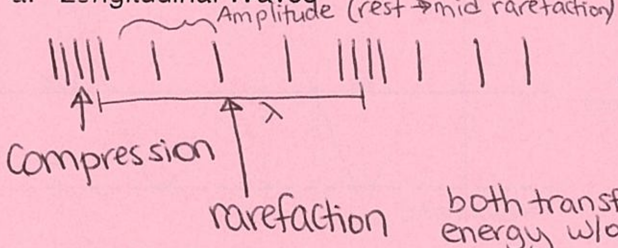
Wave Theory Review

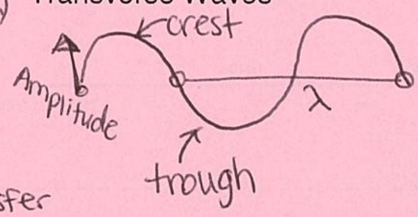
Name: Key

1.) Describe the similarities/difference between the following using words and/or pictures:

a. Longitudinal Waves



Transverse Waves



both transfer energy w/o matter

ex. sound

ex. light, ocean, people, UV, IR, γ

b. Mechanical Waves

require a medium (material) to travel through

ex. sound, ocean

Electromagnetic Waves

do not require a medium to travel through

ex. light, x-rays

c. Period of a Wave

time for one wave

units: second

Frequency of a Wave

\# of cycles per second

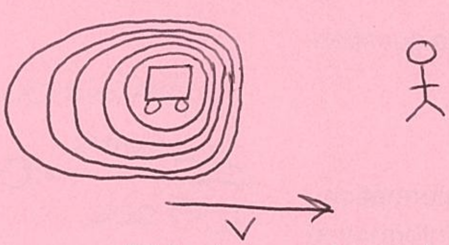
units: $\frac{\text{cycles}}{\text{sec}}$ $\frac{\text{vibrations}}{\text{sec}}$ $\frac{\text{waves}}{\text{sec}}$ $\frac{1}{s}$ Hz

$T = \frac{1}{f}$

$f = \frac{1}{T}$

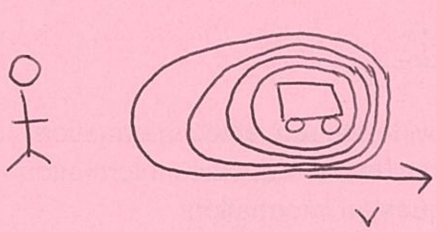
$v = f\lambda$

d. Pitch of a sound wave *approaching* an observer



waves get squished together (λ↓)
frequency goes up
pitch goes up (sounds like a higher note)

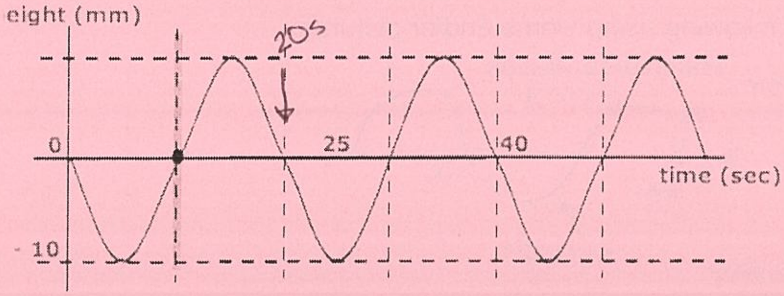
Pitch of a sound wave *traveling away from* an observer



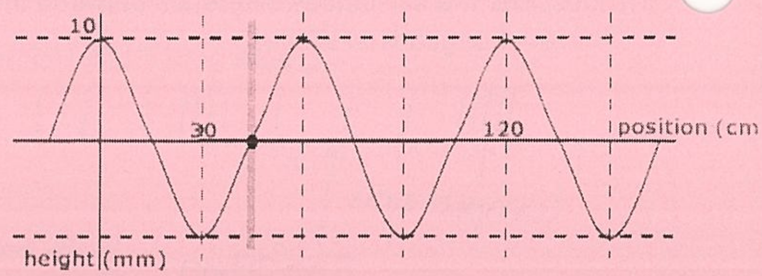
waves are more spread out (λ↑) so frequency decreases, pitch goes down (sounds like a lower note)

2.) Use the two graphs below to answer the questions that follow.

Vibration graph of point R



Waveform graph, taken at t = 10 s (R is at 45 cm)



a. What is the amplitude of this wave? 10mm

height from equilibrium position

Which graph did you use?

(A) Only the vibration graph can provide the requested information
(B) Only the waveform graph can provide the requested information
(C) Either graph can provide the requested information
(D) Information is needed from both graphs to answer this question

b. What is the wavelength of this wave? 60cm

distance from crest to crest

Which graph did you use?

(A) Only the vibration graph can provide the requested information
(B) Only the waveform graph can provide the requested information
(C) Either graph can provide the requested information
(D) Information is needed from both graphs to answer this question

c. What is the period of this wave? 20 sec

time for one wave

Which graph did you use?

(A) Only the vibration graph can provide the requested information
(B) Only the waveform graph can provide the requested information
(C) Either graph can provide the requested information
(D) Information is needed from both graphs to answer this question

d. What is the frequency of this wave? 0.05Hz

definition: $\frac{3 \text{ waves}}{60 \text{ sec}} = 0.05 \text{ Hz}$

Which graph did you use?

(A) Only the vibration graph can provide the requested information
(B) Only the waveform graph can provide the requested information
(C) Either graph can provide the requested information
(D) Information is needed from both graphs to answer this question

OR: $f = \frac{1}{T} = \frac{1}{20s}$

e. What is the wave's speed? 3 cm/s

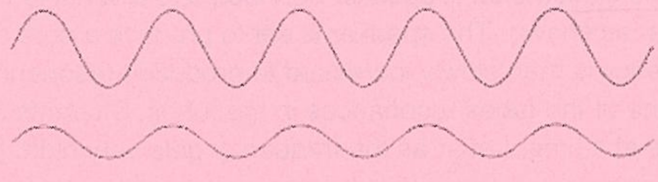
Which graph did you use?

(A) Only the vibration graph can provide the requested information
(B) Only the waveform graph can provide the requested information
(C) Either graph can provide the requested information
(D) Information is needed from both graphs to answer this question

$V = f\lambda = (0.05 \text{Hz})(60 \text{ cm})$

$V = 3 \text{ cm/s}$

3.) The following waves travel through the <u>same medium.</u>



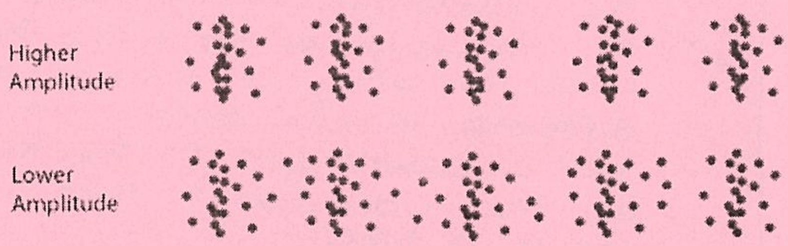
a. Describe how the velocity of each of the above waves compare. Explain why.

the velocity of each wave is the same because they are traveling through the same medium (λ and f are the same here too)

b. Describe how the velocity of the particles within each of the above waves compare. Explain why.

the particles in the top wave must be traveling faster - they have a greater amplitude - and ∴ greater energy. They must move faster since the A (distance traveled) is larger and frequency/time/speed of wave are all the same.

4.) The following waves travel through the same medium.

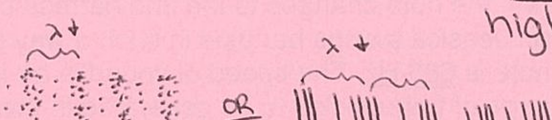


a. Describe how the above waves compare if they are specifically *sound* waves. Explain why.

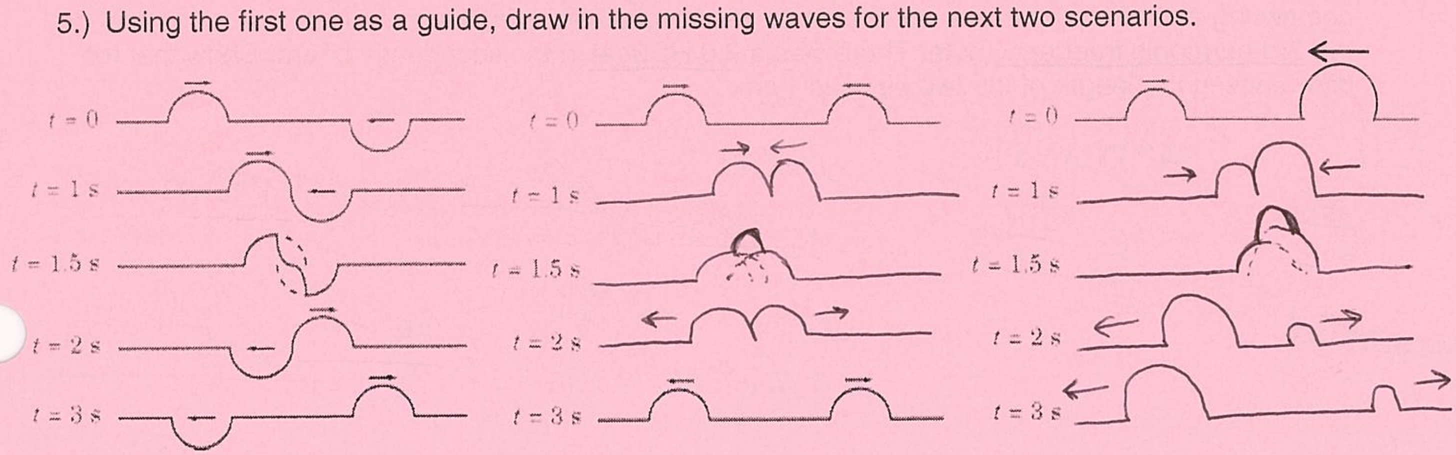
higher amplitude sounds louder - more energy in the particles

b. Draw how the sound wave would look if it was a <u>higher pitch.</u>

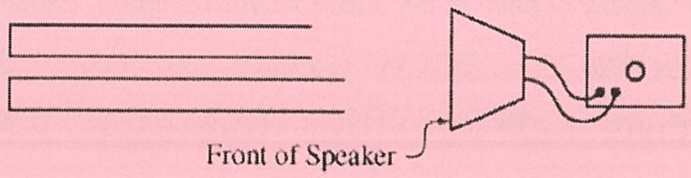
higher frequency, smaller λ



5.) Using the first one as a guide, draw in the missing waves for the next two scenarios.



6.) The figure below shows two tubes that are identical except for their slightly different lengths. Both tubes have one open end and one closed end. A speaker connected to a variable frequency generator is placed in front of the tubes, as shown. The speaker is set to produce a note of very low frequency and then turned on. The frequency is then slowly increased to produced resonances in the tubes. Students observe that at first only one of the tubes resonances in the tubes. Students observe that at first only one of the tubes resonates at a time. Later, as the frequency gets very high, there are times when both tubes resonate.

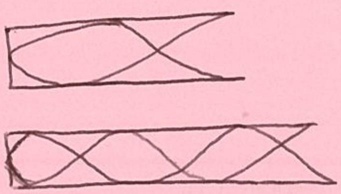


In a clear, coherent, paragraph-length answer, explain why there are some high frequencies, but no low frequencies, at which both tubes resonate. You may include diagrams and/or equations as part of your explanation.

one open/one closed:

$f_0 = \frac{V}{4L}$ ($\frac{1}{4}\lambda$)

$f_3 = \frac{3V}{4L}$ $f_5 = \frac{5V}{4L}$



In order to resonate, the length of a tube must be an odd multiple of a quarter wavelength of the sound (as seen to the left). For resonance at low frequencies, the wavelength of the sound is on the order (λ is larger) of the length of the tubes. So the match can occur for only one tube at a time - the difference in tube lengths is much smaller than half a wavelength. As the frequency goes up, the λ decreases, so more waves can fit inside a tube.

(when the λ gets small enough (like the difference in length value) then both tubes can contain odd multiples of ~~quarter~~ λs and can both resonate - for instance 17 ¼ λs and 19 ¼

7.) USING A PIPE TO MAKE MUSIC - A child's toy consists of a long, flexible, plastic pipe, open at both ends. Holding the pipe at one end, the other end can be swung around so that a standing wave is set up in the pipe, and a musical note heard. If the pipe is swung slowly the 1st harmonic frequency is heard. If the pipe is swung at a faster speed, the note changes to the 2nd harmonic frequency. Even faster swinging produces the 3rd harmonic. Jessica swings her pipe in such a way that the 3rd harmonic is heard. The frequency of the note is 685 Hz. The speed of sound in air is 3.4×10^2 m/s. Swinging the pipe causes waves with a range of frequencies to be generated in the pipe. 340 m/s

3rd harmonic

Joe swung a similar pipe at the same time as Jessica was swinging hers, and his pipe also produced the 3rd harmonic frequency note. There was a 9.0 Hz beat in the sound they heard. Show that the difference in the length of the two pipes is 1 cm.

Open

$f_0 = \frac{V}{2L}$

fundamental

3rd harmonic:

$f_3 = \frac{3V}{2L}$

Jessica:

$f_3 = 685\text{Hz} = \frac{3(340\text{m/s})}{2L}$ $L = 0.745\text{m}$

Joe:

beat

$f_3(685\text{Hz} + 9\text{Hz}) = \frac{3(340\text{m/s})}{2L}$ $L = 0.735\text{m}$

$\Delta L = 0.01\text{m} = 1\text{cm}$ ✓