Candidate Number _____
Centre Number _____

Ascham School

Trial Examination 2001

Physics

July 2001 **Time allowed: 3 hours (plus 5 minutes reading time)** **Term 3**

All questions in this paper are compulsory.

SECTION 1

PART A 15 one mark multiple choice questions.
Write your answers in pencil on the Part A answer sheet. (15 marks)

PART B Short response questions.
Write your answers in the space provided in this question booklet. (69 marks)

SECTION 2

Option: Medical physics (16 marks)

Write your answers to this section in the writing booklet.

Make sure your Student number and Centre number are on this booklet and on the Part A answer sheet.

A Periodic Table, A Data sheet and a Formula sheet are provided.

Section 1

Total marks (75)

Part A

Total marks (15)

Attempt questions 1 to 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 = (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 drawing an arrow as follows:

correct ↓

(A) ⊗ (B) ⊗ (C) ○ (D) ○

1. Two planets X and Y have equal diameters but planet X has twice the density of Y. Density is defined as the amount of mass per unit volume. The acceleration due to gravity on the surface of planet X is equal to 10 ms^{-2}.

   Which of the following statements is true regarding the acceleration due to gravity on the surface of planet Y?

   (A) It is equal to 10 ms^{-2}.

   (B) It is greater than 10 ms^{-2}.

   (C) It is less than 10ms^{-2}.

   (D) It is impossible to say; direct measurements would have to be taken.

2. You measure your pulse rate on Earth. According to the special theory of relativity, if you measure your own pulse while traveling at very high speeds, you would notice your pulse rate, compared to the measurement on Earth, to

   (A) Stay the same.

   (B) Decrease because time has slowed down for you.

   (C) Increase because the distance from your heart to your wrist has shortened due to length contraction.

   (D) Increase because there is a great deal of solar radiation incident upon you in space.

3. A rocket is just about to land onto a distant planet, whose gravitational field strength is greater than that of Earth's. It is decelerating uniformly as it descends. An astronaut is seated during the landing maneuver. The reaction force from the seat during landing will be

   (A) less than the reaction force she would feel if she were at rest on the planet

   (B) less than the reaction force she would feel if she were at rest on Earth.

   (C) greater than the reaction force she would feel if she were at rest on Earth.

   (D) equal to her weight force on the planet.

4. Satellites in low earth orbits eventually burn up in the atmosphere. This is because

(A) they are slowed down by atmospheric friction.

(B) they run out of fuel.

(C) the gravitational attraction between them and the earth becomes extremely large.

(D) They are predominantly made of metal and are attracted downwards by the earth's magnetic field.

5. The exterior of spacecraft becomes extremely hot during a re-entry procedure. This is caused by huge frictional forces between the spacecraft and the earth's atmosphere. Although this must be taken into account during re-entry, a positive aspect of this is that

(A) scientists can more easily measure the health of the astronauts.

(B) aerodynamic drag forces acting on the spacecraft are large.

(C) the electronic guidance system of the spacecraft is unaffected.

(D) the heat produced can be converted to mechanical energy, thus reducing the amount of fuel used on re-entry.

6. When an electric motor is running at high speeds, it draws

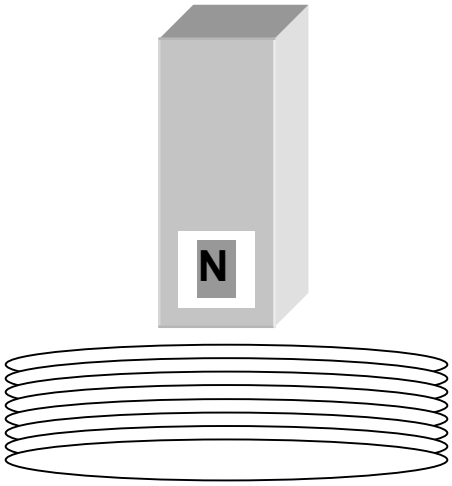
(A) low voltage because the current is high.

(B) low current because the back emf is high.

(C) high voltage because the back emf is low.

(D) low wattage because the current is high.

7. When a magnet is thrust into a coil of wire, the coil tends to



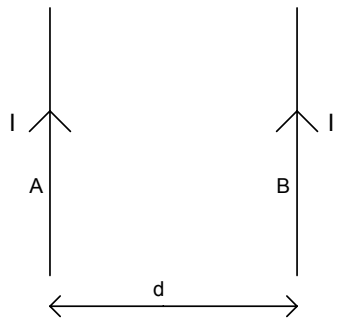
(A) become electrically charged due to an induced emf.

(B) attract the magnet as it enters.

(C) Exert no force on the magnet as it enters.

(D) repel the magnet as it enters.

8. Two wires A and B, both carrying a current I are shown below. They are separated by a distance d, and they exert a force per unit length F on each other.



The separation between the two wires is halved and the current in one of the wires is doubled and reversed. The force per unit length between the wires is now

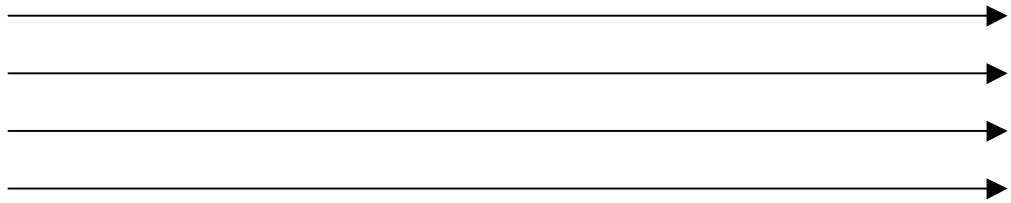
(A) 4F and attractive

(B) 4F and repulsive

(C) 2F and attractive

(D) 8F and repulsive

9. A uniform magnetic field is shown below.



Which arrangement of current-carrying wires would produce the field shown?

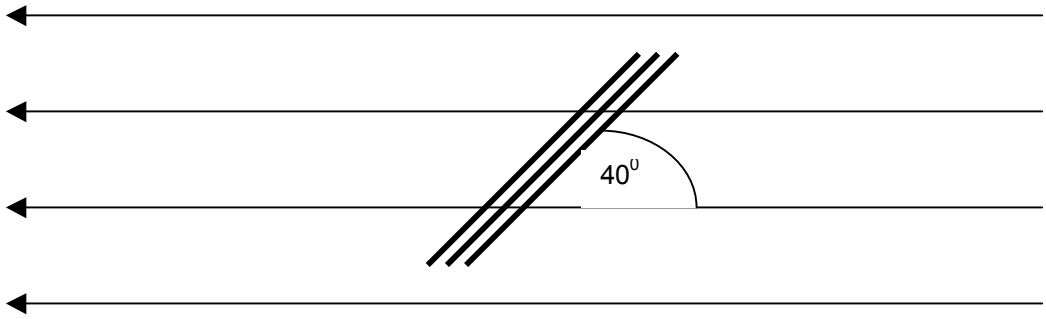
(A) a current carrying conductor with the current directed to the left.

(B) a current carrying conductor with the current directed into the page.

(C) a current carrying conductor with the current directed out of the page.

(D) a solenoid

10. A coil consists of 100 turns of wire. Each turn encloses an area of $2.0 \times 10^{-4} m^2$. The plane of the coil is positioned at 40^0 to the direction of a magnetic field of 0.50 T.



What is the value of the magnetic flux through the coil?

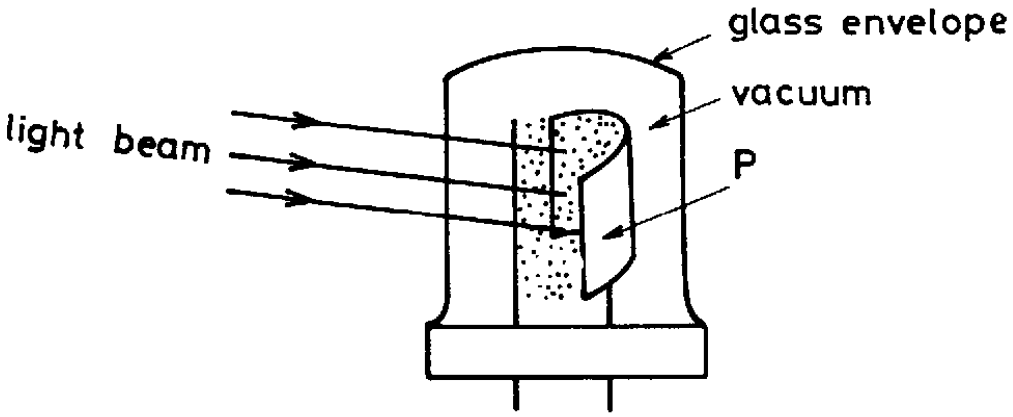
(A) 6.4×10^{-5} Wb

(B) 7.6×10^{-3} Wb

(C) 7.6×10^{-5} Wb

(D) 6.4×10^{-3} Wb

11. In the diagram below, P represents a photoemitting surface on which a beam of light is incident. The energy of each photon of light is X joules. Particles are emitted from the surface.



Which of the following statements are both true, regarding the nature and energy of the emitted particles?

	Nature of particle	Energy of particle
(A)	canal rays	greater than X
(B)	electrons	greater than X
(C)	canal rays	equal to X
(D)	electrons	less than X

12. In the fabrication of a silicon chip for electronic use, a number of atoms of the element Indium. In, were used to replace a number of atoms in the crystal lattice of the silicon. The addition of the Indium will

(A) increase the number of free electrons in the silicon lattice.

(B) decrease the number of electrons in the silicon lattice.

(C) produce a number of holes in the silicon lattice.

(D) decrease the conductivity of the silicon lattice.

13. Increased temperatures increase the thermal motion of electrons in a solid. Several factors affect the magnitude of the drift velocity of electrons in a solid conductor. Some of these factors include

The cross sectional area of the conductor, A
The electronic charge, e
The number of free electrons, n

The magnitude of the drift velocity varies

(A) directly with A, all other factors kept constant.

(B) inversely with n, all other factors kept constant.

(C) directly with e, all other factors kept constant.

(D) inversely with the temperature of the conductor, all other factors kept constant.

14. Which of the following statements is true regarding the band structure theory of solids?

(A) In semiconductors, the forbidden energy gap is smaller than for insulators.

(B) In insulators, the valence and conduction bands overlap.

(C) In conductors, there is a large forbidden energy gap between the valence and conduction bands.

(D) In insulators, the conduction band is full at O K.

15. Owen was investigating the relationship between the force between two current carrying conductors, current and separation between the wires.. He used different values of current to wires of constant separation, and measured the force on each wire in each measurement. In his investigation, the dependent variable, the independent variable and the controlled variable were respectively:

	Dependant variable	Independent variable	Controlled variable
(A)	Separation of wires	Current in wires	Force on each wire
(B)	Force on each wire	Current in wires	Separation of wires
(C)	Force on each wire	Separation of wires	Current in wires
(D)	Current in wires	Force on each wire	Separation of wires

Section 1

Part B

Total marks (69)
Attempt questions 16 to 229
Allow about 2 hours for this part

Answer each question in the space allowed in this booklet.

Show all relevant working in questions involving calculations.

Question 16 (4 marks)

Sir Isaac Newton predicted that there was a force of gravitational attraction between any two objects that depended on the product of their masses, and inversely as the square of the distance between their centres of mass. This can be expressed by the formula

$$F = \frac{Gm_1m_2}{d^2}$$

where

- F is the force of gravitational attraction
- G is the gravitational constant
- m_1 and m_2 are the masses of the two objects
- d is the distance between their centres of mass (their separation)

In an experimental test of this idea, using two small metal spheres, the following data was collected:-

m_1 (kg)	**m_2** (kg)	**separation d** (cm)	**force F** (arb. units)
2.0	1.0	6.0	6.7
2.0	2.0	6.0	13
2.0	3.0	6.0	20
2.0	4.0	6.0	27
2.0	5.0	6.0	34
2.0	6.0	6.0	40
2.0	6.0	8.0	23
2.0	6.0	10	14
2.0	6.0	12	10
2.0	6.0	14	7.4
2.0	6.0	16	5.7

Use the space below to construct a suitable table for question 16 (a)

Force	

(a) Draw a relevant graph to investigate whether these results support Newton's prediction about the dependence of force on separation

Marks 3

(b) Explain why your graph supports or does not support Newton's prediction.

1

_____

_____

Question 17 (6 marks)

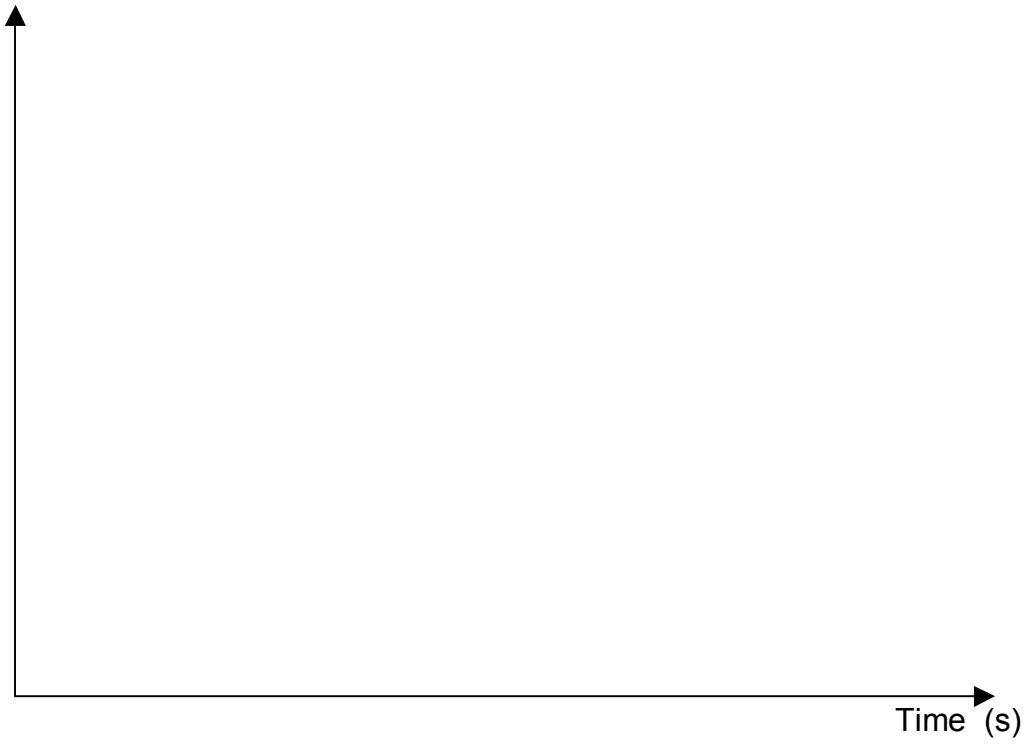
Marks

The following information applies to the Space Shuttle during the first 120 seconds of its launch

- The thrust force from the rocket engines is constant at 3.0×10^{7} N
- The mass loss per second due to rocket discharge of fuel is 1.3×10^{4} kg
- Frictional forces due to the atmosphere decrease with height.

(a) Describe qualitatively and quantitatively how the g forces acting on the astronauts vary during the first 120 seconds. Compare to g forces while at rest. **4**

(b) Sketch two graphs, on the same set of axes, how the velocity and kinetic energy of the Shuttle vary during the first 120 seconds.(No numerical values are required) Use different colours for velocity and kinetic energy. **2**



Question 18 (4 marks)

Tsiolovsky, Von Braun and Goddard are three of the most well known pioneers of rocket science. Choose any two of these scientists and briefly describe their contribution to rocketry.

Marks

4

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Question 19 (5 marks)

An object dropped from a hovering helicopter from an altitude of 2000 m above the Earth's surface will fall to Earth with an initial acceleration of slightly less than 9.8 m $s^{-2.}$ If a satellite was orbiting the Earth at this height it would have the same acceleration. The object falls to the Earth's surface but the satellite remains in orbit.

(a) Explain why the object released from the helicopter will fall to earth while the satellite does not. Answer using relevant diagrams

3

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(b) Justify, using relevant equations, the statement that the acceleration of the object dropped from the helicopter is slightly less than 9.8 ms^{-2}.

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Question 20 (3 marks)

Marks

An eager physics student is standing on top of Mt Everest, which is at a height of 8800 m above sea level. She is trying to throw a rock of mass 100g fast enough so that it will circle the earth and return directly back to her, in an attempt to verify a famous thought experiment by Isaac Newton. **2**

(a) Show that she needs to throw the rock, so that it gains the required orbital velocity, with a horizontal velocity of about 8 km s^{-1}.(Air resistance can be ignored)

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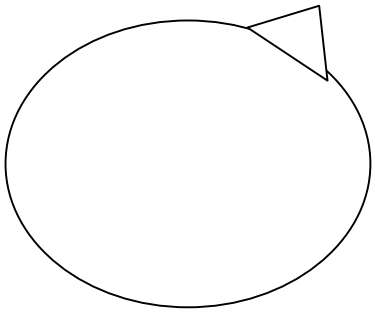
(b) Using the diagram below, sketch the path the rock would take if the initial horizontal velocity of the rock was greater than the required speed to achieve an orbital velocity at this height. **1**

Mt Everest



Question 21 (4 marks)

Outline a thought experiment to show that time is not an absolute quantity. Include a diagram to aid your explanation. **4**

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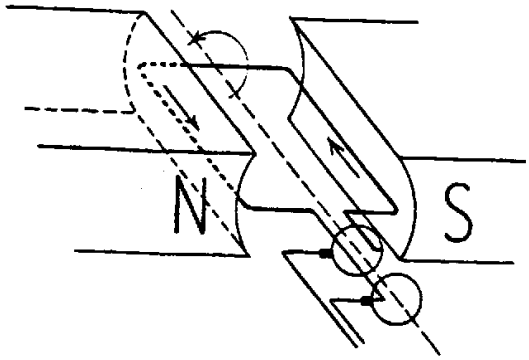
Question 22 (9 marks)

Marks

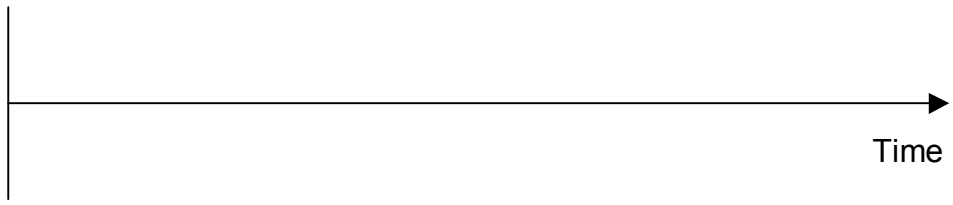
The diagram below shows a simple a.c generator.



(a) Compare the structure and function of this generator with a D.C. motor. **4**

(b) Draw a neat diagram of a d.c. generator and explain fully how it operates. **4**

(c) Sketch the output you would expect to achieve if you connected a C.R.O to the d.c generator you described above, on the axes below. **1**



Question 23 (8 marks)

Marks

(a) Describe, with aid of a diagram, a first-hand investigation you carried out to demonstrate the principle of electromagnetic induction. **3**

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(b) The distribution of electricity from large generating stations is more often than not in the form of a.c. Explain why this is preferable to distribution using d.c. **2**

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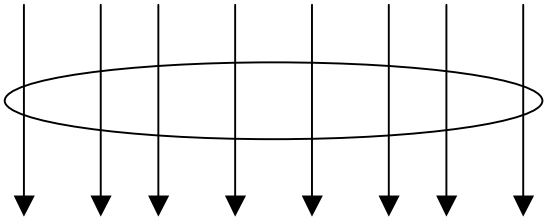
(c) A circular loop of wire with a radius of 20 cm is placed in a uniform magnetic field of strength 2.00 T, perpendicular to the plane of the loop.



(i) The area enclosed by the loop is decreased uniformly from its original value to half its value in a time of 0.20 s. What is the average induced emf in the loop? **2**

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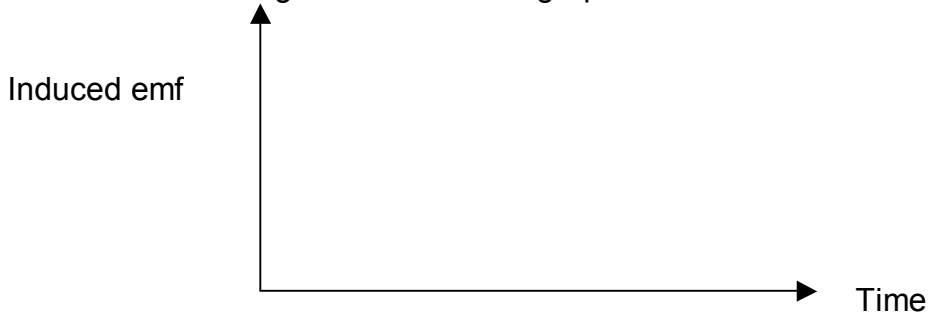
(ii) If instead of the above situation, the radius of the loop was decreased uniformly from 20 cm to 10 cm in the same time as above, sketch the induced emf against time on the graph below. **1**



Question 24 (3 marks)

Marks

A transformer has 2000 turns in its primary coil and 100 turns in its secondary coil. The primary coil is attached to a 240 V power supply

(a) Calculate the voltage across the secondary coil if the transformer is 100% efficient. **1**

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(b) Explain why an AC power supply is used in a transformer. **2**

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Question 25 (3 marks)

A power drill works because of the motor effect. In using a drill, the motor can overheat if:

- The trigger of the drill is not fully pressed and the drill rotates slowly
- There is too much friction between the drill and the substance being drilled, so that the rotation of the drill is slowed.

Explain why the drill may overheat in these situations making clear reference to the physics involved. **3**

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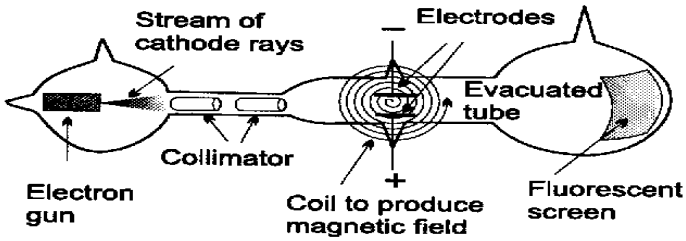
Question 26 (3 marks)

Marks

Describe fully an experiment you carried out to illustrate the principle of electromagnetic braking. Include a suitable diagram and a brief explanation of why the braking occurred. **3**

Question 27 (5 marks)

J.J.Thomson used apparatus similar to the one below to find the charge to mass ratio (q / m) of cathode rays.



Describe how he obtained a value for q / m. Include relevant equations in your discussion. **5**

Question 27 (4 marks)

Marks

Einstein's explanation of the photoelectric effect forced physicists to re-evaluate the wave model of light. Discuss this statement, paying particular attention to the reasons why the wave model of light failed to explain this effect. **4**

Question 28 (5 marks)

(a) Describe how doping can produce n-type silicon. **2**

(b) Suggest several reasons why solid state devices such as transistors have replaced thermionic devices. **3**

Question 29 (3 marks)

Describe what is meant by the term drift velocity, in terms of electrons moving in a solid conductor. Compare its magnitude to the thermal motion of electrons in a solid. **3**

Section 2 Options - Medical Physics

This section is worth 16 marks

Answer all parts of this question in a writing booklet.

Sow all relevant working in questions involving calculations.

30. Information about the internal structure of the human body can be obtained by the use of ultrasound techniques. **Marks**

(a) Describe the physical principles involved in the production and detection of ultrasound **4**

(b) Use the table below to answer the questions which follow.

Medium	Density ($kg\ m^{-3}$)	Ultrasound velocity ($m\ s^{-1}$)	Acoustic Impedance ($X\ 10^6\ kg\ m^2\ s^{-1}$)
Air	1.3	330	0.000429
Water	1000	1500	1.50
Blood	1060	1570	1.59
Brain	1025	1540	1.58
Fat	925	1450	1.38
Eye	1000	1500	1.51
Soft tissue (average)	1060	1540	1.63
Muscle (average)	1075	1590	1.70
Bone	1910	4080	7.78

(i) Why is it necessary to use a gel between the transducer and the skin? **1**

(ii) Why is ultrasound not used to study the brain? **1**

(iii) Calculate the wavelength of an ultrasound wave of frequency 1.5 MHz passing through bone. **1**

(iv) If the time delay for an echo in soft tissue is 0.133 milliseconds, at what depth was it reflected? **1**

Marks

(c) The Doppler shift refers to the apparent change in the frequency of a wave when there is relative motion between the wave source and the observer.

Explain how the Doppler shift is applied to the measurement of blood flow. **2**

To which of the following situations W, X, Y or Z, shown below, does the Doppler measurement of blood flow most closely correspond? **1**

W: Source moving towards a stationary observer
X Source moving away from a stationary observer
Y: Observer moving away from a stationary observer
Z: Observer moving towards a stationary observer

(d) An endoscope is a device used to assist in medical diagnosis.

(i) Explain, using your knowledge of the property of refraction, how an endoscope operates. Diagrams would be helpful. **3**

(ii) What are the incoherent bundles of fibres in the endoscope used for? **1**

(iii) Briefly explain how an endoscope is used to assist in a biopsy. **1**