Q1- Two loudspeakers emit 430 Hz notes. One speaker sits on the ground. The other speaker is in the back of a pickup truck. You hear 9 beats per second as the truck drives away from you. What is the truck's speed?

When two waves of different frequencies n_1 and n_2 traveling in same direction are present in the medium they produces beat (change in intensity from maximum to minimum and minimum to maximum repeatedly). The beat frequency is equal to the difference of frequencies of the two wave n_1 - n_2. The frequency of the wave received from the stationary source will be the same as that of the source which is $n_1 = n = 430$ Hz.

The frequency of the wave received from the receding source is given by using Doppler's effect as

$$n_2 = n\frac{v}{v+v_s} = 430\left(\frac{340}{340+v_s}\right)$$

Here v = 340 m/s is the speed of sound in air and v_s is the speed with which the truck drives away.

As the beat frequency is 9 per second we have

$$n_2 - n_1 = 430 - 430\left(\frac{340}{340+v_s}\right) = 9$$

Or $$\left(\frac{v_s}{340+v_s}\right) = \frac{9}{430}$$

Gives $$v_s = \frac{9*340}{421} = 7.27 \text{ m/s}$$

Q2- A balloon driven by a 35 km/h wind emits a sound of 860 Hz as it approaches a tall building.

(a) What is the frequency of the sound heard by an observer at the window of this building?

Using Doppler's effect the apparent frequency of the sound emitted by an approaching source of frequency n is given by

$$n' = n\left(\frac{v}{v-v_s}\right)$$

Where v is the wave velocity and v_s is the velocity of the source.

Hence the frequency heard by the the observer at window is given by

$$n' = n\left(\frac{v}{v-v_s}\right) = 860\left(\frac{340}{340-9.72}\right) = 885.31 \text{ Hz}$$ [35 km/h = 35*5/18 m/s = 9.72 m/s]

(b) What is the frequency of the reflected sound heard by a person riding in the balloon?

The waves of frequency n' reaching the building reflected with the same frequency n' and hence the walls now behaves as stationary source of frequency n'. The person riding in the balloon is now approaching to the source with velocity v_L = 9.72 m/s and hence the frequency heard by him is given by using Doppler's effect as

$$n'' = n'\left(\frac{v+v_L}{v}\right) = 885.31\left(\frac{340+9.72}{340}\right) = 885.31*\frac{349.72}{340} = 910.62 \text{ Hz}$$