TEST CODE **02138020**

FORM TP 2018292

MAY/JUNE 2018

CARIBBEAN EXAMINATIONS COUNCIL

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of SIX questions in TWO sections. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. ALL WORKING MUST BE SHOWN in this booklet.
5. You may use a silent, non-programmable calculator to answer questions, but you should note that the use of an inappropriate number of figures in answers will be penalized.
6. If you need to rewrite any answer and there is not enough space to do so on the original page, you must use the extra lined page(s) provided at the back of this booklet. **Remember to draw a line through your original answer.**
7. **If you use the extra page(s) you MUST write the question number clearly in the box provided at the top of the extra page(s) and, where relevant, include the question part beside the answer.**

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD TO DO SO.

LIST OF PHYSICAL CONSTANTS

Universal gravitational constant	G	=	6.67×10^{-11} N m^2 kg^{-2}
Acceleration due to gravity	g	=	9.81 m s^{-2}
1 Atmosphere	atm	=	1.00×10^5 N m^{-2}
Boltzmann's constant	k	=	1.38×10^{-23} J K^{-1}
Density of water	ρ_w	=	1.00×10^3 kg m^{-3}
Specific heat capacity of water	C_w	=	4200 J kg^{-1} K^{-1}
Specific latent heat of fusion of ice	L_f	=	3.34×10^5 J kg^{-1}
Specific latent heat of vaporization of water	L_v	=	2.26×10^6 J kg^{-1}
Avogadro's constant	N_A	=	6.02×10^{23} per mole
Molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
Stefan–Boltzmann's constant	σ	=	5.67×10^{-8} W m^{-2} K^{-4}
Speed of light in free space (vacuum)	c	=	3.00×10^8 m s^{-1}
Speed of sound in air	c	=	340 m s^{-1}
Planck's constant	h	=	6.626×10^{-34} J s
Triple point temperature	T_{tr}	=	273.16 K
1 tonne	t	=	1000 kg

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SECTION A

Answer ALL questions.

1. (a) State Newton's first law of motion.

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[2 marks]

(b) A student throws a ball of mass 0.02 kg vertically upwards into the air with an initial velocity of 25 m s^{-1} and catches it 6.0 seconds after the time of release. Table 1 shows how the velocity, v, of the ball changes with time, t, from the time of release to the time it is caught by the student.

TABLE 1: VELOCITY WITH TIME

Velocity, v (m s^{-1})	Time, t (s)
25.0	0.0
15.0	1.0
6.5	2.0
0.5	3.0
–4.5	4.0
–14.0	5.0
–31.5	6.0

(i) On the grid provided in Figure 1 **on page 7**, plot a graph of velocity, v, versus time, t. Draw the line of best fit through the points. **[5 marks]**

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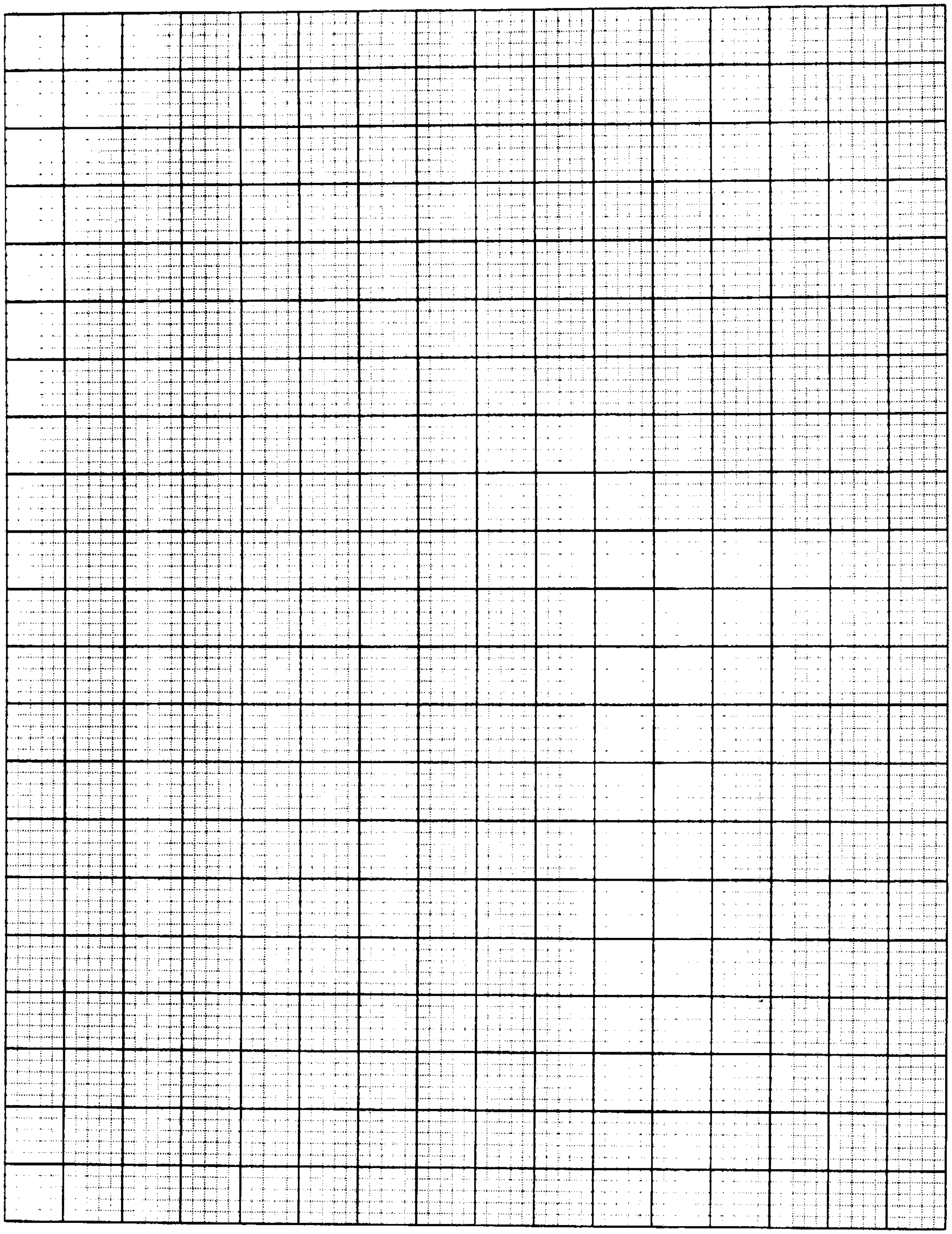

Figure 1. Velocity, *v*, versus time, *t*

(ii) From your graph, determine the time at which the ball reaches its maximum height.

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[1 mark]

(iii) Hence, or otherwise, determine the maximum height reached above the point of release.

[3 marks]

(iv) Calculate the maximum potential energy gained by the ball in this throw.

[2 marks]

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(v) The maximum potential energy calculated in (b) (iv) assumes that air resistance is negligible. Explain how this result would be affected if air resistance was significant.

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[2 marks]

Total 15 marks

2. (a) Define EACH of the following terms which are used to describe sound waves.

(i) Loudness

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(ii) Pitch

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(iii) Quality

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[3 marks]

(b) The tone heard when a person blows across the top of a bottle partially filled with liquid (as shown in Figure 2) is due to cavity resonance.

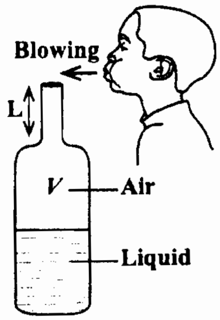

Figure 2. Cavity resonance

The frequency, f, of the tone depends on the volume, V, of air in the bottle and they are related by the following formula:

$$f = \frac{c}{2\pi}\sqrt{\frac{A}{LV}}$$

Where c = velocity of sound in the air cavity in the bottle
A = cross-sectional area of the neck of the bottle
L = length of the neck of the bottle
V = volume of air in the air cavity in the bottle

In an experiment to investigate cavity resonance, the following values for f and V in Table 2 were obtained.

TABLE 2: FREQUENCY WITH VOLUME

Frequency f (Hz)	Volume V (m^3)	$\frac{1}{\sqrt{V}}$
225	250×10^{-6}	
255	200×10^{-6}	
290	150×10^{-6}	
320	125×10^{-6}	
350	100×10^{-6}	
400	80×10^{-6}	
445	65×10^{-6}	

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Figure 3. f vs $\frac{1}{\sqrt{V}}$

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(i) Complete Column 3 in Table 5 on page 12. **[2 marks]**

(ii) Using an appropriate scale, plot a graph of f against $\frac{I}{\sqrt{V}}$ on the grid provided in Figure 3 **on page 13**. Draw the line of best fit through the points. **[4 marks]**

(iii) Determine the gradient of the graph.

[3 marks]

(c) The bottle used in the experiment had a neck length of 5.8×10^{-2} m. The cross-sectional area of the bottle's neck was 2.50×10^{-4} m^2. Use this data along with your answer in **(b) (iii)** to determine the velocity of sound in the bottle.

[3 marks]

Total 15 marks

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3. (a) With the aid of a diagram, describe an experiment to accurately determine the Young's modulus of a metal wire.

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[6 marks]

(b) Figure 4 is a plot of the results from an experiment in which a metal wire was stretched.

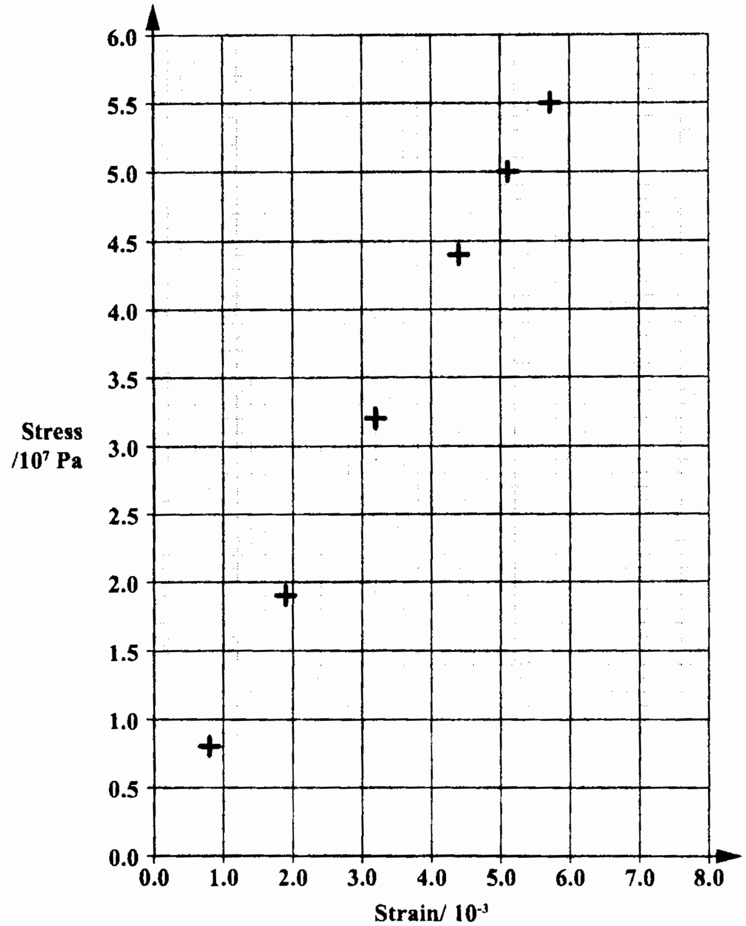

Figure 4. Stress vs strain for metal wire

(i) Draw the line of best fit through the data points. **[1 mark]**

(ii) If the area under the graph represents the energy stored per unit volume of the wire, determine the energy stored in one cubic millimetre of the wire.

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[3 marks]

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(c) A cylindrical copper wire and a cylindrical steel wire, each of length 1.5 m and diameter 2 mm, are joined to form a composite wire 3 m long. The composite wire is loaded until its length becomes 3.0003 m.

Young's modulus for copper = 1.2×10^{11} N m^{-2}
Young's modulus for steel = 2.0×10^{11} N m^{-2}

(i) Calculate the ratio of the strain in the steel wire to the strain in the copper wire.

[2 marks]

(ii) Hence, calculate the extension of the copper wire.

[3 marks]

Total 15 marks

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SECTION B

Answer ALL questions.

4. (a) Discuss the nature, cause and effect of frictional forces.

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[6 marks]

(b) A uniform ladder 5.5 m in length with a mass of 25 kg leans with its upper end against a smooth vertical wall. Its lower end rests on the rough ground. The ladder is in equilibrium when its bottom end is 3.2 m away from the wall and its top end rests against the wall.

(i) Sketch a diagram to represent the arrangement described in the scenario above showing ALL the forces acting and ALL the distances described.

[4 marks]

(ii) Calculate the frictional force between the ladder and the ground.

[5 marks]

Total 15 marks

5. (a) Define the term 'simple harmonic motion' (SHM).

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[2 marks]

(b) Write the mathematical expression relating acceleration, a, to displacement, x, in simple harmonic motion.

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[2 marks]

(c) Describe the interchange of the kinetic energy and potential energy of an oscillating system during simple harmonic motion.

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[3 marks]

(d) A particle of mass 2.0 kg is moving with SHM of period 8.0 s and amplitude 5.0 m. For this particle, calculate

(i) the maximum attainable speed of the particle

[1 mark]

(ii) the maximum energy attained by the particle.

[2 marks]

(e) A mass of 0.5 kg is attached to a string of length [illegible].0 m. It is whirled in a horizontal circle at a speed of 5 m s^{-1}.

(i) Calculate the period of oscillation for the mass.

[3 marks]

(ii) The mass is now suspended as a simple pendulum and made to oscillate. Determine the period of the resulting SHM.

[2 marks]

Total 15 marks

6. Figure 5 shows a quantity of gas in a cylinder with a piston in thermal equilibrium at a temperature of 305 K. The initial volume of gas in the container was 2.80×10^{-4} m^3 and its pressure was 1.03×10^5 Pa.

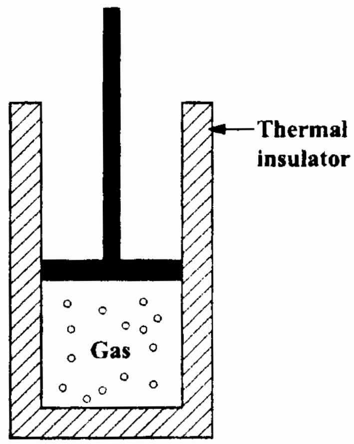

Figure 5. Gas in a cylinder

(a) Use the equation of state for an ideal gas to determine the number of moles of gas in the cylinder.

[3 marks]

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(b) The gas is then compressed adiabatically to 3.4×10^{-5} m^3 and its temperature rises to 795 K. Explain this rise in temperature

(i) on a macroscopic scale, using the first law of thermodynamics

[3 marks]

(ii) on a microscopic scale, using the kinetic theory of gases.

[3 marks]

(c) Calculate the pressure of the gas after the compression in (b).

[2 marks]

GO ON TO THE NEXT PAGE

(d) The work done on the gas during the compression is 85 J. Use the first law of thermodynamics to determine the INCREASE in the thermal energy of the gas during the compression.

[1 mark]

(e) Rather than compressing the gas as in (b), the same mass of the same gas is heated in the same cylinder at constant volume, starting with the same initial conditions. Determine its molar heat capacity, C_v, if the heat supplied is 85 joules and the final temperature is 795 K.

[3 marks]

Total 15 marks

END OF TEST

IF YOU FINISH BEFORE TIME IS CALLED, CHECK YOUR WORK ON THIS TEST.