

# PHYSICS 1020

## Homework #2

(Due Feb. 11, 2019)

1. What is the frequency of the 5th harmonic standing wave in a string that is fixed at both ends, if the string is fixed at both ends and the length of the string is 80 cm? The string is under a tension of 45.0 N, and the mass of the string is 1.6 grams.

2. (KJF 15-21) The contrabassoon is the wind instrument capable of sounding the lowest pitch in the orchestra. It is folded over several times to fit its impressive 18 ft length into a reasonable size instrument.

(a) If we model the instrument as an open-closed tube, what is its fundamental frequency? The sound speed inside is 350 m/s because the air is warmed by the player's breath.

(b) The actual fundamental frequency of the contrabassoon is 27.5 Hz, which should be different from your answer in part (a). This means the model of the instrument as an open-closed tube is a bit too simple. But if you insist on using that model, what is the "effective length" of the instrument?

3. An acoustic guitar has 6 strings, numbered from 1 (thinnest string, on the bottom of the guitar) to 6 (thickest string, at the top of the guitar). The table below shows, for each string, the "open" note played (first harmonic) and linear density of each string. The distance between the bridge and neck of the guitar (the vibrating part of the string) is 633 mm. From this information, find, for each string: (a) the wave speed, and (b) the tension required to produce the indicated note.

String	Note	Freq. (Hz)	Lin. density (g/m)
1	E <sub>5</sub>	659.26	0.0976
2	B <sub>4</sub>	493.88	0.1319
3	G <sub>4</sub>	392.00	0.2185
4	D <sub>4</sub>	293.66	0.5027
5	A <sub>3</sub>	220.00	0.7946
6	E <sub>3</sub>	164.81	1.4249

4. (KJF 14-28) Some pipe organs create sounds lower than humans can hear. This “infrasound” can still create physical sensations. What is the fundamental frequency of the sound from an open-open pipe that is 32 feet long (a common size for large organs)? What length of open-closed tube is necessary to produce this note? Assume a sound speed of 343 m/s.
5. (KJF 15-1) The wave speed on a string under tension is 200 m/s. What is the speed if the tension is doubled?
6. (KJF 15-17) A traveling wave has displacement given by  $y(x, t) = (2.0 \text{ cm}) \times \cos(2\pi x - 4\pi t)$ , where  $x$  is measured in cm and  $t$  in s.
- (a) Draw a snapshot graph of this wave at  $t = 0$  s.
  - (b) On the same set of axes, use a dotted line to show the snapshot graph of the wave at  $t = 1/8$  s.
  - (c) What is the speed of the wave?
7. (KJF 15-43) A rock band playing an outdoor concert produces sound at 120 dB 5.0 m away from their single working loudspeaker. What is the sound intensity level 35 m from the speaker?
8. (KJF 15-51) A friend of yours is loudly singing a single note at 400 Hz while driving toward you at 25.0 m/s on a day when the speed of sound is 340 m/s.
- (a) What frequency do you hear?
  - (b) What frequency does your friend hear if you suddenly start singing at 400 Hz?