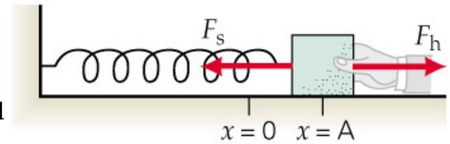
Exam I: Chapters 13 and 14

1. Hooke's law is written as **F** = –k**x**. Why the negative?
   A) Because the spring force has to be negative; springs can only pull, they cannot push an object.
   B) Because the stretch of the spring has to be negative: springs can only stretch, they cannot compress.
   C) Because the force always opposes the displacement of the spring: a stretched spring wants to return to its original rest length.
   D) 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.

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.**

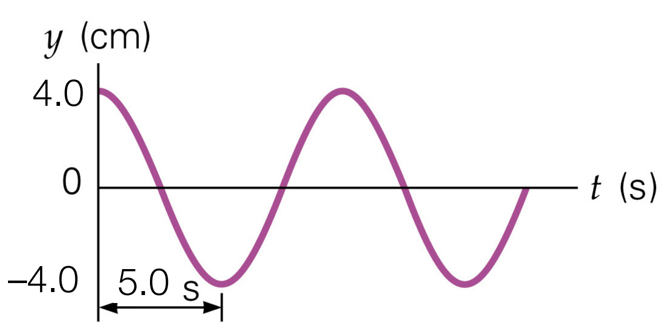
3. As the block moves from position **x=+A** to position **x=0**, the **acceleration** of the block
   A) is zero everywhere from x=A to x=0.
   B) is constant everywhere: a = (kA)/m.
   C) decreases from a = (kA)/m to zero at x=0.
   D) increases from zero to a = (kA)/m at x=0.
   E) increases from x=+A to x=+½A, then decreases back to zero from x=+½A to x=0.

4. As the block moves from position **x=0** to position **x=–A**, what happens to its **velocity**?
   A) Nothing. The speed of the block never changes: v = A√[k/m].
   B) At x=0, the velocity is zero. As the block moves left toward x=–A, the magnitude of the velocity increases while its direction remains to the right.
   C) The block never gets to position x=–A! When it hits x=0, it has zero velocity. It stops and stays stopped at x=0.
   D) The velocity is maximum at x=0, and decreases to zero at x=–A. The direction of the velocity matches the direction of motion: to the left.

5. Let's talk about the **energy** of the system.
   A) Why? The energy of the system is zero because it was released from rest.
   B) The energy varies. The total energy is zero at x=±A, and maximum at x=0.
   C) The energy is not constant. It is maximum at x=+A, zero at x=0, and minimum at x=–A.
   D) The energy is constant. It is all kinetic energy, K = ½mv², when the block is at x=±A. All potential energy at x=0.
   E) Energy remains constant. It is all potential energy, U = ½kA², when the block is at x=±A. All kinetic energy at x=0.

6. Here's a trick question about the energy. Only you can't really complain if I am telling you in advance that it's a trick, can you? Plus, you memorized this question from the exam archive, right? The trick is to look at the math carefully. When the block is at exactly x=+½A, what is the distribution of the energy?
   A) The energy is ¾ potential, and only ¼ kinetic.
   B) The energy is ¼ potential, and only ¾ kinetic.
   C) Exactly half kinetic, half potential. So that part about being a trick wasn't exactly true, was it?
   D) The exact fraction of potential energy can't be determined unless you have an actual number to plug in for the amplitude A. But there is definitely more potential energy than kinetic.

7. This particular oscillation has a frequency of 20Hz. To decrease 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 larger constant k. Double the k, half the frequency.
   D) adjust the amplitude of the oscillation. Half the amplitude will decrease the frequency by a factor of 4.



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.

8. What is the **amplitude** of this oscillation? Answer with two sig figs.

$$A = 4.0\text{cm}$$

9. What is the **frequency**? Answer with two sig figs.

$$f = \frac{1}{T} = \frac{1}{10.0s} = 0.10\text{Hz}$$

10. At t = 7.5s, the mass's position and velocity are the same as at
   A) t = 2.5s.   B) t = 12.5s.   C) t = 10s.   **D) t = 15s.**   **E) t=17.5s**

The *correct* answer is 17.5 seconds! This was my typo. The *closest* answer to correct was 15 seconds.

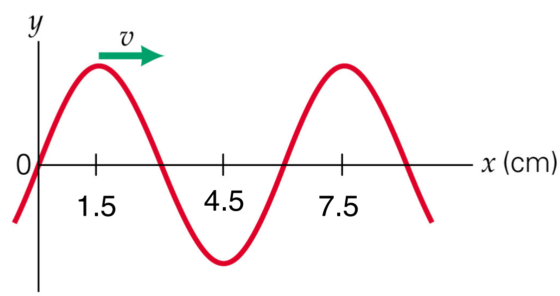
11. The position of the mass will be described by the equation:
   1) y = (8cm)cos[0.2πt]
   2) y = (8cm)sin[0.2πt]
   3) y = (4cm)cos[0.4πt]
   4) y = (4cm)sin[0.4πt]
   5) y = (4cm)cos[0.2πt]
   6) y = (4cm)sin[0.2πt]

12. The velocity and acceleration of the mass will be described by the equations:
   A) v = +(0.8π cm)sin[0.2πt]
   a = +(0.16π² cm)cos[0.2πt]
   B) v = +(0.8π cm)sin[0.2πt]
   a = −(0.16π² cm)cos[0.2πt]
   C) v = −(0.8π cm)sin[0.2πt]
   a =−(0.16π² cm)cos[0.2πt]

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.



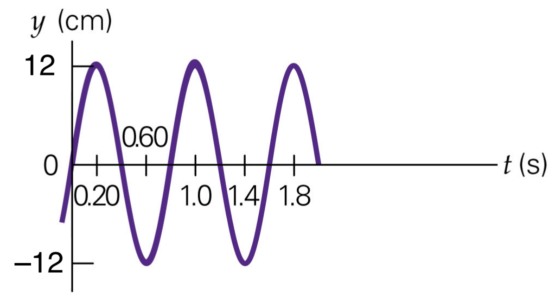
16. The wave described by the graphs is a
   A) transverse wave.   C) converse wave.
   B) longitudinal wave.   D) latitudinal wave.

17. What is the **amplitude** of this wave? Answer with two sig figs.

$$A = 12\text{cm}$$

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

$$\lambda = 6.0\text{cm}$$



19. What is the wave **speed**? Answer with two sig figs.

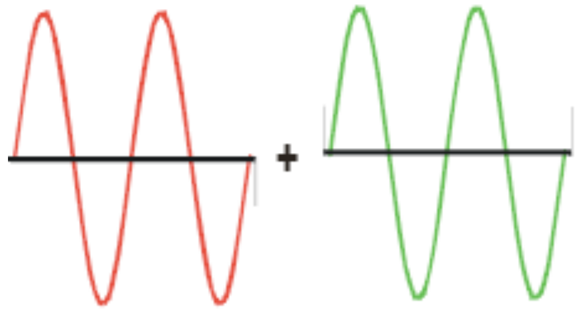
$$v = \frac{\lambda}{T} = \frac{(6.0\text{cm})}{(0.8\text{s})} = 7.5\,\frac{\text{cm}}{\text{s}}$$

20. A longitudinal wave
   A) occurs when the direction of oscillation is perpendicular to the direction of travel.
   B) occurs when the direction of oscillation is parallel 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 compressions of a longitudinal wave are analogous to the
   A) crests of a transverse wave.   C) troughs of a transverse wave.
   B) amplitude of a transverse wave.   D) wavelength 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) diabolically. D) photogenically.

25. For the waves shown to completely cancel each other, the wave on the right should be phase shifted by an angle of
    A) 0; no shift. B) π/2. **C) π.** D) 3π/2. E) 2π.

A steel guitar string is **75 cm** long, with diameter of **0.12 cm**. The fundamental frequency of vibration is **f = 288 Hz**.

26. What are the **wavelengths** of the first three harmonic resonances?
    A) 0.75m, 1.5 m, and 2.25m
    B) 0.75m, 0.375m, and 0.188m
    C) 1.5m, 3.0m, and 4.5m
    D) 1.5 m, 0.75m, and 0.50m
    E) 1.5m, 0.75m, and 0.375m

27. How **fast** will a wave propagate along the string? Answer with **three** sig figs.

$$v = \lambda f = (1.5\text{m})(288\text{Hz}) = 432\,\tfrac{\text{m}}{\text{s}}$$

You replace the string with a **thinner** one having a **smaller** mass density.

28. When the new string is plucked, how fast will the wave propagate?
    A) As long as the supports are still 75 cm apart, the wave speed will be unaffected.
    B) As long as the diameter is still 0.12cm, the wave speed will be unaffected.
    C) As long as the tension remains constant, the wave speed will be unaffected.
    D) Because the mass density decreases, the wave speed increases with constant tension.
    E) If the tension remains constant, the wave speed decreases with decreasing linear mass density.

29. What are the wavelengths of the first three harmonic resonances of this new string?
    A) If the tension remains constant, the wavelengths increase.
    B) Because the mass density decreases, so do the wavelengths.
    C) Because the string is thinner, it has to be longer, so the wavelengths increase.
    D) As long as the tension remains constant, the wavelengths will be unaffected.
    E) As long as the supports are still 75 cm apart, the wavelengths will be unaffected.

30. If the tension has been kept constant, the fundamental frequency of the thinner 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 = 288Hz** and an intensity $\mathbf{I = 10^{-14} W/m^2}$.
    A) This sound is perfectly audible to human ears. It might be a little loud, though.
    B) This sound is probably just barely audible to you. The frequency is about as high as human ears can hear,and the intensity is almost at the threshold of pain. You could hear it, but it would be like a dog whistle.
    C) This sound is not audible because the frequency is below the limit of human sensitivity. An elephant could probably hear this just fine, though.
    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) This is a trick question, like that "If a tree falls in the forest…" question in the exam archive. The intensity of this sound would shatter glass. Even though you did not hear it, it would probably rupture your eardrums.

32. Why does the speed of sound increase with air temperature?
    A) The speed of sound in air does not depend on temperature at all.
    B) The speed of sound actually decreases with increasing temperature.
    C) Increased temperature means that the air molecules are moving less; this permits the sound energy to be transmitted unimpeded.
    D) Increased molecular motion increases the rate at which the molecules collide, which aids in the transmission of the sound energy.

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

34. The 512Hz tuning fork is struck inside the lab (20°C). The wave speed is less than outdoors, where the temperature is 25°C. Striking the fork outside will result in a sound wave having the same
   A) wavelength and frequency both. Changing the temperature does not change the sound wave.
   B) wavelength, but decreased frequency.
   C) wavelength, but increased frequency.
   D) frequency, but decreased wavelength.
   E) frequency, but increased wavelength.

35. So I'm listening to the radio, and they play that Sheryl Crow song, *Good Is Good*. She sings, "Every time you hear the rolling thunder, you turn around before the lightning strikes..." What do we know that she apparently doesn't?
   A) No clue. Sheryl's probably pretty smart, so whenever you see the lightning, you have already heard the thunder. Sound travels faster through air than light.
   B) The sound of thunder will always arrive *after* the flash of lightning. Sound travels many times more slowly through air than light.
   C) Because you will always see the lightning and hear the thunder simultaneously. Light and sound travel at exactly the same speed through air.
   D) Sometimes the sound precedes the light, sometimes the light arrives first. Because the speed of sound depends on temperature, on a warm day the sound arrives before the light. But on a cold day, the light arrives first. She never tells us in the song what the temperature is!

36. 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.

37. Carbon is added to iron to form steel. The addition does not change the density by an appreciable amount, but it does increase the elasticity substantially. How is the speed of sound affected?
   A) It is not affected. Neither iron nor steel is capable of sound transmission.
   B) Increasing the elasticity will increase the speed of sound through the medium.
   C) Increasing the elasticity will decrease the speed of sound through the steel.

38. The intensity of a sound is exactly 36 W/m² at a distance of 1m. At 3m, the intensity will be
   A) 2 W/m² **B) 4 W/m²** C) 6 W/m² D) 12 W/m² E) 108 W/m²

39. 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.

40. 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

41. You're driving home from Radio Shack, where you bought a cool new sound meter. Suddenly, the tornado siren sounds just as you are driving past the loudspeaker mounted on the power pole. Coincidence? I don't *think* so.
   A) The siren registers no more than 15dB on your most excellent digital device.
   B) The siren comes in at about 60dB.
   C) Tornado siren could hit as high as 90dB.
   D) The siren will probably be wailing at 150dB or even higher.

42. What is the Doppler effect?
   A) A change in the perceived frequency of a wave because the source of the wave either approaches toward or recedes away from the receiver. There is no effect if the source remains stationary and the observer is in motion.
   B) A change in the perceived frequency of a wave because the source of the wave either approaches toward or recedes away from the receiver. Or, if the source is stationary, the same effect occurs for an observer in motion.
   C) A change in the actual frequency of a wave because the source of the wave begins to vibrate at a different frequency. Any motion of either the source or the observer is not relevant.
   D) A change in the actual frequency of a wave because the medium changes, resulting in a speed change. When the speed of the wave changes, the frequency changes because the wavelength remains constant.
   E) The inexorable sequence of events set in motion when, through no fault of your own, your tornado-propelled domicile is thrust into an alternate reality and lands on a fabulous pair of shoes rather inconveniently still attached to the feet of a witch with a vindictive (and quite literally green) sister who just happens to have a terrifying army of flying monkeys. *Flying monkeys!*

43. As you are standing stationary on the sidewalk, a black '76 Firebird zooms past (doing like, 45, in a school zone) with windows open, blasting *Crazy On You* from the in–dash 8–track (did I mention that you have traveled back in time and it actually is 1976? That's how old *Dreamboat Annie* is).
   A) The actual frequency does not change, and neither does your perception of it. The song remains the same.
   B) The actual frequency does not change, but your perception of it does. It seems to decrease in frequency as the car approaches you.
   C) The actual frequency does not change, but your perception of it does. It seems to increase in frequency as the car approaches you.
   D) The actual frequency of the song changes as it changes its vibration. If the car moves forward, the frequency increases (regardless of what you are doing).
   E) You have no idea what happened to the frequency, because you were so astonished when Tony slammed on the brakes and offered you a ride. Must've been those fabulous freaky shoes that caught his eye. That, and not every girl has a monkey on a leash flying rings around her head.

44. You are driving down the street with Tony (you're still trapped in 1976–good luck finding a radio station that isn't playing something off *Frampton Comes Alive!*, and good luck finding a Radio Shack that has replacement parts for your time machine). He's letting you drive the Firebird, so you are proceeding at a sensible 30 mph, moving away from the factory, when the whistle blows to mark the shift change. Tony always carries that portable guitar tuner you brought him from the future, which reads a frequency of 440 Hz.
   A) As you get farther from the factory, the frequency reading will decrease.
   B) As you continue to move away from the sound, the frequency reading will increase.
   C) The frequency reading will not change, because the source of the sound is stationary.
   D) The reading on the meter does not change, even though you and Tony will hear the pitch of the sound increase.