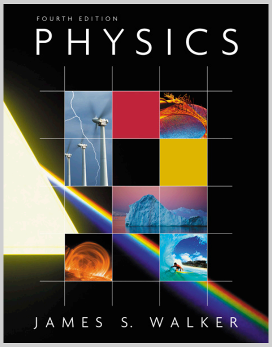


ConcepTest Clicker Questions

Chapter 13

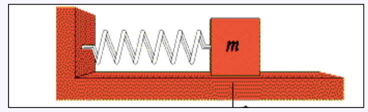
Physics, 4th Edition

James S. Walker

Question 13.1a Harmonic Motion I

A mass on a spring in SHM has amplitude *A* and period *T*. What is the total distance traveled by the mass after a time interval *T*?

a) 0
b) *A*/2
c) *A*
d) 2*A*
e) 4*A*



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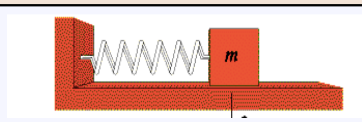


In the time interval *T* (the period), the mass goes through one complete oscillation back to the starting point. The distance it covers is *A* + *A* + *A* + *A* (4*A*).

Question 13.1b Harmonic Motion II

A mass on a spring in SHM has amplitude *A* and period *T*. What is the net displacement of the mass after a time interval *T*?

a) 0
b) *A*/2
c) *A*
d) 2*A*
e) 4*A*

Question 13.1b Harmonic Motion II

A mass on a spring in SHM has amplitude *A* and period *T*. What is the net displacement of the mass after a time interval *T*?

a) 0
b) *A*/2
c) *A*
d) 2*A*
e) 4*A*

The displacement is $\Delta x = x_2 - x_1$. Because the initial and final positions of the mass are the same (it ends up back at its original position), then the displacement is zero.

Follow-up: What is the net displacement after a half of a period?

Question 13.1c Harmonic Motion III

A mass on a spring in SHM has amplitude *A* and period *T*. How long does it take for the mass to travel a total distance of 6*A* ?

a) ½*T*
b) ¾*T*
c) 1¼*T*
d) 1½*T*
e) 2*T*

Question 13.1c Harmonic Motion III

A mass on a spring in SHM has amplitude A and period T. How long does it take for the mass to travel a total distance of $6A$?

a) ½T
b) ¾T
c) 1¼T
d) 1½T
e) 2T

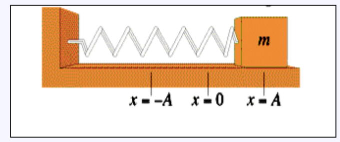
We have already seen that it takes one period T to travel a total distance of $4A$. An additional $2A$ requires half a period, so the total time needed for a total distance of $6A$ is $1\frac{1}{2}T$.

Follow-up: What is the net displacement at this particular time?

Question 13.2 Speed and Acceleration

A mass on a spring in SHM has amplitude A and period T. At what point in the motion is $v = 0$ and $a = 0$ simultaneously?

a) $x = A$
b) $x > 0$ but $x < A$
c) $x = 0$
d) $x < 0$
e) none of the above

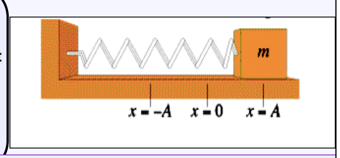


Question 13.2 Speed and Acceleration

A mass on a spring in SHM has amplitude A and period T. At what point in the motion is $v = 0$ and $a = 0$ simultaneously?

a) $x = A$
b) $x > 0$ but $x < A$
c) $x = 0$
d) $x < 0$
e) none of the above

If both v and a were zero at the same time, the mass would be at rest and stay at rest! Thus, there is *NO point* at which both v and a are both zero at the same time.



Follow-up: Where is acceleration a maximum?

Question 13.3a Spring Combination I

A spring can be stretched a distance of 60 cm with an applied force of 1 N. If an identical spring is connected in parallel with the first spring, and both are pulled together, how much force will be required to stretch this parallel combination a distance of 60 cm?

a) ¼ N
b) ½ N
c) 1 N
d) 2 N
e) 4 N

Question 13.3a Spring Combination I

A spring can be stretched a distance of 60 cm with an applied force of 1 N. If an identical spring is connected in parallel with the first spring, and both are pulled together, how much force will be required to stretch this parallel combination a distance of 60 cm?

a) ¼ N
b) ½ N
c) 1 N
d) 2 N
e) 4 N

Each spring is still stretched 60 cm, so each spring requires 1 N of force. But because there are two springs, there must be a total of 2 N of force! Thus, the combination of two parallel springs behaves like a stronger spring!!

Question 13.3b Spring Combination II

A spring can be stretched a distance of 60 cm with an applied force of 1 N. If an identical spring is connected in series with the first spring, how much force will be required to stretch this series combination a distance of 60 cm?

a) ¼ N
b) ½ N
c) 1 N
d) 2 N
e) 4 N

Question 13.3b Spring Combination II

A spring can be stretched a distance of 60 cm with an applied force of 1 *N*. If an identical spring is connected in series with the first spring, how much force will be required to stretch this series combination a distance of 60 cm?

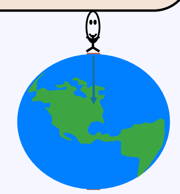
a) ¼ *N*
b) ½ *N*
c) 1 *N*
d) 2 *N*
e) 4 *N*

Here, the springs are in series, so each spring is only stretched 30 cm, and only half the force is needed. But also, because the springs are in a row, the force applied to one spring is transmitted to the other spring (like tension in a rope). So the overall applied force of $\frac{1}{2}$ *N* is all that is needed. The combination of two springs in series behaves like a weaker spring!!

Question 13.4 To the Center of the Earth

A hole is drilled through the center of Earth and emerges on the other side. You jump into the hole. What happens to you ?

a) you fall to the center and stop
b) you go all the way through and continue off into space
c) you fall to the other side of Earth and then return
d) you won't fall at all

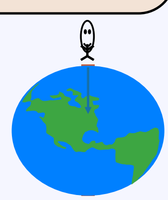


Question 13.4 To the Center of the Earth

A hole is drilled through the center of Earth and emerges on the other side. You jump into the hole. What happens to you ?

a) you fall to the center and stop
b) you go all the way through and continue off into space
c) you fall to the other side of Earth and then return
d) you won't fall at all

You fall through the hole. When you reach the center, you keep going because of your inertia. When you reach the other side gravity pulls you back toward the center. This is Simple Harmonic Motion!



Follow-up: Where is your acceleration zero?

Question 13.5a Energy in SHM I

A mass oscillates in simple harmonic motion with amplitude A. If the mass is doubled, but the amplitude is not changed, what will happen to the total energy of the system?

a) total energy will increase
b) total energy will not change
c) total energy will decrease

Question 13.5a Energy in SHM I

A mass oscillates in simple harmonic motion with amplitude A. If the mass is doubled, but the amplitude is not changed, what will happen to the total energy of the system?

a) total energy will increase
b) total energy will not change
c) total energy will decrease

The total energy is equal to the initial value of the elastic potential energy, which is $PE_s = \frac{1}{2}kA^2$. This does not depend on mass, so a change in mass will not affect the energy of the system.

Follow-up: What happens if you double the amplitude?

Question 13.5b Energy in SHM II

If the amplitude of a simple harmonic oscillator is doubled, which of the following quantities will change the most?

a) frequency
b) period
c) maximum speed
d) maximum acceleration
e) total mechanical energy

Question 13.5b Energy in SHM II

If the amplitude of a simple harmonic oscillator is doubled, which of the following quantities will change the most?

a) frequency
b) period
c) maximum speed
d) maximum acceleration
e) total mechanical energy

Frequency and period do not depend on amplitude at all, so they will not change. Maximum acceleration and maximum speed do depend on amplitude, and both of these quantities will double. (You should think about why this is so.) The total energy equals the initial potential energy, which depends on the square of the amplitude, so that will quadruple.

Follow-up: Why do maximum acceleration and speed double?

Question 13.6a Period of a Spring I

A glider with a spring attached to each end oscillates with a certain period. If the mass of the glider is doubled, what will happen to the period?

a) period will increase
b) period will not change
c) period will decrease

Question 13.6a Period of a Spring I

A glider with a spring attached to each end oscillates with a certain period. If the mass of the glider is doubled, what will happen to the period?

a) period will increase
b) period will not change
c) period will decrease

The period is proportional to the square root of the mass. So an increase in mass will lead to an increase in the period of motion.

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

Follow-up: What happens if the amplitude is doubled?

Question 13.6b Period of a Spring II

A glider with a spring attached to each end oscillates with a certain period. If identical springs are added in parallel to the original glider, what will happen to the period?

a) period will increase
b) period will not change
c) period will decrease

Question 13.6b Period of a Spring II

A glider with a spring attached to each end oscillates with a certain period. If identical springs are added in parallel to the original glider, what will happen to the period?

a) period will increase
b) period will not change
c) period will decrease

We saw in the last section that two springs in parallel act like a stronger spring. So the spring constant has been effectively increased, and the period is inversely proportional to the square root of the spring constant, which leads to a decrease in the period of motion.

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

Question 13.7a Spring in an Elevator I

A mass is suspended from the ceiling of an elevator by a spring. When the elevator is at rest, the period is *T*. What happens to the period when the elevator is moving upward at constant speed?

a) period will increase
b) period will not change
c) period will decrease

Question 13.7a Spring in an Elevator I

A mass is suspended from the ceiling of an elevator by a spring. When the elevator is at rest, the period is *T*. What happens to the period when the elevator is moving upward at constant speed?

a) period will increase
b) period will not change
c) period will decrease

Nothing at all changes when the elevator moves at constant speed. The equilibrium elongation of the spring is the same, and the period of simple harmonic motion is the same.

Question 13.7b Spring in an Elevator II

A mass is suspended from the ceiling of an elevator by a spring. When the elevator is at rest, the period is *T*. What happens to the period when the elevator is accelerating upward?

a) period will increase
b) period will not change
c) period will decrease

Question 13.7b Spring in an Elevator II

A mass is suspended from the ceiling of an elevator by a spring. When the elevator is at rest, the period is *T*. What happens to the period when the elevator is accelerating upward?

a) period will increase
b) period will not change
c) period will decrease

When the elevator accelerates upward, the hanging mass feels "heavier" and the spring will stretch a bit more. Thus, the equilibrium elongation of the spring will increase. However, the period of simple harmonic motion does not depend upon the elongation of the spring—it only depends on the mass and the spring constant, and neither one of them has changed.

Question 13.7c Spring on the Moon

A mass oscillates on a vertical spring with period *T*. If the whole setup is taken to the Moon, how does the period change?

a) period will increase
b) period will not change
c) period will decrease

Question 13.7c Spring on the Moon

A mass oscillates on a vertical spring with period *T*. If the whole setup is taken to the Moon, how does the period change?

a) period will increase
b) period will not change
c) period will decrease

The period of simple harmonic motion depends only on the mass and the spring constant and does not depend on the acceleration due to gravity. By going to the Moon, the value of *g* has been reduced, but that does not affect the period of the oscillating mass–spring system.

Follow-up: Will the period be the same on any planet?

Question 13.8a Period of a Pendulum I

Two pendula have the same length, but different masses attached to the string. How do their periods compare?

a) period is greater for the greater mass
b) period is the same for both cases
c) period is greater for the smaller mass

Question 13.8a Period of a Pendulum I

Two pendula have the same length, but different masses attached to the string. How do their periods compare?

a) period is greater for the greater mass
b) period is the same for both cases
c) period is greater for the smaller mass

The period of a pendulum depends on the length and the acceleration due to gravity, but it does not depend on the mass of the bob.

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

Follow-up: What happens if the amplitude is doubled?

Question 13.8b Period of a Pendulum II

Two pendula have different lengths: one has length L and the other has length $4L$. How do their periods compare?

a) period of $4L$ is four times that of L
b) period of $4L$ is two times that of L
c) period of $4L$ is the same as that of L
d) period of $4L$ is one-half that of L
e) period of $4L$ is one-quarter that of L

Question 13.8b Period of a Pendulum II

Two pendula have different lengths: one has length L and the other has length $4L$. How do their periods compare?

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b) period of $4L$ is two times that of L
c) period of $4L$ is the same as that of L
d) period of $4L$ is one-half that of L
e) period of $4L$ is one-quarter that of L

The period of a pendulum depends on the length and the acceleration due to gravity. The length dependence goes as the square root of L, so a pendulum four times longer will have a period that is two times larger.

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

Question 13.9 Grandfather Clock

A grandfather clock has a weight at the bottom of the pendulum that can be moved up or down. If the clock is running slow, what should you do to adjust the time properly?

a) move the weight up
b) move the weight down
c) moving the weight will not matter
d) call the repairman

Question 13.9 Grandfather Clock

A grandfather clock has a weight at the bottom of the pendulum that can be moved up or down. If the clock is running slow, what should you do to adjust the time properly?

a) move the weight up
b) move the weight down
c) moving the weight will not matter
d) call the repairman

The period of the grandfather clock is too long, so we need to decrease the period (increase the frequency). To do this, the length must be decreased, so the adjustable weight should be moved up in order to shorten the pendulum length.

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

Question 13.10a Pendulum in Elevator I

A pendulum is suspended from the ceiling of an elevator. When the elevator is at rest, the period is T. What happens to the period when the elevator is moving upward at constant speed?

a) period will increase
b) period will not change
c) period will decrease

Question 13.10a Pendulum in Elevator I

A pendulum is suspended from the ceiling of an elevator. When the elevator is at rest, the period is T. What happens to the period when the elevator is moving upward at constant speed?

a) period will increase
b) period will not change
c) period will decrease

Nothing changes when the elevator moves at constant speed. Neither the length nor the effective value of g has changed, so the period of the pendulum is the same.

Question 13.10b Pendulum in Elevator II

A pendulum is suspended from the ceiling of an elevator. When the elevator is at rest, the period is T. What happens to the period when the elevator is accelerating upward?

a) period will increase
b) period will not change
c) period will decrease

Question 13.10b Pendulum in Elevator II

A pendulum is suspended from the ceiling of an elevator. When the elevator is at rest, the period is T. What happens to the period when the elevator is accelerating upward?

a) period will increase
b) period will not change
c) period will decrease

When the elevator accelerates upward, the hanging mass feels "heavier"—this means that the effective value of g has increased due to the acceleration of the elevator. Because the period depends inversely on g, and the effective value of g increased, then the period of the pendulum will decrease (*i.e.*, its frequency will increase and it will swing faster).

Question 13.10c Pendulum in Elevator III

A swinging pendulum has period T on Earth. If the same pendulum were moved to the Moon, how does the new period compare to the old period?

a) period increases
b) period does not change
c) period decreases

Question 13.10c Pendulum in Elevator III

A swinging pendulum has period T on Earth. If the same pendulum were moved to the Moon, how does the new period compare to the old period?

a) period increases
b) period does not change
c) period decreases

The acceleration due to gravity is smaller on the Moon. The relationship between the period and g is given by:

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

therefore, if g gets smaller, T will increase

Follow-up: What can you do to return the pendulum to its original period?

Question 13.11 Damped Pendulum

After a pendulum starts swinging, its amplitude gradually decreases with time because of friction.

What happens to the period of the pendulum during this time ?

a) period increases
b) period does not change
c) period decreases

Question 13.11 Damped Pendulum

After a pendulum starts swinging, its amplitude gradually decreases with time because of friction.

What happens to the period of the pendulum during this time ?

a) period increases

b) period does not change

c) period decreases

The period of a pendulum does not depend on its amplitude, but only on its length and the acceleration due to gravity.

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

Follow-up: What is happening to the energy of the pendulum?

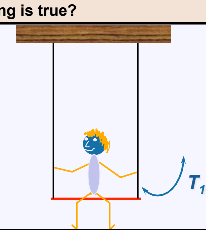
Question 13.12 Swinging in the Rain

You are *sitting* on a swing. A friend gives you a push, and you start swinging with period T_1. Suppose you were *standing* on the swing rather than sitting. When given the same push, you start swinging with period T_2. Which of the following is true?

a) $T_1 = T_2$

b) $T_1 > T_2$

c) $T_1 < T_2$



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You are *sitting* on a swing. A friend gives you a push, and you start swinging with period T_1. Suppose you were *standing* on the swing rather than sitting. When given the same push, you start swinging with period T_2. Which of the following is true?

a) $T_1 = T_2$

b) $T_1 > T_2$

c) $T_1 < T_2$

Standing up raises the *Center of Mass* of the swing, making it shorter !! Because $L_1 > L_2$, then $T_1 > T_2$.

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