Student Number: .....

2001

HIGHER SCHOOL CERTIFICATE
Sample Examination Paper

PHYSICS

General Instructions
Reading time - 5 minutes
Working time - Three (3) hours

Attempt ALL questions in Sections A and B
Write ALL your answers in the
Answer Book provided

Section A:
Multiple Choice (15 marks)

Section B:
Short and Extended questions (60 marks)

Section C:
Attempt only ONE question
Option (25 marks)

Directions to School or College

Section A

1

Angus has a mass of 78.0 kg. He is standing in a rocket leaving the surface of the Moon and is standing on some bathroom scales. The scales read 514.8 N. Given that the acceleration due to gravity of the moon is 1.62 ms^{-2} determine the acceleration with which the rocket is leaving the moon.

A 2.36 ms^{-2}

(B) 4.98 ms^{-2}

C 8.22 ms^{-2}

D 19.9 ms^{-2}

2

There are several reasons why a space vehicle must enter the Earth's atmosphere at a particular angle. Which of the following is **not** one of the reasons.

A It may bounce off the Earth's atmosphere if the angle is too shallow

B It may get too hot and burn up as the space craft plunges through the atmosphere if the angle is too steep

C The astronauts will experience a dangerous amount of G-forces if the angle is too steep

(D) If the angle is greater than the critical angle then total internal reflection will occur, reflecting the space craft out into space again. Snells law

3

What were Michelson and Morley ultimately attempting to determine when they performed their famous experiment.

(a) the relative velocity of the earth through the aether.

b the speed of light. Maxwell

c the speed of the aether.

d time dilation.

4

Which of the following does not present difficulties for effective and reliable communications between satellites and the Earth?

(a) the distance between the satellite and the Earth.

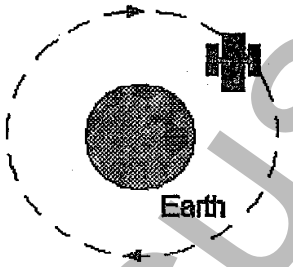
(b) van Allen radiation belts.

(c) atmospheric opacity of satellite communication frequencies.

(d) sunspot activity.

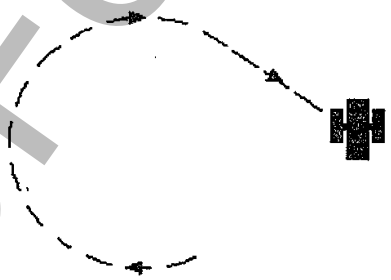
5

Below is a diagram of a satellite in orbit around the Earth.

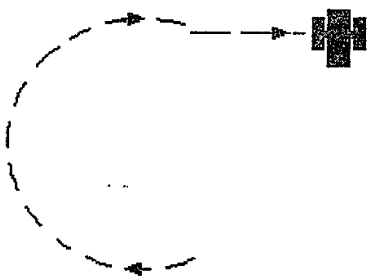


If the Earth no longer exerted an attractive force on the satellite, what would the path of the satellite look like?

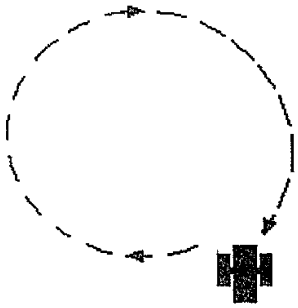
(a)



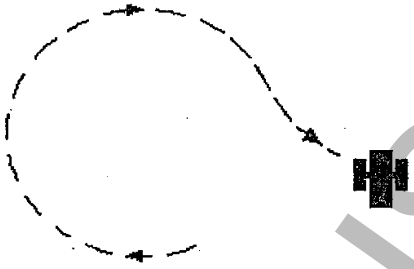
(b)



(c)

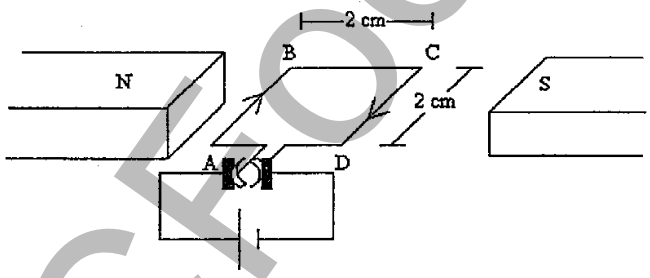


(d)



max 2 steps to do calculation

6 The following diagram shows a coil of wire in a magnetic field.



Given that the overall torque for the motor is 4.6×10^{-4} Nm, determine the force on side AB

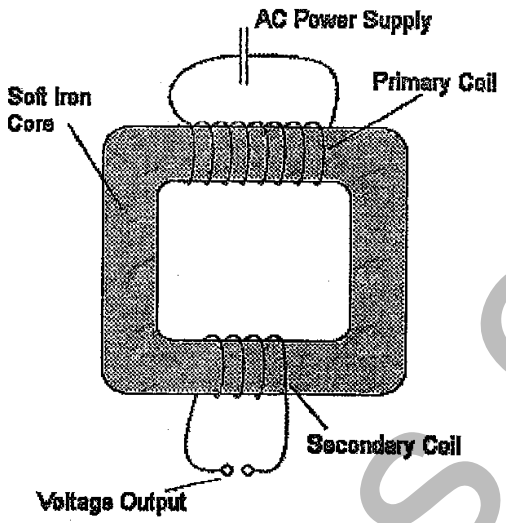
(a) 2.3×10^{-2} N down

(b) 2.3×10^{-2} N up

(c) 4.6×10^{-2} N down

(d) 4.6×10^{-2} N up

7 The following diagram illustrates a transformer. Describe the effect of changing the AC to a DC power supply.



(a) There would be no effect.

(b) The output voltage would remain the same magnitude but would be DC not AC.

(c) The output voltage would increase and decrease but always be positive.

(d) There would be no output voltage.

8 How are high voltage transmission lines protected from lightning strikes?

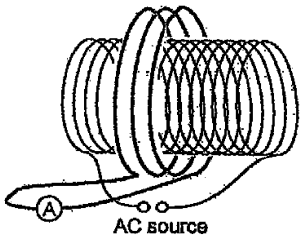
(a) They have porcelain insulating cones to stop the lightning from travelling down the tower.

(b) There are overhead wires connected to earth which the lightning preferentially strikes because of their height.

(c) Strong positive charges are located on the top of the towers to attract the lightning strikes rather than the wires.

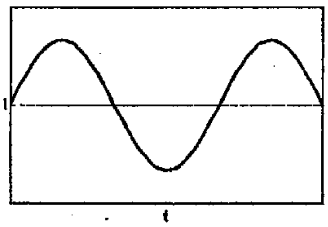
(d) The total acceptable load of the wires is 500 kV above the load they normally carry so the lightning strike will not overload the wires.

9 The following diagram shows a coil of wire connected to an alternating current source with a another coil of wire connected to an ammeter around it.

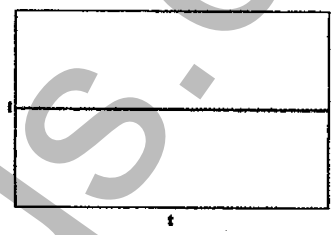


Which of the following would the a current versus time graph for the ammeter look most like.

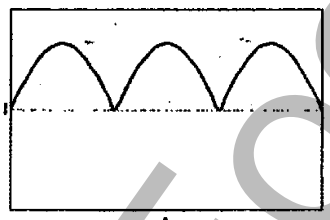
(a)



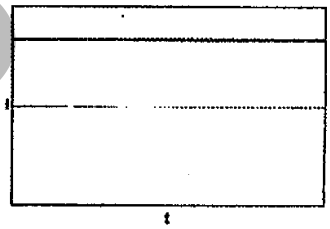
(c)



(b)



(d)



10 Eddy currents will cause a transformer to heat up. How are the difficulties associated with this heating overcome?

(a) The transformer is made larger so that it has a greater surface area to cool via contact with air.

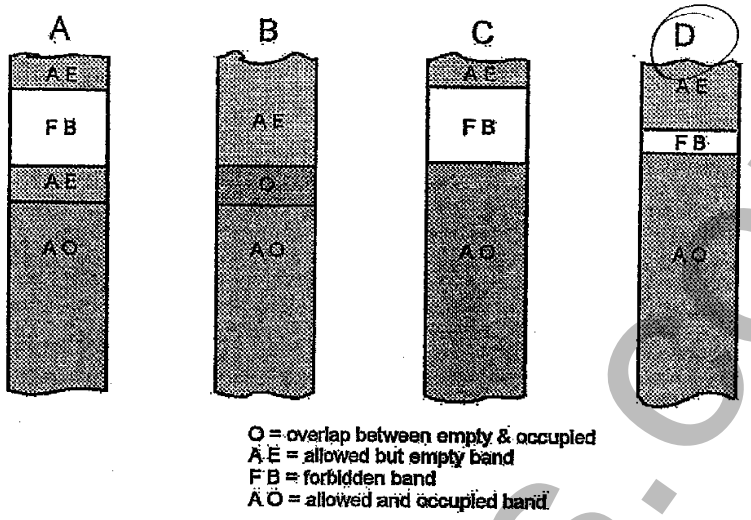
(b) The transformer's heat is channelled via heat conducting wires to local heaters so that the energy is not wasted.

(c) The core around which the wire is wrapped is cut into thin slices separated by an insulator so that the electrons cannot flow around as much.

(d) The core that the wire is wrapped around is made of a plastic that is a good insulator.

11

The diagram below shows the band structures of several different elements.



Which of the elements is a semi-conductor?

12 Which of the following would **not** increase the drift velocity

(a) an increase in electron density.

(b) an increase in the cross sectional area of the wire.

(c) an increase in the length of the wire.

(d) an increase in the potential difference.

13 Determine the photon energy for red light of wavelength 400 nm.

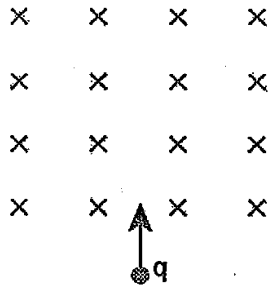
(a) 2.65×10^{-40} J

(b) 7.95×10^{-32} J

(c) 4.97×10^{-19} J

(d) 3.6×10^{10} J

14 An electron travelling at 1×10^6 ms^{-1} is moving into a magnetic field of size 2×10^{-3} T that is directed into the page as shown in the diagram below.



The force acting on the electron when it enters the magnetic field will be

(a) 3.2×10^{-16} N to the left.

(b) 3.2×10^{-16} N to the right.

(c) 2000 N to the right.

(d) 2000 N to the left.

15 Planck's hypothesis regarding the photoelectric effect was

(a) that radio waves are created at a right angle to the gap in an induction coil.

(b) that the charge to mass ratio of an electron is quantised.

(c) electrons without enough kinetic energy to cross a gap in an induction coil can do so when light of a high enough frequency is incident upon them.

(d) that radiation emitted and absorbed by the walls of a black body cavity is quantised.

Section B

Question 16 **2 marks**

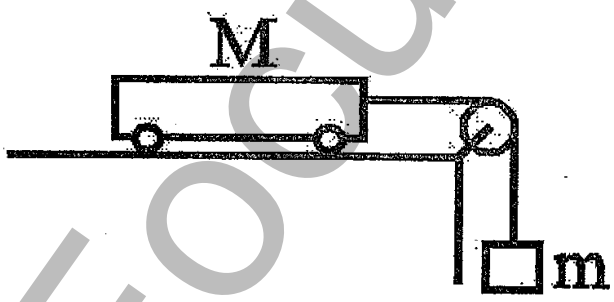
There are many scientists who have researched space exploration and helped to develop our understanding of the topic. Below is a list of 6 of those scientists.

Tsiolkovsky
Oberth
Goddard
Esnault-Pelterie
O'Neill
von Braun

Choose one of the scientists listed above and describe how they have contributed to the progress of space exploration.

Question 17

A student had set up the following equipment as shown.



(a) Draw a diagram showing the forces acting on trolley M and a diagram showing the forces acting on trolley m. **2 marks**

(b) By analysing the forces acting on both masses, determine a formula for the acceleration of the system. **2 marks**

(c) Given that the trolley had a mass of 0.784 kg, determine the mass of the trolley necessary to achieve an acceleration of 3 ms^{-2}. **1 mark**

(d) When the student performed the experiment using the mass determined in part c, the student found that the acceleration was actually 2.7 ms^{-2}. Discuss possible reasons why the measured acceleration was lower than expected. **1 mark**

Question 18

The twins Esther and Elspeth are initially on the Earth. Esther takes off in a space ship which quickly accelerates to 0.8c to reach the star Lalande 21185. Lalande 21185 is 8 light years away. Elspeth remains on the Earth. When Esther reaches the destination, she promptly turns around in her rocket and accelerates towards the Earth, quickly attaining the flight velocity of 0.8c.

(a) How long does it take Esther to complete her trip according to Elspeth? **1 mark**

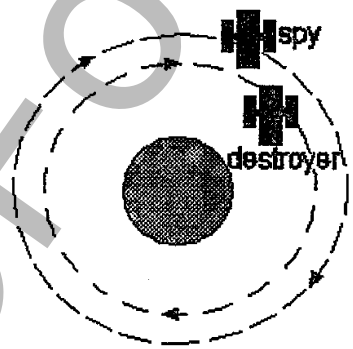
(b) How much will Esther have aged during the trip? **1 mark**

(c) Why is it not appropriate to consider Esther as being at rest and Elspeth as travelling at 0.8c? **2 marks**

(d) Discuss some evidence that suggests that time dilation and length contraction occur? **2 marks**

Question 19 **3 marks**

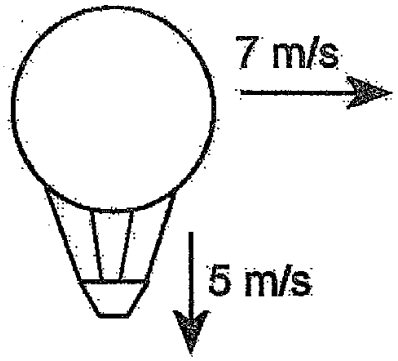
A destroyer satellite (mass 3000 kg) is orbiting the Earth (radius 6.38 x 10^7 m) at an altitude of 35 000 km above the Earth's surface. A spy satellite is orbiting the Earth in a geosynchronous orbit. The destroyer satellite must ascend to the same altitude as the spy satellite in order to shoot the spy satellite down.



What distance must the destroyer satellite ascend so that it is at the same altitude as the spy satellite?

Question 20 **3 marks**

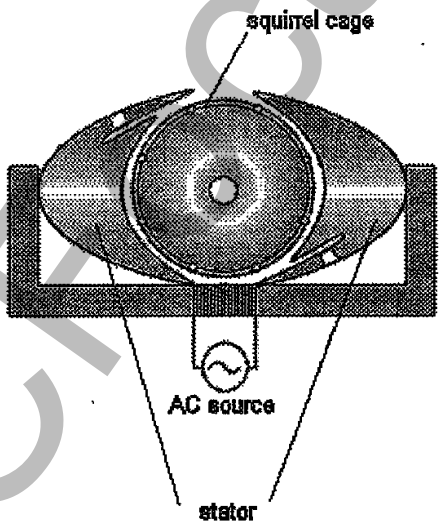
A hot air balloon is descending at a constant rate of 5 ms^{-1} whilst it is carried eastward by the wind at a rate of 7 ms^{-1}.



In order that they do not crash into the ground, the pilot releases a sandbag which causes them to start ascending at a rate of 0.5 ms^{-2}. Unfortunately it is not enough and the balloon crashes. What is the magnitude and direction of the velocity of the balloon when it crashes?

Question 21

The diagram below shows an induction motor.

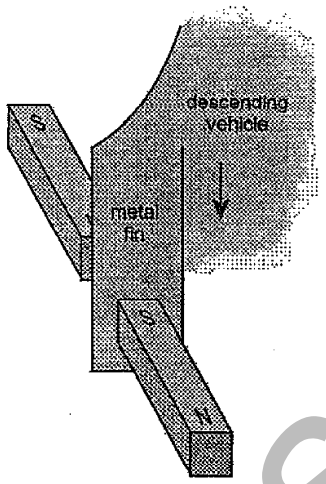


(a) Discuss why it is important to have an electromagnet as opposed to a permanent magnet creating the magnetic field and how this magnetic field causes rotation. **5 marks**

(b) Explain why the motor produces a low power and therefore would be unsuitable for use in heavy machinery. **3 marks**

Question 22 **3 marks**

At a theme park, a quickly falling vehicle relies on a magnetic field acting on metal fins to slow it down as shown in the diagram below.



Explain how the magnetic field slows down the descending vehicle describing in detail the path of subatomic particles.

Question 23 **3 marks**

DC electric motors utilise a split-ring commutator. Discuss why the invention of the commutator was so important in developing electric motors.

Question 24 **2 marks**

Describe the impact of the development of transformers on society.

Question 25 **3 marks**

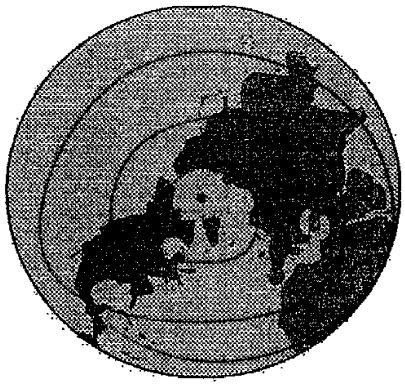
Energy is lost as it is fed through the transmission lines from the generator to the consumer. Describe where energy is lost and what forms it is converted to from electrical energy in these situations.

Question 26 **1 mark**

In an electric motor, the back emf opposes the supply emf. Describe what would happen if the back emf acted in the same direction as the supply emf.

Question 27 **2 marks**

The following diagram shows the Northern Hemisphere of the Earth.



Describe the path a positively charged particle will take that is released from the Van Allen Belts when they become overloaded.

Question 28

A student has a cathode ray tube connected to an ammeter and a lamp that emits light of variable intensity. The lamp has a filter such that light can be emitted that consists of a narrow band of wavelengths. The student noticed that when the lamp shone upon the cathode ray tube, sometimes cathode rays were emitted and sometimes they were not.

(a) Outline an experiment that the student could perform to determine whether the intensity of the light or the frequency of the light influence the production of cathode rays **3 marks**

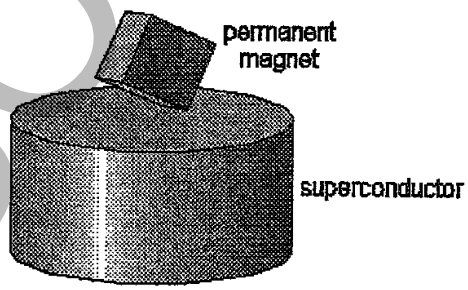
(b) Draw appropriate graphs for the two variables mentioned above. **2 marks**

(c) Explain why the cathode rays were emitted sometimes and other times they were not. **4 marks**

Question 29

The following diagram illustrates a permanent magnet levitating above a superconductor.

(a) Explain according to current theory why a superconductor has negligible resistance but



standard conductors have a significant resistance. **4 marks**

(b) Explain why the permanent magnet is able to levitate above the superconductor. **2 marks**

(c) Discuss how this has been utilised in maglev trains **3 marks**

Section C – Options

Total Marks (25)

Attempt ONE question from questions 30 – 34

Allow about 45 minutes for this section

Show all relevant working in questions involving calculations.

Question 30 Geophysics

Question 31 Medical Physics

Question 32 Astrophysics

Question 33 Quantum to Quarks

Question 34 Age of Silicon

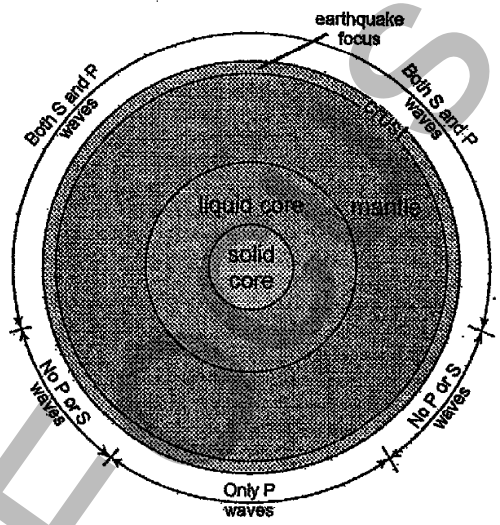
Question 30 – Geophysics (25 marks)

(a) Discuss the principles upon which paleomagnetism operates and how paleomagnetism may be used to examine continental drift.

(b) In the 18th century, geodesists in Peru noted that a plumb bob deflected a certain distance from the vertical when they were making measurements near the Andes mountain range.
(i) Why would the plumb bob deflect from the vertical?
(ii) The plumb bob actually deflected less than what they were expecting. Discuss why this might be so.

(c) (i) Describe what a gravimeter measures and the mechanics of how this quantity is measured in a spring gravimeter.
(ii) How might the gravity meter be utilised for ensuring accuracy with military missiles.

(d) The diagram below shows the type of waves that can be measured throughout the Earth when an earthquake occurs.



With the aid of the diagram in your answer booklet discuss why this phenomenon occurs and explain why it is thought that the outer core is liquid and the inner core is solid.

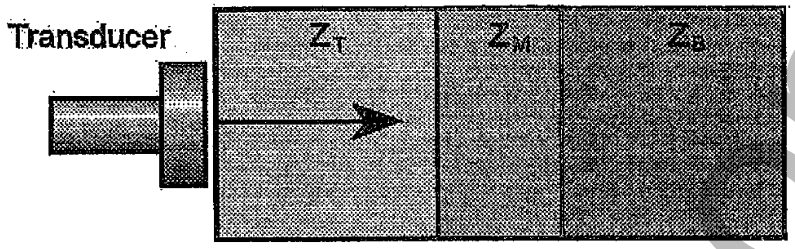
(e) Magnetic lineations can be found on either side of the mid-Atlantic ridge south of Iceland. Discuss how these anomolies support the idea of plate tectonics and continental drift.

(f) Treaties have been made between various countries not to test nuclear weapons. Discuss how geophysicists can monitor whether these treaties are being kept or not.

(g) The understanding of the earth's subsurface could be determined by gravity and seismic methods. Discuss how these geophysical methods can be applied to archaeological discoveries.

Question 31 – Medical Physics (25 marks)

(a) The diagram below shows the an ultrasound device examining a human body.



Z_T = acoustic impedance of soft tissue = 1.66 $kgm^{-2}s^{-1}$

Z_M = acoustic impedance of muscle = 1.70 $kgm^{-2}s^{-1}$

Z_B = acoustic impedance of bone = 4.70 $kgm^{-2}s^{-1}$

(i) Which will be more reflected, the ultrasound wave incident upon the muscle from the soft tissue or the ultrasound wave incident upon the bone from the muscle.

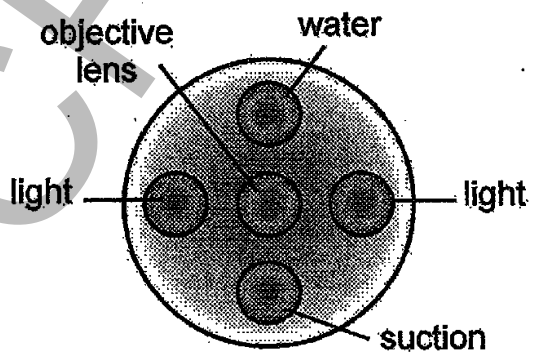
(ii) Given that the density of the soft tissue is 1060 kgm^{-3} determine the speed of the sound wave in the soft tissue.

(iii) If the intensity of ultrasound travelling in Z_M is 350 Wm^{-2}, what would the be the intensity of the reflected ultrasound.

(iv) Why would an ultrasound technician put lubricating jelly on the transducer and the skin of a patient who was having an ultrasound performed.

(b) Describe how ultrasound waves are created with a piezoelectric crystal.

(c) Below is a diagram of the tip of an endoscope. The endoscope utilises both incoherent and coherent fibre bundles.



(i) Describe how each of these types of fibre bundles are used in the endoscope.

(ii) Explain how total internal reflection is utilised in the endoscope to transmit the image to a physician.

(d) O-15 has a half-life of 2.1 mins and is used in positron emission tomography to analyse the flow of blood.

(i) Determine the amount of O-15 present after 6.3 mins if 25 g was initially present.

(ii) Describe how O-15 would be detected by the PET scanner.

(e) What are the advantages of using MRI to analyse blood flow in the brain over PET?

(f) (i) The table below shows the mass number and the atomic number of two different isotopes of carbon.

Isotope	Mass Number	Atomic Number
C-12	12	6
C-13	13	6

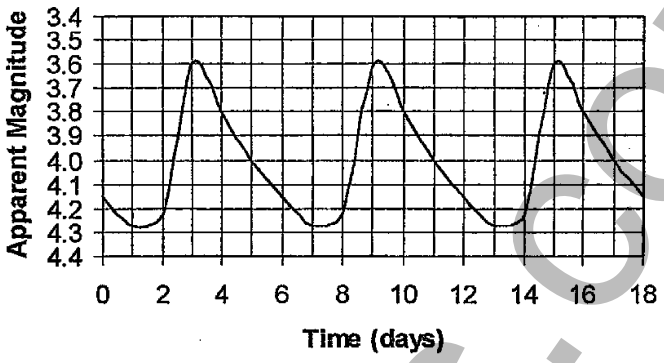
Which of the isotopes could be used in magnetic resonance imaging and why?

(ii) How could a C-13 atom be made to precess.

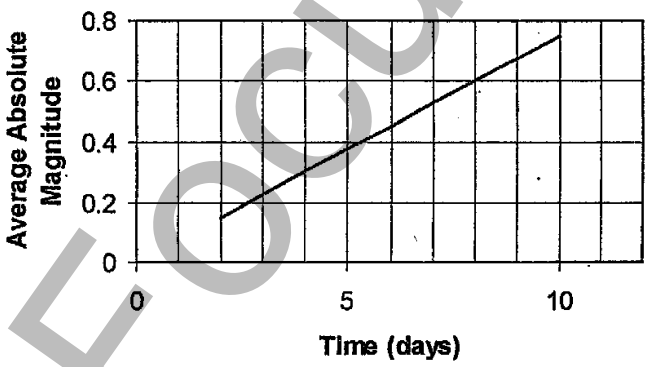
(iii) Describe what will happen, both at the time and afterwards, to a C-13 nuclei when a pulse of radio waves (at right angles to the precessing magnetisation vector) is applied to the nucleus at the Larmor frequency.

Question 32 – Astrophysics (25 marks)

(a) The graph below is the light curve showing the apparent magnitude vs time for a cepheid variable.



The graph below shows the period/luminosity relationship for this type of cepheid variable.



(i) Determine the average apparent magnitude for the cepheid variable.

(ii) Determine the average absolute magnitude for the cepheid variable.

(iii) Determine the distance to the star in parsecs.

(b) The Compact Array of the Australia National Facility at Narrabri, NSW, consists of five radio telescopes on a 3km rail track.

(i) Discuss the difficulties associated with obtaining good resolution when using ground based radio telescopes.

(ii) How do the telescopes at Narrabri overcome these difficulties.

(c) Aristarchus' heliocentric model of the universe was rejected because of the lack of observable parallax between the stars.

(i) Explain the concept of stellar parallax.

(ii) Kapteyn's star is observed to have a parallax of 0.255 arcseconds. Determine the distance to the Kapteyn's star.

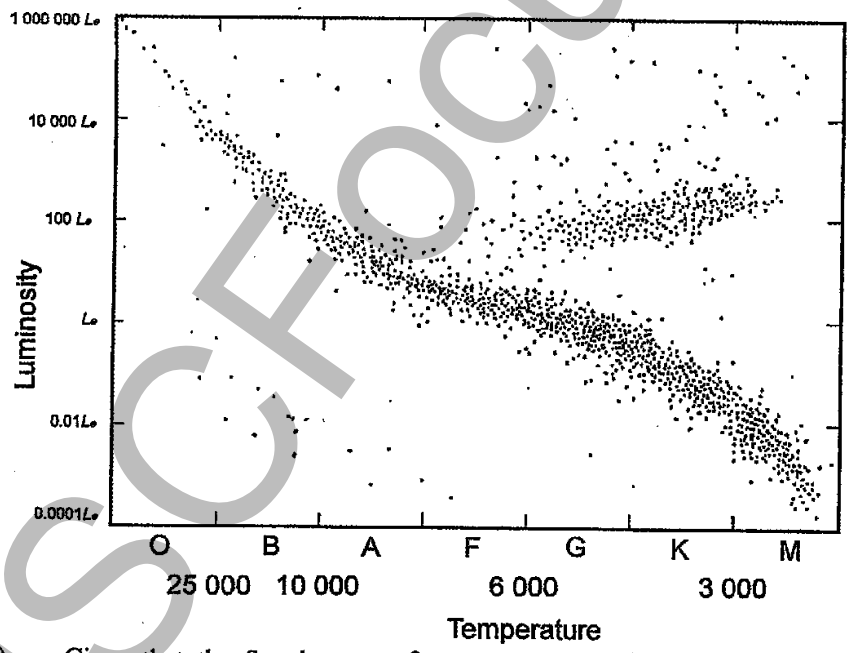
(iii) What is the lower limit of stellar parallax and what determines the limitation of the use of stellar parallax?

(d) Below is a spectra for Helium

(i) What type of spectra this is

(ii) Explain how this spectra is produced.

(e) Illustrated below is a Hertzsprung-Russell diagram.



(i) Given that the Sun has a surface temperature of approximately 6 000 K, plot on the diagram in your answer book, the current position of the Sun, and the path that the Sun will take as it evolves until it dies.

(ii) Describe why the Sun will follow this path.

Question 33 – Quantum to Quarks (25 marks)

(a) (i) Determine the first three wavelengths for the Balmer series ($n_f = 2$) of hydrogen emission lines.

(ii) Describe how this (and other) series and Planck's work lead Bohr to develop his model of the atom.

(iii) Discuss the limitations of this model.

(b) How did Davisson and Germer verify De Broglie's model of the atom in 1927?

(c) Discuss how an electron microscope is able to have a much greater magnification than light microscopes.

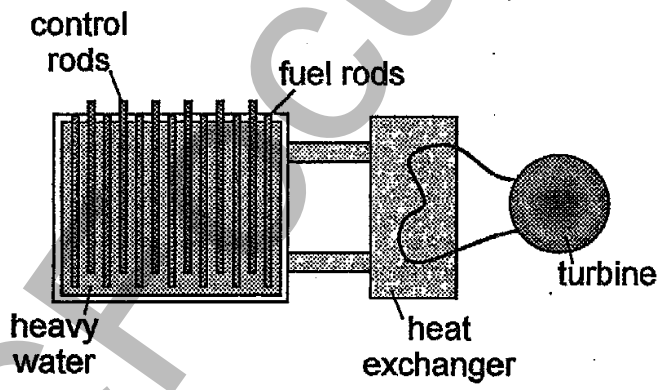
(d) The electrostatic propulsion between two protons located in a nucleus at a distance of 2.5 x 10^{-15} m apart is 37 N.

(i) What is the magnitude of the gravitational force between the two protons.

(ii) Why does this indicate that there must be a binding force?

(e) Americium 242 (symbol Am) has unstable nuclei; the atomic mass is too large for the atomic number. Write a nuclear reaction that this isotope would undergo.

(f) The following diagram illustrates a nuclear fission reactor.



Explain how the nuclear fission reactor harnesses the nuclear energy safely.

(g) Physicists often make use of particle accelerators to investigate nuclear physics.

(i) How do particle accelerators accelerate charged particles.

(ii) Why does a physicist make use of the particle accelerator to investigate atomic nuclei.

Question 34 – Age of Silicon (25 marks)

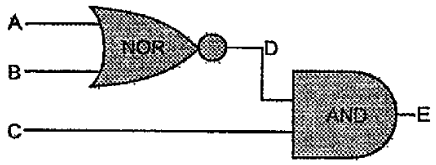
(a) Integrated circuits have made a profound impact on society. Discuss the need that lead to the development of the silicon chip and the effect that it has made on the development of electronics.

(b) The electronic age has brought the technology required for televisions to operate.

(i) What sort of system, analogue or digital, is a cathode ray tube in a television set. Explain your answer.

(ii) Discuss why the cathode ray tube may be thought of as being a transducer.

(c) The following diagram shows a logic gate.



(i) Complete the following truth table.

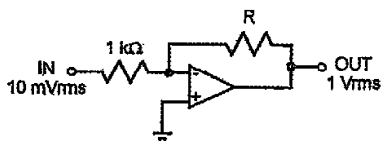
Input A	Input B	Input C	Input/Output D	Output E
0	0	0		
0	1	0		
1	0	0		
1	1	0		
0	0	1		
0	1	1		
1	0	1		
1	1	1		

(ii) Discuss how logic gates can be utilised in electronic circuit in terms of their voltages.

(d) Discuss why it is thought that there will be limitations on the speed of computers.

(e) Discuss what a thermistor is and explain the function of a thermistor in a particular technology.

(f) The following diagram shows an amplifier.



(i) What is the gain of the amplifier?

(ii) What is the value of R?

(iii) Describe this amplifier as either an inverting or non-inverting amplifier and explain what this amplifier will do to the input signal.

Physics Data Sheet

Numerical values of several constants

Charge on an electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 ms^{-1}
Earth's gravitational acceleration, g	9.8 ms^{-2}
Speed of light (in vacuo), c	3.00×10^{8} ms^{-1}
Magnetic force constant, k	2.0×10^{-7} NA^{-2}
Universal gravitational constant, G	6.67×10^{-11} Nm^2kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck's constant, h	6.626×10^{-34} Js
Rydberg's constant, R_H	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg
	931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, r	1.00×10^{3} kgm^{-3}
Specific heat capacity of water	4.18×10^{3} $Jkg^{-1}K^{-1}$