Oscillations – Waves & Sound

Vikasana - CET 2012

- **Oscillations**
- **Waves**
- **Sound**
- **Stationary waves**
- **Acoustics of Buildings**

01. The maximum velocity of a body in S.H.M.is 0.25m/s and maximum acceleration is $0.75 m/s^2$, the period of S.H.M. is

(1)(Π/3) sec (2) (Π/2) sec

(3) (2Π/3) sec (4) Π sec

01. Solution:-

$$V_{max} = 0.25 = \omega A$$

$$a_{max} = 0.75 = \omega^2 A$$

$$a_{max.} / V_{max} = \omega^2 A / \omega A = 0.75/0.25 = 3$$

$$\omega = 2\Pi/T = 3$$

$$\therefore \quad T = 2\Pi/3 \text{ sec}$$

Ans: (3)

02. The kinetic energy of a particle executing S.H.M is 16 J when it is at its mean position. If the mass of the particle is 0.32kg, then what is the maximum velocity of the particle?

(1) 10m/s **(2) 15m/s**

(3) 5m/s **(4) 20m/s**

02.Solution:-

For a body executing SHM,

$K.E = \frac{1}{2} m\omega^2(A^2-y^2)$

$K.E. = (K.E)_{max}$ when $Y=0$ (mean position)

$\therefore (K.E)_{max} = \frac{1}{2} m\omega^2 A^2 = \frac{1}{2} m (v)^2_{max}$

$16 = 1/2 \times 0.32 \times (v)^2_{max}$

$(v)^2_{max} = 100$

$\therefore \quad (v)_{max} = 10$ m/s.

Ans: (1).

03. The equation of a simple harmonic wave is given by $y = 6\sin 2\pi(2t - 0.1x)$, where x and y are in mm and t is in seconds. The phase difference between two particles 2 mm apart at any instant is

(1) 18^0 **(2) 54^0**

(3) 72^0 **(4) 36^0**

03. Solution:-

Phase difference = $(2\Pi / \lambda)$ x path diff

$y = 6 \sin 2\pi (2t - 0.1x)$ mm

$y = A \sin 2\pi (t/T - x/\lambda)$

comparing, $\lambda = 1/0.1 = 10$ mm

Phase diff $= (2\pi/10) \times 2 = 2 \times 180^0 / 5 = 72^0$

Answer: (3)

04. When the amplitude of a wave is increased by 50%, its intensity will be *increased by*

(1) 50% **(2) 100%**

(3) 125% **(4) 150%**

04.Solution:- Intensity of any wave is directly proportional to the *square* of the amplitude.Therefore, when the amplitude becomes 1.5 times (*increment* by 50%) the original value, the intensity becomes 2.25 times (1.5^2 times) the original intensity. The *increment* in intensity is 125%

Ans: (3)

05. The equation of a progressive wave is

$$y = 8\sin\left[\Pi\left(t/10 - x/4\right) + \Pi/3\right]\ m$$

The wavelength of the wave is

(1)10m **(2) 2m**

(3) 8m **(4) 4m**

05. Solution:-

$y = 8\sin [\, \Pi (t/10 - x/4) + \Pi / 3]$

Rearranging

$y = 8\sin [\, 2\Pi (t/20 - x/8) + \Pi / 3]$

Standard equation

$y = 8\sin [\, 2\Pi (t/T - x/\lambda) + \varphi]$

Comparing

$\lambda = 8m$

Ans: (3)

06. The speed of sound in hydrogen at STP is v. The speed of sound in a mixture containing 3 parts of hydrogen and 2 parts of oxygen at STP will be

(1) $v/2$ (2) $v/\sqrt{5}$

(3) $\sqrt{7}\,v$ (4) $v/\sqrt{7}$

06.Solution

Let the density of H_2, $\rho_{H=}$ 2 ρ, then the density of O_2 will be ρ_{O2}= 32 ρ

The density of mixture

$$\rho_m = 3/5 \times \rho_H + 2/5 \times \rho_{O2}$$
$$= 3/5 \times 2\rho + 2/5 \times 32\rho$$
$$= 14\rho$$

But $$v_m / v_{H2} = \sqrt{\rho_H} / \sqrt{\rho_m}$$
$$= \sqrt{2\rho} / \sqrt{14\rho}$$
$$= 1/\sqrt{7}$$
$$v_m = v / \sqrt{7}$$

Ans; (4)

07. Two sounds produce an intensity of 10^{-5} μW/m^2 and 10^{-3} μW/m^2. In terms of decibels the ratio of intensity is

(1) 3 : 1

(2) 1 : 3

(3) 1 : 100

(4) 1000 : 1

07.Solution:-

$I_1 = 10^{-5}$ μw/m^2 & $I_2=10^{-3}$ μw/m^2

$N=10 \log I/I_0$

$N_1=10 \log I_1/I_0 = 10 \log 10^{-5} X 10^{-6}/10^{-12}$

$= 10\log 10= 10dB$

$N_2=10 \log I_2/I_0 = 10 \log 10^{-5} X 10^{-3}/10^{-12}$

$=10 \log 30= 30dB$

Therefore $N_1 : N_2 : : 10 : 30 = 1:3$

Ans (2)

08. When two tuning forks are sounded together 4 beats are heard per second. One tuning fork is of frequency 346 Hz. When its prong is loaded with a little wax, the number of beats is increased to 6 per second. The frequency of the other fork is

(1) 352 Hz (2) 342 Hz

(3) 346 Hz (4) 350 Hz

08. Solution:-

Before loading, n = 4 beats per second

$f_1 = 346 Hz$

$\therefore f_2 = (346-4) Hz$ or $(346+4) Hz$

i.e. 342 Hz or 350 Hz

After loading, f_1 frequency is reduced

$n^1 = 6 > n$

$\therefore f_2 = 350 Hz$

Answer: (4)

09. Twenty tuning forks are arranged in increasing order of frequency in such a way that any two nearest tuning forks produce 5 beats per second. The highest frequency is twice that of the lowest. Possible highest and lowest frequencies are

(1) 170 & 85 (2) 110 & 55
(3) 210 & 105 (4) 190 & 95

09.Solution

If n is the frequency of the 1st tuning fork then

n, n+5, n+10,……….2n

This is in A.P

$a_n = a + (n-1)d$

$2n = n + (20-1)5$

$\therefore n = 95\text{ Hz} \ \& \ 2n = 190\text{ Hz}$

Answer: (4)

10. An observer moves towards a stationary source of sound, with a velocity one fifth of the velocity of sound. What is the percentage increase in the apparent frequency?

(1)0.2% **(2) 0.5%**

(3) 5% **(4) 20%**

10.Solution

Apparent frequency,

$f^1 = (v+v_0/v)f$ [$f^1 =(v-v_0/v-v_s)f$]

$= (v+v/5/v)f$

$=(6v/5v)f]$

$=1.2f$

∴ % increase in frequency

$= (f^1- f/f) 100$

$= (1.2f - f/f) 100$

$= (0.2f/f) 100$

$= 20\%$ Answer(4)

11. In a stationary wave every particle performs

(1) a S.H.M. at all points of the medium

(2) a S.H.M. at all points except nodal points

(3) a S.H.M. at all points except the antinodes points

(4) a S.H.M. of constant amplitude

11.Solution:-

At nodes in a stationary wave particles are permanently at rest and at all other points particles perform SHM of varying amplitude.(0-max)

Answer: (2)

12. An open pipe is suddenly closed with the result that, the second overtone on the closed pipe is found to be higher in frequency by 100 Hz, than the first overtone of the original pipe. The fundamental frequency of open pipe will be

(1) 100 Hz (2) 300 Hz

(3) 150 Hz (4) 200 Hz

12.Solution:-

F_3=5v / 4l for closed pipe(second overtone)

& F_2= 2v / 2l for open pipe (first overtone)

By data $F_3 = F_2 + 100$, $F_3 - F_2 = 100$

⇒ 5v/ 4l − 2v / 2l =100

v / 4l =100

v / 2l =200

F_0 =200 Hz **Answer: (4)**

13. A cylindrical tube, open at both ends, has fundamental frequency f in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now

(1) f/2 (2) 3f/2

(3) f (4) 3f

13.Solution:-

$f_0 = v/2l_0 = f$, for open pipe

$f_c = v/4l_c = (v/4xl_0 / 2) = v/2l_0 = f$, for closed pipe

Answer: (3)

14. A sonometer wire of density d and radius a is held between two bridges at a distance' l' apart. The wire has a tension T. the fundamental frequency of the wire will be

(1) $f = 1/2l \sqrt{(\Pi a^2 / Td)}$

(2) $f = 1/2l \sqrt{(T / \Pi a^2 d)}$

(3) $f = 1/2l \sqrt{(Td / \Pi a^2)}$

(4) $f = 1/2l \sqrt{(T\Pi a^2 d)}$

14.Solution:- fundamental frequency

$f = 1/2l \sqrt{(T/m)}$

$m = M / L$ mass/ unit length

$= d \Pi a^2 L / L = \Pi a^2 d$

$f = 1/2l \sqrt{(T/ \Pi a^2 d)}$

Answer: (2)

15.Sabine's formula for reverberation time is written as

(1) T=0.156 V / Σas (2) T=0.165 V / Σas

(3 T= Σas /0.156V (4) T=0.165s/ ΣaV

15.Solution:-

Sabine's formula for the reverberation time is given by

$$T = 0.165\,V / \Sigma as\,.$$

Ans: (2)

16. If the end correction of an open organ pipe is 0.8 cm, then the inner radius of the pipe will be

(1)1/2cm **(2) 1/3cm**

(3) 2/3cm **(4) 3/2cm**

16.Solution:- End correction e=0.6R

In case of open pipe, correction for both ends

$$2e=0.8cm$$

$$e=0.4cm$$

$$R=0.4/0.6 = 2/3 \text{ cm}$$

Answer: (3)

17. In Melde's experiment, 6 loops were formed, when the string was stretched by a weight 6 gram. What weight should be used to produce 3 loops, without changing the experiment set up?

(1) 12 gram wt.

(2) 18 gram wt.

(3) 24 gram wt.

(4) 16 gram wt.

17.Solution:- **In Melde's experiment,**

$$T/l^2 = \text{constant}, \quad l = \text{loop length}$$

Hence, $6/l^2 = \text{constant}$ **and** $T/(2l)^2 = \text{constant}$

$$\therefore 6/l^2 = T/(2l)^2 = T/4l^2$$

$$\therefore T = 24 \text{ gm wt.}$$

Answer: (3)

18. A tuning fork X produces 4 beats/sec with a tuning fork Y of frequency 384 Hz. When the prongs of X are slightly filed, 3 beats/sec are heard. What is the original frequency of X?

(1) 388 Hz

(2) 380 Hz

(3) 381 Hz

(4) 387 Hz

18.Solution:-Since 4 beats per second are produced with tuning fork Y of frequency 384 Hz, the frequency of tuning fork X must be (384+4)or (384-4) i.e. 388 Hz or 380 Hz

when the prongs of X is slightly filed, its frequency increases.

Now the no. of beats heard is 3 beats/sec (reduced)

∴ frequency of X is originally lower than Y i.e. 380 Hz. Answer: (2)

19. A source is moving towards observer with a speed of 20 m/s and having frequency 240 Hz and observer is moving towards source with a velocity 20 m/s. what is the apparent frequency heard by observer if velocity of sound 340 m/s?

(1) 270 Hz

(2) 240 Hz

(3) 268 Hz

(4) 360 Hz

19. Solution:-

Apparent frequency $f^1 = (v + v_o / v - v_s)\ f$

$= (340 + 20 / 340 – 20)\ 240$

$= (360 / 320) 240$

$= 270 Hz$

Answer: (1) Vikasana - CET 2012

20. What is the approximate range of audible frequencies for a human ear?

(1)20 kHz – 200 kHz

(2) 20 Hz – 20 kHz

(3) 200 kHz – 2000 kHz

(4) 2000 kHz – 20000 kHz

20.Solution:-

The audible frequency range is

20 Hz --- 20,000Hz

or 20 Hz --- 20 kHz

Answer: (2)

21. A body executes S.H.M with amplitude A. At what displacement, from the mean position, the kinetic energy of the body is one fourth of its total energy.

(1) A/4 **(2) A/2**

(3) $\sqrt{3}$A **(4) $\sqrt{3}$/2A**

21.Solution:- For a body executing SHM,

$$K.E = 1/2\, m\omega^2(A^2 - y^2)$$

$$T.E = 1/2\, m\, \omega^2 A^2$$

$$1/2\, m\omega^2(A^2 - y^2) = ¼ \times 1/2\, m\, \omega^2 A^2$$

$$A^2 - y^2 = 1/4 \times A^2$$

$$y^2 = A^2 - A^2/4$$

$$y^2 = 3A^2/4$$

$$y = (\sqrt{3}/2) \times A$$

Ans: (4)

22. If a simple pendulum oscillates with amplitude of 50mm and time period of 2s, then its maximum velocity is

(1) 0.10m/s

(2) 0.16m/s

(3) 0.25m/s

(4) 0.5m/s

22.Solution:-

For a simple pendulum

$$v=\omega\sqrt{(A^2-y^2)}$$

$$V= V_{max} = \omega A \text{ (when } y=0)$$

$$=(2\Pi/T) \times A$$

$$=2\times3.142\times0.05 / 2$$

$$= 0.15710= 0.16 \text{ m/s}$$

Ans: (2)

23. A wave travels in a medium according to the equation of displacement given by

$Y(x, t) = 0.03 \sin \pi (2t - 0.01x)$, where y and x are in meters and 't' is seconds. The wavelength of the wave is

(1) 100 m (2) 200 m

(3) 20 m (4) 10 m

23.Solution:-

$$y(x,t) = 0.03A \sin \pi (2t - 0.01x)$$

$$y(x,t) = 0.03A \sin 2\pi (t - 0.01x/2)$$

standard equation is

$$y(x,t) = A \sin 2\pi (t/T - x/\lambda)$$

comparing

$$\lambda = 2/0.01 = 200 \text{ m}$$

Answer: (2)

24. The ratio of speed of sound in nitrogen gas to that in helium gas at 300K is

(1) $\sqrt{(2/7)}$

(2) $\sqrt{(1/7)}$

(3) $\sqrt{3/5}$

(4) $\sqrt{6/5}$

24.Solution:-For a gas

$V=\sqrt{(\gamma p / \rho)} = \sqrt{(\gamma RT / M)}$ (since PV=RT)

Where M is the molecular mass & R is the gas constant

$\therefore v_{N2} / v_{He} = \sqrt{M_{He}} / \sqrt{M_{N2}} = \sqrt{4} / \sqrt{28}$

$= \sqrt{1} / \sqrt{7} = 1/ \sqrt{7}$

Ans : (2)

25. Beats are produced by two waves y_1 =a sin 2000 π t and y_2 = a sin 2008 π t the number of beats heard per second is

(1) Two

(2) One

(3) Four

(4) Eight

25. Beats are produced by two waves y_1 =a sin 2000 π t and y_2 = a sin 2008 π t the number of beats heard per second is

(1) Two

(2) One

(3) Four

(4) Eight

25.Solution:-The SHM wave equation is

$Y = A \sin \omega t$

Comparing with the given equation

$\omega_1 = 2000\Pi$, $2 \pi f_1 = 2000 \Pi$, $f_1 = 1000$ Hz

$\omega_2 = 2008\Pi$, $2 \pi f_2 = 2008 \Pi$, $f_2 = 1004$ Hz

number of beats heard per second $= n = f_2 - f_1 = 4$

Answer: (3)

26. A Sonar system fixed in a submarine operates at a frequency 40.0 kHz .An enemy submarine moves towards the sonar with a speed of 360km/hr. the frequency of sound reflected by the submarine will be (Speed of sound in water =1450m/sec).

(1) 46 kHz (2) 34 kHz

(3) 40 kHz (4) 80 kHz

26.Solution:-

Apparent frequency for enemy submarine

$f^1 = (v+v_0/v)f \qquad = (1450+100/ 1450)\ 40$

$= 42.8kHz$

Apparent frequency for SONAR(frequency of sound reflected by submarine)

$F^{11} =(v/v-v_s)f$

$=(1450\ /\ 1450-100)\ 42.8$

$=46kHz$

Answer : (1)

27. A standing wave having 3 nodes and 2 antinodes is found between two atoms having a distance of $1.21A^0$. The wavelength of standing wave will be

(1) $3.63\ A^0$

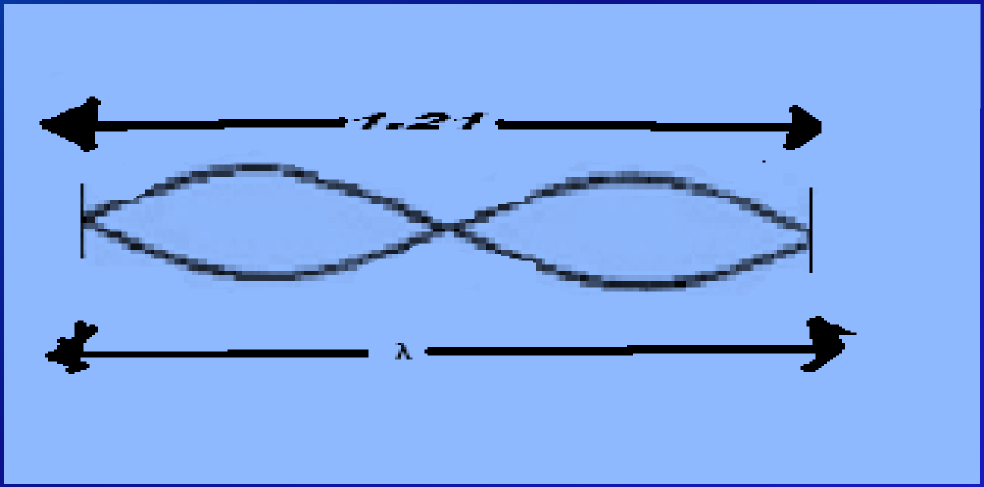
(2) $6.05\ A^0$

(3) $1.21\ A^0$

(4) $2.42\ A^0$

27. Solution:-

1.21 Å



Answer: (3)

28. A string of length *L* metre has mass *M* kg. It is kept stretched under a tension *T* newton. If a transverse jerk is given at one end of this string how long does it take for the disturbance to reach the other end?

(1) $\sqrt{(LM / T)}$

(2) $L\sqrt{(M / T)}$

(3) $\sqrt{(LT / M)}$

(4) $L\sqrt{(T / M)}$

28.Solution:-

The time taken (t) is given by

$t = L/v$ where v is the velocity of the disturbance.

But $v = \sqrt{(T/m)}$ where T is the tension and m is the *linear density* (mass per unit length) of the string. Since $m = M/L$

$$v = \sqrt{(TL/M)}$$

$\therefore\ t = L/\sqrt{(TL/M)} = \sqrt{(LM/T)}$ Answer: (1)

29. Reverberation time T and volume V of an auditorium are related as

(1) $T \propto 1/V$

(2) $T \propto 1/\sqrt{V^2}$

(3) $T \propto 1/\sqrt{V}$

(4) $T \propto V$

29.Solution:-

According to Sabine's formula

$$T = 0.165\, V / \Sigma as$$

Therefore $T \alpha V$

Answer: (4)

30. Reverberation time is

(1) The time taken for the intensity of sound to decrease to zero

(2) The time taken for the intensity of sound to decrease to one millionth of its initial value from the moment source of sound has ceased to produce sound

(3) The time taken for the intensity of sound to increase from one millionth of its initial value to maximum

(4) The time taken for the intensity of sound to increase to one millionth of its initial value from the moment source of sound has ceased to produce sound.

30.Solution:-

By definition, the reverberation time is

The time taken for the intensity of sound to decrease to one millionth of its initial value from the moment source of sound has ceased to produce sound.

Answer: (2)

31. The frequency of the note produced by plucking a given string increases as

(1) The length in the string increases

(2) The tension in the string increases

(3) The tension in the string decreases

(4) The mass per unit length of the string increases

31.Solution:-

$$f \propto \sqrt{T}$$

therefore frequency of note increases with increase of tension

Answer: (2)

32. Air is blown at the mouth of a tube (Length 25 cm and diameter 3 cm) closed at one end. Velocity of sound is 330 m/s, the sound which is produced will correspond to the frequencies

(1) 330 Hz

(2) Combination of frequencies 330, 990, 1650, 2310Hz

(3) Combination of frequencies 330, 660, 990, 1320, 1650 Hz

(4) Combination of frequencies 300, 900, 1500, 2100, Hz

32.Solution: -

In case of closed pipe, frequencies of overtones are odd harmonics of the fundamental.

i.e. $f_1 : f_2 : f_3 : ...... = 1 : 3 : 5 : ....$

and $f_1 = v/4l = 330/4 \times 0.25 = 330\text{Hz}$

$f_2 = 3 f_1 = 990\text{Hz}$

$f_3 = 5 f_1 = 1650 \text{ Hz} \; ....$

Answer: (2)

33. An organ pipe P_1 closed at one end vibrating in its first harmonic and another pipe P_2 open at both ends vibrating in its third harmonic are in resonance with a given tuning fork. Ratio of the length of P_1 that of P_2 is

(1) 8/3 (2) 3/8

(3) 1/2 (4) 1/6

33. Solution:-

For a closed pipe (p_1)

First harmonic, $f_c = v/ 4l_c$

For open pipe (p_2)

$f_0 = 3v/ 2l_0$

But $f_c = f_0$

$\therefore$ $v/ 4l_c = 3v/ 2l_0$

$l_c / l_o = 2/ 12 = 1/6$

Answer: (4)

34. A tuning fork of frequency 480 Hz produces 10 beats per second when sounded with a vibrating sonometer wire. What must have been the frequency of string if a slight increase in tension produces fewer beats per second than before?

(1) 460 Hz (2) 470 Hz

(3) 480 Hz (4) 490 Hz

34.Solution:-

Since 10 beats are produced with a tuning fork of frequency 480 Hz, The frequency of string must be 480+ 10 or 480-10

i.e. f_1 = 490 Hz or 470 Hz

When tension of string is increased, its frequency increases ($f \propto \sqrt{T}$)

Now the number of beats is reduced.

Therefore frequency of string is lower than that of tuning fork.

Therefore f_1 must be 470 Hz

Answer: (2)

35. When a source is going away from a stationary observer, with a velocity equal to that of sound in air, then the frequency heard by the observer will be

(1) Same **(2) One third**

(3) Double **(4) Half**

35.Solution:-

Apparent frequency $f^1 = (v/ v+ v_s) f$

But $v_s = v$

$\therefore \quad f^1 = (v_s / 2v_s) f$

$f^1 = f/2$

Answer: (4)

ALL THE BEST

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THANK YOU

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