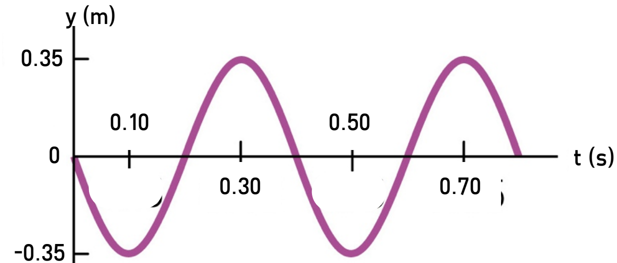
1. An **elastic** object (like a rubber band or a spring) is stretched slightly and released.
   A) There is no way to predict in advance what will happen to the object.
   B) It will remain stretched. You have done permanent damage to the object.
   C) The elastic object will return to its original shape as soon as it is released.
   D) It will remain stretched for a while, and eventually it may (or may not) return to its original shape.
2. An **inelastic** object (like clay or putty) is stretched slightly and released.
   A) There is no way to predict in advance what will happen to the object.
   B) It will remain stretched. You have done permanent damage to the object.
   C) The inelastic object will return to its original shape as soon as it is released.
   D) It will remain stretched for a while, and eventually it may (or may not) return to its original shape.
3. Which of the following is true about elasticity?
   A) All elastic materials are equally elastic; they all stretch the same amount if you apply the same force.
   B) It is possible to permanently stretch an elastic material; you can see the permanent damage when you release the object and it does not regain its original shape.
   C) All materials are elastic; anything will stretch if you pull it hard enough.
   D) The stiffer a spring is, the lower its coeffcient of elasticity (spring constant).
4. **True or false:** Steel is an example of a very elastic material.
5. According to **Hooke's Law**, an elastic material will stretch
   A) inversely proportional to the force applied.
   B) directly proportional to the force applied.
   C) exponentially as the force applied increases.
   D) is unrelated to the amount of force applied.
6. A mass m = 3kg stretches a spring by 5 cm (x = 0.05m). What is the spring constant k of this spring?
   A) k = 0.15 N/m
   B) k = 0.60 N/m
   C) k = 1.47 N/m
   D) k = 15 N/m
   E) k = 588 N/m
   F) k = 1633 N/m
7. An **oscillation**, or vibration
   A) is a completely random motion. For example, when a fly buzzes around you, the path of his motion is an oscillation.
   B) is not completely random, because the motion cannot repeat. For example, if the fly circles around your head once, he can keep flying, but never follow that same path again.
   C) is not random at all. If you are going to use that fly as an example, then you have to look at its wings. The wings move up and down, over and over (and really fast), but they stay attached to the fly. The wings are oscillating.
   D) is a back-and-forth motion that repeats, but not like the fly's wings; it has to be a back-and-forth motion, it cannot be an up-and-down motion.
8. A **wave** is
   A) an oscillation in time only.
   B) an oscillation in space only.
   C) an oscillation in space propagated through time.
   D) an oscillation in time propagated through space.
9. Gusts of wind make the Sears Tower sway back and forth, completing a cycle every 10 seconds.
   A) Its frequency = 1/10 Hz, and its period is 10 seconds.
   B) Its frequency = 10 Hz, and its period is 1/10 seconds.
   C) Its frequency = 1 Hz, and its period is 1 second
   D) Its frequency = 10 Hz, and its period = 10 seconds.
10. The pendulum of a grandfather clock swings back and forth 60 times (60 cycles) each minute (60 seconds).
    A) Its frequency f = 60 Hz, and its period T = 1 sec.
    B) Its frequency f = 1 Hz, and its period T = 60 sec.
    C) Its frequency f = 1 Hz, and its period T = 1 sec.
    D) Its frequency f = 60 Hz, and its period T = 60 sec.

Answer Questions 11–14 using the wave diagram below.
Answer each question numerically with exactly two decimal places (no units!).



11. What is the **amplitude** of this wave?
12. What is the **period** of this wave?
13. What is the **frequency** of this wave?
14. If the **wavelength** of the above wave is measured to be λ = 2.4m, what is the **wave speed** (remember $v = \lambda f$)?
    A) v = 0.17 m/s
    B) v = 0.96 m/s
    C) v = 3.0 m/s
    D) v = 6.0 m/s
15. As a wave **propagates**,
    A) the medium is pulled along with the traveling wave.
    B) the molecules of the medium vibrate, but do not propagate forward with the wave.
    C) the medium actually travels in the opposite direction, as the wave "pushes off" the molecules.
    D) the medium remains rigid, neither vibrating nor propagating as the wave passes.
16. Compare a **longitudinal** and a **transverse** wave.
    A) Longitudinal waves vibrate parallel to the direction of propagation, transverse perpendicular.
    B) Backwards! Longitudinal vibrate perpendicular to the direction of propagation, and transverse waves vibrate parallel to the direction of propagation.
    C) Longitudinal waves have longer wavelength and transverse waves have greater amplitude.
    D) Backwards! Transverse have longer wavelength, longitudinal have greater amplitude.
17. A **longitudinal** wave propagates
    A) parallel to the direction of the oscillation.
    B) perpendicular to the direction of the oscillation.
    C) neither parallel nor perpendicular to the propagation.
    D) not at all. Longitudinal waves only oscillate (while transverse waves only propagate).
18. The **rarefactions** of a longitudinal wave
    A) are analogous to the amplitude of a transverse wave.
    B) are analogous to the nodes of a transverse wave.
    C) occur where the molecules of the vibrating medium are closest together.
    D) occur where the molecules of the vibrating medium are farthest apart.

19. The **compressions** of a longitudinal wave
   A) are analogous to the crests of a transverse wave.
   B) are analogous to the amplitude of a transverse wave.
   C) are equal to the wavelength times the frequency of the wave.
   D) occur where the molecules of the vibrating medium are farthest apart.

20. The **troughs** of a transverse wave
   A) are analogous to the compressions of a longitudinal wave.
   B) are analogous to the rarefactions of a longitudinal wave.
   C) are analogous to the nodes of a longitudinal wave.
   D) occur where the molecules of the vibrating medium are closest together

21. Seismic waves
   A) are exclusively longitudinal.
   B) are exclusively transverse.
   C) are neither longitudinal nor transverse.
   D) have both longitudinal and transverse components

22. Sound waves in air are
   A) transverse. C) converse.
   B) longitudinal. D) latitudinal.

23. For a sound to be audible to an average human, it must have
   A) a frequency between 10^{-12}Hz and 1Hz.
   B) a frequency between 20Hz and 20,000Hz.
   C) a frequency between 40kHz and 40MHz.
   D) any frequency at all. Whenever molecules vibrate, human ears hear them.

24. Dolphins can hear sound waves at **very high frequencies**–as high as 40,000 Hz. A sound wave with this high frequency would be labeled
   A) infrasonic. C) ultrasonic.
   B) audible. D) radiosonic.

25. Elephants can communicate over long distances by sending **very low frequency** sound waves through the ground. These sound waves, which are below the threshold of human hearing, would be labeled
   A) infrasonic. C) ultrasonic.
   B) audible. D) radiosonic.

26. So dolphins send sound waves through **water**, elephants send them through the **ground**, and people send sound waves through the **air**. Logically, then, the **space aliens** must send their sound waves through **space**.
   A) True; the speed of sound through vacuum is literally as fast as anything can possibly travel.
   B) False; everyone knows that any alien race sufficiently advanced to travel among the stars would communicate telepathically, with no need for sound waves at all.
   C) True; while answer A is not correct about how *fast* the sound travels, it *does* travel easily through space.
   D) False; sound cannot travel through space because there is no medium to propagate the wave.

27. In space, no one can hear you scream.
   A) True; your small voice would be drowned out by the heavenly music of the spheres.
   B) False; sound travels especially well through vacuum, so your voice carries over infinite distances.
   C) True; sound cannot travel through space because there is no medium to propagate the wave.
   D) False; this may be a catchy tag line for a Hollywood movie, but it has nothing whatsoever to do with physics!

28. **True or false:** An elastic, metallic material (like steel) is typically a very poor conductor of sound.

29. The speed of sound in **steel**
   A) is greater than the speed of sound through air.
   B) is zero because steel does not transmit sound.
   C) is less than the speed of sound through water.

30. Sound travels best through a medium that is
   A) extremely dense, like lead.
   B) extremely cold, like snow.
   C) amorphous and lightweight, like styrofoam.
   D) highly elastic, like steel.

31. Why does styrofoam or cork make a good sound insulator?
   A) The crystalline structure makes it hard to propagate sound energy from molecule to molecule.
   B) Amorphous structure and many air pockets make it very difficult to pass the sound energy along.
   C) Styrofoam is white, and cork is typically light beige. Lighter colors reflect sound, not transmit it.
   D) These are dense materials, and density means there are more molecules per volume, so the sound energy has to undergo many more transmissions from molecule to molecule, which takes a lot of time.

32. Two sound waves travel through dry air at 20°C. The frequency of **Wave A** is f = 384Hz, and the frequency of **Wave B** is f= 512Hz. The waves have
   A) exactly the same wavelength and speed.
   B) different wavelengths, but the same speed.
   C) the same wavelength, but different speeds.
   D) different wavelengths and different speeds.

33. At 20°C, a 300Hz sound wave travels at a speed of 343m/s. Its wavelength is 1.14m. When the temperature **decreases**,
   A) the frequency and wavelength decrease as well, but the wave speed is unaffected.
   B) the frequency will not change, but the wavelength and speed both decrease.
   C) the frequency decreases as well. The wavelength will increase so the speed will remain constant.
   D) the frequency increases along with the wavelength. This increases the wave speed as well.

34. Why does sound travel **faster** in warm air than cold?
   A) It doesn't. Cold air is denser, so sound travels faster in cold air.
   B) Warm air is denser than cold, so sound travels faster.
   C) Warm air molecules are moving faster than cold air molecules, so sound travels faster.
   D) Warm air is made of oxygen, and cold air is made of nitrogen. Oxygen is a faster medium than nitrogen.

35. Why is **humid** air a faster medium for sound than dry air?
   A) Because water is denser than air, and a denser medium is always a faster medium.
   B) Because air does not transmit sound waves at all; only the water molecules actually transmit the sound energy.
   C) Air molecules are heavier than water molecules. With the same amount of kinetic energy, the lighter water molecules have greater speed.
   D) The speed of sound is exactly the same no matter what the humidity or the temperature. The speed of sound is a constant value through all media that transmit sound. Air, water, steel—it's all the same speed, about 340 m/s.

36. In defense of the Intergalactic Zambonian Empire, your starship, Ice Princess, fires a photon torpedo at an invading destroyer. As the enemy ship explodes into millions of pieces, you hear
   A) a roaring, rushing sound; very loud and exciting! Long live the Zambonian Empire!
   B) absolutely nothing other than the noise within your own ship.

37. How is **refraction** different from **reflection**?
    A) Reflection occurs when a wave strikes a boundary that it cannot cross, so it bounces. Refraction occurs when the wave strikes a boundary, but can continue to travel through the new medium.
    B) When a wave is reflected, it bounces straight back in the direction from which it came. When a wave is refracted, it bounces off the boundary in some random direction.
    C) A reflected wave strikes a boundary and keeps going, but it slows down. A refracted wave strikes the same boundary and keeps going, but it speeds up.

38. Sound waves traveling through air of uneven temperatures
    A) are bent from warm air toward cool air.
    B) are bent from cool air toward warm air.
    C) continue to travel in a straight line.
    D) resonate between cold and warm until they cancel out.

39. An **echo**
    A) occurs when a sound wave is transmitted from one medium to another, traveling in a straight line.
    B) is the change in the direction of the wave. When a sound wave strikes a boundary, it continues to travel forward, but gets shifted slightly, or bent away from its original path.
    C) results when a sound wave is reflected off a surface. The reflected wave has the same wavelength and frequency as the original pulse.
    D) is a reflection, but the sound wave that is reflected cannot have the same wavelength or frequency. Part of the wave is used up in bouncing off, so the reflected wave always has a different frequency and wavelength.

40. A depth-sounding vessel surveys the ocean bottom by sending out an ultrasonic pulse. The vessel receives the echo after 4 seconds. If the pulse has a speed v = 1530m/s, how deep is the ocean floor?
    A) d = 382m
    B) d = 765m
    C) d = 1530m
    D) d = 3060m
    E) d = 4590m
    F) d = 6120m

41. When bats use echolocation to hunt for food, they emit
    A) a stream of radioactive particles that instantly kills anything it hits.
    B) a beam of light, because they hunt at night. How else can they see their food?
    C) an infrasonic pulse. They use a very low frequency so as not to scare the insects.
    D) an audible pulse. This is why people are afraid of bats, because they sound so scary.
    E) an ultrasonic pulse. The frequency is too high for human ears to hear.

42. Two transverse waves have the same amplitude, frequency, and wavelength. If they are **in phase**, the resulting superposition will be
    A) a wave with twice the amplitude.
    B) a wave with twice the wavelength.
    C) a wave with twice the frequency.
    D) cancel completely, and there will be no wave at all.

43. Two transverse waves have the same amplitude, frequency, and wavelength. If they are **out of phase**, they will interfere
    A) constructively, and reinforce each other.
    B) destructively and cancel each other.
    C) instructively and teach each other physics.
    D) perspectively and disappear on the horizon.

44. **Constructive interference** occurs when two waves are
    A) in phase: $crest_1$ matches $crest_2$, and the resulting wave has an amplitude $A = A_1 + A_2$.
    B) out of phase: $crest_1$ matches $trough_2$, and the waves cancel. Amplitude $A = 0$.
    C) partially in phase, partially out of phase: the crests and troughs are not perfectly aligned, which constructs a new wave that looks nothing like either of the original waves.
    D) traveling in away from each other in two different directions. The energy is then transmitted to a greater area than if they were traveling in the same direction, so it can be used for something constructive.

45. What happens when two waves meet that are not perfectly in phase or perfectly out of phase?
    A) Nothing. The two waves will not interfere at all.
    B) The waves will still interfere constructively.
    C) The waves will interfere, but they must cancel completely.
    D) The waves do not cancel completely or reinforce; you must use the superposition principle to determine the amplitude of the new wave at each point. The new wave may have an odd shape.

46. A tone generator creates sound waves with a single frequency. The output can be adjusted for frequency and loudness (intensity level). Which of the following tones could you hear easily?
    A) Frequency = 500 Hz, intensity level = 70 dB.
    B) Frequency = 1500 Hz, intensity level = 60 dB.
    C) Frequency = 14,000 Hz, intensity level = 40 dB.
    D) You could easily hear tones A, B, and C, although many older people (perhaps even your instructor) probably could not hear tone C.

47. What intensity level would be comfortable without ear protection? Like a normal conversation.
    A) Probably somewhere around 5-10 dB.
    B) In the neighborhood of 30-40 dB.
    C) Closest to 60-70 dB.
    D) At least 100 dB, probably 110dB

48. Your cousin is visiting from Tulsa, and she brought her 3 month old baby. Cute, but colicky. You just got back from the Best Buy, where you bought a cool new digital sound meter. Coincidence? I don't think so.
    A) The screaming baby registers no more than 15dB on your most excellent digital device.
    B) Screaming baby comes in at about 30dB.
    C) Screaming baby could hit as high as 90dB.
    D) The baby will probably be screaming at 150dB or even higher. For hours. *And hours.*

49. What is the **Doppler effect**?
    A) The change in the **actual** frequency of a wave. The wave source begins to vibrate at a different frequency.
    B) The change in the **apparent** frequency of a wave because the source of the wave either approaches toward or recedes away from the receiver.
    C) The change in the **actual** frequency of a wave resulting from the pull of gravity on the wave.
    D) The change in the **apparent** frequency of a wave because the source of the wave begins to vibrate with a greater (or smaller) amplitude.

50. When they test the tornado sirens every Wednesday at noon, the sirens (located on top of high poles) rotate 360°, to broadcast the sound in every direction. As you listen, you hear the siren get a bit louder as it rotates **toward** you. Because of the **Doppler Effect**, you **also** hear
    A) the frequency increase slightly.
    B) the frequency decrease slightly.
    C) absolutely no change in the frequency at all.
    D) nothing. The Doppler Effect cancels out the sound.