Student Number	
Mark / 100	

2011

TRIAL HSC EXAMINATION

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black or blue pen
- Draw diagrams using pencil
- Write your Student Number at the top of this page and on the response sheets on page 11
- Board-approved calculators may be used
- A data sheet and a Periodic Table are provided

Total Marks – 100

Section I Pages 2 - 23

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 - 33
•Allow about 1 hour and 45 minutes for this part

Section II Page 24

25 marks

•Attempt Question 34.
•Allow about 45 minutes for this section

Section I
75 marks

Part A – 20 marks
Attempt Questions 1-20
Allow about 30 minutes for this part

Use the multiple choice answer sheet on page 10.

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

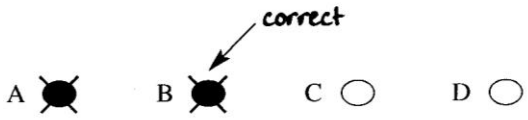
Sample: $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word **correct** and drawing an arrow as follows.



1. In which case is an astronaut closest to true weightlessness?

(A) Floating around in the cabin of the space shuttle orbiting Earth.

(B) Walking on the surface of the moon.

(C) Falling back to Earth during re-entry in the space shuttle.

(D) Halfway between the Moon and the Earth.

2. A plane flies in a uniform horizontal circle at constant speed and height.

Which statement about the forces acting on the plane is correct?

(A) Has no resultant force acting on it.

(B) Experiences a resultant force acting away from the centre of the circle.

(C) Experiences an increasing force acting towards the centre of the circle.

(D) Experiences a resultant force acting towards the centre of the circle.

3. What is the work done by a satellite as it moves around the Earth with uniform circular motion if its mass is 500 kg, its orbit radius is 1200 km above the Earth's surface and it is travelling at 1.5 kms^{-1}?

(A) 5.9×10^6 J

(B) 5.9×10^9 J

(C) 7.4×10^6 J

(D) 0

4. A ball is thrown upwards at some angle to the horizontal.
Which of the following is correct concerning the ball as it reaches its maximum height?

	Gravity	Momentum	Displacement
(A)	Constant	decreases	increases
(B)	Decreases	constant	zero
(C)	Increases	zero	constant
(D)	Constant	increases	decreases

5. A distant galaxy is travelling away from the Earth at a speed of 0.4c. The galaxy emits a radio signal that is received on the Earth. At what speed will this radio signal travel through space back to the Earth?

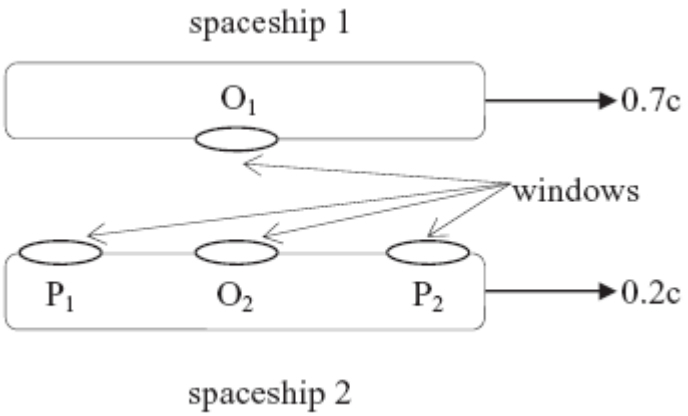
(A) 0.4 c

(B) 0.6 c

(C) 1.0 c

(D) 1.4 c

6. Two spaceships are travelling parallel to each other through space and have a relative velocity of 0.5c. On each spaceship, observers O_1 and O_2 are positioned in the middle of their respective spaceships and can look out through a window at each other. Spaceship 2 has two passengers with torches (P_1 and P_2) standing next to a window at each end of the spaceship. The passengers switch on their torches as the two spaceships come alongside each other. This event is seen simultaneously when viewed by observer O_2.



What will observer O_1 see?

(A) Both torches being switched on simultaneously.

(B) The torch of P_1 being switched on before that of P_2.

(C) The torch of P_2 being switched on before that of P_1.

(D) It is impossible to tell which torch O_1 will see switched on first.

7. In order to take advantage of the Earth's rotational motion, how are rockets launched?

(A) From near one of the poles and towards the East.

(B) From near the equator and towards the East

(C) From near one of the poles and towards the West

(D) From near the equator and towards the West

8. Thomas Edison's dominance in the electric power industry was struck a serious blow when his competitors, Nikola Tesla and George Westinghouse, began to use transformers with their alternating current (AC) electric power systems.
Why was Edison unable to use transformers in his direct current (DC) electric power systems?

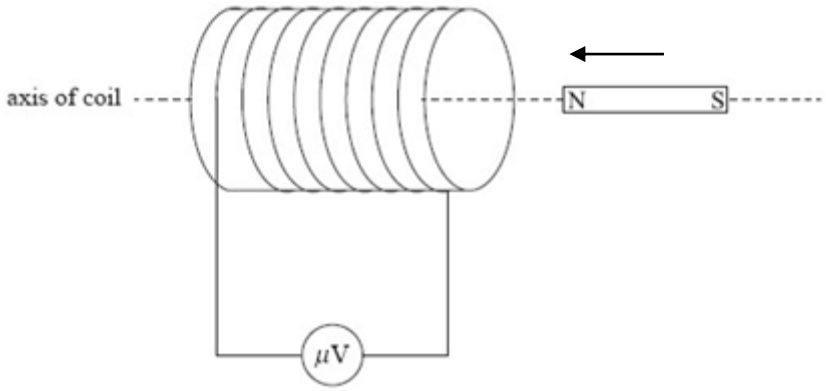
(A) Tesla and Westinghouse held the U.S. patent rights to transformers and prevented Edison from using them.

(B) Direct current electric power must flow directly from the generator to a home, without passing through any intermediate devices.

(C) A transformer requires changing currents in its coils in order to transfer power between those coils.

(D) DC electric power must flow through thicker wires than can be used efficiently in transformers.

9. The north pole of a permanent bar magnet is pushed along the axis of a coil as shown. below.



The pointer of the sensitive voltmeter connected to the coil moves to the right and gives a maximum reading of 8 units. The experiment is repeated but on this occasion, the south pole of the magnet enters the coil at twice the previous speed.

Which of the following gives the maximum defletcion of the pointer of the voltmeter?

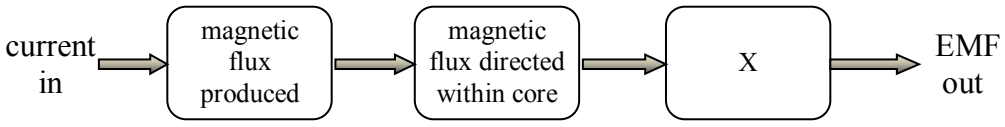
(A) 8 units to the right

(B) 8 units to the left

(C) 16 units to the right

(D) 16 units to the left

10. The flowchart below represents the processes involved within a transformer.



The process occurring at "X" is:

(A) electromagnetic induction

(B) magnetic flux reversed

(C) current produced

(D) magnetic field released

11. The diagram below represents the magnetic forces on two parallel wires P and Q carrying equal currents in opposite directions, perpendicular to the page.

Suppose the current in wire P is now reversed, while that in Q is unchanged.

Which diagram below best represents the forces that now act on the two wires?

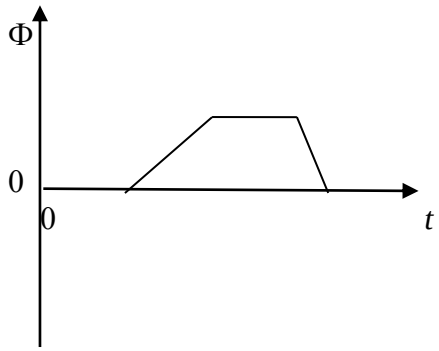
(A) 

(B) 

(C) 

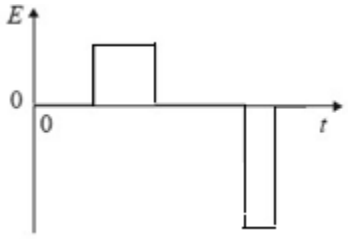
(D) 

12. The variation with time t of the magnetic flux Φ through a coil is shown below.

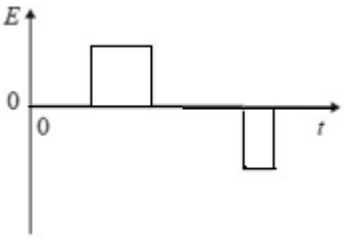


Which of the following diagrams best shows the variation with time t of the e.m.f. E induced in the coil?

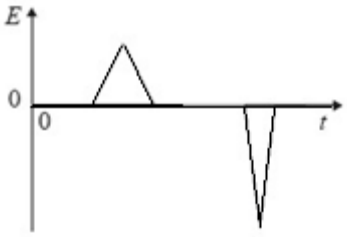
(A)



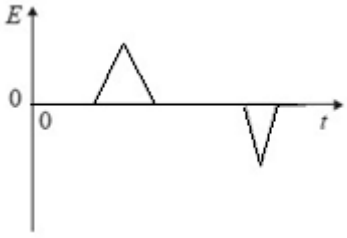
(B)



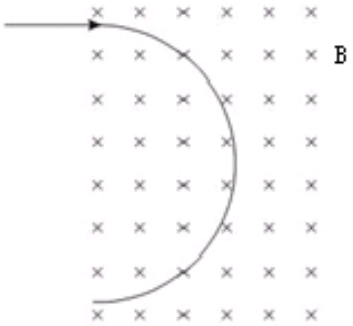
(C)



(D)



13. A charged particle is injected into a region of uniform magnetic field and travels in a circular arc. If the particle were to be injected with a greater speed, what would be true of the magnetic force on it and the radius of its path?



	Force	Arc radius
(A)	greater	smaller
(B)	greater	greater
(C)	smaller	smaller
(D)	smaller	greater

14. A direct current (dc) motor is connected to a battery by means of two leads. What is the function of the commutator of the motor?

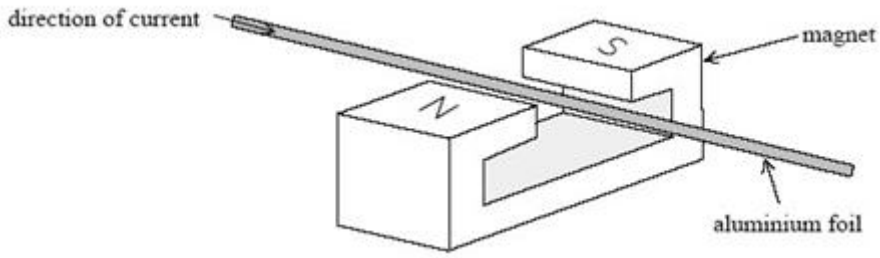
(A) To allow the motor to produce a uniform turning effect.

(B) To prevent too large a current in the coil of the motor.

(C) To reverse the direction of current in the leads to the motor.

(D) To reverse the direction of the current in the coil of the motor.

15. A strip of aluminium foil is held between the poles of a strong magnet, as shown below



When a current is passed through the aluminium foil in the direction shown, the foil is deflected. In which direction is this deflected?

(A) Vertically downwards

(B) Vertically upwards

(C) Towards the north pole of the magnet

(D) Towards the south pole of the magnet

16. X-rays photons are used to probe a crystal with energy 30 keV.
What is the wavelength of these x-rays?

(A) 0.041 nm

(B) 10.601 nm

(C) 39.125 nm

(D) 41.41 nm

17 . During the early 1950s most transistors were manufactured using germanium.

Why was germanium used ?

(A) It became an excellent conductor once it became warm.

(B) At operating temperatures the resistance obeyed ohms law.

(C) Germanium did not need to be as pure as silicon in semiconductors usage.

(D) Germanium could be made ultrapure with suitable available techniques.

18. What was the main reason for the rapid development of solid state devices?

(A) The demand for cheap televisions.

(B) The need for improved communications.

(C) The invention of the radio.

(D) The discovery of the electron.

19. What does a cathode ray tube containing a Maltese cross tell us about cathode rays?

(A) They travel in straight lines.

(B) They have mass.

(C) They have momentum.

(D) They have electric charge.

20. Which statement best describes the set of lines in a graphical plot of KE_{max} versus frequency for various photoelectric metals?

(A) Different cut off frequencies and different slopes.

(B) The same cut off frequencies and slopes.

(C) Different cut off frequencies but the same slopes.

(D) The same work function but different slopes.

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Student Number ……

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

Part A

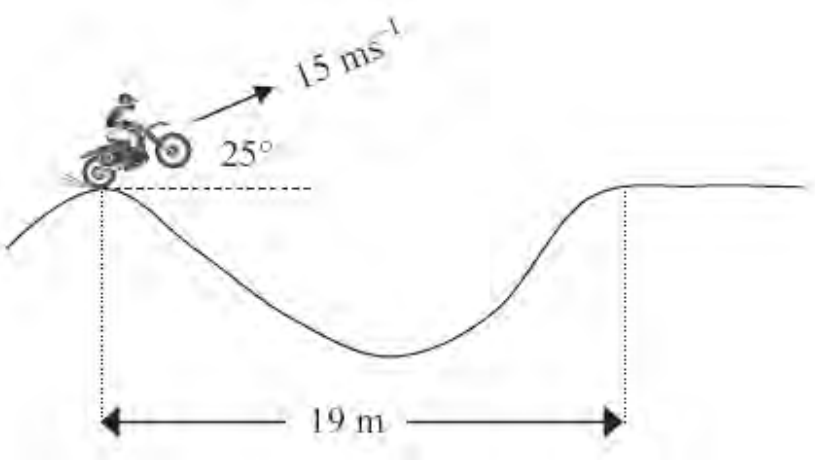
Multiple Choice Answer Sheet

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 - 32
Allow about 1 hour and 45 minutes for this part
▸ *Show all relevant working in questions involving calculations*

Question 21 (6 Marks) **Marks**

While riding his motorbike on a dirt track, Casey Stoner travels over a bump on the track at high speed and launches himself and his motorbike into the air. The launch speed is 15 ms^{-1} at an angle of 25° to the horizontal.



(a) Calculate the vertical and horizontal components of the bike's launch speed. **2**

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(b) What maximum height does the rider and motorbike reach above the launch position? **1**

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Question 21 continues on the next page

(c) For what length of time is the rider and motorbike in the air? **1**

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(d) Perform a calculation to determine if the rider and motorbike will make it onto the flat section of track after their trip through the air? **1**

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(e) Later as the motorbike rider continues along a flat section of track, Stoner accelerates from a speed of 7.0 ms^{-1} to 12.0 ms^{-1} in 3.0 s. What is the magnitude of his acceleration? **1**

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Question 22 (3 Marks) **Marks**

Determine the orbital speed of the International Space Station orbiting at 350 km above the surface of the Earth. The radius of the Earth is 6.37×10^6 m.

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Question 23 (2 Marks)

A muon is a subatomic particle with an average lifetime of 2.2 μs when stationary. During a burst of cosmic rays in the upper atmosphere, muons are observed to have a lifetime of 16 μs. How fast are they travelling?

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Question 24 (2 Marks)

Galileo discovered the moons of Jupiter. He could measure their orbital sizes by using the diameter of Jupiter as a unit of measure. He found Io, which had a period of 1.8 days, was 4.2 units from the centre of Jupiter. Callisto, Jupiter's fourth moon, had a period of 16.7 days.

Using the same units that Galileo used, predict Callisto's distance from the centre of Jupiter.

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Question 25 (5 Marks) **Marks**

Some of Einstein's predictions based on relativity were made many years before evidence was available to support them.

(a) Identify ONE of Einstein's predictions. **1**

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(b) Describe the current experimental evidence supporting this prediction. **2**

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(c) Justify the unit of length being defined in terms of time and the speed of light in a vacuum rather than it being a physical object. **2**

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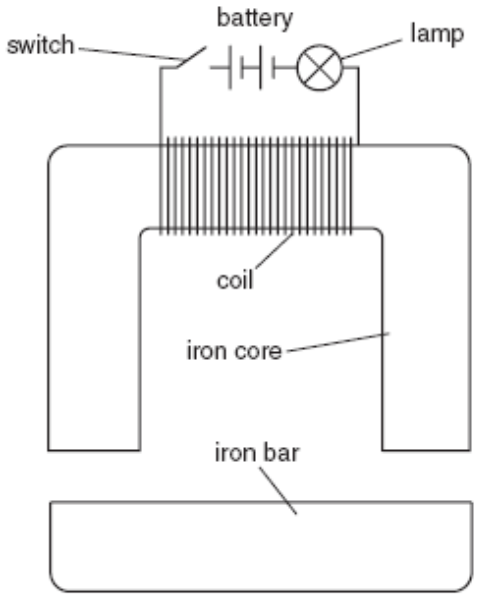
Question 26 (10 Marks) **Marks**

(a) An electromagnet is used to lift a heavy load. A coil of insulted wire is wrapped around the centre of an iron core. An iron bar is pulled up to the core when the switch is closed.



(i) On the figure above sketch two complete loops of flux produced by the coil when the switch is closed. **1**

(ii) Explain why the iron bar is pulled up to the iron core when the switch is closed. **2**

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Question 26 continues on the next page

(b) Suggest THREE other modifications to the arrangement which would increase the flux density in the iron core. **3**

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(c) Weights are added to the iron bar until the bar pulls away from the core. Explain why the brightness of the lamp momentarily increases at the instant the rod stops touching the iron core. **2**

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(d) The electromagnet uses direct current from the battery. When the same electromagnet uses alternating current from a generator the iron core heats up. Explain why it heats up. **2**

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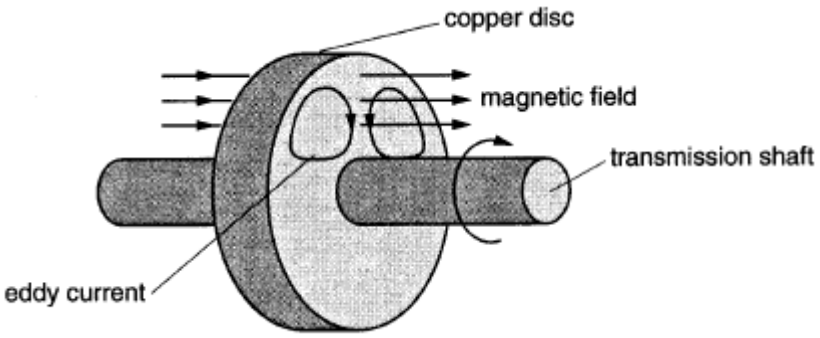
Question 27 (6 Marks) **Marks**

Magnetic fields can be used to slow down road vehicles. The figure below shows a copper disc fastened to the transmission shaft of a vehicle.



There is a magnetic field through part of the disc when slowing the vehicle. As the copper disc rotates, eddy currents apply a braking force to the shaft.

(a) Explain why eddy currents are induced in the copper disc. **2**

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(b) Explain why the eddy currents brake the motion of the disc. **2**

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(c) Explain why the braking force decreases as the speed of the disc decreases. **2**

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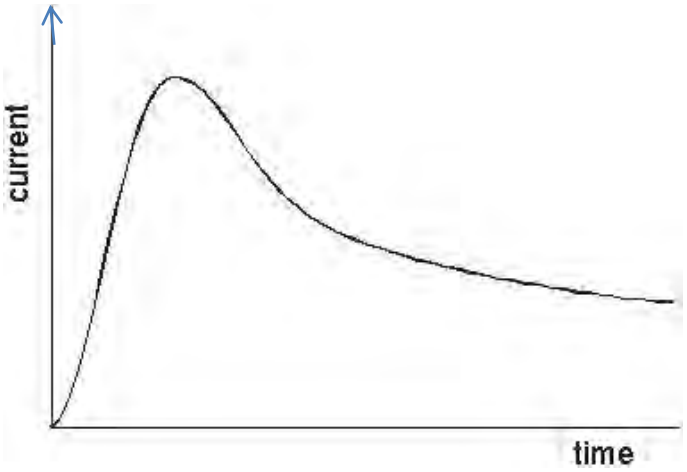
Question 28 (2 Marks) **Marks**

When a simple d.c. electric motor is connected to a battery, the current which flows during the first few seconds varies (approximately) as shown by the graph below.



Explain the shape of this graph.

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Question 29 (2 Marks)

A beam of alpha particles passes undeflected through a region of space in which there is a magnetic field of flux density 5×10^{-2} T and also an electric field of field strength 750 Vm^{-1} at 90° to each other.

Calculate the speed of the alpha particles**.**

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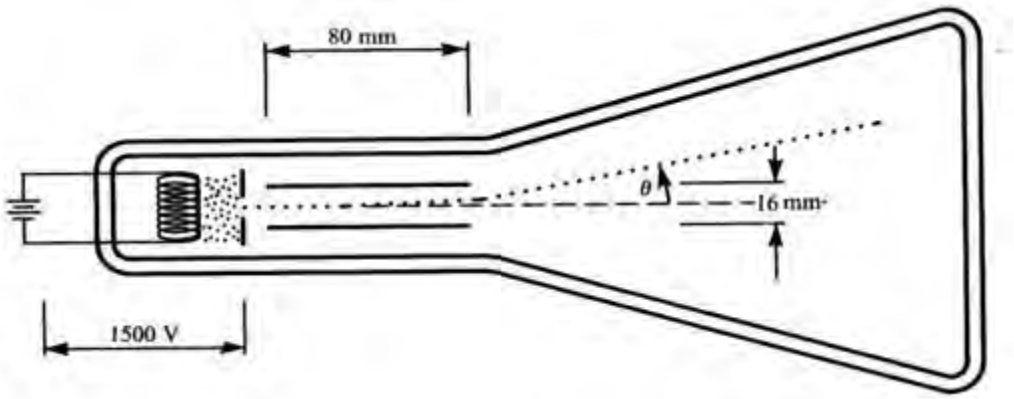
Question 30 (5 Marks) **Marks**

An electron beam is produced in a heated cathode tube as shown below and is accelerated by a potential difference of 1500 V to an anode.

This beam enters a small hole at the anode at a velocity of 5.48 X 10^7 ms^{-1} and travels through two parallel plates.

The plates are 16.0 mm apart. The potential on these two plates is 240 volts



(a) On the diagram above clearly label the positive and negative plates where the electrons experience a force. **1**

(b) Calculate the force acting on each electron. **2**

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Question 30 continued on next page

(c) Calculate the time the electrons are moving in between the parallel plates. **2**

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Question 31 (3 Marks)

Discuss the BCS theory of superconductivity.

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Question 32 (4 Marks) **Marks**

Metals, *p*-type semiconductors and *n*-type semiconductors are all conductors of electricity.

(a) Identify the relative number of free electrons in each of these three solids. **1**

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(b) Describe how each of these solids conducts electricity. **3**

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Question 33 (5 Marks) **Marks**

With the aid of a diagram, outline the steps required to test the effect of cathode rays on a glass paddlewheel.
Analyse any risks in this experiment and say how you will minimise such risks.
Describe what this experiment showed.

Question 34– From Quanta to Quarks (25 marks) **Marks**

(a) (i) Outline how you observed the visible components of the hydrogen spectrum in the school laboratory. **3**

(ii) Describe how Bohr refined Rutherford's model of the hydrogen atom. **2**

(b) (i) Define the term "transmutation". **1**

(ii) Name an isotope used in agriculture and describe its use. **2**

(c) A $^{238}_{92}U$ nucleus emits an alpha particle with KE = 5.32 MeV.

(i) Identify the final nucleus formed? **1**

(ii) What is the atomic mass (in u) of the final nucleus? **2**

Given: atomic mass of $^{238}_{92}U$ = 232.035880 u, $^{4}_{2}He$ = 4.002602 u, $^{1}_{1}H$ = 1.007825 u

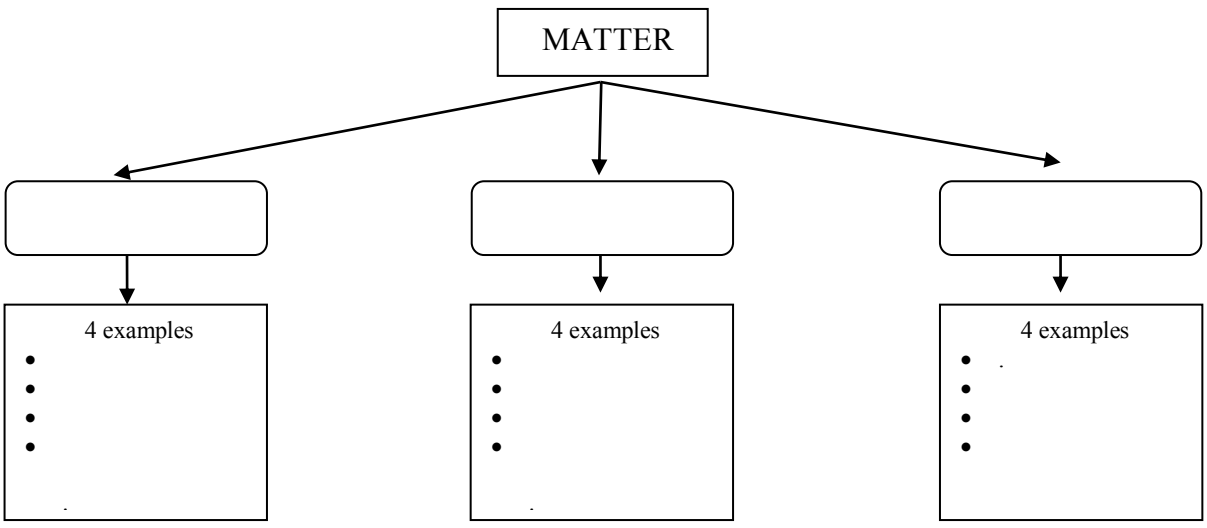
(d) Neutron scattering and accelerators are both used as probes to study the structure of matter. **6**

Compare these two very different techniques and what applications do each of them have?

(e) Identify TWO features of the strong nuclear force. **2**

(f) The work of Chadwick led to practical applications of nuclear physics. **3**
Outline the experiment that Chadwick performed in the discovery of the neutron.

(g) The standard model of matter explains the interactions between the three 'family groups'. **3**
Copy the flow chart into your answer booklet and complete the organisation of this grouping.



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Section II Page 24

25 marks

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

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A ○ B ● C ○ D ○

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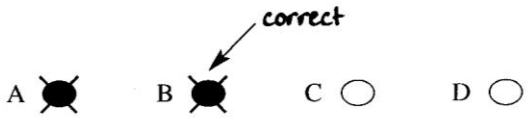

1. In which case is an astronaut closest to true weightlessness?

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(B) Walking on the surface of the moon.

(C) Falling back to Earth during re-entry in the space shuttle.

(D) Halfway between the Moon and the Earth.

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Which statement about the forces acting on the plane is correct?

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(B) Experiences a resultant force acting away from the centre of the circle.

(C) Experiences an increasing force acting towards the centre of the circle.

(D) Experiences a resultant force acting towards the centre of the circle.

3. What is the work done by a satellite as it moves around the Earth with uniform circular motion if its mass is 500 kg, its orbit radius is 1200 km above the Earth's surface and it is travelling at 1.5 kms^{-1}?

(A) 5.9×10^6 J

(B) 5.9×10^9 J

(C) 7.4×10^6 J

(D) 0

4. A ball is thrown upwards at some angle to the horizontal.
Which of the following is correct concerning the ball as it reaches its maximum height?

	Gravity	Momentum	Displacement
(A)	Constant	decreases	increases
(B)	Decreases	constant	zero
(C)	Increases	zero	constant
(D)	Constant	increases	decreases

5. A distant galaxy is travelling away from the Earth at a speed of 0.4c. The galaxy emits a radio signal that is received on the Earth. At what speed will this radio signal travel through space back to the Earth?

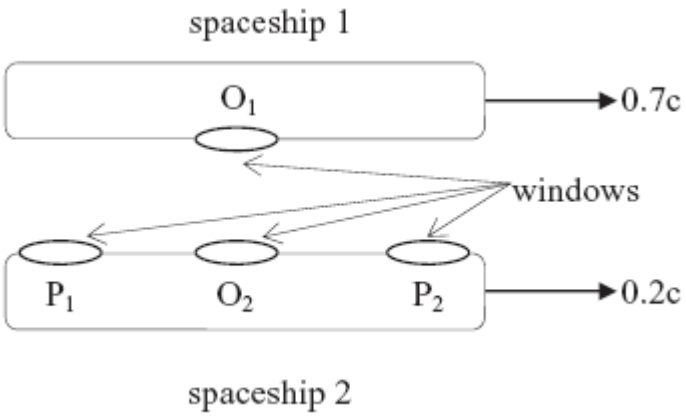
(A) 0.4 c

(B) 0.6 c

(C) 1.0 c

(D) 1.4 c

6. Two spaceships are travelling parallel to each other through space and have a relative velocity of 0.5c. On each spaceship, observers O_1 and O_2 are positioned in the middle of their respective spaceships and can look out through a window at each other. Spaceship 2 has two passengers with torches (P_1 and P_2) standing next to a window at each end of the spaceship. The passengers switch on their torches as the two spaceships come alongside each other. This event is seen simultaneously when viewed by observer O_2.



What will observer O_1 see?

(A) Both torches being switched on simultaneously.

(B) The torch of P_1 being switched on before that of P_2.

(C) The torch of P_2 being switched on before that of P_1.

(D) It is impossible to tell which torch O_1 will see switched on first.

7. In order to take advantage of the Earth's rotational motion, how are rockets launched?

(A) From near one of the poles and towards the East.

(B) From near the equator and towards the East

(C) From near one of the poles and towards the West

(D) From near the equator and towards the West

8. Thomas Edison's dominance in the electric power industry was struck a serious blow when his competitors, Nikola Tesla and George Westinghouse, began to use transformers with their alternating current (AC) electric power systems.
Why was Edison unable to use transformers in his direct current (DC) electric power systems?

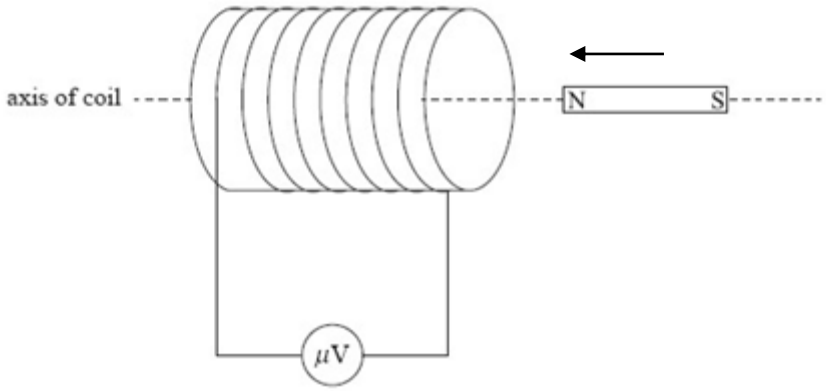
(A) Tesla and Westinghouse held the U.S. patent rights to transformers and prevented Edison from using them.

(B) Direct current electric power must flow directly from the generator to a home, without passing through any intermediate devices.

(C) A transformer requires changing currents in its coils in order to transfer power between those coils.

(D) DC electric power must flow through thicker wires than can be used efficiently in transformers.

9. The north pole of a permanent bar magnet is pushed along the axis of a coil as shown. below.



The pointer of the sensitive voltmeter connected to the coil moves to the right and gives a maximum reading of 8 units. The experiment is repeated but on this occasion, the south pole of the magnet enters the coil at twice the previous speed.

Which of the following gives the maximum defletcion of the pointer of the voltmeter?

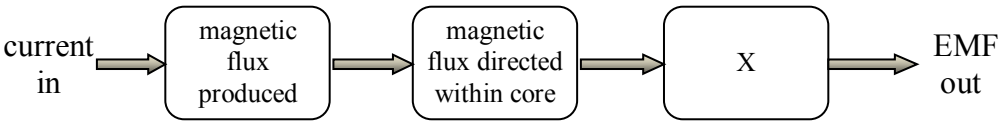
(A) 8 units to the right

(B) 8 units to the left

(C) 16 units to the right

(D) 16 units to the left

10. The flowchart below represents the processes involved within a transformer.



The process occurring at "X" is:

(A) electromagnetic induction

(B) magnetic flux reversed

(C) current produced

(D) magnetic field released

11. The diagram below represents the magnetic forces on two parallel wires P and Q carrying equal currents in opposite directions, perpendicular to the page.

Suppose the current in wire P is now reversed, while that in Q is unchanged.

Which diagram below best represents the forces that now act on the two wires?

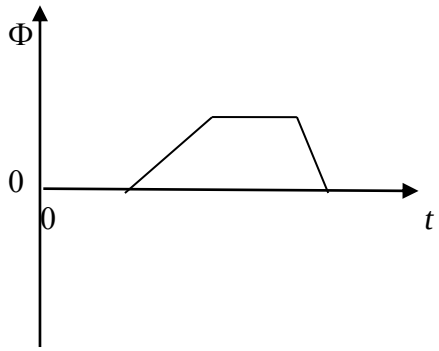
(A) 

(B) 

(C) 

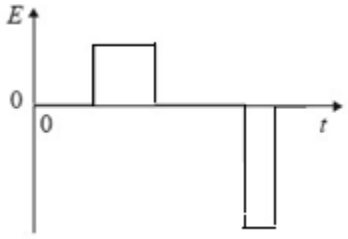
(D) 

12. The variation with time t of the magnetic flux Φ through a coil is shown below.

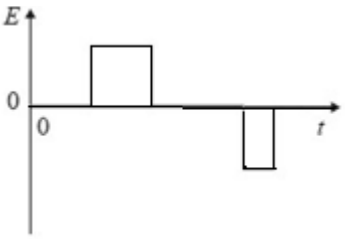


Which of the following diagrams best shows the variation with time t of the e.m.f. E induced in the coil?

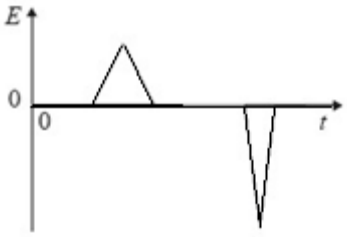
(A)



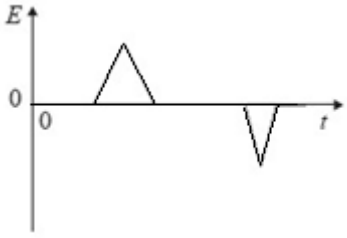
(B)



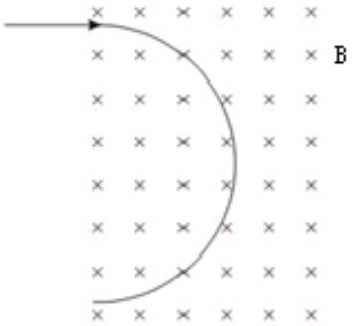
(C)



(D)



13. A charged particle is injected into a region of uniform magnetic field and travels in a circular arc. If the particle were to be injected with a greater speed, what would be true of the magnetic force on it and the radius of its path?



	Force	Arc radius
(A)	greater	smaller
(B)	greater	greater
(C)	smaller	smaller
(D)	smaller	greater

14. A direct current (dc) motor is connected to a battery by means of two leads. What is the function of the commutator of the motor?

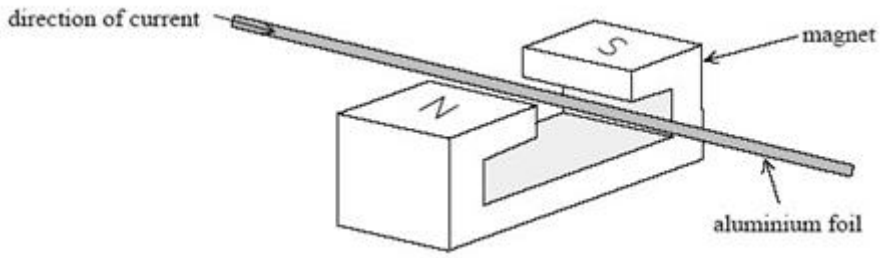
(A) To allow the motor to produce a uniform turning effect.

(B) To prevent too large a current in the coil of the motor.

(C) To reverse the direction of current in the leads to the motor.

(D) To reverse the direction of the current in the coil of the motor.

15. A strip of aluminium foil is held between the poles of a strong magnet, as shown below



When a current is passed through the aluminium foil in the direction shown, the foil is deflected. In which direction is this deflected?

(A) Vertically downwards

(B) Vertically upwards

(C) Towards the north pole of the magnet

(D) Towards the south pole of the magnet

16. X-rays photons are used to probe a crystal with energy 30 keV.
What is the wavelength of these x-rays?

(A) 0.041 nm
(B) 10.601 nm
(C) 39.125 nm
(D) 41.41 nm

17 . During the early 1950s most transistors were manufactured using germanium.

Why was germanium used ?

(A) It became an excellent conductor once it became warm.
(B) At operating temperatures the resistance obeyed ohms law.
(C) Germanium did not need to be as pure as silicon in semiconductors usage.
(D) Germanium could be made ultrapure with suitable available techniques.

18. What was the main reason for the rapid development of solid state devices?

(A) The demand for cheap televisions.
(B) The need for improved communications.
(C) The invention of the radio.
(D) The discovery of the electron.

19. What does a cathode ray tube containing a Maltese cross tell us about cathode rays?

(A) They travel in straight lines.
(B) They have mass.
(C) They have momentum.
(D) They have electric charge.

20. Which statement best describes the set of lines in a graphical plot of KE_{max} versus frequency for various photoelectric metals?

(A) Different cut off frequencies and different slopes.
(B) The same cut off frequencies and slopes.
(C) Different cut off frequencies but the same slopes.
(D) The same work function but different slopes.

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Student Number ……

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

Part A

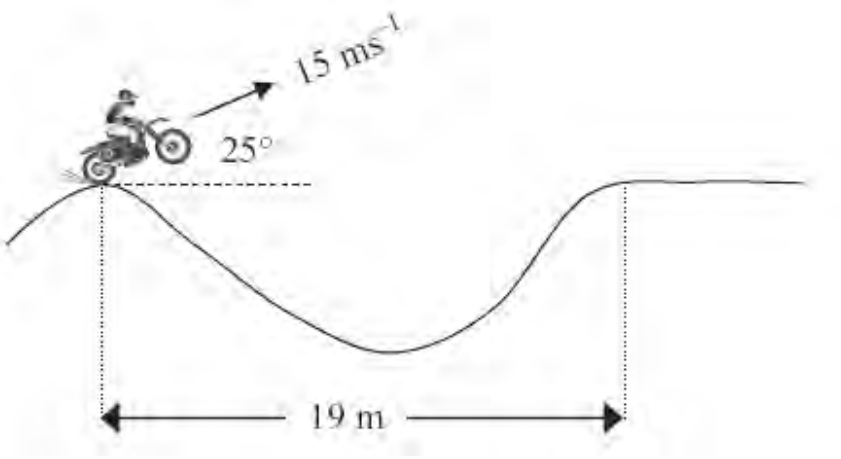
Multiple Choice Answer Sheet

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 - 32
Allow about 1 hour and 45 minutes for this part
▸ *Show all relevant working in questions involving calculations*

Question 21 (6 Marks) **Marks**

While riding his motorbike on a dirt track, Casey Stoner travels over a bump on the track at high speed and launches himself and his motorbike into the air. The launch speed is 15 ms^{-1} at an angle of 25° to the horizontal.



(a) Calculate the vertical and horizontal components of the bike's launch speed. **2**

Criteria	Marks
• Correct calculation and units for both v_x and v_y	**2**
• Correct calculation and units for either v_x or v_y	**1**

Sample answer:
$v_y = 15 \sin 25^o = 6.3\ ms^{-1}$ (2 sf)
$V_x = 15 \cos 25^o = 13.6\ ms^{-1} = 14$ m/s (2 sf)

(b) What maximum height does the rider and motorbike reach above the launch position? **1**

Criteria	Marks
• Correct calculation and units	**1**

Sample answer:
$v^2 = u^2 - 2as$
$0 = 6.339^2 - 2 \times (-9.8)$
$s = 2.03$ m $= 2.0$ m (2 sf)

Question 21 continues on the next page

(c) What time did the rider and motorbike take to reach maximum height? **1**

Criteria	**Marks**
• Correct calculation and units	**1**

Sample answer:
$v = u + at$
$0 = 6.339 - 9.8t$
$t = 0.65$ s (2 sf)

(d) Perform a calculation to determine if the rider and motorbike will make it onto the flat section of track after their trip through the air? **2**

Criteria	**Marks**
• Correct calculation of total time and range	**2**
• Incorrect calculation of time but correct calculation of range with units	**1**

Sample answer:
Total time of flight = 0.65 x 2 = 1.27 s

Range = u_x x t
= 13.6 x 1.27
= 17.236 m
= 18 m (2 sf)

Question 22 (3 Marks) **Marks**

Determine the orbital speed of the International Space Station orbiting at 350 km above the surface of the Earth. The radius of the Earth is 6.37 x 10^6 m.

Criteria	Marks
○ Correct formula, correct substitution, correct answer	**3**
○ Correct formula, incorrect substitution or incorrect rounding	**2**
○ Correct formula only	**1**

Sample answer:

$$\frac{m_1 v^2}{r} = \frac{G m_1 m_E}{r^2}$$

$$\Rightarrow v = \sqrt{\frac{G m_E}{r + h}}$$

$$= \sqrt{\frac{6.67 \times 10^{-11} . 6 \times 10^{24}}{(6.37 \times 10^6 + 350 \times 10^3)}}$$

$= 7717.1 \text{m/s}$ = 7720 m/s (3 sf)

$= 7.72 \text{ km/s}$ (3 sf)

Question 23 (2 Marks)

A muon is a subatomic particle with an average lifetime of 2.2 μs when stationary. During a burst of cosmic rays in the upper atmosphere, muons are observed to have a lifetime of 16 μs. How fast are they travelling?

Criteria	Marks
○ Correct formula, correct substitution, correct calculation	**2**
○ Correct formula, incorrect change of subject of formula, correct calculation	**1**

Sample answer:

$t_0 = 2.2$ μs

$t_v = 16$ μs

$$t_v = \gamma t_0 = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$1 - (\frac{v}{c})^2 = (\frac{t_0}{t_v})^2$$

$$\frac{v}{c} = \sqrt{1 - (\frac{2.2}{16})^2} = 0.99$$

$v = 0.99\ c$

Question 24 (2 Marks)

Galileo discovered the moons of Jupiter. He could measure their orbital sizes by using the diameter of Jupiter as a unit of measure. He found Io, which had a period of 1.8 days, was 4.2 units from the centre of Jupiter. Callisto, Jupiter's fourth moon, had a period of 16.7 days.

Using the same units that Galileo used, predict Callisto's distance from the centre of Jupiter.

Criteria	Marks
○ Correct formula, correct substitution, correct calculation	**2**
○ Correct formula, incorrect change of subject of formula, correct calculation	**1**

Sample answer:

$$\frac{r_1^3}{T_1^2} = \frac{r_2^3}{T_2^2}$$

$$\frac{(4.2)^2}{(1.8)^2} = \frac{r_2^3}{(16.7)^2}$$

$$\therefore r_2^3 = 4.2^3/1.8^2 \times 16.7^2$$

$$\Longrightarrow r_2 = 18.5\ units = distance\ to\ Calisto\ (from\ center\ of\ Jupiter)$$

Question 25 (5 Marks)

Some of Einstein's predictions based on relativity were made many years before evidence was available to support them.

(a) Identify ONE of Einstein's predictions. **1**

Criteria	Marks
○ Any one of the identifying postulates	**1**

Sample answer:

- Time dilation at relativistic speeds
- Length contraction at relativistic speeds
- Mass dilation at relativistic speeds
- Conversion of energy and mass (Einstein's equation: $E = mc^2$)

(b) Describe the current experimental evidence supporting this prediction. **2**

Criteria	Marks
○ Correct evidence with valid description related to the prediction mentioned in (a)	**2**
○ Correct evidence with valid description NOT related to the prediction mentioned in (a)	**1**

Sample answer:

- Observance of muons on earth that were produced in outer space from cosmic rays. These have short half lives (2.2 microseconds), and due to their fast speeds, their lifetimes become dilated due to relativistic effects.
- Atomic clocks run slower when travelling at high speeds in jets/spaceships, compared to stationary clocks on the ground
- Mass dilation of particles produced in particle accelerators.
- Energy conversions in fusion/fission processes.

(c) Justify the unit of length being defined in terms of time and the speed of light in a vacuum rather than it being a physical object. **2**

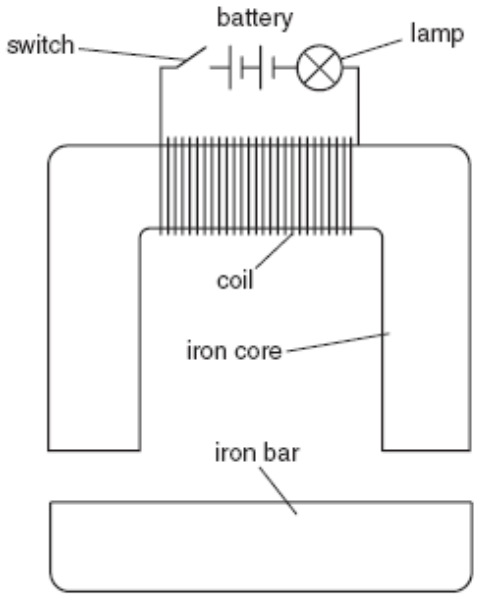
Criteria	**Marks**
o Both negative issues of the physical metre and the time/speed invariance for new standard	**2**
o Only time/speed invariance for new standard mentioned	**1**

Sample answer:

The physical metre (Platinum-Irridium bar) is subject to environmental degradation and is thus prone to fluctuations to its dimensions. Furthermore at relativistic speeds length is known to undergo contraction. However with the new standard being based on the path traversed by light in a vacuum during the time interval of 1/299 792 458 (or $1/3 \times 10^8$)th) of a second, the length of 1 metre is impossible to change under any circumstance. This assumes that light travels exactly at 299 792 458 m/s (or 3×10^8 m/s) in any part of the universe.

Question 26 (10 Marks) **Marks**

(a) An electromagnet is used to lift a heavy load. A coil of insulted wire is wrapped around the centre of an iron core. An iron bar is pulled up to the core when the switch is closed.



(i) On the figure above sketch two complete loops of flux produced by the coil when the switch is closed. **1**

(ii)

Criteria	**Marks**
○ 2 complete non-crossing loops through the coil which pass through the iron core and bar	1
○ Lines with no directions	0

Sample answer:

(iii) Explain why the iron bar is pulled up to the iron core when the switch is closed. **2**

Criteria	**Marks**
Any 2 of the following: ○ Current causes field/flux in coil ○ Which magnetises iron ○ Poles created where flux leaves /enters coil ○ Different poles attract ○ Upwards motion of bar attract shortens flux loops	**2**
○ Any 1 of above	**1**

Sample answer:
Iron bar is pulled up because the current in the coil magnetises the iron core which attracts the iron bar.

Question 26 continues on the next page

Question 26 (continued) **Marks**

(b) Suggest THREE other modifications to the arrangement which would increase the flux density in the iron core. **3**

Criteria	**Marks**
○ Any 3 of the following ○ More cells in battery/higher voltage to increase current ○ More turns of wire ○ Lower resistance/eater conductance/thicker wire ○ Shorter iron loop ○ Remove lamp from circuit ○ Soft iron core ○ Decrease cross sectional area	**3**
○ Any 2 of above	**2**
○ Any 1 of above	**1**

Sample answer:
Modifications that will increase flux density include:
More cells in battery/higher voltage to increase current
More turns of wire
Lower resistance/better conductance or thicker wire
Decrease area of coil/core
Use soft iron core

(c) Weights are added to the iron bar until the bar pulls away from the core. Explain why the brightness of the lamp momentarily increases at the instant the rod stops touching the iron core. **2**

Criteria	**Marks**
○ Flux density of coil decreases and generating emf /current in coil	**2**
○ Flux density of coil decreases or generating emf /current in coil	**1**

Sample answer:
The flux density in the coil decreases, inducing an emf (Faraday's law) and then an induced current in the coil which opposes the change. (Lenz's law)

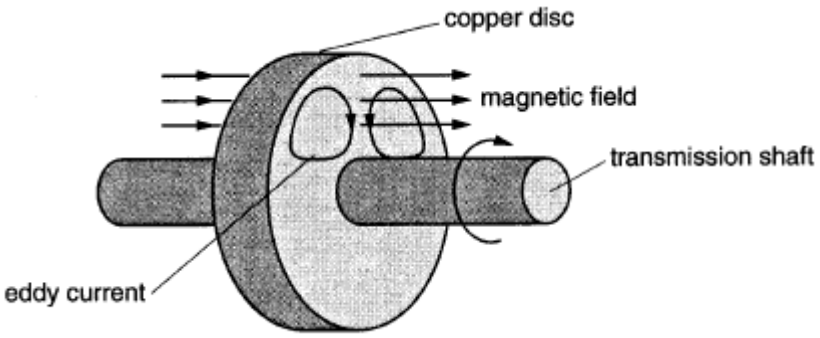
(d) The electromagnet uses direct current from the battery. When the same electromagnet uses alternating current from a generator the iron core heats up. Explain why it heats up. **2**

Criteria	**Marks**
○ Eddy currents in the core caused by changing magnetic flux, transferring electrical energy into heat	**2**
○ Eddy currents causing heat	**1**

Sample answer:
Eddy currents in the core caused by changing magnetic flux (Faraday's law), transferring electrical energy into heat.

Question 27 (6 Marks) **Marks**

Magnetic fields can be used to slow down road vehicles. The figure below shows a copper disc fastened to the transmission shaft of a vehicle.



There is a magnetic field through part of the disc when slowing the vehicle. As the copper disc rotates, eddy currents apply a braking force to the shaft.

(a) Explain why eddy currents are induced in the copper disc. **2**

Criteria	**Marks**
Any 2 of the following: o Change of flux as disc enters field region o Induces emf in disc o Low resistance of disc allows current	**2**
o Any 1 of the above	**1**

Sample answer: Change of flux as disc enters field region induces emf in disc and the low resistance of disc allows eddy currents to be induced. to oppose the change.

(b) Explain why the eddy currents brake the motion of the disc. **2**

Criteria	**Marks**
o Currents interact with field to oppose change in flux	**2**
o Eddy currents generates heat	**1**

Sample answer:
The induced eddy currents in the disc flow in a way to oppose the change (lenz's law), conservation of energy principle.

(c) Explain why the braking force decreases as the speed of the disc decreases. **2**

Criteria	**Marks**
o Slowing down the disc decreases rate of change of flux so as to oppose change in flux(explains Lenz's law)	**2**

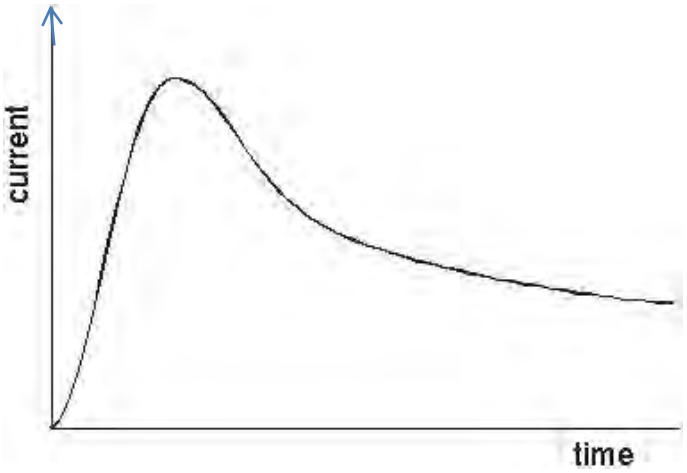
○ Lenz's law	**1**

Sample answer:

As rate of change of flux decreases, emf decreases and so does current induced (Lenz's law) so as to oppose change in flux.

Question 28 (2 Marks) **Marks**

When a simple d.c. electric motor is connected to a battery, the current which flows during the first few seconds varies (approximately) as shown by the graph below.



Explain the shape of this graph.

Criteria	**Marks**
○ As speed increases, back emf increases. When supply emf balances back emf current remains constant	**2**
○ Back emf mentioned correctly	**1**

Sample answer:

At low speeds, current flowing in coil is max because supply emf is max and back emf is min. As speed increases, back emf increases, suppy emf decreases as it is balanced by back emf and therefore supply current remains constant.

Question 29 (2 Marks)

A beam of alpha particles passes undeflected through a region of space in which there is a magnetic field of flux density 5×10^{-2} T and also an electric field of field strength 750 Vm^{-1} at 90° to each other.

Calculate the speed of the alpha particles**.**

Criteria	**Marks**
○ Correct answer 2.5 x 10^4 ms^{-1} with equations shown correctly substituted.	**2**
○ Equations complete/correct – wrong numerical answer.	**1**

Sample answer:

$F_B = qvB$ $F_E = qE$ $v = E/B$ $= 750 / (5 \times 10^{-2})$

$qvB = qE$ gives $v = E/B$ $= 250 \times 10^2 = 25000$ m/s

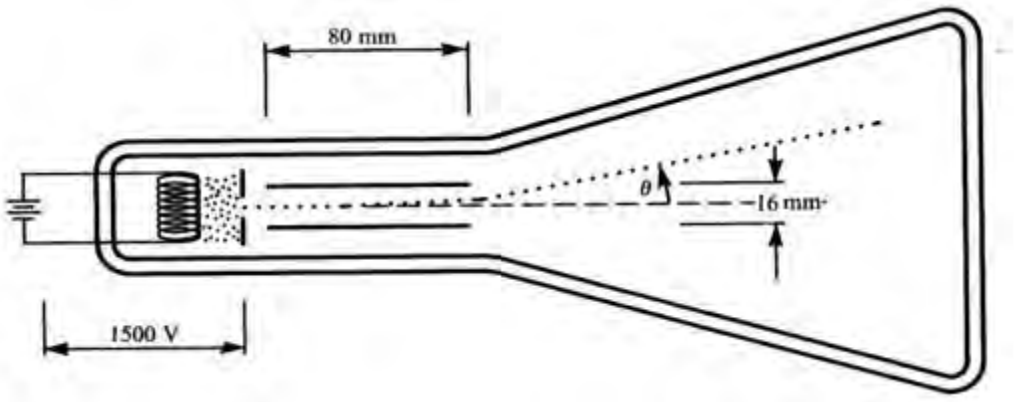
$= 2.5 \times 10^4$ m/s

Question 30 (5 Marks) **Marks**

An electron beam is produced in a heated cathode tube as shown below and is accelerated by a potential difference of 1500 V to an anode.

This beam enters a small hole at the anode at a velocity of 5.48×10^7 ms^{-1} and travels through two parallel plates.

The plates are 16.0 mm apart. The potential on these two plates is 240 volts



(a) On the diagram above clearly label the positive and negative plates where the electrons experience a force. **1**

(b) Calculate the force acting on each electron. **2**

Criteria	Marks
• Correct 2.4×10^{-15} N showing equations/substitutions (upwards not needed)	2
• Equation correct – wrong calculation	1

Sample answer:

v = 5.48×10^7 m/s V across plates 240 volts plate d = 16 mm = 16×10^{-3} m

E = V/d = $240/16 \times 10^{-3} = 15 \times 10^3$ m/s = 2.4×10^{-15} N upwards

Question 30 continued on next page

(c) Calculate the time the electrons are moving in between the parallel plates. **2**

Criteria	**Marks**
o Correct 1.46 X 10^{-9}s showing equation / substitutions	**2**
o Equation correct and substitutions - wrong answer	**1**

Sample answer:

$v = 5.48 \times 10^{7}$ m/s distance d = 80 mm = 80×10^{-3} m

$v = s/t$ $t = s/v$ $= 80 \times 10^{-3} / 5.48 \times 10^{7} = 14.598 \times 10^{-10} = 1.46 \times 10^{-9}$ s

Question 31 (3 Marks)

Discuss the BCS theory of superconductivity.

Criteria	**Marks**
o 3 correct descriptions as below	3
o 2 correct descriptions as below	**2**
o 1 correct description as below	**1**

Sample answer:

(1) When a substance reaches below its critical temperature, there is a pairing of electrons as Cooper pairs and they interact passing together through the lattice.
(2) Phonon interaction – between Cooper pairs moving through the lattice, distort and hence pull the electrons through in pairs
(3) Pairing of electrons puts the material into a low energy phase and hence no resistance occurs for these moving electrons.

Question 32 (4 Marks) **Marks**

Metals, *p*-type semiconductors and *n*-type semiconductors are all conductors of electricity.

(a) Identify the relative number of free electrons in each of these three solids. **1**

Criteria	**Marks**
o Identifies the differences in the number of electrons in metals, more holes in p type and improved conductivity for electrons in n type due to group 5 doping..	1

Sample answer:

Metals- maximum number of free (valence) electrons that can move.
n-types – more free conducting electrons than in p-type
p-type - least number of free electrons.

(b) Describe how each of these solids conducts electricity. **3**

Criteria	**Marks**
o All 3 described well showing the differences between each type	**3**
o 2 described well	**2**
o 1 general discussion	**1**

Sample answer:

(1) Metals have free electrons which can drift through the lattice under the influence of an electric field.

(2) If a donor gives up some free extra electrons we get an n-type of semiconductors. In n-type an atom from Group 5 is added into the Si lattice. The extra loose electron is easily promoted into the conduction band and able to transfer as a flow of electrons.

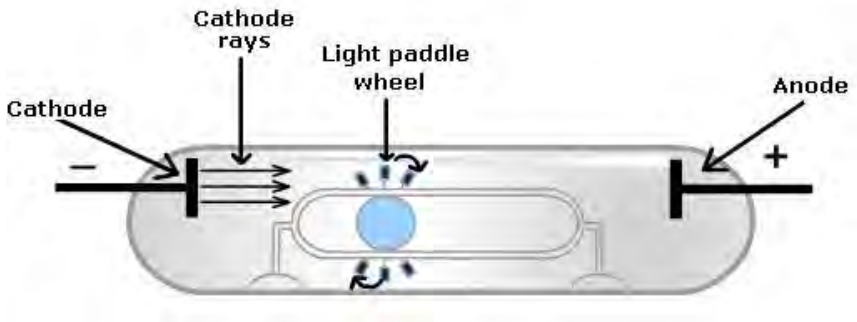
(3) If a donor soaks up some of the free electrons we get a p-type of semiconductor.
Doping with group 3 gives rise to positive holes within the lattice. The holes can accept electrons from the valence band of an adjacent Si atom. The holes provide extra charge carriers within the semiconductor and less energy is now required to mobilise charge to flow.

Question 33 (5 Marks) **Marks**

With the aid of a diagram, outline the steps required to test the effect of cathode rays on a glass paddlewheel.
Analyse any risks in this experiment and say how you will minimise such risks.
Describe what this experiment showed.

Criteria	Marks
○ Labelled diagram and steps described steps including safety, correct connection; observation showing cathode rays pushing the paddlewheel.	**5**
○ Safety issues addressed poorly, setup fully explained with names, labels correct.	**4**
○ General answer of diagram and discussion of operation of paddle wheel. No safety implications.	**3**
○ General weak response with not much detail by implying paddle wheel moves because of the cathode rays	**2**
○ Weak and missing in diagrams and correct information including wrong diagram.	**1**

Sample answer:



Connection to high voltage sparking coils to produce discharge but do not turn on till certain all is correct.. Ensure the direction of the "positive" and "negative flow of current is known so that the cathoide is identified. Ensure the setup is perfectly level on a flat surface. Ensure all safety precautions are in place so that electric shocks do not occur.

Results - (Crookes presents an experiment in which it is demonstrated that "radiant matter exerts strong mechanical action where it strikes." Built around 1879, and obviously influenced by the radiometer, the "railway tube" was a cathode ray tube with a paddlewheel inside. Supposedly, under the influence of cathode rays, the paddlewheel rotated and rolled down the rails from one end of the tube to the other. It was found that the paddlewheel turned in a direction away from the cathode. Crookes himself asserts that "the molecular stream from the negative pole is able to move any light object in front of it.")

Question 34– From Quanta to Quarks (25 marks) **Marks**

(a) (i) Outline how you observed the visible components of the hydrogen spectrum in the school laboratory. **3**

(b)

Criteria	Marks
o lists equipment used and set up, including conditions for viewing and risk assessment	**3**
o any two of above	**2**
o any one of above	**1**

Sample answer:

Equipment used included a spectral lamp containing Hydrogen, a hand-held spectroscope and a HV power supply in a darkened room.

(ii) Describe how Bohr refined Rutherford's model of the hydrogen atom. **2**

Criteria	Marks
o Main difference between Rutherford's and Bohr's model	**2**
o Description of either Bohr's or Rutherford's model	**1**

Sample answer:

In Rutherford's model, the electrons are in accelerated motion and should radiate em waves and thus lose energy. Bohr suggested that the electrons only existed in certain allowable (quantised) energy levels where they could orbit (stationary states). In the Bohr model, electrons emitted or absorbed quanta of energy when transiting between energy states. He also considered angular momentum to be quantised.

(c) (i) Define the term "transmutation". **1**

Criteria	Marks
o Provides correct definition	**1**

Sample answer:

It is the phenomenon in which one element changes its identity to become another element.

(ii) Name an isotope used in agriculture and describe its use. **2**

Criteria	Marks
o Provides name or formula and correct use	**2**
o Provides name or formula only	**1**

Sample answer:

Phosphorus-32 a beta-emitter used as a biological tracer to study nutritional uptake by plants in the natural environment.

(c) A $^{238}_{92}U$ nucleus emits an alpha particle with KE = 5.32 MeV.

(i) Identify the final nucleus formed? **1**

Criteria	Marks
o formula of correct nucleus	**1**

Sample answer:

$^{234}_{92}Th$

(ii) What is the atomic mass (in u) of the final nucleus? **2**

Given: atomic mass of $^{238}_{92}U$ = 232.035880 u, $^{4}_{2}He$ = 4.002602 u, $^{1}_{1}H$ = 1.007825 u

Criteria	**Marks**
○ Correct formula equation to calculate mass defect and conversion from MeV to u	**2**
○ Identifies correct nucleus or correct mass	**1**

Sample answer:

mass equivalent of energy of alpha particle = 5.43 /931.5 = 5.829307 x 10^{-3} u

Mass defect = 232.035880 – (4.002602 + 5.7112184 x 10^{-3})
= 4.008313218

$^{238}_{92}U$ = 232.035880 u $\longrightarrow$ $^{4}_{2}He$ = 4.002602 u + 5.829307 x 10^{-3} + ?

Unknown nucleus mass = 228.0275668 u

(d) Neutron scattering and accelerators are both used as probes to study the structure of matter. Compare these two very different techniques and outline what applications each technique has? **6**

Criteria	**Marks**
○ Thorough description of each technique, how each can be used to act as a probe, list an advantage and limitation for each technique, and list a use for each technique	**6-5**
○ Reasonable comparison of each technique, how each can be used to act as a probe, list an advantage and limitation for each technique, and list a use for each technique	**4-3**
○ Limited comparison of each technique or uses of each technique	**2-1**

Sample answer:

Particle accelerators are used to conduct experiments where charged particles, accelerated by electric and magnetic fields are propelled with very great speeds (relativistic) to smash into targets or other particles travelling in opposite direction and then used to study the particles formed in the collision.
Disadvantage: extremely expensive to construct and maintain.
Advantage: provides a vital tool for research into the nature of matter, discovering a large array of sub-atomic particles. It has provided evidence to support the SMM.
Neutron scattering is the method that utilises the wave characteristics of neutrons to study the internal structure of matter. Neutrons are useful as a probe because being neutral, they are not affected by electric fields and are able to deeply penetrate matter, scatter and form interference patterns that can reveal great structural detail.
Disadvantage: Normally requires a nuclear reactor to produce neutrons, social and safety issues.
Advantage: because they are not charged, useful for probing the nucleus and small elements and proton-rich elements.

(e) Identify TWO features of the strong nuclear force. **2**

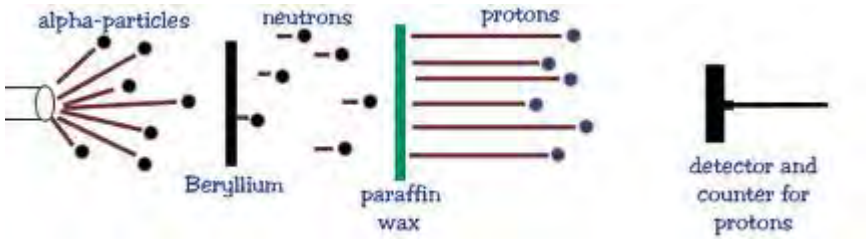
Criteria	Marks
○ Any 2 correct features listed	**2**
○ One feature identified	**1**

Sample answer:
The SNF can only act (attract) over a very short range (when particles come within 3 fm).
It can act between any nucleons irrespective of charge.

(f) The work of Chadwick led to practical applications of nuclear physics. **3**
Outline the experiment that Chadwick performed in the discovery of the neutron.

Criteria	Marks
○ Labelled diagram of Chadwick's exp. with description and results	**3**
○ Labelled diagram with results	**2**
○ Description of results or minimal description	**1**

Sample answer:



Chadwick studied the unknown radiation and applied the conservation laws of momentum and energy to determine the mass of the neutron.
$_4Be^9 + _2H^4 \rightarrow _6C^{12} + _0n^1$

(g) The standard model of matter explains the interactions between the three 'family groups'. **3**
Copy the flow chart into your answer booklet and complete the organisation of this grouping.

Criteria	Marks
○ All 6 boxes correctly completed	**3**
○ Any 4 boxes correctly completed	**2**
○ Any 2 boxes correctly completed	**1**

Sample answer: