Physics 200
Waves quiz practice problems

Name: Key

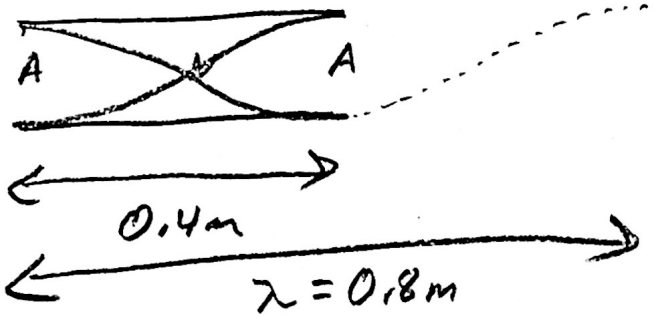
The quiz will have two practice problems. Each will relate to the fundamental frequency of one of the following:

- a pipe open at one end;
- a pipe open at both ends;
- a pipe closed at both ends;
- a string fixed at both ends.

Some helpful steps for solving these problems:

1. Draw a picture of the pipe or string. Include its length, if given.
2. At the two ends of the pipe or string...
    a. Add nodes wherever the pipe is closed or the string is "fixed."
    b. Add antinodes wherever the pipe is open or the string is "free."
3. To find the fundamental frequency, draw waves to connect the two ends with the fewest number of nodes and antinodes. Remember that Antinodes and nodes must alternate.
4. Find the wavelength of the sound wave, in terms of the length of the string or pipe. To do this, compare the pipe or string length to the wavelength of the wave that you drew.
5. Use the wave speed formula ($v=f\lambda$)
    a. Plug in the wavelength
    b. If you have the frequency, plug it in
    c. If the problem relates to a pipe...
        i. Find v using the formula involving temperature. Then plug v into the equation. or...
        ii. Solve for v and use it to find temperature (with the aforementioned formula)
6. You might possibly need $d=rt$.

Practice Problem #1. Some students want to make a 0.4m long pipe, open at both ends, resonate at its fundamental frequency. If the air temperature is 22 degrees Celsius, what frequency sound waves do the students need to project into the pipe?



$$v = 331.3\sqrt{1+\frac{22}{273.15}}$$

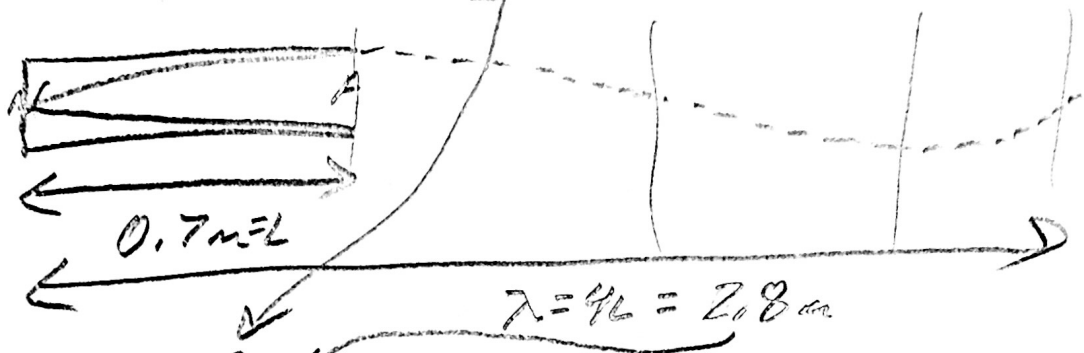
$$v = 344.4\ m/s$$

$$v = f\lambda \quad (\lambda = 0.8\ m)$$

$$344.4\ m/s = f(0.8\ m)$$

$$f = 431\ Hz$$

Practice Problem #2. On a different day, students use a 0.7m long pipe, open at one end and closed at the other, to find the speed of sound. Using a tone generator, they play sounds at the open end of the pipe, starting at a frequency of 0Hz, and they increase the frequency until the pipe begins to resonate. If the pipe resonates when their sound frequency is 145Hz, what is the temperature of the air?



$\lambda = 4L = 2.8\,m$

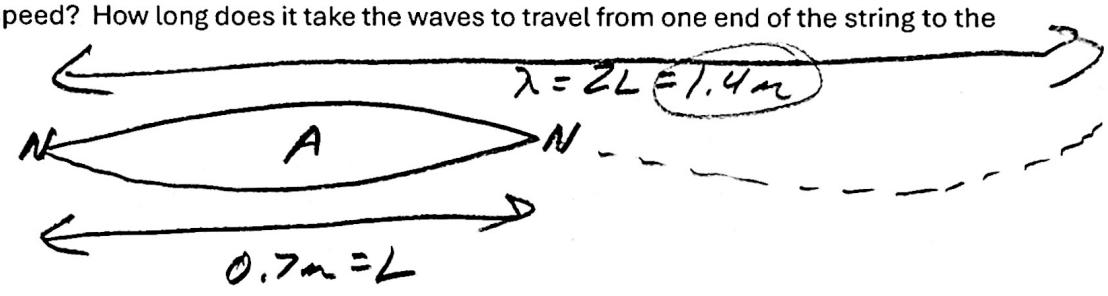
$V = f\lambda$

$V = 406\,m/s$

$406 = 331.3\sqrt{1+\frac{T}{273.15}}$

$T = 137^{\circ}C$ — hot!

Practice Problem #3. A student plucks a 0.7m long cello string, and the string vibrates at its fundamental frequency of 98Hz. If the string is fixed at both ends, how long is the string's wavelength? What is the string's wave speed? How long does it take the waves to travel from one end of the string to the other?



$V = \lambda f = 1.4\,m\,(98\,Hz) = 137.2\,m/s$

$d = rt$

$0.7\,m = 137.2\,m/s\,(t)$

$t = 5.1 \times 10^{-3}\,s$