Homework 2 (EAS 4803: Planetary Sound - SPRING SEMESTER 2020)

Total points: 100; Due 01/24/2020

1. [20] Car A moves at 72 km/h and car B moves at 90 km/h, approach each other. Car A honked with a frequency of 650 Hz. If the speed of the sound waves in air is 350 m/s, then what is the frequency of sound heard by the driver of car B from car A. What would be the sound frequency (heard by the driver of car B from car A) when both cars pass each other?

ANS: The speeds of both cars are 20 and 25 m/s. Frequency of sound by driver of car B from car A: $f_L = f_s\,(v + v_L)/(v - v_S) = 650$ Hz $(350 + 25)/(350 - 20) = 738.6$ Hz

If they pass each other, the $f_L = f_s\,(v - v_L)/(v + v_S) = 650$ Hz $(350 - 25)/(350 + 20) = 570.9$ Hz

2. [30] For a source that is generating a monotonic frequency of 1000 Hz, please calculate the observed frequencies for the four cases with the following speeds (0, 100, 200, 300, 400, 500, 600 m/s): source moving towards the receiver, source moving away from the receiver, observer moving towards the source, observer moving away from the source. Please generate one figure with horizontal axis as the speed of source or receiver, and y-axis as the observed frequency, and include all four cases. In addition, please comment on what will happen to the observed frequency when the source moving towards the observer at speed approaching to the sound speed.

ANS: assume that the sound wave in air is 350 m/s.

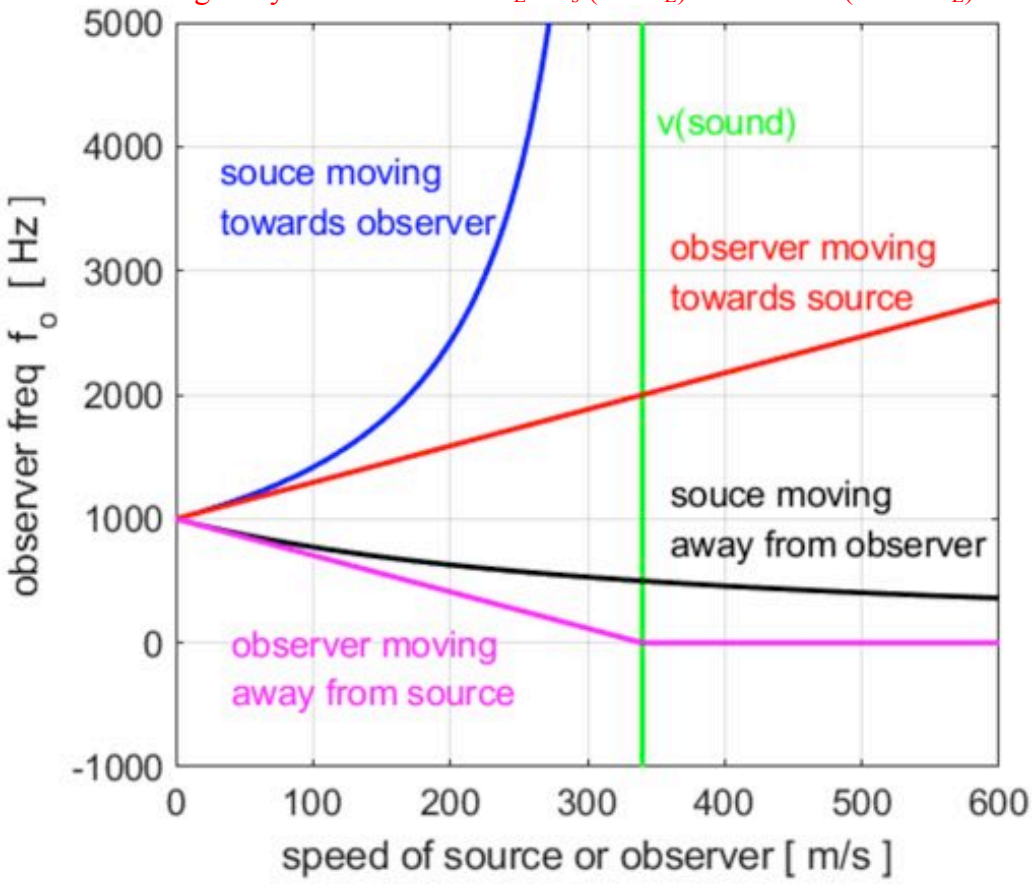
Equation:

source moving towards the receiver $f_L = f_s\,v/(v - v_S) = 1000 \times 350/(350 - v_S)$ (Note: $v_S <= 350$ m/s)

source moving away the receiver $f_L = f_s\,v/(v + v_S) = 1000 \times 350/(350 + v_S)$

observer moving towards the source $f_L = f_s\,(v + v_L)/v = 1000 \times (350 + v_L) / 350$

observer moving away from the source $f_L = f_s\,(v + v_L)/v = 1000 \times (350 + v_L) / 350$



From http://www.physics.usyd.edu.au/teach_res/hsp/sp/mod31/doppler.pdf

3. [30] Consider an 80-cm long guitar string that has a fundamental frequency (the first harmonic) of 400 Hz. Please compute
a. the wavelength of the standing wave corresponding to the 400-Hz fundamental frequency;
ANS: the fundamental-mode standing wave would have a wavelength that is twice the length of the guitar string: 160 cm.
b. the speed of the fundamental mode standing wave;
ANS: the speed $v = \lambda / T = \lambda \times f = 1.6$ m x 400 Hz = 640 m/s
c. please compute the wavelength of the second and third harmonic waves;
ANS: the wavelength of the second and third harmonic waves would be equal to the length L 0.8 m and 2/3 L = 0.53 m
d. please compute the corresponding frequency of the second and third harmonic waves;
ANS: $f = v / \lambda$ = 640 / 0.8 = 800 Hz, and 1200 Hz

e. what happens to the speed for the second and third harmonic waves?
ANS: the speed remains the same (controlled by the material property)

4. [20] The 2004 magnitude 9.2 Sumatra earthquake ruptured about 1500 km of the subduction zone within about 10 minutes. The event started at the epicenter near the equator, and ruptured unilaterally to the north (bottom left).
a. Based on this information, please compute on the rupture speed (i.e., how fast does the rupture propagates along the fault interface) in the unit of km/s.
ANS: rupture speed V_R = total length of rupture L / rupture duration T = 1500 km/600 s = 2.5 km/s
b. Is the 2004 Sumatra earthquake a supershear rupture or not? Why?
ANS: No. Local S wave speed is about 3-3.5 km/s. Besides, it is a thrust event, and supershear rupture can only occur along strike-slip faults.
c. If we have seismometers around the world, where do we observe stronger ground motions but with shorter durations, and where do we observe weaker ground motions and long durations? Why?
ANS: We would observe weaker ground motions and long durations south of the rupture zone (in the opposite direction of rupture propagation).
d. If the 1906 magnitude 7.8 San Francisco earthquake is a supershear rupture event (bottom right), and the total rupture length is about 477 km, please provide a rough estimate on the total duration of the rupture. ANS: Expect rupture speed V_R = 1.414 x Vs = 4.7 km/s. T_R = 477 km/4.7 km/s = 101 s