Neap:

HSC Trial Examination 2007

Physics

This paper must be kept under strict security and may only be used on or after the afternoon of Thursday 16 August 2007, as specified in the Neap Examination Timetable.

General Instructions

Reading time – 5 minutes

Working time – 3 hours

Write using black or blue 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 2–16

75 marks

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 17–25

25 marks

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 2007 HSC Physics Examination.

Section I

75 marks

Part A – 15 marks

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. Fill in the response oval completely.

Sample 2 + 4 = 2 6 8 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 ○

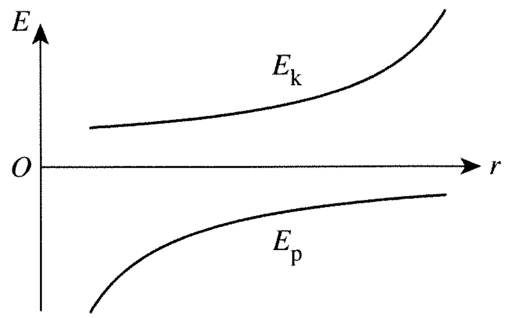
1. As a result of careful measurements he had made of balls rolling down inclined planes, Galileo was able to state that all freely falling bodies have constant acceleration near the surface of the Earth.
Which set of results for a freely falling object is consistent with his findings?

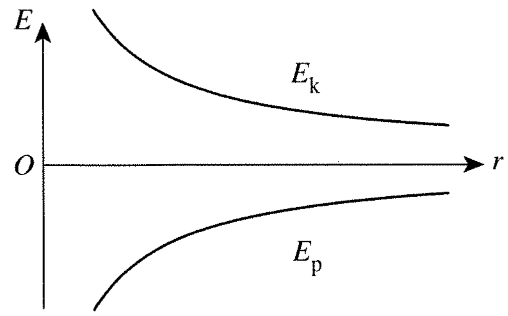
	Velocity after 1 second ($m\ s^{-1}$)	*Displacement after 1 second (m)*	*Velocity after 2 seconds* ($m\ s^{-1}$)	*Displacement after 2 seconds (m)*
(A)	9.8	4.9	19.6	19.6
(B)	4.9	4.9	9.8	9.8
(C)	9.8	9.8	19.6	19.6
(D)	4.9	9.8	9.8	9.8

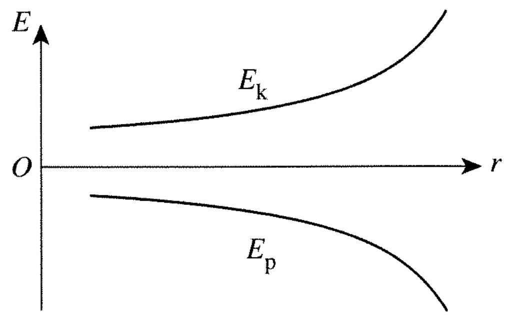
2. Which of the conditions below will allow a projectile to obtain maximum range, if air resistance is neglected?
(A) The initial vertical velocity is greater than the initial horizontal velocity.
(B) The initial vertical velocity is less than the initial horizontal velocity.
(C) The initial vertical velocity is equal to the initial horizontal velocity.
(D) The initial vertical velocity will reduce to zero at the maximum height, while the horizontal velocity will be constant.

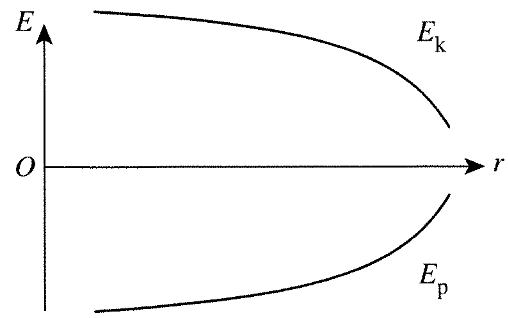
3. A 2000 kg satellite in a circular orbit around the planet Saturn has a period of 380 hours.
If the mass of Saturn is 5.7×10^{26} kg, what is the radius of the satellite's orbit?
(A) 5.1×10^{6} km
(B) 5.1×10^{6} m
(C) 1.2×10^{9} km
(D) 1.2×10^{9} m

4. As a rocket is launched from the surface of the Earth, its gravitational potential energy and its kinetic energy will change.
If the rocket's engines are fired continuously, which of the following graphs best shows the variation of the rocket's gravitational potential energy (E_p) and its kinetic energy (E_k) as the rocket's distance from the Earth's surface (r) increases?

(A)


(B)


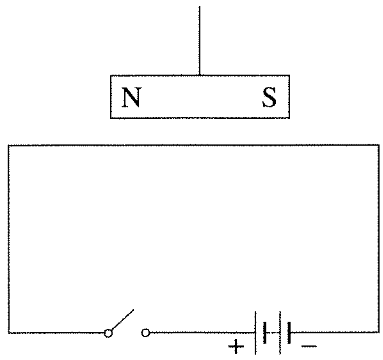
(C)


(D)


5. A planet has a lower gravitational field strength on its surface than does the Earth.
Which combination from the table below best predicts the planet's radius and mass when compared with those of the Earth?

	Radius	*Mass*
(A)	Smaller than Earth's	Larger than Earth's
(B)	Smaller than Earth's	Equal to Earth's
(C)	Larger than Earth's	Equal to Earth's
(D)	Equal to Earth's	Larger than Earth's

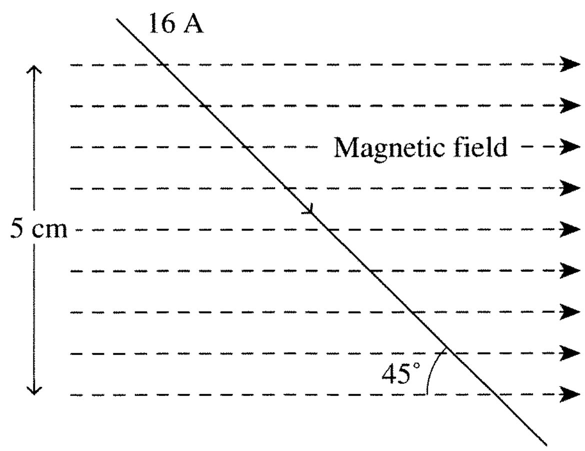
6. A magnet is suspended over a conducting wire as shown below.



Which of the following would you expect the magnet to do when the switch is closed?

(A) Move along the wire (i.e. to the left or the right)
(B) Move across the wire (i.e. into or out of the page)
(C) Rotate anticlockwise (i.e. N out of the page, S into the page)
(D) Rotate clockwise (i.e. N into the page, S out of the page)

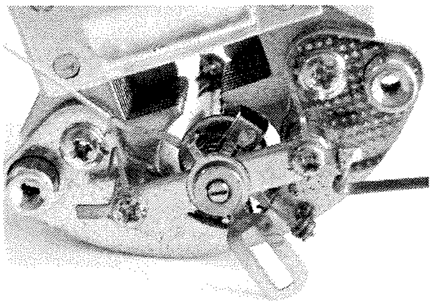
7. The diagram below represents a conductor carrying a current in a magnetic field.



When the current through the conductor is 16 A, the force on the conductor is 0.25 N.
What is the magnetic flux density of the magnetic field?

(A) 0.44 T
(B) 0.31 T
(C) 0.20 T
(D) 3.125×10^3 T

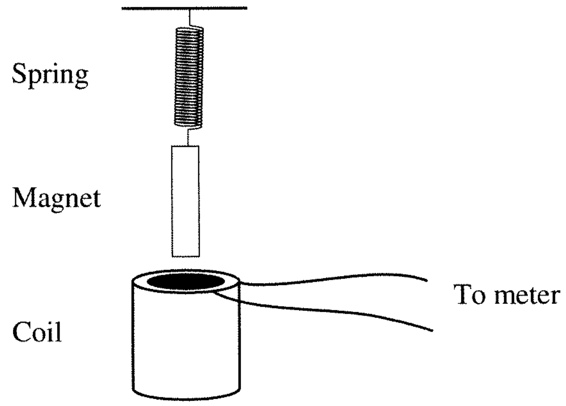
8. The photograph below shows the workings of an analogue galvanometer. The coil is wound on a small aluminium frame which forms an electrically conducting loop in the magnetic field.



What would be the reason for using a conducting frame?

(A) To provide electromagnetic damping, so that the pointer stops swinging and reaches its steady reading quickly
(B) To provide a good heat conductor to remove the heat generated in the fine wires in the coil
(C) To provide the strength to keep the coil the correct shape in the magnetic field
(D) To keep the magnetic field constant in the coil

9. A group of students is investigating electromagnetic induction by using the equipment shown in the diagram below. The bar magnet hanging from the spring is pulled down so that it is inside the coil, then released. The coil is connected to different meters to find out what current or voltage is generated.



The students note that when the coil is connected to an ammeter it stops moving up and down much more rapidly than when connected to a voltmeter.

Which of the following could be an explanation for this?

(A) The back emf from the voltmeter keeps the magnet moving.
(B) The back emf from the ammeter opposes the magnet moving.
(C) The current induced in the coil and passing through the voltmeter encourages the motion of the magnet.
(D) The current induced in the coil and passing through the ammeter opposes the motion of the magnet.

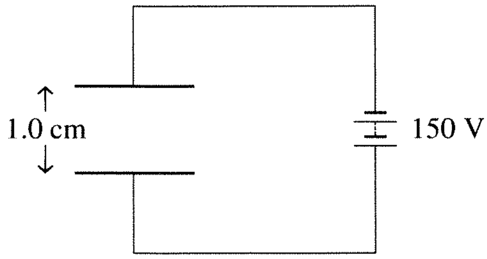
10. A plug pack transformer used to charge batteries is marked as shown below.

INPUT	240 V	100 mA
OUTPUT	12 V	800 mA

If there are 480 turns of wire on the primary of this transformer, what would be the number of turns on the secondary?

(A) 24
(B) 60
(C) 3840
(D) 9600

11. The diagram below shows two parallel plates.



What is the magnitude of the electric field between the plates?

(A) $\frac{150}{1.0}$ V m^{-1}

(B) $\frac{150}{1.0 \times 10^{-2}}$ V m^{-1}

(C) 150×10^{-1} V m^{-1}

(D) 150×1.0 V m^{-1}

12. What is the energy of a photon of blue light with a frequency $f = 7.0 \times 10^{14}$ Hz and a wavelength of 430 nm?

(A) $6.63 \times 10^{-34} \times 10^{-9}$ J

(B) $6.63 \times 10^{-34} \times 3 \times 10^{8}$ J

(C) $6.63 \times 10^{-34} \times 430$ J

(D) $6.63 \times 10^{-34} \times 7 \times 10^{14}$ J

13. Which of the following does not produce electromagnetic radiation?

(A) Turning off a light switch
(B) Creating a spark with two wires
(C) An electron 'orbiting' a nucleus
(D) Electrons hitting a metal target

14. Which substance, which could be easily purified, was used to make the first transistors?

(A) Germanium
(B) Silicon
(C) p-type aluminium
(D) n-type carbon

15. What does a cathode ray tube containing a Maltese cross tell us about cathode rays?

(A) They travel in straight lines.
(B) They have mass.
(C) They have momentum.
(D) They have electric charge.

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Section I (continued)

Part B – 60 marks

Attempt Questions 16–27
Allow about 1 hour and 45 minutes for this part

Answer the questions in the spaces provided.
Show all relevant working in questions involving calculations.

Marks

Question 16 (6 marks)

A football is kicked with a velocity of 20 m s^{-1} at an angle to the ground of 37°.
Assume that there is neither wind assistance nor air resistance.

(a) What is the vertical velocity of the football as soon as it has left the player's foot? **1**

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(b) What is the maximum height obtained by the football? **3**

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(c) How far from the player will the football land? **2**

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Marks

Question 17 (6 marks)

(a) What is meant by the term 'orbital velocity'? **1**

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(b) Discuss the nature and operation of the force that keeps Earth in orbit around the Sun. **3**

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(c) The average orbital separation between Earth and the Sun is 1.5×10^{11} m. **2**

	Mass (kg)	*Radius (km)*
Earth	6.0×10^{24}	6380
Sun	2.0×10^{30}	695500

Using the data from the table above, determine the orbital speed of the Earth.

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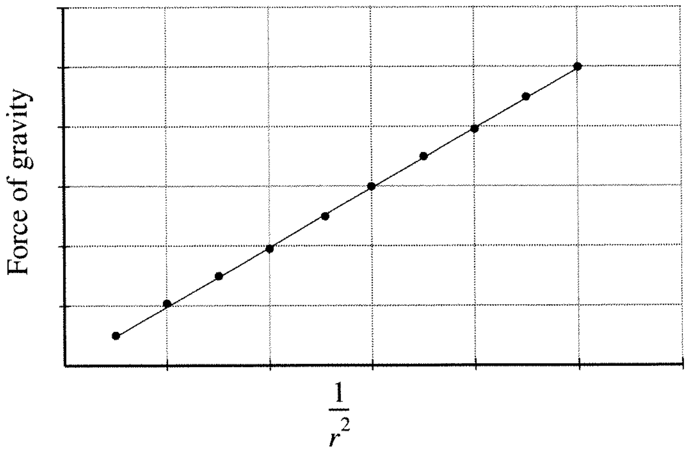
Marks

Question 18 (5 marks)

During an experimental investigation, the force of gravity between two known masses (m_1 and m_2) was determined for several values of the distance of separation (r). This data was then used to draw the graph below.



(a) Explain how the graph can be used to calculate the value of the universal gravitational constant, G. **2**

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(b) Identify and explain how this data would support Newton's law of universal gravitation. **3**

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Question 19 (3 marks)

Albert Einstein's special theory of relativity made several predictions regarding the behaviour of objects as their speed increases to an appreciable fraction of the speed of light. **3**

Scientists working in their laboratory use a particle accelerator to increase the speed of a proton to 75% of the speed of light.

Discuss the qualitative and quantitative changes that the scientists would observe.

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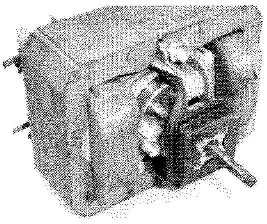
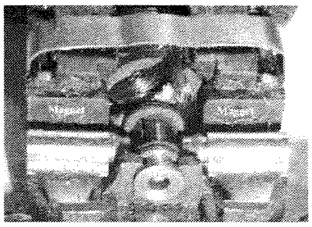
Question 20 (4 marks)

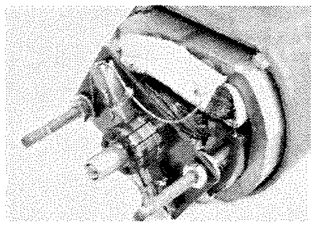
The photographs below show three electric motors.



Motor A



Motor B



Motor C

Motor A has field coils on the stator and no electrical connections to the rotor.

Motor B has permanent magnets in the stator and a split-ring commutator.

Motor C has field coils on the stator and a split-ring commutator.

(a) Which of these motors would rotate if supplied with a suitable DC voltage? **1**

(b) Which of these motors would rotate if supplied with a suitable AC voltage? **1**

(c) Justify your answers to the above questions. **2**

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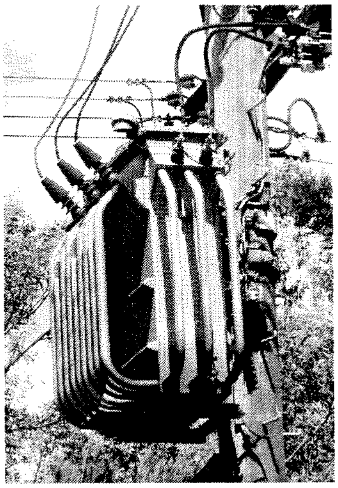
Marks

Question 21 (6 marks)

The photograph below shows a pole transformer.



(a) What is the function of this device? 1

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(b) The pipes on this device carry oil, which helps to cool the interior. 2

What are two processes that convert some of the electrical energy entering the device into unwanted heat energy?

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(c) The three insulators on the left of the transformer are a different size to the two on the closest side. 1

What is the reason for this?

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(d) Why would Westinghouse (or Tesla) have used devices like this in his power systems, while Edison would not? 2

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Marks

Question 22 (5 marks)

Some students are investigating small electric motors. They find that Motor A spins at 1000 rpm when connected to a 12 V battery. The current through the motor is 0.5 A at this speed.

They have also heard that a permanent-magnet motor can act as a generator, so they connect Motor B up to a speed-controlled electric drill, run it at different speeds and measure the output voltage and current. At each speed, they connect up the voltmeter and take the measurement, disconnect the voltmeter, connect the ammeter, make sure the speed is correct and then measure the current. The results are shown below.

Speed (rpm)	*Potential difference (V)*	*Current (A)*
300	4	0.5
600	8.1	1.0
900	12.2	1.5

One of the students looks at these results and decides that if Motor A is set up to drive Motor B as a generator, then at 1000 rpm the voltage from Motor B would be greater than 12 V. At this speed the current would be greater than 0.5 A, so the output could be used to charge the battery and the motor could be kept running.

(a) State at least three errors in the student's reasoning and hence deduce why the battery would soon go flat. **3**

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(b) If the student tried to use Motor A to drive Motor B and recharge the battery, what would be likely to happen? **2**

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Marks

Question 23 (5 marks)

(a) Name three appliances in the home that transform electrical energy into more useful forms of energy. **3**

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(b) Explain how two of these appliances carry out the conversion of electrical energy into other forms of energy. **2**

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Question 24 (4 marks)

When cathode rays were discovered, they appeared to behave in inconsistent ways. **4**

Outline these inconsistencies and explain how they initially resulted in two different ideas about the nature of cathode rays.

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Marks

Question 25 (5 marks)

Metals have a regular crystal structure.

(a) Outline the method used by the Braggs to determine crystal structure. **2**

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(b) Sketch a diagram showing a model of a metal, and use it to describe how metals conduct electricity. **3**

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Marks

Question 26 (6 marks)

Hertz discovered radio waves and studied their properties. **6**

Outline his experiments, including how he measured the speed of the radio waves.

Marks

Question 27 (5 marks)

Thomson's experiment used two different methods to deflect electrons. These methods are also used in conventional TV tubes. **5**

Outline the two methods of deflecting electrons, and explain how Thomson used both methods simultaneously.

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Section II

25 marks
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) (i) Outline two reasons why the Earth's gravitational field varies at different points on the Earth's surface. **2**

(ii) Transfer diagrams A and B below to your writing booklet. On Diagram A, identify the major topographical features, and on Diagram B draw a line graph that would represent the gravity anomaly across the region shown in Diagram A. **3**

Diagram A – Hypothetical cross-section through a volcanic island area and oceanic trench

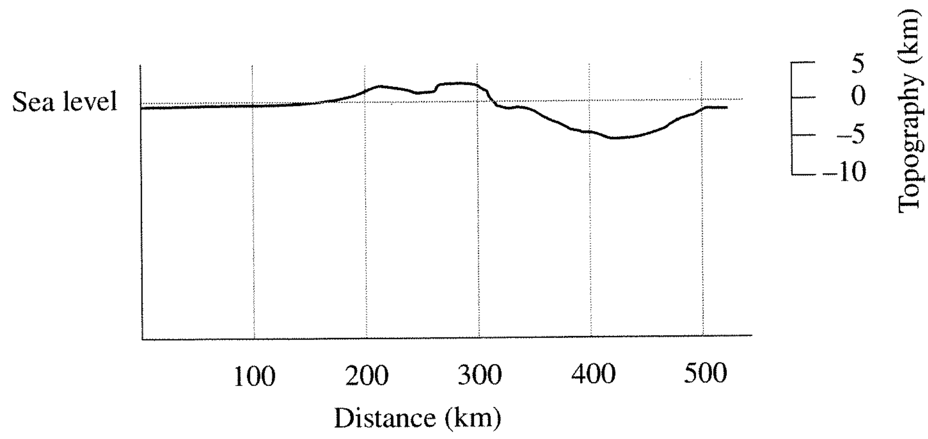
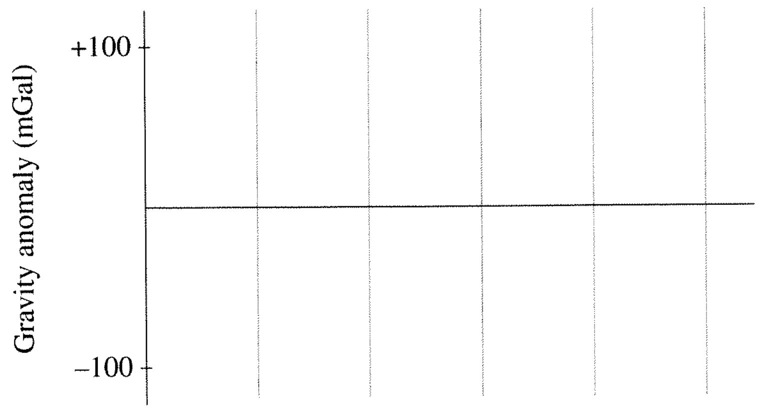


Diagram B – Graph axes for gravity anomaly



(b) It could be argued that the International Geophysical Year (IGY), which extended some 18 months from July 1957 to December 1958, was responsible for supplying the evidence that has now led to the theory of plate tectonics.

(i) Discuss why the scientific community was reluctant to accept Alfred Wegener's theory of continental drift prior to the IGY. **2**

(ii) Summarise two pieces of geophysical evidence that have been discovered following the IGY that support the theory of plate tectonics. **4**

(c) Analyse how seismic evidence has enhanced humanity's understanding of the interior of the Earth. You may find that drawing a diagram helps your answer. **7**

Question 28 continues on page 19

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Marks

Question 28 (continued)

(d) Olympic Downs (Roxby Downs) is considered to be the largest multi-mineral ore body in the world. The ore body of copper and uranium is nearly seven kilometres long, four kilometres wide and one kilometre deep and is covered by 300 metres of sediment. It was discovered entirely through geophysical exploration.

(i) Explain the benefits of geophysical methods in mineral exploration. **4**

(ii) Describe one geophysical property of the materials in the ore body that could have led to its discovery. **2**

(iii) Identify the geophysical method that could be used to locate this material. **1**

End of Question 28

Marks

Question 29 — Medical Physics (25 marks)

(a) (i) Medical practitioners use the Doppler effect of ultrasound to detect the blood characteristics of the heart. Outline how the Doppler effect works and identify one cardiac problem that can be detected using this technique. **2**

(ii) The acoustic impedance of air is 400 kg m^{-2} s^{-1}. The speed of ultrasound in the chest muscle is 1580 m s^{-1} and the density of the chest muscle is 1076 kg m^{-3}. **3**

Calculate the acoustic impedance of chest muscle and hence determine the fraction of acoustic signal transmitted through a chest muscle–air interface.

Based on these results, would you recommend the use of ultrasound imaging of the lungs?

(b) (i) Light travels in straight lines, yet, by using an endoscope, doctors are able to see inside a patient's body by means of flexible probes that repeatedly bend through the passages of the body. **3**
Describe, with the aid of a diagram, how light is transferred by optical fibres used in these endoscopes.

(ii) Compare the structure and role of coherent and incoherent bundles of optical fibres in the operation of endoscopes. **3**

(c) Assess the impact on society of the advancements made in the production and use of computed axial tomography (CAT) scans and positron emission tomography (PET) scans. **7**

Question 29 continues on page 21

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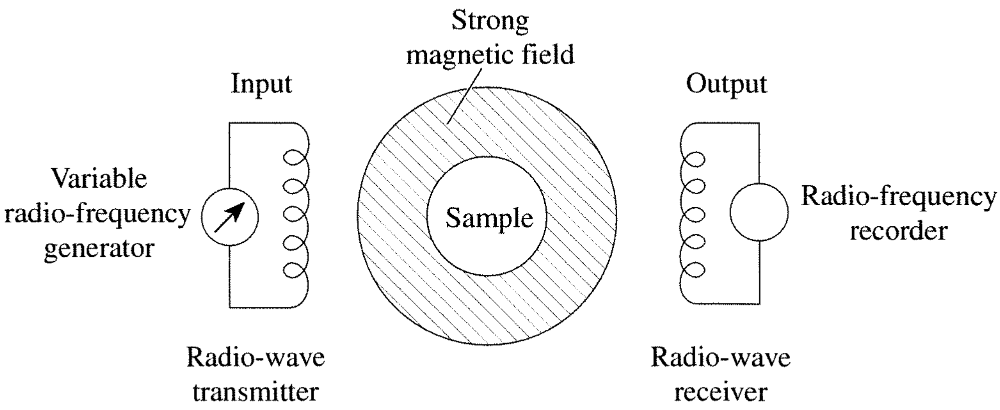
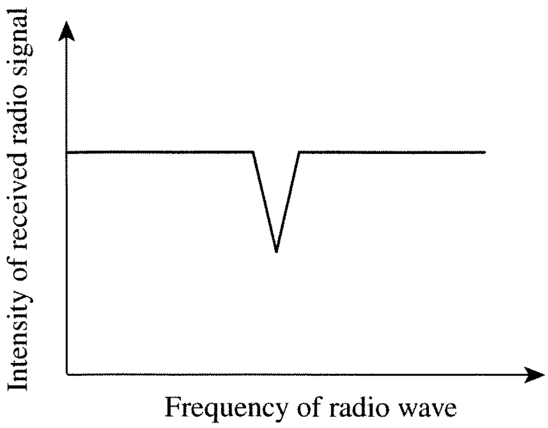
Marks

Question 29 (continued)

(d) The schematic diagram below shows the apparatus of an experiment to determine the magnetic resonant frequency of a sample of a healthy organ placed in a strong magnetic field.



The sample is subjected to radio waves of increasing frequency, and the output circuit records the strength of the radio wave signal received. The output signal is shown below.



(i) Describe the behaviour of the hydrogen nuclei in the sample in this experiment and how this relates to the output signal shown. **3**

(ii) Explain how the energy absorbed by the nuclei is released and processed to produce magnetic resonance images of a patient. **2**

(iii) Outline how the magnetic resonance imaging process is able to detect abnormalities (such as cancerous growths) in organs. **2**

End of Question 29

Marks

Question 30 — Astrophysics (25 marks)

(a) (i) Atmospheric turbulence causes severe problems with images obtained by telescopes. Outline one of the problems caused by atmospheric turbulence and examine the attempts to overcome this problem. **2**

(ii) The maximum distance at which Earth-based parallax measurements have optimum resolution is about 30 parsecs. **3**

Calculate the resolution (in arc seconds) that can be obtained at this distance, and compare this value to that of an orbiting telescope with a resolution of 0.001 arc seconds.

(b) (i) With the aid of a diagram, describe how an emission spectrum is formed and how it can be used to identify elements found in stars. **3**

(ii) Explain how three different pieces of information can be deduced from studies of the various spectra obtained from a particular star. **3**

(c) Assess the importance of the discovery of variable stars to our knowledge of the distance and magnitude of these stars. How have these stars played an important part in discovering further information about our universe? **7**

(d) (i) Describe the relationship between the absolute magnitude, apparent magnitude and the distance of a star. Use this relationship to complete the following table. **3**

Star	*Absolute magnitude*	*Apparent magnitude*	*Distance (pc)*
Sirius	–1.41	–1.44	
Deneb	–8.73		990

(ii) Describe how stellar formation occurs, outlining the physical processes involved. **2**

(iii) How do photometric measurements using photo-electric technologies compare to those obtained using photographic methods? **2**

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Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) The Rutherford–Bohr model of the atom is unable to explain completely a phenomenon called the hyperfine structure. This is a splitting of spectral lines associated with the fact that the nucleus of the atom has a magnetic dipole moment that interacts with the orbital and/or spin magnetic dipole moments of the electron.

For example, the ground level of hydrogen is split into two states, separated by only 5.9×10^{-6} eV. The photon that is emitted in the transition between these states is used by radio astronomers to map interstellar clouds of hydrogen gas that are too cold to emit visible light. From an analysis of the intensity of this radiation, astronomers have learned a great deal about the density distribution of neutral hydrogen in interstellar space.

(i) Identify two other limitations of Bohr's model of the hydrogen atom. **2**

(ii) Calculate the wavelength, λ, that radio astronomers are looking for to study interstellar clouds of hydrogen. **3**

(b) Americium-241, a radioactive element best known for its use in smoke detectors, is a transuranic element produced by the decay of plutonium-241.

$$^{241}_{94}\text{Pu} \rightarrow {}^{241}_{95}\text{Am} + {}^{0}_{-1}e$$

It emits an alpha particle.

$$^{241}_{95}\text{Am} \rightarrow {}^{4}_{2}\text{He} + {}^{237}_{93}\text{Np}$$

(i) Describe how you carried out an investigation to observe alpha and beta radiation emitted from a nucleus with a Wilson cloud chamber or similar detection device. **3**

(ii) Compare two properties of protons and neutrons, and define the term 'nucleon'. **3**

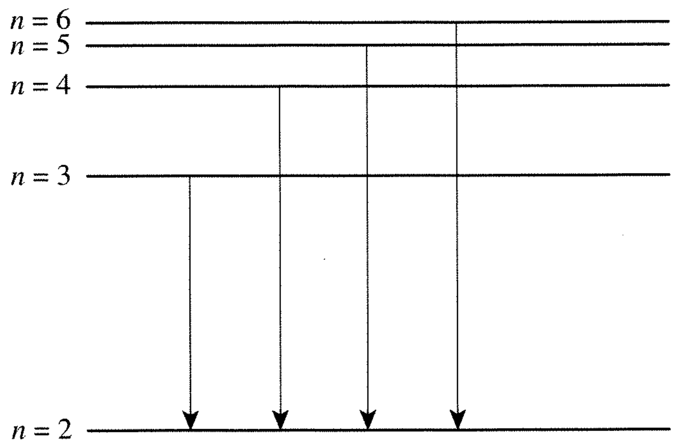
(c) Evaluate how major advances in scientific understanding and technology have changed the direction of scientific thinking, with reference to de Broglie's proposal that any kind of particle has both wave and particle properties, the experiments of Davisson and Germer and the stability of the electron orbits in the Bohr atom. **7**

Question 31 continues on page 24

Marks

Question 31 (continued)

(d) Bohr extended the Rutherford model by formulating two postulates that enabled him to apply the quantum ideas of Planck and Einstein. The diagram illustrates Bohr's explanation of the Balmer series.



(i) Describe this diagram by explaining the meaning of the horizontal lines and vertical arrows, and by identifying the name given to the number n. **3**

(ii) Determine the longest wavelength of a spectral line of hydrogen in the Balmer series. **2**

(iii) Outline how a diagram could be used to show the process involved in producing the absorption spectrum line with the wavelength calculated in (ii) and draw this diagram. **2**

End of Question 31

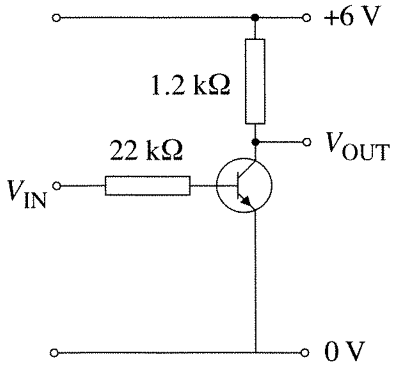
Marks

Question 32 — The Age of Silicon (25 marks)

(a) (i) Outline the similarities between an integrated circuit and a transistor. **2**

(ii) Describe how an electronic system can make use of input and output transducers to process information. Give an example to aid your description. **3**

(b) Below is a simplified circuit diagram of a voltage inverter.



(i) Calculate the maximum collector current for this circuit, and explain why it is that when the input voltage is 6 V the output voltage is almost zero. **3**

(ii) Explain how this voltage inverter can also be used as a NOT logic gate. Include a diagram and a truth table to support your description. **3**

(c) Assess why semiconducting materials became the basis of the integrated circuits that run our computers and many modern communication technologies, and discuss the possibility that there may be a physical limit on the growth of computers. **7**

(d) Diagrams A and B both show operational amplifiers.

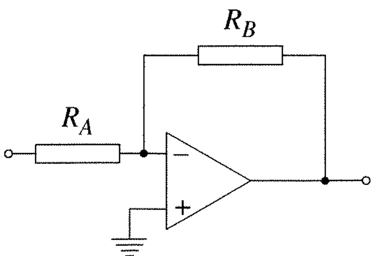


Diagram A

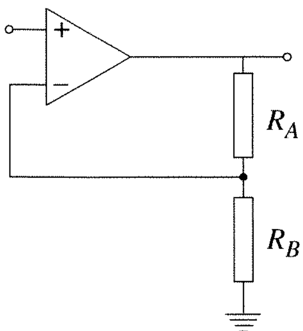


Diagram B

(i) Identify which diagram (A or B) is that of a non-inverting amplifier and calculate the gain of the amplifier shown in Diagram A if R_A is 12 kΩ and R_B is 4800 kΩ. **3**

(ii) Explain how the structure of a light-emitting diode (LED) uses the properties of semiconducting materials. **2**

(iii) Compare the resistance of a light-dependent resistor under low light levels with its resistance under high light levels. Give an example of its use. **2**

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, $\left(k \equiv \frac{\mu_0}{2\pi}\right)$	2.0×10^{-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

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

$$F = BIl\sin\theta$$

$$\tau = Fd$$

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

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

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

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

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

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

$$F = qvB\sin\theta$$

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

$$E = hf$$

$$c = f\lambda$$

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

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

$$Z = \rho v$$

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

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

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

Periodic Table of the Elements

KEY

Atomic number Atomic weight	79 **Au** 197.0 Gold	**Symbol of element** Name of element

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 Phosphorus	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** [97.91] 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 Lanthanoids	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] Francium	88 **Ra** [226] Radium	89–103 Actinoids	104 **Rf** [261] Rutherfordium	105 **Db** [262] Dubnium	106 **Sg** [266] Seaborgium	107 **Bh** [264] Bohrium	108 **Hs** [277] Hassium	109 **Mt** [268] Meitnerium	110 **Ds** [271] Darmstadtium	111 **Rg** [272] Roentgenium							

Lanthanoids	57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymium	60 **Nd** 144.2 Neodymium	61 **Pm** [145] 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
Actinoids	89 **Ac** [227] Actinium	90 **Th** 232.0 Thorium	91 **Pa** 231.0 Protactinium	92 **U** 238.0 Uranium	93 **Np** [237] Neptunium	94 **Pu** [244] Plutonium	95 **Am** [243] Americium	96 **Cm** [247] Curium	97 **Bk** [247] Berkelium	98 **Cf** [251] Californium	99 **Es** [252] Einsteinium	100 **Fm** [257] Fermium	101 **Md** [258] Mendelevium	102 **No** [259] Nobelium	103 **Lr** [262] Lawrencium

For elements that have no stable or long-lived nuclides, the mass number of the nuclide with the longest confirmed half-life is listed between square brackets.