GOVERNMENT OF WESTERN AUSTRALIA

SEA SECONDARY EDUCATION AUTHORITY (WA)

TERTIARY ENTRANCE EXAMINATION, 1996

QUESTION/ANSWER BOOKLET

PHYSICS

Please place your student identification label in this box

SEA STUDENT NUMBER - In figures

In words _____

_____

TIME ALLOWED FOR THIS PAPER

Reading time before commencing work: Ten minutes
Working time for paper: Three hours

MATERIAL REQUIRED/RECOMMENDED FOR THIS PAPER

TO BE PROVIDED BY THE SUPERVISOR

This Question/Answer Booklet
Physics: Formulae and Constants Sheet (inside front cover of this Question/Answer Booklet)

TO BE PROVIDED BY THE CANDIDATE

Standard Items: Pens, pencils, eraser or correction fluid, ruler

Special Items: MATHOMAT and/or Mathaid, compass, protractor, set square and calculators satisfying the conditions set by the Secondary Education Authority.

IMPORTANT NOTE TO CANDIDATES

No other items may be taken into the examination room.

It is your responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor BEFORE reading any further.

Ref: 017

STRUCTURE OF PAPER

Section	No. of questions	No. of questions to be attempted	No. of marks out of 200	Proportion of examination total
A: Short Answers	15	ALL	60	30%
B: Problem Solving	7	7*	100	50%
C: Comprehension and Interpretation	2	ALL	40	20%

* Note that in Section B there is some internal choice in Questions 6 and 7.

INSTRUCTIONS TO CANDIDATES

Write your answers in the spaces provided beneath each question. The value of each question (out of 200) is shown following each question.

The enclosed *Physics: Formulae and Constants Sheet* may be removed from the booklet and used as required.

Calculators satisfying the conditions set by the Secondary Education Authority may be used to evaluate numerical answers.

Answers to questions involving calculations should be evaluated and given in decimal form. Choose an appropriate number of significant figures, usually no more than three. Despite an incorrect final result, credit may be obtained for method and working, providing these are clearly and legibly set out.

Questions containing the instruction "ESTIMATE" may give insufficient numerical data for their solution. Students should provide appropriate figures to enable an approximate solution to be obtained.

SEE NEXT PAGE

SECTION A: Short Answers

Marks Alloted: 60 marks out of 200 total (30%)

Attempt **ALL** 15 questions in this section. Each question is worth 4 marks. Answers are to be written in the space indicated.

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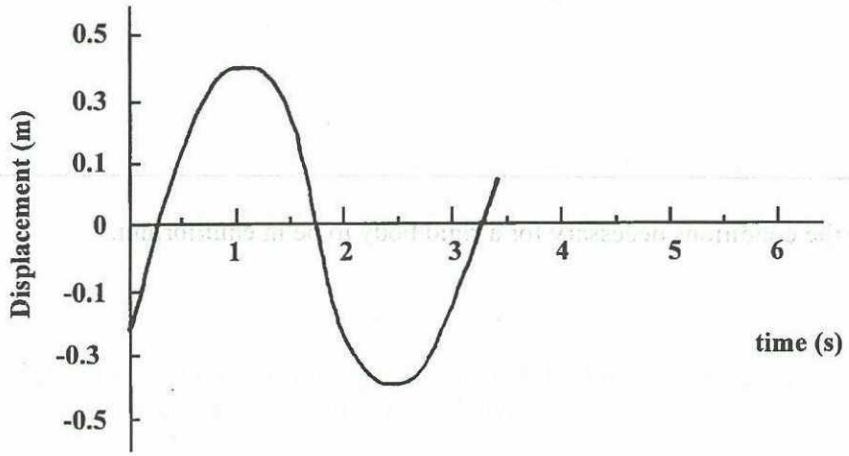
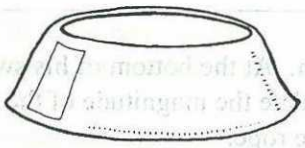
1. Draw the continuation of the periodic waveform shown up to 6 s.



2.



DOG BOWL

WITCH'S HAT (traffic hazard marker)

The items shown in the figure need to be stable. Give two reasons why the shape of these structures makes them particularly stable.

Reason 1: _____

_____

Reason 2: _____

_____

SEE NEXT PAGE

3. Twin engined aircraft, such as those used by the Royal Flying Doctor Service, often produce a sound that rises and falls in loudness.

What is the name given to this effect? _____

What are the conditions necessary for this effect to occur?

---

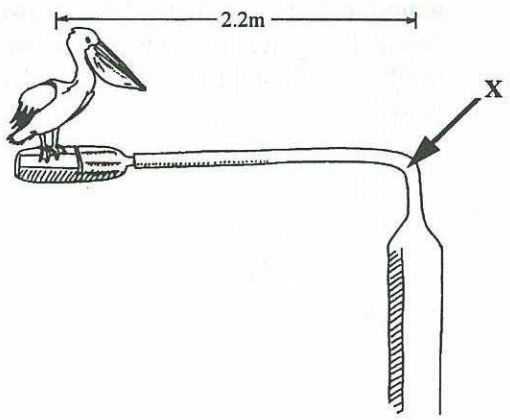
4. State the conditions necessary for a rigid body to be in equilibrium.

---

5. Tarzan swings from the trees on a vine rope of length 8.50 m. At the bottom of his swing he has a speed of 4.60 m s^{-1}. If Tarzan has a mass of 80.0 kg, calculate the magnitude of the centripetal force acting on Tarzan and, using this, find the tension in the rope.

SEE NEXT PAGE

6. Some street lights are supported by a post with the shape shown in the diagram. What would be the torque about point **X** shown, due to a pelican, with a mass of 5.5 kg, which lands and perches on the structure immediately above the street light?



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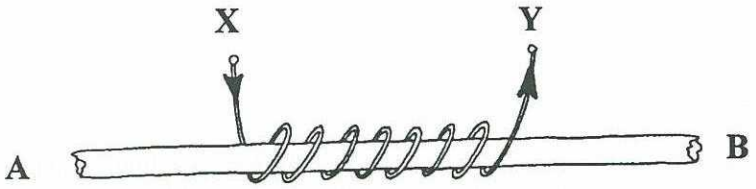
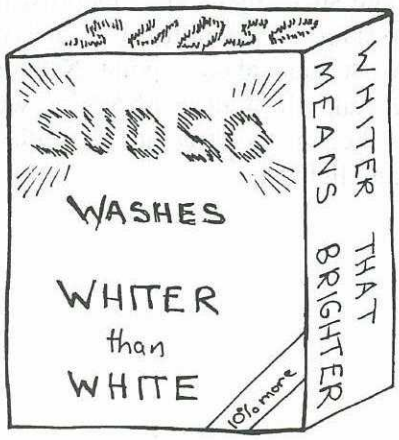
7. A small coil, XY, is wound on a current carrying wire AB. AB is carrying a current of 0.50 mA when a current is introduced into the coil XY, as shown :



(a) Will the current in AB: Increase? Stay the same? Decrease?
(Circle the best answer)

(b) Briefly explain your answer.

8. The claim made by a washing powder manufacturer is that their powder contains "optical brighteners" to make clothes "whiter and brighter". Explain how the so-called "whiteners" work.



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9. The planet Neptune has a mass about 17 times that of Earth and a radius of 22.7×10^3 km. Calculate the magnitude of the gravitational field at the surface of the planet.

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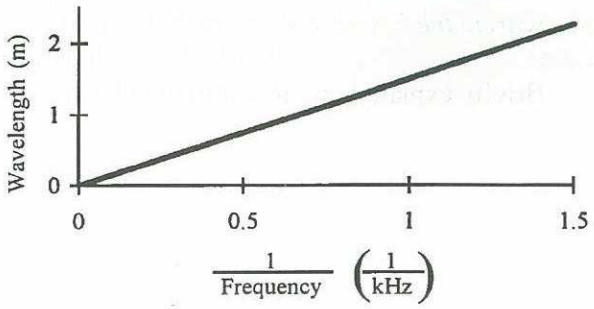
10. The graph shown is of wavelength plotted against the reciprocal of the frequency for sound travelling through an unknown medium.

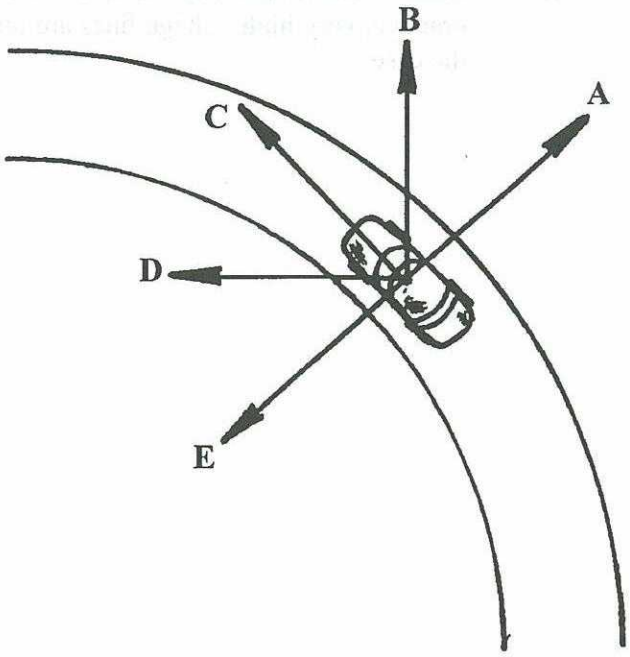


(a) From this graph obtain the speed of sound in the medium.

(b) What might the medium be? _____

SEE NEXT PAGE

11. The diagram shows how a car which is initially travelling north changes its direction to west by moving around a bend in the road. The bend is a quarter circle of 40.0 m radius and the car maintains a constant speed of 10.0 m s^{-1} throughout.



(a) **Circle the vector** given which best indicates the **direction** of the car's change in velocity.

(b) Calculate the **magnitude** of the car's change in velocity.

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12. A human hair has a diameter of 0.043 mm. A hair 105 mm long is found to increase in length by 5.0 mm when a force of 0.25 N is applied. Calculate Young's modulus for human hair.

13. Some transmission line losses can be reduced by transmitting electricity at high voltages. In practice, very high voltage lines are not used in residential areas. Give two reasons why this is the case.

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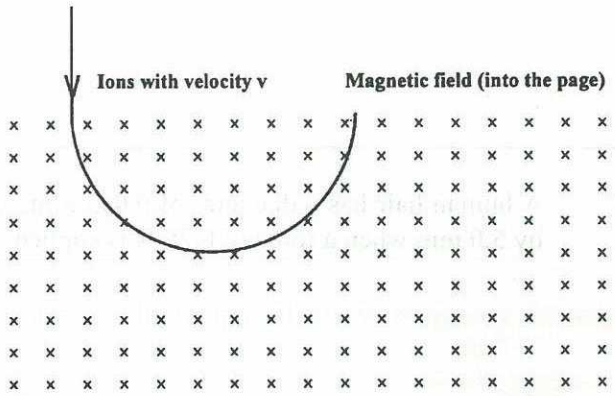
14. Singly ionised atoms enter a strong magnetic field with the same velocity. The diagram shows the path of one ion.

Mark on the diagram the resultant path for an ion of two thirds the mass of the one shown.



15. A satellite in geosynchronous orbit around the Earth has a period of 24 hours. Calculate the speed of the satellite in this orbit.

END OF SECTION A

SEE NEXT PAGE

SECTION B: Problem Solving

This section contains 7 questions, two of which contain a choice. You should answer
ALL of the questions 1, 2, 3, 4 and 5
EITHER 6A **OR** 6B
EITHER 7A **OR** 7B
Answer the questions in the spaces provided

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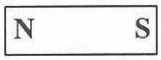
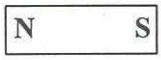
1. [16 marks total]

(a) Draw a diagram of the magnetic field around each of the following :

(i) Two bar magnets placed north to south.

[2 marks]



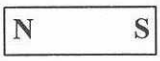


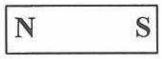
(ii) A wire carrying a current into the page.

[1 mark]

(iii) Hence draw a diagram of the magnetic field when the wire carrying the current into the page is placed between the two magnets.

[3 marks]





(b) The situation depicted in part (a) (iii) results in a force acting on the current carrying wire. If the magnetic field strength in the vicinity of the wire is 2.50 T, the length of wire in the field is 30.0 mm and a current of 6.00 A is carried by the wire, calculate the **magnitude** and **direction** of the force on the wire.

[4 marks]

(c) The effect shown in part (b) is the basis for the operation of the electric motor. The similarity between the electric motor and the electric generator is used in some motorcycles where the electrical generator is used as the starter motor.

(i) Briefly describe (with the aid of sketches if necessary) the principle of operation of the AC generator.

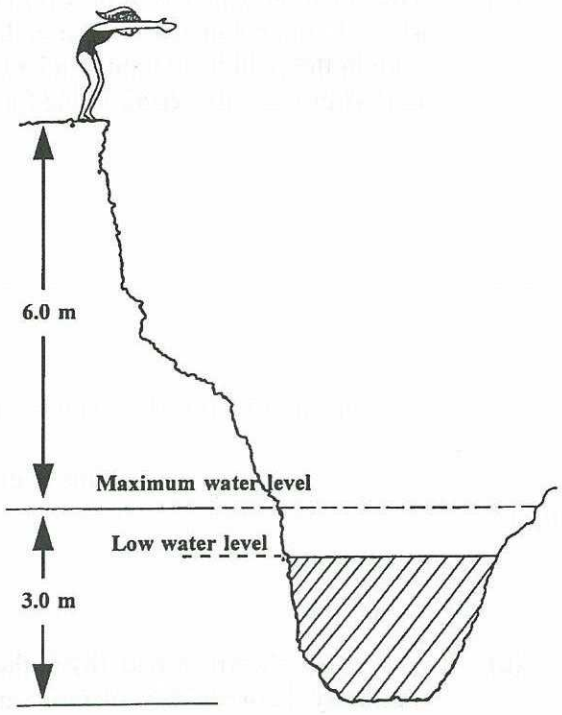
[4 marks]

(ii) Compare and contrast this with the operation of an electric motor.

[2 marks]

2. [12 marks total]

A diver wishes to make a difficult high dive from a cliff top into the water 6 metres below (see diagram). She always pushes off with zero vertical velocity. One problem is that the water is only deep enough to dive into when a large wave is directly below her. She must hit the water at the instant when the water level is at its maximum if she is to avoid injury.



(a) How long before the large wave arrives should she jump from the cliff top?

[4 marks]

Another problem is that if she pushes off with too little horizontal speed she will land on the base of the cliff that she is standing on, while if she pushes off with too much horizontal speed she will land on some rocks on the other side of the water. She needs to travel 2.5 metres in the horizontal direction during her dive to land safely in the water.

(b) What horizontal speed should she push off with?

[3 marks]

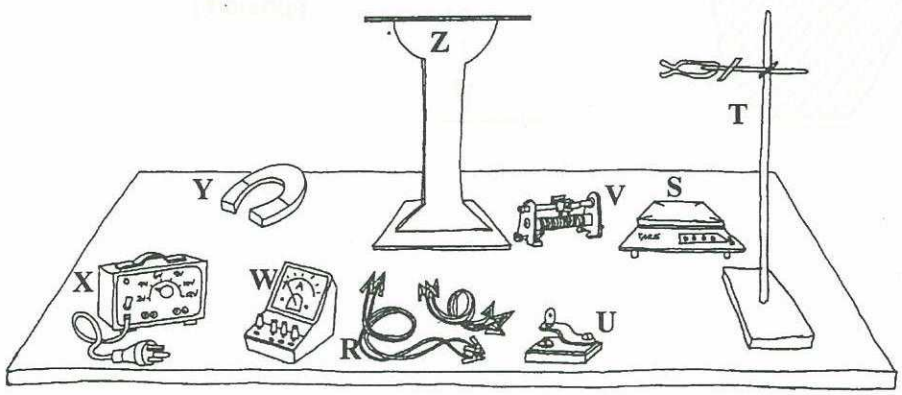
(c) Calculate her speed and direction when she hits the water.

[5 marks]

3. [16 marks total]

A group of students was asked to determine the magnetic flux density (B) between the poles of a horseshoe magnet, by using a balance to measure the force on a current-carrying wire in a magnetic field. They had to design the investigation themselves but were given the following equipment :

Z light plastic stand with a rigid piece of copper wire glued along the top edge
Y horseshoe magnet
X power supply
W ammeter
V variable resistor (rheostat)
U switch
T retort stand and clamp
S top-loading electronic balance
R an assortment of leads

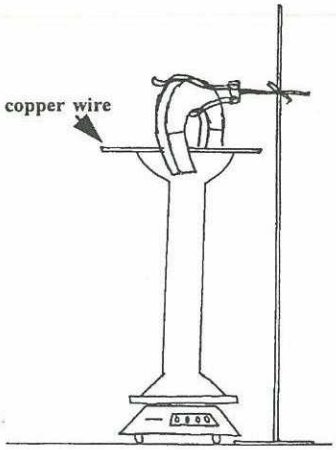


(a) State the relationship between magnetic flux density (B), current (i) and force (F).

[2 marks]

(b) The diagram below shows how part of the equipment should be arranged. Describe, by adding to the diagram below, how you would complete the electrical circuit in such a way that it would allow you to determine the value of the magnetic flux density (B).

[4 marks]



(c) What would you need to measure? How many readings would you take?

[4 marks]

(d) Explain carefully how you would use these results to produce a graph.

[4 marks]

(e) How would you analyse the results to get a value of the magnetic flux density (B) for the horseshoe magnet?

[2 marks]

4. [16 marks total]

Yasmine and Gheri were asked to consider the following three events:

Event A: A ball is thrown directly up in the air from ground level.
Event B: The ball reaches its maximum height above the ground.
Event C: The ball returns to ground level.

Gheri decided to calculate the velocity of the ball as a function of time and using the equation $v = u + at$ produced the following table of data:

Time (s)	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Velocity ($m\ s^{-1}$)	32.0	22.5	13.2	4.9	-3.9	-12.6	-21.3	-30.4

(a) Plot these data on the graph paper provided.

[6 marks]

(b) From the graph **or otherwise** find:

(i) How much time passes between event A and event B (ie how long does it take the ball to reach its highest point)?

[2 marks]

(ii) What was the value of the acceleration due to gravity, that Gheri used in his calculations.

[2 marks]

Yasmine, meanwhile, has used the equation $s = ut + \frac{1}{2}at^2$ to calculate the displacements corresponding to some of Gheri's velocities. These are given below:

Velocity ($m\ s^{-1}$)	32.0	22.5	13.2	4.9
Displacement (m)	0.0	27.1	44.4	51.9

On plotting these values, Yasmine finds that she does not get a straight line; instead, she gets a curve.

(c) describe how the data must be manipulated to obtain a straight line.
(Hint: what equation of motion would the graph represent?)

[4 marks]

(d) Carry out the manipulation of the data and insert the values that should be plotted in the spaces in the table (reproduced below). **Do not plot the graph.**

[2 marks]

Velocity ($m\ s^{-1}$)	32.0	22.5	13.2	4.9
Displacement (m)	0.0	27.1	44.4	51.9

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5. [16 marks total]
A modern X-ray tube is shown in the following figure.

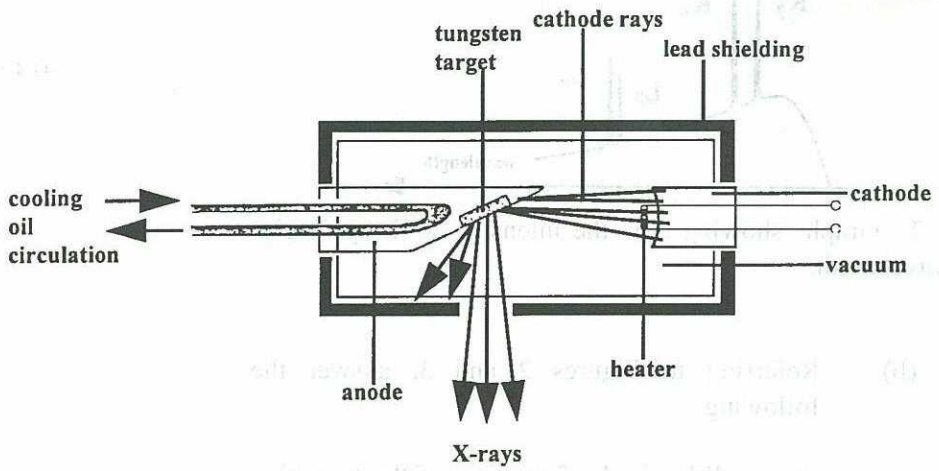


Figure 1. Modern X-ray tube

(a) Briefly answer the following questions

(i) What is the function of the cathode?

[1 mark]

(ii) Is the anode positively or negatively charged in relation to the cathode?

[1 mark]

(iii) Why does the anode need to be cooled?

[2 marks]

(iv) Explain why lead shielding surrounds the X-ray tube.

[2 marks]

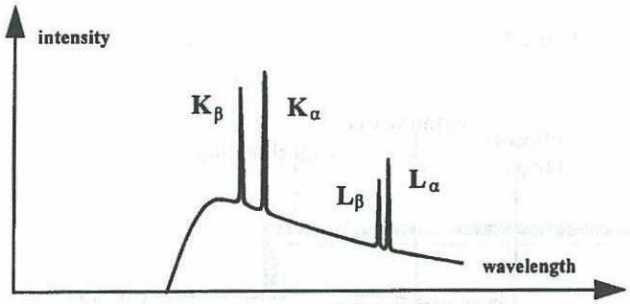


Figure 2. Graph showing how the intensity of X-rays varies with wavelength.

(b) Referring to Figures 2 and 3, answer the following:

(i) What is the frequency of the transition from -3.00 keV to -69.6 keV?

[4 marks]

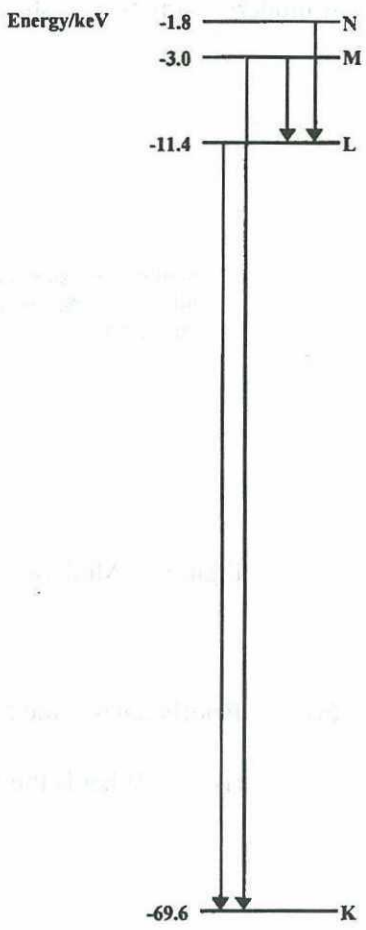


Figure 3. Some of the energy levels within an atom of tungsten. The energies involved are given in keV.

(ii) This transition is designated the K_β line. What is the minimum potential difference that must be applied across the X-ray tube to observe the K_β line?

[2 marks]

(c) In a context you have studied, describe one application of X-rays.

[4 marks]

Question 6A (page 22) refers to the context *Musical Instruments and Reproduction*
Question 6B (page 23) refers to the context *Speaking and Hearing*
You must answer only **ONE** of these questions, each worth 12 marks.

EITHER

6A. The quality of sound from a musical instrument depends on the presence of harmonics in the sound spectrum.

(a) What are harmonics?

[4 marks]

(b) If you play a single note with a fundamental frequency of 665 Hz on an instrument which behaves like a closed pipe, what will be the frequencies of the next two higher harmonics?

[4 marks]

(c) An instrument played softly produces a sound level reading of 40 decibels. The same sound amplified electronically produces a reading of 75 decibels. What is the ratio of the two intensities?

[4 marks]

OR

6B. The distinguishing quality of the human voice depends on the presence of harmonics (or formants) in the sound spectrum.

(a) What are harmonics?

[4 marks]

(b) The closed pipe is used as a model for the human vocal system. If you produce a vocal sound having a fundamental frequency of 665 Hz, what will be the frequencies of the next two higher harmonics?

[4 marks]

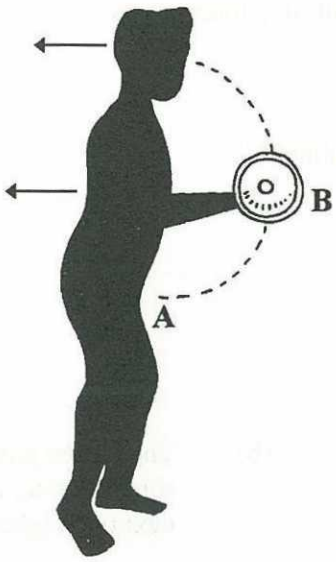
(c) A whisper has a sound level reading of 30 decibels, whereas normal conversation produces a reading of 65 decibels. What is the ratio of the two intensities?

[4 marks]

Question 7A (page24) refers to the context *Human and Animal Frames*
Question 7B (page25) refers to the context *Structures*
You must answer only **ONE** of these questions, each worth 12 marks.

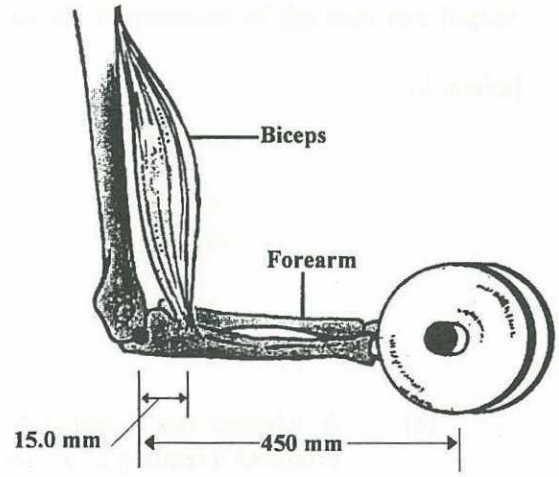
EITHER

7A. A weight training exercise commonly used in the gym to strengthen the upper arm muscles is to lift a heavy weight by holding the elbows in the same position and lifting the weight in a semi-circular motion by rotating the forearms as shown. A simplified diagram of the bones and muscles of the arm is shown below.



(a) Explain why it is necessary for the person to rock backwards slightly as the weight being lifted is moved from A to B.

[2 marks]



(b) Calculate the force required by the biceps on the forearm if the weight being lifted has a mass of 35.0 kg. Ignore the mass of the forearm.

[4 marks]

(c) In part (b), is it reasonable to ignore the mass (weight force) of the forearm? (Briefly explain your answer.)

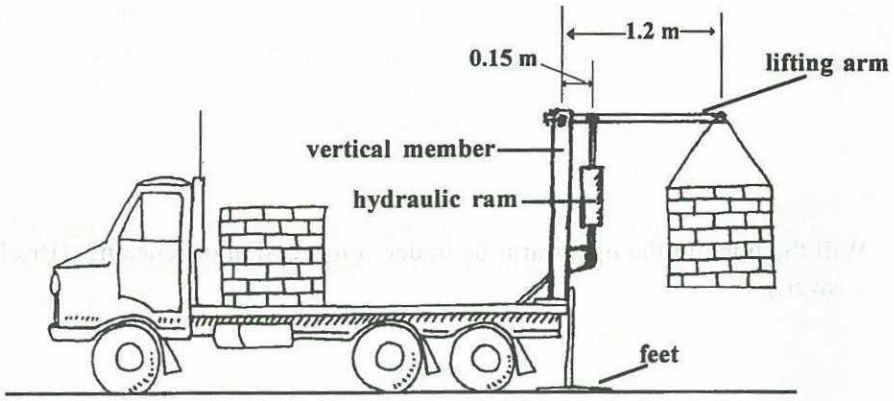
[3 marks]

(d) Will the bone in the upper arm be under compression or tension? (Briefly explain your answer.)

[3 marks]

OR

7B. When small quantities of bricks are delivered the truck driver unloads them using a lifting arm operated with a hydraulic ram as shown in the diagram. A pack of bricks on the truck is attached to the lifting arm and lifted until the arm is in the horizontal position. The arm can then be rotated and the bricks lowered to the ground.



(a) Before operating the device, the driver lowers two feet attached to the rear of the truck. Explain why these are necessary.

[2 marks]

(b) Calculate the force exerted by the hydraulic ram when holding a pack of bricks, with a mass of 1000kg, in the horizontal position. Ignore the mass of the lifting arm. Assume that the hydraulic ram acts vertically.

[4 marks]

(c) In part (b) is it reasonable to ignore the mass (weight force) of the lifting arm? Briefly explain your answer.

[3 marks]

(d) Will the vertical member be under compression or tension? Briefly explain your answer.

[3 marks]

SECTION C: Comprehension and Interpretation

Marks Allotted: 40 marks out of 200 (20%)

BOTH questions should be attempted. Each question is worth 20 marks.

Read each passage carefully and answer all of the questions referring to each passage. Candidates are reminded of the need for clear and concise presentation of the answers. Diagrams (sketches), equations and/or numerical results should be included if they are appropriate.

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1. Read the passage opposite (page 29) and answer the following questions

   (a) Why is it important to know the properties of natural gas with great accuracy?

   [2 marks]

   (b) What is the purpose of using a reference gas in the "Z" meter?

   [4 marks]

   (c) The equipment can work at high pressures, 400 bar. If 1 bar = 10^5 pascals (Pa), what is this pressure in pascals?

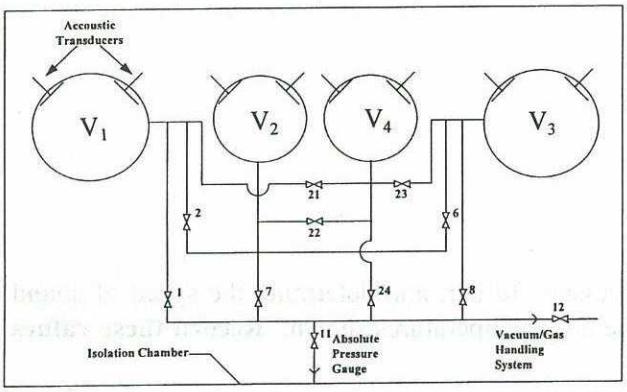
   [2 marks]

SEE NEXT PAGE

1. The Speed of Sound in Natural Gas at Pipeline Conditions

(Para 1)
The accurate measurement of high pressure natural gas flows is a major topic of concern in the European, American and Australian gas industries. High volumes are involved and errors in measurement translate into large dollar uncertainties. The errors can only be reduced by better knowledge of the properties of the natural gas over the full range of pipeline pressures and temperatures.

(Para 2)
The apparatus we have developed at Murdoch University enables us to measure the **speed of sound** in natural gas accurately over a range of pipeline conditions, and **simultaneously** measure the **compressibility** of the same gas sample.

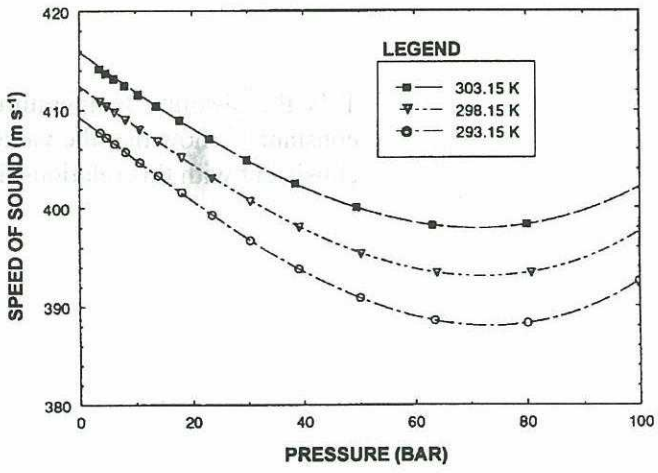


(Para 3)
The apparatus consists of four spheres, and is shown in the diagram. The larger spheres V_1 and V_3 are both 100.0 mm in diameter, the smaller spheres are 1/4 the volume of the large spheres. The spheres are constructed from stainless steel with 15 mm wall thickness, which allows operation at pressures in excess of 400 bar. Each sphere is equipped with two miniature acoustic transducers (capacitance microphones), one of which can be used to generate sound waves.

(Para 4)
Each of the pairs of spheres $\{V_1,V_2\}$, $\{V_3,V_4\}$ together with the absolute pressure gauge forms a "Z meter". In operation, the first pair of spheres contain sample gas, while the second pair contain a reference gas (argon, helium or nitrogen) with well known volumetric properties, enabling compressibilities to be measured either absolutely ($\{V_1,V_2\}$ alone) or relatively (with the expansions of the sample gas in $\{V_1,V_2\}$ being compared to similar expansions of the reference gas in $\{V_3, V_4\}$).

(Para 5)
The **speed of sound** in each sphere is measured using a resonance method. The speed of sound is a sensitive 'thermometer': the ratio of the speed of sound in V_1 to that in V_2 will depend only on the temperature difference between V_1 and V_2. Thus, monitoring the speed of sound ensures that the pressure measurements are made under conditions of constant temperature at equilibrium.

(Para 6)
A series of experiments on natural gas has produced the results shown in the graph, where the **speed of sound**, v, is plotted against pressure, p, at each of three temperatures.



Variation with pressure of the speed of sound in North West Shelf natural gas at 293.15 K, 298.15 K and 303.15 K.

SEE NEXT PAGE

(d) The speed of sound is found using a resonance technique. What is resonance? Give an example from one of the contexts that you have studied.

[4 marks]

(e) (i) On the graph, select the pressure 30 bar, and determine the speed of sound at this pressure for each of the three temperatures shown. **Record these values** in the table below.

[3 marks]

Temperature (K)	303.15	298.15	293.15
Speed of sound (m/s)			

(ii) The speed of sound varies with temperature according to the expression:

$$v = \sqrt{\frac{\gamma\, nRT}{DV}}$$

T is the absolute temperature. The density D, volume V, n, R, and γ are constants. Show that the values for the speed of sound (v) that you obtained are consistent with this relationship.

[5 marks]

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SEE NEXT PAGE

2. Tethered Satellite System Reflight

(Para 1)
The Tethered Satellite System Reflight (TSS-1R) was tested this year on the space shuttle mission STS-75. TSS-1R was designed to make use of Earth's magnetic field and electrically charged ionosphere, through which it is moving, to generate electrical current at a high voltage. The following edited extracts are from a NASA press kit produced before the mission's completion:

(Para 2)
The tether system consists of a battery-powered satellite (diameter = 1.6 m) secured by a strong, electrically conducting cord, or tether, to the satellite support structure attached to the orbiting Shuttle. Data gathering instruments are mounted in the Shuttle's cargo bay and mid-deck area, and on the satellite. During the second day in orbit, the STS-75 crew will attempt to fully reel the satellite out on its tether — which looks like a long white shoelace — to a distance 20.7 km away from the Shuttle.

(Para 3)
A small portion of the mechanical energy of the Shuttle's 7.92 km s^{-1} orbital motion will be converted into electrical energy as the electrically conducting metal strands in the tether's core pass through Earth's magnetic field lines. It is anticipated that voltages of 5000 V across the tether can be produced in this way.

(Para 4)
The conductive outer skin of the Tethered satellite will attract free electrons from the Earth's ionosphere, which will then flow down the conductive tether to the Shuttle. An electron gun on the Shuttle will then eject them back into the ionosphere to complete the loop required to close the circuit, just as a wire must close the circuit between the positive and negative poles of a car battery before a current will flow.

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2. [20 marks total]
Read the passage opposite (page 32) and answer the following questions.

(a) If a voltage of 5000 volts is created across the tether, how is this voltage produced?

[2 marks]

(b) The circuit is able to produce 1.5 kW of power for use on the shuttle.

(i) How is the circuit completed (closed)?

[2 marks]

(ii) Find the magnitude and direction of the conventional current in the tether.

[4 marks]

(iii) What effect over time does this generation of electrical energy have on the speed and orbital radius of the shuttle and tethered satellite system? *Do not calculate.* (Para 3)

[4 marks]

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(c) Unfortunately the tether broke before the satellite was fully reeled out. Assuming that the aluminium cable is 2.5 mm in diameter, calculate the minimum force (tension) needed to break the tether.

[4 marks]

(d) Why is there a tension in the tether? (Where does the force come from?)
Hint: what are the relative heights of the satellite and shuttle?

[4 marks]

END OF PAPER

ACKNOWLEDGMENTS

Material in this paper has been obtained from the following sources:

QC1 NASA, "Tethered Satellite System Reflight (TSS-1R)", STS-75 Press Kit, March 1, 1996.

QC2 Terry Edwards, Research Grant Application, Murdoch University, 1995.
Derek Fawcett, "Measurement and Prediction of Speed of Sound, with Application to Gas Flow Metering in Australian Natural Gases", PhD Thesis, Murdoch University, 1996.