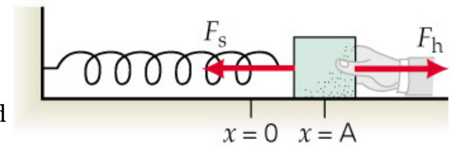
Exam I: Chapters 13 and 14

1. Hooke's law is written as **F** = –k**x**. Why the negative?
   A) The negative is not necessary; it is the result of the coordinate system you choose when solving a problem. Choosing a different coordinate system can always get rid of that negative for you.
   B) Because the spring force has to be negative; springs can only pull, they cannot push an object.
   C) Because the stretch of the spring has to be negative: springs can only stretch, they cannot compress.
   D) Because the force always opposes the displacement of the spring: a stretched spring wants to return to its original rest length.

The block shown right has a mass m. It is attached to a spring with a constant k. The spring is stretched to x=+A from its equilibrium position and the system is released from rest.



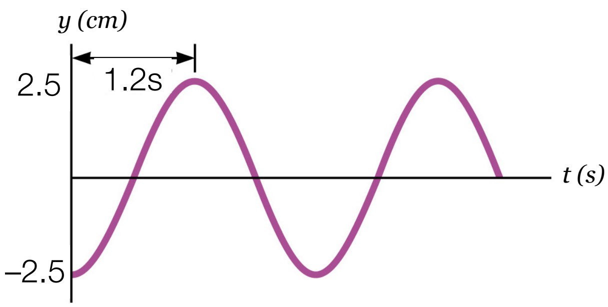
2. At the instant of release, just as the hand lets go of the block, the **force** exerted on the block by the spring is
   A) minimum. B) zero. **C) maximum.**

3. As the block moves from position **x=0** to position **x=–A**, what happens to its **velocity and acceleration**?
   A) The speed of the block never changes: v = A√[k/m], so the acceleration is zero.
   B) The velocity increases (to the left), while the acceleration remains constant (and non–zero).
   C) The velocity increases (to the left). The acceleration does not remain constant, it also increases (to the left).
   D) The velocity decreases (direction is still to the left). The acceleration is not constant, it also decreases (smaller magnitude, direction = right).
   E) Velocity decreases (direction = left), but the acceleration actually increases (magnitude increases, direction = right).

4. Let's talk about the **kinetic energy** of the system.
   A) Why? The kinetic energy of the system is zero because it was released from rest.
   B) The kinetic energy varies. It is maximum at x=+A, zero at x=0, and minimum at x=–A.
   C) The kinetic energy is not constant, but not minimum at x=–A, either. K = maximum at x=±A, K=0 at x=0.
   D) The kinetic energy is maximum when the potential energy is minimum. This occurs when x = 0, and U = 0.
   E) The kinetic energy is constant, because the speed of the block is constant: K = ½m(A√[k/m])².

5. Here's a *new* trick question about the energy. If you double the amplitude of the oscillation, releasing the block from rest at **x = 2A**, what happens to the system energy?
   A) The total energy of the oscillation is doubled.
   B) The system energy is increased by a factor of 4, not two.
   C) The potential energy is doubled, but the kinetic energy remains the same.
   D) The energy of the system decreases. According to the inverse–square rule: double the amplitude, ¼ the energy.
   E) The energy remains constant. Unless you change the mass or the spring itself, the system energy does not change.

6. This particular oscillation has a frequency of 20Hz. To *increase* the frequency, you should
   A) add mass. Replace the original mass m with a new one having exactly 2m.
   B) remove mass. Using ¼ as much mass will double the original frequency.
   C) replace the spring with one having a smaller constant k. Half the k, double the frequency.
   D) using a smaller spring constant will increase the frequency, but half the k means 4 times the frequency.
   E) adjust the amplitude of the oscillation. Doubling the amplitude will increase the frequency by a factor of 2.



On the left is a graph illustrating the vertical oscillation of a 1 kg mass attached to a spring. Assume that up is the positive direction, and down is the negative direction.

7. What is the **amplitude** of this oscillation? Answer with two sig figs. **2.5 cm**

8. What is the **frequency**? Answer with two sig figs. **f = 0.417s**

9. At what point in time is the **velocity** of the mass exactly **zero**?
   A) t = 0s. B) t = 0.6s. **C) t = 1.2s.** D) t = 1.8s. E) t = 3.0s.

10. At t = 3.0s, the mass's position and velocity are the same as at
   A) t = 0.6s. B) t = 1.2s. C) t = 1.8s. D) t = 2.4s. E) t = 3.6s.

11. The position of the mass will be described by the equation:
   1) y = (2.5cm)cos[1.7πt]
   2) y = (2.5cm)sin[1.7πt]
   3) y = –(2.5cm)cos[0.83πt]
   4) y = –(2.5cm)sin[0.83πt]
   5) y = –(5.0cm)cos[0.83πt]
   6) y = –(5.0cm)sin[1.7πt]

12. The velocity and acceleration of the mass will be described by the equations:

A) $v = +(2.1\pi \text{ cm})\sin[0.83\pi t]$
$a = +(1.7\pi^2 \text{ cm})\cos[0.83\pi t]$

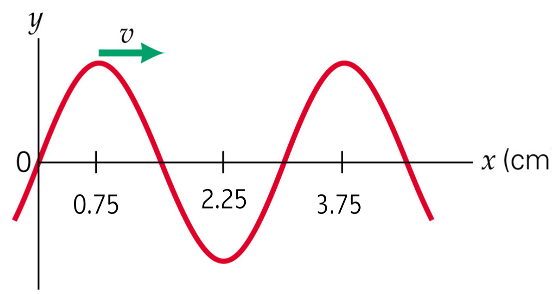
B) $v = +(2.1\pi \text{ cm})\sin[0.2\pi t]$
$a = -(1.7\pi^2 \text{ cm})\cos[0.2\pi t]$

C) $v = -(2.1\pi \text{ cm})\sin[0.2\pi t]$
$a = -(1.7\pi^2 \text{ cm})\cos[0.2\pi t]$

13. Compare an oscillation and a wave.
A) Huh? Why? They are exactly the same thing: a periodic motion with respect to a fixed reference.
B) An oscillation is a periodic motion with respect to a fixed point. A wave is not periodic, just linear.
C) An oscillation depends on wave motion; you cannot have an oscillation without a wave.
D) A wave combines an oscillation and propagation: an oscillation in time propagated through space.

14. As a wave propagates, the molecules of the medium
A) actually travel in the opposite direction, as the wave "pushes off" the molecules.
B) roll forward, like water boiling in a pan: wave propagation is a convective process.
C) are pulled forward along with the traveling wave, but do not vibrate.
D) remain rigid, neither vibrating nor propagating as the wave passes.
E) vibrate, but do not propagate forward with the wave.

15. Compare the direction of *oscillation* to the direction of *propagation* for the wave represented on the right.
A) Oscillation occurs in the y–direction, propagation occurs in the x–direction.
B) Oscillation occurs in the x–direction, propagation occurs in the y–direction.
C) Oscillation and propagation are both in the x–direction.
D) Oscillation and propagation are both in the y–direction.
E) Oscillation and propagation are both in the z–direction.

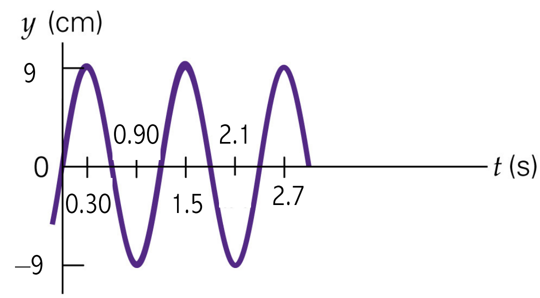


16. The wave described by the graphs is a
A) transverse wave.
B) longitudinal wave.
C) converse wave.
D) latitudinal wave.

17. What is the **amplitude** of this wave? **9 cm**

18. What is the **wavelength**? Answer with two sig figs. **3.0 cm**

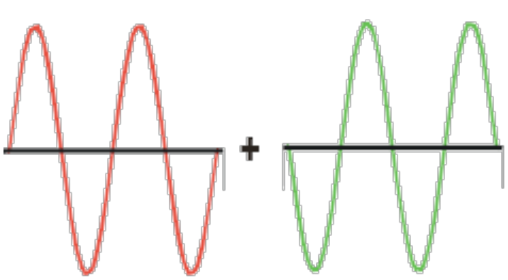
19. What is the wave **speed**? Answer with two sig figs. **v = 2.5 cm/s**



20. A longitudinal wave
A) occurs when the direction of oscillation is parallel to the direction of travel.
B) occurs when the direction of oscillation is perpendicular to the direction of travel.
C) only exists in theory; there are no longitudinal waves actually found naturally.
D) is identical to a transverse wave. If the medium is solid, the wave is called longitudinal. In a fluid medium, it's called a transverse wave.

21. The rarefactions of a longitudinal wave are analogous to the
A) amplitude of a transverse wave.
B) crests of a transverse wave.
C) wavelengths of a transverse wave.
D) troughs of a transverse wave.

22. Compare the density of the medium in regions of compression and rarefaction.
A) Why? Because longitudinal waves only travel through solids, the density remains constant in all regions.
B) A rarefaction is a region where the density is unchanged. Compressions may have higher or lower density, just not the same density as a rarefaction.
C) Compressions are denser regions than rarefactions, but both are denser than node regions.
D) A compression is a region of *reduced* density, a rarefaction has *greater* density.
E) A compression has greater density than a node. A rarefaction is a region of lower density than a node.



23. The superposition principle is based on the idea that
A) a wave propagates by superimposing a propagation over an oscillation. The result is that the wave medium moves right along with the energy.
B) two particles can occupy the same space at the same time. They superimpose to result in a new particle having the combined mass: $m = m_1 + m_2$.
C) two waves can occupy the same space at the same time. They superimpose to result in a new wave having the combined amplitude: $A = A_1 + A_2$.
D) two waves cannot occupy the same space at the same time. Neither can two particles. Which must mean that there really isn't any superposition of matter or energy. What a crazy universe we live in!

24. The to waves shown above will interfere
A) constructively. **B) destructively.** C) sarcastically. D) catatonically.

25. If two waves interfere constructively (reinforce), by how much should you shift the phase of one of the waves to create a complete destructive cancellation when the waves are superimposed?
A) 0; no phase shift.
B) π/2, or ¼ wavelength.
C) π, or ½ wavelength.
D) 3π/2, or ¾ wavelength.
E) 2π, or one whole wave-length.

A steel guitar string is **60 cm** long, with diameter **0.05 cm** and mass **15g**. The fundamental frequency is **f = 288 Hz**.

26. What are the **wavelengths** of the first three harmonic resonances?
A) 1.8m, 1.2 m, and 0.60m
B) 1.8m, 0.60m, and 0.20m
C) 1.2m, 0.60m, and 0.30m
D) 1.2 m, 0.60m, and 0.40m
E) 0.90m, 0.60m, and 0.30m

27. How **fast** will a wave having the fundamental frequency propagate along the string? **v = 345.6 m/s**

You replace the string with a **thicker** one having a **greater** mass density. It is adjusted to the same tension as the last string.

28. When this new string is plucked, how **fast** will the wave propagate?
A) As long as the diameter is still 0.05cm, the wave speed will be unaffected.
B) As long as the tension remains constant, the wave speed will be unaffected.
C) As long as the supports are still 60 cm apart, the wave speed will be unaffected.
D) Because the mass density increases, the wave speed increases with constant tension.
E) If the tension remains constant, the wave speed decreases with increasing linear mass density.

29. What are the **frequencies** of the first three harmonic resonances of this new thicker string?
A) Because the wave speed decreases but the wavelengths do not change, the frequencies also decrease.
B) Because the mass density increases, so do the wavelengths. As wavelength increases, so does frequency.
C) The thicker string is faster, so for the same wavelengths the frequency must be greater (higher).
D) As long as the tension remains constant, the wavelengths and frequencies will be unaffected.
E) As long as the supports are still 60 cm apart, the frequencies will be unaffected.

30. If the tension has been kept constant, the fundamental frequency of the thicker string is
A) greater than 288 Hz. B) equal to 288 Hz. **C) less than 288 Hz.**

31. A sound wave has a frequency **f = 18kHz** and an intensity **I =10^{-12}W/m²**.
A) This sound is perfectly audible to human ears. It's definitely going to be loud, though.
B) This sound is probably just barely audible to you. The frequency is almost as high as human ears can hear,and the intensity is at the threshold of hearing. You could just hear it, but it would not be loud or penetrating.
C) This sound is not audible because the frequency is far above the limit of human sensitivity. This is like the sound that bats emit when they are screaming at insects, using echolocation to find flying food.
D) The sound in inaudible because the intensity is too low. The frequency is in the range of human sensitivity, but there is simply not enough energy to hear anything.
E) It's not possible to determine whether this could be heard. You would need to know how fast the sound was traveling (through air or water or whatever) in order to calculate if it was audible or not.

32. **True** or false: For a sound wave propagating through the atmosphere, cold air is slow air (compared to warm air).

33. True or **false**: For a sound wave propagating through the atmosphere, humid air is slow air (compared to dry air).

34. Two sound waves travel through air at **20°C**. The second wave has **double** the frequency of the first.
A) Both waves have the same wavelength and speed. The wavelength is independent of frequency.
B) Its wavelength is half the wavelength of the original wave. The speed is the same for both waves.
C) Its wavelength is twice the wavelength of the original wave. Its speed is the same as the original speed.
D) Its speed is half the speed of the original wave. The wavelength is the same for both waves.
E) Its speed is twice the speed of the original wave. Its wavelength is twice the original frequency.

A 512Hz tuning fork is struck inside the lab (20°C). Outdoors, the temperature is 25°C.

35. True or **false**: Striking the fork will create a sound wave that travels at 331 m/s, either inside or outside.

36. True or **false**: Striking the fork outside will create a higher frequency sound (compared to striking it inside).

37. **True** or false: Striking the fork outside will create a longer wavelength (compared to striking it inside).

38. Compare the speed of sound through brass to the speed of sound through air.
    A) Air is about the fastest medium through which sound propagates (only vacuum is faster). Sound travels roughly ten times faster through air than through brass.
    B) Brass is a very fast medium compared to air. Sound travels approximately ten times faster through brass than air.
    C) Brass is faster, but no way is it a factor of ten. It's more like a factor of three faster than air.
    D) The speed of sound is constant for all media: v = [331 + 0.6T]m/s. The composition of the medium is simply not relevant. If the air and brass have the same temperature, they have the same speed.
    E) The speed of sound is not constant for all media, but by coincidence brass and air have almost identical speeds.

39. Zinc is added to copper to form brass. The addition decreases the **density** by about **7%**. It also decreases the **elasticity** (Young's modulus, Y)by about **10%**. How is the speed of sound affected?
    A) It is not affected. Neither copper nor brass is capable of sound transmission.
    B) Brass is faster because it is less elastic. That the density is less does not make any difference.
    C) Decreasing density increases the speed, but decreasing elasticity decreases the speed. They balance out, no change.
    D) The previous answer is almost correct. The greater decrease in elasticity means the speed decreases in brass.
    E) The smaller decrease in density results in a larger increase in the speed of sound. Brass is faster than copper.

40. The intensity of a sound is exactly **4 W/m²** at a distance of **12m**. At **3m**, the intensity will be
    A) 0.25 W/m² B) 1 W/m² C) 4 W/m² D) 12 W/m² **E) 64 W/m²**

41. You perceive that sound B is twice as loud as sound A. What is the difference in the intensity of these?
    A) B has half the intensity of A.
    B) B must have ¼ the intensity of A.
    C) Twice the loudness implies twice the intensity.
    D) Twice the loudness means the intensity is four times greater.
    E) A doubling of the loudness means an order of magnitude, or factor of 10, increase in intensity.

42. Doubling the intensity of a sound results in an intensity level increase of
    A) 1 dB B) 2 dB **C) 3 dB** D) 5 dB E) 10 dB

43. True or **false**: A typical conversation (where no one is shouting about politics or anything) has an intensity level of about 20dB.

44. True or **false**: The change in pitch that you hear in the train whistle as the train zooms past occurs because the frequency of the whistle changes as the train moves.

45. The ambulance siren has a frequency of 700Hz. When the ambulance approaches you (you are stationary) at 20m/s, what frequency do you perceive? Assume that the speed of sound through the air is 340 m/s.
    A) 658 Hz B) 661 Hz C) 700 Hz D) 741 Hz **E) 744 Hz**