

Chapter 15: OSCILLATIONS

- In simple harmonic motion, the restoring force must be proportional to the:
 - amplitude
 - frequency
 - velocity
 - displacement
 - displacement squaredans: D
- An oscillatory motion must be simple harmonic if:
 - the amplitude is small
 - the potential energy is equal to the kinetic energy
 - the motion is along the arc of a circle
 - the acceleration varies sinusoidally with time
 - the derivative, dU/dx , of the potential energy is negativeans: D
- In simple harmonic motion, the magnitude of the acceleration is:
 - constant
 - proportional to the displacement
 - inversely proportional to the displacement
 - greatest when the velocity is greatest
 - never greater than gans: B
- A particle is in simple harmonic motion with period T . At time $t = 0$ it is at the equilibrium point. Of the following times, at which time is it furthest from the equilibrium point?
 - $0.5T$
 - $0.7T$
 - T
 - $1.4T$
 - $1.5T$ans: B
- A particle moves back and forth along the x axis from $x = -x_m$ to $x = +x_m$, in simple harmonic motion with period T . At time $t = 0$ it is at $x = +x_m$. When $t = 0.75T$:
 - it is at $x = 0$ and is traveling toward $x = +x_m$
 - it is at $x = 0$ and is traveling toward $x = -x_m$
 - it at $x = +x_m$ and is at rest
 - it is between $x = 0$ and $x = +x_m$ and is traveling toward $x = -x_m$
 - it is between $x = 0$ and $x = -x_m$ and is traveling toward $x = -x_m$ans: A

6. A particle oscillating in simple harmonic motion is:
- A. never in equilibrium because it is in motion
 - B. never in equilibrium because there is always a force
 - C. in equilibrium at the ends of its path because its velocity is zero there
 - D. in equilibrium at the center of its path because the acceleration is zero there
 - E. in equilibrium at the ends of its path because the acceleration is zero there
- ans: D
7. An object is undergoing simple harmonic motion. Throughout a complete cycle it:
- A. has constant speed
 - B. has varying amplitude
 - C. has varying period
 - D. has varying acceleration
 - E. has varying mass
- ans: D
8. When a body executes simple harmonic motion, its acceleration at the ends of its path must be:
- A. zero
 - B. less than g
 - C. more than g
 - D. suddenly changing in sign
 - E. none of these
- ans: E
9. A particle is in simple harmonic motion with period T . At time $t = 0$ it is halfway between the equilibrium point and an end point of its motion, traveling toward the end point. The next time it is at the same place is:
- A. $t = T$
 - B. $t = T/2$
 - C. $t = T/4$
 - D. $t = T/8$
 - E. none of the above
- ans: E
10. An object attached to one end of a spring makes 20 complete oscillations in 10 s. Its period is:
- A. 2 Hz
 - B. 10 s
 - C. 0.5 Hz
 - D. 2 s
 - E. 0.50 s
- ans: E

11. An object attached to one end of a spring makes 20 vibrations in 10 s. Its frequency is:
- A. 2 Hz
 - B. 10 s
 - C. 0.05 Hz
 - D. 2 s
 - E. 0.50 s
- ans: A
12. An object attached to one end of a spring makes 20 vibrations in 10 s. Its angular frequency is:
- A. 0.79 rad/s
 - B. 1.57 rad/s
 - C. 2.0 rad/s
 - D. 6.3 rad/s
 - E. 12.6 rad/s
- ans: E
13. Frequency f and angular frequency ω are related by
- A. $f = \pi\omega$
 - B. $f = 2\pi\omega$
 - C. $f = \omega/\pi$
 - D. $f = \omega/2\pi$
 - E. $f = 2\omega/\pi$
- ans: D
14. A block attached to a spring oscillates in simple harmonic motion along the x axis. The limits of its motion are $x = 10$ cm and $x = 50$ cm and it goes from one of these extremes to the other in 0.25 s. Its amplitude and frequency are:
- A. 40 cm, 2 Hz
 - B. 20 cm, 4 Hz
 - C. 40 cm, 2 Hz
 - D. 25 cm, 4 Hz
 - E. 20 cm, 2 Hz
- ans: B
15. A weight suspended from an ideal spring oscillates up and down with a period T . If the amplitude of the oscillation is doubled, the period will be:
- A. T
 - D. $1.5T$
 - B. $2T$
 - C. $T/2$
 - E. $4T$
- ans: A

16. In simple harmonic motion, the magnitude of the acceleration is greatest when:
- A. the displacement is zero
 - B. the displacement is maximum
 - C. the speed is maximum
 - D. the force is zero
 - E. the speed is between zero and its maximum
- ans: B
17. In simple harmonic motion, the displacement is maximum when the:
- A. acceleration is zero
 - B. velocity is maximum
 - C. velocity is zero
 - D. kinetic energy is maximum
 - E. momentum is maximum
- ans: C
18. In simple harmonic motion:
- A. the acceleration is greatest at the maximum displacement
 - B. the velocity is greatest at the maximum displacement
 - C. the period depends on the amplitude
 - D. the acceleration is constant
 - E. the acceleration is greatest at zero displacement
- ans: A
19. The amplitude and phase constant of an oscillator are determined by:
- A. the frequency
 - B. the angular frequency
 - C. the initial displacement alone
 - D. the initial velocity alone
 - E. both the initial displacement and velocity
- ans: E
20. Two identical undamped oscillators have the same amplitude of oscillation only if:
- A. they are started with the same displacement x_0
 - B. they are started with the same velocity v_0
 - C. they are started with the same phase
 - D. they are started so the combination $\omega^2 x_0^2 + v_0^2$ is the same
 - E. they are started so the combination $x_0^2 + \omega^2 v_0^2$ is the same
- ans: D
21. The amplitude of any oscillator can be doubled by:
- A. doubling only the initial displacement
 - B. doubling only the initial speed
 - C. doubling the initial displacement and halving the initial speed
 - D. doubling the initial speed and halving the initial displacement
 - E. doubling both the initial displacement and the initial speed
- ans: E

22. It is impossible for two particles, each executing simple harmonic motion, to remain in phase with each other if they have different:
- A. masses
 - B. periods
 - C. amplitudes
 - D. spring constants
 - E. kinetic energies
- ans: B
23. The acceleration of a body executing simple harmonic motion leads the velocity by what phase?
- A. 0
 - B. $\pi/8$ rad
 - C. $\pi/4$ rad
 - D. $\pi/2$ rad
 - E. π rad
- ans: D
24. 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
 - B. $\pi/2$ rad
 - C. π rad
 - D. $3\pi/2$ rad
 - E. 2π rad
- ans: B
25. 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 displaced in the negative x direction and given a negative initial velocity, then the phase constant ϕ is between:
- A. 0 and $\pi/2$ rad
 - B. $\pi/2$ and π rad
 - C. π and $3\pi/2$ rad
 - D. $3\pi/2$ and 2π rad
 - E. none of the above (ϕ is exactly 0, $\pi/2$, π , or $3\pi/2$ rad)
- ans: B
26. A certain spring elongates 9.0 mm when it is suspended vertically and a block of mass M is hung on it. The natural angular frequency of this block-spring system:
- A. is 0.088 rad/s
 - B. is 33 rad/s
 - C. is 200 rad/s
 - D. is 1140 rad/s
 - E. cannot be computed unless the value of M is given
- ans: B

27. 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
 E. A^2m/k

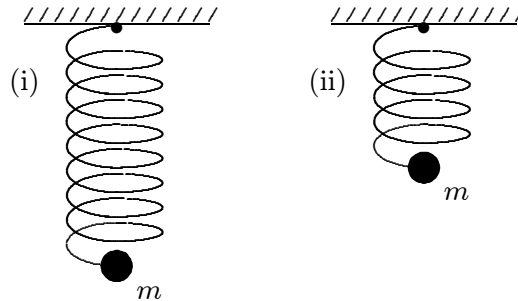
ans: A

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

A. 0.0020 m
 B. 0.10 m
 C. 0.20 m
 D. 25 m
 E. 250 m

ans: B

29. A simple harmonic oscillator consists of a particle of mass m and an ideal spring with spring constant k . Particle oscillates as shown in (i) with period T . If the spring is cut in half and used with the same particle, as shown in (ii), the period will be:



A. $2T$
 B. $\sqrt{2}T$
 C. $T/\sqrt{2}$
 D. T
 E. $T/2$

ans: C

30. A particle moves in simple harmonic motion according to $x = 2 \cos(50t)$, where x is in meters and t is in seconds. Its maximum velocity in m/s is:

A. $100 \sin(50t)$
 B. $100 \cos(50t)$
 C. 100
 D. 200
 E. none of these

ans: C

31. A 3-kg block, attached to a spring, executes simple harmonic motion according to $x = 2 \cos(50t)$ where x is in meters and t is in seconds. The spring constant of the spring is:
- 1 N/m
 - 100 N/m
 - 150 N/m
 - 7500 N/m
 - none of these
- ans: D
32. Let U be the potential energy (with the zero at zero displacement) and K be the kinetic energy of a simple harmonic oscillator. U_{avg} and K_{avg} are the average values over a cycle. Then:
- $K_{\text{avg}} > U_{\text{avg}}$
 - $K_{\text{avg}} < U_{\text{avg}}$
 - $K_{\text{avg}} = U_{\text{avg}}$
 - $K = 0$ when $U = 0$
 - $K + U = 0$
- ans: C
33. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m . At one point in its motion its kinetic energy is $K = 5 \text{ J}$ and its potential energy (measured with $U = 0$ at $x = 0$) is $U = 3 \text{ J}$. When it is at $x = x_m$, the kinetic and potential energies are:
- $K = 5 \text{ J}$ and $U = 3 \text{ J}$
 - $K = 5 \text{ J}$ and $U = -3 \text{ J}$
 - $K = 8 \text{ J}$ and $U = 0$
 - $K = 0$ and $U = 8 \text{ J}$
 - $K = 0$ and $U = -8 \text{ J}$
- ans: D
34. A particle is in simple harmonic motion along the x axis. The amplitude of the motion is x_m . When it is at $x = x_1$, its kinetic energy is $K = 5 \text{ J}$ and its potential energy (measured with $U = 0$ at $x = 0$) is $U = 3 \text{ J}$. When it is at $x = -\frac{1}{2}x_1$, the kinetic and potential energies are:
- $K = 5 \text{ J}$ and $U = 3 \text{ J}$
 - $K = 5 \text{ J}$ and $U = -3 \text{ J}$
 - $K = 8 \text{ J}$ and $U = 0$
 - $K = 0$ and $U = 8 \text{ J}$
 - $K = 0$ and $U = -8 \text{ J}$
- ans: A
35. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the system has an energy of 6.0 J, then the amplitude of the oscillation is:
- 0.06 m
 - 0.17 m
 - 0.24 m
 - 4.9 m
 - 6.9 m
- ans: C

36. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the system has an energy of 6.0 J, then the maximum speed of the block is:
- A. 0.06 m/s
 - B. 0.17 m/s
 - C. 0.24 m/s
 - D. 4.9 m/s
 - E. 6.9 m/s
- ans: E
37. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3.0 m/s, then the maximum speed of the block is:
- A. 0.13 m/s
 - B. 0.18 m/s
 - C. 3.7 m/s
 - D. 5.2 m/s
 - E. 13 m/s
- ans: D
38. A 0.25-kg block oscillates on the end of the spring with a spring constant of 200 N/m. If the oscillation is started by elongating the spring 0.15 m and giving the block a speed of 3.0 m/s, then the amplitude of the oscillation is:
- A. 0.13 m
 - B. 0.18 m
 - C. 3.7 m
 - D. 5.2 m
 - E. 13 m
- ans: B
39. An object on the end of a spring is set into oscillation by giving it an initial velocity while it is at its equilibrium position. In the first trial the initial velocity is v_0 and in the second it is $4v_0$. In the second trial:
- A. the amplitude is half as great and the maximum acceleration is twice as great
 - B. the amplitude is twice as great and the maximum acceleration is half as great
 - C. both the amplitude and the maximum acceleration are twice as great
 - D. both the amplitude and the maximum acceleration are four times as great
 - E. the amplitude is four times as great and the maximum acceleration is twice as great
- ans: C
40. A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. Its total energy is 50 J. When the displacement is half the amplitude, the kinetic energy is:
- A. zero
 - B. 12.5 J
 - C. 25 J
 - D. 37.5 J
 - E. 50 J
- ans: D

41. A mass-spring system is oscillating with amplitude A . The kinetic energy will equal the potential energy only when the displacement is:
- A. zero
 - B. $\pm A/4$
 - C. $\pm A/\sqrt{2}$
 - D. $\pm A/2$
 - E. anywhere between $-A$ and $+A$
- ans: C
42. If the length of a simple pendulum is doubled, its period will:
- A. halve
 - B. be greater by a factor of $\sqrt{2}$
 - C. be less by a factor of $\sqrt{2}$
 - D. double
 - E. remain the same
- ans: B
43. The period of a simple pendulum is 1 s on Earth. When brought to a planet where g is one-tenth that on Earth, its period becomes:
- A. 1 s
 - B. $1/\sqrt{10}$ s
 - C. $1/10$ s
 - D. $\sqrt{10}$ s
 - E. 10 s
- ans: D
44. The amplitude of oscillation of a simple pendulum is increased from 1° to 4° . Its maximum acceleration changes by a factor of:
- A. $1/4$
 - B. $1/2$
 - C. 2
 - D. 4
 - E. 16
- ans: D
45. A simple pendulum of length L and mass M has frequency f . To increase its frequency to $2f$:
- A. increase its length to $4L$
 - B. increase its length to $2L$
 - C. decrease its length to $L/2$
 - D. decrease its length to $L/4$
 - E. decrease its mass to $< M/4$
- ans: D

46. A simple pendulum consists of a small ball tied to a string and set in oscillation. As the pendulum swings the tension force of the string is:
- constant
 - a sinusoidal function of time
 - the square of a sinusoidal function of time
 - the reciprocal of a sinusoidal function of time
 - none of the above
- ans: E
47. 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:
- $2T$
 - T
 - $T/2$
 - $T/4$
 - none of these
- ans: E
48. A simple pendulum is suspended from the ceiling of an elevator. The elevator is accelerating upwards with acceleration a . The period of this pendulum, in terms of its length L , g , and a is:
- $2\pi\sqrt{L/g}$
 - $2\pi\sqrt{L/(g+a)}$
 - $2\pi\sqrt{L/(g-a)}$
 - $2\pi\sqrt{L/a}$
 - $(1/2\pi)\sqrt{g/L}$
- ans: B
49. Three physical pendulums, with masses m_1 , $m_2 = 2m_1$, and $m_3 = 3m_1$, have the same shape and size and are suspended at the same point. Rank them according to their periods, from shortest to longest.
- 1, 2, 3
 - 3, 2, 1
 - 2, 3, 1
 - 2, 1, 3
 - All the same
- ans: E

50. Five hoops are each pivoted at a point on the rim and allowed to swing as physical pendulums. The masses and radii are

hoop 1: $M = 150$ g and $R = 50$ cm

hoop 2: $M = 200$ g and $R = 40$ cm

hoop 3: $M = 250$ g and $R = 30$ cm

hoop 4: $M = 300$ g and $R = 20$ cm

hoop 5: $M = 350$ g and $R = 10$ cm

Order the hoops according to the periods of their motions, smallest to largest.

A. 1, 2, 3, 4, 5

B. 5, 4, 3, 2, 1

C. 1, 2, 3, 5, 4

D. 1, 2, 5, 4, 3

E. 5, 4, 1, 2, 3

ans: B

51. A meter stick is pivoted at a point a distance a from its center and swings as a physical pendulum. Of the following values for a , which results in the shortest period of oscillation?

A. $a = 0.1$ m

B. $a = 0.2$ m

C. $a = 0.3$ m

D. $a = 0.4$ m

E. $a = 0.5$ m

ans: C

52. The rotational inertia of a uniform thin rod about its end is $ML^2/3$, where M is the mass and L is the length. Such a rod is hung vertically from one end and set into small amplitude oscillation. If $L = 1.0$ m this rod will have the same period as a simple pendulum of length:

A. 33 cm

B. 50 cm

C. 67 cm

D. 100 cm

E. 150 cm

ans: C

53. Two uniform spheres are pivoted on horizontal axes that are tangent to their surfaces. The one with the longer period of oscillation is the one with:

A. the larger mass

B. the smaller mass

C. the larger rotational inertia

D. the smaller rotational inertia

E. the larger radius

ans: E

54. The x and y coordinates of a point each execute simple harmonic motion. The result might be a circular orbit if:
- A. the amplitudes are the same but the frequencies are different
 - B. the amplitudes and frequencies are both the same
 - C. the amplitudes and frequencies are both different
 - D. the phase constants are the same but the amplitudes are different
 - E. the amplitudes and the phase constants are both different
- ans: B
55. The x and y coordinates of a point each execute simple harmonic motion. The frequencies are the same but the amplitudes are different. The resulting orbit might be:
- A. an ellipse
 - B. a circle
 - C. a parabola
 - D. a hyperbola
 - E. a square
- ans: A
56. For an oscillator subjected to a damping force proportional to its velocity:
- A. the displacement is a sinusoidal function of time.
 - B. the velocity is a sinusoidal function of time.
 - C. the frequency is a decreasing function of time.
 - D. the mechanical energy is constant.
 - E. none of the above is true.
- ans: E
57. Five particles undergo damped harmonic motion. Values for the spring constant k , the damping constant b , and the mass m are given below. Which leads to the smallest rate of loss of mechanical energy?
- A. $k = 100 \text{ N/m}$, $m = 50 \text{ g}$, $b = 8 \text{ g/s}$
 - B. $k = 150 \text{ N/m}$, $m = 50 \text{ g}$, $b = 5 \text{ g/s}$
 - C. $k = 150 \text{ N/m}$, $m = 10 \text{ g}$, $b = 8 \text{ g/s}$
 - D. $k = 200 \text{ N/m}$, $m = 8 \text{ g}$, $b = 6 \text{ g/s}$
 - E. $k = 100 \text{ N/m}$, $m = 2 \text{ g}$, $b = 4 \text{ g/s}$
- ans: B
58. A sinusoidal force with a given amplitude is applied to an oscillator. To maintain the largest amplitude oscillation the frequency of the applied force should be:
- A. half the natural frequency of the oscillator
 - B. the same as the natural frequency of the oscillator
 - C. twice the natural frequency of the oscillator
 - D. unrelated to the natural frequency of the oscillator
 - E. determined from the maximum speed desired
- ans: B

59. A sinusoidal force with a given amplitude is applied to an oscillator. At resonance the amplitude of the oscillation is limited by:
- A. the damping force
 - B. the initial amplitude
 - C. the initial velocity
 - D. the force of gravity
 - E. none of the above

ans: A

60. An oscillator is subjected to a damping force that is proportional to its velocity. A sinusoidal force is applied to it. After a long time:
- A. its amplitude is an increasing function of time
 - B. its amplitude is a decreasing function of time
 - C. its amplitude is constant
 - D. its amplitude is a decreasing function of time only if the damping constant is large
 - E. its amplitude increases over some portions of a cycle and decreases over other portions

ans: C

61. A block on a spring is subjected to a damping force that is proportional to its velocity and to an applied sinusoidal force. The energy dissipated by damping is supplied by:
- A. the potential energy of the spring
 - B. the kinetic energy of the mass
 - C. gravity
 - D. friction
 - E. the applied force

ans: E

62. The table below gives the values of the spring constant k , damping constant b , and mass m for a particle in damped harmonic motion. Which of these takes the longest time for its mechanical energy to decrease to one-fourth of its initial value?

	k	b	m
A	k_0	b_0	m_0
B	$3k_0$	$2b_0$	m_0
C	$k_0/2$	$6b_0$	$2m_0$
D	$4k_0$	b_0	$2m_0$
E	k_0	b_0	$10m_0$

ans: E