TEST CODE **002472**

FORM TP 22246

MAY/JUNE 2002

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 02

2 hours and 15 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This paper consists of NINE questions.
2. Section A consists of THREE questions. Candidates must attempt ALL questions in this section. Answers for this section must be written in this answer booklet.
3. Section B consists of SIX questions. Candidates must attempt THREE questions in this section, ONE question from EACH Module. Answers for this section must be written in the answer booklet provided.
4. All working MUST be CLEARLY shown.
5. The use of non-programmable calculators is permitted.

NOTHING HAS BEEN OMITTED.

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LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.80 m s^{-2}
Radius of the Earth	R_E	=	6380 km
Mass of the Earth	M_E	=	5.98×10^{24} kg
Mass of the Moon	M_M	=	7.35×10^{22} kg
1 Atmosphere	Atm	=	1.00×10^{5} N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water		=	1.00×10^{3} kg m^{-3}
Thermal conductivity of copper		=	400 W m^{-1} K^{-1}
Specific heat capacity of aluminium		=	910 J kg^{-1} K^{-1}
Specific heat capacity of copper		=	387 J kg^{-1} K^{-1}
Specific heat capacity of water		=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice		=	3.34×10^{5} J kg^{-1}
Specific latent heat of vaporization of water		=	2.26×10^{6} J kg^{-1}
Avogadro's number	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan-Boltzmann constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in vacuum	c	=	3.0×10^{8} m s^{-1}

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SECTION A

Attempt ALL questions. You MUST write in this answer booklet. You must NOT spend more than 30 minutes on this section.

1. Figure 1 below shows a piece of lead which fits snugly into a glass tube of length 4 metres. The lead sits on a column of compressed air. The valve at B can be released so that the air can expand rapidly and the water can rush in and together they can accelerate the lead.

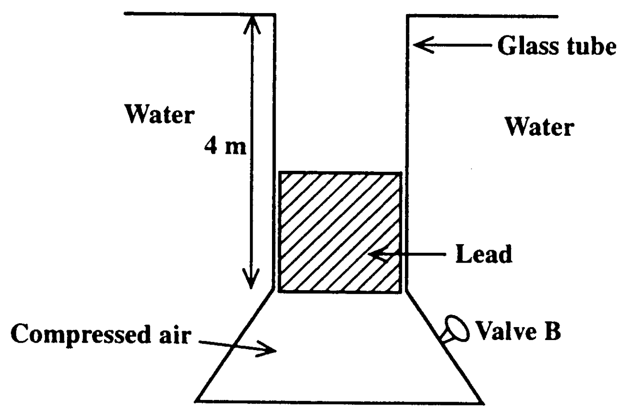

Figure 1

The table below shows how the net force on the lead varies with the distance travelled up the glass tube after the value is released.

Force (N)	Distance (m)
1220	0
1193	0.4
1132	0.8
1045	1.2
906	1.6
740	2.0
557	2.4
400	2.8
261	3.2
122	3.6
0	4.0

(a) Using the values in the table above, plot a graph on page 5 of force against distance. **[4 marks]**

1. (b) Use the graph you have plotted on page 5 to estimate the work done on the lead to bring it to the surface.

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[2 marks]

(c) Stating any assumptions you made, calculate the speed at which the lead of mass 1 kg exits the glass tube.

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[4 marks]

Total 10 marks

2. (a) (i) Describe an experiment to investigate the effect of damping on the amplitude of a mass-spring system.

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[4 marks]

(ii) What adjustments can you make to the experiment in order to investigate whether the damping is constant or not?

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[1 mark]

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2. (b)

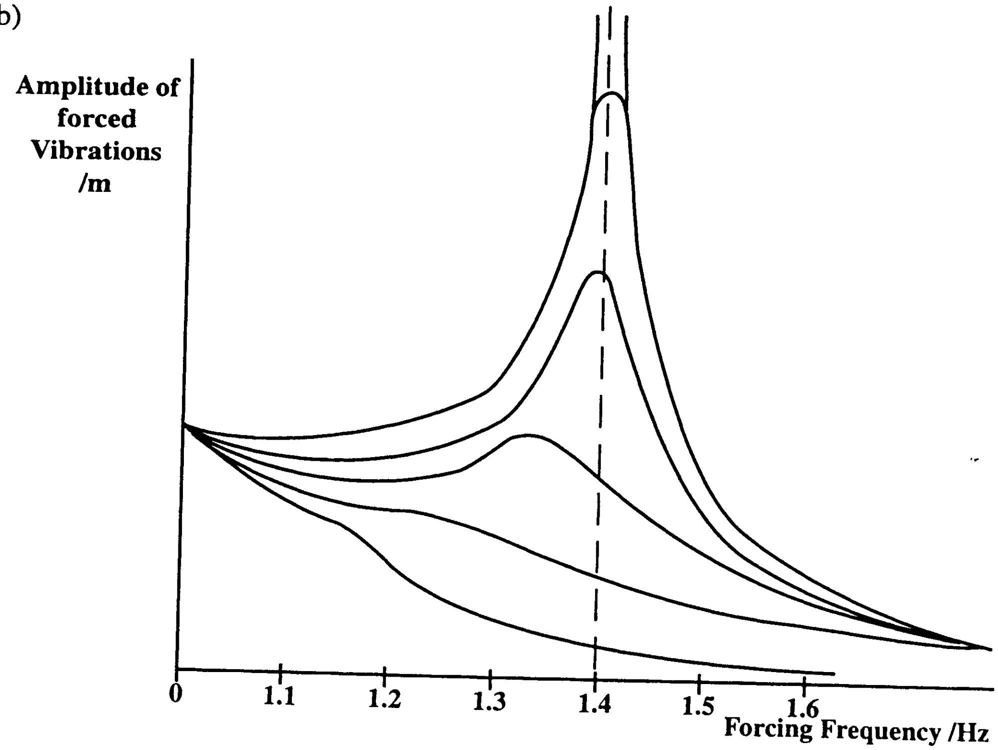

Figure 2

The graph in Figure 2 shows the amplitude response curves for a mass-spring system when it is subjected to forced oscillations and damping.

(i) The mass has value 250 g and the spring constant is 20 Nm^{-1}. Given that the natural frequency, f_o, of the system is given by

$$f_o = \frac{1}{2\pi}\sqrt{k/m}$$

Calculate the value of f_o.

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[3 marks]

(ii) What is the value of the natural frequency on the graph?

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[1 mark]

(iii) What effect occurs at this position?

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[1 mark]

Total 10 marks

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3. (a) A thermocouple can be made by carefully placing a cold junction in melting ice and heating the hot junction.

(i) Draw a suitable circuit diagram to show how the thermocouple is constructed.

[3 marks]

(ii) Why is it suitable to take temperature readings of a substance when it is cooling down rather than while it is heating up?

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[1 mark]

(iii) How can the thermocouple thermometer be made to respond better to changes in temperature?

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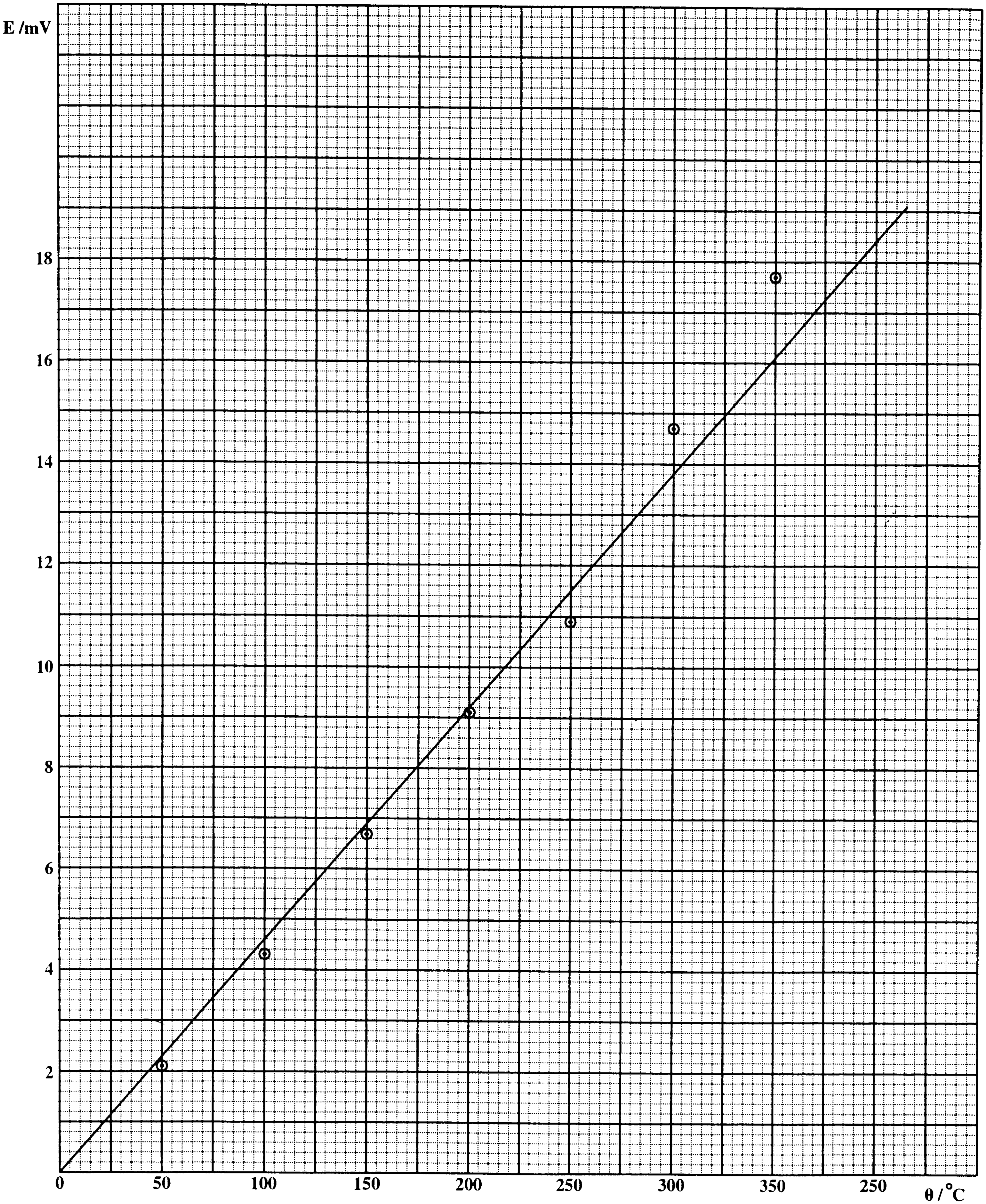
[2 marks]

A Graph of Emf / mV vs θ /°C



3. (b) (i) The graph on page 10 shows how the e.m.f. of a thermocouple varies with temperature. The thermocouple measured 6.64 mV when the hot junction was placed in boiling water at 100 °C. From the graph find the temperature of the hot junction when the e.m.f. is 14 mV.

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[1 mark]

(ii) It is found that the Celsius temperature can be calculated from

$$\theta = \frac{E_\theta - E_o}{E_{100} - E_o} \times 100\ ^\circ C$$

where E_θ , E_o and E_{100} are the respective e.m.f.s at the unknown temperature θ, the ice point and the steam point.

Use this formula to calculate the temperature when the e.m.f. is 14 m V.

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[2 marks]

(ii) Account for the different values of temperature in (b) (i) and (b) (ii).

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[1 mark]

Total 10 marks

SECTION B

You must attempt THREE questions from this section. Choose ONE question EACH from Module 1, 2 and 3. You MUST write your answers in the answer booklet provided.

MODULE 1

Answer EITHER Question 4 OR Question 5.

4. (a) State the difference between scalar and vector quantities and give ONE example of EACH.

[4 marks]

(b) Two tugs, P and Q, tow a ship along the direction BO at constant speed as seen in Figure 3. Tug P exerts a force of 35 kN at an angle of 20° to BO. Tug Q pulls with a force of 20 kN at an angle θ to BO.

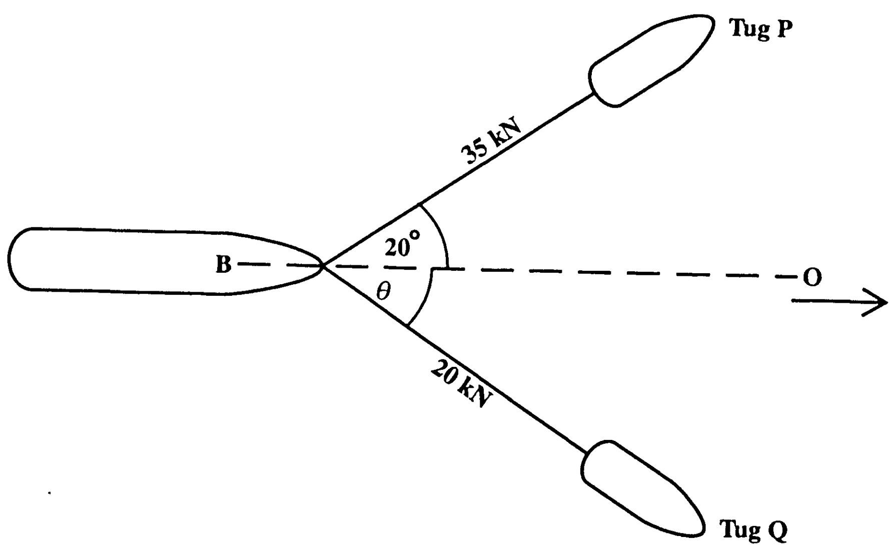

Figure 3

(i) If the resultant force acts along BO, find the angle θ.

(ii) Calculate a value of this resultant force.

[6 marks]

(c) The ship is travelling at 1.5 m/s when it is being towed. What is the velocity of Tug P and Tug Q?

[6 marks]

(d) If both cables break simultaneously and it is observed that the two tugs speed up while the ship slows down, explain what principle is observed and why energy is NOT conserved.

[4 marks]

Total 20 marks

5. (a) Our solar system is in the Milky Way galaxy. In another galaxy a planet, P, has a circular orbit equal to that of the Earth's, that is, the orbits have the same radius. The masses of the suns in the two galaxies are S_E and S_P respectively and planet P completes its orbit in half the time it takes the Earth.

(i) Show that the mass of the Sun in the Earth's orbit is four times the mass of the sun in Planet P's orbit.

(ii) Show that the period of the planet, P, is given by $T = 2\pi\sqrt{\frac{r^3}{GM_p}}$ where M_P is the mass of the planet and r the radius of the orbit.

[8 marks]

(b) The distance between Earth and planet, P, is 2.0×10^{21} m. If the mass of the planet, P, is 7×10^{24} kg, calculate the gravitational force of attraction. **[2 marks]**

(c) Calculate the distance between the planet and its sun. **[3 marks]**

(d) Calculate a value for g' the acceleration due to gravity on planet P given that the radius of the planet P is 8500 km. **[4 marks]**

(e) An astronaut weighs 585 N on earth. What will he weigh on planet P?

[3 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 OR Question 7.

6. (a) Define the term 'principal focus of a lens'. **[2 marks]**

(b) Draw a ray diagram to illustrate the formation of the image of an extended object by a convex lens when the object is at a distance from the lens, greater than the focal length of the lens, but less than twice the focal length. **[2 marks]**

(c) (i) Draw a ray diagram to show how an image is formed in a diverging lens.

(ii) Compare the images formed in (b) and (c) (i). **[4 marks]**

(d) An overhead projector lens has a focal length of 35 cm. The image of a transparency is formed 2 m from the lens, that is, the total path length from lens to screen is 2.0 m.

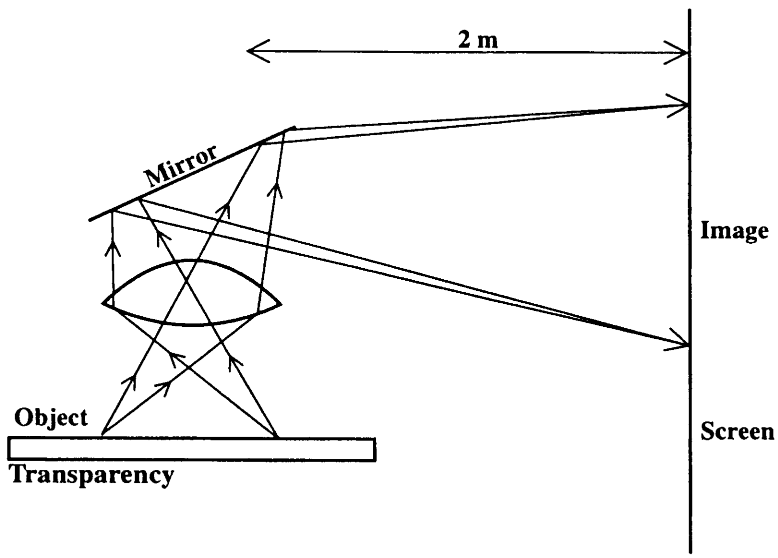

Figure 4

(i) How far above the transparency must the lens be held in order for the image to be formed on the screen?

(ii) What is the magnifying power of the lens and how does this affect image formed? **[6 marks]**

(e) The focal length of a lens can be found by measuring several values of image distance V, corresponding to different values of the object distance U, using a pin or no parallax method.

Explain how, by plotting a suitable graph, the focal length of the lens could be determined from the data collected. Include a sketch of the graph you would expect to obtain. **[6 marks]**

Total 20 marks

7. (a) It is observed that fifteen crests of water waves pass a certain point in 21.5 s. The distance between two successive crests is 4.10 m. What is the speed of the wave?

[4 marks]

(b) (i) Describe, with the aid of a labelled diagram, an experiment to demonstrate interference of sound waves.

(ii) Why are sound waves described as progressive longitudinal waves?

[8 marks]

(c) (i) The velocity of a transverse wave on a wire stretched between two fixed points is

$$v = \sqrt{T/u}$$

where T is the tension of the wave and u is its mass per unit length. A piano wire is 75 cm long and of mass 7.5 g. The wire is stretched with a tension of 400 N.

Use the equation above to calculate the velocity of a wave along the string.

(ii) If the wire has length l, the fundamental frequency is given by $f = \frac{v}{2l}$, where v is the velocity of the wave.

Calculate this frequency. What can you say about the wavelength of the wave?

(iii) Calculate the change in the intensity level when the power output from a piano changes from 100 mW to 200 mW. **[8 marks]**

Total 20 marks

MODULE 3

Answer EITHER Question 8 OR Question 9.

8. Figure 5 shows a piece of equipment which allows steam at a very high temperature to be blown through the pipe at A and eventually causing the light frictionless piston at D to just push on the switch at E. Originally the equipment is at 25°C, then steam is blown through the pipe at A.

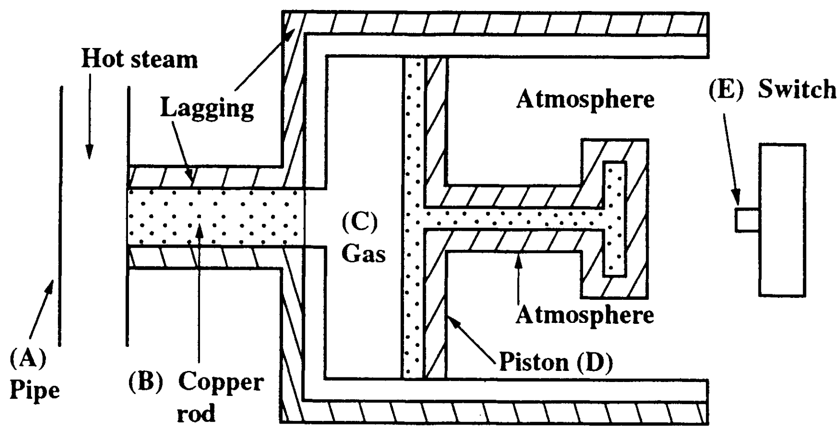

Figure 5

(a) (i) Name the process by which heat is supplied to the gas at C via the copper rod at B.

(ii) Use the kinetic theory to explain why the piston at D eventually pushes on the switch at E.

(iii) Why must the copper rod be lagged and the piston light and frictionless?

[8 marks]

(b) 126 J of heat is supplied to the gas at C via the copper rod at B. 90 J of the energy supplied to the gas is used up as work done by the gas to push back the piston.

(i) Calculate an estimate for the change of internal energy of the gas at C.

(ii) Why is the actual value for the change of internal energy of the gas at C lower than the value you calculated in (b) (i) above.

(iii) Helium gas is contained in the vessel. The gas occupies a volume of 1.0×10^{-3} m^3 at a pressure of 1.0×10^5 Pa and temperature of 25°C.

Calculate the

a) number of moles of helium atoms in the container

b) total kinetic energy of the helium atoms. **[9 marks]**

(c) When the piston at D pushes on the switch at E, the flow of hot steam is turned off. Explain what happens to the piston at D and why. **[3 marks]**

Total 20 marks

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9. (a) Define 'tensile stress' and 'tensile strain'. **[2 marks]**

(b) A wire is stretched by a force, F, which causes an extension, e. Hooke's law relates F to e by

$$F = ke$$

Show how is k related to the Young's Modulus E of the wire. **[3 marks]**

(c) A load of 30 N is hung from a copper wire 5 m long and 1.0 mm in diameter to keep it taut as shown in Figure 6. The position of the lower end of the wire was read on a scale.

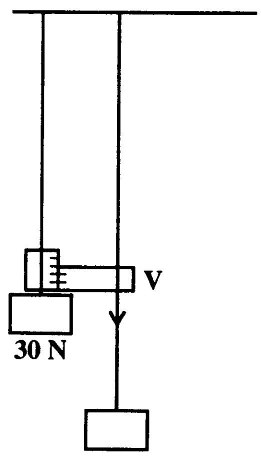

Figure 6

Weights are then added and the corresponding increase in lengths is read off from the scale. The readings were recorded in the table below.

Weight (N)	30	40	50	60	70	80	90	100	105	110
Extension/ m x 10^{-3}	1.40	1.80	2.35	2.80	3.25	3.70	4.30	4.85	5.05	5.25

(i) Plot a graph of load against extension using the values from the table.

(ii) Use the graph plotted in (c) (i) to calculate the Young Modulus of Copper.

(iii) What is the maximum load that can be supported by the wire?

(iv) What was the stress at the proportional limit?

(v) Calculate the elastic energy stored in the wire just before the wire became permanently stretched. **[15 marks]**

Total 20 marks

END OF TEST