Name: _____ Date: _____

Block: ____

Sound

f = frequency (in Hz)
T = period (in seconds)
v = speed of sound (and T is the temperature) (no T, assume v = 330 m/s)
β = is the intensity level of sound in dB
I = is the intensity of sound in W/m^2
L = is the length of a string or open-tube for a musical instrument
f' = is the Doppler frequency
v_s = is the velocity of the sound source (+ toward / - away)

$$f = \frac{1}{T} \qquad T = \frac{1}{f} \qquad v = \lambda f \qquad v = (330 + 0.60T)m/s \qquad \beta = 10\log\left(\frac{I}{I_o}\right)$$

$$f = \frac{v}{2L} \qquad f' = \frac{f}{\left(1 - \frac{v_s}{v}\right)} \qquad f_{beat} = |f_1 - f_2|$$

1. A hiker determines the length of a lake by listening for the echo of her shout reflected by a cliff at the far end of the lake. She hears the echo 1.5 s after shouting. Estimate the length of the lake.

2. Calculate:
   a. The wavelengths in air at 20ºC for sounds in the maximum range of human hearing, 20 Hz to 20,000 Hz.

   b. What is the wavelength of a 10-MHz ultrasonic wave?

3. A person sees a heavy stone strike the granite pavement. A moment later two sounds are heard from the impact: one travels in the air and the other in the granite, and they are 1.4 s apart. How far away did the impact occur?

4. What is the intensity level of a sound whose intensity is 1.0×10^{-6} W/m^2?

5. At a recent rock concert, a dB meter registered 130 dB when placed 2.5 m in front of a loudspeaker on the stage.
    a. What was the power output of the speaker, assuming uniform spherical spreading of the sound and neglecting absorption in the air? (Surface area of a sphere is $4\pi r^2$)

    b. How far away would the intensity level be a somewhat reasonable 90dB?

6. Determine the length of an open organ pipe that emits middle C (262 Hz) when the temperature is 21ºC?

7. Calculate:
    a. The resonant frequency if you were to blow across the top of an empty soda bottle that is 15 cm deep.

    b. How would that change if it was one-third full of soda?

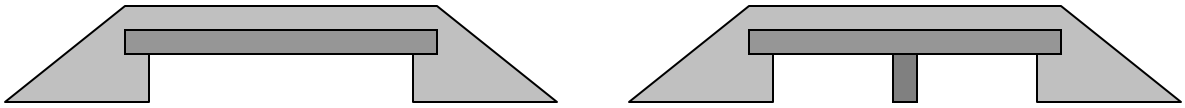
8. If you were to build a pipe organ with open-tube pipes spanning the range of human hearing (20Hz to 20kHz), what would be the range of the lengths of pipes required?

9. An organ pipe is 112 cm long. What are the fundamental and first three audible overtones if the pipe is open at both ends?

10. At T=15ºC, how long must a closed organ pipe be if it is to have a fundamental frequency of 294 Hz?

11. How many overtones are present within the audible range for a 2.44-m-long organ pipe at 20ºC if it is open at both ends?

12. A highway overpass was observed to resonate as one full loop when a small earthquake shook the ground vertically at 4.0 Hz. The highway department put a support at the center of the overpass, anchoring it to the ground as shown below. What resonant frequency would you now expect for the overpass? It is noted that earthquakes rarely do significant shaking above 5 or 6 Hz. Did the modifications do any good?



13. A piano tuner hears one beat every 2.0 s when trying to adjust two strings, one of which is sounding 440 Hz, so that they sound the same tone. How far off in frequency is the other string?

14. What will be the "beat frequency" if middle C (262 Hz) and $C^{\#}$ (277 Hz) are played together? Will this be audible? What if each is played two octaves lower (each frequency reduced by a factor of 4)?

15. The predominant frequency of a certain police car's siren is 1800 Hz when at rest. What frequency do you detect if the police car moves (a) toward you at 30.0 m/s and (b) away from you at 30 m/s?

16. You look directly overhead and see a plane exactly 1.5 km above the ground flying faster than the speed of sound. By the time you hear the sonic boom, the plane has traveled a horizontal distance of 2.0 km.
    a. Find the angle of the shock cone, θ.
    b. Find the speed of the plane (the Mach number).