Candidate Name Tan Zhi Yong

Registration Number

0382624

NATIONAL JUNIOR COLLEGE
JC 1 PROMOTIONAL EXAMINATION
SECTIONS B & C

PHYSICS — **9248**

Wednesday — 15 October 2003 — 2 h 10 min

INSTRUCTIONS TO CANDIDATES

Do not open this booklet until you are told to do so.

Write your **name** and **registration number** in the spaces at the top of this page and all writing paper used.

You are given **2 hours 10 minutes** to complete **Sections B** and **C**.

Answer **ALL** the questions.

Section B [70 marks]

Write your answers in the **spaces provided on the question paper**.

For numerical answers, **all working should be shown**.
The number of marks is given in brackets [ ] at the end of each question or part question.

Section C [30 marks]

Answer **each** question on a **new sheet** of writing paper provided.
The **quality of your language** will be taken into account in the marking of your answers.

Submit the following answers separately

1. Section B (with answers)
2. Section C Q 28 answers on writing paper
3. Section C Q 29 question (detached from question paper) stapled to answers on writing paper.

FOR EXAMINER'S USE	
Section A	
1 to 20 Subtotal	

FOR EXAMINER'S USE	
Sections B & C	
Qn	Marks
21	5
22	7½
23	5
24	2
25	4
26	9
27	2½
28	
29	
Subtotal	

Total :	81 / 140
Percentage:	

This sections consist of 18 printed pages including this cover page.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	μ_0	$= 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	ϵ_0	$= 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$ $\approx (1/(36\pi)) \times 10^{-9}\ \mathrm{F\,m^{-1}}$
elementary charge,	e	$= 1.60 \times 10^{-19}\ \mathrm{C}$
the Planck constant,	h	$= 6.63 \times 10^{-34}\ \mathrm{J\,s}$
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}\ \mathrm{kg}$
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}\ \mathrm{kg}$
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}\ \mathrm{kg}$
molar gas constant,	R	$= 8.31\ \mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
gravitational constant,	G	$= 6.67 \times 10^{-11}\ \mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall,	g	$= 9.81\ \mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
gravitational potential,	$\phi = -Gm/r$
refractive index,	$n = 1/\sin C$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = Q/4\pi\epsilon_0 r$
capacitors in series,	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
energy of charged capacitor,	$W = \frac{1}{2}QV$
alternating current/voltage,	$x = x_0 \sin \omega t$
hydrostatic pressure,	$p = \rho g h$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$
critical density of matter in the Universe,	$\rho_0 = 3H_0^2/8\pi G$
equation of continuity,	$Av = \text{constant}$
Bernoulli equation (simplified),	$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$
Stokes' law,	$F = Ar\eta v$
Reynolds' number,	$R_e = \rho v r/\eta$
drag force in turbulent flow,	$F = Br^2\rho v^2$

[Turn over

Section B [70 marks]

21. **Figure 21** below shows an aeroplane flying horizontally at a steady speed of 67.0 ms^{-1}. A parachutist falls from the aeroplane freely for 80.0 m before the parachute opens. For the purpose of calculation, you may assume that air resistance is negligible before the parachute opens.

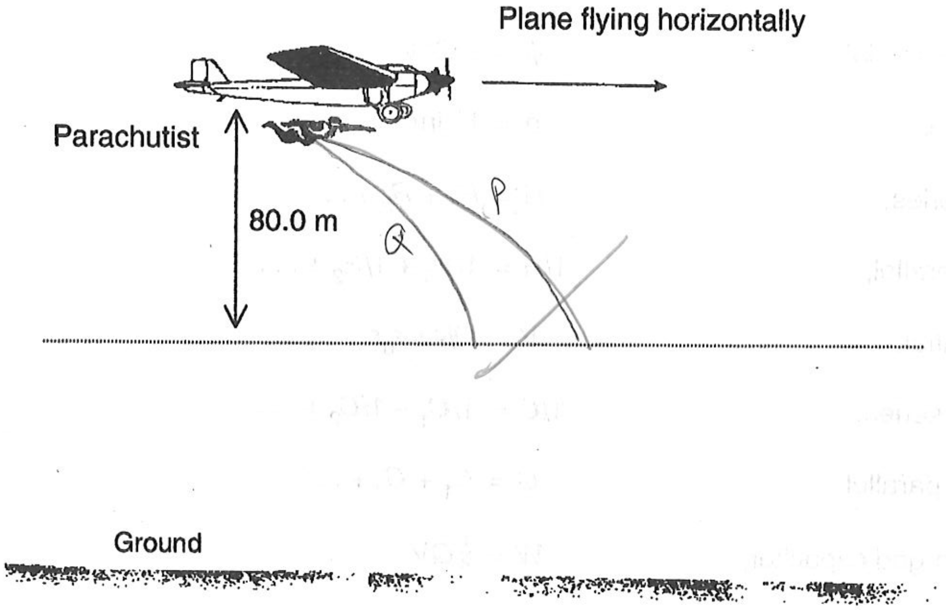


Fig. 21

(a) Calculate the velocity of the parachutist when it has fallen 80.0 m. [4]

$$\text{Velocity} = \sqrt{(67.0)^2 + (9.81 \times 80.0)^2}$$
$$= 788\ ms^{-1}\ (3s.f)$$

0

21(b) Sketch on **Figure 21**, two labelled paths, ***P*** and ***Q***, of the parachutist during the free-fall, assuming that

(1) for path ***P***, air resistance is negligible
(2) for path ***Q***, air resistance cannot be neglected.

[2]

(c) State one difference between the two paths **P** and **Q** and suggest an explanation for it. [2]

In Q, the parachutist has ~~ft~~ fallen a shorter distance. This is due to the air resistance exerting an upthrust on him, which causes the resultant vertical acceleration to be lower than ~~of~~ if air resistance were absent.

6

(d) After the parachute opens, the parachutist slows down and reaches a terminal velocity of 7.00 ms^{-1}. When the parachutist is 100 m above the ground, he throws a ball vertically upwards with a velocity of 10.0 ms^{-1} with respect to himself. At this point, there is no horizontal velocity. Calculate the time taken for the ball to reach the ground.

[3]

~~Resultant velocity~~

Resultant ~~horizontal~~ vertical velocity $= 7.00 - 10.0$
$= -3.00 \text{ ms}^{-1}$

$s = ut + \frac{1}{2}gt^2$

$100 = (-3.00)t + \frac{1}{2}(9.81)t^2$

$4.905t^2 - 3.00t - 100 = 0$

$t = \frac{-(-3.00) \pm \sqrt{(-3.00)^2 - 4(4.905)(-100)}}{2(4.905)}$

$= \frac{3.00 \pm \sqrt{9.00 + 1962}}{9.81}$

$= \frac{3.00 \pm \sqrt{1971}}{9.81}$

$\therefore t = -4.22\text{s (N.A)}$ (3s.f) or $t = 4.83\text{s}$ (3s.f)

$\therefore t = 4.83\text{s}$ (3s.f)

3

22(a) State the *Principle of Conservation of Linear Momentum.* [1]

If ~~an~~ a collision between two bodies is perfectly elastic the ~~inti~~ sum of the initial and final momentums of the two bodies are the same.

(b) A pendulum of length 2.00 m was released from position **A (Fig 22A)**. The mass of the pendulum bob is 300 g. It strikes a wooden block of mass 500 g and rebounds to position **B (Fig 22B)**. Assume air resistance and frictional forces are negligible.

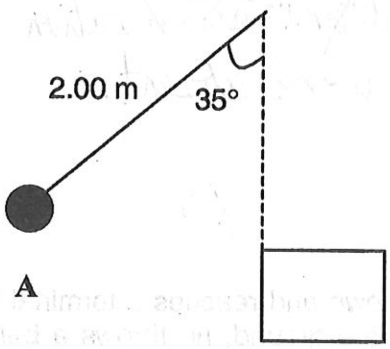


Fig. 22A

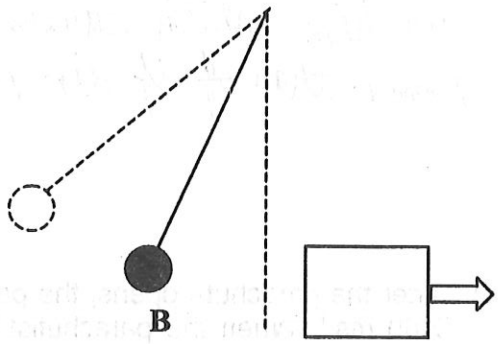
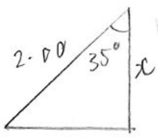


Fig. 22B

(i) What is the velocity of the pendulum bob just before impact? [2]



$\cos 35° = \frac{x}{2.00}$

$x = 2.00\cos 35°$

Change in height $= (2.00 - 2.00\cos 35°)\,m$

$\frac{1}{2}mv^2 = mgh$

$v = \sqrt{2gh}$

$= \sqrt{2(9.81)(2.00 - 2.00\cos 35°)}$

$\approx 2.66\ ms^{-1}$

(ii) During impact, the magnitude of the force exerted by the wooden block on the pendulum bob varies according to the graph shown in **Fig 22C**.

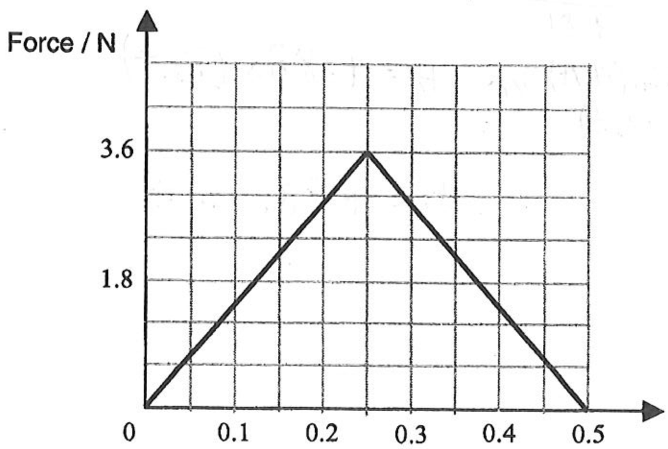


Fig. 22C

2

22(b) (ii) What is the velocity of the pendulum bob immediately after impact? [3]

$\Delta p = \cancel{\tfrac{1}{2}} \cancel{\times} 0.5 \times 3.6 \times 0.5$

$= 0.9\ Ns$

$p = mv$

$\Delta v = \frac{0.9}{0.3}$

$= 3\ ms^{-1}$

Velocity after impact $= 2.664 - 3$

$= -0.336\ ms^{-1}$

3

(iii) What is the velocity of the wooden block immediately after impact? [2]

$\cancel{\Delta p}$ p of block $= 0.9\ Ns$

$p = mv$

Velocity of block $= \frac{0.9}{0.5}$

$= 1.8\ ms^{-1}$

2

(iv) Using appropriate calculations, justify whether the collision between the pendulum bob and the wooden block is elastic or inelastic. [3]

For elastic collisions, $u_A - u_B = \cancel{v_A + v_B}\ v_B - v_A$

$2.66 - 0 \neq 1.8 - (-0.336)$

∴ collision is inelastic

$\frac{1}{2}$

$5\frac{1}{2}$

23(a) Define the term *moment of a force*. [2]

The moment of a force is the force applied about a pivot perpendicular to the displacement from the pivot

~~Force~~ Moment = Force × ~~Perpendicular~~ ~~Displ~~ Displacement from pivot

(b) A hungry bear weighing 700 N walks out on a uniform beam in an attempt to retrieve a basket of food hanging at the end of the beam (**Fig 23**). The beam weighs 200 N and is 6.00 m long. The basket weighs 80 N. The beam is supported by a rope, which exerts a tension ***T*** on the right end and is hinged securely to the wall on the left end.

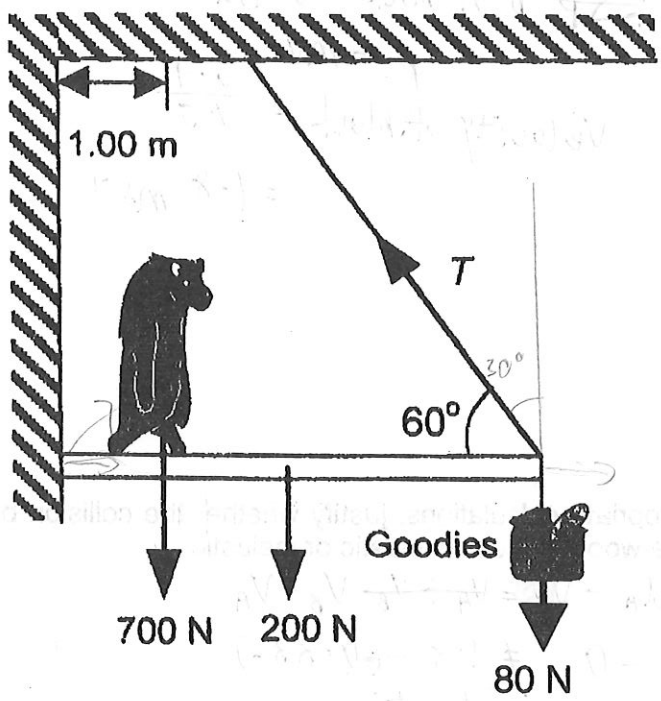
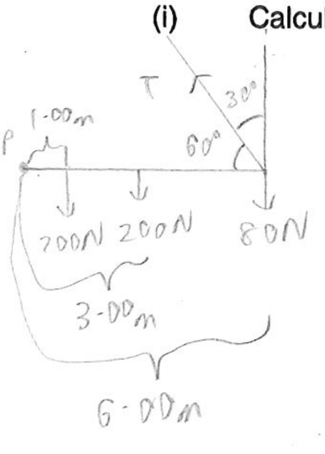


Fig. 23

At a certain instant, the bear is 1.00 m from the hinged end of the beam.

(i) Calculate the tension in the wire. [2]



Let the vertical component of the tension be x N

$x(6.00) = 700(1.00) + 200(3.00) + 80(6.00)$

$x = 296.7$ N

$\cos 30° = \frac{296.7}{T}$

$T = \frac{296.7}{\cos 30°}$

$= 343$ N

2

23(b) (ii) Determine the magnitude and direction of the force exerted by the wall on the left end of the beam. **[4]**

Let the force be F

Total weight of all the objects

$= 700 + 200 + 80$

$= 980N$

~~T = 342.6N~~

~~$T^2 = F^2 + W^2$~~

~~$(342.6)^2 = F^2 + 980^2$~~

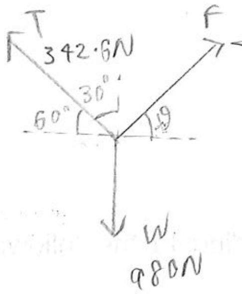
~~$F =$~~

~~$(F\cos\theta)^2 + W^2 = T^2$~~

~~$(F\cos\theta)^2 = T^2 - W^2$~~

~~$= 342.6^2 - 980^2$~~

~~$F\cos\theta =$~~



$F\cos\theta = T\cos 60° = 171.3N$ —(1)

$F\sin\theta = 980N$ —(2)

$\frac{(2)}{(1)}$: $\tan\theta = \frac{980}{171.3}$

$\theta = 80.1°$

Subt $\theta = 80.09°$ into (2)

$F\sin 80.09° = 980$

$F = 995N$

∴ force exerted is 995N

80.1° anticlockwise from the right of the horizontal.

(iii) If the wire can withstand a maximum tension of 700 N, can the bear reach the basket before the wire breaks? **[2]**

$6T\cos 30° = (200)(3.00) + (80)(6.00) + (700)(6.00)$

$T = 1730N$

$> 700N$

∴ the bear cannot reach the basket.

3

24(a) A small bead of mass m is constrained to slide without friction inside a circular hollow tube of radius r. The circular hollow tube is aligned in a vertical plane (see **Figure 24**). The tube is then made to rotate about a vertical axis at a constant frequency f. When the tube is rotating, the bead was observed to move up along the tube such that it subtends an angle θ relative to the vertical axis.

$\cos\theta = \frac{\quad}{r}$

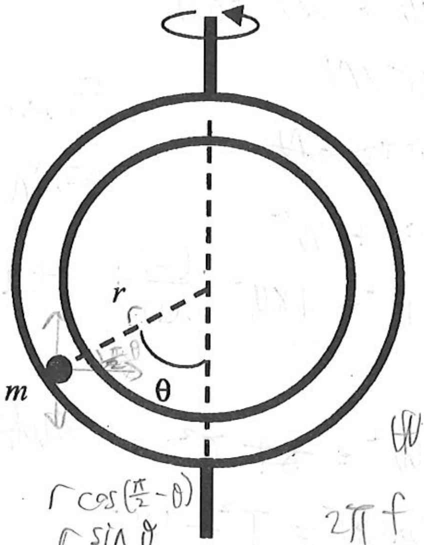


Fig. 24

$w = 2\pi f$

$\omega = \frac{2\pi}{T}$ $f = \frac{2\pi}{w}$

$r\cos(\frac{\pi}{2} - \theta)$

$r\sin\theta$

$2\pi f = \frac{2\pi}{T}$

$f = \frac{1}{T}$

(i) Show that the angle θ is related to the frequency f according to the following expression.

$$\theta = \cos^{-1}\left(\frac{g}{4\pi^2 f^2 r}\right)$$

[3]

$\theta = wt$

$w = 2\pi f$

$\therefore \theta = 2\pi f t$

Resultant centripetal force = ~~mRw^2~~

$mw^2[r\cos(\frac{\pi}{2} - \theta)]$

$= m(\frac{\theta}{t})^2[r\cos(\frac{\pi}{2} - \theta)]$

$= m(\frac{\theta}{t})^2(r\sin\theta)$

$f = \frac{2\pi}{w}$

0

24(a) (ii) Can the bead ride as high as the centre of the circle i.e. $\theta = 90^o$? Explain. [2]

No. There must be a component of vertical contact force to balance the weight.

2

(b) Explain why a cosmonaut in a satellite, which is in a free circular orbit around the Earth, experiences the sensation of weightlessness even though he is under the influence of the gravitational field of the Earth. [2]

There is ~~AF~~ a centripetal force acting on him.

0

25(a) It is proposed to investigate the surface of the planet Mars by putting a spacecraft (the command module) into orbit around the planet and sending an exploration module down to surface of the planet and subsequently recovering it.

Mass of the planet Mars = 6.42×10^{23} kg
Radius of the planet Mars = 3.39×10^{6} m

This is an excerpt from a newspaper report on the command module

"...*Mars exerts a greater force on the command module compared to the force that the command module exerts on Mars as Mars has a greater mass than the command module* ..."

State and explain whether you agree with the statement. [2]

No. The ~~forces~~ force exerted by Mars on the command module is equal to the force exerted by the command module on Mars. M why?

$F = \frac{GMm}{r^2}$

1

0

4.28214×10^{13} 15357108.5 5.97391×10^{14}

25(b) The command module is positioned in a circular orbit at a height of 5.00×10^5 m above the surface of the planet. Calculate the period of the command module's orbit about Mars.

[4]

$$mr\omega^2 = \cancel{\frac{GMm}{R^2}} \frac{GMm}{r^2}$$

$$\omega = \frac{2\pi}{T}$$

$$mr\left(\frac{2\pi}{T}\right)^2 = \frac{GMm}{r^2}$$

$$\frac{4\pi^2}{T^2} = \frac{GM}{r^3}$$

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

$$T = \sqrt{\frac{4\pi^2 r^3}{GM}}$$

$$= \sqrt{\frac{4\pi^2(3.39\times10^6 + 5.00\times10^5)^3}{(6.67\times10^{-11})(6.42\times10^{23})}}$$

$$= \cancel{3.59\times10^{-7}\ s}\ 3.74\ s$$

(c) Calculate the gravitational field strength at a point on the orbit of the command module.

[2]

$$g = \frac{GM}{R^2}$$

$$= \frac{(6.67\times10^{-11})(6.42\times10^{23})}{(3.39\times10^6 + 5.00\times10^5)^2}$$

$$= 2.83\ N\,kg^{-1}$$

2

(d) Calculate the energy required to move the exploration module of mass 1.20×10^3 kg from the surface of Mars to a point on the orbit of the command module.

[2]

$$\text{Energy required} = -\frac{GM}{r_2} - \left(-\frac{GM}{r_1}\right)$$

$$= \cancel{6.67\times10^{-11}}\ -\frac{GM}{r_2} + \frac{GM}{r_1}$$

$$= GM\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$$

$$\cancel{= (6.67\times10^{-11})(6.42\times10^{23})\left(\frac{1}{(3.39\times10^6 + 5.00\times10^5)} - \frac{1}{3.39\times10^6}\right)}$$

$$= (6.67\times10^{-11})(6.42\times10^{23})\left(\frac{1}{3.39\times10^6} - \frac{1}{(3.39\times10^6 + 5.00\times10^5)}\right)$$

$$= 1.62\times10^6\ J$$

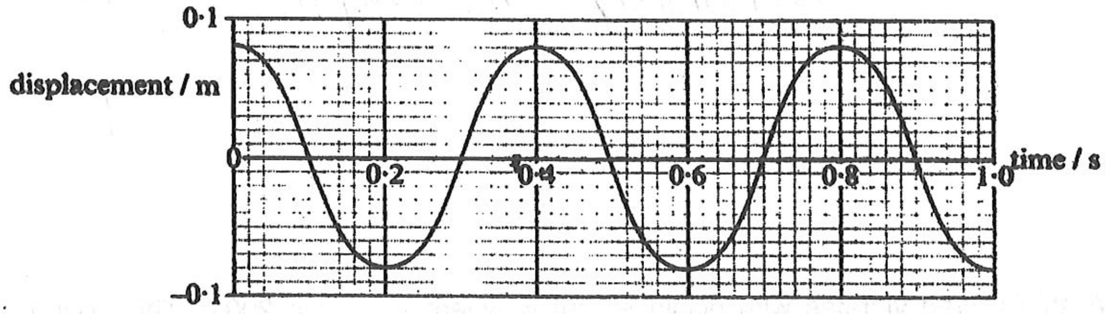
0

4

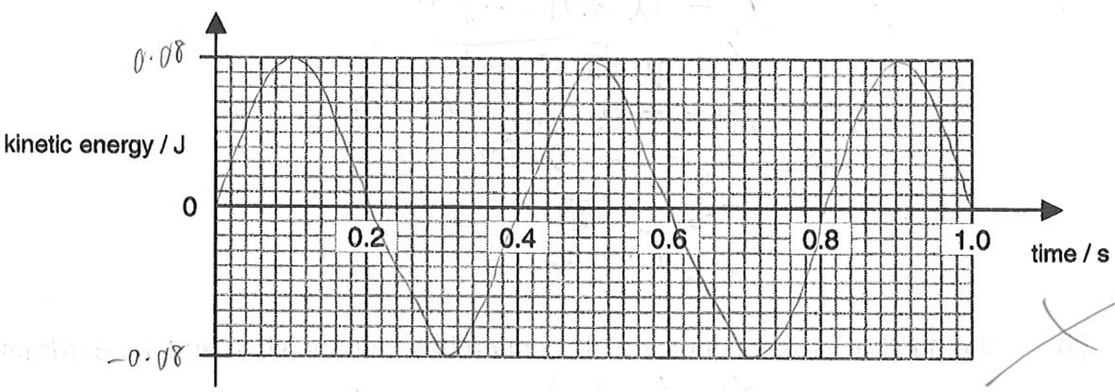
$$\frac{1}{3890000}$$

26(a) A metal sphere of mass 0.250 kg hangs from a spring. The top end of the spring is clamped. The sphere is raised 8.00×10^{-2} m above its equilibrium position and released.

A displacement vs. time graph for the motion is given below. $V = \omega\sqrt{x}$

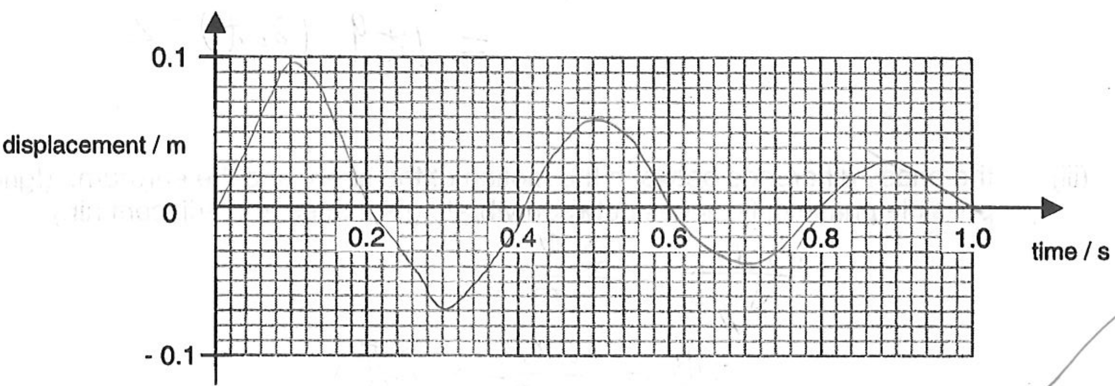


(i) Plot the points representing maxima and minima of kinetic energy on the graph grid below and sketch the graph of kinetic energy vs. time. [2]



1

(ii) The metal sphere is replaced by a large ball of plastic foam of mass 0.250 kg. The ball is raised 8.00×10^{-2} m above its equilibrium position and released. The oscillations which now occur are noticeably damped. Sketch a possible displacement vs. time graph for the oscillations. [2]



2

26(a) (iii) Explain, in terms of the force(s) acting on the ball, why damping occurs. [2]

Damping occurs due to frictional forces such as air resistance on the ball, hence ~~momentu~~ energy is lost to the surroundings and damping occurs.

$a = -\omega^2 x$

$x = \omega$ $v = \omega\sqrt{x_0^2 - x^2}$

(b) A ship's siren vibrates with displacement y, where $y = a \sin 200\pi t$. This sound causes vibration of the diaphragm of an eardrum of an observer 500 m away. The speed of sound is 335 ms^{-1}. Calculate

$x = a\cos\omega t$
$\sin\omega t$

$\omega = 2\pi f$

(i) the frequency of the sound, [2]

$$x = a \sin 2\pi f t$$
$$\cancel{v = \omega\sqrt{x_0^2 - x^2}}$$
$$a \sin 2\pi f t = a \sin 200\pi t$$
$$\sin 2\pi f t = \sin 200\pi t$$
$$2\pi f = 200\pi$$
$$f = 100 \text{ Hz}$$

2

(ii) the number of wavelengths of this sound between the siren and the eardrum, [2]

$$v = f\lambda$$
$$335 = 100\lambda$$
$$\lambda = 3.35 \text{ m}$$
$$\text{No. of wavelengths} = \frac{500}{3.35}$$
$$= 149 \text{ (3s.f)}$$

2

(iii) the phase difference between the motion of the siren and the eardrum. (Ignore any possible phase differences between vibrating surfaces and adjacent air.) [2]

$$\frac{\Delta x}{\lambda} = \frac{\Delta\phi}{2\pi}$$
$$\Delta\phi = \frac{500}{3.35} \times 2\pi$$
$$= 938\pi \text{ (3s.f)}$$

$\therefore$ phase difference $= 0$

27. **Figure 27A** shows a thin taut wire held horizontally between supports 0.40 m apart.

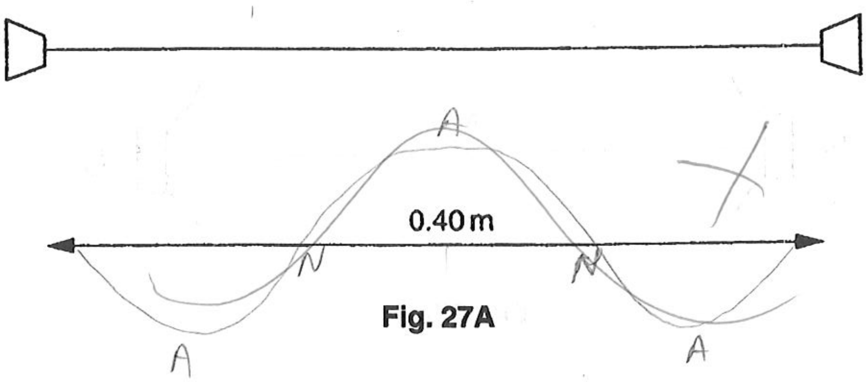


Fig. 27A

(a) When the wire is plucked at its centre a standing wave is formed and the wire vibrates in its fundamental mode.

(i) Explain how the standing wave is formed. [2]

The waves moving ~~to the right and the waves reflected to the left~~ from the centre and the waves reflected back ~~unf~~ interfere with each other to produce a standing wave.

$1\frac{1}{2}$

(ii) On **Fig. 27A** draw the fundamental mode of vibration. Label the position of any node with the letter **N** and any antinode with the letter **A**. [2]

0

(iii) Determine the wavelength of this standing wave. [1]

$$\frac{3}{2}\lambda = 0.40$$

$$\lambda = \frac{0.40(2)}{3}$$

$$= 0.267 \text{ m}$$

X

27(b) **Figure 27B** shows two small loudspeakers positioned a few metres apart with a small microphone, **M**, connected to an oscilloscope, positioned exactly midway between them. The loudspeakers are connected in parallel to a signal generator producing oscillations at a frequency of 3300 Hz.

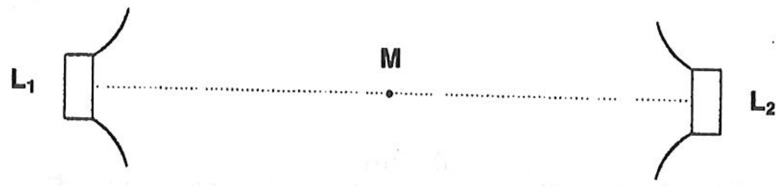


Fig. 27B

The microphone is now moved slowly to the right.

(i) Describe how the trace height on the oscilloscope will change as the position of the microphone is changed. [2]

The trace height will increase progressively to a maximum and decrease progressively to a minimum alternately as the microphone is shifted. ~~The trace height also increases as the microphone moves closer to the loudspeaker.~~

(ii) Explain why this change occurs. [2]

Sound is a longitudinal wave. As the microphone is shifted, the source of the sound changes position and this creates a source difference. ~~which causes~~ The displacement ~~wavefront~~ of the sound waves ~~is no~~ hitting the loudspeakers are no longer identical.

due

coherent

interference

MINISTRY OF EDUCATION

1. Enter your NAME (as in NRIC). Tan Zhi Yong
2. Enter the SUBJECT TITLE. Physics
3. Enter the TEST NAME. Promo Exam
4. Enter the CLASS. 03S6H

RUB OUT ERRORS THOROUGHLY

USE PENCIL ONLY
FOR ALL ENTRIES ON THIS SHEET

0	1	[✓ 2]	3	4	5	6
0	[✓ 1]	2	3	4	5	6
[✓ 0]	1	2	3	4	5	6

5. Enter your CLASS NUMBER or INDEX NUMBER.

6. Now SHADE the corresponding lozenge in the grid for EACH DIGIT or LETTER

WRITE	SHADE APPROPRIATE BOXES									
INDEX NUMBER										
2	0	1	[✓ 2]	3	4	5	6	7	8	9
4	0	1	2	3	[✓ 4]	5	6	7	8	9
	0	1	2	3	4	5	6	7	8	9
	0	1	2	3	4	5	6	7	8	9
	0	1	2	3	4	5	6	7	8	9
	A	B	C	D	E	F	G	H	I	

7. **INSTRUCTIONS FOR RECORDING ANSWERS**

Suggested answers to each question are given in the question paper. Choose an answer and shade the corresponding lozenge. If there are only four suggested answers, A, B, C, D, ignore E on this sheet. Don't worry if the question paper has less than the 60 questions allowed for below.

1	A	B	[✓ C]	D	E
2	[✓ A]	B	C	D	E
3	A	B	C	[✓ D]	E
4	[✓ A]	B	C	D	E
5	A	[✓ B]	C	D	E
6	A	B	[✓ C]	D	E
7	A	B	C	[✓ D]	E
8	A	[✓ B]	C	D	E
9	A	B	[✓ C]	D	E
10	A	[✓ B]	C	D	E
11	A	B	[✓ C]	D	E
12	A	[✓ B]	C	D	E
13	A	B	C	[✓ D]	E
14	A	[✓ B]	C	D	E
15	A	B	C	[✓ D]	E
16	A	B	C	[✓ D]	E
17	A	B	C	[✓ D]	E
18	[✓ A]	B	C	D	E
19	A	B	C	[✓ D]	E
20	A	[✓ B]	C	D	E
21	A	B	C	D	E
22	A	B	C	D	E
23	A	B	C	D	E
24	A	B	C	D	E
25	A	B	C	D	E
26	A	B	C	D	E
27	A	B	C	D	E
28	A	B	C	D	E
29	A	B	C	D	E
30	A	B	C	D	E
31	A	B	C	D	E
32	A	B	C	D	E
33	A	B	C	D	E
34	A	B	C	D	E
35	A	B	C	D	E
36	A	B	C	D	E
37	A	B	C	D	E
38	A	B	C	D	E
39	A	B	C	D	E
40	A	B	C	D	E
41	A	B	C	D	E
42	A	B	C	D	E
43	A	B	C	D	E
44	A	B	C	D	E
45	A	B	C	D	E
46	A	B	C	D	E
47	A	B	C	D	E
48	A	B	C	D	E
49	A	B	C	D	E
50	A	B	C	D	E
51	A	B	C	D	E
52	A	B	C	D	E
53	A	B	C	D	E
54	A	B	C	D	E
55	A	B	C	D	E
56	A	B	C	D	E
57	A	B	C	D	E
58	A	B	C	D	E
59	A	B	C	D	E
60	A	B	C	D	E

SCORE:20/40(50%)