - v^2/c^2}$

$\gamma = 1 / \sqrt{1 - 2.8^2/3^2}$

≈ 2.785

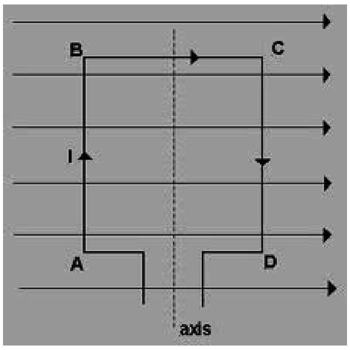
$\therefore m = \gamma m_o$

$\therefore m = 2.785\ m_o$

$\approx 2.5 \times 10^{-30}$ kg

Question 25 (5 marks) **Marks**

A single, square loop of area 20 cm^2 carrying a current of 10 A is placed with the plane of the loop parallel to a magnetic field of strength 0.60 T.



(a) Calculate the magnitude of the torque on this square loop. **1**

Marking Criteria	Marks
• Formula and correct substitution and units	1
• Incorrect substitution or missing units • Failed to convert 20 cm^2 to m^2 • Expressed torque in T, or any other crazy unit	0

$\tau = nBIA$

$= 1\times 0.60 \times 10 \times (2\times10^{-3})$

$= 0.012$ Nm

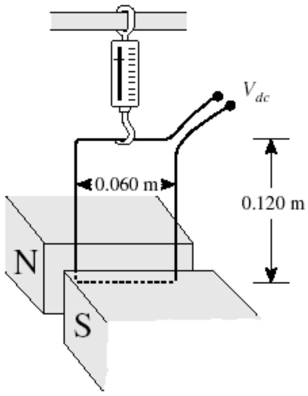
(b) Jo drew the diagram above to demonstrate her understanding of the structure of a DC motor. **3**
With reference to the diagram, assess Jo's understanding of the structure of a DC electric motor consisting of a coil in a single plane.

Marking Criteria	Marks
An assessment of the model based on any three of the following: • Only 1 loop used unlike motor with several loops • No commutator – with brief function • No brushes – with brief function • Radial magnetic field • Power source • Arnature, axle, rotor	4
• An assessment of the model based on any two of the above	3
An assessment of the model based on any one of the above • Any 2 of the above	2
An assessment of the model only	1

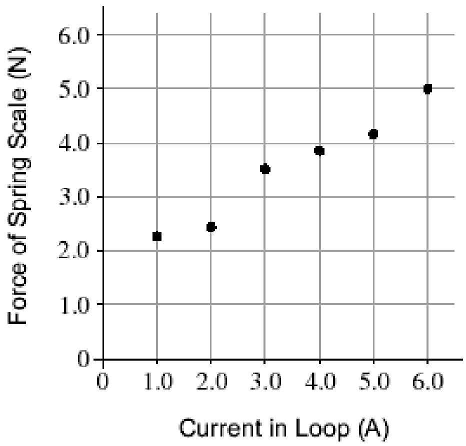
Jo showed some understanding of the principles of the DC motor, but the diagram is inadequate to show the structure of a DC motor. Some omissions were:
Only 1 loop used unlike motor with several loops
No commutator
No brushes
Radial magnetic field
No power source
No axle, armature, rotor etc.

Question 26 (5 marks)

A rectangular loop is suspended by a spring scale between magnetic poles. The loop is 0.060 m wide by 0.120 m high.



As the current in the loop is varied, the readings of the spring scale and current are plotted on a graph.



(a) What is the weight, in Newtons, of the loop? **1**

Marking Criteria	Marks
• Based on line of best fit from graph, including units	1

1.5 N

(b) What is the slope of the best fit line? **2**

Marking Criteria	Marks
• Gradient of line with working shown and units	2
• Gradient without working or no units	1

0.58 N/A

(c) What is the magnitude of the magnetic field? 2

Marking Criteria	Marks
• Formula with correct substitution and units	2
• Incorrect substitution or units missing	1
• If individual points used (rather than slope) into $F = BiL$, then maximum 1	1

$$B = \frac{slope}{L} = \frac{0.58}{0.06} = 9.7\ T$$

Question 27 (4 marks)
An electric device operates on 9.0 V ac and has a total resistance of 21 Ω. An ideal transformer is used to change the incoming line voltage of 120 V ac to the operating voltage of 9.0 V ac.

(a) Is the transformer a step-up or step-down transformer? **1**

Marking Criteria	Marks
• Identify as step down transformer	1

step down

(b) What is the current in the primary side? **2**

Marking Criteria	Marks
• Correctly calculating both Is and Ip	2
• Correctly calculating either Is or Ip	2

$I_s = V_s/R_s$
$= 9/21A$
≈ 0.429 A

$V_pI_p = V_s I_s$
$I_p = V_s I_s / V_p$
$\approx 9\times0.429 / 120$
$I_p \approx 0.032$ A (9/280 A)

Question 28 (3 Marks)

Account for the production of back emf in the coils of a DC electric motor. **3**

Marking Criteria	Marks
• Correctly accounts for back emf using the terms $\Delta\Phi$, emf_{ind} (Faraday's law) and its **opposition to change causing it** (opposing supply emf (Lenz's law))	3
• 2 of the above	2
• 1 of the above	1

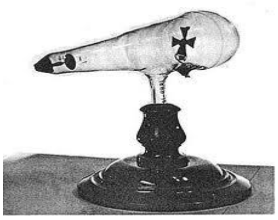
When the coil of the DC motor rotates inside the external magnetic field, the coil experiences a changing magnetic flux ($\Phi = BA$ B is constant; A changes from max to zero). This changing magnetic flux induces an emf ($\mathcal{E}$) in the coil, (Faraday's Law: $\mathcal{E}_{ind} = n\Delta\Phi/\Delta t$).

As a consequence of Lenz's law, $\mathcal{E}_{ind}$ is set up in such a way that it will oppose the changing magnetic flux that caused it (cause of induction - the rotation of the coil).

The back emf opposes the supply emf (as a necessary consequence of the conservation of energy).

Question 29 (8 marks) **Marks**

The following diagram shows part of the experimental set up for the identification of some properties of cathode rays.



(a) Describe the observations made when the metal target was upright in the path of the cathode rays. 2

Marking Criteria	Marks
• Any two of the observations	**2**
• Any one of the observations	**1**

Sample answer:

(i) A sharp shadow is cast on the inside of the discharge tube (opposite end to the cathode).
(ii) The opposite end to the cathode fluoresces, when the cathode rays impinge onto it.
(iii) A green beam of light is seen emanating from the cathode.
(iv) The rays leave the cathode at right angles (Cathode rays travel from cathode to anode)

Not accepted: shadow magnified, or uniform colour

(b) Identify the properties of cathode rays that is revealed by the observation you have described in part (a)

Marking Criteria	Marks
• Any two of the properties directly linked to the correct observation	**2**
• Any one of the properties directly linked to the correct observation	**1**

Sample answer

(i) Cathode rays travel in straight lines.
(ii) Cathode rays fluoresces when exposed to a material that is coated with sensitive fluorescent material.
(iii) Cathode rays blocked by metal target – hence are particles
(iv) Sharp shadow, hence not diffracted – hence particle

(c) Explain why the apparent inconsistent behaviour of cathode rays caused a debate as to whether they were charged particles or electromagnetic waves. 2

Marking Criteria	Marks
• Illustrates both wave and particle characteristics and sites experimental ,evidence.	**2**
• Illustrates both wave and particle characteristics without experimental evidence	**1**

Sample Answer

In some cases, cathodes rays behave as a particle (paddle wheel discharge tube, deflection in a magnetic field as Observed by English Physicists (Crookes etc)). However it was found that these cathode rays were NOT deflected by an electric field by Hertz and the Germans due to insufficiently evacuated tubes and rays passing through thin gold foil, which all lead them to believe in the wave nature. Hence this inconsistent behaviour caused much debate.

(d) Explain the risks involved when conducting this experiment. 2

Marking Criteria	Marks
• One risk identified and steps indicated to mitigate against the risk	2
• One risk identified but no steps indicate to mitigate against the risk	1

Sample Answer

(i) Due to the high voltage source (High tension or induction coil), care must be taken to avoid electric shocks by avoiding direct contact with the equipment during operation.

(ii) Cathode rays when striking a metal target produce X-rays, which are harmful. To avoid exposure observations must be made from at least 3 m from the source.

(iii) The induction coil also produces harmful X-rays, hence +- 3 m exclusion zone

Question 30 (7 Marks) **Marks**

The Hertz experiment was thought, in 1888, to have provided final experimental evidence as to the nature of electromagnetic radiation such as light.

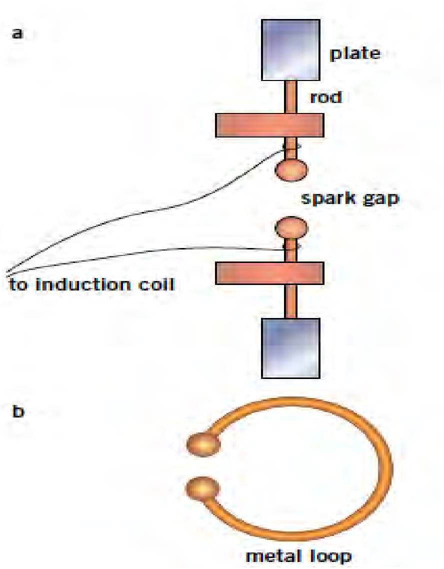
Discuss the methods employed in the Hertz experiment and the model of light that his experimental results clearly supported.

Marking Criteria	Marks
• Provides a detailed description of Hertz's experiment (use of a diagram) and includes properties of EM waves i.e. speed, refraction, polarisation, interference, effect of uv, clearly linking the result t to the model of light supported by them	7
• Provides a detailed description of Hertz's experiment and includes two of the properties of EM waves, clearly linking the result to the model of light supported by them	6
• Provides a detailed description of Hertz's experiment and includes one of the properties of EM waves, clearly linking the result to the model of light supported by them	5
• Provides a detailed description of Hertz's experiment only clearly linking the result to the model of light supported by them	4
• Provides a sketchy description of Hertz's experiment, without identifying the apparatus	3
• Provides a brief description of Hertz' experiment without reference to the actual components of the apparatus	2
• Provides a labelled diagram only of the experimental set up	1

Sample Answer

Maxwell – EM waves exist with a range of frequencies, and propagate through space at the speed of light. Hence Hertz used the following apparatus to demonstrate the production of EM waves:

(i) Radio wave transmitter, pair of metal rods with spark gap



(ii) Radio wave receiver of various designs, including a spark gap

(iii) Induction coil as a high voltage (oscillating) source

Hertz used an induction coil (high voltage source) to place charges on the rods so that sparks (oscillating currents) could jump across the gaps. This was the transmitter.

By placing another metal rod (with gaps) nearby, Hertz found that sparks also jumped across the gaps, even though this set up was completely separate from the transmitter. This set up was called the receiver.

Hertz showed that the frequency of the EM waves produced by the transmitter, matched that produced by the receiver.

By considering standing waves that were set up in a large flat zinc sheet, he measured the wavelength of the standing waves (node to node), and knowing the frequency of the oscillating source, he was able to calculate the speed of the EM waves to within as c (+- 7% error).

By passing these EM waves through an asphalt prism, he showed that these waves could under refraction. He also demonstrated that the EM wave had an electric and magnetic component and hence showed that they can be polarised.

By suing parabolic mirrors, he showed that they can be reflected.

Further, Hertz also found that by shining light on the receiver loop, more sparks were generated, which was not pursued any further. This phenomenon , the photoelectric effect, which was later followed up by Einstein, showed that EMR is particle in nature, a model of EMR widely accepted.

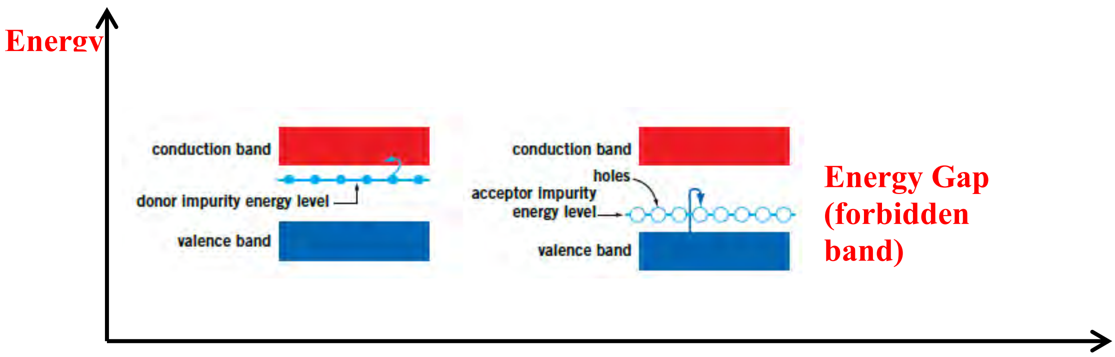
Hertz's experiment thus demonstrated that EMR has wave and particle properties and both lend strong credence to the wave particle duality of light.

Question 31 (6 marks) **Marks**

(a) Draw labelled diagrams of energy bands to account for the electrical properties of n-type and p-type semiconductors. **2**

Marking Criteria	Marks
• Correctly shows the valance and conduction bands, donar and acceptor energy levels, holes and electrons, forbidden band (energy gap) AND the vertical axis as the energy axis	2
• Correctly shows all of the above, but leaves out one of vb/cb; fb, del, ael, e/e^+ or vert axis	1

Sample Answer



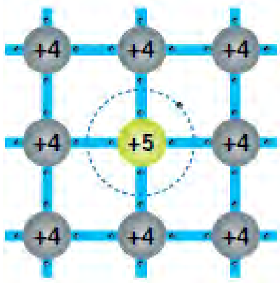
(b) Describe how doping can be used to produce n-type and p-type semiconductors and the resulting electrical properties of these materials. **4**

Marking Criteria	Marks
• Describes in correct detail the doping process using examples (group iii and v atoms in Si) and showing how the conductivity of the materials is increased.	4
• Describes in moderate detail the doping process using examples (group iii and v atoms in Si) and showing how the conductivity of the materials is increased.	3
• Describes in detail the doping process without using examples (group iii and v atoms in Si) and showing how the conductivity of the materials is increased.	2
• Describes in sketchy detail, without examples and no mention of increased conductivity	1

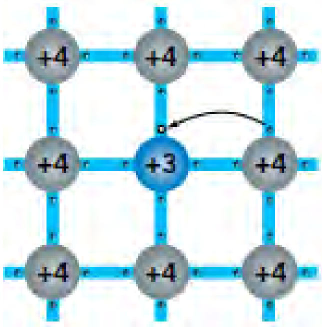
Sample answer

The $E_K^{Ave}(electron) \approx 0.026eV < Energy\ gap\ for\ Si\ (1.14\ eV)$. Si does not have many of these low and even high energy electrons to jump this gap and assist in the conductivity. However, by adding an impurity (i.e. by doping), the conductivity of Si can be significantly enhanced.

To produce an n-type semiconductor, an atom from group (v) element (with an extra valence electron) is used as a dopant; e.g. P atom from group V can donate an electron to Si (which has 4 electrons for normal bonding). This then ensures that Si now has an unbound electron, which can easily move from the vb to the cb using the available ambient heat due to the reduced energy gap, thus increasing Si's conductivity.



A similar scheme is used to produce a p-type semiconductor, where an atom from group (III) serves as a donar atom. This donor atom has only 3 electrons to bond with Si, for example, which has 4 electrons available. This combination then results in a positive hole being created. A p-type semiconductor is thus produced. An electron from a neighbouring Si atom can the fill this hole, thus creating hole movement in one direction and electron movement in the either. The energy gap is reduced and thus the conductivity of the semiconductor has been enhanced.



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

(a) **Evaluate** the Bohr model of the atom. 4

Marking Criteria	Marks
• Outlines the Bohr model of the atom (3 postulates) based on the H spectrum and evaluates it with reference to the limitations (4) and success with reference to the H atom and to the later work done by scientists	4
• Outlines the Bohr model of the atom (3 postulates) and evaluates it with reference to the limitations (4) and success with reference to the H atom and to the later work done by scientists	3
• Some postulates and 4 limitations of model	2
• 2 limitations of model	1

The Bohr model (1913) was developed following the Rutherford model (1911). Bohr developed a model of the H atom with quantised energy levels corresponding to circular orbits of different radii.
The **H spectrum** results from the electrons dropping from a higher to lower energy level. Bohr showed that these quantised levels are simply related by an integer, n, with n=1,2,3 etc. Bohr was able to calculate the energies of all H spectrum lines.
Bohr's 3 postulates.
Limitations: limited to H atom, could not explain varying intensity of spectral lines, hyperfine spectral lines, Zeeman effect and was an ad hoc mixture of classical and quantum physics.
Led to work by de Broglie, Pauli and Heisenberg.

(b) (i) Write an equation for the natural transmutation of uranium -238 by alpha decay. 1

Marking Criteria	Marks
• Equation showing mass and atomic number and new nucleus	1

$$^{238}_{92}U \rightarrow ^{4}_{2}He + ^{234}_{90}Th$$

(ii) A cobalt-59 nucleus captures a neutron to become cobalt-60 with a half-life of 5.3 years. The masses of the components are given as;

Cobalt – 59 = 58.9332 u
Cobalt – 60 = 59.9338 u
Neutron = 1.00867 u

Compare the masses of reactants and products for this reaction and **show how energy** may be released in this process. 2

Marking Criteria	Marks
• Calculates mass defect and energy released with correct units	2
• Calculate mass defect	1

$$^{59}_{27}Co + ^{1}_{0}n \rightarrow ^{60}_{27}Co$$

Mass defect = (58.9332 + 1.0087) - 59.9338 = 0.0081 u or 1.3404×10^{-29} kg

Energy equivalent = 0.0081 x 931.5 = 7.541 MeV or $1.2063843 \times 10^{-12}$ J

(c) Neutron scattering and particle accelerators are both **used as probes to study the structure of matter**. **6**

Outline these two very different techniques and give one application of each.

Marking Criteria	Marks
• Provides clear, detailed information about each method and gives one application of each method	6
• Provides clear, detailed information about each method and gives one application	5
• Provides scanty information about each method and gives one application of each method P	4
• Provides clear, detailed information about one method and gives one application of each method	3
• Provides scanty information about one method and gives one application of one method	2
• Provides one application of each method	1

Neutron scattering: This method utilises the wave characteristics of neutrons to study the internal structure and properties of matter.
A beam of **neutrons** from a nuclear reactor is scattered from the surface of the material. A movable detector records the intensity at various anglers. Neutrons have **no charge**, can penetrate electron clouds to **interact with the nucleus**. Neutrons display **wave nature**. They can be scattered by even light atoms such as H. Need to have a **nuclear reactor**.
Application: can be used to study magnetic material because they have magnetic moment and usful for probing small elements and proton-rich materials.

Particle accelerators are devices that give particles the required energy in an evacuated chamber. **Charged** particles are accelerated using **magnetic or electric** fields. By smashing particles into targets, or other particles travelling in the opposite direction, and then studying the particles formed in the collision, the tracks and trails could be collected by a **sensor** and analysed. Particle accelerators are **expensive** to construct and maintain.
Application: to study the composition of matter at subatomic level and led to the discovery of over 100 subatomic particles. Provided the experimental evidence for the SMM.

(d) **Assess** the significance of Davisson and Germer's experiment. **3**

Marking Criteria	Marks
• Description of the D and G exp and its major impact on the understanding of the nature of electrons, confirming de Broglie's hypothesis	3
• Description of the D and G exp and a suggestion of its significance	2
• Description of the D and G exp /confirmed de Broglie's hypothesis	1

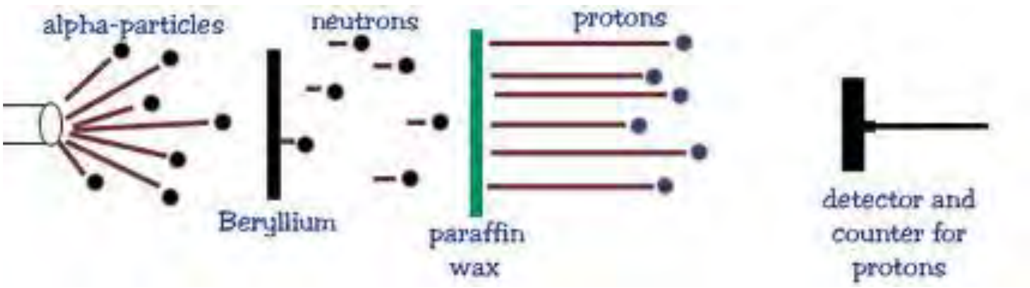
Davisson and Germer **accelerated electrons** and fired them at metal crystals and found that they were diffracted. Since **diffraction** is a property of waves and not particles, they had **confirmed** that electrons had the wave nature that was **proposed by de Broglie** and that the wavelength of the electrons matched his predicted value.
The experiment proved the wave nature of the electrons and hence the existence of matter waves. The value agreed with the wavelength calculated using the de Broglie's equation **$\lambda = h/mv$** to describe these **matter waves**

(e) The work of Chadwick led to practical applications of nuclear physics.

(i) **Draw** the experiment that Chadwick performed in the discovery of the neutron. **3**

Marking Criteria	Marks
• Draw an outline of the experiment including alpha source bombarding Be, unknown radiation, paraffin wax, protons and detection device in an appropriate labelled diagram	3
• Any 4 of the above	2
• Any 2 of the above	1

A description of the experiment as shown below.



(ii) How did Chadwick apply conservation laws? **2**

Marking Criteria	Marks
• Describes how the laws of conservation of energy and momentum were applied to the experimental results	2
• Describes how one law of conservation was applied to the experimental results	1

Prior to Chadwick, Joliot and Curie had bombarded Be with alpha particles. This led to an unknown radiation that caused protons to be ejected from a block of paraffin. Chadwick repeated their experiments and measure the velocities of the protons and unknown radiation. Since he knew the mass of the target and protons ejected as well as their velocities, he was able to apply the **conservation of energy and momentum laws** mathematically to his experimental measurements. He showed the protons moved off with the same momentum as the radiation had before the collision. From this, he determined that the radiation consisted of neutral particles (neutrons), which had about the same mass as a proton.

(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 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.

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.

End of examination