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MAY/JUNE 2019

C A R I B B E A N   E X A M I N A T I O N S   C O U N C I L

CARIBBEAN ADVANCED PROFICIENCY EXAMINATION®

PHYSICS

UNIT 1 – Paper 02

2 hours 30 minutes

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READ THE FOLLOWING INSTRUCTIONS CAREFULLY.

1. This paper consists of THREE questions. Answer ALL questions.
2. Write your answers in the spaces provided in this booklet.
3. Do NOT write in the margins.
4. Where appropriate, 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.**

A004

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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Answer ALL questions.

1. (a) A child launches a projectile with a velocity, ***u***, at various angles, θ, to the horizontal as shown in Figure 1. He obtains different maximum heights above the original launch position.

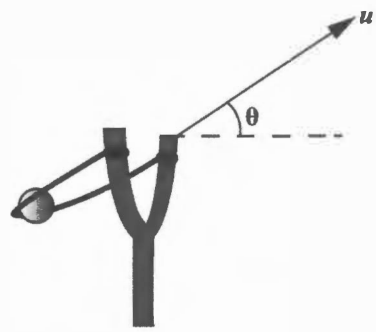

Figure 1. Launch of projectile

(i) Write an expression for the horizontal distance travelled.

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[2 marks]

(ii) Write an expression for the vertical distance travelled.

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[3 marks]

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(iii) Combine the expressions in (a) (i) and (a) (ii) to obtain an equation for the trajectory and hence deduce that the motion is parabolic.

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[5 marks]

(b) The values of the maximum height, H, achieved for different angles of θ are given in Table 1.

TABLE 1: HEIGHT AND ANGLE OF PROJECTILE

θ (°)	H (m)	$\sin^2\theta$
20	1.34	
30	2.87	
40	4.74	
50	6.73	
60	8.60	
70	10.13	

(i) Complete Column 3 in Table 1. **[2 marks]**

(ii) On the grid provided in Figure 2 **on page 9**, plot a graph of H versus $\sin^2\theta$. Draw the line of best fit through the points. **[4 marks]**

(iii) Determine the gradient of the graph in (b) (ii).

[3 marks]

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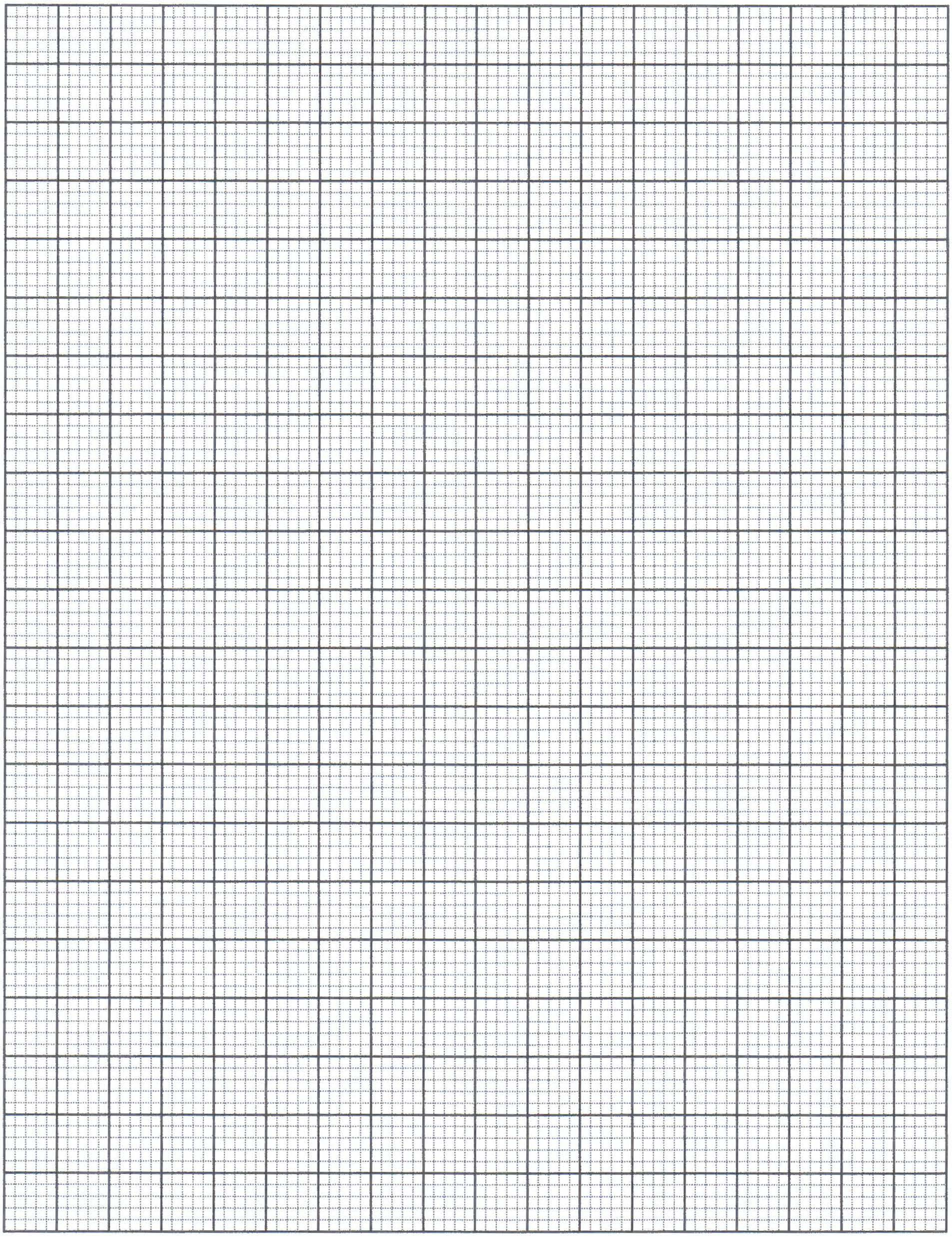

Figure 2. Graph of *H* versus $\sin^2\theta$

(iv) Hence, calculate the initial velocity of the projectile.

[3 marks]

(c) When the projectile is launched at an angle of 45° to the horizontal, it hits an object at a horizontal distance of 18 m from the point of projection. Determine the height of the object, if the height of the launcher is 0.5 m.

[5 marks]

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(d) The object falls vertically to the ground and bounces twice before coming to rest. Sketch a velocity–time graph of its motion.

[3 marks]

Total 30 marks

2. A grandmother complains that she is unable to read her newspaper clearly, unless she holds it a distance of 15 cm from her eye. The normal near point of the eye is 25 cm.

(a) (i) Identify the grandmother's eye defect.

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[1 mark]

(ii) Name the type of lens that could be used to correct the eye defect identified in (a) (i).

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[1 mark]

(b) Sketch a diagram of the eye clearly showing how the grandmother's eye forms the image

(i) without her corrective lens

[2 marks]

(ii) with her corrective lens.

[2 marks]

(c) Calculate the power of the lens needed to correct her eye defect.

[5 marks]

(d) A magnifying glass has a focal length of 6.4 cm. An object of height 1.5 cm is placed at a distance of 2.5 cm away from the optical centre of the lens. By scale drawing, determine the image height and image distance.

[8 marks]

(e) With the aid of a diagram, show how an image is formed in a simple camera.

[2 marks]

(f) (i) Define the term 'refraction'.

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[2 marks]

(ii) A light ray hits a glass prism as shown in Figure 3.

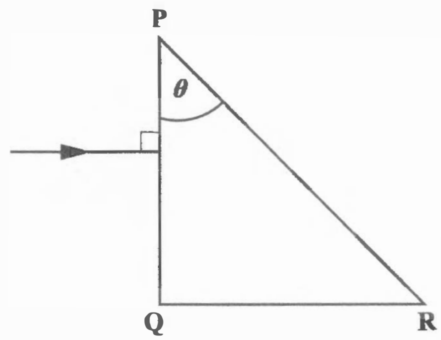

Figure 3. Light ray hitting a glass prism

The refractive index of glass is 1.52 and $\theta = 45°$. Determine, by calculation, whether the ray will pass through PR.

[5 marks]

(iii) On the diagram in Figure 3, draw the passage of the ray of light through the glass prism. **[2 marks]**

Total 30 marks

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3. A thermocouple was calibrated by placing it in different temperatures and reading the emf across its junctions. The following results in Table 2 were obtained.

TABLE 2: CALIBRATION VALUES FOR THERMOCOUPLE THERMOMETER

Temperature, *t* (°C)	**emf (mV)**
–20	46.75
0	49.20
20	50.75
40	52.00
60	52.60
70	52.75
80	52.60
100	52.10
120	50.00

(a) On the grid provided in Figure 4 **on page 19**, plot the calibration curve (emf vs temperature) for the thermocouple. Draw the line of best fit through the points. **[4 marks]**

(b) (i) Using the calibration curve plotted in (a), determine the temperatures when the thermocouple reads 51.0 mV.

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[1 mark]

(ii) With reference to the answer in (b) (i) and the calibration curve plotted in (a), state why this thermocouple is NOT the best option for use as a thermometer.

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[1 mark]

Figure 4. Graph of emf vs temperature

(c) State TWO advantages of a thermocouple and give TWO corresponding situations where it will be the best choice of thermometer.

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[4 marks]

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(d) Another thermometer is used to measure the temperatures of a monatomic ideal gas in an engine as it goes through its cycle. The quantity of gas in the engine is 0.0052 moles. There are FOUR stages in the cycle as shown in Table 3.

TABLE 3: STAGES OF MONATOMIC IDEAL GAS IN AN ENGINE

Stage	Properties of Gas	Process Leading to Next Stage
A	Pressure = 6.0×10^5 Pa Volume = 5.0×10^{-5} m^3	Constant volume heating
B	Temperature = 800 K	Adiabatic expansion, work = 37 joules
C	Pressure = 8.6×10^5 Pa Volume = 7.0×10^{-5} m^3	Constant volume cooling
D	Pressure = 6.0×10^5 Pa Volume = 7.0×10^{-5} m^3	Back to Stage A

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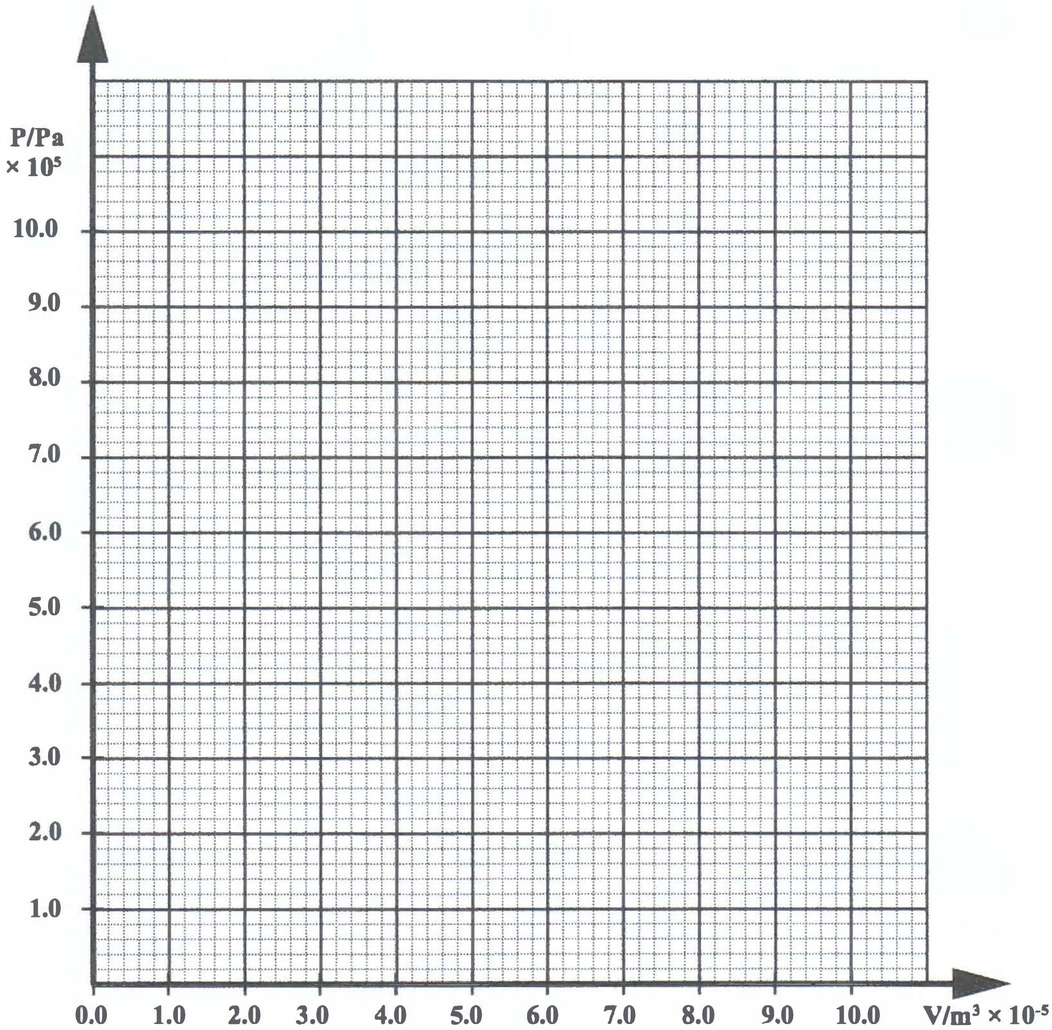
At Stage **A**, the gas has a pressure of 6.0×10^5 Pa and a volume of 5.0×10^{-5} m^3. The gas is then heated at constant volume to go to Stage **B**, so that its temperature increases to 800 K. The gas then undergoes an adiabatic expansion doing 37 J of work, until its pressure is 8.6×10^5 Pa and its volume is 7.0×10^{-5} m^3 at Stage **C**. At Stage **D**, the pressure is 6.0×10^5 Pa and the volume is 7.0×10^{-5} m^3.

(i) Using the information given in Table 3 **on page 20**, sketch a P-V graph of the gas engine cycle, clearly labelling EACH stage and its corresponding pressure and volume.



[4 marks]

(ii) Calculate the initial temperature of the gas (Stage **A**).

[3 marks]

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(iii) Determine the heat energy supplied to the gas in going from Stage **A** to Stage **B**.

[3 marks]

(e) Define the internal energy of a gas.

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[1 mark]

(f) State the first law of thermodynamics, clearly defining EACH term.

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[4 marks]

(g) With reference to the first law of thermodynamics, calculate the change in internal energy of the gas in the engine as it goes from Stage **B** to Stage **C**.

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[2 marks]

(h) The gas in the engine completes the cycle by going from Stage **D** back to Stage **A**. State what happens to the volume, temperature and pressure of the gas in this process.

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[3 marks]

Total 30 marks

END OF TEST

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