Student Number | |

SYDNEY BOYS HIGH SCHOOL

2005

HIGHER SCHOOL CERTIFICATE

TRIAL EXAMINATION

PHYSICS

General Instructions

- Reading time - 5 minutes.
- Working time 3 hours.
- Board-approved calculators may be used.
- Write using blue or black pen.
- Draw diagrams using pencil.
- A data sheet, Formulae Sheets and Periodic Table are provided at the back of this paper.
- Write your student number and/or name at the top of every page

Section I
Total marks 75
This section has two parts, Part A and Part B.

Part A – 15 marks.
Attempt Questions 1 – 15.
Allow about 30 minutes for this part.

Part B – 60 marks.
Attempt Questions 16 – 27.
Allow about 1 hour and 45 minutes for this part.

Section II
Total marks 25
Attempt Question 28
Allow about 45 minutes for this section.

This paper MUST NOT be removed from the examination room

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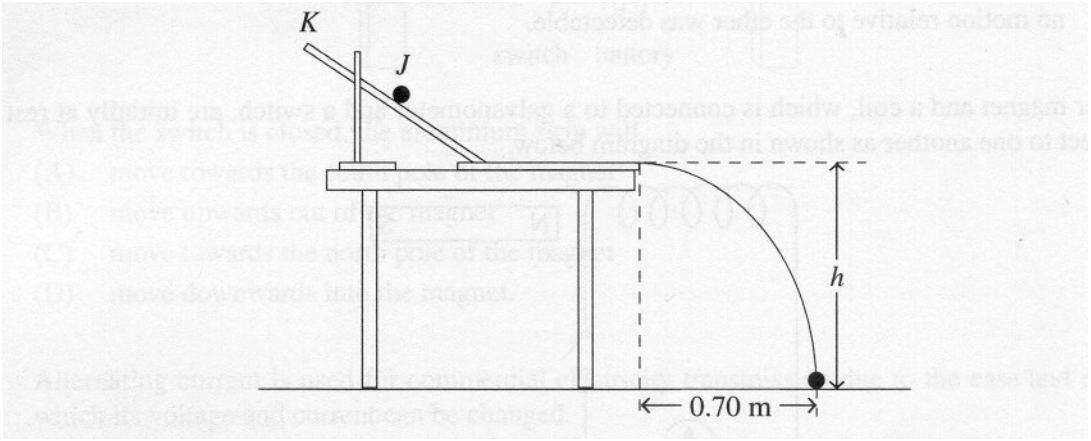
1. Astronauts floating in the space station while it is orbiting Earth are said to be weightless. This is because:

   (A) gravity is the only force acting on them.
   (B) gravitational force on them is zero.
   (C) the gravitational force is balanced by the centrifugal force.
   (D) their mass is now zero.

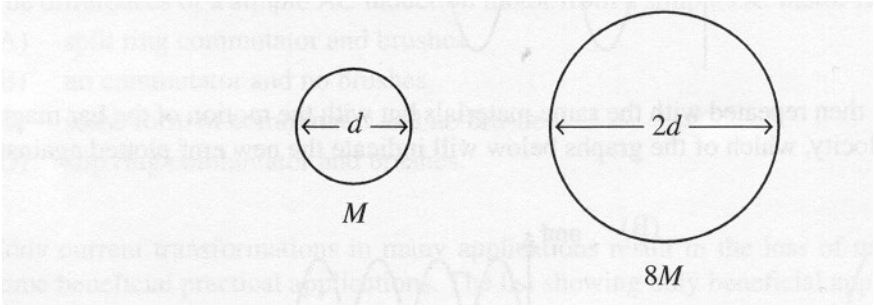
2. a group of students performed an experiment where a steel ball rolls down a ramp, along a horizontal tabletop then off the table as shown. When the ball was released from half way down a ramp (point *J*) it landed 0.7 m from the edge of the tabletop.



   If the ball is released from the top of the ramp (Point *K*) it would:

   (A) take a shorter time to fall from the table to the floor and land 1.4 m out.
   (B) take 1.4 times as long to fall from the table to the floor and land 1.0 m out.
   (C) take the same time to travel from the table to the floor but land further out.
   (D) be impossible to predict what happens as we don't know *h*, the height of the table.

3. Planet *A*, with a diameter, *d*, and mass, *M*, has a gravitational acceleration at its surface of 6 m s^{-2}. Planet *B* has a diameter of 2*d* and a mass of 8*M*.



   What is the gravitational acceleration at the surface of Planet *B*?

   (A) 1.5 m s^{-2}
   (B) 6.0 m s^{-2}
   (C) 12 m s^{-2}
   (D) 24 m s^{-2}

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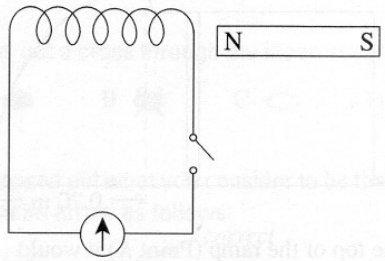
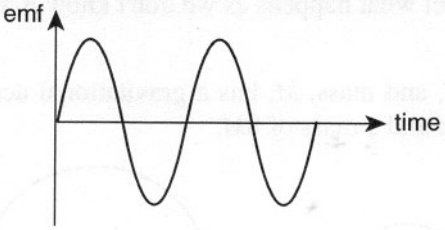
4. What measurements could be made from the Earth to determine the mass of the Sun?
   (A) The diameter of the Sun and its average density.
   (B) The distance to the Moon, its orbital period and the gravitational constant.
   (C) The mass of the Earth and its distance from the Sun.
   (D) The distance to the Sun, the orbital period of Earth and the gravitational constant.

5. The Michelson-Morley experiment showed that:
   (A) objects travelling relative to the ether contract along their direction of motion.
   (B) no motion relative to the ether was detectable.
   (C) the ether doesn't exist.
   (D) objects travelling relative to the ether show a time dilation.

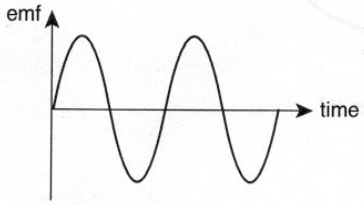
6. A bar magnet and a coil, which is connected to a galvanometer and a switch, are initially at rest with respect to one another as shown in the diagram below.

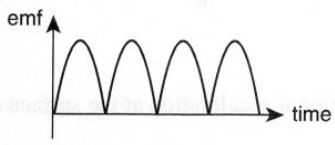


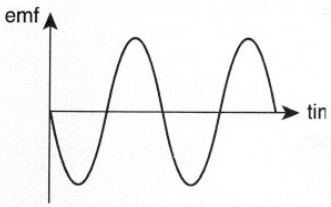
The switch is then closed and the magnet is moved towards the coil and then back away from the coil. This action is then repeated. The galvanometer indicates that a current is induced within the coil. If the electromotive force (emf) is plotted against time a graph as shown below is obtained.

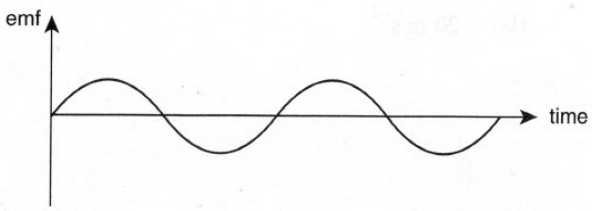


If the experiment is then repeated with the same materials but with the motion of the bar magnet being half the original velocity, which of the graphs below will indicate the new emf plotted against time.

(A)


(B)


(C)


(D)


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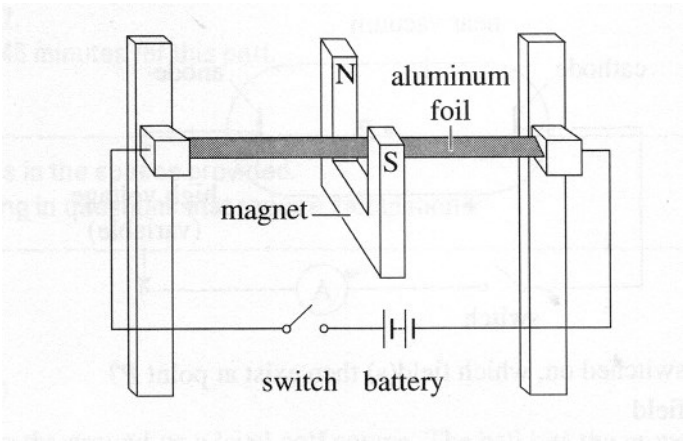
7. A thin piece of aluminium foil is connected by a conducting wire to a switch and battery as shown. The foil is placed between the poles of a magnet.



When the switch is closed, the aluminium strip will:

(A) move towards the south pole of the magnet.
(B) move downwards into the magnet.
(C) move towards the north pole of the magnet.
(D) move upwards out of the magnet.

8. Alternating current is used for commercial electricity transmission due to the ease and efficiency at which its voltage and current can be changed.
Which set of conditions is the most energy efficient way of transmitting alternating current?
(A) High voltage and high current.
(B) Low voltage and low current.
(C) Low voltage and high current.
(D) High voltage and low current.

9. When an electric motor on mains AC supply it needs to be of a slightly different construction than one operating on a DC supply.
The differences of a simple AC induction motor from a simple DC motor is that the induction motor has:
(A) split ring commutator and brushes.
(B) slip ring commutator and brushes.
(C) some form of commutator and no brushes.
(D) no commutator and no brushes.

10. Eddy current transformations in many applications result in the loss of useful energy, but there are some beneficial practical applications. The list showing only beneficial applications is:
(A) electromagnetic braking; damping oscillations in balances; heating effects in solid iron cores.
(B) electromagnetic braking; damping oscillations in balances; inductive heating.
(C) increasing oscillations in balances; inductive heating; heating effects in solid iron cores.
(D) electromagnetic braking; increasing oscillations in balances; inductive heating.

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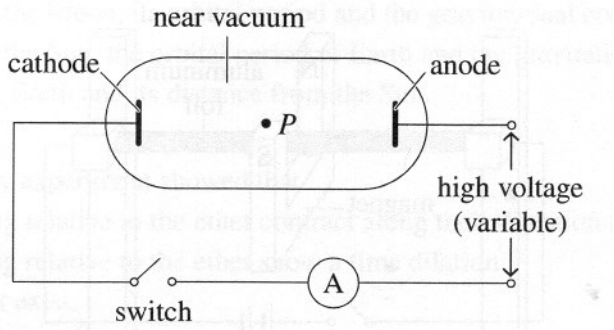
11. This diagram shows two metal plates sealed inside an evacuated glass tube. This tube is sitting on a laboratory bench in Canberra.



When the circuit is switched on, which field(s) then exist at point *P*

(A) gravitational field.
(B) magnetic field, vector and electric fields.
(C) gravitational, electric and magnetic fields.
(D) electric field.

12. Identify one difference between conductors and semiconductors.

(A) Conductors have a band structure, semiconductors do not.
(B) The addition of impurities or dopants will most likely cause conductivity to increase in semiconductors and decrease in conductors.
(C) Semiconductors have no free electrons, conductors do.
(D) The addition of impurities or dopants will most likely cause conductivity to decrease in semiconductors and decrease in conductors.

13. In Thomson's charge to mass experiment, both magnetic and electric fields are used together. They are adjusted so that:

(A) the fields deflect electrons in opposite directions.
(B) the fields are parallel to each other.
(C) the fields deflect electrons in the same direction.
(D) the fields cancel each other.

14. A correct explanation of why metals conduct electricity is:
(A) the positive charges are free to move.
(B) they contain more electrons than insulators.
(C) the electrons are free to move.
(D) they have a band structure.

15. An electron of charge -1.6×10^{-19} C is located in an electric field whose strength is determined to be 2.34 N C^{-1}. The force on the electron, caused by the field, is:

(A) 3.74×10^{-19} N.
(B) 3.74×10^{-19} N in the same direction as the field.
(C) 3.74×10^{-19} N at right angles to the field.
(D) 3.74×10^{-19} N in the opposite direction to the field.

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Part B

Total marks 60
Attempt Question 16 – 27.
Allow about 1 hour and 45 minutes for this part.

Answer Part B questions in the spaces provided.
Show all relevant working in questions that require calculations.

Marks

Question 16 (4 marks)

A golfer strikes a ball on the ground on a level golf course. The ball hits the Ground 180 metres north from where it was struck, 6 seconds later. Assuming Negligible air resistance find :

(a) the maximum height the ball reached. **2**

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(b) the initial velocity (direction, angle and speed) of the ball as it left the golf club. **2**

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Marks

Question 17 (5 marks)

(a) What does the term geostationary mean? **1**

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(b) Why are most communications satellites in a geostationary orbit? **1**

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(c) Explain briefly why a geostationary satellite couldn't be placed directly above Sydney. **3**

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Question 18 (5 marks) **Marks**

A spy satellite of mass 100 kg is orbiting the Earth (radius 6380 km) at an altitude Of 300 km. It has a period of 90 minutes and an orbital speed of 28 000 km h^{-1}. High resolution photographs on film are sent back to Earth in a special container which can withstand a maximum acceleration of 8g. The container and contents has a mass of 50 kg.

(a) What is the kinetic energy of the container as it is travelling with the satellite? **1**

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(b) Calculate the gravitational potential energy of the container relative to the surface of the Earth. **1**

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(c) What is the shortest time the container can take to reach the Earth's surface with zero velocity, if it cannot exceed the 8g acceleration limit? **1**

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(d) Given that total orbital energy = kinetic energy + potential energy, at what rate must energy be lost from the container to remove its total orbital energy by the time it reaches the Earth's surface? (i.e. At what average power must energy be removed from the container?) **2**

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Marks

Question 19 (6 marks)

(a) Using Newtonian physics, calculate the kinetic energy (in eV) of a proton travelling at 3×10^8 ms^{-1}. **2**

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(b) A student makes the statement that "The maximum kinetic energy a proton can have is 4.7×10^8 eV because it can't travel faster than the speed of light." Assess this statement on the basis of your answer to part (a). **2**

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(c) Particle accelerators can produce protons with kinetic energies greater than 3×10^{10} eV. Discuss this in relation to your answer to part (b). **2**

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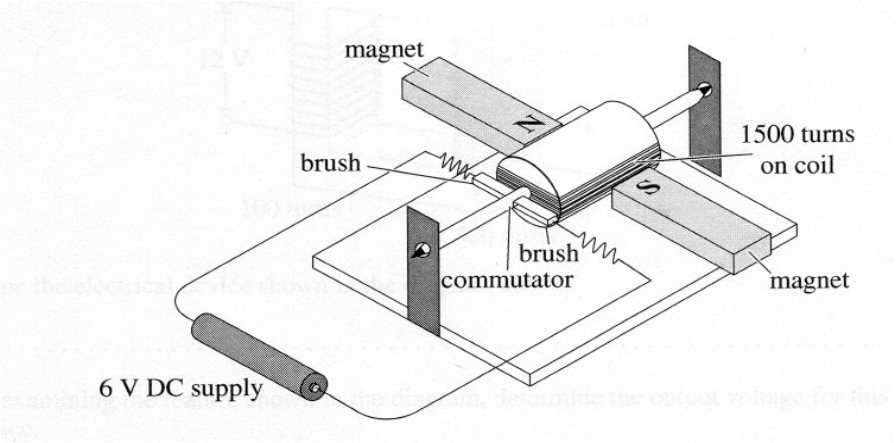
Question 20 (4 marks) **Marks**

A group of physics students constructed a working model of an electric motor. A Diagram of their model is shown below.



By taking careful measurements from their model the following results were obtained.

Number of turns of armature coil	1500
Resistance of coil	50 Ω
Voltage	6.0 V
Maximum torque	0.055 Nm
Magnetic flux	2.9 T

(a) Determine the area of the armature coil of the motor. **2**

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The students wished to decrease the magnitude of the torque, but did not wish to alter the constructed motor.

(b) Describe exactly how they could decrease the torque without making any structural changes to their model. **2**

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Question 21 (4 marks) **Marks**

Explain, with the aid of a labelled diagram, the main electromagnetic principles Which operate within a moving coil galvanometer. **4**

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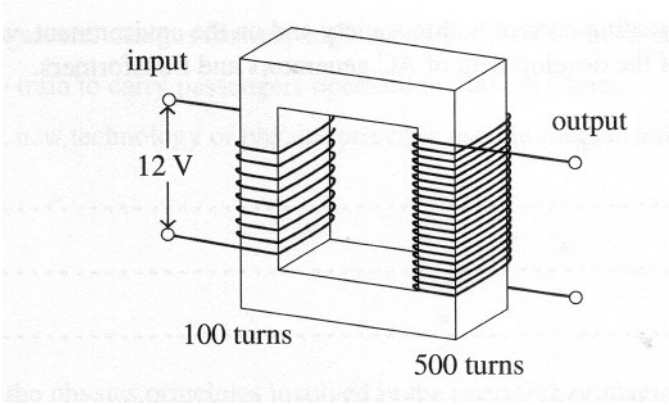
Marks

Question 22 (5 marks)



(a) Name the electrical device shown in the diagram above. **1**

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(b) By examining the feature shown in the diagram, determine the output voltage for this device. **2**

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(c) Explain how power losses from this device can be reduced. **2**

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Student Number | |

Marks

Question 23 (7 marks)

Assess the effects of the use of alternating current within society and on the Environment, with particular reference to the impact of the development of AC generators and transformers. **7**

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Student Number | |

Marks

Question 24 (7 marks)

There have been several designs for very high speed trains over recent decades.

The first *maglev* train to carry passengers operated in 2003 in China.

(a) Name the new technology or physics principle used in maglev trains. **1**

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(b) Describe the physics principles involved in the operation of maglev trains. **3**

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Question 24 continues on page 15

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Marks

(c) State two other possible applications of superconductors and explain why they would be of benefit. **3**

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End of question 24

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Marks

Question 25 (5 marks)

During your course you carried out an investigation to identify several properties Of cathode rays using a discharge tube.

(a) Explain and describe an investigation with a discharge tube that demonstrates that cathode rays are negative, **2**

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(b) Describe another property of cathode rays. Using a diagram to assist, show how this property is demonstrated by a different discharge tube. **3**

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Marks

Question 26 (6 marks)

One hundred years ago, in 1905, Einstein published his special theory of relativity And several other important scientific papers.

Black body radiation could not be understood until both Einstein and Planck had Made their contributions to quantum theory (as it relates to black body radiation.)

Identify and describe both scientists' contributions to understanding and solving the Difficulties presented by black body radiation. **6**

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Student Number | |

Marks

Question 27 (2 marks)

Describe how p-type semi conductors are produced, and how and why they differ from pure semiconductors. **2**

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Section II

Total marks (25) **Marks**

Attempt Question 28
Allow about 45 minutes for this part

Answer the question in a separate writing booklet. Extra writing booklets are Available. Show all relevant working in questions involving calculations.

Question 28 Quantum to Quarks

(a) (i) Name the scientist responsible for the suggestion that any kind of particle has both wave and particle properties. **1**

(ii) Determine the velocity and frequency of the electron in the ground state of the hydrogen atom, whose wavelength is 5.3×10^{-11} m. **3**

(b) Calculate the wavelength of a photon released when an electron in a hydrogen atom moves energy levels from one with principle quantum number n = 5 to one with n = 3. **2**

(c) (i) Outline the different contributions that electrostatic and gravitational forces have between nucleons. **2**

(ii) Discuss how the strong nuclear force operates and describe its characteristics in relation to the other forces acting within the nucleus. **4**

(d) Account for the fact that the nucleus of an atom weighs less than the sum of the weights of the individual nucleons. **2**

(e) Assess the contributions made by Heisenberg and Pauli to the development of atomic theory. **4**

(f) Describe how Fermi was able to demonstrate a controlled nuclear reaction and discuss how the energy in a fission reaction is related to Einstein's concept of the equivalence between mass and energy. **7**

2005 Trial Physics SBHS
Suggested Answers.

Section 1

Part A.
Answer and explanation

Question 1 A
Weight is measured by measuring the force that cancels gravity. No force, hence weightless.

Question 2 C
Time of fall independent of horizontal speed

Question 3 C
8 gives time the acceleration. Doubling the diameter gives ¼ the acceleration. Results is double the acceleration, i.e. 12 ms $^{-2}$

Question 4 D
Using Kepler's laws of periods and Newton's law of gravitation: Not A, as density comes from mass and volume. Not B, as Moon orbits earth. Not D, as there is not enough in formation and the period is independent of the earth's mass.

Question 5 B
A,C and D are all 'explanations' of the Michelson-Morley result summarised by B.

Question 6 D
The magnitude of the induced emf between the ends of the coil is directly proportional to the rate at which it cuts magnetic lines of flux. Hence, when the magnet is moved with half the original velocity, the rate of flux change will be reduced.

Question 7 B
The direction of the magnet force when a current carrying wire is placed within an existing magnetic field is given by the right hand palm rule. Hence, the wire will be moved at right angles to both the current direction and the magnetic field, i.e. down into the magnet.

Question 8 D
Alternating current is used for the electricity transmission and can be transmitted at either high voltage and low current or low voltage and high current. At very high voltage, the current is very small and hence little power loss and is the most efficient way of transmission.

Question 9 D
In simple induction motors, electric currents are induced in the metal rotor and no commutator nor brushes are required.

Question 10 B
Eddy currents flow in flat conductors when the magnetic flux through the conductor changes. Beneficial effects include electro-magnetic braking, damping oscillations in balances and inductive heating. The heating of solid iron cores within transformer is a detrimental effect.

Question 11 C
The circuit produces an electric field and the Earth produces both magnetic and gravitational fields.

Question 12 B
Adding impurities to conductors reduces the conductivity, but in the case of semiconductors conductivity is increased.

Question 13 A
The fields are adjusted until the beam is not deflected, thus deflections of the two fields are equal and in opposite directions. Option D is incorrect since these different fields cannot cancel each other.

Question 14 C
Conductivity in metals is a result of the electrons not being attached to particular atoms and are therefore free to move.

Question 15 D
Since the charge is negative and the field is electric, the force is in the opposite direction to the field. If the charge were positive, the force would be in the same direction as the field.

Part B

Question 16

(a) $s = ut + \frac{1}{2} at^2$

For fall from top, $s = \frac{1}{2} \times 9.8 \times 3^2$

44.1m

Maximum height is 44.1 metres

(b) V horizontal = $180/6 \text{ ms}^{-1}$

$= 30.0 \text{ ms}^{-1}$

V vertical = gt

$= 9.8 \times 3$

$= 29.4 \text{ ms}^{-1}$

$\sqrt{(29.4)^2 + (30.0)^2} = 42.0 \text{ ms}^{-1}$

$\theta = \tan^{-1} \frac{(29.4)}{(30.0)} = 44^{\circ} 25$

Final velocity = 42.0 ms^{-1} north at $44^{0} 25$ above the horizontal.

Question 17

(a) This means that the satellite stays over the one place on the Earth's surface. The period of the orbit is 23hrs 56 mins, the same as the rotation of the Earth.

(b) The satellite stays in the same position in the sky relative to the Earth. This means that the satellite dishes at the ground stations can remain fixed, pointing in the same direction.

(c) The plane of all satellite orbits passes through the centre of the Earth. To be directly over Sydney at any time, the plane of the orbit must be tilted relative to the orbital plane of the Earth. If the satellite is over Sydney at a particular time then 12 hours later it will have to rotate about half a revolution. This will put the satellite over the northern hemisphere, i.e. due north of Sydney over a spot as far north of the equator as Sydney is south of the equator.

Question 18

(a) $KE = \frac{1}{2} mv^2$

$= 50/2 \times \left(\frac{28\,00 \times 10^3}{3600}\right)^2$

$= 1.51 \times 10^9 \text{ J}$

(b) $PE = \frac{(GM_E \times 50)}{6380 \times 10^3} - \frac{(GM_E \times 50)}{6680 \times 10^3}$

$= 1.408 \times 10^8 \text{ J}$

OR

Orbit is close to Earth, thus PE close enough to mgh.

$PE = 50 \times 9.8 \times 300 \times 10^3 \text{ J} = 1.47 \times 10^8 \text{ J}$

(Question 18 continued)

(c) $u = 7778 m\ s^{-1}$, $v = O$, $a = 8g = 78.4\ m\ s^{-2}$

Using $v = u + at$

$t = \frac{7778}{78.4}$

$= 99.2\ s$

Prog. Motion using

$a = 98 \times 8\ m5^2$

$s = ut + 1/2\ at^2$ not allowed

as accel is not vertical

(d) total energy = PE + KE

rate of loss = $\frac{\text{total energy}}{\text{time}}$

$= \frac{1.51 \times 10^9 + 1.4 \times 10^8}{99.2}$

1.67×10^7 W

Question 19

(a) $KE = \frac{1}{2} mv^2$

$= \frac{\frac{1}{2} (1.673 \times 10^{-27}) \times (3 \times 10^8)^2}{1.602 \times 10^{-19}\ eV}$

$= 4.67 \times 10^8$ eV

(b) If a proton travelling at the speed of light (the speed for part (a)) has a kinetic energy of 4.67×10^8 eV then this appears to be its maximum kinetic energy. The statement appears to be true according to Newtonian physics.

(c) This is more than 60 times as great as calculated, therefore something must be incorrect. Relativity shows that as velocity approaches 'c' mass increases. The added energy goes into mass increase rather than velocity increase.

Question 20

(a) $\tau = n\ BIA \cos \theta$

$A = \frac{\tau}{nBI}$

$= \frac{0.055}{1500 \times 2.4 \times \frac{6.0}{50}}$

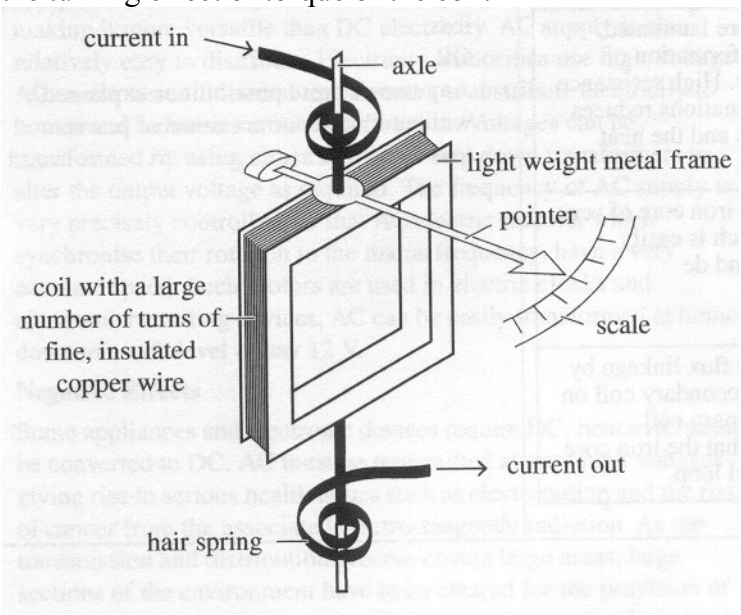
$= 1.05 \times 10^{-4}\ m^2$

(Question 20 continued)

(b) The torque depends on the number of turns of the coil, the cross-sectional area of the coil and the current. However, since the current is the only non- structural method and as torque is directly proportional to the current, they would have to decrease the current flowing in the coil. This would have to be achieved by decreasing the voltage applied.

Question 21

A moving coil galvanometer operates upon the motor effect wherein a current carrying wire within a magnetic field experiences a force ($f = BIl\sin\theta$).
Since the wire in the galvanometer is a coil it experiences forces, which contribute to the turning effect or torque of the coil.



As the galvanometer should be sensitive enough to detect very small currents, the main design principals are

- A large number of turns as this provides a long length of wire within the magnetic field
- A large coil area as this increases the length of wire and also increases the turning effect
- Strong permanent magnets, whose pole faces are curves to provide a radical magnetic field
- Soft iron core
- A hair spring to provide the restoring torque and stop the rotation
- A scale to read the angle and calibrate to the flowing within the coil.

Question 22

(a) Step up transformer.

(b)
$$\frac{n_p}{n_s} = \frac{V_p}{V_s}$$
$$V_s = \frac{n_s V_p}{n_p}$$
$$= \frac{12 \times 500}{100}$$
$$= 60 \text{ V}$$

Cause of power loss in transformer	**Means to reduce power loss**
Heating effect of current in wires of the coils	Use thick copper wire of low resistance for the coil carrying the higher current at lower voltage
Heating effect of eddy currents in iron core.	Make iron core laminated, reducing the formation of eddy currents. High resistance between laminations reduces eddy currents and the heat they produce.
Energy is used in the process of magnetising the iron core and then reversing the magnetisation	Construct the iron core of very soft iron, which is easily magnetised and de-magnetised.
Emf may be reduced as some of the	Maximise the flux linkage by winding the

magnetic flux of the primary coil does not thread the secondary coil.	secondary coil on top of the primary coil, making sure that the iron core forms a closed loop.

Question 23

Positive Effects
The electricity produced by most generators is in the form of AC. In general, AC generators, and other electrical equipment are simpler, cheaper and more reliable than their DC counterparts. AC electricity can be easily transformed into higher or lower voltages making it more versatile than DC electricity. AC supply is also relatively easy to distribute. Electricity authorities use high-voltage AC transmission lines and transformers to distribute electricity to homes and industries around each region. Voltage s can be transformed by using either step up or step down transformers to alter the output voltage as required. The frequency of AC supply is very precisely controlled, so that AC electric motors, which synchronise their rotation to the mains frequency, have a very accurate speed. Such motors are used in electric clocks and electronic recording devices. AC can be easily transformed at home down to a safe level of safe level of say 12 V.

Negative Effects
Some appliances and electronic devices require DC, hence AC must be converted to DC. AC must be transmitted at a very high voltages giving rise to serious health issues such as electrocution and the risk of cancer from the associated electro-magnetic radiation. As the transmission and distribution process covers large areas, large sections of the environment have to be cleared for the provision of transmission wires. This has significant impact upon the flora, fauna and ecology of these areas.

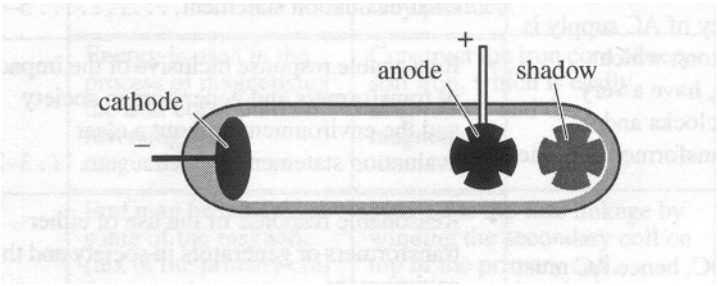
Evaluation
While it is relatively economical to generate electric power at a steady rate, there are both financial and environmental issues that should be considered when assessing the long-term impact of supplying commercial and household AC power. AC supply has been able to deliver relatively low costs energy to our modern, highly industrialised and energy dependent society.

Question 24

(a) Superconductivity (Meissner effect, magnetic levitation by superconductor)
(b) Levitation can be achieved by magnetic attraction/repulsion using superconducting electromagnets. Propulsion can be achieved by varying the magnetic fields, causing forward forces on the train (an application of Lenz's law).
(c) Two other applications could be:
    (1) Electric transmission of power with zero resistance power loses would be prevented in transmission.
    (2) Appliances such as motors, when using superconductors, would avoid current heating and thus reduce power loss.

Question 25

(a) Our tube had a screen which showed the path of the electrons. It had two electric deflecting plates inside it and when they were turned on the beam was bent towards positive plate (and away from the negative plate) showing that the cathode rays are negative.
(b) Cathode rays travel in straight lines. Our tube showed this by casting a sharp shadow of the Maltese cross, which was inside the tube, on the end of the tube.



Question 26

Planck addressed the problem that existing theories of electromagnetic radiation failed to explain the observed frequency distribution of radiation emitted by hot bodies (usually called black body radiation). Planck's solution was to assume that energy was emitted from hot solids in small packets was related to the frequency of the electromagnetic radiation by the formula $E = hf$

Deducing by calculation the theoretical effects of this assumption, he found that he could now accurately predict the observed frequency distribution mentioned above. This success was the beginning of quantum theory.
Einstein, in attempting to solve the unexpected properties shown in the photoelectric effect, also assumed that electromagnetic radiation consisted of packets of energy

called photons. By doing so he was able to completely explain the photoelectric effect. This was additional support for Plank's idea that energy existed in packets.

Question 27

p-type semiconductors are produced by doping (adding an impurity to) the pure semiconductor. The impurity added would be the element with one less proton (and electron) than the semiconductor. This causes the existence of holes, which increases the conductivity of the semiconductor.