Kincoppal-Rose Bay
School of the Sacred Heart

Year 12 TRIAL EXAMINATIONS

JULY 2008

Student Number _____

Physics

General Instructions

- Reading time – five minutes
- Working time – three hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided separately
- Write your name at the top of the Answer Booklet and Multiple Choice Answer Sheet

Total Marks (100)

This paper has two parts, Part A and Part B

Part A
Total Marks (15)

- Attempt Question 1 – 15
- Allow about 25 minutes for this part

Part B
Total Marks (85)

- Questions 16 to 33
- Attempt ALL Questions
- Allow about two and a half hours for this part

Part A – 15 marks
Attempt Questions 1-15
Allow about 25 minutes for this part

Record answers on the multiple choice answer sheet.

1. What statement about the weight of an object is correct?

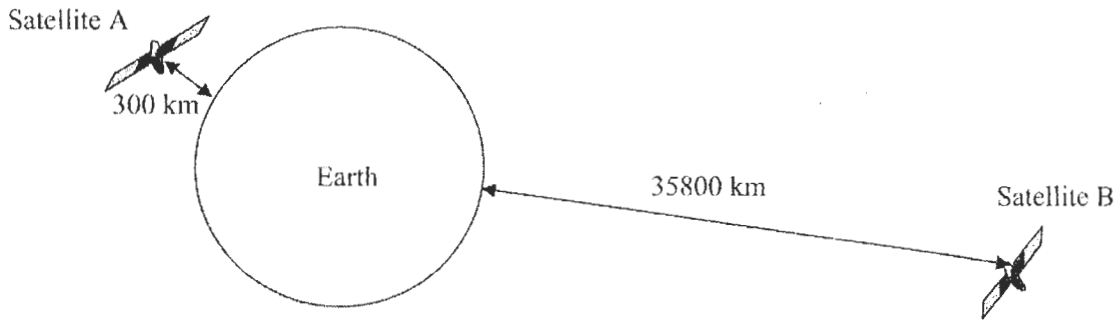
   (A) If gravitational acceleration is zero, then weight is zero.

   (B) The weight of a particular object is constant on a particular planet.

   (C) The weight of an object will not change when it is taken to another planet.

   (D) Weight is independent of the value of the acceleration due to gravity.

2. The diagram below shows two satellites of the same mass and the altitude at which they are orbiting above the Earth. The diagram is not drawn to scale.



Which statement is most correct?

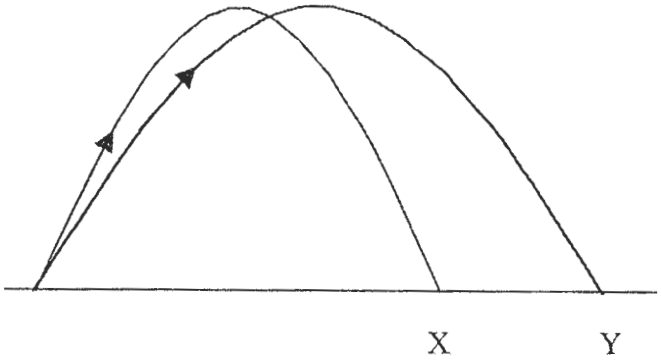
(A) Satellite B completes one orbit of the Earth in less time than satellite A.

(B) Satellite A experiences a greater centripetal force than satellite B

(C) Satellite B moves at a faster speed than satellite A

(D) Satellite A is likely to remain at a fixed position in the sky.

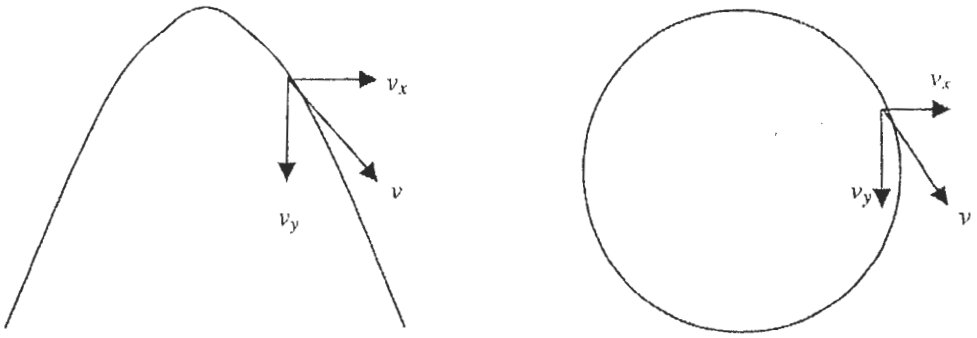
3. The diagram below shows the paths of flight of two projectiles, X and Y.



Which of the following is the same for X and Y?

(A) horizontal velocity
(B) time of flight
(C) range
(D) initial velocity

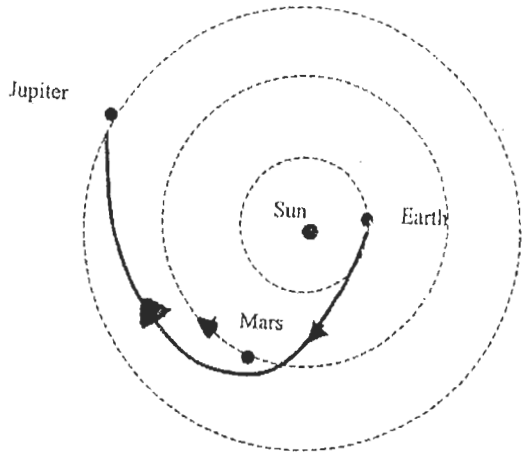
4. The following diagram represents a parabolic projectile path and uniform circular motion.



Which of the following pairs correctly contrasts projectile motion and uniform circular motion?

	Projectile motion	**Uniform circular motion**
(A)	• velocity of an object is constant	• velocity of an object is variable
(B)	• acceleration of an object is constant	• magnitude of acceleration of an object is constant
(C)	• motion in the x-direction is variable	• motion in the x-direction is constant
(D)	• motion in the y-direction is variable	• motion in the y-direction is constant

5. The following diagram shows the trajectory of a spacecraft on a mission to Jupiter from Earth.



What can be said about the spacecraft as it passes Mars?

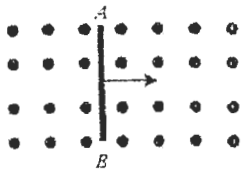
(A) It slows down due to Mars' atmospheric friction.

(B) It is slowed down by Mars' gravitational force.

(C) It wastes fuel to escape Mars' gravitational pull.

(D) It speeds up due to the slingshot effect.

6. The diagram below shows a conductor being moved to the right through a magnetic field.



Which statement below best describes what will occur in the conductor?

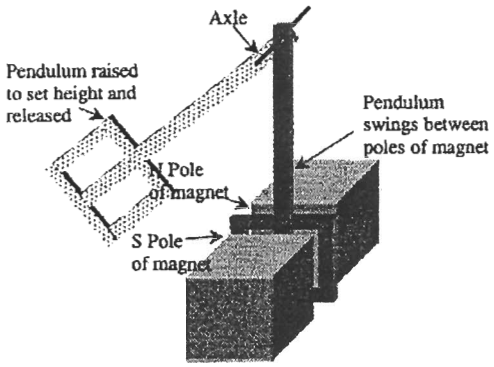
(A) There will be a potential difference induced between the two ends and the electrons will flow toward end A.

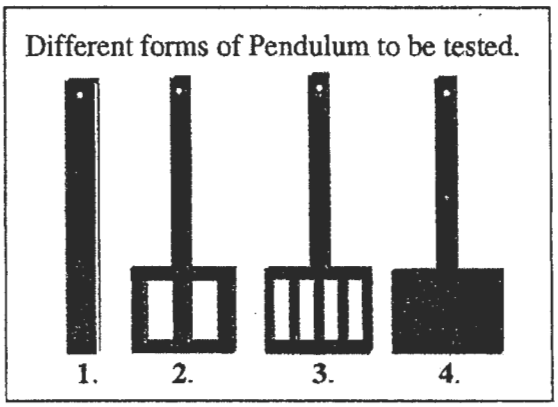
(B) There will be a potential difference induced between the two ends and the electrons will flow toward end B.

(C) The conductor will experience a force and move down the page.

(D) The conductor will experience a force and move up the page.

7. An apparatus has been constructed to investigate eddy currents. It consists of a large, very strong permanent magnet and several pendulum structures made of aluminium plate. The pendulums can be hung from an axle to allow them to swing between the poles of the large magnet. An example is represented in the following diagram.





Each of the FOUR different pendulums was tested. It was that the motion of each pendulum was slowed as it passed between the poles of the magnet.

Considering the shape of the FOUR pendulums, which of the following is most likely?

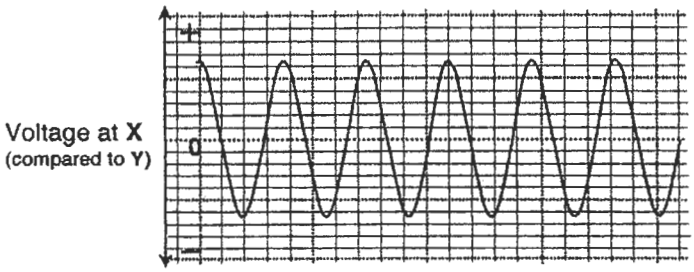
(A) Each of the four pendulums will come to rest at the same time.

(B) The pendulum number 1 will come to rest quicker than the others.

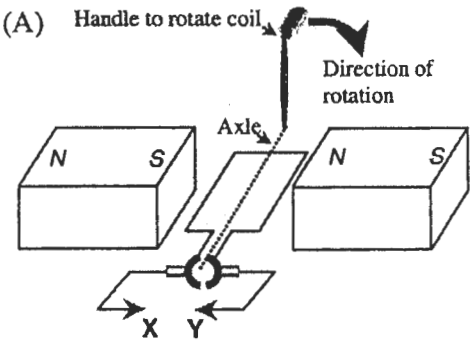
(C) The pendulum number 3 will come to rest quicker than the others.

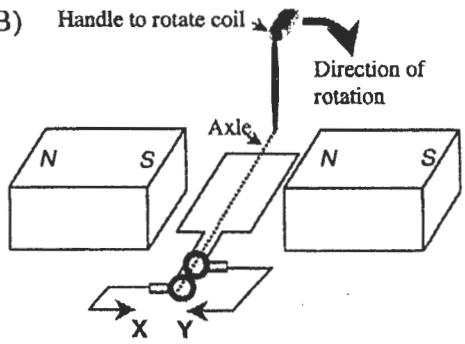
(D) The pendulum number 4 will come to rest quicker than the others.

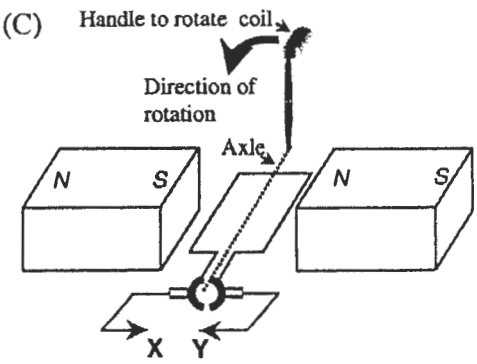
8. During an experiment, TWO forms of simple generator were each attached to a cathode ray oscilloscope. The handle of the generator was rotated at a steady rate and a plot of the voltage produced at the contact **X**, compared to **Y**, was recorded for each of the generators.
The following graph shows the result for one of the generators tested.

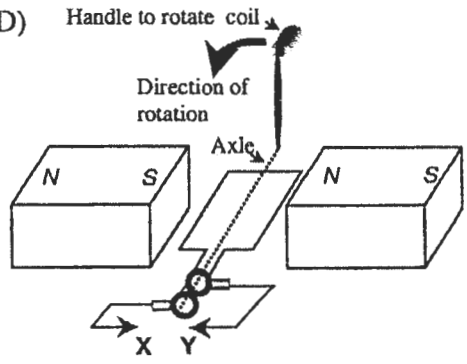


Considering the graph starts with the generators in the positions shown, which of the following alternatives would correctly represent the direction of rotation and form of generator that produced the plot shown.

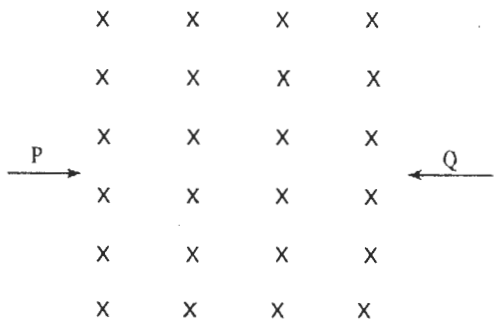
(A)


(B)


(C)


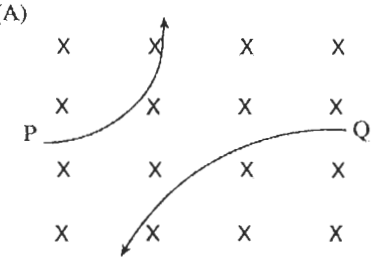
(D)


9. The following diagram shows a region of a uniform magnetic field directed down into the page. Two particles P and Q, of equal mass and speed, enter the magnetic field as shown. P has a charge of $+ 2 \times 10^{-17}$ C, and Q has a charge of $+ 4 \times 10^{-17}$ C.

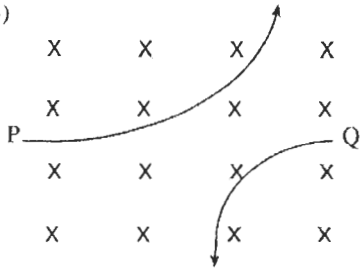


Which of the following diagrams correctly shows the subsequent paths of both particles?

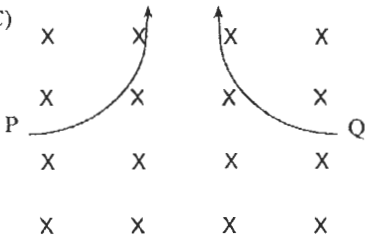
(A)



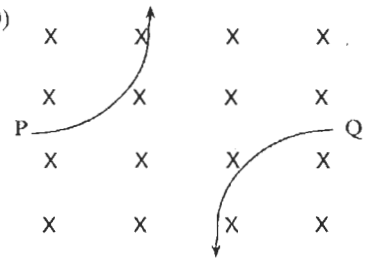
(B)



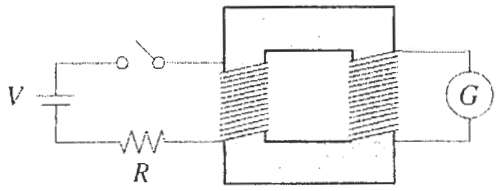
(C)



(D)

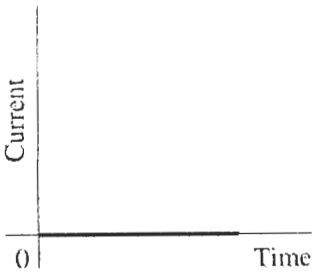


10. The primary coil of a transformer is connected to a battery, a resistor and a switch. The secondary coil is connected to a galvanometer.

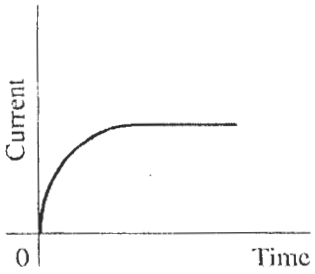


Which of the following graphs best shows the current flow in the galvanometer when the switch is closed?

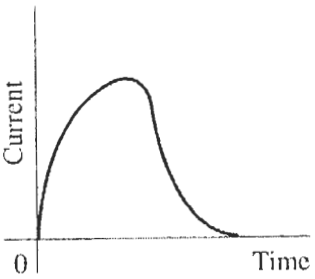
(A)



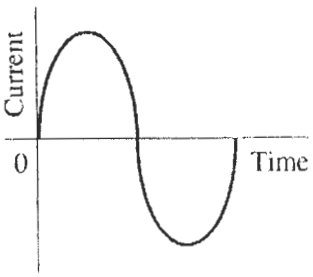
(B)



(C)



(D)



11. An *n*-type semiconductor is produced when silicon crystal is doped with small quantities of phosphorus.
How will this doping change the crystal's electrical conductivity?

(A) The conductivity will decrease because there are fewer holes in the valence band.

(B) The conductivity will increase because there are more holes in the valence band.

(C) The conductivity will decrease because there are fewer electrons in the conduction band.

(D) The conductivity will increase because there are more electrons in the conduction band.

12. Heinrich Hertz was able to measure the speed of radio waves of known frequency by doing which task outlined below?

(A) Studying cathode rays in a vacuum tube.

(B) Measuring the charge to mass ratio of the radiation.

(C) Measuring the wavelength using interference effects.

(D) Measuring the time taken for the waves to be reflected back from the detecting loop.

13. Which statement below about superconductors is TRUE?

(A) Some pure metals when cooled to the critical temperature can become superconductors.

(B) Phonons are produced by electrons joining up to form Cooper pairs.

(C) The individual electrons involved in a Cooper pair remain together while-ever the critical temperature is maintained.

(D) BCS theory is used to explain the behaviour of Type II superconductors.

14. A small magnet can be made to hover above a superconducting material that is cooled below its critical temperature. Which of the following alternatives provides the best explanation for why this occurs?

(A) Below the critical temperature superconductors produce their own magnetic fields.

(B) The superconductor responds to the magnetic field of the small magnet by producing internal currents that produce magnetic fields to repel the small magnet.

(C) The magnetic field of the small magnet cannot enter the superconductor and is perfectly reflected from the surface of the superconductor causing the magnet to repel itself.

(D) Below the critical temperature all the electrons in the superconductor attract each other to form Cooper pairs that repel magnetic fields.

15. Which statement below is TRUE about the photoelectric effect?

(A) If dim light of a given frequency does not result in a photocurrent, then increasing its brightness will increase the likelihood of a photocurrent being produced.

(B) If dim light of a given frequency produces a photocurrent, then increasing the brightness will have no effect on the amount of photocurrent produced.

(C) If dim light of a given frequency produces a photocurrent, then increasing the brightness is also likely to increase the photocurrent produced.

(D) If light of a given frequency does not result in a photocurrent, then lowering the frequency will increase the likelihood of producing a photocurrent.

END OF PART A

Kincoppal-Rose Bay

Year 12 Trial Physics Examination 2008

Part B Questions 16 to 33 (85 marks)

Write all answers in the space provided.

Student Number .....

Marks

Question 16 (3 marks) **3**

In your Physics course you studied one of the following contributors to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun. Choose ONE of the above persons and analyse their significance to space science.

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Question 17 (2 marks) **2**

Explain how the characteristics of a geostationary orbit relate to the main purposes of satellites placed in them.

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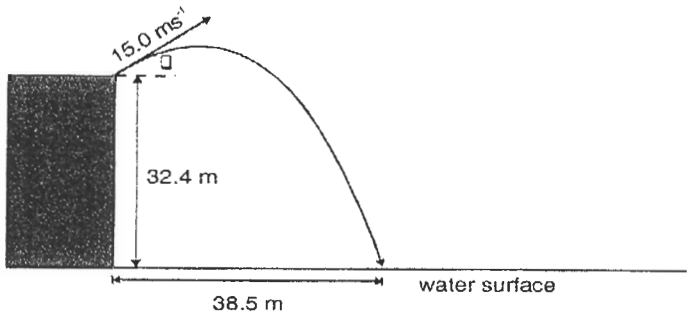
Question 18 (5 marks) **Marks**

Consider the diagram below of a stone projected from a cliff at 15.0 ms^{-1} at an angle θ above the horizontal. The cliff was 32.4 m high and the stone was seen to land 38.5 m from the base of the cliff. The time of flight was 4.0 seconds.



(a) Calculate the magnitude of the horizontal component of the stone's initial velocity. **1**

(b) At what angle, θ above the horizontal was the stone projected? **1**

(c) Determine the magnitude of the velocity of the stone at its maximum height. **1**

(d) Calculate the maximum height above the **surface of the water** that the stone reached. **2**

Question 19 (5 marks) **Marks**

A spacecraft from the planet Zondor was travelling in the vicinity of Earth. The inhabitants of this spacecraft were travelling at 0.8 *c*. Astronomers on Earth tracked the spacecraft's motion across the sky. From their observations they determined the length of the spacecraft to be 15 m long and 10 m high.

(a) Determine the length and height of the Zondorian spacecraft as measured by the Zondorians on board the craft **3**

(b) The Zondorians used their advanced technology to capture an Earth based astronomer to their spacecraft in order to meet her and see what a human being looked like. The astronomer was then returned to Earth. The astronomer reported that she had been on the Zondorian spacecraft for 10 hours (while the spacecraft maintained its 0.8 *c* velocity). For what period of time did the astronomers remaining on earth observe their colleague to be absent? **2**

Question 20 (6 marks) **Marks 6**

Most celestial objects outside our solar system are too distant to reach at current maximum speeds. However, research is continuing into a new generation of craft that may be able to travel at speeds vastly greater than today's vehicles.
Discuss the consequences of near light-speed space travel to destinations outside our solar system.

Question 21 (8 marks) **Marks**

A satellite of mass 250 kg maintains an orbit of 320 km above the Earth's surface. The Earth has a radius of 6.38×10^6m and a mass of 5.97×10^{24} kg.

(a) Determine the gravitational potential energy of the satellite at this altitude. **2**

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(b) Justify the use of the minus sign in the formula for gravitational potential energy **2**

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(c) The satellite is moving with uniform circular motion. Describe how it can be thought of as accelerating. **1**

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(d) Determine the period of orbit of this satellite. **2**

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(e) Identify what happens to the period of the satellite if its *mass was to be halved.* **1**

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Question 22 (4 marks) **Marks 4**

Describe a first hand investigation to demonstrate the operation of a transformer. Include a discussion of the limitations shown in your results.

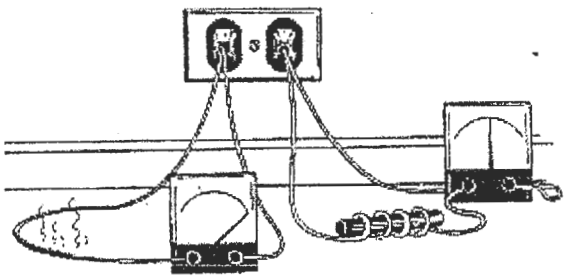
Question 23 (2 marks) **2**

The transformer in an electric keyboard reduces the 240 AC voltage to a 12 V AC voltage. The secondary coil has 60 turns. Determine the number of turns in the primary coil.

Question 24 (5 marks) **Marks**

(a) State Lenz's Law and outline a situation where it has been useful and a situation where it causes problems. **3**

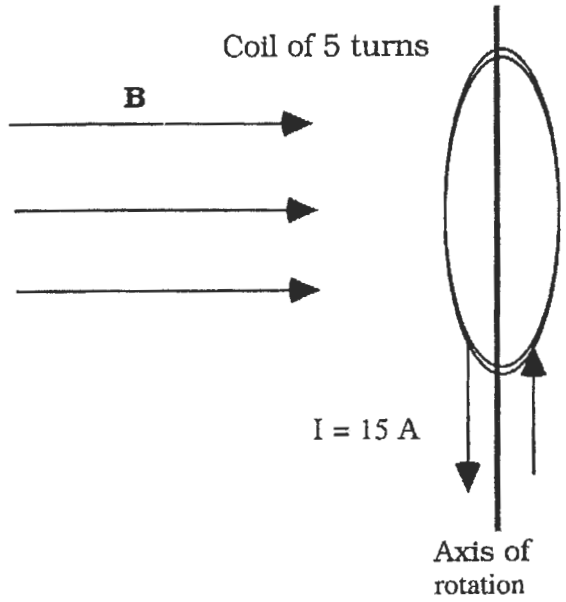
(b) In the diagram below the wire on the left is plugged directly into a 240 volt alternating current source and has a very large current flow which may blow the fuse.



Explain why the same wire, if coiled around a soft iron core, will have a lower current and is less likely to blow the fuse. **2**

Question 25 (3 marks)

A circular coil is able to rotate around an axis along its diameter.



A uniform magnetic field of strength 6.1×10^{-5} T is directed perpendicularly to the axis of the coil. When a current of 15 A passes through the coil it experiences a maximum torque of 1×10^{-4} Nm. Calculate the area of the coil. **2**

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(b) At what angle must the direction of the magnetic field be directed with respect to the plane of the coil if the torque is to be reduced by half? **1**

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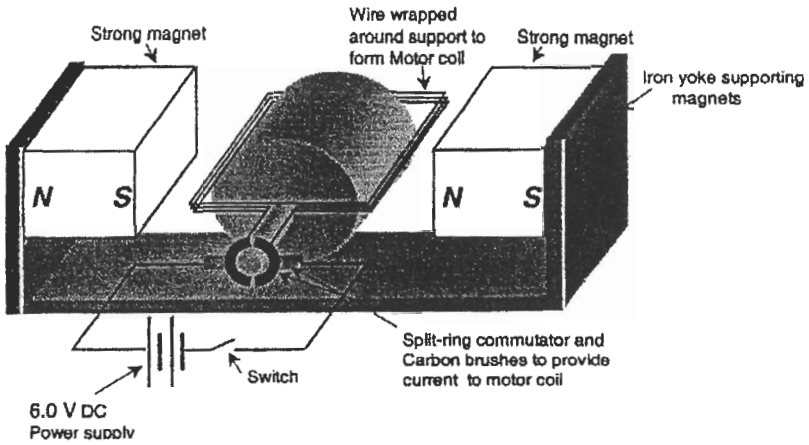
Question 26 (4 marks) **Marks 4**

As part of their studies a group of students successfully constructed a simple DC motor as shown below.



The student conducted tests on the motor and found that it operated best when using a 6.0 volt power supply, with the motor rotating at a frequency of 3 hertz.
Consider starting the motor when it is in its present position as shown on the diagram. Explain how the torque on the motor will vary as the coil begins to rotate and eventually reaches full speed.

Question 27 (3 marks) **Marks 3**

Describe and compare the underlying physics of AC induction motors and DC motors.

Question 28 (4 marks)

A positively charged particle of charge 3.2×10^{-19} C and mass 4.0×10^{-27} kg moves perpendicularly to a uniform magnetic field of 0.18 T. The particle is moving at 9.0×10^{4} m/s.

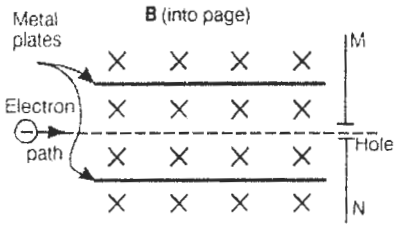
(a) Calculate the magnitude of the magnetic force that the particle experiences. **2**

(b) Determine the centripetal force on the particle. **1**

(c) Explain what effect this force has on the kinetic energy of the particle. **1**

Question 29 (5 marks) **Marks**

A pair of parallel metal plates is placed parallel to a uniform magnetic field which is directed into the page.



An electric field is applied to the plates so that an electron entering the plates follows a straight line path due to the balance achieved between the magnetic and electric forces. Because of this the electron is able to pass through the hole in the metal sheet MN.

(a) What must be the direction of the electric field in order to achieve this balance between forces? **1**

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(b) Derive an expression for the velocity of the electron in terms of the electric field , E, and the magnetic field B, neglecting any gravitational forces on the electron. **2**

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(c) Calculate the magnitude of the electric field strength if the magnetic field strength is 6.0×10^{-2} T and the velocity of the electron is 1.2×10^{6} m/s. **1**

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(d) J.J Thomson set up a similar experiment using crossed electric and magnetic fields on a beam of cathode rays. By doing this he was able to measure the charge to mass ratio of the cathode rays. This value was 1.76 x 10 11 C kg^{-1}.
State his observations about this charge to mass value when he used cathodes made of different materials. **1**

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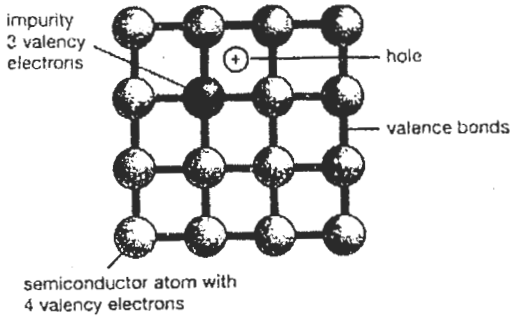
Question 30 (6 marks) **Marks**

Consider the diagram below of a doped semiconductor.



(a) Identify whether the diagram represents a n-type or p-type semiconductor. **1**

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(b) Explain how doping with an impurity containing three valence electrons results in improved conduction. **2**

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(c) Such doped semiconductors have been used to make transistors. Explain ONE reason why transistors were used to replace valves as switches and amplifying devices. **2**

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(d) To explain how semiconductors work physicists develop models such as band theory. Describe an important benefit to scientists of using models to explain physical phenomena. **1**

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Question 31 (6 marks) **Marks 6**

Assess the impact on society and the environment of the potential applications of superconductors.

Question 32 (5 marks) **Marks**

You performed (or were shown) a first-hand investigation to demonstrate the properties of cathode rays using discharge tubes.

(a) Identify ONE safety risk involving in the carrying out of these experiments and explain how this was addressed. **2**

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(b) Analyse information from TWO of these experiments to suggest why there was a debate whether cathode rays were charged particles or waves. **2**

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(c) Cathode rays were later found to be electrons. Describe what causes the resistance in ordinary metal conductors when electrons form a current. **1**

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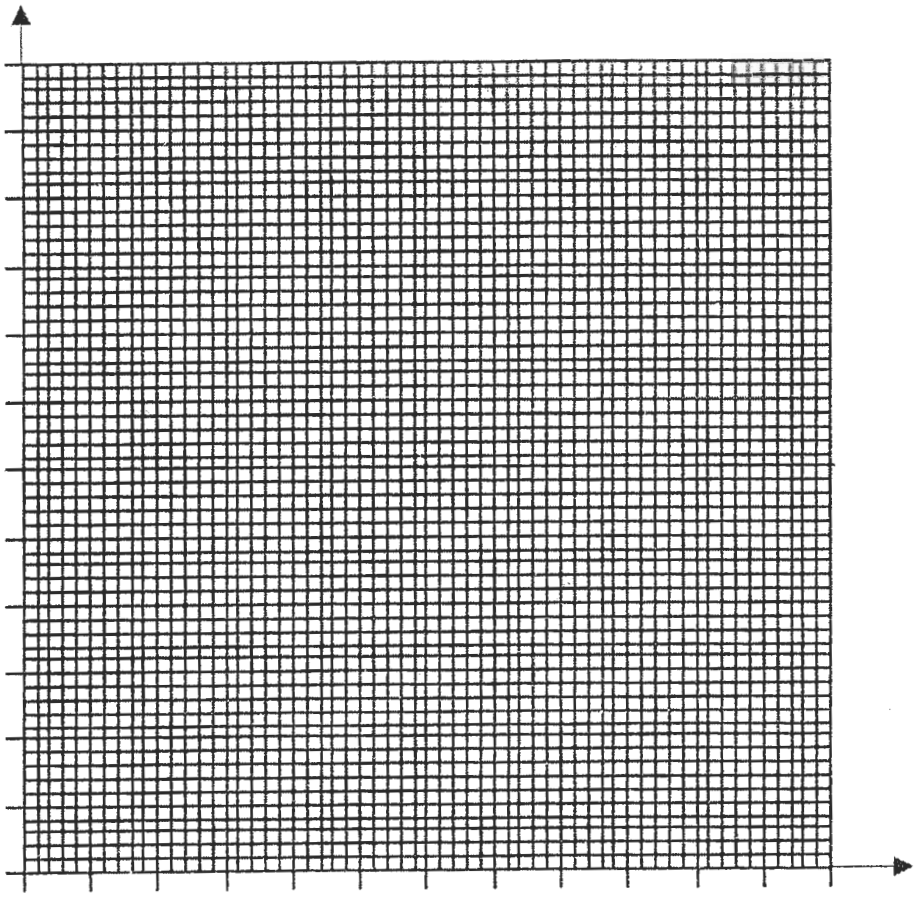
Question 33 (9 marks) **Marks**

A student carried out an experiment on the photoelectric effect. The frequency of the incident radiation and the energy of the photoelectrons were both determined from measurements taken during the experiment.

The results are shown in the table below:

Energy of photoelectrons ($x\ 10^{-19}$ *J*)	*Frequency of incident radiation* ($x\ 10^{14}$ *Hz*)
1.22	6.9
1.70	8.2
2.70	9.1
3.05	9.9
3.38	10.6
3.91	11.8

(a) Graph the results on the grid provided **4**



Question 33 is continued on the next page --------->

Question 33 continued. **Marks**

(b) Use the appropriate equation and the graph you have drawn to calculate Planck's constant. **2**

(c) Describe how Einstein explained the photoelectric effect, and how this changed our understanding of the nature of light. **2**

(d) The photoelectric effect has been used in conjunction with n and p-type semiconductors to make useful devices. Identify ONE of these devices **1**

END OF EXAMINATION

Kincoppal-Rose Bay
School of the Sacred Heart

Year 12 TRIAL EXAMINATIONS

JULY 2008

Student Number _____

Physics -SOLUTIONS

General Instructions

- Reading time – five minutes
- Working time – three hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formula sheets and Periodic Table are provided separately
- Write your name at the top of the Answer Booklet and Multiple Choice Answer Sheet

Total Marks (100)

This paper has two parts, Part A and Part B

Part A
Total Marks (15)

- Attempt Question 1 – 15
- Allow about 25 minutes for this part

Part B
Total Marks (85)

- Questions 16 to 33
- Attempt ALL Questions
- Allow about two and a half hours for this part

KINCOPPAL-ROSE BAY

HSC PHYSICS

TRIAL EXAMINATION 2008

MARKING GUIDELINES

Part A (1 mark each)

1. A
2. B
3. B
4. B
5. D
6. A
7. D
8. B
9. B
10. C
11. D
12. C
13. A
14. B
15. C

Part B

16. Contributions to rocket science

Criteria	Marks
Identifies contributions and analyses why it is important	2-3
Identifies contribution OR confuses contributions of different scientists	1

17. Explaining the use of geostationary orbits

Criteria	Marks
Geostationary orbit has a period of 24 hours Causes satellite to remain above one fixed spot This enables communication between the Earth and satellite (such as for TV broadcasts) to be easier.	2
TWO Characteristics stated but not related to the purpose of the satellite Note: some candidates confused earth's rotational velocity on its axis (24 hr) with its orbital velocity around the Sun. The orbital velocity is not relevant in this question.	1

18. Projectile motion

(a) Horizontal velocity calculated correctly (9.6 m/s). No penalty for units (1 mark)

(b) The angle correctly calculated (50.2^0) (1 mark)

(c) At maximum height velocity is equal to the initial horizontal velocity (9.6 m/s) (1 mark)

(d) Calculation above the surface correctly done. (39.2 m) (2 marks)

Subtract one mark for mathematical error OR for not calculating height *above the water*.
No penalties deducted for incorrect units.

19. Relativity

(a)

Criteria	Marks
No change to the height (remains at 10 metres) Use of length contraction formula to find L_0 of 25 metres	3
One error	2
Two errors	1

(b)

Criteria	Marks
Use of time dilation formula to find t_v, 16.7 h	2
One error	1

20. Consequences of near light-speed travel

Criteria	Marks
Mass increase (dilation) means more energy required to move the craft Length contraction (travelers measure distances to be much shorter and/or observers will measure the craft to be much shorted in length) Time dilation effects (travellers will age more slowly compared to those left behind on Earth) (A score of six marks awarded to those answers showing a deeper understanding of the consequences of changes to mass, length and time)	5-6
Discussion of TWO changes to mass, length and/or time OR: changes to mass, length or time identified but no or poor discussion of what this means	3-4
Discussion of one change to either mass, time or length OR: changes to any two of mass, length or time identified (but no discussion)	2
One consequence identified	1

21. GPE and satellite motion

(a) Use of GPE formula to find GPE of satellite (-1.48×10^{10} J) (2 marks)

One error (such as not making the GPE negative OR not taking the Earth's radius into account OR mathematical error) (1 mark)

(b) Why GPE is negative

Criteria	Marks
Negative because infinity is set as zero Some details of how this argument means that points close to the Earth will have a large negative value of GPE	2
A limited or incomplete argument	1

(c) Why the satellite can be defined as accelerated motion.

Criteria	Marks
Direction always changing, therefore velocity is changing Acceleration is defined as a change in velocity	1

(d) Period of orbit

Use of Kepler's Law formula to find period of 1.5 h (90 minutes)
All metric conversions correctly carried out (such as km into metres), and the use of the Earth's mass in the formula (*not* the satellite mass) (2 marks)

One mathematical error (1 mark)

(e) The satellite's period remains the same. An analysis of the relevant formula shows that the mass of the planet and the height are the only two variables, not the satellite's mass. (1 mark)

22. First-hand investigation of a transformer

Criteria	Marks
Labelled diagram or explanation of set-up, including the need for AC voltage supply, whether the device was a set-up or step-down transformer, how measurements were taken. Limitations in results (why results were not ideal), such as due to the lack of a laminated iron core)	4
Some key information omitted. For example: inadequacies in description of method or limitations not discussed	3
Two correct statements relating to transformer design	2
One correct statement on experiment design	1

23 Transformer calculation

Correct use of transformer equation to find number of turns in primary coil (1200) (2 marks)

Correct equation selection and substitution into equation OR mathematical error (1 mark)

24.

(a) Application of Lenz's Law

Criteria	Marks
Statement of Lenz's Law and two applications outlined.	3
Statement of Lenz's Law and two applications identified (but not outlined) OR: applications outlined but no adequate statement of Lenz's Law	2
Statement of Lenz's Law OR one application outlined	1

(b) Avoiding of blowing a fuse in a wire

Criteria	Marks
Due to the *alternating* nature of the supplied current, there will be a *changing* magnetic field in the wire. The iron core will magnify and enhance this changing field. There will now be a *back emf* set up in the wiring, which oppose the supplied voltage. This will lower the current in the wire, thus meaning it is less likely that the fuse will blow.	2
Partial explanation (note: the verb *explanation* requires statements of *cause* and *effect*) OR: statement of Lenz's law, but not adequately linked to this specific question. OR: recognition that there is a back emf produced, but this was wrongly attributed to the core rather than to the coil of wire itself.	1

25. (a) Torque in a coil

Correct use of torque equation to find the area of the coil. ($0.022m^2$) (1 mark)

Mathematical error OR correct selection of equation and substitution of values. (1 mark)

(b) Angle should be 60^0, as cosine of sixty degrees is 0.5, and this will reduce torque by half (1 mark)

26. Torque on a DC motor

Criteria	Marks
Full explanation of how torque varies. This includes: In its starting position the torque is a maximum. This will decline to a minimum as the motor reaches the vertical position. The motor's torque will then increase again as (due to the split ring commutator) it continues to rotate in the same direction. In addition, as the coil begins to rotate there will be a back emf generated in the windings of the coil. The back emf will oppose the supplied emf and this will mean that the motor reaches a terminal speed and torque remains constant after that point.	3-4
ONLY the torque/position explanation given (including its direction of motion) OR the back emf explanation	2
Partial explanation of either back emf or torque/position, such as the fact that the torque starts at a maximum value	1

27. AC induction and DC motors

Criteria	Marks
AC induction motors use electromagnetic induction, where a current is induced in the coil which then chases after the rotating magnetic field. DC motors operate on the motor effect, where a torque in the current carrying coil is created when the coil is in the presence of an external magnetic field. Therefore, the underlying physics is fundamentally different. (For three marks, the descriptions need to be more than just identification statements)	2-3
One correct description of the underlying physics of DC or AC induction motors , such as the fact that it is the motor effect used in DC motors and electromagnetic induction in AC motors	1

28. (a) Correct use of $F = q\ v\ B \sin\theta$., $F = 5.2 \times 10^{-15}$ N (2 marks)
Correct units of force.

(b) 5.2×10^{-15} N (1 mark)

(c) The kinetic energy does not change, as the force is a centripetal force which only changes the direction of the particle, and not its speed. (1 mark)

29. (a) Electric field must be directed down the page. (1 mark)

(b) Selection of the two equations: $F = qvB \sin\theta$ and $F = Eq$ (2 marks)

Equate the above two expression to obtain $v = E / B$

One mark awarded if correct equations are chosen but an algebraic error is made.

(c) Correct use of $v = E / B$ to find E. (7.2×10^4 N/C) (1 mark)
Incorrect units not penalized.

(d) The charge to mass value was *always* the same, regardless of the material used in the cathode. (1 mark)

30. Semiconductors

(a) This is a p-type semi-conductor (1 mark)

(b) Doping and conductivity

Criteria	Marks
The doping will introduce positive holes in the semiconductor's valence band. Under the influence of an applied electric field, electrons will move in to fill these holes. The hole current and electron current will be in opposite directions	2
Partial explanation OR some confusing or contradictory material in explanation	1

(c) Transistors.

Transistors replaced valves for several reasons.
TWO marks awarded for any from of the list below:
ONE mark awarded for one correct statement.
Note: need to *explain* the benefit, not just identify an issue to be awarded two marks.

- Transistors are less fragile and more robust, therefore less wear and tear and maintenance issues (or longevity of the device is improved)
- Valves produce much waste heat, thus are less energy efficient than transistors
- Valves are larger than transistor, thus portability and miniaturization is improved
- Valve need larger energy sources, thus can be expensive to operate
- Valves take time to warm up, thus transistors offer instant start-ups when operating appliances.

(d) Models offer a framework to help guide research into better semiconductors .
OR: allow predictions to be made about new phenomena
OR: allow visualization of things too small to ever observe directly (1 mark)

31. Superconductors

Criteria	**Marks**
• Identifies at least two applications. For at least two describes at least one impact on society and/or the environment • Makes a value statement with respect to at least two impacts identified	5–6
• Identifies at least two applications. For at least two describes an impact on society and/or the environment	3–4
• Identifies at least two applications OR • Identifies one application and an impact	2
• Identifies an application OR • Identifies an impact	1

NOTE: many candidates had responses far too long, taking a while to get to the main point.

32. Discharge tubes

(a) safety risk

Criteria	Marks
Issues identified *and* dealt with Example: High voltage (which could cause shock) is dealt with by having students kept away form the induction coil and only the teacher operates this device. OR: X-Ray production from the discharge tubes (such as the Maltese cross experiment) was dealt with by having students kept at least 2 metres from the discharge tube	2
Issue identified but not explained how it was dealt with	1

(b) Wave or particle nature of cathode rays.

Criteria	Marks
Contrasting information from TWO experiments Example: Maltese cross experiment showed that they travelled in straight lines, which is a wave property They were deflected by magnetic fields, which is a property of *charged* particles. Specifically, they were behaving as negatively charged particles.	2
One correct observation and its meaning in terms of waves or particles	1

(c) The resistance in metals

Vibrations of the lattice cause collisions of the electrons (1 mark)
OR: electrons collide with impurities in the material

33. Photoelectric effect

(a) Graph

Criteria	Marks
Rules of graphing all followed: Dependent vs independent (energy on vertical axis and frequency on horizontal axis) Units stated on each axis Points correctly plotted Use of at least 50% of graph paper Sensible linear scale chosen Line of best fit drawn	4
One error	3
Two errors	2
Three errors	1

(b) Planck's constant

Use of gradient to find Planck's constant. (2 marks)
Correct calculation
Correct units. (gradients have units, they are not just numbers)

One error or units not given (1 mark)

(c) Photoelectric effect and the nature of light

Criteria	Marks
Before Einstein light was assumed to be a wave Einstein extended Planck's quantum idea to light. Light was now seen as packets of discrete energy called photons. a photon of light incident on a metal surface would give up all or none of its energy	2
Partial explanation	1

(d) Solar cells use doped semiconductors and the photoelectric effect. (1 mark)
NOT *photocells*.

END OF EXAMINATION

Kincoppal-Rose Bay

Year 12 Trial Physics Examination 2008

Part B Questions 16 to 33 (85 marks)

Write all answers in the space provided.

Student Number .....

Marks

Question 16 (3 marks) **3**

In your Physics course you studied one of the following contributors to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun. Choose ONE of the above persons and analyse their significance to space science.

Robert Goddard:
Robert Goddard made several key contributions in the development of rockets including:
Development of the first liquid fuel rockets.
Development of systems to guide and stabilise rockets
He proved that rockets can work in empty space, and do not need air to 'push against' in order to work.
The significance is that he put theoretical ideas into practice and showed that rockets can actually work as more than just toys. His ideas were built on by later researchers in space programs.

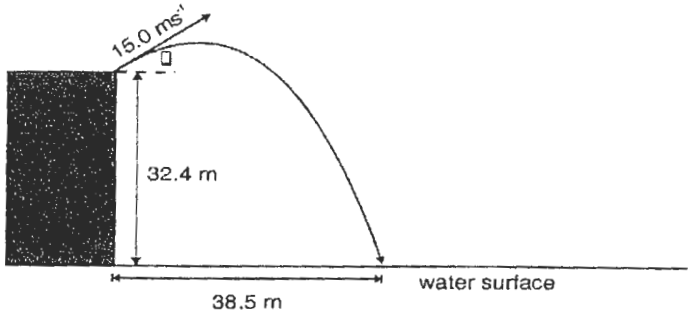
Question 17 (2 marks) **2**

Explain how the characteristics of a geostationary orbit relate to the main purposes of satellites placed in them.

Geostationary orbits have a period of 24 hours.
This means that they remain at one fixed spot above the Earth's surface.
This enables easy and convenient communication between the satellite and Earth for TV broadcasting, as the satellite does not have to be tracked across the sky.

Question 18 (5 marks) **Marks**

Consider the diagram below of a stone projected from a cliff at 15.0 ms^{-1} at an angle θ above the horizontal. The cliff was 32.4 m high and the stone was seen to land 38.5 m from the base of the cliff. The time of flight was 4.0 seconds.



(a) Calculate the magnitude of the horizontal component of the stone's initial velocity. **1**

$U_x = s / t = 38.5 / 4 = 9.6$ *m/s*

(b) At what angle, θ above the horizontal was the stone projected? **1**

$U_x = u \cos \theta$

$\cos \theta = u_x / u = 9.6 / 15.0 = 0.64$ *Therefore* $\theta = 50.2^0$

(c) Determine the magnitude of the velocity of the stone at its maximum height. **1**

At maximum height the stone's velocity is equal to the horizontal velocity, which is 9.6 m/s

(d) Calculate the maximum height above the **surface of the water** that the stone reached. **2**

Consider the vertical motion:
V_y *= zero at maximum height.,* $a = -9.8$ *m/s*^{2}, $u_y = 15 \sin 50.2$, $s_y = ?$ *m*

$V^2 = u^2 + 2 a s$

$0 = (15 \sin 50.2)^2 + (2 \times -9.8 \times s)$

$s = 6.78$ *m*

Therefore the height above the surface = 6.78 + 32.4 m = 39.2 *m*

Question 19 (5 marks) **Marks**

A spacecraft from the planet Zondor was travelling in the vicinity of Earth. The inhabitants of this spacecraft were travelling at 0.8 *c*. Astronomers on Earth tracked the spacecraft's motion across the sky. From their observations they determined the length of the spacecraft to be 15 m long and 10 m high.

(a) Determine the length and height of the Zondorian spacecraft as measured by the Zondorians on board the craft 3

$V = 0.8c \qquad L_V = L_o\sqrt{1-\frac{V^2}{c^2}}$

$15 = L_o\sqrt{1-\frac{(0.8c)^2}{c^2}}$

$15 = L_o\sqrt{1-0.64}$

$15 = L_o \times 0.6$

$\therefore L_o = 25m$ (2)

However the height will not be changed - as length contraction only occurs in the direction of motion. (1)

(b) The Zondorians used their advanced technology to capture an Earth based astronomer to their spacecraft in order to meet her and see what a human being looked like. The astronomer was then returned to Earth. The astronomer reported that she had been on the Zondorian spacecraft for 10 hours (while the spacecraft maintained its 0.8 *c* velocity). For what period of time did the astronomers remaining on earth observe their colleague to be absent? 2

$t_o = 10$ hours

$t_V = \frac{t_o}{\sqrt{1-\frac{V^2}{c^2}}}$

$t_V = \frac{10}{\sqrt{1-\frac{(0.8)^2}{c^2}}}$

$t_V = \frac{10}{\sqrt{1-0.64}}, \quad t_V = 16.7\,h$

Question 20 (6 marks) **Marks 6**

Most celestial objects outside our solar system are too distant to reach at current maximum speeds. However, research is continuing into a new generation of craft that may be able to travel at speeds vastly greater than today's vehicles.
Discuss the consequences of near light-speed space travel to destinations outside our solar system.

At relativistic speeds (say, greater than 0.1 c) Einstein's special theory of relativity will have effects on time, mass and length.

Consider mass:

At relativistic speeds the mass dilation occurs (ie: the mass increases)

This means that more energy (therefore fuel) is required to move the craft, and that this energy requirement will increase exponentially as the speed increases. Eventually a limit is reached, as to exceed 'c' would produce an infinite mass requiring an infinite amount of energy to move it!

Consider time:

The astronauts will experience time dilation (ie: time slows down for them, as compared to those left behind on Earth). This will mean that for an extended trip at relativistic speeds, the astronauts will age only a few years but those left on Earth may well be very old or even dead by the time the astronauts return.

Consider length:

Length contraction will occur. This means that the astronauts will measure distances and the length of celestial objects that they pass to be shorter than what an observer on earth would measure.

Question 21 (8 marks) **Marks**

A satellite of mass 250 kg maintains an orbit of 320 km above the Earth's surface. The Earth has a radius of 6.38 x 10^6m and a mass of 5.97 x 10^{24} kg.

(a) Determine the gravitational potential energy of the satellite at this altitude. 2

$E_p = \frac{-GM_1M_2}{r}$

$E_p = \frac{-6.67\times10^{-11}\times250\times5.97\times10^{24}}{6.38\times10^6 + 320\times10^3}$

$E_p = \frac{-9.95\ldots\times10^{16}}{6.7\times10^6}$

$E_p = -1.498\times10^{10}\,J$

(b) Justify the use of the minus sign in the formula for gravitational potential energy 2

The GPE will be zero at infinite distance away from the Earth.
Work is done in moving the satellite from infinity to the point above the surface, and this value gets more negative the closer the satellite is brought to the Earth.

(c) The satellite is moving with uniform circular motion. Describe how it can be thought of as accelerating. 1

The craft is always changing direction, therefore its velocity is changing.

(d) Determine the period of orbit of this satellite. 2

(d) Determine the period of orbit of this satellite. 2

$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$

$\frac{(6.7\times10^6)^3}{T^2} = \frac{6.67\times10^{-11}\times5.97\times10^{24}}{4\pi^2}$

$\therefore \frac{3.0076\times10^{20}}{T^2} = \frac{3.98\times10^{14}}{39.478}$

$\therefore T^2 = 5460.6$ seconds

$= 1.5$h.

(e) Identify what happens to the period of the satellite if its *mass was to be halved.* 1

No change to the period, as mass and period are not related - as shown by the Kepler formula in part (d)

Question 22 (4 marks) **Marks 4**

Describe a first hand investigation to demonstrate the operation of a transformer. Include a discussion of the limitations shown in your results and how safety issues were addressed.

1. *An school laboratory power pack was connected to the mains 240 AC supply voltage.*
2. *The power pack was connected to a 100 turn coil of insulated copper wire, and a voltmeter was placed across this coil. This coil was called the primary coil.*
3. *Another (smaller) coil, of 50 turns was placed inside the first coil. This coil was not in electrical contact with the primary coil or with the power pack. This smaller coil was called the secondary coil.*
   Another voltmeter was placed across the secondary coil.
4. *An iron rod was also inserted into the middle of the coils.*
5. *The power pack was switched on, and set to 6 volts.*
6. *The voltage of the primary coil was read from the voltmeter. It had a reading of 6.0 volts.*
7. *The secondary coil voltmeter had a reading of only 1.5 volts.*

(2 marks)

This set-up demonstrated a step-down transformer, as the secondary voltage was less than the primary voltage. (1 mark)

The results were not ideal. This is because we generated eddy currents in the iron core, which created waste heat. To improve our efficiency, we could add a laminated iron core. (2 mark)

Question 23 (2 marks) **2**

The transformer in an electric keyboard reduces the 240 AC voltage to a 12 V AC voltage. The secondary coil has 60 turns. Determine the number of turns in the primary coil.

$V_p / V_s = n_p / n_s$

$240 / 12 = n_p / 60$ *(1 mark)*

$\underline{N_p = 1200 \text{ turns}}$ *(1 mark)*

Question 24 (5 marks) **Marks**

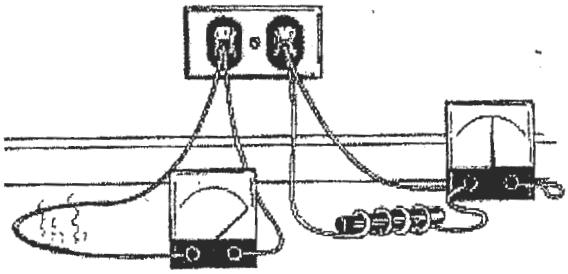
(a) State Lenz's Law and outline a situation where it has been useful and a situation where it causes problems. **3**

Lenz's law state that the direction of the induced emf is such that the resulting current's magnetic field will oppose the change in magnetic flux (that caused the induced emf and current). (1 mark)

Lenz's Law is responsible for production of eddy currents which has been used in braking systems on trains. (1 mark)

Lenz's Law also creates eddy currents which produce waste heat, lowering the efficiency of transformers. (1 mark)

(b) In the diagram below the wire on the left is plugged directly into a 240 volt alternating current source and has a very large current flow which may blow the fuse.



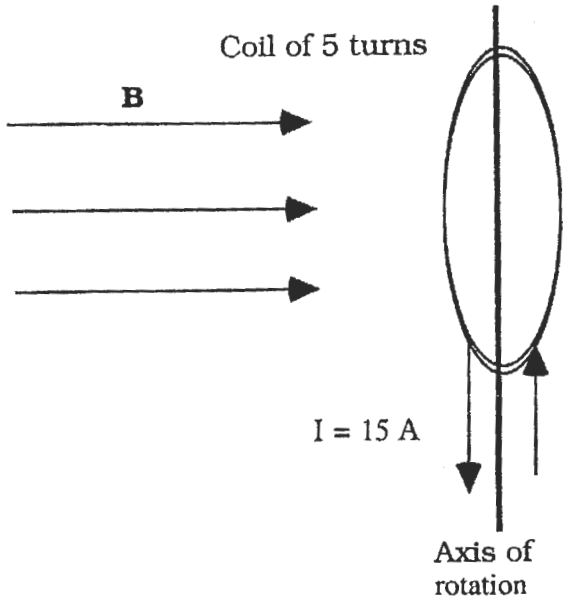
Explain why the same wire, if coiled around a soft iron core, will have a lower current and is less likely to blow the fuse. **2**

Due to the alternating nature of the supplied current, there will be a changing magnetic field in the wire. The iron core will magnify and enhance this changing field.
There will now be a back emf set up in the wiring, which oppose the supplied voltage. This will lower the current in the wire, thus meaning it is less likely that the fuse will blow.

(This is similar to the creation of back emf in motors, where the supplied voltage and current is opposed by the creation of a back emf in the coil as it turns in the magnetic field of the motor).

Question 25 (3 marks)

A circular coil is able to rotate around an axis along its diameter.



A uniform magnetic field of strength 6.1 x 10^{-5} T is directed perpendicularly to the axis of the coil. When a current of 15 A passes through the coil it experiences a maximum torque of 1 x 10^{-4} Nm. Calculate the area of the coil. **2**

$T = nBIA \cos \theta$

$1 \times 10^{-4} = 5 \times 6.1 \times 10^{-5} \times 15 \times A$

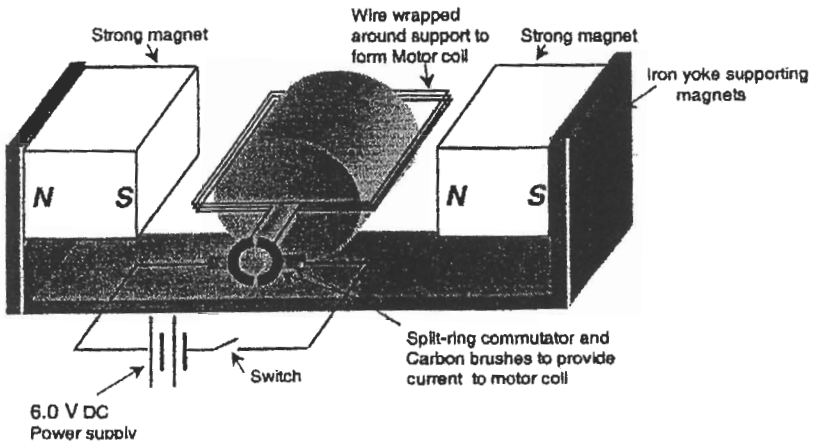
$A = 0.021875 = \underline{0.022\ m^2}$

(b) At what angle must the direction of the magnetic field be directed with respect to the plane of the coil if the torque is to be reduced by half? **1**

60 degrees, as cos of 60 degrees is 0.5

Question 26 (4 marks) **Marks 4**

As part of their studies a group of students successfully constructed a simple DC motor as shown below.



The student conducted tests on the motor and found that it operated best when using a 6.0 volt power supply, with the motor rotating at a frequency of 3 hertz.
Consider starting the motor when it is in its present position as shown on the diagram. Explain how the torque on the motor will vary as the coil begins to rotate and eventually reaches full speed.

At its present position, torque will be at a maximum , and the left hand side of the coil will then move upwards. (1 mark) (use RH rule to confirm this)

The torque will then decline as the motor moves through ninety degrees, and the coil reaches the vertical position. Due to its momentum the coil will not stop moving, and the presence of the split ring commutator will ensure that it will keep turning in the same direction. (1 mark)

As the coil turns there will also be a back emf generated in the coil, as the coil is 'cutting' magnetic field lines. The back emf will increase as the coil speeds up, and it will oppose the supplied voltage. Therefore the coil will eventually reach a terminal speed. (2 marks)

Question 27 (3 marks) **Marks 3**

Describe and compare the underlying physics of AC induction motors and DC motors.

AC induction motors use electromagnetic induction, where a current is induced in the coil which then chases after the rotating magnetic field.

DC motors operate on the motor effect, where a torque in the current carrying coil is created when the coil is in the presence of an external magnetic field.

Therefore, the underlying physics is fundamentally different.

Question 28 (4 marks)

A positively charged particle of charge 3.2×10^{-19} C and mass 4.0×10^{-27} kg moves perpendicularly to a uniform magnetic field of 0.18 T. The particle is moving at 9.0×10^{4} m/s.

(a) Calculate the magnitude of the magnetic force that the particle experiences. **2**

$F = q\ v\ B \sin\theta$

$F = 3.2 \times 10^{-19} \times 9.0 \times 10^{4} \times 0.18$

$\underline{F = 5.2 \times 10^{-15}\ N}$

(b) Determine the centripetal force on the particle. **1**

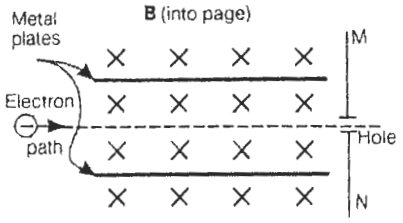
$\underline{F = 5.2 \times 10^{-15}\ N}$ *(the magnetic force provides the centripetal force)*

(c) Explain what effect this force has on the kinetic energy of the particle. **1**

No effect...as the centripetal force only changes the direction, not the speed.

Question 29 (5 marks) **Marks**

A pair of parallel metal plates is placed parallel to a uniform magnetic field which is directed into the page.



An electric field is applied to the plates so that an electron entering the plates follows a straight line path due to the balance achieved between the magnetic and electric forces. Because of this the electron is able to pass through the hole in the metal sheet MN.

(a) What must be the direction of the electric field in order to achieve this balance between forces? **1**

Electric field is down the page

(b) Derive an expression for the velocity of the electron in terms of the electric field , E, and the magnetic field B, neglecting any gravitational forces on the electron. **2**

Consider: $F = qvB$ *and* $F = Eq$

$qvB = Eq$

$v = E / B$

(c) Calculate the magnitude of the electric field strength if the magnetic field strength is 6.0×10^{-2} T and the velocity of the electron is 1.2×10^{6} m/s. **1**

$V = E / B$

$1.2 \times 10^{6} = E / 6.0 \times 10^{-2}$

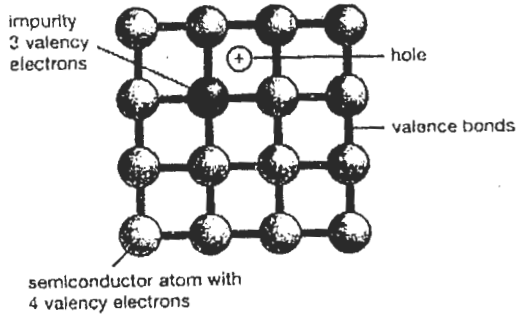
$\underline{E = 7.2 \times 10^{4}\ N/C}$

(d) J.J Thomson set up a similar experiment using crossed electric and magnetic fields on a beam of cathode rays. By doing this he was able to measure the charge to mass ratio of the cathode rays. This value was 1.76 x 10 11 C kg^{-1}.
State his observations about this charge to mass value when he used cathodes made of different materials. **1**

The value was always the same.

Question 30 (5 marks) **Marks**

Consider the diagram below of a doped semiconductor.



(a) Identify whether the diagram represents a n-type or p-type semiconductor. **1**

p-type semiconductor

(b) Explain how doping with an impurity containing three valence electrons results in improved conduction. **2**

There is one fewer electron available for bonding (per impurity atom)
This creates a positive hole where an electron should be.
Under the influence of an applied electric field, an electron can move into the hole. This will then mean that there is a hole where this electron used to be.
The process then continues, and the effect is that electrons and holes move in opposite directions.

(c) Such doped semiconductors have been used to make transistors. Explain ONE reason why transistors were used to replace valves as switches and amplifying devices. **2**

Sample answers:

- *Transistors are less fragile and more robust, therefore less wear and tear and maintenance issues (or longevity of the device is improved)*
- *Valves produce much waste heat, thus are less energy efficient than transistors*
- *Valves are larger than transistor, thus portability and miniaturization is improved*
- *Valve need larger energy sources, thus can be expensive to operate*
- *Valves take time to warm up, thus transistors offer instant start-ups when operating appliances.*

(d) To explain how semiconductors work physicists develop models such as band theory. Describe an important benefit to scientists of using models to explain physical phenomena. **1**

Such models can offer a research framework to guide research into finding even better semiconductors.

Question 31 (6 marks) **Marks 6**

Assess the impact on society and the environment of the potential applications of superconductors.

Consider electricity generation:

Electricity is currently sent along copper or aluminium wires that lose much of the energy due to heating of the wires, and also requires the use of expensive transformer infrastructure to help minimizes these losses. Superconductors mean that electricity can be generated and then transmitted over vast distances without loss. The transmission wires can be made fro superconductors rather than ordinary metals. This will improve efficiency and reduce costs to consumers. For the environment, it will mean that resources are used more efficiently, conserving valuable non-renewable resources such as coal or oil. This also means that is the case of a coal fired power station, there is less coal burnt (with less carbon dioxide emissions and lower global warming impacts) as far more of each tonne of coal used actually results in electricity reaching the consumer rather than being lost along the transmission wires.

Consider maglev trains:

The use of superconductors to provide the strong magnetic fields needed can help with the manufacture of maglev trains. These offer rapid transport (city centre to city centre, unlike aircraft) to citizens, competing with aircraft (and lowering airport congestion and aircraft noise). They are a low friction form of transport, so more of the energy used to run the train actually goes into kinetic energy rather than overcoming friction. Again, this means that scarce energy resources can be conserved.

A downside is that the energy needed to achieve the low temperatures of superconductors may be very high, and could offset energy savings in other areas. So while more research is needed, superconductors have the potential to save energy, lower consumer costs, and help the environment through less pollution and conservation of resources.

Question 32 (4 marks) **Marks**

You performed (or were shown) a first-hand investigation to demonstrate the properties of cathode rays using discharge tubes.

(a) Identify ONE safety risk involving in the carrying out of these experiments and explain how this was addressed. **2**

Issues identified and dealt with
Example: High voltage (which could cause shock) is dealt with by having students kept away form the induction coil and only the teacher operates this device.
OR: X-Ray production from the discharge tubes (such as the Maltese cross experiment) was dealt with by having students kept at least 2 metres from the discharge tube

(b) Analyse information from TWO of these experiments to suggest why there was a debate whether cathode rays were charged particles or waves. **2**

Contrasting information from TWO experiments:

Example: Maltese cross experiment showed that they travelled in straight lines, which is a wave property commonly associated with light.

The cathode rays were deflected by magnetic fields, which is a property of charged particles. Specifically, they were behaving as negatively charged particles.

(c) Cathode rays were later found to be electrons. Describe what causes the resistance in ordinary metal conductors when electrons form a current. **1**

Vibrations of the lattice cause the electrons to collide
OR: the presence of impurities can increase the number of collisions.

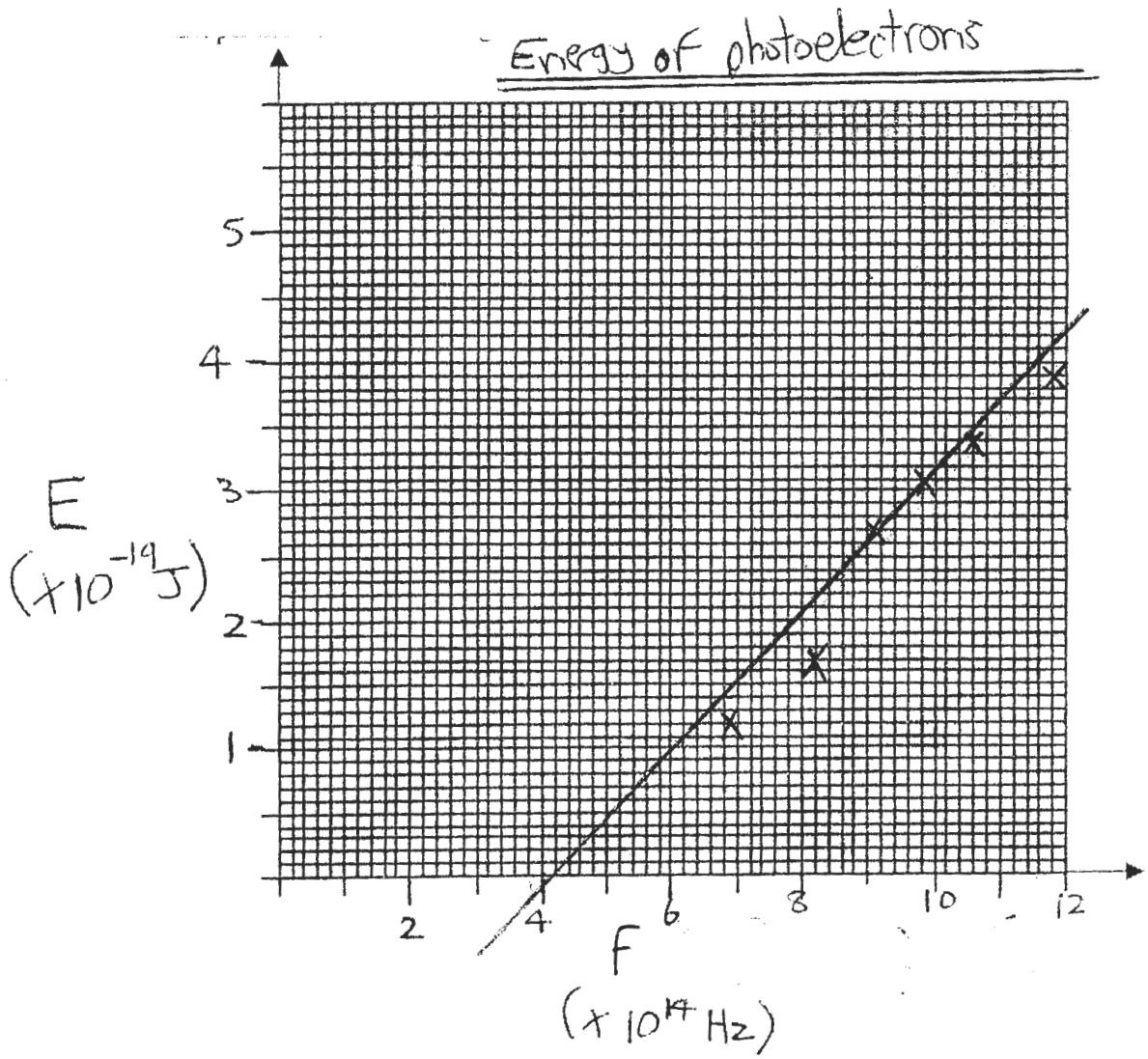
Question 33 (8 marks) **Marks**

A student carried out an experiment on the photoelectric effect. The frequency of the incident radiation and the energy of the photoelectrons were both determined from measurements taken during the experiment.

The results are shown in the table below:

Energy of photoelectrons ($x\ 10^{-19}$ *J*)	*Frequency of incident radiation* ($x\ 10^{14}$ *Hz*)
1.22	6.9
1.70	8.2
2.70	9.1
3.05	9.9
3.38	10.6
3.91	11.8

(a) Graph the results on the grid provided **4**



Question 33 is continued on the next page ---------->

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Question 33 continued. **Marks**

(b) Use the appropriate equation and the graph you have drawn to calculate Planck's constant. **2**

Consider $E = hf$, $\therefore h$ = gradient.

gradient = $\frac{\text{rise}}{\text{run}} = \frac{3.05 - 0 \ (\times 10^{-19})}{9.9 - 4.2 \ (\times 10^{14})}$

$\therefore$ gradient = 5.35×10^{-34}

$= 5.4 \times 10^{-34}$ J s

(c) In explaining the photoelectric effect, describe how Einstein changed our understanding of the nature of light. **2**

Einstein assumed light acted as discrete, particle like, packets of energy, rather than as a continuous wave of energy (1)
He stated that a photon of light would give up all (or none) of its energy to the electron on the metal surface. This was used to explain the photoelectric effect.

(d) The photoelectric effect has been used in conjunction with n and p-type semiconductors to make useful devices. Identify ONE of these devices **1**

Solar cells use doped semiconductors and the photoelectric effect.

END OF EXAMINATION