

PH2101: Mid-semester examination

Full marks: 20

1. Consider a set of 2 perpendicular SHMs whose resultant motion is shown in Figure 1. For each figure ((a)-(d)) indicate the possible ratio of frequencies (specify in terms of ω_x and ω_y) and phase differences wherever possible [4]

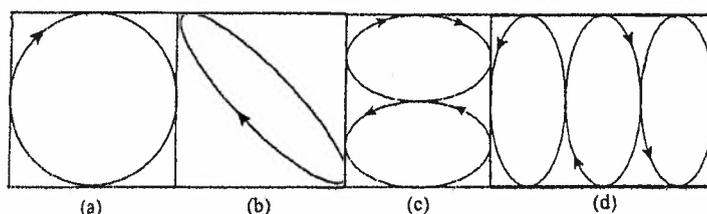


Figure 1. Resultant motion due to perpendicular oscillations in the x and y directions.

2. (i) For a forced harmonic oscillator, show that the velocity is out of phase from the displacement by $\pi/2$. Using this, explain why in a LCR circuit driven by a variable frequency voltage source, the current during resonance is in phase with the driving voltage. [1+2]
- (ii) Light of wavelength 600 nm is emitted by an electron in an atom behaving as a lightly damped simple harmonic oscillator with a Q -value of 5×10^7 . Determine the width of this spectral line (in wavelength or frequency units) considering the resonance bandwidth. [2]
- (iii) I excite a tuning fork at its resonant frequency, and observe its vibrations on an oscilloscope through a microphone. The excitation is turned off, and the response of the tuning fork is studied with the fork (a) in air, and (b) in water. In which case will the tuning fork vibrations die down faster? Explain with equations where necessary. [3]
3. Consider a diatomic molecule as a pair of harmonic oscillators of different masses coupled by an interaction force. If a NaCl molecule has a natural vibration frequency of 1.14×10^{13} Hz, find the value of the interatomic force constant. [Mass of Na atom = 23 amu, Mass of Cl atom = 35 amu, 1 amu = 1.67×10^{-27} kg] [3]
4. (a) A tuning fork A produces 6 beats per second with another fork B of frequency 220 Hz. When the prongs of A are filed off a little, the beats per second decrease to 3. Find the initial frequency of A. [2]
- (b) Two masses M and m are joined by a spring of stiffness k . A variable force $F \cos \omega t$ is applied to M . At what value of the frequency ω (in terms of M , k , and m) will the mass M not move? [3]