PHYSICS

BOOKS - RESNICK AND HALLIDAY PHYSICS (HINGLISH)

OSCILLATIONS

Sample Problem

1. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What are the angular frequency, the frequency, and the period of the resulting motion?

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2. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What is the amplitude of the oscillation?

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3. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What is the maximum speed v_m of the oscillating block, and where is the block when it has this speed?

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4. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What is the magnitude a_m of the maximum acceleration of the block?

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5. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What is the phase constant ϕ for the motion?

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6. A block whose mass m is 680g is fastened to a spring whose spring constant k is 65N/m. The block is pulled a distance x=11cm from its equilibrium position at x=0 on a frictionless surface and released from rest at t= 0.

What is the displacement function x(t) for the spring block system?

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7. At t=0, the displacement x(0) of the block in a linear oscillator like that of Fig . 15.5 is $-8.50cm$. (Read x(0) as "x at time zero") The block's velocity v(0) then is $-0.920m/s$, and its acceleration a(0) is $+47.0m/s^2$.

What is the angular frequency ω of this system?

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What are the phase constant ϕ and amplitude x_m?

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9. If the position of the block in a block-spring oscillator is given by

$x(t) = (3.00 \times 10^{-3} m)\cos[(4.00\text{rad/s})t + 0.120\text{rad}]$

, what is the block's position, velocity and acceleration at time t= 2.30s?

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10. At t=0, the displacement x(0) of the block in a linear oscillator like that of Fig. 15.5 is $-8.50cm$. (Read x(0) as "x at time zero"). The block's velocity v(0) then is $-0.920m/s$, and its acceleration a(0) is $+47.0m/s^2$.

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What is the phase constant ϕ and amplitude x_m ?

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12. Write equation of SHM of angular frequency ω and amplitude x_m if the particle is situated at $x_m/\sqrt{2}$ at t= 0 and is going toward mean position.

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13. A particle move along y-axis according to equation $y = 3 + 4\cos\omega t$. The motion of the particle is

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14. A particle is moving on y axis under a varible force $F = -ky + C$.

If in part (a) $F = -10y + 20$, and mass m of the particle is 2.5kg and it is released from rest from $y = +3$, at t= 0, write the equation of SHM.

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15. Many tall building have mass dampers, which are antisway devices to prevent them from oscillating in a wind. The device might be a block oscillating at the end of a spring and on a lubricated track. If the building sways, say eastward, the block also moves eastward but delayed enough so that when it finally moves, the building is then moving back westward. Thus, the motion of the oscillator is out of step with the motion of the building. Suppose the block has mass $m = 2.72 \times 10^5 kg$ and is designed to oscillate at frequency f= 10.0 Hz and with amplitude $x_m = 20.0cm.$

What is the total mechanical energy E of the spring block system?

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16. Many tall building have mass dampers, which are antisway devices to prevent them from oscillating in a wind. The device might be a block oscillating at the end of a spring and on a lubricated track. If the building sways, say eastward, the block also moves eastward but delayed enough so that when it finally moves, the building is then moving back westward. Thus, the motion of the oscillator is out of step with the motion of the building. Suppose the block has mass $m = 2.72 \times 10^5 kg$ and is designed to oscillate at frequency f= 10.0 Hz and with amplitude $x_m = 20.0cm$.

What is the block's speed as it passes through the equilibrium point?

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17. A block of mass 4m is attached to a vertical spring of spring constant k. The block is made by gluing two blocks of mass 3m and m, respectively. Initially, the block is in equilibrium and at rest (Fig. 15.13a). At t=0, the part of the block having ass 3m falls down. Considering hanging point on ceiling as y=0 and downward direction as positive y, find y-coordinate of mass m as a function of time.

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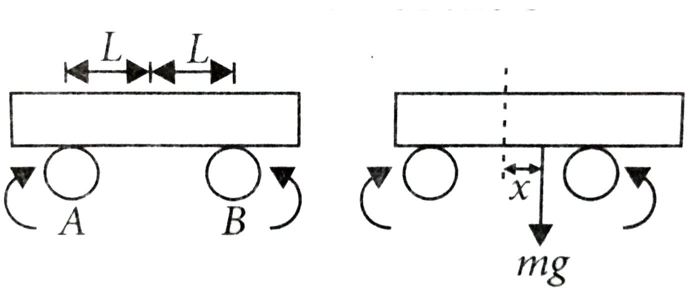
18. 

A uniform bar with mass m lies symmetrically across two rapidly rotating fixed rollers, A and B with distance L=2.0 cm between the bar's centre of mass and each roller. The rollers, whose directions of rotation are shown in figures slip against the bar with coefficient of kinetic friction $\mu_k = 0.40.$ suppose the bar is displaced horizontally by the distance x as shown in figure and then released. the angular frequency ω of the resulting horizontal simple harmonic motion of the bar is (in $rad \quad s^{-1}$)

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19. Figure 15.16a shows a thin rod whose length L is 12.4cm and whose mass m is 135g, suspended at its midpoint from a larg wire. Its period T_a of angular SHM is measured to be 2.53s. An irregularly shaped object, which we call object X, is then hung from the same wire, as in Fig. 15.13b, and its period T_b is found to be 4.76s. What is the rotational inertia of object X about its suspension axis?

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20. In Fig 15.19a, a meter stick swings about a pivot point at one end, at distance h from the stick's center of mass.

What is the period of oscillation T?

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21. In Fig 15.19a, a meter stick swings about a pivot point at one end, at distance h from the stick's center of mass.

What is the distance L_0 between the pivot point O of the stick and the center of oscillation of the stick?

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22. For the damped oscillator of Fig. 15.20, m= 250g, k= 85N/m, and b= 70g/s

What is the period of the motion?

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23. For the damped oscillator of Fig. 15.20, m= 250g, k= 85N/m, and b= 70g/s

How long does it take for the amplitude of the damped oscillations to drop to half its initial value?

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24. For the damped oscillator of Fig. 15.20, m= 250g, k= 85N/m, and b= 70g/s

How long does it take for the mechanical energy to drop to one-half its initial value?

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Checkpoint

1. A particle hanging from a thread is launched horizontally such that it completes a circle. Is the motion periodic or oscillatory?

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2. A particle hanging from a thread is launched horizontally with small speed that it does not even reach to the horizontal level. Is the motion periodic or oscillatory?

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3. A particle undergoing simple harmonic oscillation of period T (like that in Fig. 15-1) is at $-x_m$ at time t=0. Is it at $-x_m$ at $+x_m$ at 0, between $-x_m$ and 0, or between 0 and $+x_m$ when (a) t= 2.00T, (b) t = 3.05T, and (c) t= 5.25T?

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4. Which of the following relationships between a particle's acceleration a and its position x harmonic oscillation (a) $a = 3x^2$, (b) a= 5x, (c) $a = -4x$, (d) $a = -2/x$? For the SHM. What is the angular frequency (assume the unit of rad/s)?

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5. Which of the following relationships between the force F on a particle and the particle's position x gives SHM: (a) $F = -5x$, (b) $F = -400x^2$, (c) F= 10x, (d) $F = 3x^2$?

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6. Find the distance traveled by a particle execcuting SHM with time period T and amplitude x_m in time T/12 after starting from rest.

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7. In Fig 15.5, the block has a kinetic energy of 3J and the spring has an elastic potential energy of 2J when the block is at $x = +2.0cm$. (a) What is the kinetic energy when the block is at x= 0? What is the elastic potential energy when the block is at (b) $x = -2.0cm$ and (c) $x = -x_m$?

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8. Here are three sets of values for the spring constant, damping constant, and mass for the damped oscillator of Fig. 15.17. Rank the sets according to the time required for the mechanical energy to decrease to one-fourth of its initial value, greatest first.

Set 1	$2k_0$	b_0	m_0
Set 2	k_0	$6b_0$	$4m_0$
Set 3	$3k_0$	$3b_0$	m_0

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Problems

1. Hanging from a horizontal beam are nine simple pendulums of the following lengths: (a) 0.10, (b) 0.30, (c) 0.70, (d) 0.80, (e) 1.2 (f) 2.6 (g) 3.5 (h) 5.0 and (i) 6.2m. Suppose the beam undergoes horizontal oscillations with angular frequencies in the range from 2.00 rad/s to 4.00 rad/s. Which of the pendulums will be (strongly) set in motion?

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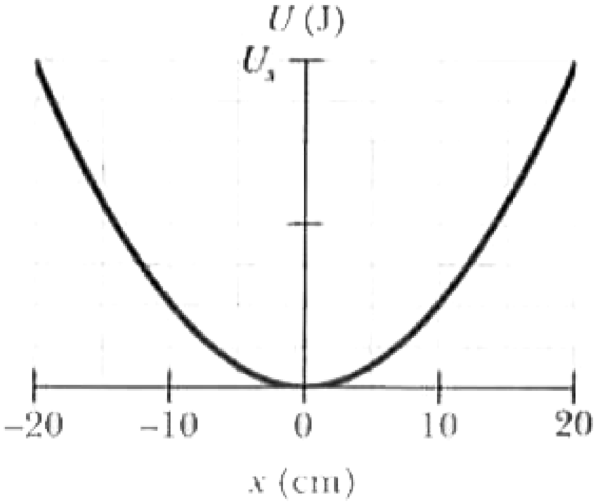
2. Figure 15-24 gives the one-dimensional potential energy well for a 4.0kg particle (the function U (x) has the form bx^2 and the vertical axis scale is set by U= 2.0 J). (a) If the particle passes through the equilibrium position with a velocity of 85 cm/s, will it be turned back before it reaches x= 15cm? (b) If yes, at what position, and if no, what is the speed of the particle at x= 15cm?



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3. An oscillator consists of a block of mass 0.500kg connected to a spring. When set into oscillation with amplitude 35.0 cm, the oscillator repeats its motion every 0.350s. Find the (a) period, (b) frequency, (c) angular frequency, (d) spring constant, (e) maximum speed, and (f) magnitude of the maximum force on the block from the spring.

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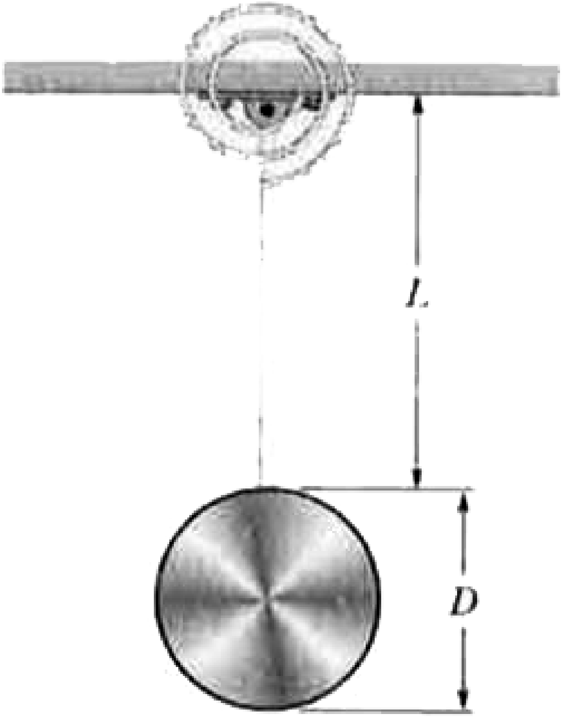
4. In Fig 15.25, a 5.00 kg dish of diameter D= 42.0 cm is supported by a rod of length L = 76.0 cm and negligible mass that is pivoted at its end. (a) With the massless torsion spring unconnected, what is the period of oscillation? (b) With the torsion spring connected, the rod is vertical at equilibrium. What is the torsion constant of the spring if the period of oscillation has been decreased by 0.500s?



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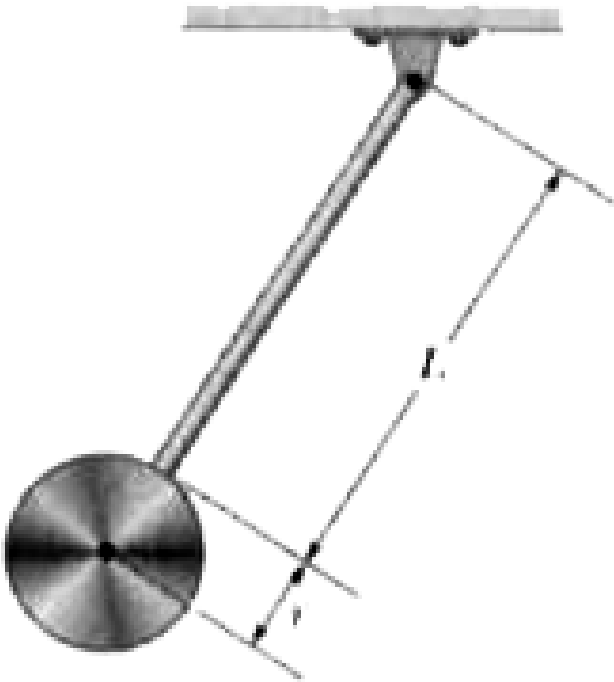
5. In Fig. 15.26, the pendulum consists of a uniform disk with radius r= 10.0cm and mass 500g attached to a uniform rod with length L = 500mm and mass 250g. (a) Calculate the rotational inertia of the pendulum about the pivot point. (b) What is the distance between the pivot point and the center of mass of the pendulum? (c) Calculate the period of oscillation.



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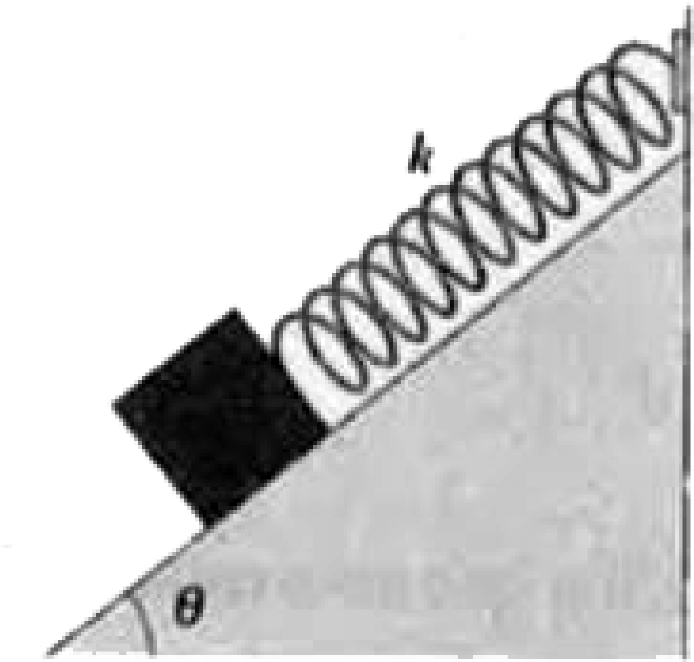
6. In Fig 15.27 a block weighing 14.0 N, which can slide without friction on an incline at angle

$\theta = 40.0^\circ$, is connected to the top of the incline by a massless spring of unstretched length 0.450m and spring constant 135N/m. (a) How far from the top of the incline is the block's equilibrium point ? (b) If the block is pulled slightly down the incline and released, what is the period of the resulting oscillations?



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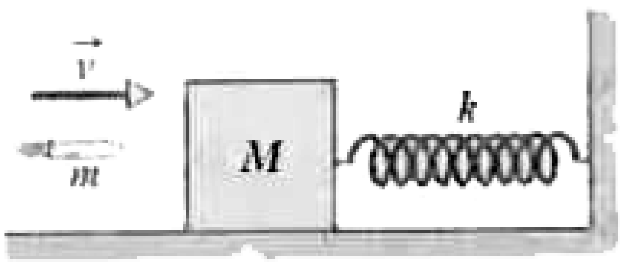
7. A block of mass M = 5.4 kg at rest on a horizontal frictionless table, is attached to a rigid support by

a spring of constant k= 6000N/m. A bullet of mass m= 9.5g and velocity $\vec{v}$ of magnitude 680 m/s strikes and is embedded in the block (Fig. 15.28). Assuming the compression of the spring is negligible until the bullet is embedded, determine (a) the speed of the block immediately after the collision and (b) the amplitude of the resulting simple harmonic motion.



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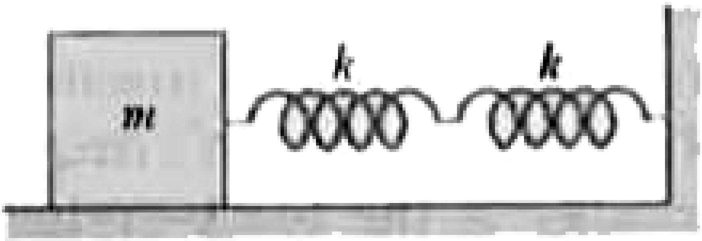
8. In Fig. 15.29 two springs are joined and connected to a block of mass 0.490kg that is set oscillating over a frictionless floor. The springs each have spring constant k= 5000N/m. What is the frequency of the oscillations?



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9. In an electric shaver, the blade moves back and forth over a distance of 2.0 mm in simple harmonic motion, with frequency 100Hz. Find (a) the amplitude, (b) the maximum blade speed and (c) the magnitude of the maximum blade acceleration.

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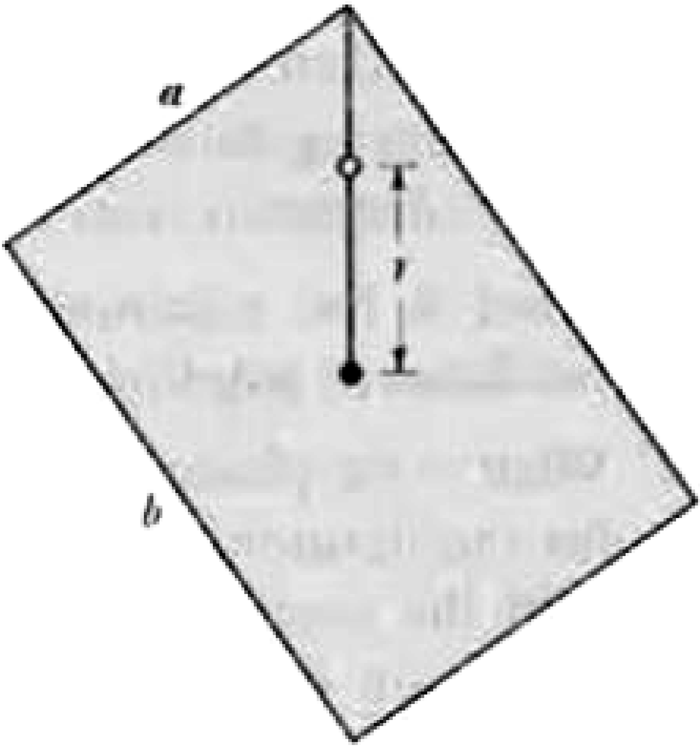
10. A rectangular block, with face lengths a= 35cm and b= 45 cm, is to be suspended on a thin horizontal rod running through a narrow hole in the block. The block is then to be set swinging about the rod like a pendulum, through small angles so that is is in SHM. Figure 15.30 shows one possible position of the hole, at distance r from the block's center, along a line connecting the center with a corner. (a) Plot of the period versus distance r along that line such that the minimum in the curve is apparent. (b) For what value of r does that minimum occur? There is a line of points around the block's center for which the period of swinging has the same minimum value. (c) What shape does that line make?



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11. A massless spring hangs from the ceiling with a small object attached to its lower end. The object is initially held at rest in a position y such that the spring is at its rest length. The object is then released from y and oscillates up and down, with its lowest position being 10cm below y, (a) What is the frequency of the oscillation? (b) What is the speed of the object when it is 8.0 cm below the initial position? (c) An object of mass 600g is attached to the first object, after which the system oscillates with half the original frequency. What is the mass of the first object? (d) How far below y, is the new equilibrium (rest) position with both objects attached to the spring?

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12. Two particles execute simple harmonic motion of the same amplitude and frequency along close parallel lines. They pass each other moving in opposite directions each time their displacement is half their amplitude. Their phase difference is

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13. Find the mechanical energy of a block-spring system with a spring constant of 1.8 N/cm and an amplitude of 2.4cm.

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14. AN oscillating block-spring system has a mechanical energy of 2.00J, an amplitude of 10.0cm, and a maximum speed of 0.800 m/s. Find (a) the spring constant, (b) the mass of the block and (c) the frequency of oscillation.

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15. An automobile can be considered to be mounted on four identical springs as far as vertical oscillations are concerned. The springs of a certain car are adjusted so that the oscillations have a frequency of 3.00Hz. (a) What is the spring constant of each spring if the mass of the car is 2110kg and the mass is evenly distributed over the springs? (b) What will be the oscillation frequency if five passengers, averaging 85.0kg each, ride in the car with an even distribution of mass?

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16. The position function x= (6.0m) $\cos[(3\pi\text{rad}/s)t + \pi/3 \ \text{rad}]$ gives the simple harmonic motion of a body. At t=21s, what are the (a) displacement, (b) velocity, (c) acceleration, and

(d) phase of the motion? Also, what are the (e) frequency and (f) period of the motion?

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17. Two particles oscillate in simple harmonic motion along a common straight-line segment of length A. Each particle has a period of 1.5s but they differ in phase by $\pi/6$ rad. (a) How far apart are they (in terms of A) 0.60s after the lagging particle leaves one end of the path? (b) Are they then moving in the same direction, toward each other, or away from each other?

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18. A 10g particle undergoes SHM with an amplitude of 2.0mm, a maximum acceleration of magnitude $6.5 \times 10^3 m / s^2$, and an unknown phase constant ϕ. What are (a) the period of the motion, (b) the maximum speed of the particle, and (c) the total mechanical energy of the oscillator? What is the magnitude of the force on the particle when the particle is at (d) its maximum displacement and (e) half its maximum displacement?

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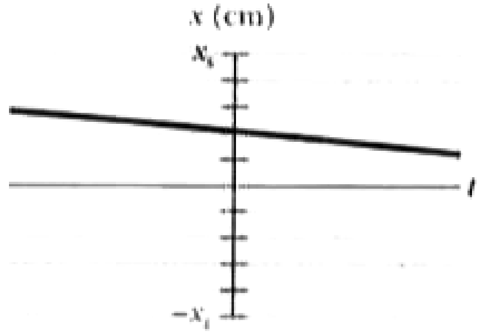
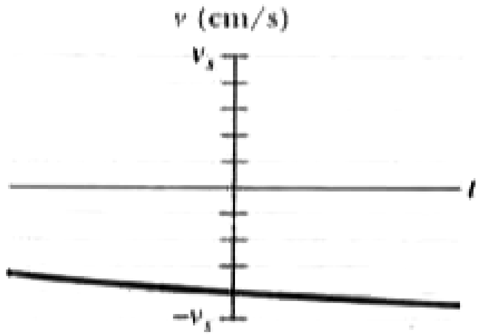
19. Figure 15.32a is a partial graph of the position function x(t) for a simple harmonic oscillator with an angular frequency of 1.00 rad/s. Fig 15.32b is a partial graph of the corresponding velocity function v(t). The vertical axis scales are set by $x_s = 5.00cm$ and $v_s = 10.0cm/s$. What is the phase constant of the SHM if the position function x(t) is in the general form $x = x_m \cos(\omega t + \phi)$?



(a)



(b)

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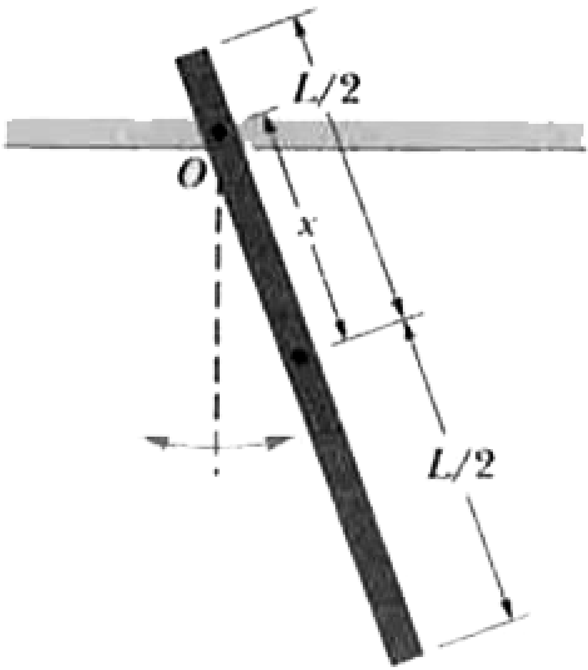
20. In Fig. 15.33, a stick of length L= 1.65 m oscillates as a physical pendulum. (a) What value of distance x between the stick's center of mass and its pivot point O gives the least period? (b) What is that least period?



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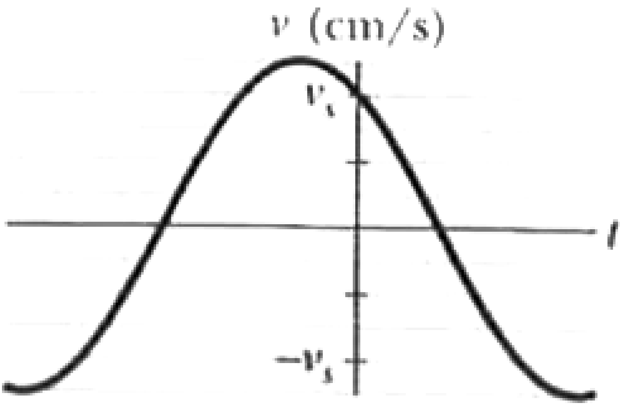
21. What is the phase constant for the harmonic oscillator with the velocity function v(t) given in Fig. 15.34 if the position function x(t) has the form $x = x_m \cos(\omega t + \phi)$? The vertical axis scale is set by $v_x = 8.0 cm / s$.



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22. What is the oscillation amplitude of a 4.00kg box oscillating on a spring with spring constant 100N/m if at time t= 1.00s the position is x = 0.129m and the velocity is v= 5.00m/s? At t= 0, what are (a) the position and (b) the velocity?

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23. A 5.00kg object on a horizontal frictionless surface is attached to a spring with k= 1000N/m. The object is displaced from equilibrium 40.0cm horizontally and given an initial velocity of 10.0m/s back toward the equilibrium position. What are (a) the motion's frequency (b) the initial potential energy of the block-spring system, (c) the initial kinetic energy and (d) the motion amplitude?

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24. What is the maximum acceleration of a platform that oscillates at amplitude 2.50cm and frequency 6.60Hz?

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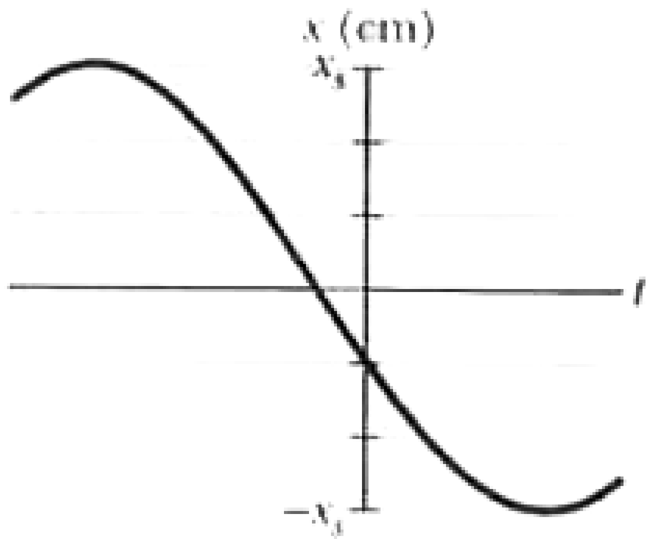
25. What is the phase constant for the harmonic oscillator with the position function x(t) given in Fig. 15.36 if the position function has the form $x = x_m \cos(\omega t + \phi)$? The vertical axis scale is set by $x_s = 9.0 cm$



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26. A body undergoes simple harmonic motion of amplitude 4.25cm and period 0.200s. The magnitude of the maximum force acting on it is 10.0N. (a) What is the mass? (b) If the oscillations are produced by a spring, what is the spring constant?

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27. A thin uniform rod (mass= 0.90kg) swings about an axis that passes through one end of the rod and is perpendicular to the plane of the swing.

The rod swings with a period of 1.5s and an angular amplitude of 10°. (a) What is the length of the rod? (b) What is the maximum kinetic energy of the rod as it swings?

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28. A pendulum is formed by pivoting a long thin rod about a point on the rod. In a series of experiments, the period is measured as a function of the distance x between the pivot point and the rod's center. (a) If the rod's length is L= 2.20 m and its mass is m= 22.1g, what is the minimum period?

(b) If x is chosen to minimize the period and then L is increased does the period increase, decrease, or remain the same? (c) If, instead, m is increased without L increasing does the period increase, decrease or remain the same?

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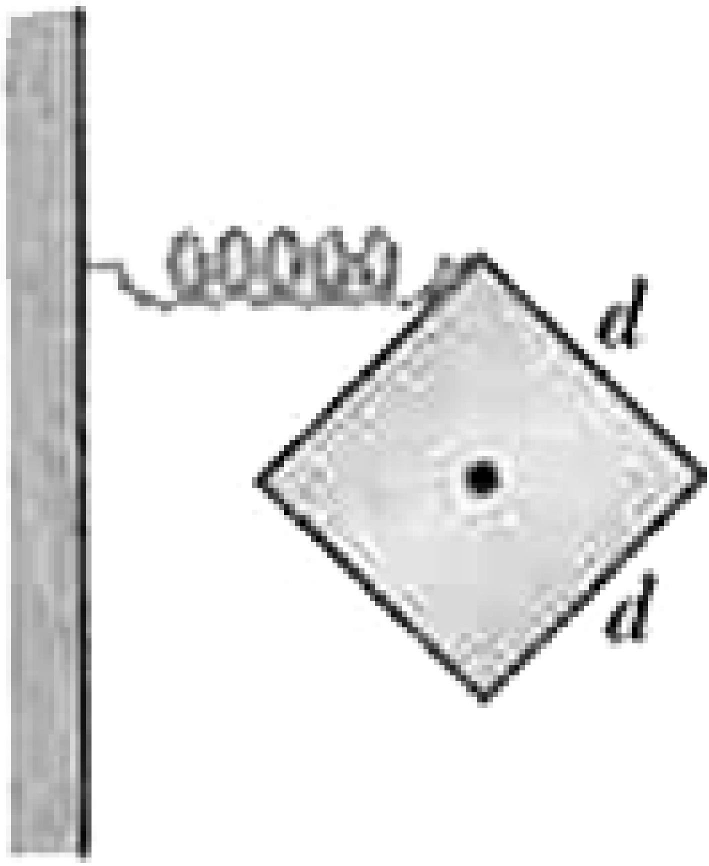
29. The 0.800kg cube in Fig. 15.38 has edge lengths d= 6.00cm and is mounted on an axle through its center. A springs (k= 3600N/m) connects the cube's upper corner to a rigid wall. Initially the spring is at its rest length. If the cube is rotated 3° and released, what is the period of the resulting SHM?



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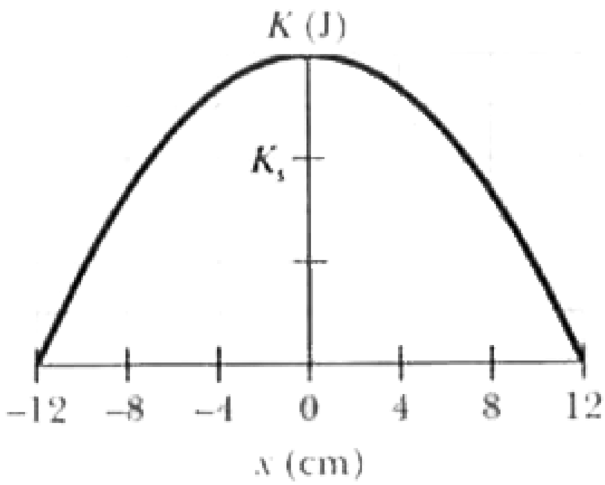
30. Figure 15.39 shows the kinetic energy K of a simple harmonic oscillator versus its position x. The vertical axis scale is set by $K_s = 8.0 J$. What is the spring constant?



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31. An object undergoing simple harmonic motion takes 0.25g to travel from one point of zero velocity to the next such point. The distance between those points is 32cm. Calculate the (a) period (b) frequency and (c) amplitude of the motion.

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32. If the phase angle for a block -spring system in SHM is $\pi / 8$ rad and the block's position is given by $x = x_m \cos(\omega t + \phi)$, what is the ratio of the kinetic energy to the potential energy at time t= 0?

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33. An oscillator consists of a block attached to a spring (k= 425N/m). At some time t, the position (measured from the system's equilibrium location), velocity and acceleration of the block are x= 0.100m, $v = 13.6m/s$, and $a = -123m/s^2$. Calculate (a) the frequency of oscillation, (b) the mass of the block and (c) the amplitude of the motion.

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34. An oscillating block-spring system takes 0.25s to begin repeating its motion. Find (a) the period, (b) the frequency in hertz, and (c) the angular frequency in radians per second.

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35. A particle with a mass of $3.00 \times 10^{-20} kg$ is oscillating with simple harmonic motion with a period of $2.00 \times 10^{-5} s$ and a maximum speed of $1.00 \times 10^{3} m/s$. Calculate (a) the angular frequency and (b) the maximum displacement of the particle.

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36. When the displacement in SHM is 0.40 times the amplitude x_m, what fraction of the total energy is (a) kinetic energy and (b) potential energy? (c) At what displacement, in terms of the amplitude, is the energy of the system half kinetic energy and half potential energy?

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37. A block rides on a piston (a squatcylindrical piece) that is moving vertically with simple harmonic motion. (a) If the SHM has period 1.0s, at what aplitude of motion will the block and piston separate? (b) If the piston has an amplitude of 3.0cm. What is the maximum frequency for which the block and piston will be in contact continuously ?

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38. Suppose that a simple pendulum consists of a small 60.0g bob at the end of a cord of negligible mass. If the angle θ between the cord and the vertical is given by

$\theta = (0.0800\text{rad})\cos[(6.80\text{rad}/s)t + \phi]$ what are (a) the pendulum's length and (b) its maximum kinetic energy?

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39. A block is on a horizontal surface (a shake table) that is moving back and forth horizontally with simple harmonic motion of frequency 2.0 Hz. The coefficient of static friction between block and surface is 0.45. How great can the amplitude of the

SHM be if the block is not to slip along the surface?

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Practice Questions

1. Which one of the following statement is true concerning an object executing simple harmonic motion?

A. The object's velocity is never zero

B. The object's acceleration is never zero.

C. The object's velocity and acceleration are simultaneously zero

D. The object's velocity is zero when its acceleration is a maximum.

Answer: D

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2. Resonance occurs in harmonic motion when

A. The system is overdamped

B. the system is critically damped

C. the energy in the system is a minimum

D. the driving frequency is the same as the natural frequency of the system.

Answer: D

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3. A simple pendulum has length L and period T. As it passes through its equilibrium position, the string is suddenly clamped at its midpoint. The period then becomes

A. 2T

B. T

C. $\frac{T}{2}$

D. none of these

Answer: D

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4. An object of mass m, oscillating on the end of a spring with spring constant k has amplitude A. its maximum speed is

A. $A\sqrt{k/m}$

B. A^2k/m

C. $A\sqrt{m/k}$

D. Am/k

Answer: A

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5. The velocity of a certain simple harmonic oscillator is given by $v = -(12m/s)\sin[(6.0\text{rad}/s)t]$. What is the amplitude of the simple harmonic motion?

A. 2.0m

B. 4.0m

C. 6.0m

D. 8.0m

Answer: A

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6. A 0.20kg object mass attached to a spring whose spring constant is 500N/m executes simple harmonic motion. If its maximum speed is 5.0m/s, the amplitude of its oscillation is

A. 0.0020m

B. 0.10m

C. 0.20m

D. 25m

Answer: B

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7. A ball hung from a vertical spring oscillates in simple harmonic motion with an angular frequency of 2.6 rad/s and an amplitude of 0.075m. What is the maximum acceleration of the ball?

A. $0.13m/s^2$

B. $0.20m/s^2$

C. $0.51m/s^2$

D. $2.6m/s^2$

Answer: C

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8. A 1.2kg mass is oscillating without friction on a spring whose spring constant is 3400N/m. When the mass's displacement is 7.2cm. What is its acceleration?

A. $-3.8m/s^2$

B. $-200m/s^2$

C. $-240m/s^2$

D. $-2.0\times10^4 m/s^2$

Answer: B

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9. The displacement of an object oscillating on a spring is given by $x(t)=x_m\cos(\omega t+\phi)$. If the initial displacement is zero and the initial velocity is in the negative x direction. Then the phase constant ϕ is

A. 0 rad

B. $\frac{\pi}{2}$ rad

C. π rad

D. $\frac{3\pi}{2}$ rad

Answer: B

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10. The displacement of an object oscillating on a spring is given by $x(t) = x_m \cos(\omega t + \phi)$. If the object is initially displacement in the negative x direction and given a negative initialy velocity, then the phase constant ϕ is between

A. 0 and $\frac{\pi}{2}$ rad

B. $\frac{\pi}{2}$ and π rad

C. π and $\frac{3\pi}{2}$ rad

D. $\frac{3\pi}{2}$ and 2π rad

Answer: B

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11. A 0.25kg block oscillates on the end of the spring with a spring constant of 200N/m. If the oscillation is started by elongating the spring 0.15m and giving the block a speed of 3.0m/s, then the maximum speed of the block is

A. 0.13m/s

B. 0.18m/s

C. 3.7m/s

D. 5.2m/s

Answer: D

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12. The amplitude of oscillation of a simple pendulum is increased from 1° to 4°. Its maximum acceleration changes by a factor of

A. $\frac{1}{4}$

B. $\frac{1}{2}$

C. 2

D. 4

Answer: D

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13. A particle undergoes damped harmonic motion. The spring constant is 100N/m, the damping constant is $8.0 \times 10^{-3} kgm/s$, and the mass is 0.50kg. If the particle starts at its maximum displacement, x= 1.5m at time t=0, what is the particle's position at t= 5.0s?

A. $-1.5m$

B. $-0.73m$

C. 0m

D. 0.75m

Answer: B

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14. Five particles undergo damped harmonic motion. Value for the spring constant k, the damping constantb, ad the mass m are given below. Which leads to the smallest rate of loss of mechanical energy?

A. k=100N/m, m=50g, b= 8g m/s

B. k= 150N/m, m=50g, b= 5gm/s

C. k=150N/m, m=10g,b= 8gm/s

D. k=200N/m, m=8g, b=6gm/s

Answer: B

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15. A particle is osicllating according to the equation $X = 7\cos(0.5\pi t)$, where t is in second. The point moves from the position of equilibrium to maximum displacement in time

A. 4.0s

B. 2.0s

C. 1.0s

D. 0.5s

Answer: C

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16. An archer pulls the bowstring back for a distance of 0.470m befor releasing the arrow. The bow and string act like a spring whose spring constant is 425N/m. (a) What is the elastic potential energy of the drawn bow?

A. 93.8J

B. 49.9J

C. 46.9J

D. 61.8J

Answer: C

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17. A simple pendulum is made from a 0.65m long string and a small ball attached to its free end. The ball is pulled to one side through a small angle and then released from rest. After the ball is released, how much time elaspses before it attains its greatest speed?

A. 0.40s

B. 0.10s

C. 0.80s

D. 0.20s

Answer: A

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18. The length of a simple pendulum is 0.79m and the mass of the particle (the "bob") at the end of the cable is 0.24kg. The pendulum is pulled away from its equilibrium position by an angle of 8.50° and released from rest. Assume that friction can be neglected and that the resulting oscillatory motion is simple harmonic motion. What is the angular frequency of the motion?

A. 9.1 rad/s

B. 12 rad/s

C. 8.2 rad/s

D. 3.5 rad/s

Answer: D

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19. A block is attached to a horizontal spring and oscillates back and forth on f frictionless horizontal surface at a frequency of 3.00Hz. The amplitude of the motion is $5.08 \times 10^{-2} m$. At the point where the block has its maximum speed, it suddenly splits into two identical parts, only one part remaining attached to the spring. What is the amplitude and the frequency of the simple harmonic motion that exists after the block splits?

A. $5.08 \times 10^{-2} m, 4.24 Hz$

B. $3.59 \times 10^{-2} m, 4.24 Hz$

C. $2.54 \times 10^{-2} m, 3.00 Hz$

D. $3.59 \times 10^{-2} m, 6.00 Hz$

Answer: B

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20. A copper rod (length =2.0m, radius $= 3.0 \times 10^{-3} m$) hangs down from the ceiling. A 9.0kg object is attached to the lower end of the rod. The rod acts as a "spring" and the object oscillates vertically with a small amplitude. Ignoring the rod's mass, find the frequency f of the simple harmonic motion.

A. 66Hz

B. 13Hz

C. 93Hz

D. 37Hz

Answer: A

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21. Two physical pendulums (not simple pendulums) are made from meter sticks that are suspended from the ceiling at one end. They are identical, except that one is made of wood and the other of metal. They are set into oscillation and execute simple harmonic motion. The wood and metal pendulums have masses of 0.17 and 0.85kg, respectively. Determine the period of wood pendulum.

A. 1.64s

B. 1.98s

C. 1.02s

D. 1.35s

Answer: A

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22. The position of a simple harmonic oscillator is given by $x(t) = (0.50)\cos\left(\frac{\pi}{3}t\right)$, where t is measured in seconds. What is the maximum velocity of this oscillator?

A. 0.17m/s

B. 0.52m/s

C. 0.67m/s

D. 1.0m/s

Answer: B

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23. The acceleration of a certain simple harmonic oscillator is given by $a = -(15.8m/s^2)\cos(2.51t)$. What is the amplitude of the simple harmonic mootion?

A. 2.51m

B. 4/41m

C. 6/30m

D. 11.1m

Answer: A

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24. A 1.0kg block oscillates with a frequency of 10Hz at the end of a certain spring. The spring is then cut into two halves. The 1.0kg block is then made to oscillate at the end of one of the halves. What is the frequency of oscillation of the block?

A. 5Hz

B. 10Hz

C. 14Hz

D. 20Hz

Answer: C

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25. A simple harmonic oscillator with a period of 2.0s is subject to damping so that it loses one percent of its amplitude per cycle. About how much energy does this oscillator lose per cycle?

A. 0.005

B. 0.01

C. 0.02

D. 0.03

Answer: C

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26. A pendulum is transported from sea-level, where the acceleration due to gravity g is $9.80m/s^2$, to the bottom of Death Valley. At this location, the period of the pendulum is decreased by 3.00%. What is the vaue of g in Death Valley?

A. $9.22m/s^2$

B. $9.51m/s^2$

C. $9.80m/s^2$

D. $10.4m/s^2$

Answer: D

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27. In a certain clock, a pendulum of length L_1, has a period $T_1 = 0.95s$. The length of the pendulum is adjusted is adusted to a new L_2 such that $T_2 = 1.0s$. What is the ratio L_2 / L_1?

A. 0.90

B. 0.95

C. 1.0

D. 1.1

Answer: D

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28. A simple pendulum consists of a ball of mass m suspended from the ceiling using a string of length L. The ball is displaced from its equilibrium position by a small angle θ. What is the magnitude of the restoring force that moves the toward its equilibrium position and produces simple harmonic motion?

A. kx

B. mg

C. $mg(\cos\theta)$

D. $mg(\sin\theta)$

Answer: D

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29. An iron ball hangs from a 21.5m steel cable and is used in the demolition of a building at a location where the acceleration due to gravity is $9.75m/s^2$. The ball is swung outward from its equilibrium position for a distance of 4.20m. Assuming the system behaves as a simple pendulum, find the maximum speed of the ball during its swing.

A. 4.45m/s

B. 2.83m/s

C. 17.8m/s

D. 1.71 m/s

Answer: B

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30. The motion of a particle is given by $x = A\sin\omega t + B\cos\omega t$. The motion of the particle is

A. not simple harmonic

B. simple harmonic with amplitude $A + B$

C. simple harmonic with amplitude $(A + B)/2$

D. simple harmonic with amplitude $\sqrt{A^2 + B^2}$.

Answer: D

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31. A particle executes simple harmonic motion with a frequency. (f). The frequency with which its kinetic energy oscillates is.

A. $f/2$

B. f

C. 2f

D. Zero

Answer: C

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32. A thin uniform rod of length l is pivoted at its upper end. It is free to swing in a vertical plane. Its time period for oscillation of small amplitude is

A. $2\pi\sqrt{l/g}$

B. $2\pi\sqrt{2l/3g}$

C. $2\pi\sqrt{3l/2g}$

D. $2\pi\sqrt{l/2g}$

Answer: B

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33. A particle moves on the X-axis according to the equation $x = x_0 \sin^2 \omega t$. The motion simple harmonic

A. with amplitude x_0.

B. with amplitude $2x_0$.

C. with the time period $2\pi / \omega$.

D. with the time period π / ω

Answer: D

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34. Statement 1: While crossing a bridge, soldiers are asked to break steps.

Statement 2: When natural frequency of an oscillating system equals frequency of external impulse, its amplitude of oscillating may become very high.

A. Statement 1 is true, Statement 2 is true, Statement 2 is the correct explanation of Statement 1.

B. Statement 1 is true, Statement 2 is true, Statement 2 is not correct explanation of

Statement 1

C. Statement 1 is true, Statement 2 is false

D. Statement 1 is false, Statement 2 is true

Answer: A

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35. Two springs of spring constant $6N/m$ and $4N/m$ are attached to a block of mass 1 kg and to fixed support. Then time period of the given oscillation is

(consider $\sqrt{10} = \pi$)

A. 1s

B. 2s

C. 0.5s

D. 4s

Answer: B

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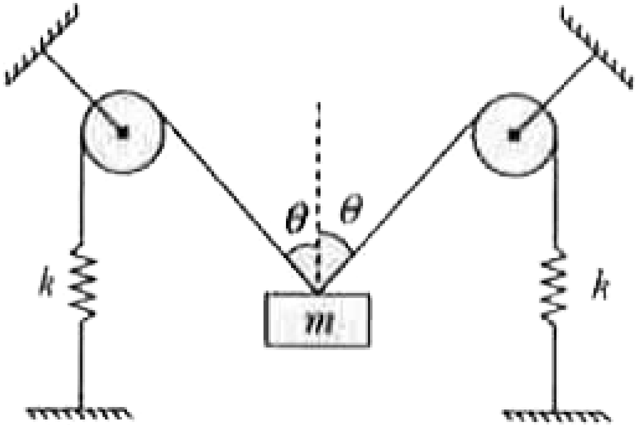
36. Time period of vertical oscillation of the block in the system in the figure is



A. $2\pi \sec\theta\sqrt{\frac{m}{2k}}$

B. $2\pi \cos\theta\sqrt{\frac{m}{2k}}$

C. $2\pi \sin\theta\sqrt{\frac{m}{2k}}$

D. $2\pi \cos ec\theta\sqrt{\frac{m}{2k}}$

Answer: A

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37. A particle moves in the xy plane according to the equation

$$\vec{r} = \left(\hat{i} + 2\hat{j}\right) A \cos \omega t$$

The motion of the particle is

A. on a straight line

B. in an ellipse

C. periodic

D. simple harmonic.

Answer: A::C::D

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38. An object is released from rest. The time it takes to fall through a distance h and the speed of the object as it falls through this distance are measured with a pendulum clock. The entire apparatus is taken on the Moon and the experiment is repeated. Then,

A. the measured times are same.

B. the measured speeds are same.

C. the actual times in the fall are equal.

D. the actual speeds are equal.

Answer: A::B

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39. Which of the following quantities are always negative in a simple harmonic motion?

A. $\overrightarrow{F} . \overrightarrow{a}$

B. $\overrightarrow{v} . \overrightarrow{r}$

C. $\overrightarrow{a} . \overrightarrow{r}$

D. $\overrightarrow{F} . \overrightarrow{r}$

Answer: C::D

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40. The amplitude of a particle executing SHM about O is $10cm$. Then

A. When the kinetic energy is 0.64 of its maximum kinetic energy, its displacement is 6 cm from point O.

B. when the displacement is 5 cm from point O, its kinetic energy is 0.75 of its maximum potential energy.

C. its total energy at any point is equal to its maximum kinetic energy.

D. its velocity is half the maximun velocity when its displacement is half the maximun displacement.

Answer: A::B::C

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41. A (hypothetical) large slingshot is stretched 2.30 m to launched a 170 g projectile with speed sufficient to escape from Earth $(11.2km/s)$. Assume the elastic bands of the slingshot obey Hooke's law.

What is the spring constant of the device if all the elastic potential energy is converted to kinetic energy?

A. $4.03 \times 10^6 N/m$

B. $2.02 \times 10^6 N/m$

C. $8.06 \times 10^6 N/m$

D. $6.09 \times 10^6 N/m$

Answer: A

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42. A (hypothetical) large slingshot is stretched 2.30 m to launched a 170 g projectile with speed sufficient to escape from Earth $(11.2km/s)$. Assume the elastic bands of the slingshot obey Hooke's law.

Assume that an average person can be exert a force of 490 N. How many people are required to stretch the elastic bands?

A. 9.5×10^3

B. 1.89×10^4

C. 3.78×10^4

D. 2.85×10^4

Answer: B

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43. A 2.0 - kg block executes SHM while attached to a horizontal spring of spring constant $200N/m$. The maximum speed of the block as it slides on a horizontal frictionless surface is $3.0m/s$. What is the amplitude of the block's motion?

A. 0.15 m

B. 0.45 m

C. 0.30 m

D. 0.60 m

Answer: C

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44. A 2.0 - kg block executes SHM while attached to a horizontal spring of spring constant $200N/m$. The maximum speed of the block as it slides on a horizontal frictionless surface is $3.0m/s$.

What is the magnitude of its maximum and minimum accelerations?

A. $30m/s^2, 15m/s^2$

B. $30m/s^2, 5m/s^2$

C. $15m/s^2, 0m/s^2$

D. $30m/s^2, 0m/s^2$

Answer: D

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45. A 2.0 - kg block executes SHM while attached to a horizontal spring of spring constant $200N/m.$ The maximum speed of the block as it slides on a horizontal frictionless surface is $3.0m/s.$

How long does the block take to complete 7.0 cycles of its motion?

A. 4.0 s

B. 4.4 s

C. 3.8 s

D. 3.5 s

Answer: B

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46. A block weighing 10.0 N is attached to the lower end of a verticle spring $(k = 200.0 N / m)$, the other end of which is attached to a ceiling. The block oscillates vertically and has a kinetic energy of 2.00 J as it passes through the point at which the spring is unstretched.

What is the period of the oscillation?

A. 0.45 s

B. 0.90 s

C. 0.15 s

D. 0.303 s

Answer: A

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47. A block weighing 10.0 N is attached to the lower end of a verticle spring $(k = 200.0N/m)$, the other end of which is attached to a ceiling. The block oscillates vertically and has a kinetic energy of 2.00 J as it passes through the point at which the spring is unstretched.

Use the law of conservation of energy to determine the maximum distance the block moves both above and below the point at which the spring is unstretched (these are not necessarily the same)

A. 0.05 m and 0.25 m

B. 0.1. m and 0.20 m

C. 0.15 m and 0.15 m

D. 0.13 m and 0.17 m

Answer: B

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48. A block weighing 10.0 N is attached to the lower end of a verticle spring $(k = 200.0N/m)$, the other end of which is attached to a ceiling. The block oscillates vertically and has a kinetic energy of 2.00 J as it passes through the point at which the spring is unstretched.

What is the amplitude of the oscillation and the maximum kinetic energy of the block as it oscillates?

A. 0.20 m and 4.50 J

B. 0.30 m and 3.35 J

C. 0.25 m and 3.25 J

D. 0.15 m and 2.25 J

Answer: D

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49. Match the statement in Column I with the statements in Column II. One or more than one choice from ColumnII can match with a statement from Column I.

Column I	Column II
(a) Velocity–displacement graph	(p) Straight line
(b) Acceleration–velocity graph	(q) Circle
(c) Acceleration–displacement	(r) Ellipse
(d) Acceleration–time graph	(s) Sine curve
	(t) Cosine curve

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50. In the given table, Column I gives type of motion, Column II gives the path traced and Column III gives other characteristic of the motion.

Column I	Column II	Column III
(I) Back and forth type of motion	(i) along a circular path	(J) after regular intervals of time
(II) A body or a moving particle that changes its motion	(ii) restoring force is proportional to displacement from the mean position	(K) does not oppose the increase in motion
(III) A body or a moving particle that repeats its motion	(iii) need not be periodic	(L) need not have fixed extreme positions
(IV) Motion in which	(iv) along a definite path	(M) opposes the increase in motion

Choose the combination that defines the characteristics of periodic motion.

A. (III) (ii) (L)

B. (III) (iv) (J)

C. (II) (i) (M)

D. (II) (i) (K)

Answer: B

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51. In the given table, Column I gives type of motion, Column II gives the path traced and Column III gives other characteristic of the motion.

Column I	Column II	Column III
(I) Back and forth type of motion	(i) along a circular path	(J) after regular intervals of time
(II) A body or a moving particle that changes its motion	(ii) restoring force is proportional to displacement from the mean position	(K) does not oppose the increase in motion
(III) A body or a moving particle that repeats its motion	(iii) need not be periodic	(L) need not have fixed extreme positions
(IV) Motion in which	(iv) along a definite path	(M) opposes the increase in motion

Choose the combination that defines the characteristics of simple harmonic motion.

A. (I) (iii)(K)

B. (IV) (iii) (J)

C. (II) (iii) (M)

D. (I) (iii) (L)

Answer: D

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52. In the given table, Column I gives type of motion, Column II gives the path traced and Column III gives other characteristic of the motion.

Column I	Column II	Column III
(I) Back and forth type of motion	(i) along a circular path	(J) after regular intervals of time
(II) A body or a moving particle that changes its motion	(ii) restoring force is proportional to displacement from the mean position	(K) does not oppose the increase in motion

Column I	Column II	Column III
(III) A body or a moving particle that repeats its motion	(iii) need not be periodic	(L) need not have fixed extreme positions
(IV) Motion in which	(iv) along a definite path	(M) opposes the increase in motion

Choose the combination that defines the characteristics of simple harmonic motion.

A. (III) (i) (K)

B. (I) (i) (L)

C. (IV) (ii) (M)

D. (I) (iv) (L)

Answer: C

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53. In the given table, Column I gives type of oscillation, Column II gives change in amplitude of oscillation and Column III gives examples of these types of oscillation.

Column I	Column II	Column III
(I) Oscillation of a particle with fundamental frequency under the influence of restoring force	(i) Amplitude of oscillation decreases due to damping forces but on account of the energy gained from the external source it remains constant.	(J) Balancing wheel of watch.
(II) Oscillation in which a body oscillates under the influence of an external periodic force.	(ii) Amplitude of oscillation remains constant.	(K) Shock absorbers in automobiles.
(III) Oscillation of a body whose amplitude goes on decreasing with time.	(iii) Amplitude of oscillation keeps increasing.	(L) Flicking a wine glass.
(IV) The oscillation in which the loss of oscillator is compensated by the supplying energy from an external source.	(iv) Amplitude of oscillation decreases exponentially due to damping forces like frictional force, viscous force, and hysteresis.	(M) Striking a tuning fork.

The combination that defines the features of damped oscillation is

A. (I) (iii) (L)

B. (IV) (i) (M)

C. (II) (iv) (K)

D. (III) (iv) (K)

Answer: D

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54. In the given table, Column I gives type of oscillation, Column II gives change in amplitude of oscillation and Column III gives examples of these types of oscillation.

Column I	Column II	Column III
(I) Oscillation of a particle with fundamental frequency under the influence of restoring force	(i) Amplitude of oscillation decreases due to damping forces but on account of the energy gained from the external source it remains constant.	(J) Balancing wheel of watch.
(II) Oscillation in which a body oscillates under the influence of an external periodic force.	(ii) Amplitude of oscillation remains constant.	(K) Shock absorbers in automobiles.
(III) Oscillation of a body whose amplitude goes on decreasing with time.	(iii) Amplitude of oscillation keeps increasing.	(L) Flicking a wine glass.
(IV) The oscillation in which the loss of oscillator is compensated by the supplying energy from an external source.	(iv) Amplitude of oscillation decreases exponentially due to damping forces like frictional force, viscous force, and hysteresis.	(M) Striking a tuning fork.

The combination that defines the features of forced oscillation is

A. (III) (ii) (L)

B. (II) (i) (L)

C. (II) (iii) (K)

D. (I) (i) (M)

Answer: B

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55. In the given table, Column I gives type of oscillation, Column II gives change in amplitude of oscillation and Column III gives examples of these types of oscillation.

Column I	Column II	Column III
(I) Oscillation of a particle with fundamental frequency under the influence of restoring force	(i) Amplitude of oscillation decreases due to damping forces but on account of the energy gained from the external source it remains constant.	(J) Balancing wheel of watch.
(II) Oscillation in which a body oscillates under the influence of an external periodic force.	(ii) Amplitude of oscillation remains constant.	(K) Shock absorbers in automobiles.
(III) Oscillation of a body whose amplitude goes on decreasing with time.	(iii) Amplitude of oscillation keeps increasing.	(L) Flicking a wine glass.
(IV) The oscillation in which the loss of oscillator is compensated by the supplying energy from an external source.	(iv) Amplitude of oscillation decreases exponentially due to damping forces like frictional force, viscous force, and hysteresis.	(M) Striking a tuning fork.

The combination that defines the features of free oscillation is

A. (I) (ii) (M)

B. (I) (i) (K)

C. (III) (iii) (L)

D. (I) (ii) (L)

Answer: A

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56. When a 20 N can is hung from the bottom of a vertical spring, it causes the spring to stretch 20 cm. The spring is now placed horizontal on a frictionless table. One end of it is held fixed, and the other end is attached to a 5.0 N can. The can is then moved (stretching the spring) and released from rest. What is the period $\left(\text{in} \times 10^{-2} s\right)$ of the resulting oscillation?

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57. An engineer has odd-shaped 10 kg object needs to find its rotational inertia about an axis through its center of mass. The object is supported on a wire stretched along the desired axis. The wire has a torsion constant $k = 0.50N.\,m$. If this torsion pendulum oscillates through 20 cycles in 50 s, what is the rotational inertia $(\text{in}10^{-2}kgm^2)$ of the object?

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