QB365 Question Bank Software Study Materials

Oscillations Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Physics

Total Marks : 60

2 Marks

30 x 2 = 60

1) Classify the following motions as periodic and non-periodic motions?

a. Motion of Halley's comet.

b. Motion of clouds.

c. Moon revolving around the Earth

Answer : a. Periodic motion

b. Non-periodic motion

c. Periodic motion

2) A nurse measured the average heart beats of a patient and reported to the doctor in terms of time period as 0.8 s. Express the heart beat of the patient in terms of number of beats measured per minute.

Answer : Let the number of heart beats measured be f. Since the time period is inversely proportional to the heart beat, then

$f=\frac{1}{T}=\frac{1}{0.8}=1.25s^{-1}$

One minute is 60 second,

(1 second = $\frac{1}{60}$ minute ⇒ 1 s^{-1} = 60 min^{-1})

f =1.25 s^{-1} ⇒ f = 1.25×60 min^{-1} = 75 beats per minute

3) Calculate the amplitude, angular frequency, frequency, time period and initial phase for the simple harmonic oscillation given below

a. y = 0.3 sin (40πt + 1.1)

b. y = 2 cos (πt)

c. y = 3 sin (2πt − 1.5)

Answer : Simple harmonic oscillation equation is

y = A sin(ωt + φ_0) or y = A cos(ωt + φ_0)

a. For the wave, y = 0.3 sin(40πt +1.1)

Amplitude is A = 0.3 unit

Angular frequency ω = 40π rad s^{-1}

Frequency f = $\frac{\omega}{2\pi}=\frac{40\pi}{2\pi}=20Hz$

Time period T= $\frac{1}{f}=\frac{1}{20}=0.05s$

Initial phase is φ_0 = 1.1 rad

b. For the wave, y = 2cos(πt)

Amplitude is A = 2 unit

Angular frequency ω = π rad s^{-1}

Frequency f = $\frac{\omega}{2\pi}=\frac{\pi}{2\pi}=0.5Hz$

Time period T= $\frac{1}{f}=\frac{1}{0.5}=2s$

Initial phase is φ_0 = 0 rad

c. For the wave, y = 3 sin(2πt + 1.5)

Amplitude is A = 3 unit

Angular frequency ω = 2π rad s^{-1}

Frequency f =$\frac{\omega}{2\pi}=\frac{2\pi}{2\pi}=1Hz$

Time period T= $\frac{1}{f}=\frac{1}{1}=1s$

Initial phase is φ_0 = 1.5 rad

4) Consider two springs whose force constants are 1 Nm^{-1} and 2 Nm^{-1} which are connected in series. Calculate the effective spring constant (k_s) and comment on k_s.

Answer : k_1 = 1 N m^{-1}, k_2 = 2 N m^{-1}

$k_s=\frac{k_1k_2}{k_1+k_2}N\ m^{-1}$

$k_s = \frac{1\times2}{1+2} = \frac{2}{3} N\, m^{-1}$

$k_s < k_1$ and $k_s < k_2$

Therefore, the effective spring constant is lesser than both k_1 and k_2.

5) Consider two springs with force constants 1 N m^{-1} and 2 N m^{-1} connected in parallel. Calculate the effective spring constant (k_p) and comment on k_p.

Answer : k_1 = 1 N m^{-1}, k_2 = 2 N m^{-1}

$k_p = k_1 + k_2$ N m^{-1}

k_p = 1 + 2 = 3 N m^{-1}

$k_p > k_1$ and $k_p > k_2$

Therefore, the effective spring constant is greater than both k_1 and k_2.

6) A mass m moves with a speed v on a horizontal smooth surface and collides with a nearly massless spring whose spring constant is k. If the mass stops after collision, compute the maximum compression of the spring.

Answer : When the mass collides with the spring, from the law of conservation of energy "the loss in kinetic energy of mass is gain in elastic potential energy by spring".

Let x be the distance of compression of spring, then the law of conservation of energy

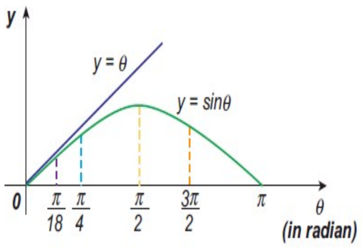
$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \Rightarrow x = v\sqrt{\frac{m}{k}}$

7) In simple pendulum experiment, we have used small angle approximation. Discuss the small angle approximation.

Answer :

θ(in degrees)	θ(in radian)	sinθ
0	0	0
5	0.087	0.087
10	0.174	0.174
15	0.262	0.256
20	0.349	0.342
25	0.436	0.422
30	0.524	0.500
35	0.611	0.574
40	0.698	0.643
45	0.785	0.707

For θ in radian, sin $\theta \approx \theta$ for very small angles



This means that "for θ as large as 10 degrees, sin θ is nearly the same as θ when θ is expressed in radians". As θ increases in value sinθ gradually becomes different from θ

8) If the length of the simple pendulum is increased by 44% from its original length, calculate the percentage increase in time period of the pendulum.

Answer : Since, $T = \propto \sqrt{l}$

Therefore,

T = constant$\sqrt{l}$

$\frac{T_f}{T_i} = \sqrt{\frac{l+\frac{44}{100}l}{l}} = \sqrt{1.44} = 1.2$

Therefore, $T_f = 1.2\, T_i = T_i + 20\%\, T_i$

9) Write down the kinetic energy and total energy expressions in terms of linear momentum, For one-dimensional case.

Answer : Kinetic energy is KE= $\frac{1}{2}mv_x^2$

Multiply numerator and denominator by m

$KE = \frac{1}{2m}m^2v_x^2 = \frac{1}{2m}(mv_x)^2 = \frac{1}{2m}P_x^2$

where, P_x is the linear momentum of the particle executing simple harmonic motion.

Total energy can be written as sum of kinetic energy and potential energy, therefore, from equation (10.73) and also from equation (10.75), we get

E = KE + U(x) $= \frac{1}{2m}P_x^2 + \frac{1}{2m}m\omega^2v_x^2$ = constant

10) Compute the position of an oscillating particle when its kinetic energy and potential energy are equal.

Answer : Since the kinetic energy and potential energy of the oscillating particle are equal,

$\frac{1}{2}m\omega^2\left(A^2 - x^2\right) = \frac{1}{2}m\omega^2x^2$

$A^2 - x^2 = x^2$

$2x^2 = A^2$

$\Rightarrow x = \pm\frac{A}{\sqrt{2}}$

11) What is meant by force constant of a spring?

Answer : Force constant of a spring is defined as the restoring force per unit length.

12) Define time period of simple harmonic motion.

Answer : Time period is defined as the time taken by a particle to complete one oscillation in simple harmonic motion.

T = $\frac{2\pi}{\omega}$

13) Define frequency of simple harmonic motion.

Answer : Frequency of simple harmonic motion is defined as the number of oscillations produced by the Particle.

14) State the laws of simple pendulum?

Answer : **(i) Law of length:**

For a given value of acceleration due to gravity, the time period of a simple pendulum is directly proportional to the square root of length of the pendulum.

$T \propto \sqrt{l}$ ....(1)

(ii) Law of acceleration:

For a fixed length, the time period of a simple pendulum is inversely proportional to square root of acceleration due to gravity.

$T \propto \frac{1}{\sqrt{g}}$ ....(2)

15) What is meant by maintained oscillation? Give an example.

Answer : In a maintained oscillation, the amplitude of the oscillation can be made constant by supplying energy from an external source.

Example: The vibrating tuning fork get energy from a battery to vibrate continually.

16) Explain resonance. Give an example.

Answer : It is a special case of forced vibrations where the frequency of external periodic force (or driving force) matches with the natural frequency of the vibrating body (driven). As a result the oscillating body begins to vibrate such that its amplitude increases at each step and ultimately it has a large amplitude. Such a phenomenon is known as resonance and the corresponding vibrations are known is resonance vibrations.

Example: The breaking of glass due to sound.

17) A piece of wood of mass m is floating erect in a liquid whose density is ρ. If it is slightly pressed down and released, then executes simple harmonic motion. Show that its time period of oscillation is $T = 2\pi\sqrt{\frac{m}{Ag\rho}}$

Answer : When a piece of wood is pressed and released,

$\mathrm{F}=\mathrm{ma}, \quad \mathrm{m}=$ volume $\times$ density $=\mathrm{A} \times \rho$

Change in force $=\mathrm{mg}=\mathrm{A} \times \rho \mathrm{g}$

$\therefore$ Acceleration a $=\frac{F}{m}$

$a=\left(\frac{A \rho g}{m}\right) x \quad$ .....(1)

For SHM, $a=\omega^2 x$ .....(2)

From equation (1) & (2) we get

$\omega^2=\frac{A \rho g}{m} \quad \therefore \omega=\sqrt{\frac{A \rho g}{m}}$

Time period $\mathrm{T}=\sqrt{\frac{2 \pi}{\omega}} \quad \therefore \mathrm{T}=2 \pi \sqrt{\frac{m}{A \rho g}}$

18) Show that for a particle executing simple harmonic motion

a. the average value of kinetic energy is equal to the average value of potential energy.

b. average potential energy = average kinetic energy = $\frac{1}{2}$ (total energy)

Hint: average kinetic energy =< kinetic energy > = $\frac{1}{T} \int_0^T$(Kineticenergy) dt and

average Potential energy = < Potential energy > = $\frac{1}{T} \int_0^T$ (Potential energy) dt

Answer : (a) Suppose a particle of mass m executes SHM of time period T. The displacement of the particle of any instant A is given by

$\mathrm{y}=\mathrm{A} \sin \omega t$ .....(1)

Velocity $\mathrm{v}=\frac{d y}{d t}=\frac{d}{d t}$

$(\mathrm{A} \sin \omega t)=\omega A \cos \omega t$

$\therefore$ Kinetic energy $E_k=\frac{1}{2} m v^2=\frac{1}{2} m \omega^2 \cdot A^2 \cos ^2 \omega t$ ......(2)

Potential energy $\mathrm{E}_{\mathrm{p}}=\frac{1}{2} m \omega^2 y^2$

$\mathrm{E}_p=\frac{1}{2} m \omega^2 A^2 \sin ^2 \omega t$ .....(3)

Average K.E for one period of oscillation is

$E_{k_{av}}=\frac{1}{T} \int_0^T E_k d t$

$=\frac{1}{T} \int \frac{1}{2} m \omega^2 A^2 \cos ^2 \omega t d t$

$=\frac{1}{2 T} m \omega^2 A^2 \int_0^T \frac{(1+\cos 2 \omega t)}{2} d t$

$E_{k_{ov}}=\frac{1}{4 T} m \omega^2 A^2\left[t+\frac{\sin 2 \omega t}{2 \omega}\right]_0^T=\frac{1}{4 T} m \omega^2 A^2(T)$

$E_{k_{av}}=\frac{1}{4 T} m \omega^2 A^2$ .....(4)

Average potential energy over a period of oscillation is

$E_{p_{\omega}}=\frac{1}{T} \int_0^T E_p d t=\frac{1}{T} \int_0^T \frac{1}{2} m \omega^2 A^2 \sin ^2 \omega t d t$

$=\frac{1}{2 T} m \omega^2 A^2 \int_0^T\left(\frac{1-\cos 2 \omega t}{2}\right) d t$

$=\frac{1}{4 T} m \omega^2 A^2\left[t-\frac{\sin 2 \omega t}{2 \omega}\right]_0^T=\frac{1}{4 T} m \omega^2 A^2 C_1$

$E_{p_{av}}=\frac{1}{4 T} m \omega^2 A^2$ .....(5)

clearly from equation (4) and (5)

$E_{k_{ow}}=E_{p_{wo}}$

Average value of K.E = Average value of P.E

(b) Total energy

$\mathrm{T.E}=\frac{1}{2} m \omega^2 y^2+\frac{1}{2} m \omega^2\left(A^2-y^2\right)$

But $\mathrm{y}=\mathrm{A} \sin \omega t$

$\mathrm{T.E}=\frac{1}{2} m \omega^2 A^2 \sin ^2 \omega t+\frac{1}{2} m \omega^2 A^2 \cos ^2 \omega t$

$=\frac{1}{2} m \omega^2 A^2\left(\sin ^2 \omega t+\cos ^2 \omega t\right)$

$But \sin ^2 \omega t+\cos ^2 \omega t=1$

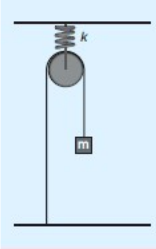
Equation (6) becomes

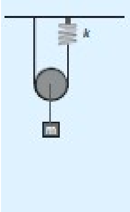
$\mathrm{T.E}=\frac{1}{2} m \omega^2 A^2(1)=\frac{1}{2} m \omega^2 A^2$

Average potential energy = Average kinetic energy

$=\frac{1}{2}$ (Total energy)

19) Compute the time period for the following system if the block of mass m is slightly displaced vertically down from its equilibrium position and then released. Assume that the pulley is light and smooth, strings and springs are light.





Answer : **Case(a):**

Pulley is fixed rigidly here.

When the mass displace by y and the spring will also stretch by y.

Hence, F = T = ky

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Case(b):

Mass displace by y, pulley also displaces by y.

T = 4ky.

$$T = 2\pi\sqrt{\frac{m}{4k}}$$

20) What is an epoch?

Answer : Initial phase of a particle executing SHM is called epoch.

When t = 0, $\phi = \phi_0$

ϕ_0 is epoch of a particle executing SHM.

21) What is an epoch?.

Answer :

22) The displacement of harmonic oscillator is given by x = α sin wt + β cos wt. what is the amplitude of the oscillation?

Answer : x = a sin wt + β cos wt

α = r cos θ and, B = r sin θ

x = r cos θ sin wt + r sin θ cos

wt = r sin (wt + θ)

23) The acceleration dual to gravity on the surface of moon is 1.7 ms^{-2}. What is the time period of a simple pendulum on the surface of moon if its time period on the surface of earth is 3.5 s?

Answer : On earth time period

T = $2\pi\sqrt{\frac{l}{g}}$

3.5 = $2\pi\sqrt{\frac{l}{9.8}}$

∴ Acceleration due to gravity of the moon's is 1.7 ms^{-2}

T^1 = $\sqrt{\frac{l}{1.7}}$

Dividing $\frac{T^1}{3.5} = 2\pi\sqrt{\frac{1}{1.T}}/2\pi\sqrt{\frac{l}{9.8}}v$

T^1 = $\sqrt{\frac{9.8}{1.7}} \times 3.5$

= 8.4 s

24) A particle executes linear simple harmonic motion with an amplitude of 3 cm. When the particle is at 2 cm from the mean position, the magnitude of its velocity is equal to that of its acceleration. Then find its time period in seconds.

Answer : a = $\omega^2 \times$ a = vA = 3 cm x = 2 cm

$$v = \omega\sqrt{A^2 - x^2}$$

$$\omega^2 x = \sqrt{A^2 - x^2}$$

$$\left(\frac{2\pi}{T}\right)2 = \sqrt{3^2 - 2^2}; \frac{4\pi}{T} = \sqrt{5}$$

$$T = \frac{4\pi}{\sqrt{5}} \Rightarrow T = 5.6 sec$$

25) A body of mass m is attached to lower end of a spring whose upper end is fixed. The spring has negligible mass. When the mass m is slightly pulled down and released, it oscillates with a time period of 3s. When the mass m is increased by 1 kg, the time period of oscillations becomes 5s. Find the value of m is kg.

Answer : $T_1 = 3 = 2\pi\sqrt{\frac{m}{k}}$

$T_2 = 5 = 2\pi\sqrt{\frac{m+1}{k}}$

$\frac{T_1}{T_2} = \frac{3}{5} = \sqrt{\frac{m}{m+1}}$

$\frac{9}{25} = \frac{m}{m+1} \Rightarrow 9m + 9 = 25m$

$m = \frac{9}{16} kg$

26) A 0.2 kg of mass hangs at the end of a spring. When 0.02 kg more mass is added to the end of the spring, it stretches 7 cm more. If the 0.02 kg mass is removed, what will be the period of vibration of the system?

Answer : When 0.02 kg mass is added, the spring stretches by 7 cm

As mg= kx

$\therefore K = \frac{mg}{x} = \frac{0.02 \times 10}{7 \times 10^{-2}} = \frac{20}{7} Nm^{-1}$

When 0.02 kg mass ia removed, the period of vibration will be

$T = 2x\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{0.2}{20/7}} = 2\pi\sqrt{\frac{7}{100}} = \frac{2\pi \times 2.645}{10} = 1.66s$

27) A mass M is suspended from a spring of negligible mass. The spring is pulled a little and then released so that the mass executes SHM of time period T. If the mass is increased by m, the time period becomes 5T/3. What is the ratio m/M?

Answer : With mass M, the time period of the spring is $T = 2\pi\sqrt{\frac{M}{k}}$

With mass M + m, the time period becomes

$\frac{5T}{3} = 2\pi\sqrt{\frac{M+m}{k}} \frac{5}{3} \times 2\pi\sqrt{\frac{M}{k}} = 2\pi\sqrt{\frac{M+m}{k}}$

$\frac{25}{9}M = M + m; \frac{16}{9}M$ or $\frac{m}{M} = \frac{16}{9}$

28) What is meant by displacement of a particle executing simple harmonic motion?

Answer : The distance travelled by a vibrating particle executing simple harmonic motion at any instant of time from its mean position.

29) Why does a swinging simple pendulum eventually stop?

Answer : Due to friction between air and bob, the amplitude of simple pendulum goes on decreasing and eventually it comes to rest.

30) A girl is swinging in the sitting platform. How will the period of the swing change if she stands up?

Answer : Time period of the girl and swing together is given by

$T = 2\pi\sqrt{\frac{\ell}{g}}$

As the girl stands up, her centre of gravity is raised. The distance between the point of suspension and the centre of gravity decreases. As the length decreases, time period T would be decreased.