NATIONAL JUNIOR COLLEGE

SENIOR HIGH 1 PROMOTIONAL EXAMINATION

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS **9749/02**

Paper 2 Structured Questions

Candidate answers on the Question Paper.

30 September 2020

2 hours

No Additional Materials are required.

READ THE INSTRUCTION FIRST

Write your subject class, registration number and name on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answers **all** questions.

At the end of the examination, fasten all your work securely together.

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

For Examiner's Use	
1	**/ 9**
2	**/ 6**
3	**/ 6**
4	**/ 8**
5	**/ 10**
6	**/ 10**
7	**/ 15**
8	**/ 16**
Total (80m)	

This document consists of **xx** printed pages and **x** blank page**.**

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
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	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
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.	$v = v_0 \cos\omega t$ $= \pm\,\omega\sqrt{x_0^2 - x^2}$
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	$V = \frac{Q}{4\pi\varepsilon_0 r}$
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 density 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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1	**(a)**	**(i)**	Distinguish between *random* and *systematic error*.	
			....	
			....	
			....	
			....	[3]

Suggested Solution:

- Systematic errors have same magnitude while random errors have different magnitude.
  Or
  Systematic errors are predictable depending on the conditions while random errors are not.
- Systematic errors are either consistently larger or smaller than the true value while random errors scatter about a mean value. (refers to sign of the error)
- Systematic error can be eliminated by identifying and removing the error while random error can only be reduced by averaging.

Examiner's Comments:

Many students failed to appreciate that 3 marks are awarded for 3 independent points.

Some students tried the give examples to distinguish the two.

A handful of students mixed up random and systematic errors

		(ii)	Explain why using a graph and drawing line of best fit for the different points will reduce the random error.	
			....	
			....	[1]

Suggested Solution:

In drawing the line of best fit, outliers can be eliminated.

The line of best fit is drawn to accommodate as much of the data as possible by cutting in between the set of data points. In this way, the data is averaged, with most weighting given to the most similar values. This reduces the effects of random error.

Examiner's Comments:

Some students unsuccessfully try to paraphrase the question to answer the question.

(b) A ball approaches a ramp with an inclination of 30°. It hits the surface of the ramp at a speed of 5.0 m s^{-1} at 45° to the normal and bounces off with a speed of 5.0 m s^{-1} as shown in Fig. 1.1.

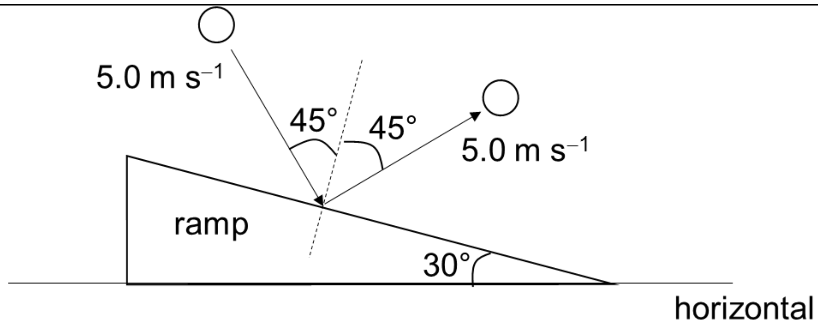


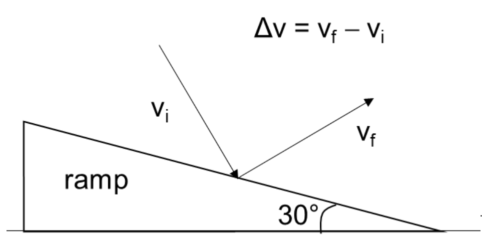
Fig. 1.1

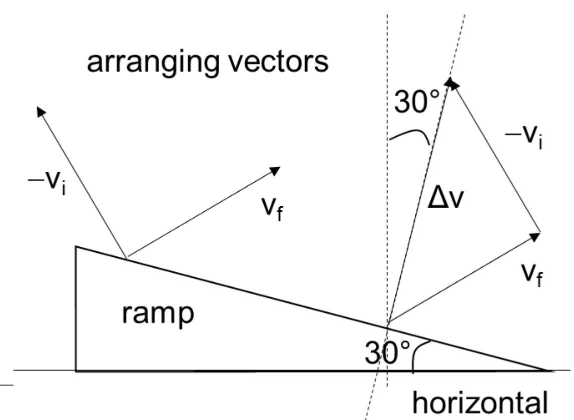
Determine the change in velocity of the ball.

magnitude of change in velocity = ……………………… m s^{-1} [2]

direction of change in velocity is ……………………… °
with respect to the horizontal [1]

<u>Suggested Solution:</u>





determining the direction of Δv using $\Delta v = v_f - v_i$

Since Δv is 90° to the surface of the ramp, Δv is 60° with respect to the horizontal

$$A^2 = B^2 + C^2 - 2BC\cos A$$

$$\Delta v^2 = 5^2 + 5^2 - 2(5)(5)\cos 90^\circ$$

$$\Delta v = 7.1\ m\ s^{-1}$$

Examiner's Comments:

Most students didn't show detailed working for either the parts.

Many students are able to calculate the change in velocity.

Many students got the direction of change in velocity wrong.

(c) A physical equation is of the form

$$Q = k\frac{r^3(P_1 - P_2)}{L}$$

where k is a constant,

r = (1.55 ± 0.03) mm,

P_1 = (125 ± 1) kPa,

P_2 = (100 ± 1) kPa,

L = (120 ± 5) m.

Determine the fractional uncertainty of Q?

fractional uncertainty of Q = ……………………… [2]

Suggested Solution:

$$Q = k\frac{r^3(p_1 - p_2)}{L}$$

$$p_1 - p_2 = 125 - 100 = 25\ kPa$$

$$\Delta(p_1 - p_2) = \Delta p_1 + \Delta p_2 = 1 + 1 = 2\ kPa$$

$$\frac{\Delta(p_1 - p_2)}{(p_1 - p_2)} = \frac{2}{25} = 0.08$$

$$\therefore \frac{\Delta Q}{Q} = 3\frac{\Delta r}{r} + \frac{\Delta(p_1 - p_2)}{(p_1 - p_2)} + \frac{\Delta L}{L} = 3\left(\frac{0.03}{1.55}\right) + 0.08 + \frac{5}{120} = 0.2(1s.f.)$$

Examiner's Comments:

Some the students are unable to consider the change in p first, and that that there is a +/- there in the equation.

Many students used the max, min, average method. Mostly well executed.

[Total: 9]

2 Popcorn is produced in a shallow pan. One piece of popcorn is projected out of the pan from the base of the pan. Fig. 2.1 shows the trajectory of this piece of popcorn.

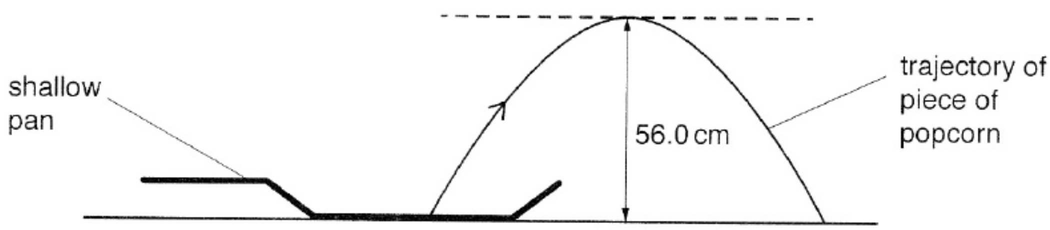


Fig. 2.1

The piece of popcorn reaches a maximum height of 56.0 cm above the base of the pan. You may assume air resistance is negligible.

(a) **(i)** Show that the vertical component u_v of the initial velocity of the piece of popcorn is about 3.3 m s^{-1}. [1]

Suggested Solution:

use $v^2 = u^2 + 2as$

$0 = u_v^2 + 2 \times (-9.81) \times 56 \times 10^{-2}$

So, $u_v = 3.3\,\text{m s}^{-1}$

OR

loss in kinetic energy = gain in gravitational potential energy

$\frac{1}{2} m u_v^2 = mgh$

$u_v = \sqrt{2 \times 9.81 \times 56.0 \times 10^{-2}}$

= 3.3 m s^{-1}

Examiner's Comments:

This part is mostly well done.

	(ii)	The piece of popcorn lands at the same level as its starting point in the pan at a horizontal distance of 1.20 m from its starting point. Show that the magnitude of the initial velocity *u* of the popcorn is about 3.8 m s^{-1}.	
			[3]

Suggested Solution:

For vertical motion,

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

$$0 = 3.3t + \frac{1}{2} \times (-9.81)t^2$$

t = 0.6728 s

Horizontal motion is constant velocity,

$$u_h = \frac{1.20}{0.6728} = 1.784 \text{ m s}^{-1}$$

So, initial velocity $u = \sqrt{1.784^2 + 3.3^2}$

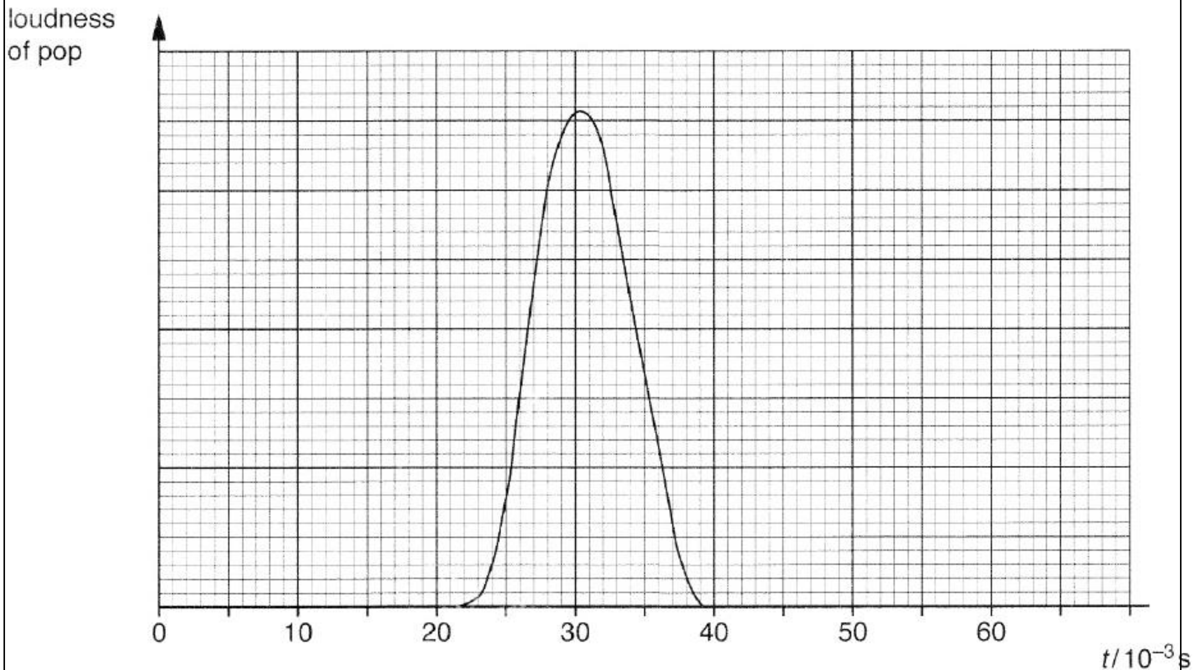
$= 3.8 \text{ m s}^{-1}$

Examiner's Comments:

A handful of students did not realize that the velocity required is the vector sum of the vector and horizontal components.

A number of students cannot appreciate the timing for the different positions like the total time taken is 2 x the time taken for the upwards journey.

A few students tried to jump steps and was not awarded the marks.

	(b)	A microphone placed near the pan recorded the sound emitted as the piece of popcorn was produced. Fig. 2.2 shows how the loudness of the popping sound varied with time.  **Fig. 2.2** Determine the average acceleration of the popcorn as it pops.	
		acceleration = …………………… m s^{-2}	[2]
		Suggested Solution: Average initial acceleration = $\dfrac{3.8}{17 \times 10^{-3}}$ $= 220$ m s^{-2} Examiner's Comments: Many students are unable to link the values found in the earlier part to this part. Some students forget to covert time into seconds.	

[Total: 6]

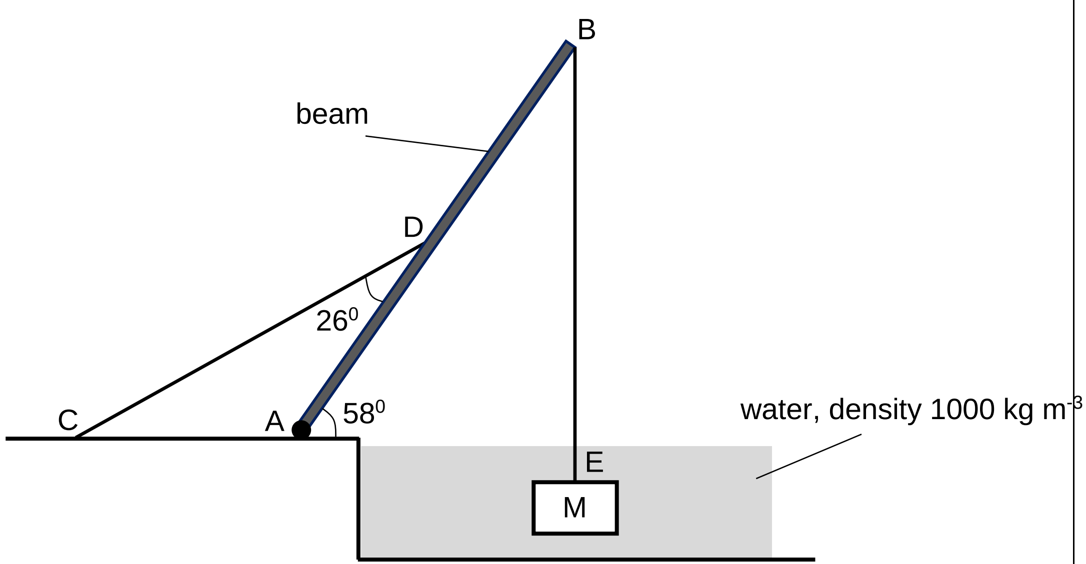
3	**(a)**	When a body is submerged in a fluid, it experiences an upthrust due to the fluid. Explain the origin of upthrust.	
		....	
		....	
		....	[2]
		Suggested Solution: The pressure in the fluid increases with depth. Force by fluid acting upwards on the body is always larger than force acting downwards on the body. (Causing a net upward force on the body) Examiner's Comments: Answers are not specific. Reference should be made to how pressure varies with height and the force is in the upwards direction!	
	(b)	A block of concrete M, of mass 950 kg and density 4750 kg m^{-3} is held in equilibrium by a vertical cable BE. The block is fully immersed in water of density 1000 kg m^{-3}. Cable BE is attached to a uniform rigid beam AB which is freely hinged to the ground at A and held by another cable CD. The beam makes an angle of 58° with the ground. The angle between cable CD and the beam is 26°. Fig. 3.1 shows the arrangement.  	

Fig. 3.1

The beam AB has mass 80.0 kg. The mid-point of the beam is D.

(i) Show the tension in the cable BE is about 7360 N.

[2]

Suggested Solution:

Upthrust = $\rho Vg = 1000 \times \frac{950}{4750} \times 9.81$

Tension = weight of block $-$ upthrust

$= 950 \times 9.81 - 1000 \times \frac{950}{4750} \times 9.81$

= 7360 N

Examiner's Comments:

In questions requiring you to show an expression, theory and principles must be explicitly written down!

(ii) Determine the tension in cable CD.

tension = ... N [2]

[Total: 6]

Suggested Solution:

Take moment about A:

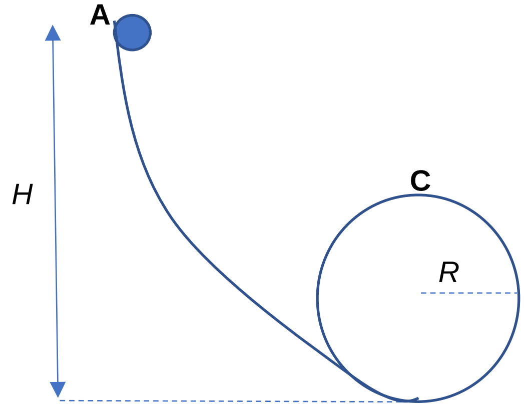
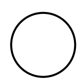
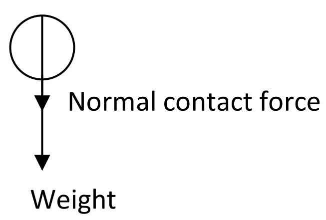
ACWM = CWM

$$T_{CD} \times \frac{1}{2} L \sin 26^0 = 80.0 \times 9.81 \times \frac{1}{2} L \cos 58^0 + 7360 \times L \cos 58^0$$

So, $T_{CD} = 18740$ N

Examiner's Comments:

There are quite a number of students who cannot solve this part. Please do it again if you get it wrong.

4	A ball slides without friction around the loop-the-loop apparatus of radius *R* as shown in Fig. 4.1. It starts from rest at point **A** at a height *H* above the bottom of the loop.  **Fig. 4.1**			
	The radius of the loop, R, is 0.40 m and the ball has a mass of 0.10 kg.			
	(a)	**(i)**	Draw a free-body diagram of the sphere when it reaches the highest point **C**. Label your forces clearly in the diagram below. 	[2]
		Suggested Solution:  Examiner's Comments: Note that centripetal force, which is a resultant force, CANNOT be included in a FBD. Good to see that many define the forces clearly.		

	(ii) Calculate the minimum speed required at the highest point **C** for the ball to remain in contact with the track.		
		minimum speed = …………………..m s^{-1}	[2]
		Suggested Solution: $Fc = N + W$ N > 0 $\frac{mv^2}{r} = mg$ $v = \sqrt{rg}$ = 1.98 ms^{-1} Examiner's Comments: It is important to write the condition N > 0.	
		(iii) Hence, determine the minimum value of *H* so that the ball will always remain in contact with the track.	
		minimum value of H = ………………..m	[2]
		Suggested Solution: By COE, mgH = mg(0.4x2) + 1/2m$(1.98)^2$ H = 1.0 m. Examiner's Comments: Many students are able to complete this part.	
	(b)	If the ball is instead moving at 4.0 m s^{-1} at the highest point **C** of the loop, calculate the force exerted by the track on the ball.	

		force = …………………N	[2]
		Suggested Solution: $N = Fc - W$ $= \frac{mv^2}{r} - mg$ = 3.02 N Examiner's Comments: Many students are able to complete this part.	
			[Total: 8]

5	A shopping trolley and its contents are being pushed from rest.			
	(a)	Explain, in terms of forces on the contents, why when the trolley starts to move, some of its contents slide backwards.		
		………………………………………………………………………………………		
		………………………………………………………………………………………		[1]
		Suggested Solution: (forward) friction on the contents is not enough (to accelerate the contents at the same rate as the trolley) Examiner's Comments: Many students fail to recognise that maximum friction is exceeded when the contents move.		
	(b)	The trolley and its contents have a total mass of 42 kg. The trolley moves at a speed of 1.2 m s^{-1} when the applied force is removed. A constant resistive force acts on the trolley and causes it to stop in 3.2 s.		
		(i)	Calculate the resistive force acting on the trolley.	
			resistive force = ………………… N	[2]
			Suggested Solution: impulse = change in momentum = 42 (0 – 1.2) = −63.0 or −63 N s	

			force = impulse / time = 63 / 3.2 = 19.7 or 20 N (accept e.g. $F = ma$) Examiner's Comments: Many students are able to complete this part.	
		(ii)	Hence or otherwise, determine the power required to keep the trolley moving at a constant speed of 1.2 m s^{-1}. power = …………………… W	[2]
			Suggested Solution: $P = Fv$ = (19.7)(1.2) = 23.6 or 24 W Examiner's Comments: Majority of students answered this very well.	
	(c)	The trolley is now on a straight slope that is inclined at an angle 4.8° to the horizontal, as shown in Fig. 5.1. A constant resistive force with the same magnitude as that in **(b)(i)** acts on the trolley.  **Fig. 5.1**		
		(i)	A force, parallel to the slope, either up or down the slope, is applied on the trolley such that it moves down the slope with constant speed of 1.2 m s^{-1}. Determine the magnitude and state the direction of the applied force.	
			magnitude = ………………………… N direction: ……………………………	[3]

			Suggested Solution: (The weight of the trolley can be resolved into the components *mg* sinθ down the slope and *mg* cosθ perpendicularly away from the slope) (hence taking down the slope as positive) Assuming applied force is down the slope, resultant force on trolley = $mg \sin\theta - R + F$ since resultant force = 0 for constant velocity, $F = R - mg \sin\theta = 19.7 - (42\times9.81)\sin4.8° = -14.8$ N or -15 N (a negative answer indicates that the assumption made that the force applied is down the slope is wrong hence) direction of applied force is up the slope Examiner's Comments: Majority of students answered this well. However, a fair number of students were not able to correctly state the component of the weight along the slope.	
		(ii)	The trolley now moves up the same slope. A force is applied on the trolley such that it moves up the slope with the same constant speed. The magnitude of the resistive force acting on the trolley remains the same. Explain whether the magnitude of the applied force remains the same, increases or decreases compared to the value in **(i)**.	
			…………………………………………………………………………………………	
			…………………………………………………………………………………………	
			…………………………………………………………………………………………	
			…………………………………………………………………………………………	[2]
				[Total: 10]
			Suggested Solution: applied force (up the slope) needed to balance the effects of both the component of the weight (down the slope) and the resistive force (down the slope) (for resultant force to be zero) hence increases Examiner's Comments:	

			For those who answered (i) well were able to continue to correctly deduce the answer to this part.	

6	A student is studying a *transverse* plane water wave in which all the wavefronts are parallel to one another on a ripple tank experiment at shown in Fig. 6.1. The variation with time t of the displacement x of a particular particle in the wave is shown in Fig. 6.2.	

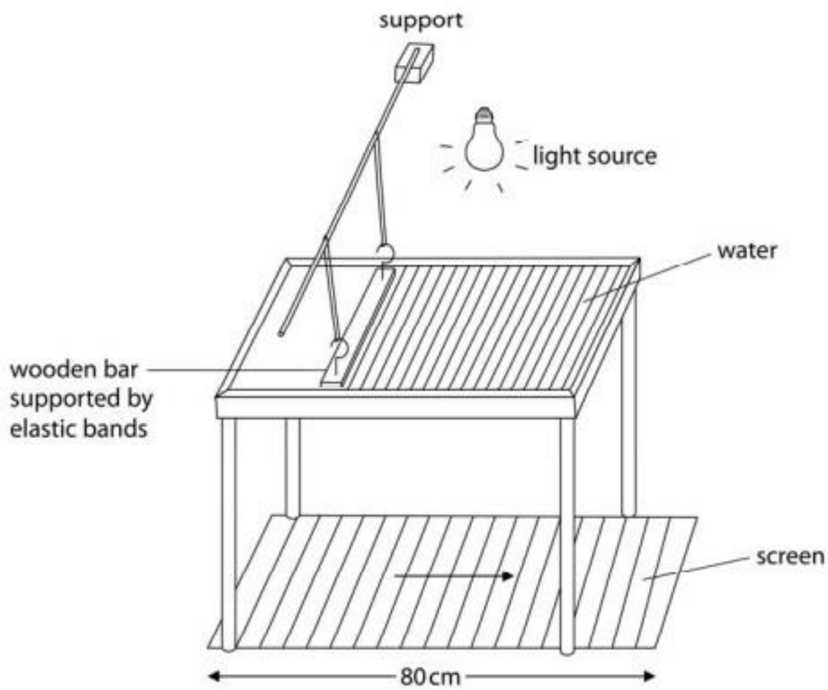


Fig. 6.1

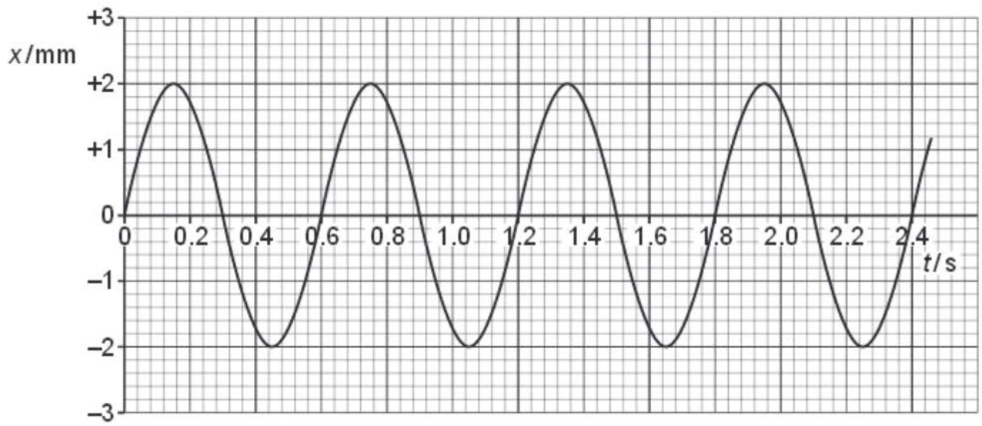


Fig. 6.2

The distance *d* from the source of the wave of the oscillating particles wave is measured.
At a particular time, the variation of displacement *x* with *d* is shown in Fig. 6.3.

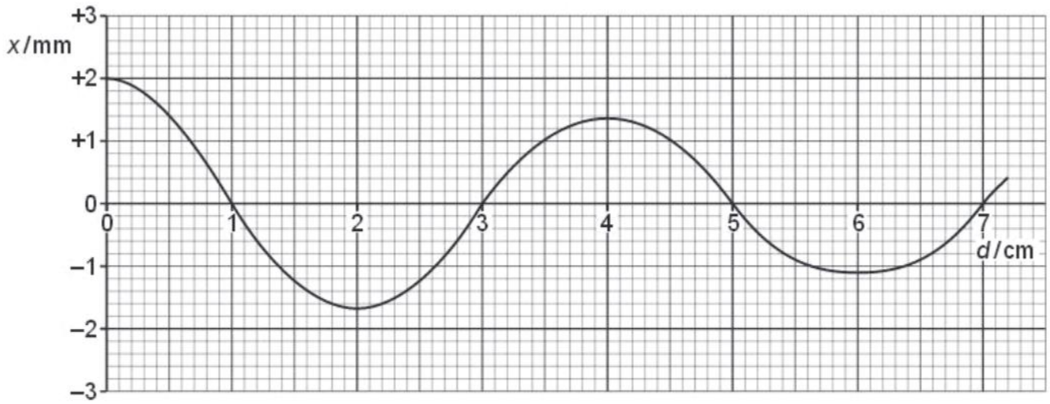


Fig. 6.3

(a) Distinguish between a *transverse* wave and a *longitudinal* wave.

....

....

.... [2]

Suggested Solution:

transverse: displacement of particles in the wave perpendicular **and** *longitudinal*: displacement of the particles in the wave parallel

to direction of energy transfer

Examiner's Comments:

Only a few scripts made reference to the "direction of energy transfer". Most students were able to differentiate correctly the direction of oscillations or displacement of the particles as being perpendicular or parallel to the direction of wave propagation.

(b) Use Figs. 6.2 and 6.3 to determine the speed the water wave to 3 significant figures.

		speed = ………………………… m s^{-1}	[3]
		Suggested Solution: wavelength = 4 cm (for 1 cycle) **and** period = 0.6 s (more than 1 cycle) speed = 4 ÷ 0.6 = 6.67 cm s^{-1} or 6.7 cm s^{-1} = 0.0667 m s^{-1} or 0.067 m s^{-1} Examiner's Comments: Well answered by majority of stduents.	
(c)	**(i)**	Use the Figs. above to state and explain whether the wave is losing power as it moves away from the source.	
		…………………………………………………………………………………………	
		…………………………………………………………………………………………	
		…………………………………………………………………………………………	[2]
		Suggested Solution: Fig. 6.2 shows that the amplitude and hence intensity of the wave decreases the further the wave is from the source since the area (or length) of the (parallel) wavefronts remains the same, the power of the wave decreases Examiner's Comments: While most students considered the wave losing power, many did not cite the correct reason to support the claim.	
	(ii)	Determine the efficiency of energy transfer from the source to a point 6.0 cm from the source.	

			efficiency = ... %	[3]
			Suggested Solution: Efficiency = power of wave 6.0 cm from source / power of wave at source × 100% Since area of wavefront remain the same, Efficiency = intensity of wave 6.0 cm from source / intensity of wave at source × 100% Since intensity α amplitude^2 Efficiency = (amplitude of wave 6.0 cm from source)^2 / (amplitude of wave at source)^2 × 100% = $1.1^2 / 2.0^2 \times 100\%$ = 30% or 30.3% Examiner's Comments: Many students did not explain the working and these were not given full credit.	
				[Total: 10]

7	**(a)**	State what is meant by *simple harmonic motion*.	
		....	
		....	
		....	[2]
		Suggested Solution: The motion of an object is simple harmonic if its acceleration is directly proportional to its displacement from its equilibrium position and its acceleration is always opposite in direction to its displacement.	
	(b)	A mass *m* connected by two stretched vertical springs with equal spring constants *k* is set up as illustrated in Fig. 7.1 and undergoes simple harmonic motion.	

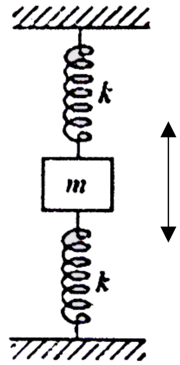


Fig. 7.1

For a displacement x, the acceleration a of the mass m is given by the expression

$$a = -\frac{2k}{m}x$$

(i) Explain why the expression leads to the conclusion that the mass m is performing simple harmonic motion.

....

....

.... [2]

Suggested Solution:

As k and m are positive constants, 2k/m is a constant and hence the acceleration is proportional to the displacement.

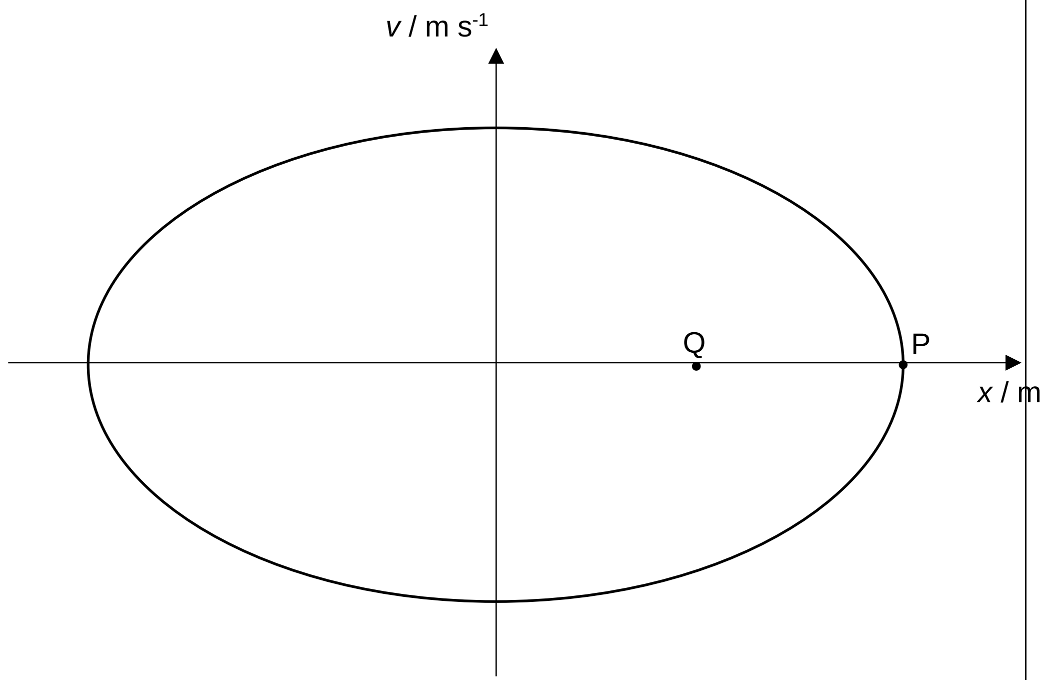
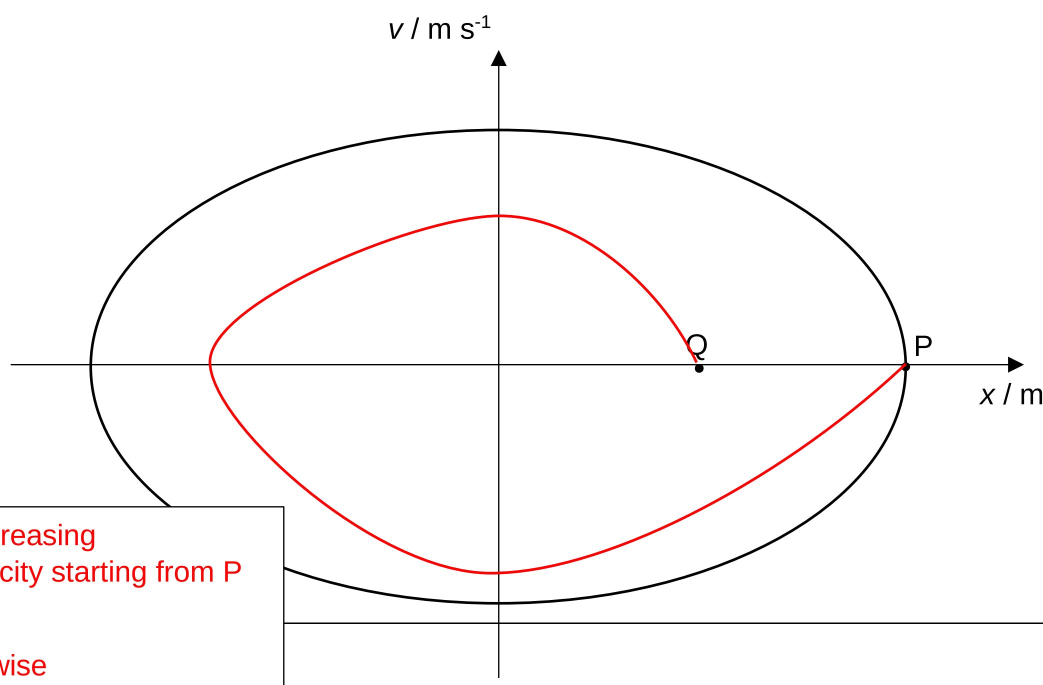
The negative sign indicates that the acceleration is opposite in direction to the displacement.

Hence the mass m is performing simple harmonic motion.

(ii) The mass m is 150 g and the spring constants k of the springs are 25 N m^{-1}.

Show that the frequency of the oscillations is 2.9 Hz.

			[2]
		Suggested Solution: $\omega^2 = \frac{2k}{m}$ $\omega = \sqrt{\frac{2\times25}{0.150}} = 18.26\, rad\ s^{-1}$ $f = \frac{18.26}{2\pi}$ $= 2.9\ Hz$	
		(iii) An initial displacement was applied to the mass *m* resulting in the maximum kinetic energy of the oscillations to be 63 mJ. Calculate the amplitude x_0 of the oscillations.	
		x_0 = ... m	[2]
		Suggested Solution: Maximum KE == $\frac{1}{2}m\omega^2{x_0}^2$ $\frac{1}{2} \times 0.15 \times (2\pi \times 2.9)^2{x_0}^2 = 63 \times 10^{-3}$ $x_0 = 0.050\ m$	
		(iv) State and explain what will happen to the frequency of the oscillations if the initial displacement applied to mass *m* is increased.	
		....	
		....	
		....	[2]
		Suggested Solution: As ω is independent of the amplitude, frequency will stay the same	

		(v)	Fig. 7.2 shows the variation of velocity v with displacement x of the oscillations with the original maximum kinetic energy of 63 mJ.  **Fig. 7.2** The setup in Fig. 7.1 is placed in a viscous medium resulting in damping of the oscillations. Sketch the graph of the variation of velocity v with displacement x in Fig. 7.2 as the mass m undergoes one damped oscillation from point P to point Q.	[2]
		Suggested Solution:  		

Spiral with decreasing amplitude/velocity starting from P and ends at Q

Spiral is clockwise

(iv) A variable frequency oscillator is now attached to the set such that the mass *m* can oscillate at different frequencies. The set up is still placed in the viscous medium.

The variation of amplitude with frequency of the oscillator is shown in Fig. 7.3.

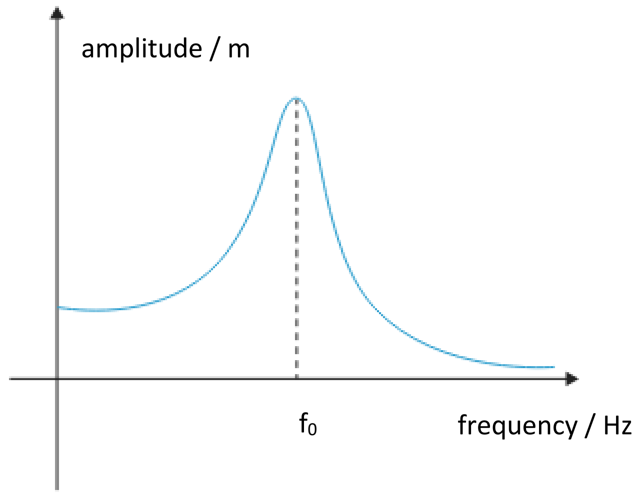


Fig. 7.3

1. State the phenomenon illustrated in Fig. 7.3.

.... [1]

2. Explain whether the value of f_0 in Fig. 7.3 is equal to, more than or less than the frequency of 2.9 Hz calculated in **(b)(ii)**.

....

.... [2]

Suggested Solution:

1. Resonance

2. 2.9 Hz is the natural frequency of the undamped spring mass system.

Since the spring mass system is damped here

f_0 is lower

[Total: 15]

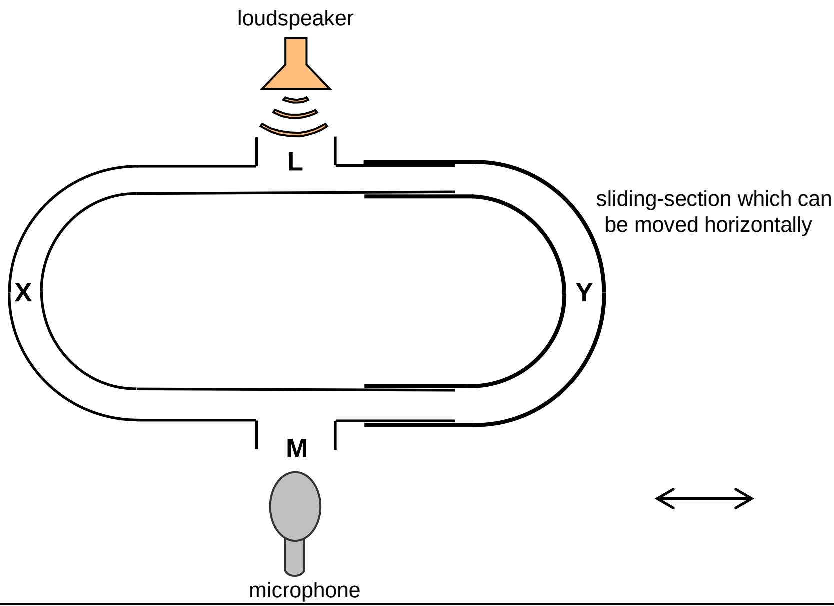
8	**(a)**	State the *principle of superposition*.	
		…………………………………………………………………………………………	
		…………………………………………………………………………………………	
		…………………………………………………………………………………………	[1]
		Suggested Solution: The principle of superposition states that when 2 or more waves of the **same kind** exist simultaneously at a point, the **resultant displacement** of the waves at that point in time and space is the **vector sum** of the displacements due to each wave acting independently. Examiner's Comments: Many students missed out 'same kind'. Some students stated 'resultant amplitude' rather than resultant displacement. This is incorrect. Some students may have mistaken the question and answered as if question is asking for the conditions for formation of stationary waves or observable interference.	
	(b)	Sound produced by the loudspeaker shown in Fig 8.1 has a frequency of 4.0×10^3 Hz. The sound waves arrive at microphone M via two different paths, LXM and LYM. The left-tube is fixed in position, while the right-tube is a sliding-section. At position M, the sound waves from the two paths interfere.  	

Fig 8.1

Initially, the lengths of paths LXM and LYM are equal. The sliding-section is then pulled out horizontally by 0.020m, and the loudness at microphone M changes from a maximum to a minimum.

(i) Determine the path difference between the two waves after the sliding-section is pulled out.

Path difference = …………………… m [1]

Suggested Solution:

path difference = 2 x 0. 020m

= 0.040 m

Examiner's Comments:

Well done for most students. A simple working is necessary to show how the path difference is determined.

(ii) Calculate the speed at which sound travels through the tube.

Speed = ………………..……m s^{-1} [3]

Suggested Solution:

From loud (no path difference leading to constructive interference at M) to soft sound (path difference leading to destructive interference at M),

$\Rightarrow$ path difference = $\lambda/2$

$\Rightarrow$ $\lambda/2 = 0.040\text{m}$

$\Rightarrow$ $\lambda = 2 \times$ path difference

$= 2 \times 0.040\text{m}$

$= 0.080\text{ m}$

$\therefore v = f\lambda$

$= 4000 \times 0.080$

$= 320\text{ ms}^{-1}$

Examiner's Comments:

Some students simply stated that wavelength is twice the path difference. Even though the right answer is obtained. The working does not show the reasoning clearly. Whenever there is constructive/destructive interference, it is recommended that students state the explanation, constructive interference therefore path difference equal $n\lambda$ or destructive interference therefore path difference equal $(n-1/2)\lambda$.

This scenario can also be thought of using stationary waves. However the analysis of the position of the antinodes and nodes and how they have shifted after the sliding section has shifted is very difficult to visualise.

		(iii)	When the opening at M is sealed, explain why a standing wave is set up in the tube.	
			....	
			....	
			....	[3]

<u>Suggested Solution:</u>

The sound waves from <u>paths LXM and LYM</u> meet in the <u>opposite directions</u>.

Since both waves are of <u>equal amplitude, frequency and speed</u>,

they <u>superpose</u> to form a stationary wave.

Examiner's Comments:

Many students thought this is a superposition between an incident and a reflected wave without noting that actualy the waves from LXM and LYM superpose. There is actually no clear boundaries for reflection to take place within the tube.

(iv) The frequencies of the sound produced by the loudspeaker ranges from 40 Hz to 4.0 kHz. Calculate the range of wavelengths of sound produced by loudspeaker.

Range of wavelengths = ………………… m to ………………… m [1]

Suggested Solution:

λ_{min} = v / f = 320/4000 = 0.080 m (2 or 3 sf) allow for ecf

λ_{max} = v / f = 320/40 = 8.0 m

Examiner's Comments:

Surprisingly many careless calculation and sf error for a straightforward question. Students should note that even for a simple calculation question, a simple working is still necessary.

(v) A good loudspeaker should be able to diffract sound over a large area. Estimate the optimal diameter of the loudspeaker in order to achieve the maximum spreading of sound waves. Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

Suggested Solution:

When the diameter of the speaker is comparable to the wavelength of the sound it produces, significant diffraction occurs.

Optimal diameter around 0.080 m

Examiner's Comments:

The simplest answer to this question is to state the fact that diffraction is most signficant when the wavelength is comparable to the slit size. Many students seem dissatisfied

		with this straightforward explanation and feel a need to use equations with undefined symbols. It is only acceptable to use equations when all symbols are defined clearly.		
	(c)	Light of wavelength 590 nm is incident on a diffraction grating with slits of separation 1.6×10^{-6} m.		
		(i)	Determine the maximum order of the interference pattern that will be observed on a screen.	
			Maximum order = ………………	[2]
			Suggested Solution: $d \sin\theta = m\lambda$ Since $\sin\theta$ cannot be greater than 1 For max order, $\sin\theta < 1$ $m\lambda / d < 1$ $m < 2.7$ Since m must be an integer, and it cannot exceed 2.7, the max order = **2** Examiner's Comments: Some students misinterpreted the question as asking for the number of maxima rather rather than the maximum order of maxima.	

Clarity of working can be improved by including an explanation why substitution of $\sin\theta=1$ or $\theta=90°$ was made.

(ii) Another diffraction grating of the same slit separation is placed in front of the original grating such that their slits are perpendicular to one another as shown in Fig 8.2. A 2-dimensional pattern of bright spots is formed on the screen.

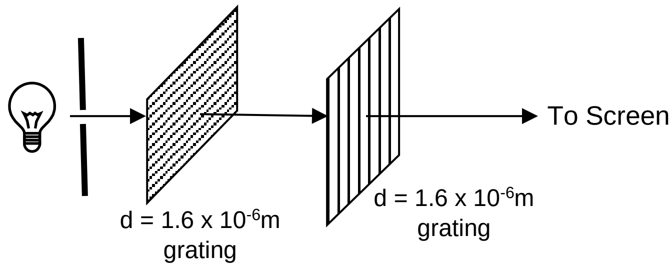
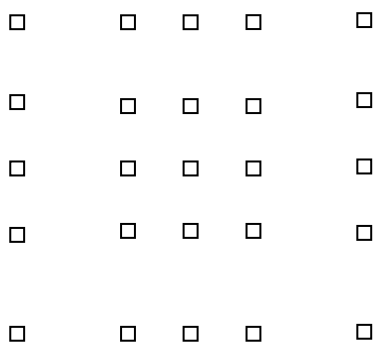


Fig 8.2

Sketch the pattern obtained, showing clearly the relative separation of the spots. [2]

Suggested Solution:



- Correct shape grid of spots 5x5
- 2nd order dots are further apart than 1st order dots

Examiner's Comments:

A difficult question that is unsurprisingly not well done by the majority of students. Only the best are able to note both the implication of having two diffraction grating with slits perpendicular to each either and the implication that 2nd order maxima from the 1st order maxima are further apart than 1st order maxima is from the central maximum. It can be checked that $(\theta_2-\theta_1) > (\theta_1-\theta_0)$.

[Total: 15]