Ahmedabad University

School of Arts and Sciences

PHY212 - Oscillations, Waves and Optics
Mid Term Examination 2022 (Winter Semester)

Total Marks = 100 **Time - 3 hours**

Enrolment number: .....
Date: 7/3/2022
No. of printed pages: 4

PART-A

Answer any 6 questions in part-A. Each question carries 3 marks. **6×3=18**

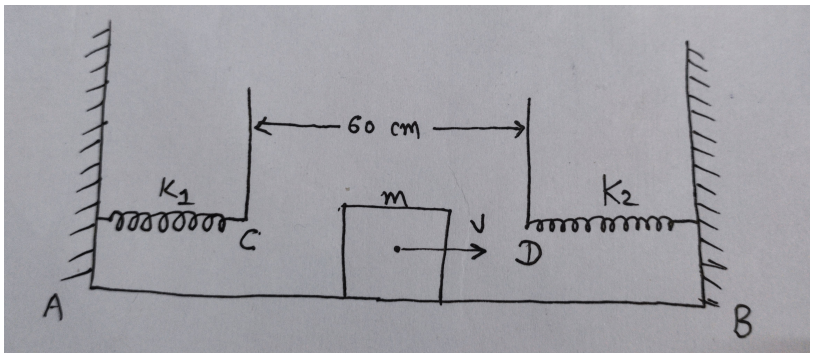
1. For a wave travelling in a dispersive medium, show that the phase velocity (v_p) is higher than the group velocity (v_g).
2. What does the Poynting vector ($\mathbf{P} = \mathbf{E} \times \mathbf{H}$) represent for an electromagnetic wave? The symbols have their usual meanings.
3. A simple pendulum is displaced from its mean position to a position until its height from the mean position is 0.05 m. It is then released. (a) Show that the velocity is independent of mass of the pendulum. (b) Calculate its velocity when it passes the mean position. Take $g = 10\ m/s^2$ and neglect the friction offered by the medium.
4. Show that the reflected wave from the rigid boundary is at out of phase with the incident wave.
5. Prove that $\psi(z,t) = A\ sin(\omega t - kz)$ is a solution of the classical one dimensional wave equation. The symbols have their usual meanings.
6. A mass of 1 kg attached to the bottom of a spring has a certain frequency of vibration. What mass is to be added in order to reduce the frequency by half?

7. Amplitude of a simple harmonic oscillator (SHO) is 4 cm. At what distance from the equilibrium position, the kinetic energy and the potential energy becomes equal?

PART-B

Answer any 2 questions in part-B. Each question carries 10 marks. **2×10=20**

8. Two light springs of force constants k_1 and k_2 and a block of mass m are in one line AB on a smooth horizontal table such that one end of each spring is on rigid supports and the other end is free as shown in the figure below. The distance CD between the free ends of the springs is 60 cm. If the block moves along AB with a velocity 120 cm/s in between the springs, calculate the period of oscillation of the block, where $k_1 = 1.8\ N/m,\ k_2 = 3.2\ N/m,\ m = 200\ g$.



9. The phase velocity of a wave in water medium is given by $v_p = \sqrt{(g\lambda/2\pi) + (2\pi\sigma/\rho\lambda)}$, where $g = 9.8$ m/s^2, $\rho = 1000$ kg/m^3, and $\sigma = 0.72$ N/m. Determine the wavelength λ_0 of the waves which don't disperse in the water. What are the phase and group velocities at this wavelength (λ_0)?

10. The intensity (average Poynting vector magnitude) of sunlight (electromagnetic wave) at the normal incidence on the Earth's surface is 1.35 kW/m^2. Calculate the amplitude of the electric (E_0) and magnetic field (H_0) of the electromagnetic wave at the Earth's surface, given that $\mu = 4\pi \times 10^{-7}$ Henry/meter and $\epsilon = \frac{1}{36\pi \times 10^9}$ Farad/meter.

PART-C

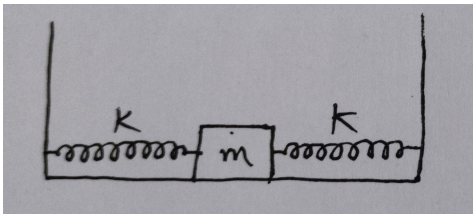
Answer any 6 questions in part-C. Each question carries 7 marks. **6×7=42**

11. Two strings of linear mass densities ρ_1 and ρ_2 are joined together and the composite spring is stretched with a certain tension. A transverse wave travelling in the first string is incident on the junction separating the second string. Calculate the reflection and transmission energy coefficients at the junction, if (a) $\frac{\rho_1}{\rho_2} = 0.25$ and (b)$\frac{\rho_1}{\rho_2} = 4$.

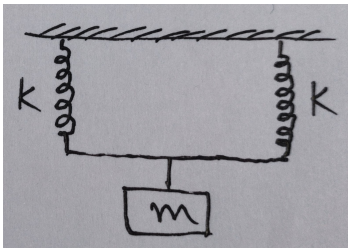
12. A particle of mass 0.1 kg is moving along the positive x-axis under the influence of a force $F(x) = -K/2x^2$, where $K = 0.01\ Nm^2$. At $t = 0$ it is at $x = 1\ m$ and its velocity $v = 0$. Calculate its velocity when it reaches $x = 0.5\ m$.

13. Show that the amplitude of a weakly damped LCR oscillator reduces to half of its initial value in time $t = \tau\ ln2$, where τ is the relaxation time of the LCR oscillator.

14. Two identical springs have spring constant $k = 15\ N/m$. A 300 g mass is connected to them as shown in the figures (a) and (b) below. Find the period of oscillation for each system (a) and (b). Ignore the frictional forces.

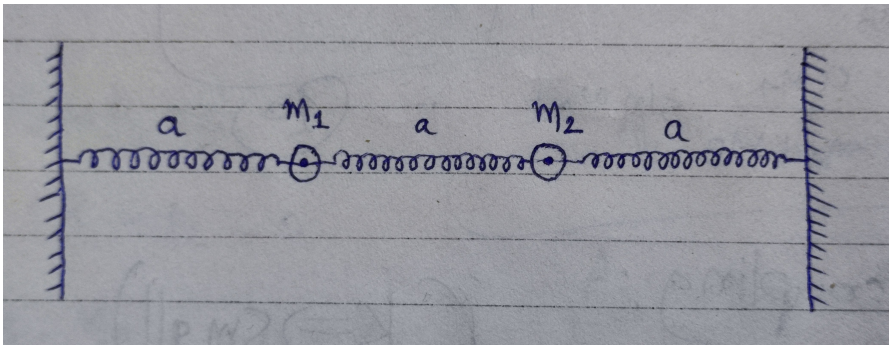


(a)



(b)

15. Longitudinal oscillations of two coupled masses: Two bodies of masses m_1 and m_2 are attached to each other and to two fixed points by three identical light springs of relaxed length a. The whole arrangement rests on a smooth horizontal table as shown in the figure below. If $m_1 = m_2$, then (i) Find the angular frequencies of the normal modes for small amplitude longitudinal oscillations. (ii) Draw the schematic to represent the configurations of these two modes (similar way as indicated in the figure below).



16. A transverse harmonic disturbance is produced in a string. The maximum transverse velocity is 3 m/s and maximum transverse acceleration is 90 m/s^2. If the wave velocity is 20 m/s , then find the waveform $\psi(z, t)$.

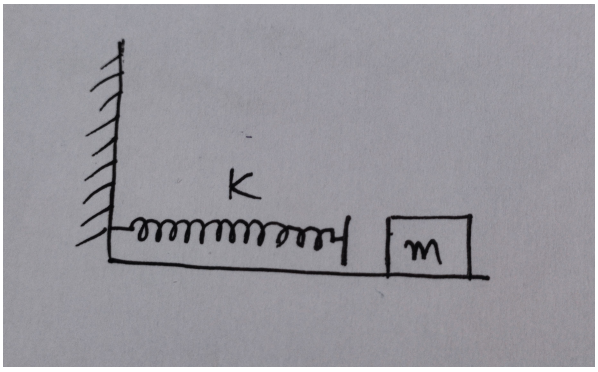
17. Calculate the frequency, relaxation time, and the quality factor for an LCR circuit with $L = 1\ mH$, $C = 5\ \mu F$, and $R = 0.5\ \Omega$.

PART-D

Answer any 4 questions in part-D. Each question carries 5 marks. **4×5=20**

18. A mass of 1 g vibrates through 1 mm on each side of the middle point of its path and makes 500 complete vibrations per second. Assuming its motion to be simple harmonic, find out the maximum force acting on the particle.

19. The 100 g mass shown in figure below is pushed to the left against a light spring of spring constant $k = 500\ N/m$ and compresses the spring 10 cm from its relaxed position. The system is then released and the mass shoots to the right. If the friction is ignored, what is the velocity of the mass as it shoots away?



20. Prove that $\psi(z+\lambda, t) = \psi(z, t)$ for a one-dimensional wave travelling along the z-axis, where λ is the wavelength.

21. A compressional wave of frequency 300 Hz is set up in an iron rod and passes from the iron rod into air. The speed of the wave is 4800 m/s in iron and 330 m/s in air. Find the wavelength in each material.

22. A string of length 0.4 m and mass 0.1 kg is tightly clamped at its ends. The string is under the tension 16 N. Calculate the velocity of the pulse down the string.