(b) Show that the standing wave $f(x, t) = A\sin(kx)\cos(kvt)$ satisfies the wave-equation and express it as the sum of a wave travelling to left and a wave travelling to the right. (5)



08/01/2024

[This question paper contains 8 printed pages.]



08.01.2024(M)

**Your Roll No.....**

**Sr. No. of Question Paper : 1631** **G**

Unique Paper Code : 2222011103

Name of the Paper : Waves and Oscillations (DSC 3)

Name of the Course : **B.Sc. Hons. – (Physics)**

Semester : I

Duration : 2 Hours Maximum Marks : 60

**Instructions for Candidates**

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **four** questions in all.
3. Question No. **1** is compulsory.
4. Use of non-programmable scientific calculator is allowed.

P.T.O.

1. Attempt **all** questions. Each question carries equal marks.

(a) Two particles of masses $m_1$ and $m_2$ lying on a smooth horizontal plane are connected by a light spring such that when $m_1$ is held fixed, $m_2$ oscillates harmonically in the line of the spring with period $T_{12}$. Show that if $m_2$ is held fixed, mi will oscillate harmonically with period of $T_{21}$, such that $m_2T_{21}^2 = m_1T_{12}^2$.

(b) What is a compound pendulum? A circular ring of diameter d and mass M hangs on a nail fixed to a wall. What is the time period of small oscillation of ring?

(c) Discuss the mechanism of energy exchange in a coupled pendulum.



5. (a) Two equal masses m are connected with two identical massless springs with spring constant k as shown in Fig. 3. Show that the angular frequencies of two normal modes of vertical oscillation are given by :

$$\omega = \left(3 \pm \sqrt{5}\right) \frac{k}{2m}$$

Also, show that in the slower mode the ratio of the amplitudes is $\frac{1}{2}\left(\sqrt{5}-1\right)$ while in faster mode this ratio is $\frac{1}{2}\left(\sqrt{5}+1\right)$. (10)

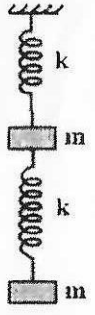


Fig. 3

P.T.O.

(b) Give the analytical solution of Lissajous figure formed by the superposition of two perpendicular waves having frequency ratio 1:2 and phase difference $\phi$. Give graphical representation of Lissajous figure if $\phi = \pi/4$. (6,4)

4. (a) Establish the equation of motion of a damped harmonic oscillator subjected to a damping force that is proportional to first power of its velocity. If the system is under damped, show that motion of the system is oscillatory with its amplitude decaying exponentially with time. (10)

(b) An under damped oscillator has its amplitude reduced to $(1/10)^{th}$ of its initial value after 100 oscillations. If the time period is 2 seconds, calculate (i) the damping constant and (ii) Relaxation time. (5)



(d) In a series LCR circuit, L = 0.5 henry, C = 5 μF. What should be the maximum value of the resistance R for the condition the discharge to be oscillatory?

(e) A string length 3a and negligible mass is attached to two fixed ends. The tension in the string is T. A particle of mass m is attached at distance a from one end of the string as shown in the Fig. 1. Find the time period of the transverse oscillations (small oscillations) of the mass m.

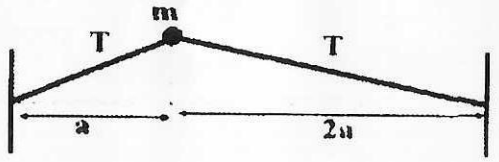


Fig. 1

2. (a) A uniform spring of spring constant k and a finite mass $m_s$ is loaded with a mass M. If $m_s$ is not negligible compared to M show that the period of vertical oscillations of mass spring system is-

$$T = 2\pi\sqrt{\frac{M + \frac{m_s}{3}}{K}} \quad . \qquad (10)$$

(b) Two massless springs of force constant $k_1$ and $k_2$ are connected to mass m placed on a horizontal functionless surface as shown in Fig.2(a) and Fig. 2(b). Obtain an expression for the time period of the horizontal oscillations in each case. (5)

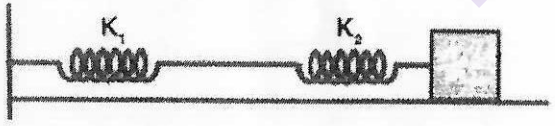


Fig. 2(a)



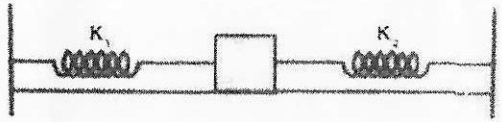


Fig. (b)

3. (a) Two collinear simple harmonic motions, each of amplitude 1.0 cm and frequencies 8 Hz and 6 Hz respectively, act simultaneously on a particle. Assuming that they are in phase, draw the displacement-time curves for the two motions. Also, draw the curve of the resultant displacement over one beat period. What is the beat frequency? (5)