Section I
75 marks

Part A - 15 marks

Attempt ALL questions
Allow about 30 minutes for this part.

Use the Multiple-choice Answer Sheet provided.

Answer the questions by selecting the alternative that best answers the question. Indicate your choice by filling in the appropriate place on the Answer sheet, as shown below, where A has been selected as the best alternative,

A ● B ○ C ○ D ○

If you make a mistake, indicate your choice by labelling the correct alternative, as shown below where, the original choice A was a mistake, and C is now selected as being the correct answer.

Correct

A ⊗ B ○ C ● D ○

1. The following information, for the weight of the same stationary object at different locations on the surface of the Earth, was obtained using an accurate measuring device.

Position 1 – 9.810 N Position 2 – 9.821 N Position 3 – 9.796 N Position D – 9.814 N

Which of the following could explain the variation in the measurements?

(A) the measurements were made at different altitudes

(B) the measurements were made at different latitudes

(C) the measuring device was faulty

(D) both (A) and (B) could explain the results

2. A bullet is fired into the air and followed a flight path, represented by the diagram below.

If all effects due to air friction are negligible, while the bullet is in flight, which of the following statements is true?

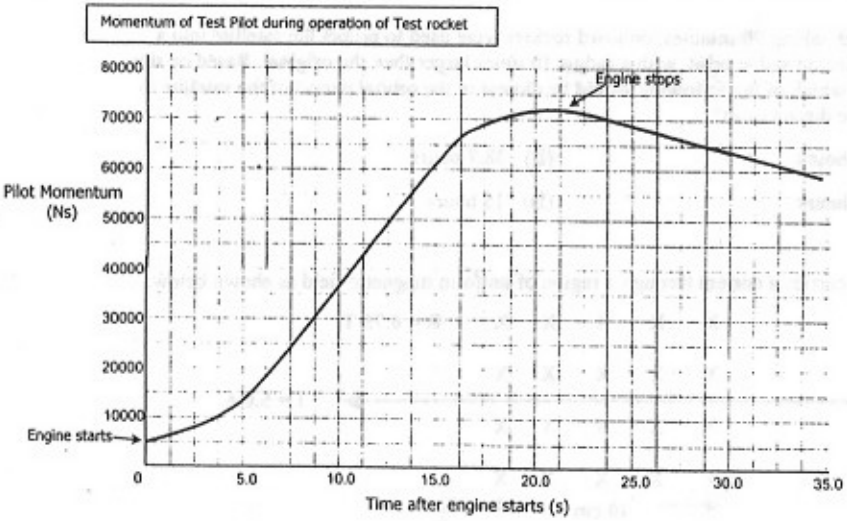
(A) the energy and acceleration of the bullet remain constant

(B) the energy of the bullet varies while the acceleration remains constant

(C) the energy of the bullet remains constant while the acceleration varies

(D) both the energy and acceleration of the bullet vary while in flight

3. The following graph shows the way the momentum of a 100 kg test pilot changed during the trialling of a new rocket engine.



Based on the evidence from the graph, which of the following statements is correct?

(A) the pilot experienced maximum ***g***'s just before the engine stopped.

(B) the maximum acceleration produced by the rocket was close to 40 ms^{-2}.

(C) the pilot was travelling at 50 ms^{-1} when the rocket started, experiencing a maximum of about 3.6 ***g***'s before the engine stopped.

(D) the pilot reached a speed of about 720 ms^{-1}, experiencing a maximum of about 5***g***'s.

4. In the future, a spacecraft leaves Earth for a trip to examine a nearby star, a distance 9 light years from Earth. Before the launch, an atomic clock on the spacecraft is synchronised with a second atomic clock that remains on Earth. The spacecraft flies to the star, completes a single orbit, and then returns directly to Earth. The spacecraft has an average speed of 0.81***c*** for the trip. On returning to Earth, which of the following would correctly describe the observed results.

(A) both the clock on Earth and the clock on the spacecraft would record the same time for the trip

(B) the clock on Earth would record about 22.2 years have elapsed while the clock on the spacecraft will have registered a shorter time for the trip.

(C) the clock on Earth would record about 22.2 years have elapsed while the clock on the spacecraft will have registered a longer time for the trip.

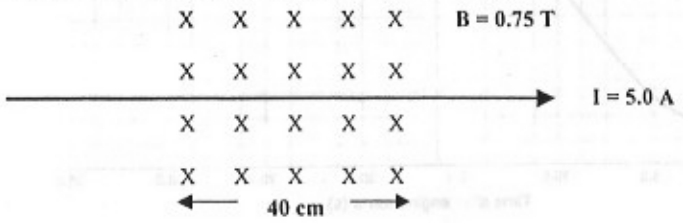
(D) the clock on Earth would record about 11.1 years have elapsed while the clock on the spacecraft will have registered a shorter time for the trip.

5. In the launch of a particular satellite, the satellite was released from a rocket such that it moved into a stable orbit around the Earth. After the satellite had completed a number of orbits of Earth, each taking 90 minutes, onboard rockets were used to propel the satellite into a much more distant stable orbit, with a radius 10 times larger than the original. Based on this information, which of the following would be closest to the orbital period of the satellite in the final more distant orbit?

(A) 47.4 hours (B) 38.7 hours

(C) 22.5 hours (D) 15 hours

6. A conductor carries a current through a region of uniform magnetic field as shown below.

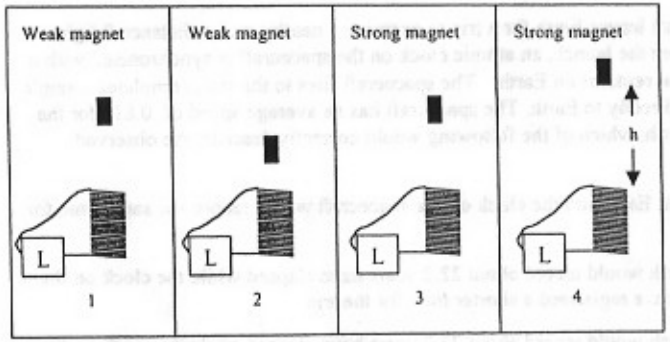


Which of the following would be closest to the force acting on the wire?

(A) 150 N into the page (B) 150 N up the page

(C) 1.5 N up the page (D) 1.5 N down the page

7. A student performed an experiment in which two magnets were dropped through a coil from different heights (**h**), shown in the diagram below. The coil was connected to a datalogger (L) that measured the potential difference across the coil each time a magnet was dropped through it.

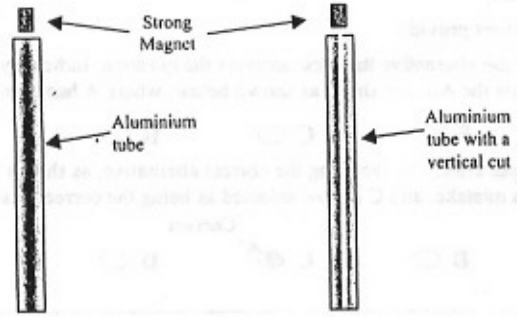


Which of the following represents the experiments shown, listed in increasing order of the maximum potential difference recorded across the coil by the data-logger.

(A) 4, 3, 2, 1 (B) 4, 3, 1, 2

(C) 1, 3, 2, 4 (D) 2, 1, 3, 4

8. A student dropped a small but very strong magnet down through two aluminium tubes as shown below. One of the tubes had a vertical cut down one side.



After repeating the experiment several times, the student noted that the magnet seemed to float slowly down through the complete tube and fell much faster through the tube with the cut.

Which of the following is a reasonable conclusion from these results?

(A) The magnet lost its magnetic field when it was inside the tube with the vertical cut

(B) Larger magnetic forces produced inside the complete tube slowed the magnet's progress.

(C) There were no magnetic forces slowing the magnet's progress through the cut tube.

(D) Aluminium is a magnetic metal that is only attracted to strong magnets.

9. A transformer has 200 turns of wire on its primary coil and 1500 turns on its secondary coil. If 50 volts AC was connected to the primary coil, and there were no energy losses, which of the following would be closest to the output voltage provided from the secondary coil?

(A) 75 000 volts (B) 6 000 volts

(C) 375 volts (D) 6.7 volts

10. Which of the following correctly describes the function of the split-ring commutator in a D.C generator?

(A) To ensure the current to the external circuit always flows in the same direction.

(B) To change the current direction in the generator coils so that it always flows through them in the same direction.

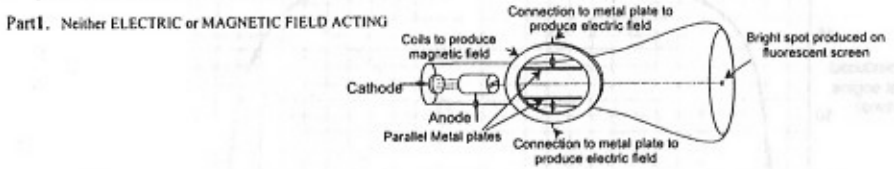
(C) To change the direct current produced by the rotating coil into alternating current for use in the external circuit.

(D) To ensure the torque on the generator coil is always in the same direction so that it continues rotating.

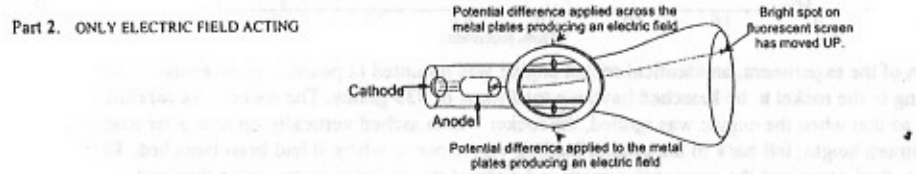
11. After the discovery of cathode rays, study of the rays produced debate as to whether they were electromagnetic waves or streams of particles. The experiment that collected convincing evidence to resolve this debate was performed by which of the following scientists.

(A) Heinrich Hertz
(B) J.J Thomson
(C) William Crookes
(D) Max Planck

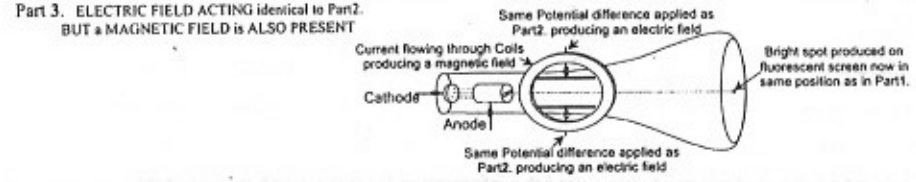
12. During an experiment with cathode rays, the highly evacuated glass tube included a set of parallel metal plates inside the tube. The metal plates can be attached to a source of potential difference, to allow an electric field to be set up inside the tube. The apparatus also included a set of coils that, when attached to a power supply and a current flows through them, produce a magnetic field in the same region where the parallel metal plates produce the electric field. In Part 1. of the experiment, the magnetic and electric fields were NOT acting. The result produced is shown in the following diagram.



In Part 2 of the experiment, an electric field was produced by applying a potential difference to the connections to the metal plates. The bright spot was observed to change its position on the fluorescent screen, as shown below.



In Part 3 of the experiment the electric field was left on, as in Part 2, but a DC current was now supplied to the coils to also produce a magnetic field. The strength of the magnetic field was adjusted, producing the result shown below.



Based on the results observed in the parts of the experiment, which of the following would correctly describe the direction of the magnetic field that was acting in Part 3.

(A) straight DOWN the page
(B) vertically INTO the page
(C) straight UP the page
(D) vertically OUT of the page

13. Which of the following changes is most likely to increase the resistance of a particular wire?

(A) reducing the temperature of the wire
(B) increasing the diameter of the wire
(C) adding impurities to the metal that makes up the wire
(D) reducing the length of the wire

14. Which of the following would best describe the basic idea behind the BCS theory in its attempt to explain superconductivity?

(A) electrons come together in pairs that are able to travel through the lattice of the superconductor with no interactions at all with the nuclei in the lattice.
(B) electron pairs interact with each other to produce magnetic fields that allow the paired electrons to travel through the lattice of the superconductor with no resistance.
(C) groups of electrons interact with the nuclei to allow the electrons to combine and move through the lattice of the superconductor with no resistance to their motion.
(D) the nuclei and the electrons interact to allow pairs of electrons to drift through the crystal lattice of the superconductor with no resistance to their motion.

15. Which of the following would best describe the material composing a p_r-type semiconductor?

(A) extremely pure silicon with some of the silicon electrons removed leaving holes in the resulting crystal lattice.
(B) extremely pure silicon with a certain number of extra electrons added leaving some free electrons in the resulting crystal lattice.
(C) pure silicon that has small amounts of an element, that has one less valence electron than a silicon atom, added to result in a crystal lattice where some of the silicon atoms in the lattice have a space for another electron.
(D) pure silicon that has small amounts of an element, that has one more valence electron

than a silicon atom, added to result in a crystal lattice with a number of extra electrons.

Part B - 60 marks

Attempt ALL questions 16 to 26.

Allow about 1 hour 45 minutes for this part.

Answer these questions in the space provided.

Be sure to put your Student Number in the space provided at the top of each page.

Where questions require calculations, show ALL working relevant to producing your answer.

Question 16. (4 marks) **Marks**

Three newly discovered planets all orbit a very distant star nicknamed "N-Chig".
The following data has been collected,

	Planet A	Planet B	Planet C
Diameter	84200 km	21100 km	168400 km
Mass	2.99×10^{26} kg	2.87×10^{26} kg	3.71×10^{26} kg
Orbital period	48 Earth days	284 Earth days	14 Earth years
Rotational period	200 hours	46 hours	20 hours

(a) Providing a reason for your answer, on which of the planets would you expect the gravitational acceleration at the surface to be greatest? 2

(b) Planet **B** is found to be orbiting a distance of 1.50×10^{11} m. from the star, "N-Chig", and to move with an orbital speed of 55.8 $km.s^{-1}$. Clearly showing your working, calculate the gravitational force that "N-Chig", is exerting on planet **B**. 2

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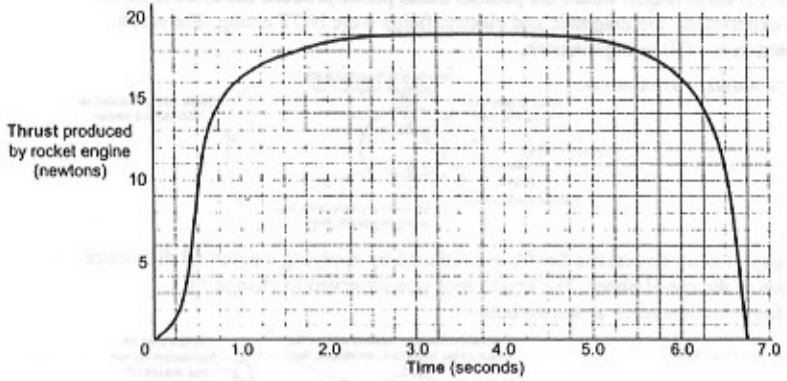
Question 17. (5 marks) **Marks**

The following graph shows the experimental results collected by a group of students where a toy rocket engine was tested using a force sensor and computer. A rocket engine was positioned in a mounting attached to the force sensor , the sensor triggered, and then the rocket engine fired. This allowed the thrust (force) produced by the rocket engine to be recorded over the time the fuel burnt.

GRAPH : Force produced by Toy Rocket engine during the Time the fuel burns.



As part of the experiment, an identical rocket engine was mounted in position in an actual rocket, resulting in the rocket to be launched having a total mass of 435 grams. The rocket was carefully set-up so that when the engine was ignited, the rocket was launched vertically up and, after reaching a maximum height, fell back to the ground landing very close to where it had been launched. The students then compared the measured maximum height of the rocket with the value they had predicted based on their analysis of the graph.

(a) Describe how the students could use information from the graph to determine the expected maximum acceleration of the final toy rocket that was launched vertically? 2

(b) Explain how the students might have used the information from the graph to predict the maximum speed their rocket would reach when launched. 3

Question 18. (6 marks) **Marks**

A futuristic spacecraft arrives back to Earth having been on a successful mission into deep space testing a revolutionary propulsion system. The whole test spacecraft had ended up with a mass of only 2.54×10^6 kg after its construction on Earth. The spacecraft was propelled by a newly created anti-matter propulsion system that allows the engine to produce enormous thrust with only fifty kilograms of the fuel required for a 100 year mission. After leaving the Earth and entering space, the trial had involved propelling the spacecraft to its top speed of $0.92\ c$., and then maintaining this speed while the spacecraft completed an enormous loop through deep space, to eventually return to Earth. A scientist on Earth notes, with the return of the spacecraft, it has been exactly two years since the spacecraft had departed on the trial.

(a) An observer is viewing the spacecraft from Earth with a powerful telescope, and watches it travelling at full speed, just as the spacecraft reaches the point halfway through the mission. Outline any changes that would appear to take place for the spacecraft. 2

b) From launch, an onboard sensor continually measured the mass of the spacecraft while it was on the mission. This information was automatically transmitted to Earth. Justifying your answer, what would have been observed by the scientist on Earth who was responsible for continually monitoring the data received on the mass from the spacecraft. 2

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(c) Outline the considerations for the spacecraft as it was approaching the Earth nearing the end of the mission. 2

Question 19. (5 marks) **Marks**

Discuss the aether, including reasons for its proposal and any significant contributions to resolve whether it existed. 5

Question 20. (5 marks)

Two conductors 3.0 metres in length were hung beside each other, as shown below. The conductors were parallel and separated by a distance of 50 mm. When a switch in a circuit with the conductors was closed and current flowed, the conductors were observed to move towards each other.

(a) If when the switch was closed, the wires each carried a current of 5.0 A., calculate the magnitude of the force between the wires. 2

Question 20. continues on next page

Question **20** continued. **Marks**

(b) Describe why the wires moved towards each other when the switch was closed. 3

Question 21. (4 marks)

Discuss the energy losses that occur in the transmission of electrical energy produced by a large generator at a power station, to supply the electrical energy for use by consumers some distance away. 4

Question 22. (6 marks) **Marks**

(a) Outline the difference between a step-up and a step-down transformer? 2

(b) In a transformer, the primary and secondary coils are not electrically connected to each other. Describe how the voltage is produced in the secondary coil. 2

(c) Describe ONE benefit for modern society arising from the development of transformers. 2

Question 23. (5 marks)

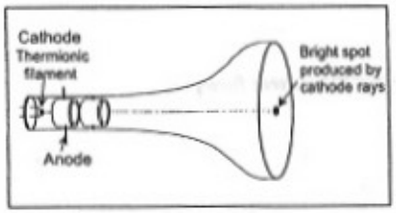
During your studies you carried out an investigation to examine the principles involved in an AC induction motor. Including relevant information on the procedure used, explain how the principles of an AC induction motor were demonstrated. 5

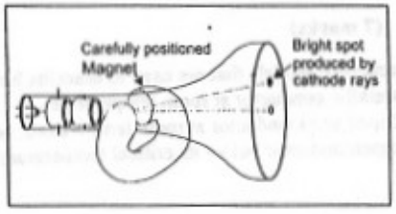
More space is available for the answer to **Q23**, on the next page.

Space for answer to Q23. continued. **Marks**

Question 24. (8 marks)

In a particular modern cathode ray tube, the electrons are produced by thermionic emission from a hot filament forming the cathode. The heating of the filament by a low voltage DC power source causes electrons to be "bubbled" of the filament (having no excess kinetic energy). The electrons are then accelerated from the filament by the large potential difference applied between the anode and cathode. The result is a very narrow beam of electrons, all with the same velocity, that travel on to the fluorescent screen to produce a bright spot in the centre (see diagram). The power supply for the cathode ray tube, provides a number of different connections, so that the large potential difference between the cathode and anode can be varied, with possible choices of ; 2.5 kV, 5.0 kV, 7.5 kV, and 10.0 k V.
The cathode ray tube was used in an experiment to determine the strength of a specially prepared magnet made by the students. The students used the 5.0kV connection for their experiment.
The results produced, without the magnet, and then with the magnet in position producing a magnetic field acting perpendicular to the path of the cathode rays, are represented in the following diagrams.





Measurement of the vertical displacement of the bright spot on the screen allowed the students to determine that the cathode rays had followed a curved path of radius 642 mm while they were passing through the region of magnetic field created by their magnet. Using this result and known information on the cathode rays, the students were able to calculate an experimental result for the strength of the magnetic field produced by their magnet.

(a) As part of their method, the students needed to know the velocity of the electrons in the beam produced by the cathode ray tube used. Outline the physical principles that would have been used to allow the students to determine the velocity of the cathode rays in their experiment. **2**

Question 24. continues on next page

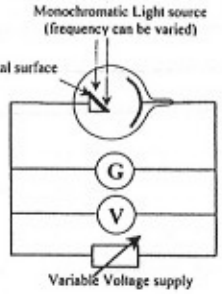
Question 24 continued. **Marks**

(b) Describe a suitable technique the students could have employed to allow them to calculate their experimental result for the strength of the magnetic field produced by their magnet. **3**

(c) Explain how the students could have made an improvement to the method they used, to allow them to obtain a more reliable experimental result for the strength of the magnetic field being produced by the magnet they made. **3**

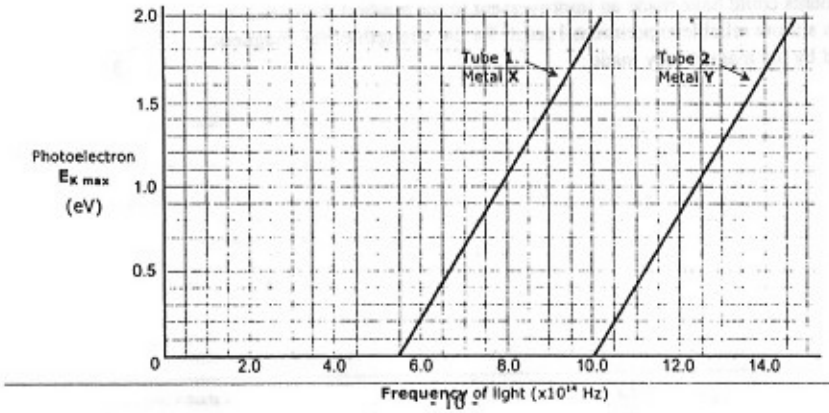
Question 25. (5 marks) **Marks**

In an experiment to examine the photoelectric effect, two identical evacuated tubes with different metals coated onto the target, were attached into the same circuit. A beam of light was directed onto the target metal surface producing photoelectrons that could be registered using a sensitive galvanometer in the circuit. The circuit included a variable source of potential difference that could be adjusted to apply the desired potential difference between the electrode and metal surface inside the tube, with a voltmeter included in the circuit to record the applied potential difference. The following diagram represents the circuit with one of the evacuated tubes in place,



The experiment involved changing the frequency of the monochromatic light source and then adjusting the potential difference, between the metal surface and other electrode inside the evacuated tube, with the results collected enabling the scientists to determine the maximum kinetic energy of the emitted photoelectrons for each different frequency of light used.

The graph below was prepared from the scientists' results for the two evacuated tubes.



(a) Naming the scientist involved, describe the observations that originally led to the discovery of the photoelectric effect. **2**

Question 25. continues on next page.

Question **25** continued. **Marks**

(b) Discuss how an analysis of the scientists' experimental results can provide important detail on the photoelectric effect. **3**

Question 26. (7 marks)

Compare the accepted models that are used to describe how an electric current flows in;

- a metallic conductor at room temperature,
- a doped semiconductor at room temperature, and
- a superconductor below its critical temperature. **7**

Student Number :

More space is provided for the Answer to **Q26**, on the next page.

Space for answer to Question **26**, continued.