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	$T/\text{K} = T/^\circ\text{C} + 273.15$
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]

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

....
.... [1]

(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.

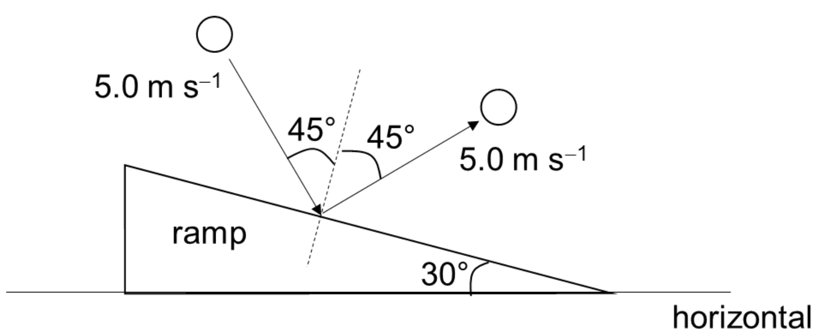


Fig. 1.1

Determine the change in velocity of the ball.

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

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

(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]

[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.

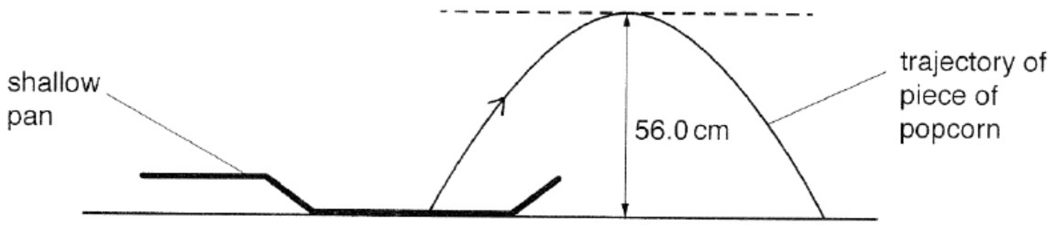


Fig. 2.1

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]

(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]

(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.

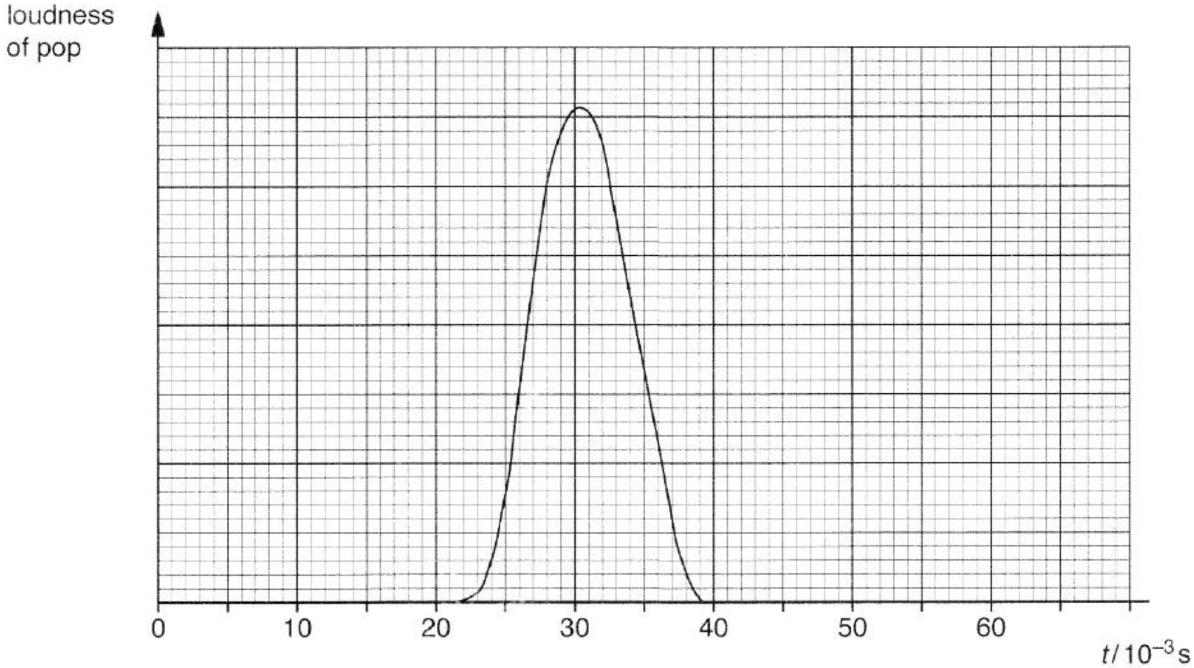


Fig. 2.2

Determine the average acceleration of the popcorn as it pops.

acceleration = …………………… m s^{-2} [2]

[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]

(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.

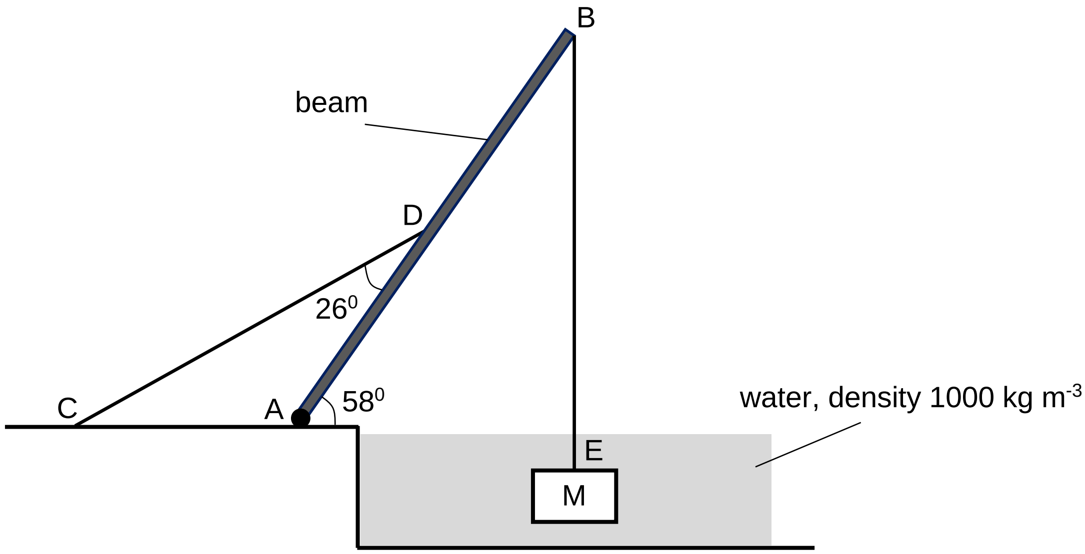


Fig. 3.1

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]

(ii) Determine the tension in cable CD.

tension = …………………… N [2]

[Total: 6]

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.

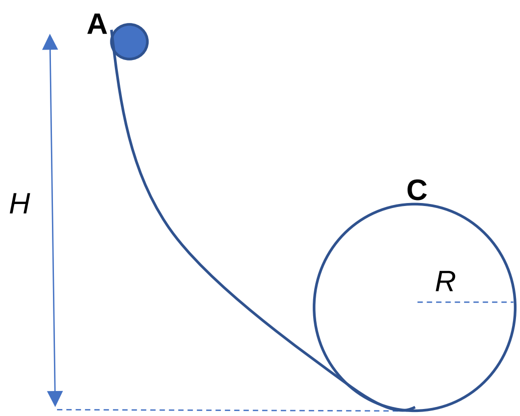
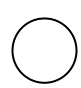


Fig. 4.1

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]

(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]

(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]

(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]

[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]

(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]

(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]

(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.

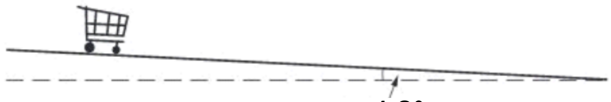


Fig. 5.1

(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]

(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]

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.

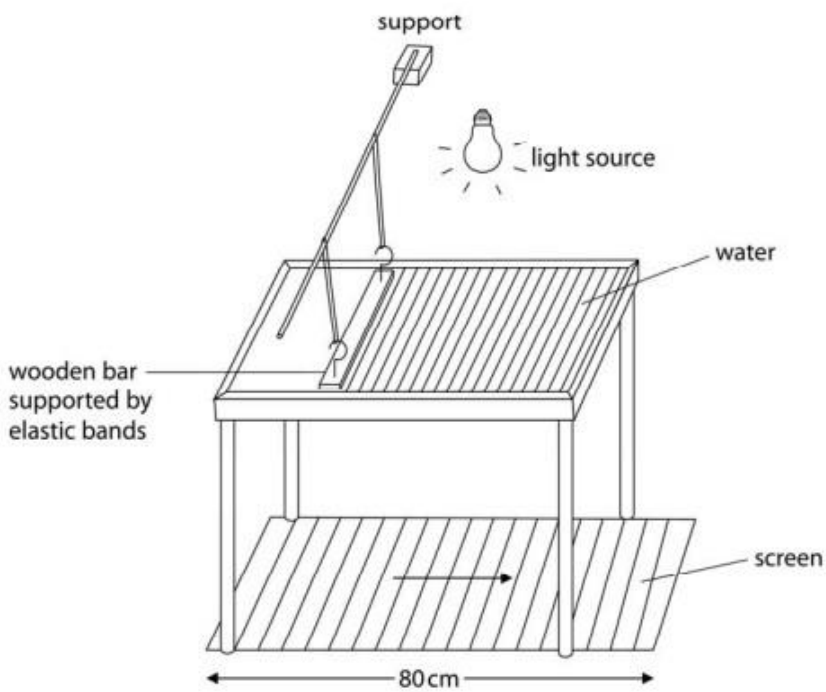


Fig. 6.1

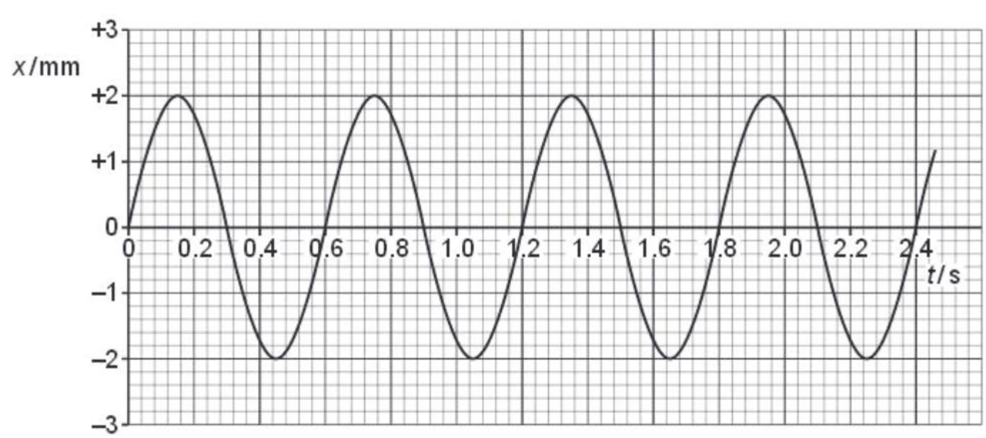


Fig. 6.2

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.

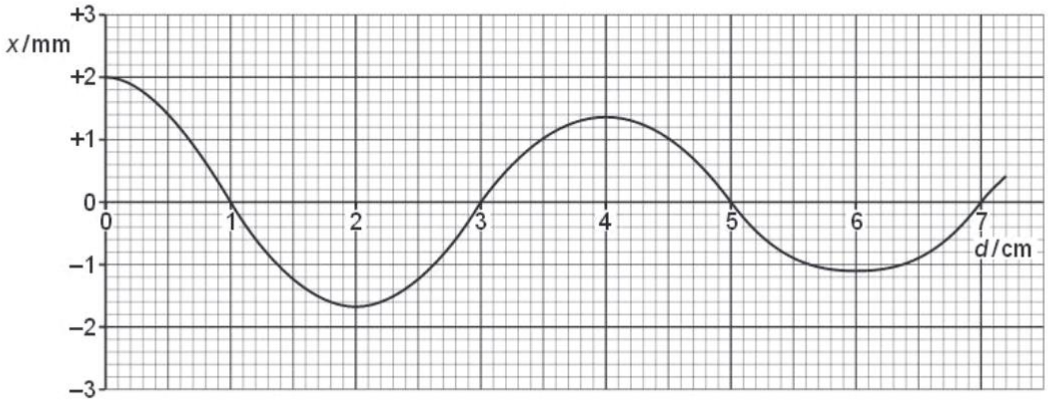


Fig. 6.3

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

……

……

…… [2]

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

speed = ………………………… m s^{-1} [3]

(c) **(i)** Use the Figs. above to state and explain whether the wave is losing power as it moves away from the source.

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

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

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

(ii) Determine the efficiency of energy transfer from the source to a point 6.0 cm from the source.

efficiency = ... % [3]

[Total: 10]

7 **(a)** State what is meant by *simple harmonic motion*.

....

....

.... [2]

(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.

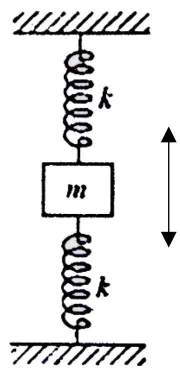


Fig. 7.1

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]

(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]

(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]

(iv) State and explain what will happen to the frequency of the oscillations if the initial displacement applied to mass m is increased.

....

....

.... [2]

(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.

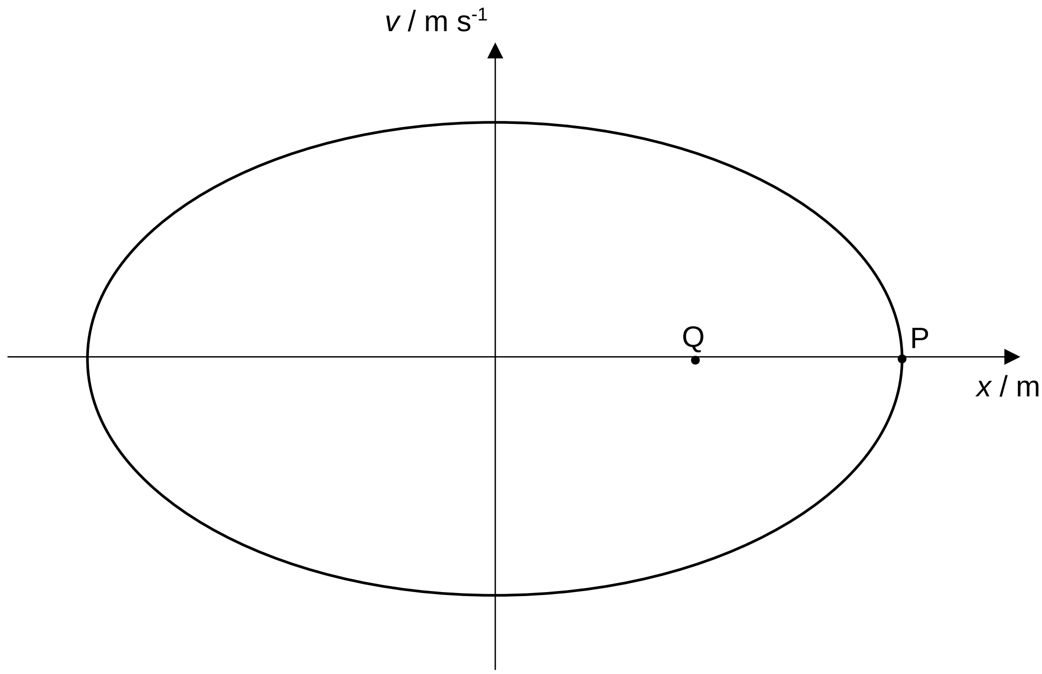


Fig. 7.2

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]

(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.

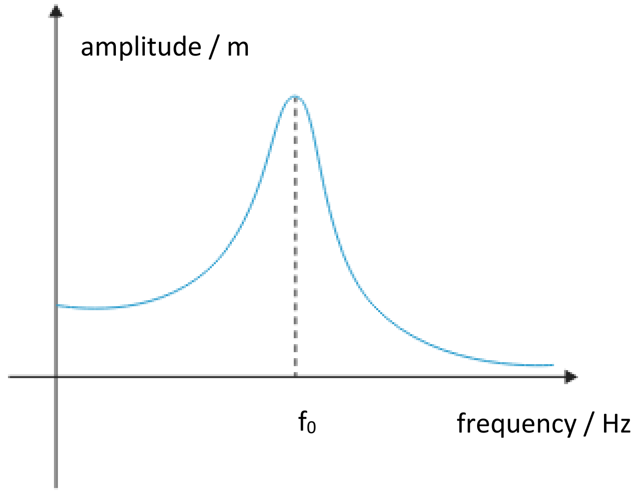


Fig. 7.3

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]

[Total: 15]

8 **(a)** State the *principle of superposition*.

....

....

.... [1]

(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.

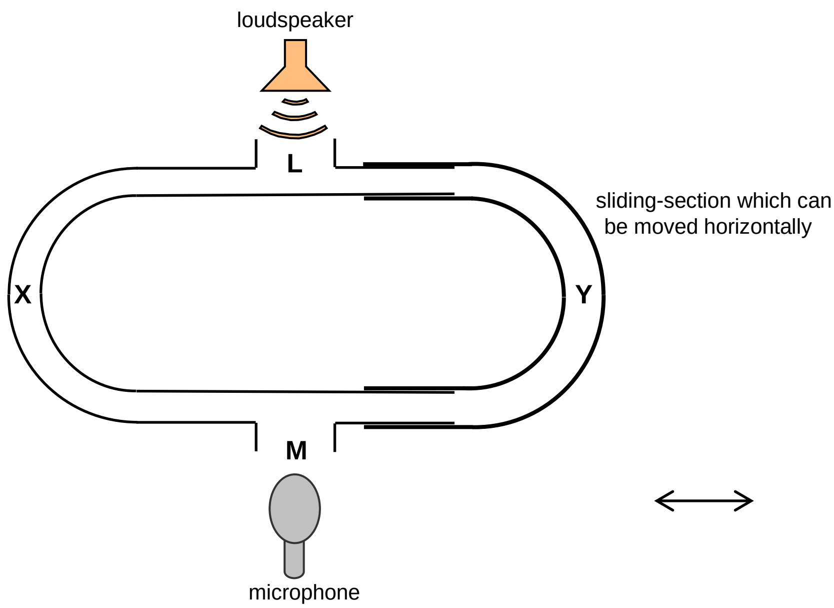


Fig 8.1

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]

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

Speed = ……………..……m s^{-1} [3]

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

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(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]

(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]

(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]

(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.

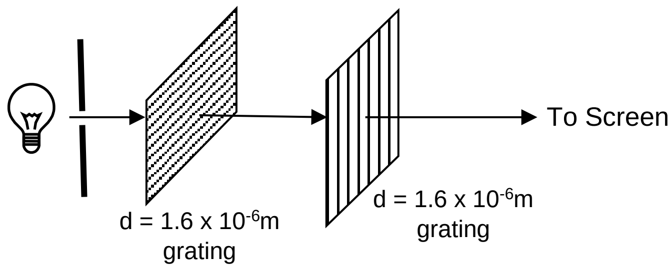
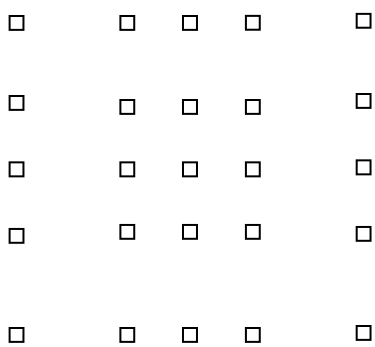


Fig 8.2

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

[Total: 15]