

- In both cases restoring force is proportional to displacement
- The negative sign indicates that the restoring force is directed towards equilibrium, as displacement (θ,x) is directed away from equilibrium.

Period of oscillations for two simple harmonic oscillators

Simple pendulum



Mass-spring system



- the period gets smaller if a stronger spring (larger k) is used
- the period of oscillation is longer if a bigger mass (m) is used

- period is independent of amplitude
- period only depends on its length
- period does not depend on the mass
- *period depends on the value of g* e.g.. the same pendulum oscillates slower on the moon than on earth.

SHM-HW 1

- 1. In simple harmonic motion, the restoring force must change the same way as:
 - a. amplitude c. velocity e. distance squared
 - b. frequency d. distance
- 2. Tripling the displacement from equilibrium of an object in simple harmonic motion will change the object's maximum acceleration by what factor?
 - a. one-third c. 3
 - b. 1 d. 9
- 3. What is the period of a 4.12 m long pendulum?
 - a. 2.01 s c. 4.07 s
 - b. 3.11 s d. 9.69 s
- 4. Three physical pendulums, with masses m_1 , $m_2 = 2m_1$, and $m_3 = 3m_1$, have the same shape and length and are suspended at the same point. Rank them according to their periods, from shortest to longest.
 - a. 1, 2, 3 b. 3, 2, 1 c. 2, 3, 1 d. 2, 1, 3 e. All the above are the same

5. How does the restoring force acting on a pendulum bob change as the bob swings from maximum displacement toward the equilibrium position, and then passing through the equilibrium position to the other side? How do the bob's acceleration (along the direction of the motion) and velocity change?



- 6. A clown is rocking on a rocking chair in the dark. His glowing red nose moves back and forth a distance of 0.42 m exactly 30 times a minute, in a simple harmonic motion.
 - a. What is the amplitude of this motion?
 - b. What is the period of this motion?
 - c. What is the frequency of this motion?
- 7. Is every periodic motion SHM? Explain.
- 8. A mass moves in simple harmonic motion with amplitude *A* and period *T*. How long does it take for the mass to move a distance of *2A*? A distance *3A*?
- 9. A mass moves in simple harmonic motion with amplitude A and period T. How much distance does it cover in the time T? In the time 5T/2?
- 10. An object oscillating with simple harmonic motion completes a cycle in time *T*. If the objects amplitude is doubled, the time required for one cycle is still *T*, even though the object covers twice the distance. How can this be? Explain.

SHM-HW 2

1.By what factor should the length of a simple pendulum be changed if the period of vibration were to be tripled?

- a. 3 c. 9
- b. 6 d. 27
- 2. On the planet Xenos, an astronaut observes that a 1.00 m long pendulum has a period of 1.50 s. What is the free-fall acceleration on Xenos?
- 3. An object attached to one end of a spring makes 20 vibrations in 10 seconds. Its frequency is:

- 4. 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
- 5. A basketball player dribbles a ball with a steady period of T seconds. Is the motion of the ball periodic? Is it simple harmonic? Explain.
- 6. A grandfather clock keeps correct time at sea level. If the clock is taken to the top of a nearby high mountain, would you expect it to (i) keep correct time, (ii) run slow, or (iii) run fast? Explain.
- 7. A pendulum of length L has a period T. How long must the pendulum be if its period is to be 2T?
- 9. Suppose two people are swinging on identical playground swings that are next to one another. They are talking to each other as the swings move back and forth in synchronism. Why do the swings remain synchronized, even though the two people have different masses.
- 10. How is it possible for some opera singers to shatter a crystal goblet with their voices?

SHM-HW3

- 1.Gina's favorite exercise equipment at the gym consists of various springs. In one exercise, she pulls a handle grip attached to the free end of a spring to 0.80 m from its unstrained position. The other end of the spring (spring constant = 53 N/m) is held in place by the equipment frame. What is the magnitude of the force that Gina is applying to the handle grip?
 - A) 31 N B) 36 N C) 42 N D) 54 N E) 66 N
 - 2. A vertical block-spring system on earth has a period of 6.0 s. What is the period of this same system on the moon where the acceleration due to gravity is roughly 1/6 that of earth?
 - A) 1.0 s B) 2.4 s C) 6.0 s D) 15 s E) 36 s
 - 3. Which ones of the following statements is true concerning an object executing simple harmonic motion?
 - A) Its velocity is never zero.
 - B) Its acceleration is never zero.
 - C) Its velocity and acceleration are simultaneously zero.
 - D) Its velocity is zero when its acceleration is a maximum.
 - E) Its maximum acceleration is equal to its maximum velocity.
 - 4. When a force of 20.0 N is applied to a spring, it elongates 0.20 m. Determine the period of oscillation of a 4.0-kg object suspended from this spring.
 - A) 0.6 s B) 1.3 s C) 3.1 s D) 4.1 s E) 6.3 s

- A 1.0-kg object is suspended from a spring with k = 16 N/m. The mass is pulled 0.25 m downward from its equilibrium position and allowed to oscillate. What is the maximum kinetic energy of the object?
 A) 0.25 J B) 0.50 J C) 1.0 J D) 2.0 J E) 4.0 J
- 11. A spring required a force of 1.0 N to compress it 0.1 m. How much work is required to stretch the spring 0.4 m? A) 0.4 J B) 0.6 J C) 0.8 J D) 2 J E) 4 J
- 12. A spring with constant k = 40.0 N/m is at the base of a frictionless, 30.0° -inclined plane. A 0.50-kg block is pressed against the spring, compressing it 0.20 m from its equilibrium position. The block is then released. If the block is not attached to the spring, how far along the incline will it travel before it stops?



- A) 0.080 m B) 0.16 m C) 0.32 m D) 1.6 m E) 3.2 m
- 13. A ping-pong ball weighs 2.5 x 10⁻² N. The ball is placed inside a cup that sits on top of a vertical spring. If the spring is compressed 0.055 m and released, the maximum height above the compressed position that the ball reaches is 2.84 m. Neglect air resistance and determine the spring constant.



- A) 47 N/m B) 24 N/m C) 11 N/m D) 5.2 N/m E) 2.6 N/m
- 14. An iron ball hangs from a 24-m steel cable and is used in the demolition of a building at a location where the acceleration due to gravity is 9.9 m/s². The ball is swung outward from its equilibrium position for a distance of 4.5 m. Assuming the system behaves as a simple pendulum, find the maximum speed of the ball during its swing.
 A) 1.9 m/s B) 7.0 m/s C) 11 m/s D) 2.9 m/s
 - E) 9.8 m/s
- 15. Which one of the following terms is used to describe a system in which the degree of damping is just enough to stop the system from oscillating?
 - A) slightly damped D) overdamped
 - B) underdamped E) resonance
 - C) critically damped
- 16. A simple harmonic oscillator with a period of 2.0 s 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) 0.5% B) 1.0% C) 1.4% D) 2.0% E) 4.0%
- 17. A 0.750-kg object hanging from a vertical spring is observed to oscillate with a period of 2.00 s. When the 0.750-kg object is removed and replaced by a 1.25-kg object, what will be the period of oscillation?
 - A) 1.55 s B) 2.58 s C) 3.32 s D) 4.38 s E) 7.45 s

Use the following to answer questions 18-23:

When a 0.20-kg block is suspended from a vertically hanging spring, it stretches the spring from its original length of 0.050 m to 0.060 m.

The same block is attached to the same spring and placed on a horizontal, frictionless surface. The block is then pulled so that the spring stretches to a total length of 0.10 m. The block is released at time t = 0 and undergoes simple harmonic motion.



- 18. Complete the following statement: In order to increase the frequency of the motion, one would have to
 - A) reduce the spring constant.
 - B) decrease the mass of the block on the end of the spring.
 - C) increase the length of the spring.
 - D) reduce the distance that the spring is initially stretched.
 - E) increase the distance that the spring is initially stretched.
- 19. Which one of the following statements is true concerning the motion of the block?
 - A) Its acceleration is constant.
 - B) The period of its motion depends on its amplitude.
 - C) Its acceleration is greatest when the spring returns to the 5.0 cm position.
 - D) Its velocity is greatest when the mass has reached its maximum displacement.
 - E) Its acceleration is greatest when the mass has reached its maximum displacement.
- 21. What is the speed of the block each time the spring is 5.0 cm long?
 A) zero B) 5 cm/s C) 16 cm/s D) 100 cm/s
 E) 157 cm/s
- 22. What is the maximum acceleration of the block?
 - A) 1.57 m/s² B) 3.14 m/s² C) 49 m/s² D) 98 m/s² E) 157 m/s²
- 23. What is the total mechanical energy of the system at any instant?A) 0.25 J B) 0.49 J C) 0.98 J D) 4.9 J E) 9.8 J
- 24. A 2.0-kg object is attached to a spring (k = 55.6 N/m) which hangs vertically from the ceiling. The object is displaced 0.045 m vertically. When the object is released, the system undergoes simple harmonic motion. What is the magnitude of the maximum acceleration of the object?
- A) 1.3 m/s² B) 2.3 m/s² C) 4.4 m/s² D) 9.8 m/s² E) 11 m/s²

- 25. A wooden block is at rest on a horizontal frictionless surface.
- A horizontal spring is attached between the block and a rigid support.



The block is displaced to the right by an amount X and is then released. The period of oscillations is T and the total energy of the system is E.

For an initial displacement of X/2 which of the following shows the best estimate for the period of oscillations and the total energy of the system?

	Period	Total energy
Α.	т	<u>E</u> 2
В.	Т	<u>E</u> 4
C.	$\frac{T}{2}$	E 2
D.	$\frac{1}{2}$	<u>E</u> 4