FORM TP 2005259

TEST CODE **02138020**

MAY/JUNE 2005

CARIBBEAN EXAMINATIONS COUNCIL

ADVANCED PROFICIENCY EXAMINATION

PHYSICS

UNIT 01 – Paper 02

2 hours 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.

The following grid refers to question 1.

GO ON TO THE NEXT PAGE

SECTION A

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

1. The following data were collected in a terminal velocity experiment. Small metal spheres were timed over a distance of **80.0 cm** as they fell at constant velocity in thick engine oil.

Table 1

Radius r/mm	Time/s	Velocity v/cm s^{-1}	lg (v/cm s^{-1})	lg (r/ mm)
1.00	44.8			
1.49	20.1			
2.02	11.3			
2.51	7.2			
2.99	5.0			

It is suggested that the terminal velocity v is related to the radius r by the formula

$v = k\,r^n$ where k and n are constants.

(a) Complete Table 1 and plot a suitable graph on the grid on page 4 to enable you to find the value of n. (Note that it is NOT necessary to convert the units to metres.)

[7 marks]

(b) Write the equation of the graph you have drawn.

____

[1 mark]

(c) What is the MOST likely value of the constant n?

____

____

____

[2 marks]

Total 10 marks

2. TWO steel pendulum bobs are suspended in such a way that the heavy one drives the lighter one when it oscillates. (See Figure I) The length of the heavy pendulum is fixed at 40.0 cm but the length L of the lighter one can be varied.

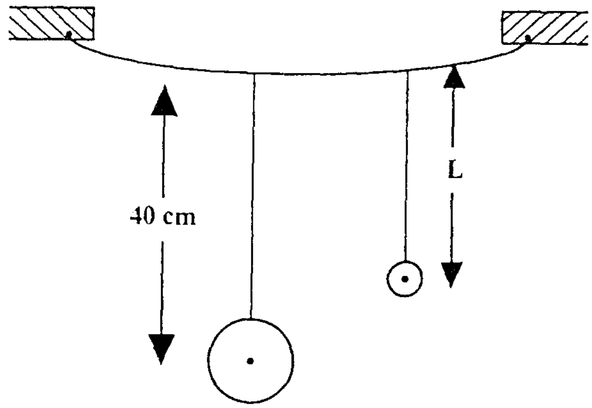

Figure I

The data in Table 2 shows the amplitude of oscillation of the small pendulum for various lengths. The large pendulum bob had a constant amplitude of 5.0 cm each time.

Table 2

L/cm	amplitude/cm
32.0	1.7
34.0	2.0
36.0	2.7
38.0	4.5
40.0	11.0
42.0	8.0
44.0	4.0
46.0	2.5
39.0	9.0
41.0	10.0

(a) On the grid provided on page 6, plot a graph to show how the amplitude of the driven pendulum varies with its length. **[5 marks]**

(b) The last TWO readings in Table 2 seem to be extra readings. Why did the experimenter consider it necessary to go back and take these extra readings?

____

____

[1 mark]

(c) Calculate the period and frequency of the heavy pendulum.

____

____

____

____

____

[3 marks]

(d) What is the resonant frequency of the light pendulum?

____

____

[1 mark]

Total 10 marks

3. The following instruments were used in an electrical method to determine the specific heat capacity of a metal using the equation $VIt = mc\,\Delta\theta$. The metal sample was in the form of a cylinder with holes drilled for a heater and a thermometer.

Moving coil voltmeter	0 – 10 V	smallest division 0.2 V
Moving coil ammeter	0 – 5 A	smallest division 0.1 A
Stop clock		smallest division 0.01 s.
Balance	0 – 1000 g	smallest division 10 g
Mercury thermometer		smallest division 1°C

(a) Complete Table 3 to show the estimated uncertainty (random error) in EACH measurement.

Table 3

Quantity	**Value**	**Uncertainty**
mass, m	930 g	±
initial temp θ_1	28.0°C	±
final temp θ_2	51.8°C	±
p.d., V	9.8 V	±
current, I	4.3 A	±
time, t	500 s	negligible

[4 marks]

GO ON TO THE NEXT PAGE

(b) Calculate the value of the specific heat capacity given by this experiment TOGETHER with the uncertainty in the value.

[4 marks]

(c) Suggest TWO ways in which the systematic error in this experiment could be reduced.

____

____

____

____

[2 marks]

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) Figures II (a) and II (b) show an apparatus known as Newton's cradle, consisting of 5 identical spheres hung from a frame. It is used to demonstrate elastic collisions.

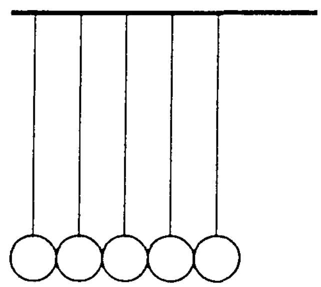

Figure II (a)

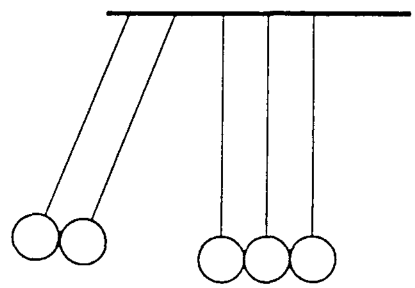

Figure II (b)

(i) Define the term '*momentum*.'

(ii) Which TWO physical quantities are conserved in an elastic collision?

(iii) TWO of the spheres, each of mass m, are pulled to one side as shown in Figure II (b) and released so that they strike the others with velocity v. A student observing the demonstration predicts that immediately after the collision ONE sphere will move off from the other side with velocity $2v$ while the first TWO spheres come to rest.

Show that this is NOT possible since only one of the two quantities in (a) (ii) is conserved.

(iv) In fact in the above demonstration the incoming spheres come to rest but TWO spheres move off together on the other side with velocity v. Show that BOTH the conservation laws are now satisfied.

[8 marks]

(b) In a crash test a car of mass 1200 kg hits a wall and recoils. The initial velocity of the car is 20 m s^{-1} and it bounces back at 1.5 m s^{-1} as shown in Figure III. The contact with the wall lasts for 0.18 s.

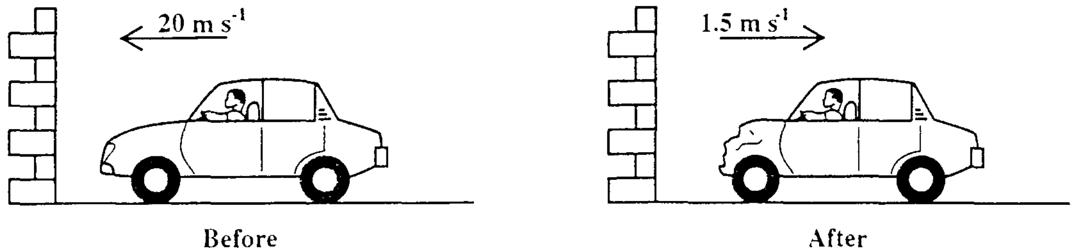

Figure III

(i) What is the change of momentum of the car during this collision?

(ii) Find the impulse of the force acting on the car.

(iii) Sketch a graph to show the typical variation of force with time during a collision like this and state what the area under the graph represents.

(iv) Find the average force acting on the car during the collision.

(v) Discuss why modern cars are designed to crumple in a head-on collision. Illustrate your answer with a sketch graph (labelled CRASH 2) using the same scale as in part (b) (iii) to show how the force varies with time when a car crumples more than the one in the diagram.

[12 marks]

Total 20 marks

5. (a) (i) Explain using Newton's laws how the propeller of a light aeroplane like the one shown in Figure IV is able to provide forward thrust.

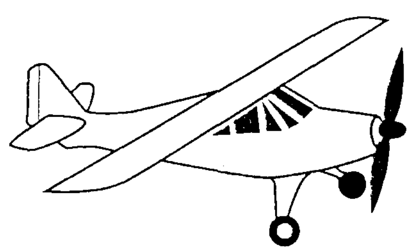

Figure IV

(ii) The forward thrust caused by the propeller of an aeroplane is 18 000 N and the air flowing through it leaves with a velocity of 250 m s^{-1}. What mass of air must pass through the propeller EACH second? **[5 marks]**

GO ON TO THE NEXT PAGE

(b) In order to turn, an aeroplane must "bank" as shown in Figure V, so that the lift force is no longer vertical. (Assume that the aeroplane remains in level flight and travels at constant speed.)

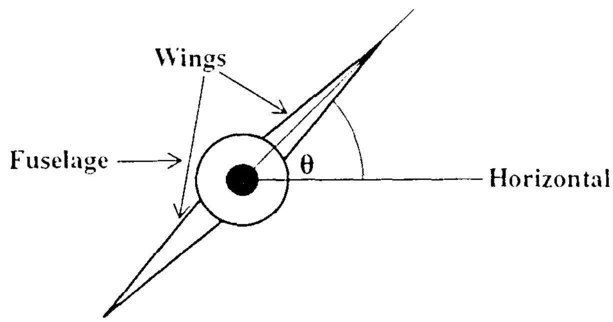

Figure V

(i) Draw a diagram like the one in Figure V with arrows to show the direction of the external forces acting on the aeroplane as it turns. On a second, similar diagram show the direction of the RESULTANT force acting on the plane.

(ii) Calculate the radius of the circular path for a plane of mass 3 000 kg with a horizontal speed of 120 km per hour if the resultant force acting is 16 000 N.

(iii) Find the size of the lift force on the plane and the banking angle θ.

(iv) Each passenger on the light aeroplane must also experience a resultant unbalanced force to move in a circular path. With the aid of a diagram state how this force is provided.

[15 marks]

Total 20 marks

MODULE 2

Answer EITHER Question 6 OR Question 7.

6. (a) Explain the physical principles of the production of spectra by diffraction gratings. Include in your account an explanation of how the zero order, first order and second order spectra are produced. **[5 marks]**

(b) (i) A source emits a mixture of monochromatic red and monochromatic yellow light. Draw a ray diagram to show the production of the zero, first and second order spectra of this light from this source by a diffraction grating.

(ii) The diffraction grating produces a second order spectrum for the red light of wavelength 630 nm at an angle of 43.9° from the normal to the grating. What is the spacing of the lines in the grating? How many lines per millimetre does the grating have?

(iii) Find the angle of deviation from the normal for the first order red light and first order yellow light of wavelength 570 nm.

(iv) Show that the yellow light produces a 3rd order spectrum but the red light can only produce two orders with this grating. **[15 marks]**

Total 20 marks

GO ON TO THE NEXT PAGE

7. (a) (i) Derive the formula $y = \lambda D/a$ for interference of light waves from a double slit where y is the spacing of the fringes on a screen at a distance D from a double slit with spacing a and λ is the wavelength of the monochromatic light producing the interference pattern.

(ii) Explain why the formula gives only an approximate value. **[8 marks]**

(b) TWO loudspeakers connected in parallel to a signal generator are used to demonstrate the interference of sound waves in an experiment analogous to that for light. Figure VI illustrates the experiment set up.

As a microphone is moved along the line YX it detects a maximum of sound intensity at O and then another maximum at X.

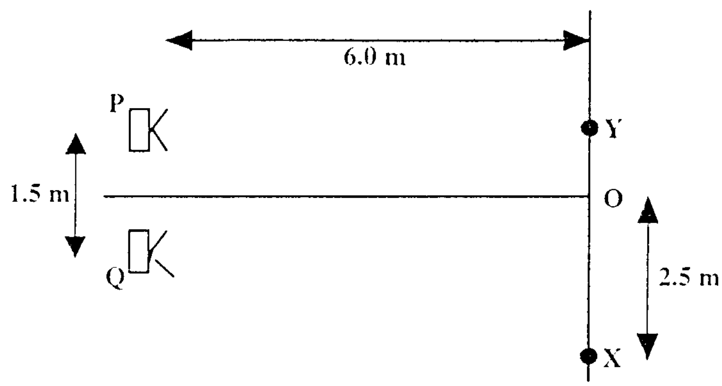

Figure VI

(i) Find the distances PX and QX from the speakers to the first maximum at X and hence find the wavelength of the sound waves.

(ii) What value does the formula $y = \lambda D/a$ give for the wavelength of the sound waves?

(iii) Discuss the fact that the values given in (b) (i) and (ii) are different.

(iv) What is the frequency of the sound from the speakers?

(v) The phase of speaker P is changed by 180°. What effect will this have on the sound heard at points O and X ?

Data:
[Velocity of sound in air = 330 ms^{-1}]

[12 marks]

Total 20 marks

MODULE 3

Answer EITHER Question 8 OR Question 9.

8. (a) (i) Write the formula for linear heat flow by conduction explaining EACH of the terms in the equation carefully.

(ii) When measuring the thermal conductivity of a sample of metal in the form of a cylinder it is usual for the cylinder to be about 20 cm long with a diameter of about 3 cm. Outline THREE reasons why these dimensions are suitable.

(iii) What is the MAIN potential source of error in an experiment like this and how is it overcome?

[8 marks]

(b) A home-made cooler is constructed from plywood and foam plastic. The walls consist of two pieces of plywood 1.0 cm thick with a 1 cm layer of foam plastic in between. When in use the temperature inside the box is 2 °C while the outside temperature is 30 °C.

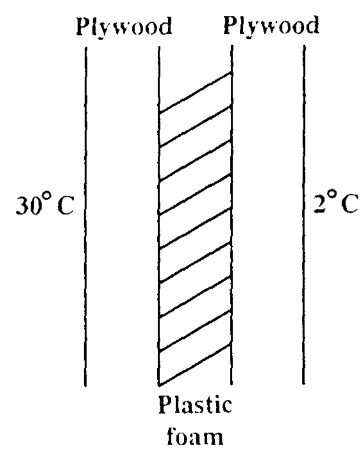

Figure VII

(i) Sketch a graph to show how the temperature varies across the wall of the box.

(ii) The thermal conductivity of plywood is 0.24 W m^{-1} K^{-1} whilst that of the plastic foam is 0.012 W m^{-1} K^{-1}. Calculate the thickness of a piece of plywood which would have the same insulating effect as 1 cm of foam.

(iii) Using this equivalent thickness, or otherwise, find the rate of conduction of heat through a rectangular wall of the box which is 0.6 m by 0.4 m and deduce the temperatures at the two interfaces between plywood and plastic foam.

[12 marks]

Total 20 marks

GO ON TO THE NEXT PAGE

9. (a) (i) Explain why the molecules of a gas do not all move at the same speed.

(ii) What is the meaning of the term *r.m.s. speed*? How is it calculated?

(iii) Derive the expression relating the *r.m.s. speed* of the molecules of an ideal gas to the pressure exerted by the gas:

$$pV = \frac{1}{3} Nm\,\overline{c^2}$$

[8 marks]

(b) A volume of 0.14 m^3 of helium (molar mass 4 g/mol) at a temperature of 400 K has a pressure of 1.6 x 10^5 Pa.

(i) What is the mass of the helium?

(ii) Find the *r.m.s. speed* of the helium molecules.

(iii) What would be the *r.m.s. speed* of oxygen molecules (molar mass 32 g/mol) at the same temperature of 400 K?

[12 marks]

Total 20 marks

END OF TEST