S.B.V.P. Samaj's

Sahakar Maharshi Bhausaheb Santuji Thorat College Of Arts, Commerce and Science ,Sangamner 422605.

Department Of Physics

Question Bank

Class :- S.Y.B.Sc. **Paper :- Phy.221 Waves, Oscillations and Sound**

By, Prof . V. R. Pande

Chapter 1 - Undamped Free Oscillations

A)Short Answer Type Question:

1) What is stable equilibrium?
2) What is unstable equilibrium?
3) Define linear simple harmonic motion?
4) Define angular simple harmonic motion?
5) What are Lissajous figures?
6) Give two applications of Lissajous figures?
7) What is phase of oscillations?
8) Show that energy of oscillation is proportional to square of amplitude?

B) Long Answer Type Question:

1) Obtain the expression of period and frequency for linear simple harmonic motion?

2) Obtain an expression of kinetic energy and potential energy for a simple harmonic oscillator. At what distance, the kinetic energy and potential energy are same?

3) Give an analytical treatment for composition of two S.H.M.s perpendiculars to each other and having their frequencies in the ratio 1:2. Discuss the cases when the phase difference is zero and $\pi/2$ radians.

4) What is composition of two S.H.M.s? Show that composition of two S.H.M.s along same line is also a simple harmonic motion along the same line.

5) Write a note on Lissajous figures. Give two applications. Describe one of the methods to demonstrate Lissajous figures.

C) Unsolved Problem:

1) What is period of oscillation of a mass of 40 kg on a spring with constant k=10 N/m?

2) The space-time equation of an angular S.H.M. is θ = φ sin qt. proves that the instantaneous angular velocity ω and acceleration α are related by the equation$\omega^2 q^2 + \alpha^2 = \Phi^2 q^4$

3) The total energy of the undamped oscillation is 1.25 ×10^{-5} j. The restoring force per unit

displacement is 10^{-2} N/m. What is the amplitude? (Ans. 5 cm)

4) A particle is subjected to two rectangular S.H.M.s such that the displacement at an instant are given by x=2 cos (ωt + π/4) and y=2cos ωt .Find the nature and equation of the path . (Ans. Ellipse,$x^2 - \sqrt{2xy} \pm y^2 = 2$)

5) Electron beam in oscilloscope is deflected by two mutually perpendicular field's in such a manner that the displacements at an instant are given by x=3 sin (100πt) and y=4 cos (100πt).Find the nature of the resultant path.

14) A simple harmonic motion is represented by the equation, x=8 sin (10πt- π/6) where x is measured in metres, t is seconds and the phase angle in radians. Calculate (1) the frequency, (2) the time period, (3) the maximum displacement, (4) the maximum velocity and (5) the maximum acceleration. (Ans. 5Hz, 0.2 sec, 8m, 80 π m/s, 800 π m/s^2)

15) An object of mass 250 g oscillates by a spring and its motion is described by the following time dependence: X (t) =1.2 sin (5t +30°) All quantities expressed in SI units. Determine the equation for the speed, acceleration, and force acting on the object as functions of time.

Chapter 2- Damped oscillations

(A)Short Answer Type Question:

1) What is damped oscillations?
2) What is log decrement?
3) Define quality factor.
4) Why there is decrease in amplitude in damped oscillation?
5) What is meant by over-damped motion?
6) What is meant by critically damped motion?
7) What is meant by damped oscillatory motion?
8) On which factor quality factor depends?

(B)Long Answer Type Question:

1) What are damped oscillations? Give two illustrations. How do you represent them graphically?
2) Distinguish between damping force and restoring force.
3) Set up differential equation for the damped oscillations in the form

m $(\frac{d^2x}{dt^2}) + R\left(\frac{dx}{dt}\right) + kx = 0$

Obtain its solution.

4) Write a note on (1) Logarithmic decrement,(2) Quality factor
5) Establish the relation between the angular frequency and quality factor of the damped oscillator.
6) Determine the expressions for amplitude, angular frequency and frequency for the oscillations in damped oscillatory motion.
7) Define the term log decrement. Derive the expression for it.
8) Set up differential equation for damped electrical oscillations and hence obtain an expression for the frequency of oscillations.
9) Derive the expression for average energy over a period of damped harmonic oscillator. Hence show that it exponentially decreases with time.
10) Obtain the relation between natural frequency and damping frequency of a damped oscillator.

(C)Unsolved Problem:

1) A capacitor of 2μF, an inductor of 80mH and the resistor are connected in series. What Should be the value of resistance to make the circuit oscillatory? (Greater than 400Ω)
2) The restoring force per unit displacement of magnitude 3 N/m acts on an oscillator of mass 4×10^{-2} kg. If the coefficient of damping is 0.6N/ms , show that the motion is critically damped.
3) The amplitude of simple pendulum of the period 1sec. falls to half of its initial value in 200 Seconds. Determine the quality factor. (Ans. 908)
4) A conductor of 1μF, an inductance of 0.2 henry and a resistance of 800 ohms are joined in Series. Is the circuit oscillatory?

Chapter 3-Forced Oscillations

(A)Short Answer Type Question:

1) What are forced oscillations? Give two examples.
2) Distinguish between forced oscillations and damped oscillations.
3) Give different conditions for phase difference in forced oscillations.
4) What is meant by resonance? Give example of mechanical resonance.
5) What is amplitude resonance in case of forced vibrations? State its condition.
6) Define quality factor.
7) What is velocity resonance?

(B.)Long Answer Type Question:

1) What are free and forced oscillations? Set up differential equation for forced oscillations.
2) What is meant by resonance? Give three examples.
3) Derive the condition for velocity resonance and obtain amplitude of velocity at resonance.
4) Derive the condition for amplitude resonance and obtain amplitude at resonance. Also obtain quality factor at resonance.
5) Obtain the expression for average power absorbed during the forced oscillations.
6) Discuss the phenomenon of sharpness of resonance and show how it depends on the damping factor.
7) Calculate the frequency of amplitude resonance in case of forced oscillations.

(c)Unsolved problem:

1) The equation of forced oscillations of a body is given as $5\left(\frac{d^2x}{dt^2}\right) + 20\left(\frac{dx}{dt}\right) + 245x = f_{\circ}sinqt$,Determine the resonant angular frequency at which velocity resonance takes place. Also,Determine the half width of resonance. (Ans. 7units, 2units)

2) In case of forced oscillator, the amplitude of oscillations increases from 0.1 mm at very low frequencies to 25 mm at resonant angular frequency. Determine the quality factor of forced Oscillations. (Ans. 250)

3) The equation of forced oscillations of an oscillator is given by

$4\left(\frac{d^2x}{dt^2}\right) + 3\left(\frac{dx}{dt}\right) + 64x = 60sin4t$

Determine the amplitude and phase difference between the periodic forced and the displacement in CGS unit. (Ans. 5 cm, π/2 rad)

5) An alternating e.m.f. of amplitude 230V is applied across a circuit in which an inductance of 10 mH, a capacitance of 1 μF and a resistance of 23 ohms are connected in series. Determine the resonant angular frequency, current at resonance, quality factor and band width.

(Ans. 10^4 rad/s, 10 A, 4.35, 2300 rad/sec)

6) The equation of forced oscillation is expressed in the form

$$4\left(\frac{d^2x}{dt^2}\right) + 2\left(\frac{dx}{dt}\right) + 12x = 30sin2t$$

Where the quantities are in S.I. units. If the motions stand from the origin, find amplitude and (b) period.

Chapter 4- Wave Motion

(A) Short Answer Type Question:

1) What is wave motion?

2) Explain longitudinal wave.
3) State on which factors velocity of longitudinal wave depends.
4) Define energy density of wave. Give its units.
5) Define intensity of wave. Give its units.

(B) Long Answer Type Question:

1) Obtain an expression for velocity of longitudinal waves propagating through a medium of density ρ and bulk modulus of elasticity K.
2) Prove that the velocity of transverse wave over a string of linear density μ is C=$\sqrt{\frac{T}{\mu}}$, where T is the tension.
3) What do you mean by wave velocity and particle velocity? Show that wave velocity, c=$\frac{\omega}{k}$
4) Obtain an expression for energy density of a plane progressive wave propagating through a medium.
5) Obtain the equation of motion of simple harmonic progressive sound wave.
6) Explain the terms: Seismology, Seismic wave and Seismograph.
7) Write a note on seismic waves.
8) What are P-waves, S-waves, R-waves and L-waves?

(C) Unsolved Problem:

1) The amplitude of transverse wave is 10 cm. The velocity of wave is 330 m/s and the frequency is 330 Hz. Write down the equation of wave motion along the positive direction of X-axis. Ans. y=0.1 sin 2π (330t-x)
2) A metal wire of length 50 cm weighs 5 gm. If it is stretched by a force of 10N, what would be the speed of a transverse wave passing on it? (Ans. 31.62 m/s)
3) The equation of transverse wave motion is expressed by $y=y_\circ \sin 2\pi(0.005x-t)$. If the maximum velocity of a particle is 44 cm/s, find the amplitude of the wave. Calculate also the wave velocity.

$$\left[Hint: \frac{\partial y}{\partial x} = -2\pi y_\circ cos2\pi(0.005x - t) \therefore maximum velocity = 2\pi y_\circ\right]$$

(Ans. $y_\circ$=7 cm, c=200 cm/s)

4) Calculate the energy density and intensity of a plane progressive wave of frequency 300Hz, of amplitude 0.07 cm and of velocity 33000 cm/s. The density of the medium is 1.293×10^{-3} gm/cm^3. (Ans. E=11.26 ergs/cm^3,I=371500 ergs/cm^2-s)
5) Suppose that sound is emitted uniformly in all directions by a public address system. The intensity at a location 22 m away from the sound source is 3×10^{-4}W/m^2. What is the intensity at a spot that is 44m away? (Ans. 7.5×10^{-5} W/m^2)

6) A certain transverse wave is described by $y(x,t)=(6.50mm)\cos 2\pi\left(\frac{x}{28.0cm}-\frac{t}{0.0360\,s}\right)$
Determine the waves (a) amplitude, (b) wavelength, (c) frequency, (d) speed of propagation, (e) direction of propagation.
7) One end of a horizontal rope is attracted to a prong of an electically driven tunning fork that vibrates at 120 Hz. The other end passes over a pully and supports a 1.50 kg mass. The linear mass density of the rope is 0.0550 kg/m.
(a) What is the speed of a transverse wave on the rope?
(b) What is the wavelength?
(c) How would your answers to parts (a) and (b) change if the mass were increased to 3.0 kg?

Chapter 5- Doppler Effect

(A) Short Answer Type Questions:
1) What is Doppler effect in sound?
2) What is Doppler effect in light?
3) What is red shift?
4) What is radar speed trap?
5) Justify the statement-"Universe is expanding".

(B) Long Answer Type Question:
1) Obtain an expression of apparent frequency of sound heard by the observer when both are in relative motion with respect to each other.
2) Explain Doppler effect in light.
3) Show that the Doppler effect in light is symmetric.
4) Give two applications of Doppler effect in light.
5) What is red shift? What is its significance?
6) Explain width of spectral lines on the basis of Doppler effect.

(C) Unsolved Problems:
1) A spectral line of wavelength 6000 A ^{o} in the spectrum of a star is found to be displaced from its normal position towards red end by 1 A ^{o}. Calculate the velocity of the star and sense of motion. (Ans. 5×10^{4} m/s away from earth)
2) Two trains are approaching each other with speeds 60 km/hr. and 45 km/hr. A whistle of frequency 512Hz is sounded by the first train. Calculate the frequency of the note heard by a listener in the second train (a) before and (b) after the trains pass each other. (Speed of the sound=332 m/s). (Ans. 559.3 Hz,469 Hz)
3) A spectral line of wavelength 5890 A ^{o} in the spectrum of star is found to be displaced by 1.178 A ^{o} from its normal position towards the red end of the

spectrum. Determine the velocity of the star and mention sense of motion. (Ans. 6×10^4 m/s towards the earth)

4) A railway engine blowing a whistle of frequency 96 Hz and a listener are moving with velocities 10 m/s and 2 m/s towards each other. The speed of sound in air is 330 m/s. Determine the apparent frequency of sound as heard by the listener, if air is at rest.

(Ans. 996 Hz)

5) A source and a listener move away from each other, with speed 15 m/s each w.r.t. ground when there was no wind. If the apparent frequency heard by the listener is 500 Hz, what is the original frequency of note given by source? (Given: speed of sound=340 m/s) (Ans. 458 Hz)

Chapter 6- Sound

(A) Short Answer Type Question:

1) Define: (a) Intensity of sound, (b) Intensity level, (c) Threshold of audibility, (d) Sensation level, (e) Decibel, (f) Timber.
2) Define: reverberation and reverberation time.
3) What are the factors which affect quality of sound?
4) What are the factors which affect acoustic of hall?
5) What is the principle of stroboscope?

(B) Long Answer type Question:

1) Explain intensity of sound. How it is related to loudness of sound?
2) Explain following:
   (a) Loudness, (b) Pitch and (c) Quality or Timber.
3) Describe Rayleigh disc method to determine intensity level of sound.
4) Define and explain reverberation time.
5) State and explain Sabine's formula for reverberation time of a hall.
6) Describe stroboscopic method to determine frequency of tuning fork or A.C. signal.

(C) Unsolved Problem:

1) Calculate the change in intensity level when the intensity of sound increases by 10 times to original intensity.
   (Ans. 10 dB)
2) A hall of capacity 56×10^3 cft is found to have a reverberation time of 2 seconds. If area of sound absorbing be 7000 sq ft, Calculate absorption coefficient. (Ans, 0.2)
3) Calculate the intensity of sound waves with ρmax=3×10^{-2} Pa. Assuming the temperature is 20 ℃ so that density of air is 1.20 kg/m^3 and velocity of sound is 344m/s. (Ans. 1.1×10^{-6} w/m^2)

4) The stroboscopic disc marked with 120 dots is rotated and minimum speed is adjusted till the dots appear stationary when looked through a slit attached to the prong of a tuning fork. If the minimum speed of rotation of the disc is 150 rpm, Calculate frequency of the tuning fork. (Ans. 300 Hz)
5) Two identical machines are positioned at the same distance from a worker. The intensities of sound delivered by each machine at the location of the worker are 2×10^{-7} W/m^2. Find the sound intensity level heard by the worker (a) when one machine is working and (b) when both machines are working. (Take threshold of hearing=1.0×10^{-12} W/m^2).

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