Name:		Index Number:		Class:	

DUNMAN HIGH SCHOOL
Promotional Examination
Year 5

H2 PHYSICS

Section B Structured Questions

9749

27 September 2022

1 hour 30 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions in the spaces provided on the question paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
MCQ	**15**
Section B	
1	**6**
2	**6**
3	**7**
4	**7**
5	**6**
6	**6**
7	**4**
8	**10**
9	**8**
s.f.	**-1**
Total	**75**

This document consists of **19** printed pages and **1** blank page.

Data

speed of light in free space,	c	= 3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	= $4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	= 8.85×10^{-12} F m^{-1}
		= $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	= 1.60×10^{-19} C
the Planck constant,	h	= 6.63×10^{-34} J s
unified atomic mass constant,	u	= 1.66×10^{-27} kg
rest mass of electron,	m_e	= 9.11×10^{-31} kg
rest mass of proton,	m_p	= 1.67×10^{-27} kg
molar gas constant	R	= 8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	= 6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	= 1.38×10^{-23} J K^{-1}
gravitational constant,	G	= 6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	= 9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions.

1 **(a)** Make reasonable estimates of the following quantities.

(i) the frequency of an audible sound wave,

frequency = ... Hz [1]

(ii) the wavelength of ultraviolet radiation.

wavelength = ... nm [1]

(b) State what is meant by a *vector* quantity.

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…………………………………………………………………………………………………..... [1]

(c) An aircraft is travelling towards the west. Fig. 1.1 shows the velocities of the aircraft in still air and of the wind.

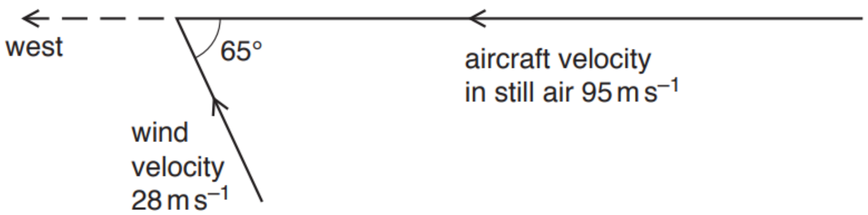

Fig. 1.1

(i) On Fig. 1.1, draw an arrow, labelled *R*, in the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

velocity = ... m s^{-1} [2]

[Total: 6]

2 In the absence of air resistance, a projectile is launched at point O with an initial speed u at an angle θ to the horizontal. OA is the maximum horizontal distance that can be reached. The path of the projectile is shown in Fig. 2.1.

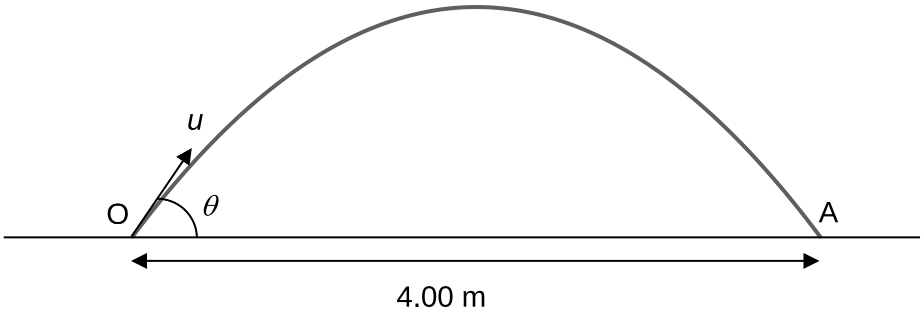

Fig. 2.1

(a) State the angle θ that will give the maximum horizontal distance of the projectile.

θ = ... ° [1]

(b) The maximum horizontal distance OA is 4.00 m. Calculate the initial speed *u.*

u = ... m s^{-1} [3]

(c) Calculate the maximum height reached by the projectile.

maximum height = ... m [1]

(d) In practice, air resistance cannot be ignored. On Fig. 2.1, sketch the path of the projectile when air resistance is not negligible. [1]

[Total: 6]

3 A jet of water hits a vertical wall at right angles, as shown in Fig. 3.1.

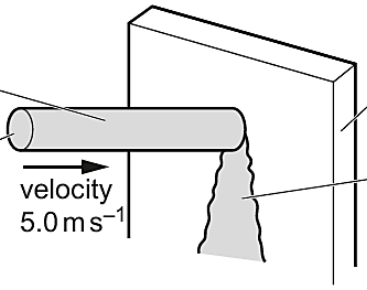

Fig. 3.1 (not to scale)

The water hits the vertical wall with a velocity of 5.0 m s^{-1} in a horizontal direction. The cross-sectional area of the jet is 1.5×10^{-4} m^2. The density of the water is 1.0×10^3 kg m^{-3}.

The water runs down the wall after hitting it.

(a) Show that, over a time of 1.6 s, the mass of water hitting the wall is 1.2 kg.

[2]

(b) Calculate

(i) the decrease in the horizontal momentum of the mass of water in **(a)** due to hitting the wall,

decrease in momentum = ... N s [1]

(ii) the magnitude of the horizontal force exerted on the water by the wall.

force = ... N [1]

(c) State and explain the magnitude of the horizontal force exerted on the wall by the water.

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…………………………………………………………………………………………………... [1]

(d) Calculate the pressure exerted on the wall by the water.

pressure = ... Pa [1]

(e) State how the principle of conservation of momentum applies for the interaction between the water and the wall.

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…………………………………………………………………………………………………... [1]

[Total: 7]

4 **(a)** State the conditions for an object to be in equilibrium.

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…………………………………………………………………………………………………..... [2]

(b) A uniform ladder of length 12.0 m and mass 40.0 kg rests on a wall. The lower end of the ladder is 6.00 m from the wall as shown in Fig. 4.1. The wall is smooth while the ground is rough.

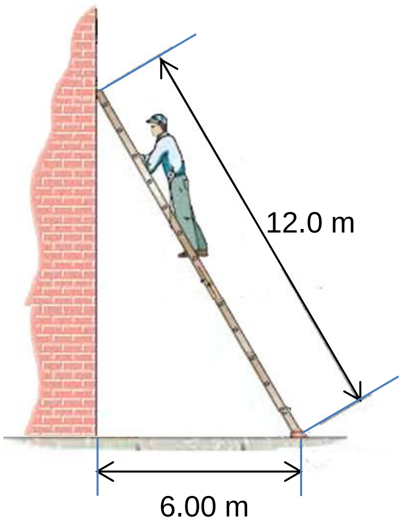

Fig. 4.1

A man of mass 72.0 kg starts to climb up the ladder. He stops when he is three-quarters way up the ladder.

(i) Calculate the normal contact force

1. by the wall on the ladder,

normal contact force = ... N [2]

2. by the ground on the ladder.

normal contact force = ... N [1]

(ii) Hence determine the magnitude of the total reaction force the ground exerts on the ladder.

total reaction force = ... N [1]

(iii) On Fig 4.1, draw an arrow, labelled *R*, to show the direction of the total reaction force found in **(b)(ii)**. [1]

[Total: 7]

5 **(a)** Show, using the equations of motion and the definition of work done, the kinetic energy E_K of an object of mass m travelling with speed v is

$$E_K = \frac{1}{2}mv^2 .$$

[2]

(b) A child of weight 330 N is at point X at the top of a slide. The slide is at the edge of a swimming pool, as shown in Fig. 5.1.

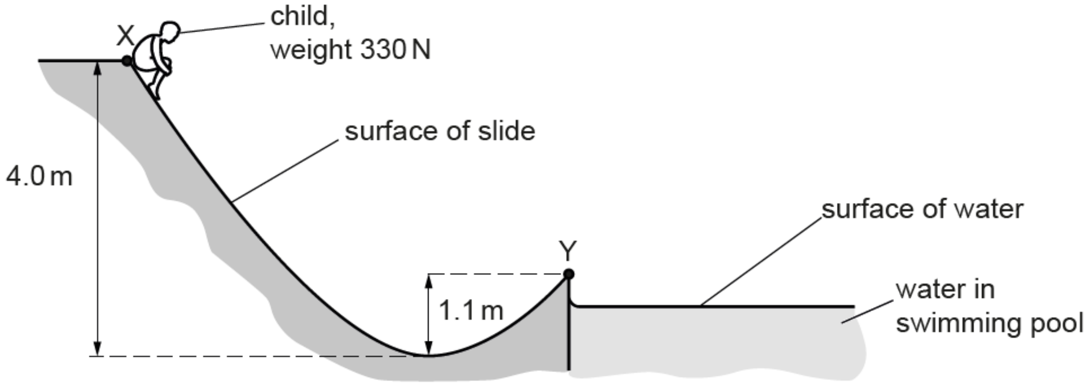

Fig. 5.1

The child moves from rest to the lowest point of the slide that is a vertical distance of 4.0 m below X. The child continues moving towards point Y which is at the end of the slide and a vertical distance of 1.1 m above the lowest point. The kinetic energy of the child at Y is 540 J. Assume that a constant total resistive force of 52 N acts on the child when moving from X to Y.

(i) Calculate the change in gravitational potential energy of the child from point X to Y.

change in gravitational potential energy = ... J [1]

(ii) Determine the distance moved by the child in moving from X to Y.

distance moved = ... m [2]

(iii) Explain why, in practice, it is incorrect to assume that the total resistive force is constant as the child moves between X and Y.

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…………………………………………………………………………………………….... [1]

[Total: 6]

6 In a child's toy, a small ball moves down a straight smooth slope and then travels around a vertical circular loop, as shown in Fig. 6.1.

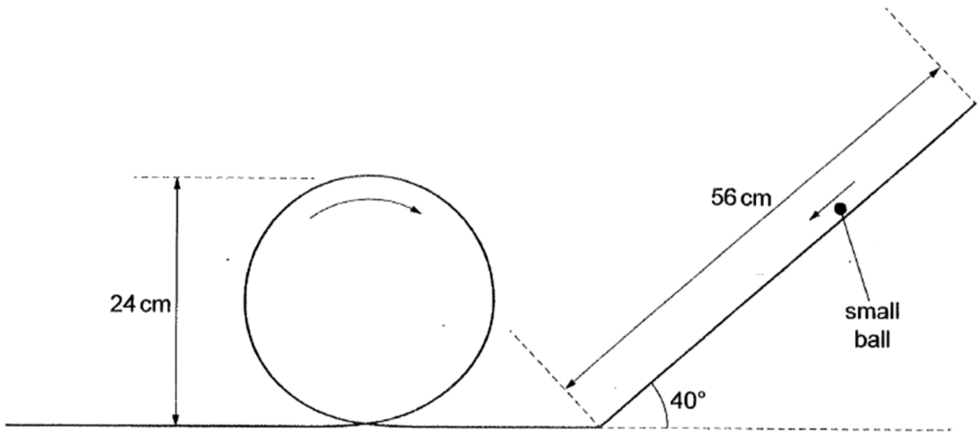

Fig. 6.1

The loop has a diameter of 24 cm.

The slope has a length of 56 cm and is inclined at an angle of 40^0 to the horizontal.

Initially, the ball is at rest at the top of the slope.

(a) For the ball moving down the slope,

(i) calculate the acceleration of the ball,

acceleration = ... m s^{-2} [1]

(ii) use your answer in **(a)(i)** to determine the speed of the ball at the bottom of the slope.

speed = ... m s^{-1} [1]

(b) The speed of the ball at the top of the loop is 1.5 m s^{-1}, as shown in Fig. 6.2.

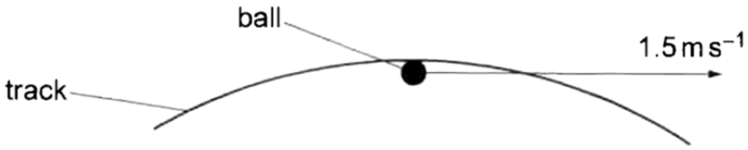

Fig. 6.2

The ball has a mass of 72 g.

Determine, for the ball at the top of the loop,

(i) the magnitude of the centripetal force acting on the ball,

force = ... N [2]

(ii) the magnitude and direction of the force due to the track acting on the ball.

force = ... N [1]

direction = ... [1]

[Total: 6]

7 **(a)** A gravitational field may be represented by lines of gravitational force.
State what is meant by a *line of gravitational force.*

……..

……..

………………………………………………………………………………………………….... [1]

(b) By reference to lines of gravitational force near to the surface of the Earth, explain why the gravitational field strength g close to the Earth's surface is approximately constant.

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………………………………………………………………………………………………….... [3]

[Total: 4]

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8 An ideal gas of mass 4.00 g undergoes a cycle of changes A → B → C → A as shown in Fig. 8.1. The process A → B occurs at constant temperature, B → C occurs at constant pressure and C → A occurs at constant volume.

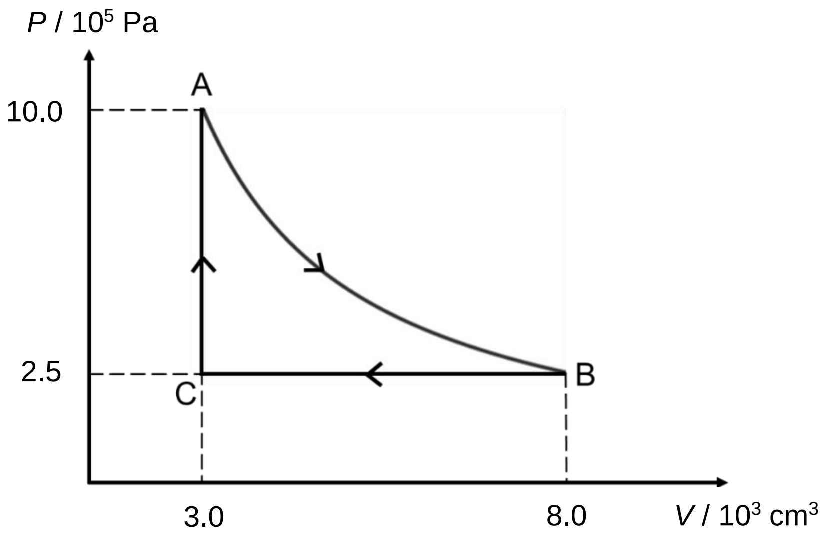

Fig. 8.1

(a) State what is meant by an *ideal gas.*

…………………………………………………………………………………………………..………..

……………………………………………………………………………………………………... [1]

(b) Determine the root-mean-square speed of the gas molecules at A.

root-mean-square speed = ... m s^{-1} [3]

(c) Calculate,

(i) the work done on the gas during the change B → C,

work done on the gas = ... J [1]

(ii) the change in internal energy of the gas during the change C → A.

change in internal energy = ... J [2]

(d) Fig. 8.2 is a table of energy changes during one cycle. Use your answers in **(c)(i)** and **(c)(ii)** to complete Fig. 8.2.

section of the cycle	heat supplied to the gas / J	work done on the gas / J	increase in internal energy of the gas / J
A → B	2940		
B → C			
C → A			

Fig. 8.2

[3]

[Total: 10]

9 A small wooden block of mass m floats in water, as shown in Fig. 9.1.

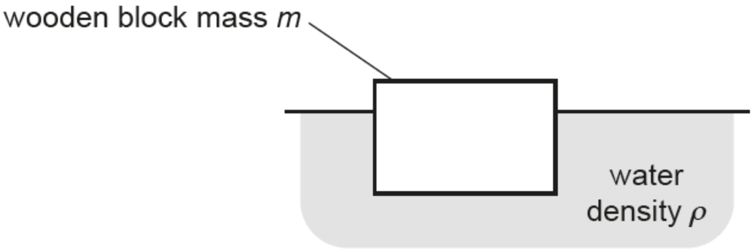

Fig. 9.1

The top face of the block is horizontal and has area A. The density of the water is ρ.

The block is now displaced downwards as shown in Fig. 9.2 so that the surface of the water is higher up the block.

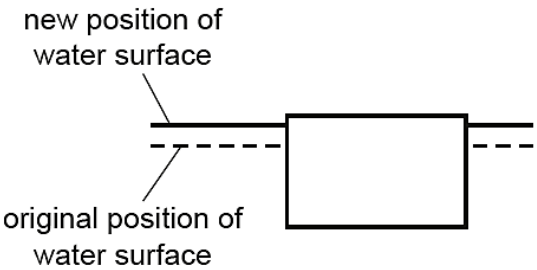

Fig. 9.2

The block is now released so that it oscillates vertically.

The resultant force F acting on the block is given by

$$F = -Ag\rho x$$

where g is the gravitational field strength and x is the vertical displacement of the block from the equilibrium position.

(a) Explain why the oscillations of the block are simple harmonic.

....

....

.... [2]

(b) Show that the angular frequency ω of the oscillations is given by

$$\omega = \sqrt{\frac{A\rho g}{m}} \; .$$

[2]

The block is now placed in a liquid with a greater density. The block is displaced and released so that it oscillates vertically. The variation with displacement x of the acceleration a of the block is measured for the first half oscillation, as shown in Fig. 9.3.

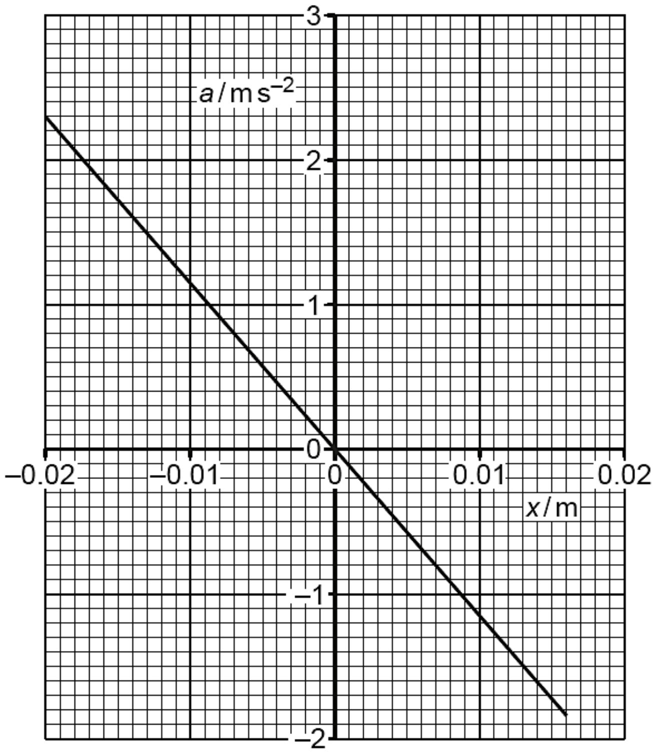

Fig. 9.3

(c) Explain why the maximum negative displacement of the block is not equal to its maximum positive displacement.

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…………………………………………………………………………………………….... [1]

(d) The mass of the block is 0.57 kg.

Use Fig.9.3 to determine the decrease in energy, ΔE, of the oscillation for the first half oscillation.

ΔE = ... J [3]

[Total: 8]