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HSC Trial Examination 2005

Physics

This paper must be kept under strict security and may only be used on or after the morning of Thursday 11 August, 2005, as specified in the NEAP Examination Timetable.

General Instructions

Reading time 5 minutes

Working time 3 hours

Write using blue or black pen.

Draw diagrams using pencil.

Board-approved calculators may be used.

A data sheet, formulae sheets and Periodic Table are provided at the back of this paper.

Total marks – 100

Section I Pages 2–19

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 Pages 20–25

Total marks 25

Attempt ONE question from Questions 28–32.
Allow about 45 minutes for this section.

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2005 Physics HSC Trial Examination.

Section I

Total marks 75

Part A

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

Use the multiple-choice answer sheet.
Select the alternative A, B, C, or D that best answers the question.

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

A ○ B ● C ○ D ○

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

A ● B ⊗ C ○ D ○

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

correct ↙

A ⊗ B ⊗ C ○ D ○

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

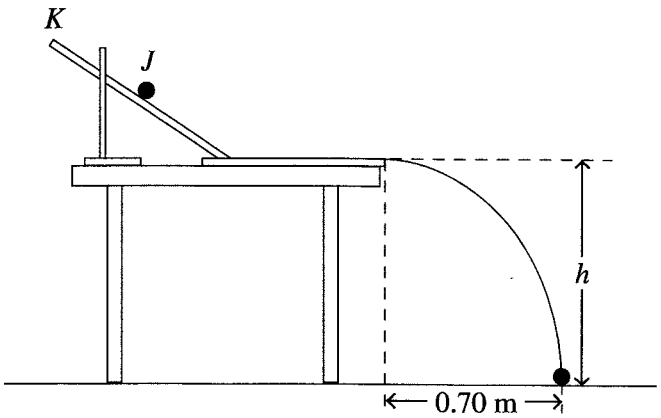
(A) their mass is now zero.

(B) the gravitational force on them is zero.

(C) the gravitational force is balanced by the centrifugal force.

(D) gravity is the only force acting on them.

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 table top.



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

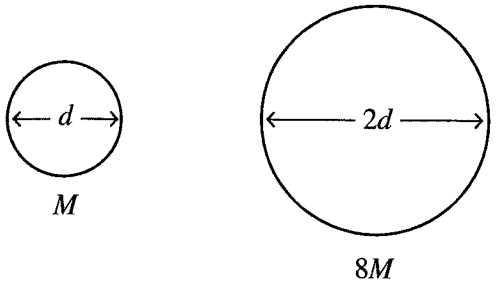
(A) take the same time to travel from the table to the floor but land further out.

(B) take 1.4 times as long to fall from the table to the floor and land 1.0 m out.

(C) take a shorter time to fall from the table to the floor and land 1.4 m 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 5 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) 1.25 m s^{-2}

(B) 5.0 m s^{-2}

(C) 10 m s^{-2}

(D) 20 m s^{-2}

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 distance to the Sun, the orbital period of Earth and the gravitational constant.

(D) The mass of the Earth and its distance from the Sun.

5. The Michelson-Morley experiment showed that

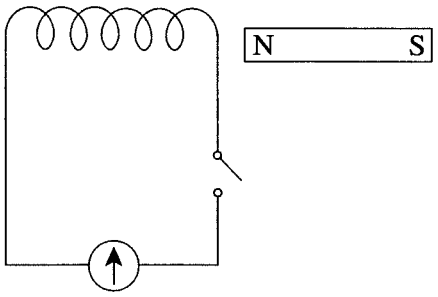
(A) objects travelling relative to the ether contract along their direction of motion.

(B) objects travelling relative to the ether show a time dilation.

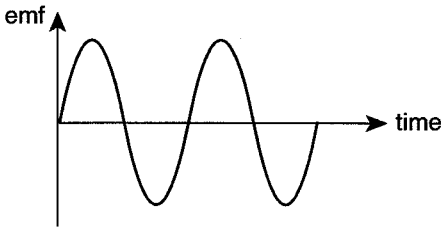
(C) the ether doesn't exist.

(D) no motion relative to the ether was detectable.

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.

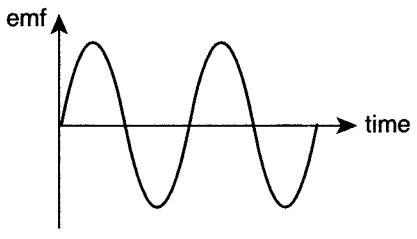


The switch is then closed and the magnet is moved towards the coil and then back away from the coil. This action is then repeated. The galvanometer indicates that a current is induced within the coil. If the electromotive force (emf) is plotted against time a graph as shown below is obtained.

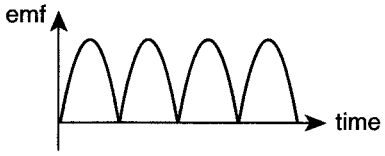


If the experiment is then repeated with the same materials but with the motion of the bar magnet being half the original velocity, which of the graphs below will indicate the new emf plotted against time.

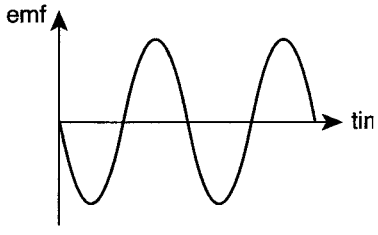
(A)



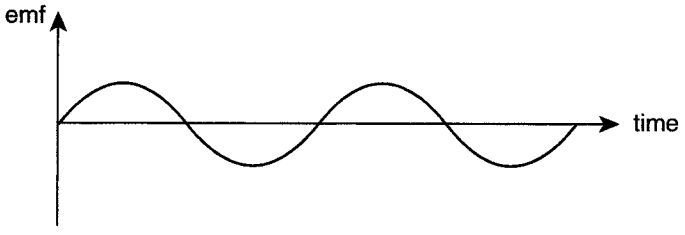
(B)



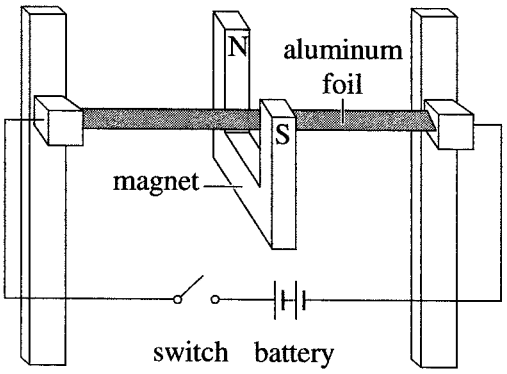
(C)



(D)



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 upwards out of the magnet

(C) move towards the north pole of the magnet

(D) move downwards into 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) High voltage and low current.

(C) Low voltage and high current.

(D) Low voltage and low current.

9. When an electric motor operates 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 it has

(A) split ring commutator and brushes.

(B) no commutator and no brushes.

(C) some form of commutator and no brushes.

(D) slip ring commutator and 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

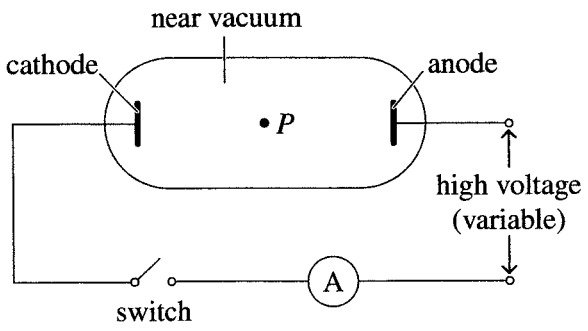
(A) electromagnetic braking; damping oscillations in balances; heating effects in solid iron cores.

(B) electromagnetic braking; increasing oscillations in balances; inductive heating.

(C) increasing oscillations in balances; inductive heating; heating effects in solid iron cores.

(D) eddy current testing of material; damping oscillations in balances; inductive heating.

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
(C) electric field
(D) gravitational, electric and magnetic fields

12. Identify one difference between conductors and semiconductors.

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

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

(A) the fields are parallel to each other.
(B) the fields deflect electrons in opposite directions.
(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 electrons are free to move.
(B) they contain more electrons than insulators.
(C) the positive charges 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 in the opposite direction to the field.
(D) 3.74×10^{-19} N at right angles to the field.

Part B

Total marks 60
Attempt Questions 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, 5.6 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)

Geostationary communication satellites all orbit directly above the equator.

(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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Marks

Question 18 (5 marks)

A spy satellite of mass 1000 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 m s^{-1}. **2**

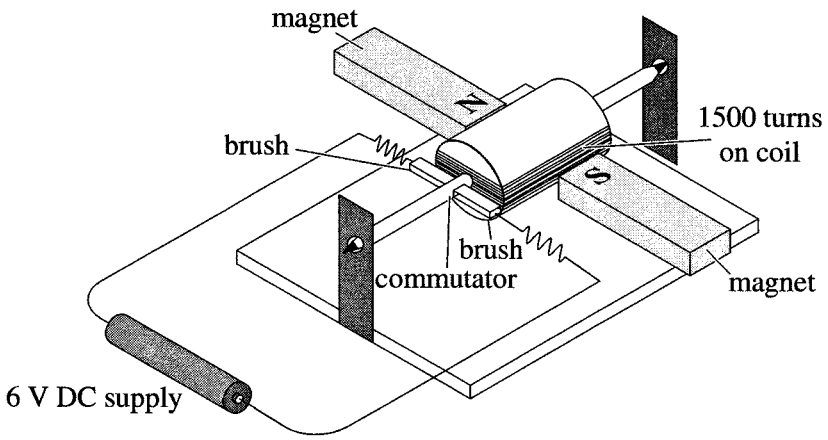
(b) A student makes the statement that "The maximum kinetic energy a proton can have is 4.7×10^8 eV because it can't travel faster than the speed of light." Assess this statement on the basis of your answer to part (a). **2**

(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**

Marks

Question 20 (4 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	2.0 T

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

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

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

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Question 21 (4 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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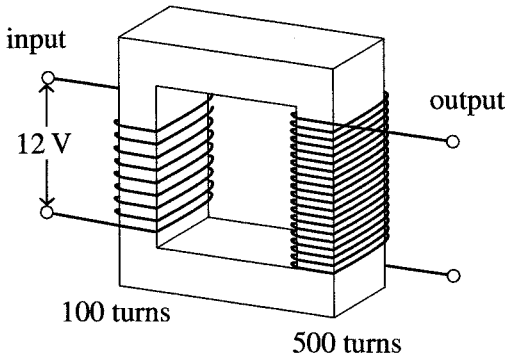
Marks

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 loses from this device can be reduced. **2**

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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**

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 16

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

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**

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
Attempt ONE question from Questions 28–32.
Allow about 45 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.

Show all relevant working in questions involving calculations.

Marks

Question 28 — Geophysics (25 marks)

(a) Describe the role played by geophysics in natural hazard reduction, using an appropriate example to illustrate your answer. **3**

(b) (i) Recall **two** uses of remote sensing in mineral exploration. **2**

(ii) Explain how remote sensing techniques have been used to monitor changes in climate or vegetation over time. **3**

(c) (i) Using the table below, graph both the *P* & *S* wave velocities on the same axes. (Allocate depth to the horizontal axis.) **2**

Depth (km)	Velocity of *P* waves (km sec^{-1})	Velocity of *S* waves (km sec^{-1})
200	8.26	4.60
1000	11.42	6.36
2200	13.03	7.02
2898	13.64	7.30
3000	8.22	no waves detected
5700	11.26	

(ii) Explain the behaviour and nature of both these waves as they travel through the Earth's interior. **4**

(d) "Geophysics has played a significant role in the support of the theory of plate tectonics."

Choosing suitable geophysical methods, summarise the evidence to support plate tectonics at **either** the mid ocean ridges where sea floor spreading takes place **or** at oceanic trenches where subduction occurs. **5**

(e) (i) Assuming that the Earth is a sphere (it is actually described as an oblate spheroid), calculate the volume of the Earth using **1**

$$V_E = \frac{4}{3}\pi r^3,$$

where r = Earth radius = 6.371×10^6 m.

(ii) calculate the average density of the Earth using **2**

$$\text{density} = \frac{\text{mass}}{\text{volume}} = \frac{M}{V},$$

and your answer from part (i). Show your working.

(iii) Having calculated the average density of the Earth, and knowing that the average density of surface rocks is less than 3000 kg m^{-3}or 3g cm^{-3}, what conclusion can be made about the density of the Earth's interior? **3**

Marks

Question 29 — Medical Physics (25 marks)

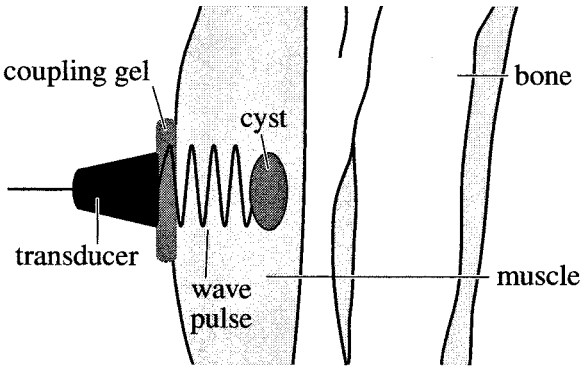
(a) Describe how X-rays are currently produced. Illustrate your response with an appropriately labelled diagram/s. **3**

(b) The table below provides the ultrasound data required for parts (i) and (ii).

Body tissue	Density (kg m^{-3})	Speed of sound (m s^{-1})
Skeletal muscle (SM)	1075	1590
Skeletal bone (SB)	1650	4080
Fluid filled cyst (FFC)	980	1440

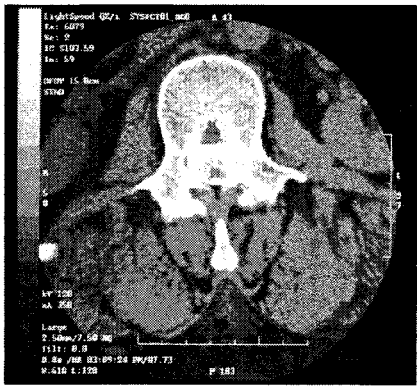
(i) Determine the acoustic impedance of skeletal bone. **1**

The following diagram represents the cross-section of a patient undergoing an ultrasound scan.



(ii) Using the data, analyse the intensities of the reflected ultrasound waves as the wave pulse moves through the different types of body tissue. **3**

(c) The image of a cross-section of the spine below has been produced using CAT (computed axial tomography) scan technology.



(i) Explain how a CAT scan is produced. **2**

(ii) Compare the advantages and disadvantages of CAT scans with PET scans. **4**

(d) You have undertaken a first-hand investigation to demonstrate the transfer of light by optical fibres. Describe the experimental method employed and relate the qualitative results obtained to the structure of optical fibres and total internal reflection. **5**

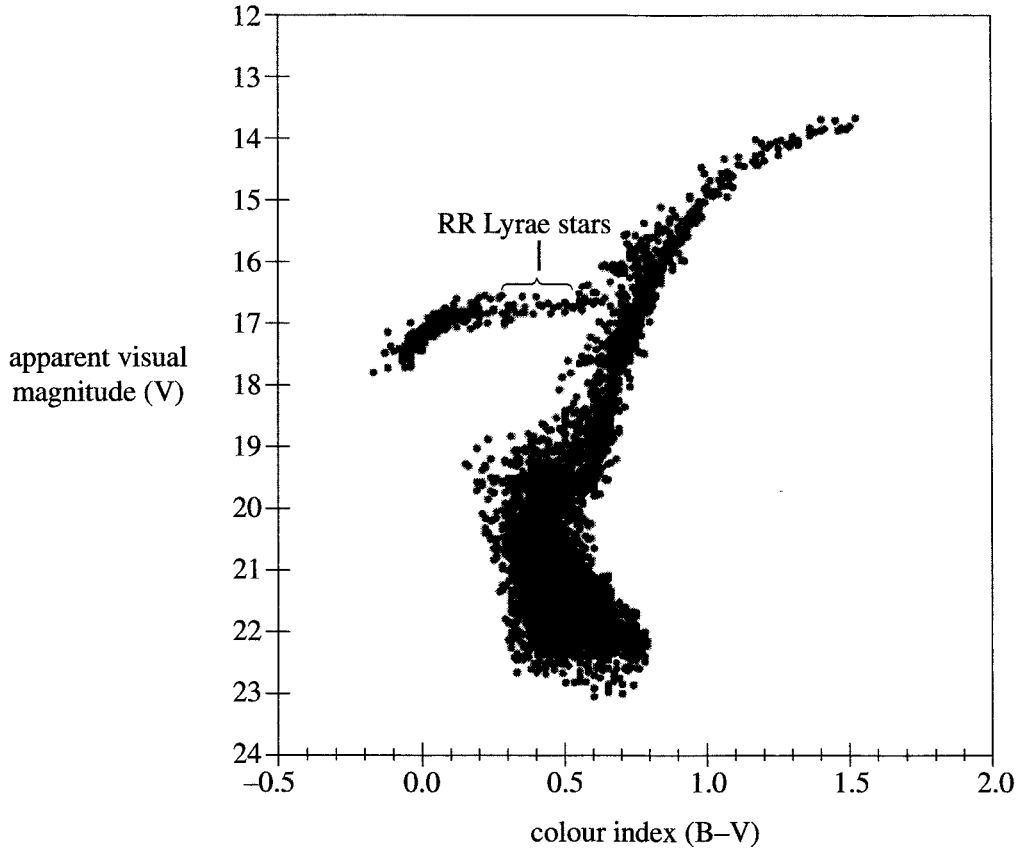
(e) Assess the significance of the role of MRI (Magnetic Resonance Imaging) technology in modern medicine. **7**

Marks

Question 30 — Astrophysics (25 marks)

(a) Explain how trigonometric parallax can be used to determine the distance to a nearby star. **3**

(b) Below is a Hertzsprung-Russell (colour-magnitude) diagram of a cluster of stars.



(i) Identify the type of cluster represented by this diagram. **1**

(ii) The 'RR Lyrae' stars in this cluster have a mean absolute magnitude, $M_V = +0.6$. Use this information to calculate the distance to the cluster. **3**

(c) (i) The Sun is classified as a G2V star on the basis of its absorption spectrum. Account for the production of the Sun's absorption spectrum. **2**

(ii) The bright star 'Capella' also has a G-type spectrum but its absorption lines periodically double every 52 days. Describe in detail how this phenomenon is produced. **4**

(d) Outline the evolution of a sun-like star from birth through to old age. In your answer, refer briefly to the main nuclear reactions that occur in each evolutionary phase. **5**

(e) Discuss the problems associated with ground-based astronomy in terms of resolution and selective absorption of radiation. **7**

Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) Show with the use of a labelled diagram how Bohr was able to explain the Balmer series of wavelengths within the hydrogen spectrum. **3**

(b) (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**

(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**

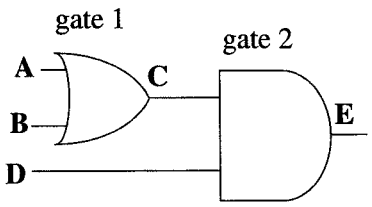
(d) For both of the medical and industrial sectors name a different radio-isotope and describe its applications within that sector. **5**

(e) 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**

Marks

Question 32 — The Age of Silicon (25 marks)

(a) Examine the situation of logic gates shown in the following diagram.



Name each of the gates involved, then copy and complete the partial truth table. **3**

A	B	C	D	E
0	0		0	
0	1		0	
1	0		1	
1	1		1	

(b) (i) Name the three main components of an electronic circuit. **1**

(ii) Outline the signal pathway within an electronic circuit between the components named in part (i), giving an example to show the process involved. **3**

(c) (i) An inverting operational amplifier has a feedback resistor of 200 kΩ and an input resistor of 10 kΩ. Draw a circuit diagram to represent this situation, if it has an input signal of 0.4 V. **2**

(ii) Calculate the output voltage and the voltage gain for the circuit. **4**

(d) Evaluate two situations where LEDs would be preferable to an ordinary light source. Include a circuit diagram to show how LEDs operate. **5**

(e) Assess the impact of the development of the silicon chip on the use of electronics and discuss the possible future directions of computers in terms of quantum effects. **7**

End of paper

Data sheet

Charge on the 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 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Speed of light, c	3.00×10^8 m s^{-1}
Magnetic force constant, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2×10^{-7} N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R_{hydrogen}	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, ρ	1.00×10^3 kg m^{-3}
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

Formulae sheet

$v = f\lambda$

$I \propto \frac{1}{d^2}$

$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$

$E = \frac{F}{q}$

$R = \frac{V}{I}$

$P = VI$

Energy $= VIt$

$v_{av} = \frac{\Delta r}{\Delta t}$

$a_{av} = \frac{\Delta v}{\Delta t}$ therefore $a_{av} = \frac{v - u}{t}$

$\Sigma F = ma$

$F = \frac{mv^2}{r}$

$E_k = \frac{1}{2}mv^2$

$W = Fs$

$p = mv$

Impulse $= Ft$

$E_p = -G\frac{m_1 m_2}{r}$

$F = mg$

$v_x^2 = u_x^2$

$v = u + at$

$v_y^2 = u_y^2 + 2a_y\Delta y$

$\Delta x = u_x t$

$\Delta y = u_y t + \frac{1}{2}a_y t^2$

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

$F = \frac{Gm_1 m_2}{d^2}$

$E = mc^2$

$l_v = l_0\sqrt{1 - \frac{v^2}{c^2}}$

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

$m_v = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}$

Formulae sheet

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$d = \frac{1}{p}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{(m_B - m_A)/5}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\lambda = \frac{h}{mv}$$

$$A_0 = \frac{V_{\text{out}}}{V_{\text{in}}}$$

$$Z = \rho v$$

$$\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

$$\frac{V_{\text{out}}}{V_{\text{in}}} = -\frac{R_f}{R_i}$$

Periodic Table of the Elements

1 **H** 1.008 Hydrogen																	2 **He** 4.003 Helium
3 **Li** 6.941 Lithium	4 **Be** 9.012 Beryllium											5 **B** 10.81 Boron	6 **C** 12.01 Carbon	7 **N** 14.01 Nitrogen	8 **O** 16.00 Oxygen	9 **F** 19.00 Fluorine	10 **Ne** 20.18 Neon
11 **Na** 22.99 Sodium	12 **Mg** 24.31 Magnesium											13 **Al** 26.98 Aluminium	14 **Si** 28.09 Silicon	15 **P** 30.97 Phosphorous	16 **S** 32.07 Sulfur	17 **Cl** 35.45 Chlorine	18 **Ar** 39.95 Argon
19 **K** 39.10 Potassium	20 **Ca** 40.08 Calcium	21 **Sc** 44.96 Scandium	22 **Ti** 47.87 Titanium	23 **V** 50.94 Vanadium	24 **Cr** 52.00 Chromium	25 **Mn** 54.94 Manganese	26 **Fe** 55.85 Iron	27 **Co** 58.93 Cobalt	28 **Ni** 58.69 Nickel	29 **Cu** 63.55 Copper	30 **Zn** 65.41 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 72.64 Germanium	33 **As** 74.92 Arsenic	34 **Se** 78.96 Selenium	35 **Br** 79.90 Bromine	36 **Kr** 83.80 Krypton
37 **Rb** 85.47 Rubidium	38 **Sr** 87.62 Strontium	39 **Y** 88.91 Yttrium	40 **Zr** 91.22 Zirconium	41 **Nb** 92.91 Niobium	42 **Mo** 95.94 Molybdenum	43 **Tc** [98.91] Technetium	44 **Ru** 101.1 Ruthenium	45 **Rh** 102.9 Rhodium	46 **Pd** 106.4 Palladium	47 **Ag** 107.9 Silver	48 **Cd** 112.4 Cadmium	49 **In** 114.8 Indium	50 **Sn** 118.7 Tin	51 **Sb** 121.8 Antimony	52 **Te** 127.6 Tellurium	53 **I** 126.9 Iodine	54 **Xe** 131.3 Xenon
55 **Cs** 132.9 Caesium	56 **Ba** 137.3 Barium	57–71 Lanthanides	72 **Hf** 178.5 Hafnium	73 **Ta** 180.9 Tantalum	74 **W** 183.8 Tungsten	75 **Re** 186.2 Rhenium	76 **Os** 190.2 Osmium	77 **Ir** 192.2 Iridium	78 **Pt** 195.1 Platinum	79 **Au** 197.0 Gold	80 **Hg** 200.6 Mercury	81 **Tl** 204.4 Thallium	82 **Pb** 207.2 Lead	83 **Bi** 209.0 Bismuth	84 **Po** [209.0] Polonium	85 **At** [210.0] Astatine	86 **Rn** [222.0] Radon
87 **Fr** [223.0] Francium	88 **Ra** [226.0] Radium	89–103 Actinides	104 **Rf** [261.1] Rutherfordium	105 **Db** [262.1] Dubnium	106 **Sg** [266.1] Seaborgium	107 **Bh** [264.1] Bohrium	108 **Hs** [277] Hassium	109 **Mt** [268] Meitnerium	110 **Ds** [271] Darmstadtium	111 **Rg** [272] Roentgenium							

KEY

Atomic number

Atomic mass

79 **Au** 197.0 Gold

Symbol of element

Name of element

Lanthanides	57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.9 Neodymium	61 **Pm** [146.9] Promethium	62 **Sm** 150.4 Samarium	63 **Eu** 152.0 Europium	64 **Gd** 157.3 Gadolinium	65 **Tb** 158.9 Terbium	66 **Dy** 162.5 Dysprosium	67 **Ho** 164.9 Holmium	68 **Er** 167.3 Erbium	69 **Tm** 168.9 Thulium	70 **Yb** 173.0 Ytterbium	71 **Lu** 175.0 Lutetium
Actinides	89 **Ac** [227.0] Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** [237.0] Neptunium	94 **Pu** [244.1] Plutonium	95 **Am** [243.1] Americium	96 **Cm** [247.1] Curium	97 **Bk** [247.1] Berkelium	98 **Cf** [251.1] Californium	99 **Es** [252.1] Einsteinium	100 **Fm** [257.1] Fermium	101 **Md** [258.1] Mendelevium	102 **No** [259.1] Nobelium	103 **Lr** [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.