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HSC Trial Examination 2002

Physics

This paper must be kept under strict security and may only be used on or after the afternoon of Monday 12 August, 2002, 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.

Examination structure

Section I Pages 2–15 Total marks 75

This section has two parts, Part A and Part B.

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

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

Section II Pages 16–23 Total marks 25

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

Students are reminded that this is a trial examination only and cannot in any way guarantee the content or the format of the 2002 Physics Higher School Certificate examination.

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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.

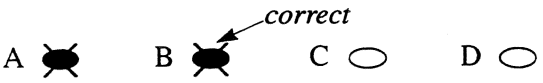
Sample $2 + 4 =$ (A) 2 (B) 6 (C) 8 (D) 9

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:



1. The acceleration due to gravity on planet X within our solar system is determined to be 8.8 m s^{-2}. An astronaut has a mass of 70 kg at the Earth's surface. What is the weight of this astronaut on planet X?
   (A) 616 kg
   (B) 616 N
   (C) 670 kg
   (D) 670 N

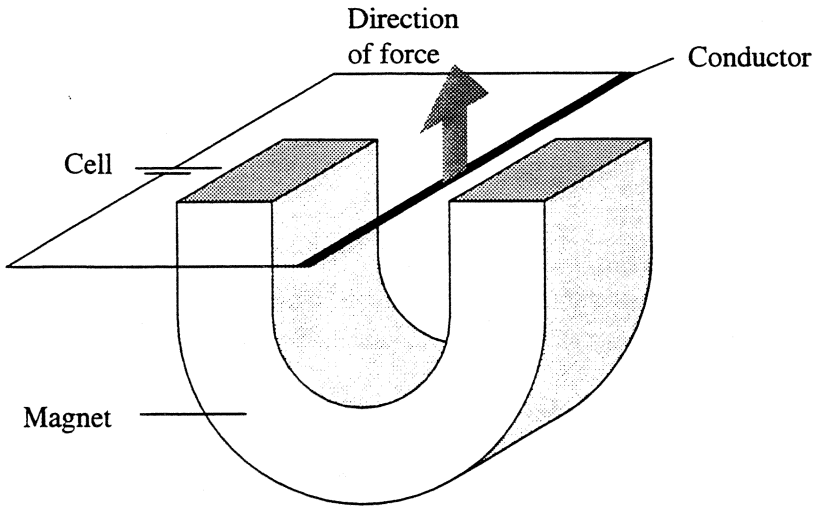
2. A roller coaster going through a vertical loop gives its passengers a momentary feeling of weightlessness. Which of the following statements is the main reason for this weightlessness?
   (A) At the top of the loop, gravity is working to pull the passengers down and the reaction force is the greatest.
   (B) At the bottom of the loop, gravity is working to pull the passengers down and the reaction force is the least.
   (C) At the top of the loop, gravity is working to pull the passengers down and the reaction force is equal to the gravitational force.
   (D) At the top of the loop, gravity is working to pull the passengers down and the reaction force is the least.

3. A rocket is normally launched vertically and then tilted to travel parallel to the Earth's surface when the required orbital speed is reached. Two rockets containing satellites are launched from the same location on the Earth's surface. They have the same initial energy. Rocket A is launched towards the east and Rocket B is launched towards the west. Which statement is correct?
   (A) Both Rocket A and Rocket B may attain stable Earth orbits, but their orbital velocities will be influenced by the Earth's rotational velocity.
   (B) Rocket A only will attain a stable Earth orbit, since it can be assisted by the Earth's rotational velocity.
   (C) Rocket B only will attain a stable Earth orbit, since it can be assisted by the Earth's rotational velocity.
   (D) Both Rocket A and Rocket B will attain stable Earth orbits with the same orbital velocities.

4. Many scientists were shocked by the null result produced by the Michelson–Morley experiment. Some scientists even suggested that the results were attributable to other effects. Which of these suggestions was not proposed to explain the null result and preserve the ether theory?
   (A) The ether must have be travelling parallel to the direction of the Earth.
   (B) The length of the apparatus contracted in the direction of motion.
   (C) The speed of light is independent of the speed of source or the observer.
   (D) The ether must be travelling with the Earth.

5. An inertial frame of reference was fundamental to Einstein's theory of special relativity. Which of the following can be used to describe an inertial frame of reference?
   (A) An inertial frame of reference is an accelerating frame of reference.
   (B) An inertial frame of reference is a frame of reference in which the law of inertia is violated.
   (C) An inertial frame of reference is a frame of reference with constant acceleration.
   (D) An inertial frame of reference is a frame of reference with constant velocity.

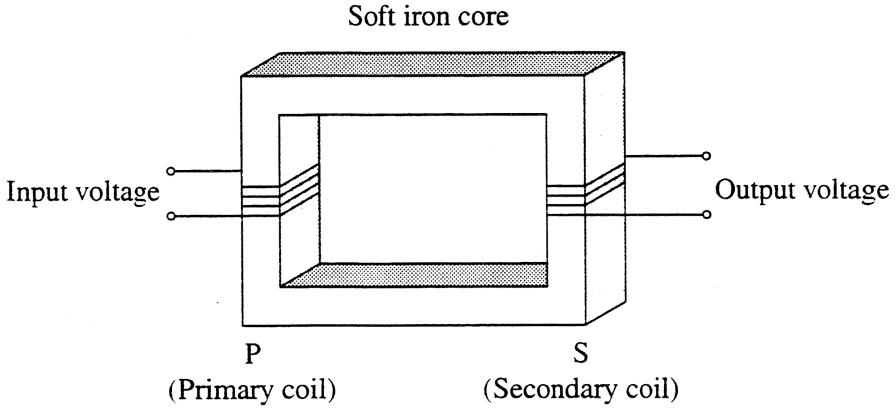
6. A thin conductor is placed between the poles of a magnet and is briefly connected to a cell, as shown in the diagram below. The conductor experiences an upwards force.



The magnetic poles are now reversed. Which combination of changes to the direction of current and the direction of the force on the conductor will result from this reversal?

	Direction of current	*Direction of force*
(A)	reversed	reversed
(B)	reversed	unchanged
(C)	unchanged	reversed
(D)	unchanged	unchanged

7. The diagram below represents a transformer. A primary coil P is connected to one side of a soft iron core, while a secondary coil S is connected to the other side.



Which combination of factors would create a device that produces a greater output voltage than the input voltage?

	Nature of input voltage	*Number of turns in Primary coil P*	*Number of turns in Secondary coil S*
(A)	AC	12	24
(B)	DC	12	24
(C)	AC	24	12
(D)	DC	24	12

8. Current supplies to homes, schools and industry are usually of alternating current.

Which of the following is a principal reason for this supply?

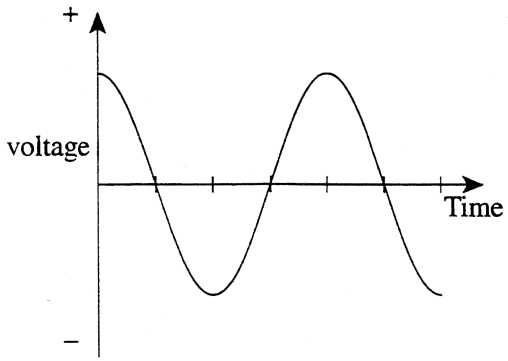
(A) Less energy is available as heat if electricity is sent from distant power stations to cities using low voltages and low currents.

(B) More energy is available as heat if electricity is sent from distant power stations to cities using high voltages and high currents.

(C) Less energy is lost as heat if electricity is sent from distant power stations to cities using high voltages and low currents.

(D) More energy is lost as heat if electricity is sent from distant power stations to cities using high voltages and low currents.

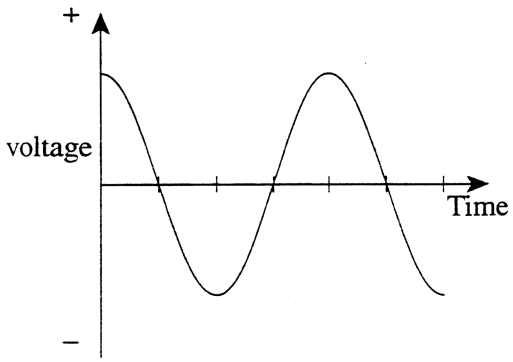
9. The voltage produced by a simple AC generator varies with time as shown in the following graph.



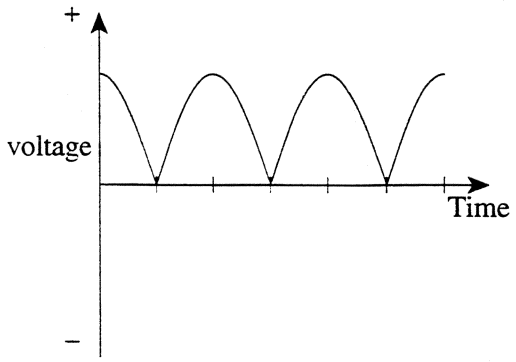
This generator is to be converted into a DC generator. Its coil loop commences from exactly the same starting position and has exactly the same initial orientation.

Which graph shows the voltage variations with time it produces?

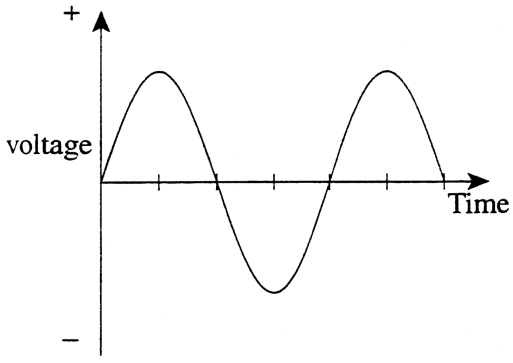
(A)



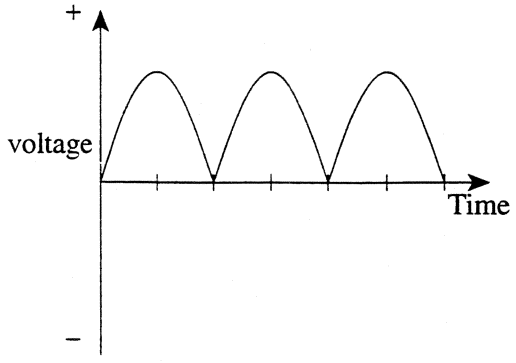
(B)



(C)



(D)



10. An electric motor is often placed in series with an adjustable resistor. Why is this resistor connected in this manner?
    (A) To reduce the operating current and protect the windings in the coil.
    (B) To increase the starting current and improve efficiency of the motor.
    (C) To increase the operating current and reduce the starting current.
    (D) To reduce the starting current and protect the winding in the coil.

11. When a high voltage from an induction coil is applied across the terminals of a gas tube, a discharge may result. Changes to the pressure of the gas produce changes within the tube.
    Which of the following statements is incorrect?
    (A) At the lowest pressure, no gas glow is observed but a glow is noted in the glass opposite the cathode.
    (B) As the pressure of the gas within the tube is reduced the positive column breaks up into a series of striations.
    (C) At the highest pressure, no gas glow is observed but a glow is noted in the glass opposite the cathode.
    (D) As the pressure of the gas within the tube is reduced, an area called Faraday's dark space is observed between the positive glow and the negative glow.

12. Metallic conductors have a fairly constant resistance at specific temperatures. Which statement best explains why this resistance is usually low?
    (A) The conduction band has much greater energy than the valence band.
    (B) The valence band has much greater energy than the conduction band.
    (C) There are many electrons available for conduction.
    (D) There are few electrons available for conduction.

13. An electromagnetic wave has a wavelength is 450 nanometres. What is the energy of one quantum associated with this wave?
    (A) 2.26×10^{18} J
    (B) 4.42×10^{18} J
    (C) 2.26×10^{-19} J
    (D) 4.42×10^{-19} J

14. The conduction of current with a p-type semiconductor is as a result of
    (A) an excess electron
    (B) a missing electron
    (C) the substituted arsenic atoms
    (D) the silicon atoms

15. The cathode ray oscilloscope (CRO) has been used as a test instrument in a variety of scientific and industrial situations. Why is the CRO such a widely used diagnostic tool?
    (A) The CRO has the ability to make electrical signals visible.
    (B) The CRO can focus a beam of light onto a screen.
    (C) The CRO has the ability to deflect protons in both electric and magnetic fields.
    (D) The CRO can focus a beam of protons onto a screen.

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.

Question 16 (4 marks) **Marks**

The acceleration due to gravity varies around the Earth's surface.

(a) State two reasons as to why the acceleration due to gravity on the surface of the Earth is not a constant value. **2**

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(b) A planet has been discovered orbiting a nearby star. Its mass is three times the mass of the Earth, its diameter is four times that of the Earth and its orbital radius is twelve times that of the Earth. **2**

Calculate the value of the acceleration due to gravity on the newly discovered planet.

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Marks

Question 17 (6 marks)

Satellites are used for communication, navigation and weather forecasting. They may be in a low Earth orbit or a geostationary orbit.

(a) Using words and calculations, describe where a satellite must be placed in order to be geostationary. **3**

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(b) Compare the antenna and transmitter power requirements of a low Earth orbit satellite with those of a geostationary satellite in dealing with communications to an Earth-based station. **3**

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Marks

Question 18 (6 marks)

The greatest challenge for rocket designers is to develop engines that are capable of providing a thrust to overcome the Earth's gravitational pull.

(a) Outline the contribution towards rocket design by one of Tsiolkovsky or Oberth or Goddard or von Braun. **2**

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(b) Discuss how the principle of conservation of momentum and Newton's second law is utilized by rocket designers to place a satellite in orbit. **4**

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Question 19 (4 marks)

At present spacecraft can only travel at a few tens of thousands kilometres per hour. With these speeds man will be limited in the further exploration of space. **4**

Discuss the limitation of currently achievable velocities being too slow for extended space travel.

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Marks

Question 20 (4 marks)

During your coursework you have performed a first hand investigation to model the experiments of Michael Faraday. **4**

Justify how your results support the relationship between the generated potential difference and the rate of change of magnetic flux.

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Question 21 (3 marks)

A 12 V DC battery supplies the electrical requirements of most cars. The spark plugs require a voltage of around 48 000 V to produce the spark that ignites the fuel in each of its cylinders. A specific device is used for this increase in voltage to occur.

(a) Name the type of device that increases output voltage. **1**

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(b) Explain how these voltage changes are related to the conservation of energy. **2**

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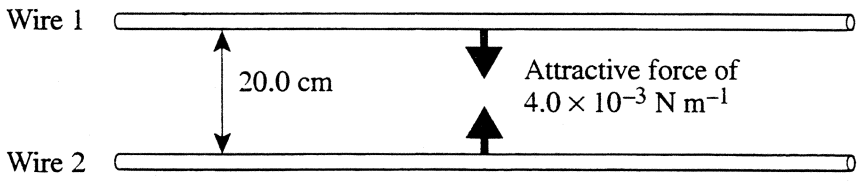
Marks

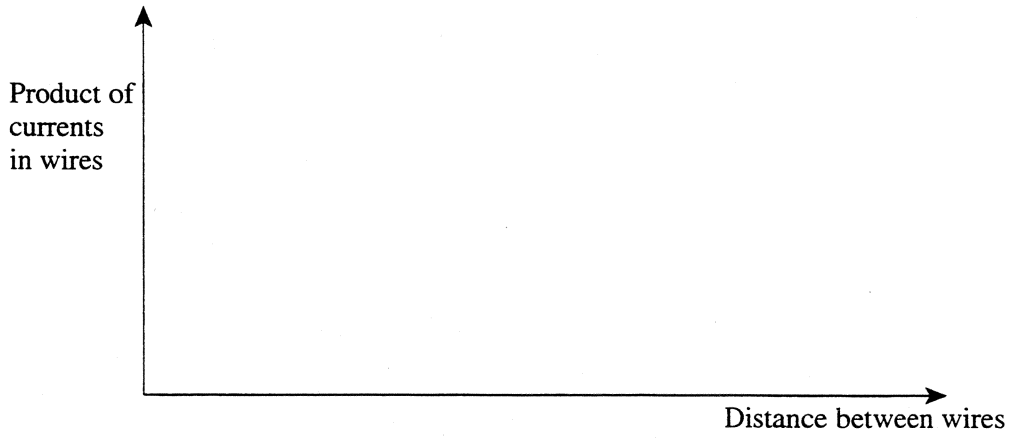
Question 22 (7 marks)

Two parallel wires that may be considered to be infinitely long are placed 20.0 cm apart.



Wire 1 carries twice the current of Wire 2 and they experience a magnetic force of attraction of 4.0×10^{-3} N m^{-1} between them.

(a) On the axes, sketch a graph to show how the product of the current between the two wires would vary as the distance between the two wires increased if the magnitude of magnetic force between the wires were to be kept constant. **2**



(b) Determine what would happen to the magnitude of this magnetic force if both currents were doubled and their distance of separation reduced to 2.5 cm. **2**

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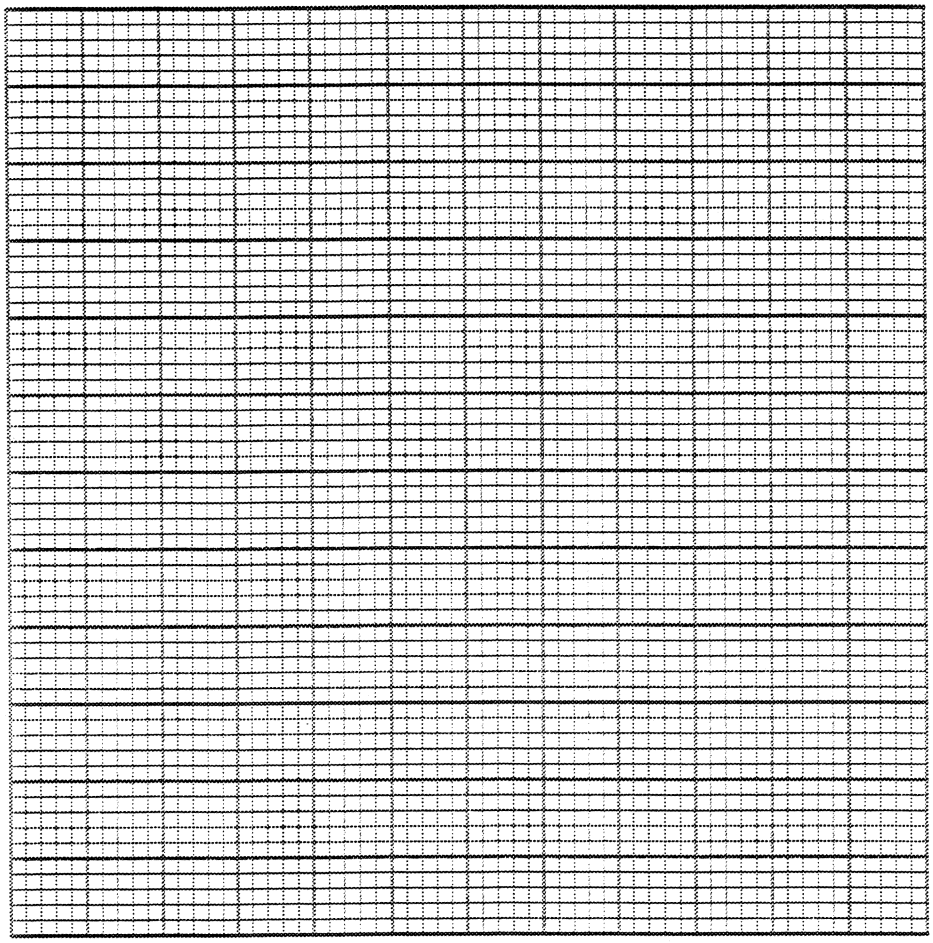
Marks

(c) A student performed a first-hand investigation to determine the force between long parallel conductors. The magnitude of the force between the conductors and their distance apart were measured during the investigation. 3

The results obtained are shown in the table.

Force between conductors (N)	*Distance apart (m)*
22.5	0.10
11.3	0.20
7.50	0.30
5.63	0.40
4.50	0.50

Graph these results on the grid, including the line of best fit.



Marks

Question 23 (6 marks)

Evaluate the advantages of using an AC induction motor over other types of AC motors in household situations. **6**

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Question 24 (4 marks)

An electron travelling in an easterly direction within the cathode ray tube of a television set travels at a velocity of 2.8×10^7 m s^{-1}. It is acted upon by both the Earth's gravitational field and its magnetic field.

The horizontal component of the Earth's magnetic field in the area is 5.0×10^{-5} T and is directed towards the northeast.

(a) Determine the direction of the magnetic force due to this horizontal component. **1**

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(b) Determine the magnitude of the magnetic force and compare it with the gravitational force acting on the electron. **3**

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Marks

Question 25 (6 marks)

Developments in the early part of the twentieth century proposed a completely new model to explain the behaviour of light. **6**

Explain this new model for light with particular reference to the connection between its speed, energy and frequency.

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Question 26 (4 marks)

Solar cells are being investigated as an alternative source of energy on a large scale. **4**

Describe how the photoelectric effect is utilized in a piece of silicon with a p-type and n-type junction to act as a source of electrical energy.

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Marks

Question 27 (6 marks)

(a) State TWO possible applications for the use of superconductors. **2**

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(b) Discuss the advantages of using one of the applications you stated in (a) and outline one current limitation to its use. **4**

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Section II

Total 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.

Marks

Question 29 — Medical Physics (25 marks)

(a) (i) Name the process used to produce ultrasound waves. **1**

(ii) Describe the production of ultrasound waves. **2**

(b) The table shows information relating to the transmission of sound through some types of body tissue.

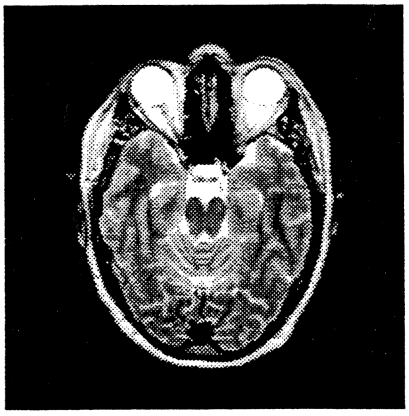
Tissue	*Density* ($kg\ m^{-3}$)	*Velocity of sound* ($m\ s^{-1}$)
Muscle	1070	1585
Healthy bone	2600	3000
Diseased bone	1400	4500

(i) Determine the acoustic impedance of muscle. **1**

(ii) Explain the use of ultrasound to differentiate between healthy and diseased bone. **3**

(c) You have conducted a first-hand investigation to observe the transfer of light by optical fibres. Outline your investigation and discuss the relevance of your results to the function of an endoscope. **4**

(d) The images below were produced by different methods. **6**



MRI image of the brain

CAT scan of the brain

Compare magnetic resonance imaging (MRI) with computed axial tomography (CAT) and discuss their diagnostic applications.

(e) *Positron emission tomography (PET) is an extremely valuable diagnostic tool. It is often underestimated when compared with other diagnostic tools, because it produces a scan of low resolution and requires the injection of a radioisotope.* **8**

Evaluate the use of positron emission tomography (PET) as a diagnostic tool.

Marks

Question 28 — Geophysics (25 marks)

(a) (i) Name the instrument used to study earthquake waves. **1**

(ii) Describe how the output from this instrument may be used to obtain two types of useful information. **2**

(b) The table below gives information about several different satellites orbiting the Earth. The radius of the Earth is 6378 km. Use this or other information to calculate the period of a satellite in a polar orbit at an altitude of 5000 km. **4**

Satellite	*Mass* (kg)	*Altitude* (km)	*Period* (minutes)
A	250	285	90
B	500	4 200	180
C	2500	20 300	720

(c) Describe an investigation you could do to show and plot the inclination of the magnetic field at different points within a school laboratory. **4**

(d) State the purpose of data reduction in gravity surveys, with particular mention of latitude correction, free air correction and Bouguer correction. What do large scale gravity anomalies tell us about the structure of the earth? **6**

(e) Satellites are now often used to collect geophysical information. Using at least three different types of satellite information discuss how data gathered by satellites may be used in mineral exploration. **8**

Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) (i) What was de Broglie's proposal for the nature of phenomena such as electrons? **1**

(ii) What is the de Broglie wavelength of an electron which is moving at a speed of 1.6×10^6 m s^{-1}? **2**

(b) In an attempt to explain his model of the atom, Neils Bohr abandoned some of the ideas of classical physics. In doing so, he was able to clearly explain the emission and absorption spectra of hydrogen, but his model of the atom still had several inadequacies.

(i) How did Neils Bohr relate the concept of emission spectra to electron orbits in his model of the atom? **2**

(ii) Outline two of the inadequacies of the Bohr model of the atom. **2**

(c) Describe how your observations of the Balmer series for the emission spectrum of hydrogen gas illustrate Bohr's model of the atom. **4**

(d) Compare the resolving powers of light and electron microscopes and discuss the impact of the development of the electron microscopes. **6**

(e) Analyse the development of particle accelerators and the impact that advances in particle physics have had on our understanding of matter. **8**

Marks

Question 30 — Astrophysics (25 marks)

(a) In 1967 Jocelyn Bell was using a radio telescope to look at distant objects called quasars. The telescope she was using picked up a signal that pulsed every 1.3 seconds.

(i) Identify the stellar object that she had discovered. **1**

(ii) Describe this object and how it produces the pulses recorded by Bell. **2**

(b) Two stars are found at almost the same point in the night sky.

Star	*Apparent magnitude*	*Absolute magnitude*
X	2.00	−4.50
Y	2.50	1.00

(i) State the difference between absolute and apparent magnitude scales. **1**

(ii) Determine the distance between star X and star Y. **2**

(iii) Determine the apparent magnitude of star X as viewed from star Y. **1**

(c) Describe the difference between emission and absorption spectra by explaining how you can observe them in a physics lesson. **4**

(d) Compare two different methods that astronomers use to determine the distance to stars and discuss their relative usefulness and limitations. **6**

(e) Evaluate the importance of the Hertzsprung-Russell diagram in our understanding of the evolution and life of stars. **8**

Marks

Question 31 — From Quanta to Quarks (25 marks)

(a) (i) What was de Broglie's proposal for the nature of phenomena such as electrons? **1**

(ii) What is the de Broglie wavelength of an electron which is moving at a speed of 1.6×10^6 m s^{-1}? **2**

(b) In an attempt to explain his model of the atom, Neils Bohr abandoned some of the ideas of classical physics. In doing so, he was able to clearly explain the emission and absorption spectra of hydrogen, but his model of the atom still had several inadequacies.

(i) How did Neils Bohr relate the concept of emission spectra to electron orbits in his model of the atom? **2**

(ii) Outline two of the inadequacies of the Bohr model of the atom. **2**

(c) Describe how your observations of the Balmer series for the emission spectrum of hydrogen gas illustrate Bohr's model of the atom. **4**

(d) Compare the resolving powers of light and electron microscopes and discuss the impact of the development of the electron microscopes. **6**

(e) Analyse the development of particle accelerators and the impact that advances in particle physics have had on our understanding of matter. **8**

Marks

Question 32 — The Age of Silicon (25 marks)

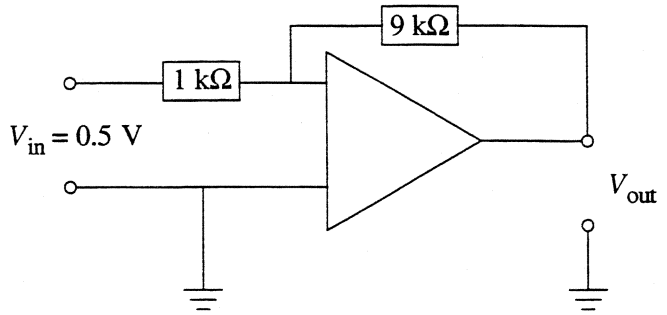
(a) (i) Outline the difference between an analogue signal and a digital signal. **1**

(ii) Describe one advantage that a digital system has over an analogue system in the communications sector. **2**

(b) (i) Name a situation where the use of a light emitting diode (LED) would be preferable to an ordinary source of light. **1**

(ii) Describe how the structure of a LED involves the use of a combination of semiconductors to operate. **3**

(c) In a first-hand investigation of operational amplifiers, a circuit was constructed. A simplified diagram of this circuit is shown below. **4**



If the input voltage is 0.5 V, determine the gain and output voltage.

(d) Discuss the properties of silicon that contributed towards its development in integrated circuits and explain how these properties allowed for its application in a range of industrial situations. **6**

(e) Analyse specific situations to explain how transducers act as an interface between the environment and an electronic system. **8**

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 (in vacuo), 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 gravitation constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth	6.0×10^{24} kg
Planck's constant, h	6.626×10^{-34} J s
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, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}

Formulae

$$c = f\lambda$$

$$\text{Intensity} \propto \frac{1}{d^2}$$

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

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

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

$$P = VI$$

$$\text{Energy} = VIt$$

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

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

$$\Sigma F = ma$$

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

$$p = mv$$

$$\Delta p = Ft$$

$$F = -\frac{Gm_1m_2}{r^2}$$

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

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

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

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

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

$$F = BIl\sin\theta$$

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

$$\tau = Fd$$

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

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

Periodic Table

Key

Atomic number

Atomic mass

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 Phosphorou	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** 65.39 Zinc	31 **Ga** 69.72 Gallium	32 **Ge** 72.61 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 Molybdenu	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** 183.9 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** [210.0] 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] Rutherfordiu	105 **Db** [262.1] Dubnium	106 **Sg** [263.1] Seaborgium	107 **Bh** [264.1] Bohrium	108 **Hs** [265.1] Hassium	109 **Mt** [268] Meitnerium	110 **Uun** — Ununnilium	111 **Uuu** — Unununium	112 **Uub** — Ununbium	113	114 **Uuq** – Ununquadiu	115	116 **Uuh** – Ununhexium	117	118 **Uuo** – Ununoctium

57 **La** 138.9 Lanthanum	58 **Ce** 140.1 Cerium	59 **Pr** 140.9 Praseodymi	60 **Nd** 144.2 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
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** [239.1] Plutonium	95 **Am** [241.1] Americium	96 **Cm** [244.1] Curium	97 **Bk** [249.1] Berkelium	98 **Cf** [252.1] Californium	99 **Es** [252.1] Einsteinium	100 **Fm** [257.1] Fermium	101 **Md** [258.1] Mendeleviu	102 **No** [259.1] Nobelium	103 **Lr** [262.1] Lawrencium

Where the atomic wieghts are 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.

Section I

Part A

Answer and explanation	Outcomes assessed
Question 1 **B** The astronaut's weight is given by $F = ma$ $= 70 \times 8.8$ ms^{-1} $= 616$ N	H4, H9
Question 2 **D** When a roller-coaster is operating, we must consider a vertical circle. At the top of the loop, gravity is still working to pull the passengers down but the reaction force is the least.	H6, H14
Question 3 **A** The Earth's rotational velocity is in an easterly direction. A rocket launched in this direction will gain an advantage of a velocity of about 450 m s^{-1}. Both rockets may attain successful orbit if they are able to obtain the correct orbital velocity. It may be more easily obtained for Rocket A, but Rocket B could still obtain a stable Earth orbit if its velocity was sufficient.	H2, H6
Question 4 **C** Those scientists who accepted the ether theory proposed suggestions to support it. These included the possibility of the findings being in error due to the motion of the Earth at the particular time at which the experimental data was being recorded or changes having taken place to suggest that the result itself was in error. Only Einstein suggested that the theory was flawed and that the speed of light is independent of the speed of source or the observer.	H2, H9, H14
Question 5 **D** An inertial frame of reference is a frame of reference moving with constant velocity and not accelerating. Within this frame of reference Newton's first law (the law of inertia) operates.	H9
Question 6 **C** The conductor experiences an upward force due to the motor effect: a current-carrying wire placed in a magnetic field is subjected to a force. (The direction of the force is shown by the right hand palm rule). If the magnetic poles are then reversed, the direction of the magnetic field is changed. The current direction remains the same but the direction of the resulting force is reversed.	H9
Question 7 **A** Using the transformer equation, $V_p / V_s = n_p / n_s$. A higher output voltage requires more turns in the secondary coil than in the primary coil. This could only be achieved with 12 turns in the primary coil and 24 in the secondary. The input voltage needs to be AC to ensure that the secondary coil produces any voltage at all. DC would not create a changing magnetic field to allow the production of the induced voltage.	H7
Question 8 **C** Generators are typically located some distance away from most customers. Less energy is lost as heat when transmission uses high voltages and low currents.	H7

Part A (Continued)

Answer and explanation	Outcomes assessed
Question 9 **B** The emf produced by a simple AC generator varies with time and oscillates between a positive and negative maximum value. When operating as a DC generator there is no negative value, since the current can only flow in one direction. If the coil loop commences from exactly the same starting position and has exactly the same initial orientation, then its graph will simply show a variation from positive to zero and back to positive again.	H9, H14
Question 10 **D** When an electric motor is starting there is a large current supplied to it. A resistance needs to be in place to ensure that the motor is protected for burning out. When running normally, a back emf limits the current and there is no need for a high resistance. Hence an adjustable resistor is often used in series with the motor.	H7, H9
Question 11 **C** A gas discharge tube operates when a high voltage from an induction coil is applied across its terminals. At normal pressure, air and other gases are insulators but at reduced pressure the gas may conduct. When the pressure is reduced there are changes produced to the observed patterns within the tube. At the lowest pressure, there is no gas glow observed but cathode rays appear from the cathode and travel along the tube to the anode.	H9, H10
Question 12 **C** According to the band structure theory, metallic conductors have their conduction band overlapping the valence band and hence have many electrons available for conduction.	H9
Question 13 **D** $E = hf = \frac{hc}{\lambda}$ $= \frac{6.63 \times 10^{-34} \times 3.00 \times 10^{8}}{450 \times 10^{-9}}$ $= 4.42 \times 10^{-19}$ J	H8
Question 14 **B** p-type semiconductors are doped with small amounts of Group III atoms, for example boron, and are only able to supply three electrons instead of the normal four. The gap left is called a hole. As a result of this hole they conduct as though they were a missing electron.	H9
Question 15 **A** Cathode ray oscilloscopes produce a stream of electrons from the heated cathode at the back of the tube. The beam is deflected by an electronic signal and then strikes the screen, which is coated with a material that glows when struck by electrons. Thus the CRO has the ability to make electrical signals visible.	H1

Part B

Sample answer	Syllabus outcomes and marking guide
Question 16	
(a) • The earth is not a perfect sphere: it does not have a constant radial distance from the centre of mass. • There are variations in the Earth's lithosphere and crust. • The rotational spin of the Earth creates an effect reducing the value of g.	H9 • Gives two reasons ..... 2 • Gives one reason 1
(b) Acceleration due to gravity is given by $g = \frac{Gm}{r^2}$. For the new planet, $r_{new} = 4r_{Earth}$ and $m_{new} = 3m_{Earth}$. $\therefore g_{new} = \frac{Gm_{new}}{r_{new}^2}$ $= \frac{G3m_{Earth}}{(4r_{Earth})^2}$ $= \frac{3}{16}\frac{Gm_{Earth}}{r_{Earth}^2}$ $= \frac{3}{16} \times 9.8$ $= 1.8375 = 1.8 \text{ m s}^{-2}$ (to 2 s.f.)	H9 • Correctly uses formula • Correctly states value for the magnitude of the acceleration ..... 2 • Correctly states and uses formula OR • Correctly states value for the magnitude of the acceleration 1
Question 17	
(a) A geostationary satellite must be placed in a circular orbit in the same plane as the Earth's equator at the orbital radius which results in an orbital period of 24 hours. Using $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$, we obtain $r = 4.23 \times 10^7$ m, i.e. the orbit is 42,300 km above the Earth's centre.	H9, H13 • Correctly describes orbit • Correctly uses formula relating period and radius of orbit ..... 3 • Correctly describes orbit OR • Describes a key feature and uses a relevant formula ..... 2 • Correctly describes a key feature or uses a relevant formula 1

(b)

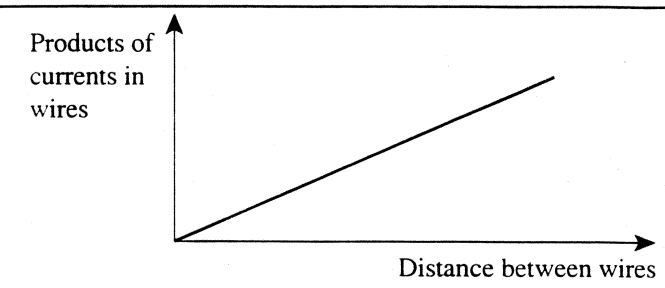
Requirements	*Low Earth orbit satellite*	*Geostationary satellite*
Antennae	Small antenna Low gain Must have tracking capability to follow target Microwave capable	Large antenna High gain Must maintain satellite orientation Microwave capable
Transmitter Power	Low power (since distance to be covered is shorter)	Generally higher power (but depends on satellite gain)

H4, H9
• Correctly compares at least two antenna features and one power-related feature for each satellite type 3
• Correctly compares two relevant features for each satellite type 2
• Correctly states an antenna or power feature for each satellite type 1

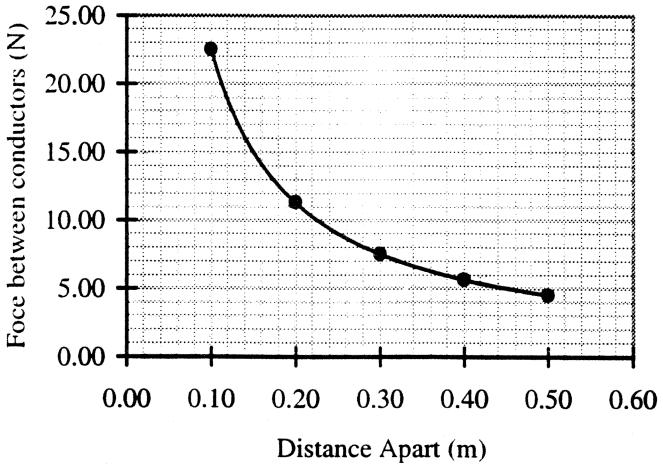
Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 18	
(a) For example: Hermann Oberth (1894–1989) wrote a key book in 1923, *The Rocket into Planetary Space*, based on his PhD dissertation. He inspired rocket societies to spring up all over the world, one of which lead directly to the development of the V2 rocket. His book covered manned and unmanned rocket flight, liquid fuel rocket construction, propulsion, inertial guidance and navigation, aerodynamics, thermodynamics, flight mechanics, pre-testing, life-support systems, space flight hazards and their remedies, bio-astronautics, re-entry and recovery techniques, telescopic tracking and applications of rocket technology to space flight. Oberth also described the basic theoretical principles for rocket thrust and determining the most favourable velocity to reach a target planet.	H1, H4 • Gives a reasonable outline covering any two points of one of the named pioneers of rocket propulsion ..... 2 • Correctly attributes one contribution of a correctly named pioneer of rocket propulsion 1
(b) Rocket engines produce their thrust forces by burning fuel and expelling the gases produced. The principle of conservation of momentum (momentum before ignition = momentum after ignition) ensures that the rocket is propelled in the opposite direction to that of the exhaust gases. When the fuel is burnt by the engines, the total mass of the rocket is decreased. From Newton's second law, $F = ma$, the acceleration is inversely proportional to the mass ($m \propto 1/a$). This means that, given a constant thrust force, the acceleration of the rocket will increase as fuel is consumed, thus achieving the required velocity to maintain a stable orbit (approx. 8.2 km s^{-1}).	H6, H13 • Clearly and correctly states the two named physical principles and explains their relevance to rocket design ..... 4 • Gives a mostly correct statement of both principles and how they apply ..... 3 • Gives a correct statement of both principles or a correct statement and explanation involving one principle..... 2 • Gives a mostly correct statement of conservation of momentum or Newton's second law 3
Question 19	
Currently achievable velocities for travel (compared with liftoff and manoeuvring, which utilize rocket engines) are obtained by inertia, assisted by the gravitational acceleration of the planets. These velocities are relatively low relative to the vast distances required to travel to any significant destination in space. In order to increase speed for extended space travel, forms of technology other than rocket engines would have to be developed. Perhaps ion propulsion, nuclear fusion or sun sailing may be adopted in the future.	H1, H13 • Gives a thorough and accurate understanding of the limitations of currently achievable velocities and a clear explanation of future technologies..... 4 • Shows some understanding of limitations of currently achievable velocities and some explanation of future technologies..... 3 • Shows some understanding of limitations of currently achievable velocities OR • Some explanation of future technologies. 2 • States one limitation of currently achievable velocities OR • One explanation of future technologies.. 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 20	
Faraday experimentally determined that an emf is induced whenever a conductor experiences a changing magnetic field, and that the induced emf is proportional to the rate of change of magnetic flux through the conductor. Experiments involving moving a magnet through a solenoid, or moving a solenoid about a magnet, or switching on and off an electromagnet within a solenoid, all produce situations in which a conductor is threaded by a changing magnetic field. In investigations in class, the created emf could be measured using a galvanometer connected to the solenoid. Moving the magnet more quickly or changing the flux more rapidly were both seen to increase the magnitude of the emf produced.	H9, H12, H13, H14 • Clearly explains how the results demonstrate the relationship • Displays a thorough knowledge of induction and relates to the specific investigation they undertook ..... 4 • Explains how the results demonstrate electromagnetic induction • Displays a sound knowledge of induction and relates to the specific investigation they undertook ..... 3 • States the knowledge of induction and describes their investigation but provides no link between the two..... 2 • Describes their investigation OR • States some knowledge of induction 1
Question 21	
(a) step-up transformer	H4 • Gives correct answer 1
(b) The law of conservation of energy states that energy cannot be created nor destroyed, but may be changed from one form to another. When voltages are transformed, the current is inversely affected. Assuming that we have an ideal transformer, Power input = Power output, i.e. increasing the voltage output would decrease the current output.	H7 • Explains voltage changes and relates changes to conservation law ..... 2 • States voltage changes OR • States conservation law 1
Question 22	
(a) 	H9, H13 • Draws a correct sketch..... 2 • Shows an increasing relationship..... 1
(b) $I_1' = 2I_1$, $I_2' = 2I_2$ and $d' = \frac{d}{8}$. $F' = \frac{kI_1'I_2'l}{d'}$ $= \frac{k2I_1 2I_2 l}{\frac{d}{8}}$ $= 32F$ $= 0.128 \text{ N m}^{-1}$	H9 • Correctly calculates force per metre .... 2 • Correctly uses formula OR • Attempts to relates force to distance and currents 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
(c) 	H13 • Correctly plots graph with line of best fit. . . . . 3 • Correctly plots points without showing line of best fit OR • Attempts to draw line of best fit with incorrectly plotted points . . . . . 2 • Plots some correct points 1
Question 23	
AC induction motors have a simple design, involving a stator with AC current inducing an electric current in the "squirrel cage" rotor. They have low power operation (approx. 0.5–1.0 kW). They have a relatively low cost of production. They operate at high efficiency. Reliability is good, as there are no brushes or commutators to wear out. Other AC motors, such as synchronous motors, have limitations, which include not being self starting (special arrangements must be made), and if slowed down by a heavy load, they may stop completely.	H4, H7 • Demonstrates a thorough understanding of at least three advantages of AC induction motors in household situations . . . . . 5–6 • Provides two advantages of AC induction motors and compares uses OR • Indicates a thorough knowledge of AC induction motors and one advantage . . 3–4 • Provides two advantages of AC induction motors OR • Indicates a thorough knowledge of AC induction motors and one advantage . . . . 2 • Provides one advantages of AC induction motors OR • Indicates some knowledge of AC induction motors 1
Question 24	
(a) The direction of the force on the electron is downwards towards the ground, as given by the right hand palm rule. (Remember the electron travels in the opposite direction to a positive charge).	H9 • Gives correct answer 1
(b) $F_{magnetic} = qvB\sin\theta$ $= 1.6 \times 10^{-19} \times 2.8 \times 10^{7} \times 5.0 \times 10^{-5} \times \sin 135°$ $= 1.58 \times 10^{-16}$ N $F_{gravitational} = ma$ $= 9.1 \times 10^{-31} \times 9.8$ $= 8.9 \times 10^{-30}$ N The gravitational force is much smaller than the magnetic force.	H9 • Uses the correct formula and substitutes correct values . . . . . 3 • Uses the correct formula . . . . . 2 • Identifies the correct formula. 1

Part B (Continued)

Sample answer	Syllabus outcomes and marking guide
Question 25	
Einstein was able to explain that light has particle-like properties. He did this by assuming that light (and other electromagnetic radiation) is made up of packets of wave energy, called photons. Each photon is one quantum of energy. His notion was that light travels as a series of photons. Despite this particle nature, the quantum theory of light still requires a knowledge of the frequency of light in order to determine the energy. The energy of each quantum depends on the frequency of the source (from Planck's equation, $E = hf$ and the wave equation, we obtain $E = hc/\lambda$). The energy of the photon is directly proportional to its frequency and speed. The photoelectric effect is explained by the use of a quantum theory; a wave theory cannot explain it. It predicts that the maximum photoelectron energy is dependent upon the frequency of the incident light and not its intensity.	H7, H8, H10 • Explains the model indicating a thorough knowledge highlighting connection between speed, energy and frequency ..... 5–6 • Explains the model indicating a thorough knowledge OR • States and explains the connection between speed, energy and frequency of light ..... 3–4 • Describes model indicating some knowledge OR • States the connection between speed, energy and frequency of light ..... 2 • States some features of the model 1
Question 26	
A p-type semiconductor has relatively few electrons while an n-type semiconductor has many electrons. When joined together there is a diffusion of electrons from the n-type semiconductor into the p-type and conversely a movement of positive holes into the n-type semiconductor. This diffusion ceases when the dispersive forces balance the forces of attraction between the charge carriers and the ions. This creates a potential barrier, which opposes further diffusion. When exposed to light, photo-ionisation creates electron-hole pairs, which separate the pairs creating an electromotive force. The emf is dependent upon the intensity of the incident radiation. This emf may be used as a source of electrical energy when used in a circuit.	H3, H7 • Gives a thorough description of the photoelectric effect and its operation in semiconductors ..... 4 • Gives a general description of the photoelectric effect and its operation in semiconductors ..... 3 • Describes the photoelectric effect OR • Describes the operation in semiconductors ..... 2 • States photoelectric effect OR • Gives a general description of semiconductors 1

Part B (Continued)

	Sample answer	Syllabus outcomes and marking guide
Question 27		
(a)	• Magnetic resonance imaging machines (MRI) • Switching devices in computers • Electricity transmission • Magnetic levitation-assisted transport	H3, H4 • States two applications. . . . . 2 • States one application 1
(b)	Advantages • Ability to carry large electric currents without heat losses. • Ability to generate large magnetic fields • Switching can occur at ten times equivalent semiconductor switching speed Limitations • Brittle nature of superconductive materials • Difficult to manufacture • Difficult to make them into wires • Materials may break down chemically in certain environmental situations	H3, H4, H13 • Gives a reasonable discussion of one of the named applications from (a), including at least two advantages and one limitation of the application . . . . . 4 • Gives some discussion of one of the named applications from (a), including at least two advantages and one limitation of the application . . . . . 3 • States one advantage and one limitation for the application OR • States two advantages for the application . . . . . 2 • States one advantage for the application OR • States one limitation for the application . 1

Section II

Question 28 Geophysics

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	seismometer or seismograph	H8 • Gives correct answer 1
	(ii)	Determine the magnitude of an earthquake by the amplitude of the displacements as shown on the seismogram. Determine the distance to the earthquake from the different arrival times of the P and S waves. Detect boundaries in rock structures by detecting extra waves caused by reflection due to velocity changes at the boundary.	H8, H13, H14 • Gives two correct responses. . . . . 2 • Gives one correct response . . . . . 1 • If response to (i) was gravity meter give marks for relevant answers here.
(b)		$\frac{r_1^3}{T_1^2} = \frac{r_2^3}{T_2^2}$ $\therefore T_2 = \sqrt{\frac{r_2^3 T_1^2}{r_1^3}} = \sqrt{\frac{(5000+6378)^3 90^2}{(285+6378)^3}} = 201 \text{ min}$ Period = 200 minutes. Students could also use $\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$ and data from the data sheet.	H9 • Correctly calculates period using a suitable method . . . . . 4 • Correctly substitutes values in a suitable equation without correct answer . . . . . 3 • Substitutes some correct values into a suitable formula. . . . . 2 • States a suitable formula OR • Calculates a correct orbital radius 1
(c)		Use a magnaprobe or suitably suspended compass needle (dip circle) to determine the direction of the field at a number of different places in the lab. Record these in the form of a set of field lines in one plane, or lines joining points with the same inclination.	H9 • Gives a clear response which describes the apparatus used and a systematic method for collecting recording and displaying data. . . . . 4 • Gives a response which describes the apparatus used but doesn't specify a systematic data collection . . . . . 3 OR • Gives a response which is vague about how the data is collected but, but does describe how it can be displayed . . . . . 3 • Gives a response that is vague about the apparatus and data collection. . . . . 2 • Gives a response that mentions a suspended magnet or compass. 1

Question 28 Geophysics (Continued)

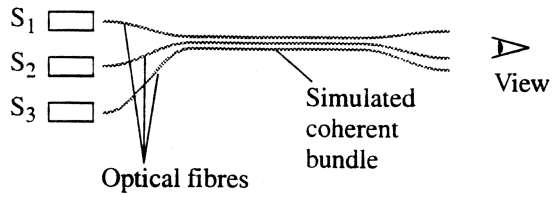
	Sample answer	Syllabus outcomes and marking guide
(d)	Data reduction attempts to account for known factors that influence the gravitational field. By doing this, unknown factors become more obvious. • *Latitude correction*: The earth bulges at the equator so reducing the gravitational field there different from what would be expected from a non rotating spherical earth. This correction removes these effects. • *Free air correction*: Altitude effects gravity due to the distance from the earth's centre. This correction accounts for this i.e. it reduces the measurement to a standard sea level. • *Bouguer correction* accounts for the rock between the station and sea level. These corrections mean that if we assume the earth was a uniform rotating oblate spheroid, all corrected measurements would be the same. Variations must be due to some non-uniformity in the earth's material. Large scale variations are usually due to sedimentary basins, mountain roots or incomplete isostatic compensation.	H9, H12 • Gives a response which explains the purpose of data reduction to remove known factors leaving the anomalies, then explains the three corrections and states something about large scale structures ..... 5–6 • Gives a response which explains the purpose of data reduction, explains at least one correction and states something about large scale structures ..... 3–4 • Gives a partial explanation of the purpose of data reduction which correctly describes at least one correction 1–2
(e)	Suitable types of information are: • Photographs taken in different spectral bands which can show differences in vegetation, reflectivity, absorption and surface temperature. Mineralisation close to the surface often affects the vegetation above it. Different minerals also have their own specific reflectivities in the different wavelengths. Pixel size on the ground can be as good as 2m square, but is more usually 10 m square. • Radar images depend on the reflection of radio waves which in turn depends on the surface conductivity and roughness. Radar can also penetrate ice and dry sand to show the underlying topography. The intensity of the reflection depends on the conductivity of the surface. This can show information about mineral concentrations and water conductivity. Different wavelengths can be reflected in different ways. Resolution can be about 5 m. • Radar altimetry over water can measure average water height to within several cm so showing gravity anomalies at the surface of the water. This can reveal density variations in the crust under the water. Suitable processing can show density variations in the top 10 km. This is useful for large-scale sedimentary basins, e.g. in petroleum exploration. The resolution is about 30 km at present. • Orbital anomalies of low altitude satellites can plot gravitational variations showing large sedimentary basins and deposits of denser minerals. It is only useful for large-scale structures as the resolution is greater than 30 km. • Magnetic field variations can detect magnetic minerals or subsurface electric currents. These may be associated with currents in the mantle and can lead to the discovery of old hotspots or plate boundaries where minerals may have been deposited. Resolution is greater than 30 km. • Measurement of gravitational and magnetic field variations can give hints leading to large-scale structures where minerals and petroleum may be found. This can then lead to higher resolution searches using reflected or emitted radiation for minerals in general, or a specific mineral e.g. gold.	H9, H10, H13, H14 • For each type of information, 1 mark for information collected, and 1 mark for how it is used • 2 marks for discussion of how different data sets can be combined to complement each other 1–8

Question 29 Medical Physics

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	The piezoelectric effect.	H8, H13 • Gives the correct name. 1
	(ii)	An oscillating potential difference is applied to a piezoelectric crystal, which has aligned dipoles within its crystalline structure. The oscillating potential difference causes uniform movement of the dipoles, which results in expansion and contraction of the crystal. The surface of the crystal compresses and rarefies the surrounding air, resulting in the production of a sound wave (ultrasound) whose frequency is equal to the frequency of the applied alternating potential difference.	H7, H9 • Gives a clear description of the structure of a piezoelectric crystal. • Outlines the effect of an oscillating potential difference on the crystal. . . . . 2 • Gives a clear description of the structure of a piezoelectric crystal. OR • Outlines the effect of an oscillating potential difference on the crystal. 1
(b)	(i)	$Z_m = \rho v$ $= 1070 \text{ kg m}^{-3} \times 1585 \text{ m s}^{-1}$ $= 1.70 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$	H8, H13 • Gives correct calculation of value 1
	(ii)	$Z_{hb} = \rho v$ $= 2600 \text{ kg m}^{-3} \times 3000 \text{ m s}^{-1}$ $= 7.80 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$ $Z_{db} = \rho v$ $= 1400 \text{ kg m}^{-3} \times 4500 \text{ m s}^{-1}$ $= 6.30 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$ $\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$ $I_r = 100 \times \frac{[7.80 \times 10^6 - 1.70 \times 10^6]^2}{[7.80 \times 10^6 + 1.70 \times 10^6]^2} = 41.2\%$ i.e., 41.2% of incident ultrasound is reflected from a muscle–healthy bone boundary. $\frac{I_r}{I_o} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$ $I_r = 100 \times \frac{[6.30 \times 10^6 - 1.70 \times 10^6]^2}{[6.30 \times 10^6 + 1.70 \times 10^6]^2} = 33.1\%$ i.e. 33.1% of incident ultrasound is reflected from a muscle–diseased bone boundary. The reflected signal strength from diseased bone is significantly lower than that for healthy bone.	H8, H14 • Correctly calculates acoustic impedance and reflection coefficients; and • Correctly identifies the differences between the values for healthy and diseased bone tissue. OR • Relates given values to differences in acoustic impedance for healthy and diseased bone tissue; and • Correctly deduces a change in the energy associated with the reflected ultrasound signal, which is measurable . . . . . 3 • Correctly calculates values without identification of the significance of values. OR • Gives a description about the relationship between reflected signal strength and the magnitude of the difference in acoustic impedances at the tissue boundary. . . . . 2 • Identifies correct equations and substitutes numbers but does not reach the correct answers. OR • Gives a statement outlining the reflection of ultrasound at a tissue boundary due to the difference of acoustic impedances. 1

Question 29 Medical Physics (Continued)

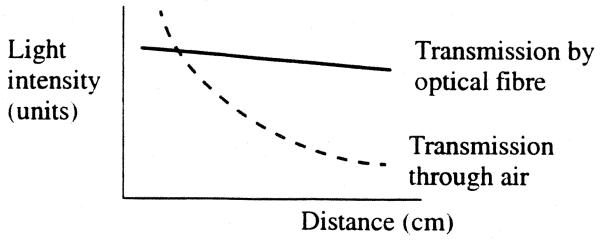
Sample answer	Syllabus outcomes and marking guide
(c) Experimental apparatus were set up as follows in a darkened laboratory:	H8, H11, H12, H13, H14



1. The light from each of the sources (S_1, S_2, S_3) was varied in colour and intensity.
2. The transmitted light was observed and intensity measured using a light probe.
3. The experiment was repeated for different lengths of optical fibre using a single source of white light and recording transmitted light intensity.
4. Part 3 was repeated, without the use of optical fibres, measuring light intensity at corresponding distances.

Results:

The colour of the light exiting each fibre corresponded to the colour of the light entering the fibre. The intensity of the light exiting each fibre corresponded to the intensity of the light entering the fibre. The following curves were obtained:



Conclusions:

Light is transmitted through the optical fibre by total internal reflection. Therefore, light intensity remains approximately constant and does not attenuate as dictated by the inverse square law. The light emitted from each fibre corresponds to the light entering that fibre, allowing a coherent bundle to transmit an image, which is not inverted laterally or vertically.

The endoscope:

The endoscope is based on a coherent bundle of optical fibres, which transmit an image of an internal organ. The relative position of each fibre remains constant along the coherent bundle. The coherent bundle provides a clear, non-inverted image.

- Gives a complete description of investigation methods (results) and conclusion.
- Explains how an endoscope works based on the experimental results and conclusions 4

- Gives a complete description of investigation methods (results) and conclusion

OR

- Explains how an endoscope works 3

- Partially describes methods and/or conclusion
- Partially explains how an endoscope works 2

- Partially describes methods and/or conclusion

OR

- Partially explains how an endoscope works 1

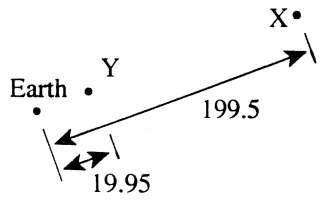
Question 29 Medical Physics (Continued)

Sample answer	Syllabus outcomes and marking guide
(d) CAT: Image production Many thin x-ray beams pass through the patient and into a detector array, which records the intensity of the beam at angular intervals. The intensity data is converted into many 2D images (by a computer), which represent slices through the patient. These slices can be combined to produce a 3D image. Applications CAT is a non-invasive diagnostic tool. It allows study of the structure of hard tissue (bone), and of soft tissue within bone, e.g. brain, spine. It can be used to find size, type, location of a stroke, and can pinpoint the location of tumours and soft tissue disease. With the injection of opaque dyes, further resolution can be achieved in the study of the lungs, kidneys and bladder. Advantages CAT can be used on patients with metal devices. It has a rapid scan time. It can present information on tissue shielded by bone and on bones and teeth. Limitations CAT scans have a limited resolution when used on soft tissues with high water content. Also, the number of scans a patient can take is limited due to exposure to ionizing radiation. MRI: Image production The patient is placed in a uniform and strong (0.1–2 tesla) magnetic field. A small field gradient is introduced to enable the different regions of the scan to be differentiated. H-nuclei align with the magnetic field (spin up or down). Radio frequency EM waves at a specific (Larmor) frequency results in precession about the axis of rotation and the flipping of the spin of protons (an example of resonance). The protons return to their original state (relax), emitting the same frequency wave. The intensity of this EM radiation decreases, producing a free induction decay curve from which the relaxation time can be determined. The relaxation time depends on the bonding of the protons, which varies significantly in different tissues. This enables the computerized production of a high-resolution scan. Applications • MRI is a non-invasive diagnostic tool which can have very high resolution on soft tissues with high water content. • It is suitable for the study of soft tissue within bone, e.g. brain, spine, and for finding the size, type and location of strokes. MRI allows early, superior location of tumours and soft tissue disease. Its ability to differentiate between grey and white brain matter is of use in the early diagnosis of MS and other diseases. Advantages • MRI does not use ionising radiation, so the number of scans is not limited. It presents information on tissue shielded by bone, and has superior resolution when used on soft tissues. Limitations • MRI cannot be used to study bone or teeth structure (no protons). It cannot be used on patients with metal devices and has a slow scan time. It is a relatively expensive procedure.	H1, H3, H7, H9, H10, H13, H14 • Demonstrates a thorough knowledge of the production and application of MRI and CAT scans. • Presents a clear comparison between the two technologies. • Gives a discussion of diagnostic applications of the two technologies. • Presents the information coherently .. 5–6 • Demonstrates a thorough knowledge of the production and application of MRI and CAT scans. • Presents a comparison between the two technologies ..... 3–4 • Demonstrates a thorough knowledge of the production or application of MRI and/or CAT scans 1–2

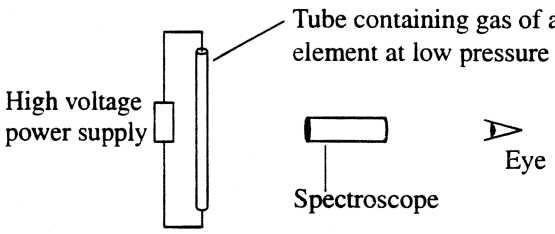
Question 29 **Medical Physics (Continued)**

Sample answer	Syllabus outcomes and marking guide
(e) Positron emission tomography (PET) is a diagnostic tool based on the decay of a short half-life radioisotope, which emits a positron. These radioisotopes are produced in a cyclotron, a device that accelerates protons to very high speeds (using E fields) in a circular path (held by a strong B field). These protons collide with target atoms and the resulting nuclear transformation produces the required radioisotope. The radioisotope required must also be metabolised by the body so that it will move to the target organ, e.g. Carbon-11 in the form of carbon monoxide, which attaches to the haemoglobin in blood, will go to the brain, heart etc. A positron is a particle which has the same mass as an electron and a positive charge with the same magnitude as an electron ($q = +1.6 \times 10^{-19}$ C). The electrostatic attraction between a positron and an electron is very large, resulting in an interaction which annihilates both particles and produces 2 coincidental gamma rays, which are emitted in opposite directions. The injected patient is placed in a circular array of gamma cameras, which record the detection and direction of coincidental gamma rays. Regions of high activity, due to the accumulation of the radioisotope, are accurately identified. Advantages PET provides a measure of organ functionality by measurement of rate of uptake/expulsion of the labelled substance (e.g. glucose). In comparison, CAT scans only provide a structural view which may not be sufficient to make an accurate diagnosis. The amount of radioisotope (called a tracer) injected is minutely small (nanograms) and is usually rapidly expelled through respiration, urination and or perspiration. The radioisotopes used typically have short half-lives due to rapid decay. As a result the typical PET scan exposes a patient to less ionizing radiation than a CT scan. Limitations PET scans are low-resolution images. They are often used in conjunction with another diagnostic technology that provides high-resolution images, such as CAT. The combination of information from the scans allows maximum diagnostic capability. Cyclotrons are very expensive to set up in a separate installation that must be close to the nuclear medicine unit, as the half-lives are typically too short to allow for transportation. By comparison, CAT scans are also expensive but do not require as much infrastructure, typically they are self contained units found on site. They do need a stable supply of electricity. Evaluation PET scan technology is a valuable diagnostic tool capable of determining organ functionality. It is non-invasive and limits the exposure of the patient to ionizing radiation. When used in conjunction with high-resolution techniques, it enables a complete analysis of medical conditions. Setup costs are significant and must be factored in to the efficient provision of this technology.	H1, H4, H6, H7, H9, H10, H12, H13, **H14, H16** • Demonstrates a thorough knowledge of the advantages and limitations of the use of PET in comparison to at least one other diagnostic tool. • Demonstrates an accurate understanding of the physical principles involved: positron emission, positron electron interactions, emission of gamma rays, metabolism of particular radioisotopes. • Clearly evaluates the use of this technology. • Presents the information coherently .. 7–8 • Demonstrates some knowledge of the advantages and or the limitations of the use of PET. • Demonstrates an accurate understanding of some of the physical principles involved: positron emission, positron electron interactions, emission of gamma rays, metabolism of particular radioisotopes ..... 5–6 • Demonstrates some knowledge of the advantages and or the limitations of the use of positron emission tomography. OR • Demonstrates an accurate understanding of some of the physical principles involved: positron emission, positron electron interactions, emission of gamma rays, metabolism of particular radioisotopes ..... 3–4 • Demonstrates a basic knowledge of the advantages and/or limitations of the use of positron emission tomography 1–2

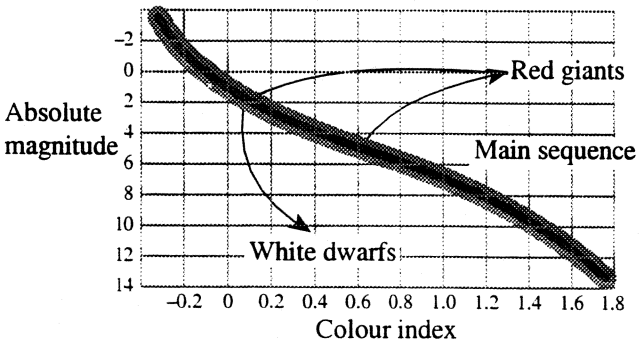
Question 30 Astrophysics

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	She had discovered a pulsar.	H9 • Correctly names pulsar 1
	(ii)	A pulsar is a rapidly rotating neutron star. Neutron stars are super-dense stars at the end of their lives which continuously emit narrow beams of radio frequency radiation from their magnetic poles. If the beam of radiation from a neutron star's magnetic pole is oriented such that it passes the line of sight to the Earth, then we can pick up a radio pulse every time the neutron star spins.	H7, H9 • Correctly describes neutron star and explains the origin of pulses ..... 2 • Describes some important features of the neutron star 1
(b)	(i)	Absolute magnitude is a scale based on the brightness of a star as viewed from 10 parsecs away from the star. It gives a measure of the intrinsic brightness of a star. The apparent magnitude of a star is its brightness as viewed from the Earth. Apparent magnitude depends on intrinsic brightness but also on the Earth's distance to the star, which varies hugely from one star to the next.	H7, H13 • Correctly describes the difference between the two scales..... 1
	(ii)	Find the distance from Earth to X: $M = m - 5\log\left(\frac{d}{10}\right)$ $-4.5 = 2 - 5\log\left(\frac{d}{10}\right)$ $d = 199.5$ pc Find the distance from Earth to Y: $M = m - 5\log\left(\frac{d}{10}\right)$ $1 = 2.5 - 5\log\left(\frac{d}{10}\right)$ $d = 19.95$ pc  Note that stars X and Y are in the same line of sight from the Earth. The distance from X to Y is 199.5 – 19.95 = 179.5 pc.	H7, H14 • Correctly relates apparent and absolute magnitudes to find distances • Correctly calculates distance between X and Y ..... 2 • Correctly relates apparent and absolute mediated to find distance for a star OR • Uses a correct method to find distance between X and Y 1
	(iii)	The apparent magnitude of X from Y is given by: $M = m - 5\log\left(\frac{d}{10}\right)$ $-4.5 = m - 5\log\left(\frac{179.5}{10}\right)$ $m = 1.77$	H14 • Correctly calculates apparent magnitude..... 1

Question 30 Astrophysics (Continued)

	Sample answer	Syllabus outcomes and marking guide
(c)	Emission spectra are easy to see using a handheld spectroscope when viewing a discharge tube.  The electrons in the atoms in the discharge tube are excited and have left their atoms. As they return they move to lower energy levels, releasing energy as they go. Hence we see a mainly black spectrum with bright lines that represent the frequencies that match the energy the electrons release as they go from one energy level to the next. The easiest way to see absorption spectra is to look at a white piece of paper that is reflecting sunlight, through a hand held spectroscope. The electrons in the outer layers of the sun are absorbing the light from the centre of the sun. They absorb only the frequency of light that matches the energy they need to jump to an outer energy shell. Hence the absorption spectrum shows all colours interrupted by darker lines which represent these absorbed frequencies.	H7, H8, H10, H11 • Clearly describes equipment used • Compares absorption and emission spectra and how they are generated ..... 4 • Clearly describes equipment used • Basic description of how spectra are generated ..... 3 • Correctly describes either both sets of equipment or both types of spectra but not both or not clearly linked ..... 2 • Gives any correct description of equipment or spectra 1
(d)	The *parallax method* uses the apparent motion of nearby stars compared to background distant stars when viewed from two positions a long way apart. The easiest way to do this is to observe stars at 6 monthly intervals using the motion of the Earth around the Sun as the baseline distance. This method works for a small number of nearby stars because the relative motion of stars is less than one tenth of a second of arc and the ability of telescopes to measure angles smaller than this is limited. Hipparcos and other satellites avoid the distortion of the Earth's atmosphere and measure the position of stars at different times with greater precision than the Earth-based telescope. This has lead to more precise measurement of the previously catalogued stars and means that the distance to more distant stars can now be measured using parallax. The *Cepheid variable* method is used to measure the distance to more distant stars, including stars in other local galaxies. This method uses the period vs luminosity relationship for this type of variable star: the bigger the star, the longer the period of its luminosity cycle. The relationship between period and absolute magnitude has been determined using nearby Cepheids as a reference. When a Cepheid is detected, its period is obtained by observing it for many years. The period is used to find the absolute magnitude and the apparent magnitude is obtained by observation. The formula $M = m - 5\log(d/10)$ is used to find the distance to the Cepheid. The Cepheid variable method is useful, but is not the only method for measuring distances to galaxies. At present there is some disagreement between this method and other standard candle methods and so it is used in conjunction with other methods. Of course this method is limited to stars from which the apparent magnitude information can be obtained. If the galaxy is so far away that the individual stars in the galaxy cannot be obtained then this method is not used.	H11, H12, H14 • Clearly compares two methods of measuring distance in space, focusing on relative advantages and limitations. 5–6 • Describes two methods of measuring distance in space and states some advantages and limitations of each but without a clear comparison ..... 3–4 • Shows knowledge of one or two methods of measuring distance in space 1–2

Question 30 Astrophysics (Continued)

Sample answer	Syllabus outcomes and marking guide
(e) The Hertzsprung-Russell (HR) diagram was the initial and most important diagram in developing our understanding of the life of stars. It illustrates the progress of stars from dust cloud to supernova or white dwarf. Above all it is an essential part of the language that astronomers use to describe the similarities and differences between stars and star clusters. The HR diagram shows the relationship between the surface temperature and luminosity of stars.  99% of stars lie on one band, the main sequence. This suggests that stars spend 99% of their time on this band. This obvious relationship between temperature and luminosity led astronomers to develop their understanding of how the rate of nuclear reactions in the star could be governed by temperature. This is turn helped to explain the stable time of a star when the nuclear reactions causing the star to expand were balanced by the force of gravity which caused the star to contract. No one has been watching stars long enough to follow the path of one star through its evolutionary sequence. However, by mapping large numbers of stars a number of patterns have been established that suggest this sequence. For example: • Stars in a particular galactic or globular cluster can be graphed on the HR diagram. All the stars in that cluster are assumed to be around the same age, and therefore the relative positions on the diagram of stars of different size have revealed a great deal on the evolutionary sequence. • Old clusters have much of the upper main sequence missing, indicating that more luminous stars spend less time on the main sequence than the less bright ones. • Clusters with lots of white dwarf stars have very short main sequences. This suggests that old stars eventually evolve to the white dwarf region. • Mapping clusters on this diagram now help astronomers to find the age of newly discovered clusters. The death of stars is also mapped on the HR diagram. Astronomers have developed models to explain the changes in a star's position as it becomes a red giant, and have shown these stages on an HR diagram. Again, older clusters (globular clusters) show stars that match each of the stages. Computer simulations of stellar evolution now match the HR diagrams of clusters observed by practical astronomers.	H1, H2, H7, H13 • Gives a good description of what the HR diagram is used to graph • Provides many examples of how it is used • Gives detail on stellar evolution (e.g. a diagram to help clarity) • States link between age of cluster and shape on diagram • Demonstrates knowledge that a star's position on the diagram is related to its age • States a clear conclusion of how significant the HR diagram is ..... 7–8 • Gives a good description of what the HR diagram is used to graph • Provides many examples of how it is used • Demonstrates knowledge that a star's position on the diagram is related to its age • Gives detail on stellar evolution (e.g. a diagram to help clarity) • Makes some mention of its significance to development of evolution theory ... 5–6 • Gives a good description of what the HR diagram is used to graph • Provides many examples of how it is used • Demonstrates knowledge that a star's position on the diagram is related to its age ..... 3–4 • Gives a description of what the HR diagram is used to graph • Demonstrates knowledge that a star's position on the diagram is related to its age ..... 2 • Gives a description of what the HR diagram is used to graph 1

Question 30 Astrophysics (Continued)	
Sample answer	**Syllabus outcomes and marking guide**
(e) (continued) The HR diagram is the basis of the classification of stars and, just as in many other sciences, by classifying and grouping our data, patterns have emerged that leads to better understanding. If, for example, stars were only classified according to colour, then the difference between cool main sequence stars and the red giants could not be established. The HR diagram has also led to predictions being made. The search for very small old stars, for example, must be a search in the red bands of the spectrum, as they are probably cool main sequence stars. The discovery of the very strong relationship between luminosity and surface temperature was profound in our understanding of astronomy. It has led to a better understanding of the structure and evolution of stars, and is an essential part in our discussion and classification of all stars yet discovered.	

Question 31 From Quanta to Quarks

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	De Broglie proposed that phenomena such as electrons could have wavelike properties.	H10 • Gives a correct response 1
	(ii)	$\lambda = \frac{h}{mv}$ $= \frac{6.6 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.6 \times 10^{6}}$ $= 4.5 \times 10^{-10}$ m	H7, H10 • Correctly uses formula and calculates correct value for wavelength ..... 2 • Correctly states and uses formula OR • States correct value for wavelength 1
(b)	(i)	Bohr related the concept of emission spectra to atomic theory by suggesting that in an atom the electrons can only move between stable stationary states.	H1, H2 • Outlines the correct relationship between emission spectra and Bohr's model of the atom ..... 2 • Describes emission spectra OR • Outlines Bohr's model of the atom 1
	(ii)	Any two of: • The Bohr model was ad hoc in nature, being a mixture of classical and quantum physics. • It did not explain multi-electron atoms. • It was not able to explain the Zeeman effect (the splitting of spectral lines when exposed to a magnetic field) • It was not able to explain the superfine spectral lines. • It was not able to explain the relative intensity of the spectral lines	H2, H14 • Outlines two inadequacies ..... 2 • States one inadequacy 1
(c)		The Balmer series consists of a number of discrete lines, which correspond to specific wavelengths. Four principal lines are evident: H_α (red at 656 nm), H_β green at 486 nm), H_γ (blue at 434 nm) and H_δ (violet at 410 nm). The red line results from a transition from the third energy level to the second energy level and has a specific wavelength according to Balmer's empirical equation. Bohr was able to provide a physical basis for these observations by stating that each specific line of a particular wavelength corresponded to an energy transmission permitted in Bohr's model. He was able to use a mixture of classical and quantum physics to derive an equation for the hydrogen spectral lines that matched Balmer's equation	H1, H8, H14 • Gives a thorough description of how observations of emission spectrum illustrate Bohr's model. ..... 4 • Gives a reasonable description of how observations of emission spectrum illustrates Bohr's model ..... 3 • Describes some observations of emission spectrum and states Bohr's model ..... 2 • Describes some observations of emission spectrum OR • States Bohr's model 1

Question 31 **From Quanta to Quarks (Continued)**

	Sample answer	Syllabus outcomes and marking guide
(d)	The higher the resolving power, the smaller the angular separation of objects that can be distinguished. Resolving power is inversely proportional to the wavelength of the waves being used. The wavelength of visible light is around 1000 times larger than that of an electron, so an electron microscope has a resolving power approximately 1000 times greater than a light microscope. Light microscopes allow individual cells and their interiors to be studied, but the development of electron microscopes enabled scientists to view individual atoms on a surface. By allowing us to see down to an atomic size, electron microscopes help us to identify and study internal and external structural features of viruses. Geologists can study crystal surfaces and metallurgists are able to identify flaws in silicon and zircon crystals.	H2, H8, H13 • Compares the microscopes and discusses the impact of the development demonstrating a thorough understanding of resolving power and operation ..... 5–6 • Compares the microscopes demonstrating a understanding of resolving power and operation OR • Compares both microscopes and discusses the impact of their development ..... 3–4 • Compares both microscopes demonstrating some understanding of resolving power OR • Discusses the impact of their development..... 2 • Shows some understanding of differences between both microscopes OR • States some uses of both microscopes... 1
(e)	Particle accelerators supply charged particles with the kinetic energy required to collide with specific nuclei. Particles must be accelerated to very high speeds to penetrate the nucleus. These collisions may result in disruption of the nuclei and allow physicists to study the nuclear force and the nature of fundamental particles. The early accelerators, such as van der Graff generators, accelerated charged particles using electric fields while later models (cyclotrons) added magnetic fields to control the direction of particles. The development of these high-energy accelerators meant that particles could be fired at target nuclei with specific energies and that the resulting collisions studied under controlled conditions. The CERN facility allowed for two accelerated particles to collide head-on. As a result, scientists have been able to learn about short-lived subatomic particles, investigate the structure of matter and propose new particles (such as quarks and leptons) that may lead to the discovery of the ultimate fundamental particle. Alternative theories have been proposed to explain matter and the fundamental forces (strong nuclear, weak nuclear, electromagnetic and gravitational) interacting between these particles.	H1, H5, H6, H13 • Analyses the development of particle accelerators and discusses at least three advances that have contributed to our understanding of matter..... 7–8 • Outlines the development of particle accelerators and discusses two advances that have contributed to our understanding of matter..... 5–6 • Outlines the development of particle accelerators and discusses one advance OR • Discusses two advances that have contributed to our understanding of matter..... 3–4 • Describes the operation of particle accelerators OR • States two advances that have contributed to our understanding of matter..... 2 • Describes a particle accelerator OR • States one advance that has contributed to our understanding of matter..... 1

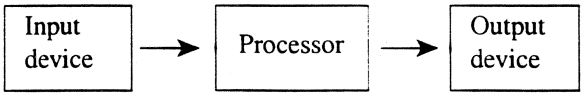
Question 32 The Age of Silicon

		Sample answer	Syllabus outcomes and marking guide
(a)	(i)	An analogue signal is one in which the input signal is in a continuous format whereas a digital system is where input signal is in a non-continuous format.	H3 • Gives a correct response 1
	(ii)	A complete description of any one of the following. • *Regeneration*: signals lose power as they travel along, they can also be affected by noise. To restore their power and restore the signal, digital signals can be amplified and cleaned up by regenerators at intervals (analogue signals can only be amplified, this also increases the noise) • *Data handling*: computers operate digitally, so digital transmission is ideal for long-distance computer links.	H4 • Gives a complete description of one advantage. . . . . 2 • Gives some description of one advantage OR • States one advantage 1
(b)	(i)	For example: • indicator lights to show the presence of an output voltage • car brake lights • traffic lights • picture elements for very large television screens	H4, H7 • Correct response 1
	(ii)	Inside the diode a piece of p-type semiconductor is joined to a piece of n-type semiconductor. A p-type semiconductor has positive holes, while n-type has an excess of electrons. When the extra electrons combine with positive holes at the junction, light is produced.	H4, H13 • Gives a complete description of semiconductor structure and operation of LEDs. . . . . 3 • Describes semiconductor structure of LEDs OR • Describes semiconductor operation of LEDs . . . . . 2 • States what an LED is 1
(c)		$\text{Gain} = \frac{R_f}{R_i} = \frac{9\ \text{k}\Omega}{1\ \text{k}\Omega} = 9$. Output voltage is obtained from: $\frac{V_{out}}{V_{in}} = \text{gain}$ $\frac{V_{out}}{0.5} = 9$ $\therefore V_{out} = 4.5\ \text{V}$	H4, H9, H14 • Correctly calculates gain and output voltage using relevant formulae. . . . . 4 • Correctly uses formulae and obtains correct value for gain or output voltage • Makes some attempt to use formula to calculate other quantity . . . . . 3 • Correctly uses formulae and obtains correct value for gain OR • Correctly uses formulae and obtains correct value for output voltage . . . . . 2 • Makes some attempt to use formula for gain OR • Makes some attempt to use formula for output voltage. 1

Question 32 The Age of Silicon (Continued)

	Sample answer	Syllabus outcomes and marking guide
(d)	Silicon-based materials from Group IV of the periodic table dominate the semiconductor industry. The principal reason is that as a semiconductor, silicon has properties between those of conductors and insulators. However by adding small amounts of impurities, it is possible to change the electrical resistance of silicon by 10,000 times, allowing it to be engineered between metallic and insulating behaviour. With suitable doping, silicon can easily form p and n-type semiconductors, making it suitable for use in the semiconductor junctions that form the basis for all solid state electronics. It was realised that if resistors and capacitors could be fabricated in silicon they could be incorporated with transistors into a single silicon substrate. As well as miniaturising circuits, consolidating circuit elements and doing away with connecting wires, soldering errors could also be eliminated. Photographic techniques are used to transfer patterns to the silicon wafer and introduced precise concentrations of dopants to form an integrated chip. The small size of the integrated circuit has allowed for design of smaller equipment such watches, calculators and space probes, but the major advance is its ability to process information in computers. Additionally: Silicon devices can operate at temperatures up to 200°C and so may be used in applications involving high temperatures. Silicon is plentiful, easily prepared and easily purified. Silicon forms an oxide film with electrical insulation properties. This can be utilised in ICs with microprocessors to control equipment.	H3, H4 • Gives a full discussion of the properties of silicon as part of development of ICs • Gives a complete explanation of at least two industrial applications ..... 5–6 • Gives a full discussion of the properties of silicon as part of development of ICs OR • Gives a complete explanation of at least two industrial applications ..... 3–4 • Gives a brief statement of two properties of silicon as part of development of ICs OR • Gives a brief explanation of two industrial applications ..... 2 • States one property of silicon as part of development of ICs OR • States one industrial application 1

Question 32 **The Age of Silicon (Continued)**

Sample answer	Syllabus outcomes and marking guide
(e) Most electronic systems can be presented by a simple box diagram as shown.  The information which the processor in the centre of an electronic circuit is handling must be in the form of an electric current or voltage. Such systems use transducers (such as microphones, thermistors and LDRs) as input devices and other transducers (such as loudspeakers, buzzers and LEDs) as output devices. Transducers change signals from one form to another (e.g. sound to electrical). These transducers change environmental signals into electrical signals and, after being processed, back to other again. Input signals can be very weak, but by means of electronic circuits, they can control output signals which can be much stronger. Specific situations could be: • A temperature sensitive system involving a thermistor (input transducer) switch (processor) and LED (output transducer). The LED emits light when a small current passes through. It can be used as an indicator lamp to show the presence of an output voltage. • A light sensitive system involving a photocell (input transducer), switch (processor) and bulb (output transducer).	H1, H3, H4, H13 • Analyses at least two specific situations to fully explain how transducers operate as an interface. . . . . 7–8 • Describes clearly two specific situations to briefly AND clearly explains how transducers operate as an interface . . . 5–6 • Describes clearly one specific situation AND explains how transducers operate as an interface. . . . . 3–4 • Describes one specific situation to briefly explain how transducers operate as an interface OR • Explains clearly how transducers operate as an interface . . . . . 2 • Names one specific situation where transducers operate as an interface OR • States how transducers operate as an interface. 1