PHYSICS

NCERT - NCERT PHYSICS(HINGLISH)

OSCILLATIONS

Solved Example

1. On an average a human heart is found to beat 75 times in a minute. Calculate its beat frequency and period.

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2. Which of the following funchtions of time represent (a) periodic and (b) non-periodic motion? Give the period for each of period motion. (ω is any positive constant)

(i) $\sin \omega t + \cos \omega t$

(ii) $\sin \omega t + \cos 2\omega t + \sin 4\omega t$

(iii) $e^{-\omega t}$ (iv) $\log \omega t$

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3. Which of the following functions of time represent (a) simple harmonic motion and (b) periodic but not simple harmonic motion? Give the period for each case.

(i) $\sin \omega t - \cos \omega t$ (ii) $\sin^2 \omega t$ (iii) $\cos \omega t + 2\sin^2 \omega t$

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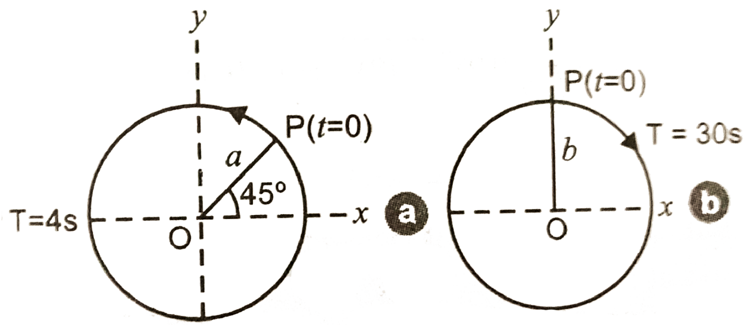
4. Fig.(a) and (b) depict two circular motions. The radius of the circle, the period of revolution, the initial position and sense of revolution are indicated in the figures. Obtain the simple harmonic motions of the x-projection of the radius vector of the rotating particle P in each case.



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5. A body oscillates with SHM, accroding to the equation,

$x = (5.0m)\cos\left[\left(2\pi rads^{-1}\right)t + \pi/4\right]$

At $t = 1.5s$, calculate the (a) diplacement (b) speed and (c) acceleration of the body.

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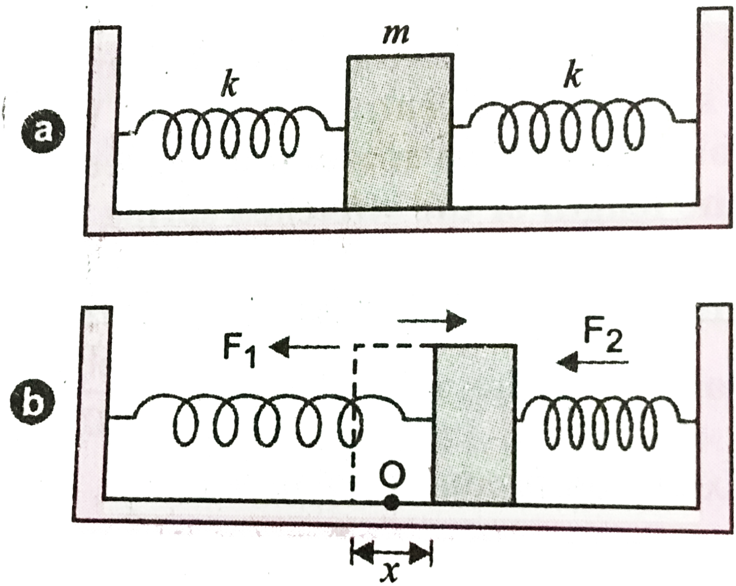
6. Two identical springs of spring constant k are attached to a block of mass m and to fixed supports as shown in figure . Show that when the mass is displaced from its equilibrium position on either side, it executes a simple harmonic motion. Find the period of oscillation.



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7. A block whose mass is 1 kg is fastened to a spring.The spring has a spring constant $50 Nm^{-1}$. The block is pulled to a distance

$x = 10cm$ from its equilibrium position at $x = 0$ on a frictionless surface at $t = 0$. Calculate the kinetic, potential and total energies of the block when it is 5cm away from the mean position.

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8. A 5 kg collar is attached to a spring of spring constant $500Nm^{-1}$. It slides without friction over a horizontal rod. The collar is displaced from its equilibrium position by 10 cm and released. Calculate (a) The period of oscillations (b) The maximum speed and (c) maximum acceleration of the collar.

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9. What is the length of a simple pendulum which ticks second?

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10. In damped oscillatory motion a block of mass $20kg$ is suspended to a spring of force constant $90N/m$ in a medium and damping constant is $40g/s$. Find (a) time period of oscillation (b) time taken for amplitude of oscillation to drop to half of its intial value (c) time taken for its mechanical energy to drop to half of its initial value.

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Exercise

1. Which of the following examples represent periodic motion?

(a) A swimmer completing one return trip from one bank of a river to other bank. (b) A freely suspended bar magnet displaced from its $N-S$ direction and released. (c) A hydrogen molecule rotating about its centre of mass. (d) An arrow released from a bow.

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2. Which of the following examples represent (nearly) simple harmonic motion and which represent periodic but not simple harmonic motion?

(a) The rotation of earth about its axis. (b) Motion of an oscillating mercury column in a U tube,

(c) Motion of a ball bearing inside a smooth curved bowl, when released from a point slightly above the lower most position. (d) General vibrations of a polyatomic molecule about its equilibrium position.

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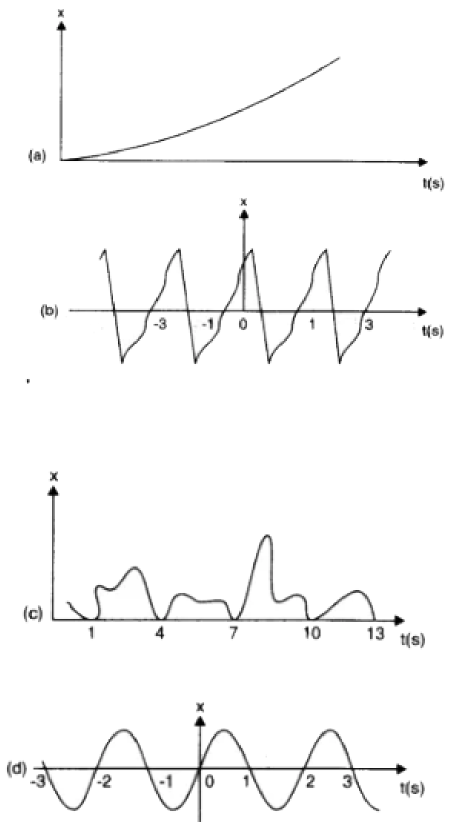
3. Fig. 14.23 depicts four x-t plots for linear motion of a particle. Which of the plots represent periodic motion? What is the period of motion (in case of periodic motion) ?



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4. Which of the following functions of time represent (a) simple harmonic, (b) periodic but not simple harmonic, and (c) non-periodic motion? Give period for each case of periodic motion (w is any positive constant):

(a) $\sin \omega t - \cos \omega t$

(b) $\sin^3 \omega t$

(c) $3 \cos(\pi / 4 - 2\omega t)$

(d) $\cos \omega t + \cos 3\omega t + \cos 5\omega t$

(e) "exp" (-omega^(2)t^(2))(f)1+ omega t + omega^(2)t^(2)`.

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5. A particle is in linear S.H.M. between two points A and B, 10 cm apart. Take the direction from A to B as the positive direction and give the signs of velocity, acceleration and force on the particle when it is.

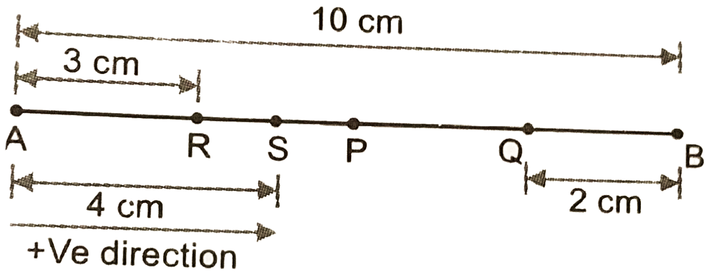
(a) at the end A (b) at the end B,

(c) at the mid point of AB going towards A,

(d) at 2 cm away from B going towards A,

(e) at 3 cm away from A goiing towards B, and

(f) at 4 cm away from A going towards A.



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6. Which of the following relationship between the acceleration, a and the displacement x of a particle involve simple harmonic motion.

(a) $a = 7.0x$ (b) $a = -200x^2$ (c) $a = -10x$

(d) $a = 100x^3$

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7. The motion of a particle in S.H.M. is described by the displacement function, $x = A\cos(\omega t + \phi)$, If the initial $(t=0)$ position of the particle is 1cm and its initial velocity is ωcms^{-1}, what are its amplitude and initial phase angle ? The angular frequency of the particle is πs^{-1}. If instead of the cosine function, we choose the sine function to describe the SHM $: x = B\sin(\omega t + \alpha)$, what are the amplitude and initial phase of the particle with the above initial conditions ?

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8. A spring balance has a scale that reads from 0 to 50kg. The length of the scale is 20cm. A body suspended from this spring, when displaced and released, oscillates with period of 0.60s. What is the weight of the body?

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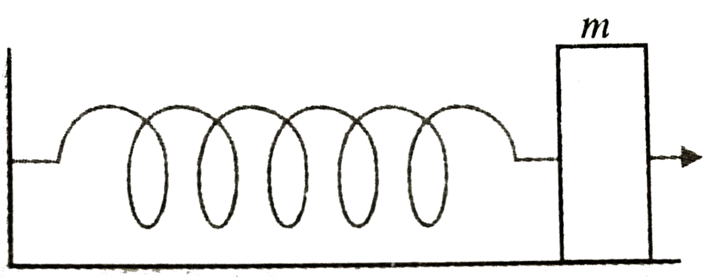
9. A spring of force constant $1200Nm^{-1}$ is mounted on a horizontal table as shown in figure. A mass of 3.0kg is attached to the free end of the spring, pulled side ways to a distance of 2.0cm and released. Determing.

(a) the frequency of oscillation of the mass.

(b) the maximum acceleration of the mass.

(c) the maximum speed of the mass.



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10. In Exercise 14.9, let us take the position of mass when the spring is unstreched as x = 0, and the direction from left to right as the positive direction of x-axis. Give x as a function of time t for the oscillating mass if at the moment we start the stopwatch (t = 0), the mass is

(a) at the mean position,

(b) at the maximum stretched position, and

(c) at the maximum compressed position.

In what way do these functions for SHM differ from each other, in frequency, in amplitude or the initial phase ?

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11. Figures,. Correspond to two circular motions. The radius of the circle, the peirod of revolution, the initial position, and the sense of revolution (i.e. clockwise or anticlockwise) are indicated on each. Obtain the corresponding equations of simple harmonic motions of the revolving particle P in each case.

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12. Plot the corresponding reference circle for each of the following simple hoarmonic motions. Indicate the intial$(t=0)$ position of the particle, the radius of the circle, and the angular speed of the rotating particle. For simplicity, the sense of rotation may be fixed to be anticlockwise in every case : $(x$ is in cm and t is in s).

(a) $x = -2\sin(3t + \pi/3)$ (b) $x = \cos(\pi/6 - t)$ (c) $x = 3\sin(2\pi t + \pi/4)$

(d) $x = 2\cos\pi t$

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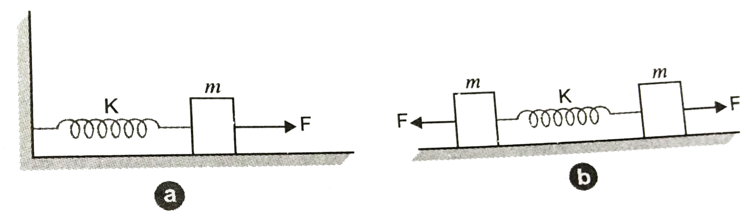
13. Figure a) shows a spring of force constant k clamped rigidly at once end and a mass m attached to its free end. A force F applied at the free end stretches the spring. Figure b) shows the same spring with both ends free and attached to a mass m at either end. Each end of the spring in figure is stretched by the same force F.

(a) What is the maximum extension of the spring in the two cases ?

(b) If the mass in figure and the two masses in figure are released free, what is the period of oscillation in each case?



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14. The piston in the cylinder head of a locomotive has a stroke (twice the amplitude) of 1.0m. If the piston moves with simple harmonic motion with an angular frequency of $200 rev / \min$., what is its maximum speed ?

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15. The acceleration due to gravity on the surface of the moon is $1.7 ms^{-2}$. What is the time period of a simple pendulum on the surface of the moon, if its time period on the surface of earth is $3.5s$? Take $g = 9.8ms^{-2}$ on the surface of the earth.

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16. Answer the following questions: (a) Time period of particle is S.H.M. depends on the force constant k and mass m of the particle $: T = 2\pi\sqrt{m / k}$. A simple pendulum executes S.H.M. approximately. Why then is the time-period of a pendulum independent of the mass of the pendulum?

(b) The motion of simple pendulum is approximately simple harmonic for small angles of oscillation. For large angle of oscillation, a more involved analysis (beyond the scope of this book) shows that T is greater that $2\pi\sqrt{l/g}$. Think of a quantitative argument to appreciate this result.

(c) A man with a wrist watch on his hand falls from the top of tower. Does the watch give correct time during the free fall?

(d) What is the frequency of oscillation of a simple pendulum mounted in a cabin that is freely falling under gravity?

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17. A simple pendulum of length l and having a bob of mass M is suspended ina car. The car is moving on a circular track of radius R with a uniform speed v. If the pendulum makes small oscillations in a radial direction about its equilibrium, what will be its time period ?

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18. A cylindrical piece of cork of base area A and height h floats in a liquid of density ρ_1. The cork is depressed slightly and then released. Show that the cork oscillates up and down simple harmonically with a period

$$T = 2\pi\sqrt{\frac{h\rho}{\rho_1 g}}$$

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19. One end of a U-tube containing mercury is connected to a suction pump and the other end to atmosphere. A small pressure difference is maintained between the two columns. Show that, when the suction pump is removed, the column of mercury in the U-tube executes simple harmonic motion.

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20. An air chamber of volume V has a neck area of cross section A into which a ball of mass m just fits and can move up and down without any friction, figure. Show that when the ball is pressed down a little and released, it executes SHM. Obtain an expression for the time period of oscillations assuming pressure volume variations of air to be isothermal.

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21. You are riding an automobile of mass 3000kg. Assuming that you are examining the oscillation characteristics of its suspension system. The suspension sags 15cm when the entire automobile is placed on it. Also, the amplitude of oscillation decreases by50% during one complete oscillation. Estimate the values of (a) the spring constant k and (b) damping constant b for the spring and shock absorber system of one wheel, assuming that each wheel supports $750kg. g = 10m/s^2$.

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22. Show that for a particle in linear S.H.M., the average kinetic energy over a period of oscillation equals the average potential energy over the same period.

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23. A circular disc of mass 10kg is suspended by a wire attahced to its centre. The wire is twisted by rotating the disc and released. The period of torsional oscillations is found to be 1.5s. The radius of the disc is 15cm. Determing the torsional spring constant of the wire. (Torsional spring constant α is definied by the relation $J = -\alpha\theta$, where J is the restoring coubple and θ the angle of twist.

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24. A body describes simple harmonic motion with an amplitude of 5 cm and a period of $0.2s$. Find the acceleration and velocity of the body when the displacement is (a) 5cm, (b) 3cm, (c) 0 cm.

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25. A mass attached to a spring is free to oscillate, with angular velocity ω, in a horizontal plane without friction or damping. It is pulled to a distance x_0 and pushed towards the centre with a velocity v_0 at time $t = 0$. Determine the amplitude of the resulting oscillations in terms of the parameters ω, x_0 and v_0.

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