6) Temperature and the Speed of Sound

The speed of sound is affected by temperature in a given medium. For air at sea level, the speed of sound is given by:

$$v = 331\sqrt{\frac{273.15+T}{273.15}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5.6)$$

Or

$$v = 331 + (0.6T) \quad \ldots\ldots\ldots\ldots \quad (5.7)$$

where the temperature is in degrees Celcius.

Example 3

Calculate the wavelengths of sounds at the extremes of the audible range, 20 and 20,000 Hz, in 30.0°C air.

Example 4

Show that the speed of sound in 20.0ºC air is 343 m/s

Example 5

What frequency sound has a 0.10 m wavelength when the speed of sound is 340 m/s?

7) Air pressure and the Speed of Sound

The speed of sound is unaffected by air pressure in a given medium. Because any change in air pressure makes a change in its volume. If the density of the air is:

$$\rho = \frac{m(Mass)}{V(Volume)}$$

Then according to the Boyle's law:

$$PV = Constant$$

$$P\left(\frac{m}{\rho}\right) = \frac{P}{\rho} = another\ Constant$$

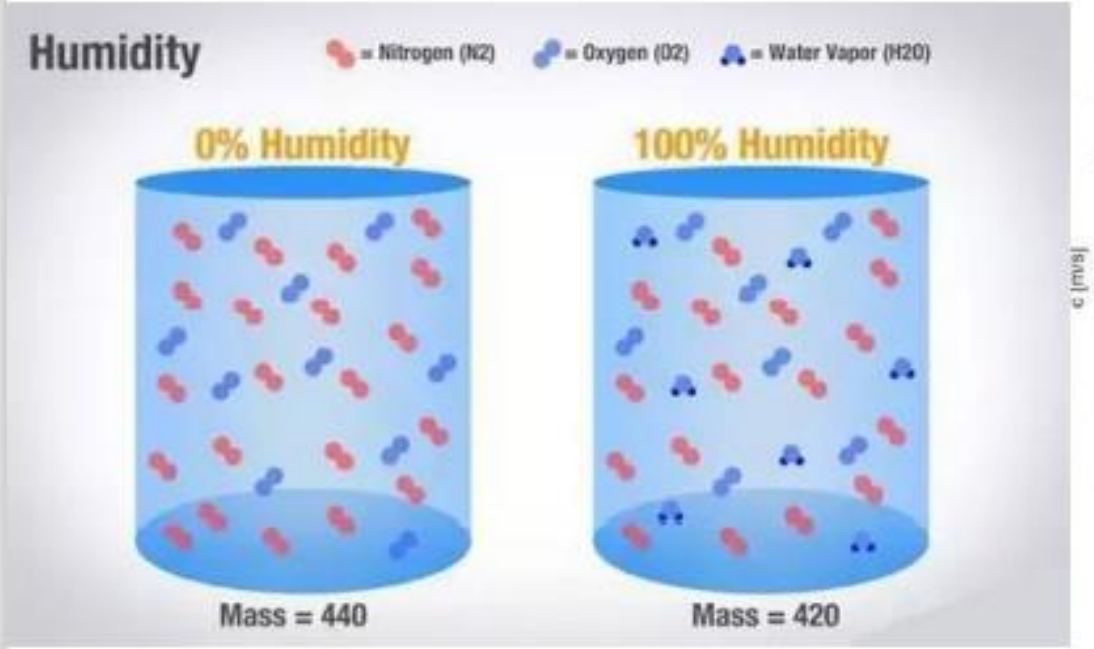
According to equation (5.2)

$$v = \sqrt{\frac{P}{\rho}} = \text{Constant}$$

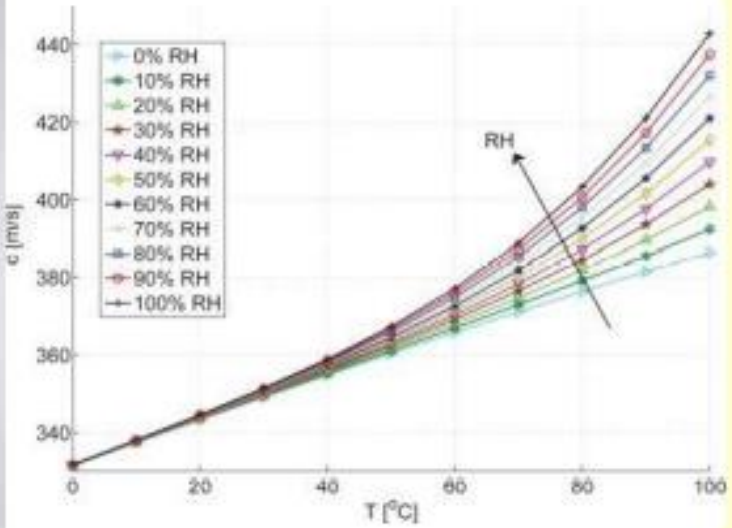
So, at a constant temperature, the gas pressure has no effect on the speed of sound.

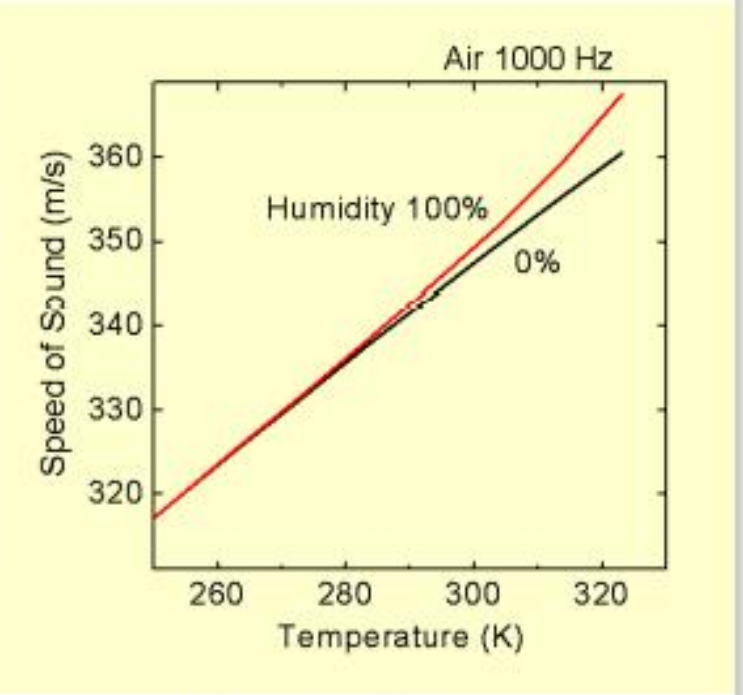
8) Air humidity and the Speed of Sound

The attenuation of sound in air is affected by the relative humidity. Dry air absorbs far more acoustical energy than does moist air. This is because **moist air is less dense than dry air** (water vapor weighs less than air).



Moist air is lighter than dry air





Speed of sound vs. temperature and relative humidity

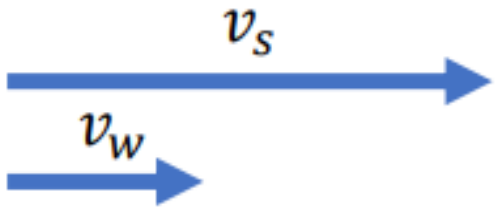
9) Wind direction and the Speed of Sound

Generally, the speed of the wind v_w relative to the speed of sound v_s has three situation:

(a) Same direction

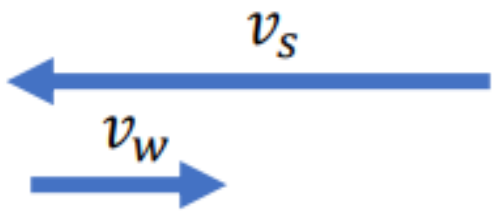
(b) Opposite direction

(c) The sound direction is perpendicular to the wind direction.



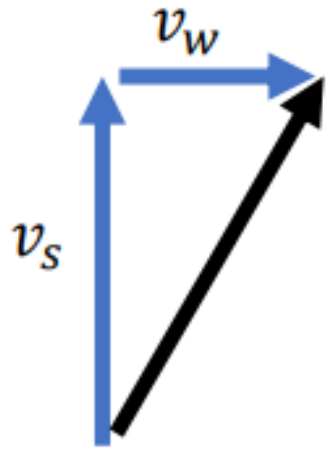
$$v_{Total} = v_s + v_w$$

(a)



$$v_{Total} = v_s - v_w$$

(b)

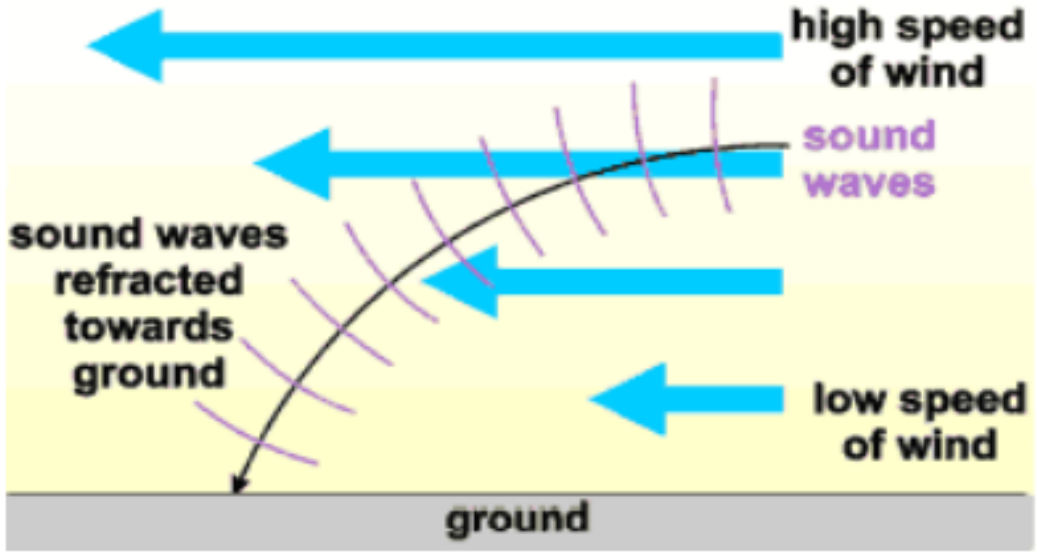


$$v_{Total} = \sqrt{v_s^2 + v_w^2}$$

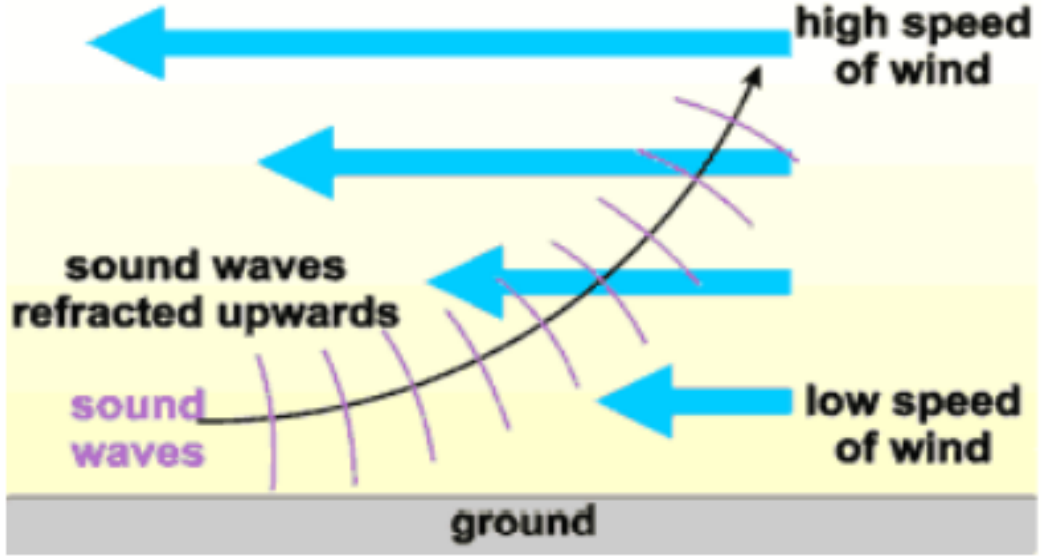
(b)

Why can a distant sound be heard easier when it travels with the wind? Why does it become weaker if it travels against the wind?

Answer: When sound wave travels against the wind, that is, when it travels in the opposite direction with the wind, the speed of sound will be reduced by the wind speed, resulting in a lower speed in the upper region. According to the principle mentioned above, sound wave will be refracted upwards, and hence it cannot easily reach a distant person



Sound wave will be refracted to the ground when traveling with the wind.



Sound wave will be refracted upwards when traveling against the wind.

http://www.hk-phy.org/iq/sound_wind/sound_wind_e.html

Factors affecting velocity of sound in gases (Summery)

(a) Effect of density: Velocity of sound in gas is inversely proportional to the square root of density of the gas.

$$v_{air} = \sqrt{\frac{\gamma P}{\rho}}$$

(b) Effect of Temperature:- With increase in temperature velocity of sound in a gas increases $v \propto T$. (***T in Kelvin***)

$$v = \sqrt{\frac{\gamma RT}{\rho V}} = \sqrt{\frac{\gamma RT}{M}}$$

(c) Effect of Pressure : At a constant temperature, the gas pressure has no effect on the speed of sound

(d) Effect of relative humidity: When humidity increases, there is an increase in the relative number of water molecules and hence a decrease in the molar mass (avg. molecular wt.), and the speed of sound increases.

(e) The direction of wind: Direction of wind also affect the velocity of sound. The velocity of sound is higher in the direction of wind and slower in the opposite direction of the wind.

Note: The speed of sound in air is not affected by amplitudes, frequency, phase, loudness, pitch, air pressure or quality-Factor affecting Velocity of Sound

http://www.quantumstudy.com/physics/waves-9/

The speed of sound in medium depends upon
1. amplitude
2. frequency
3. wavelength
4. properties of the medium

Which of the following will remain unchanged when a sound wave travels in air or in water?
1. Amplitude
2. Wavelength
3. Frequency
4. Speed

A source of frequency of 500 Hz emits waves of wavelength 0.4 m, how long does the waves take to travel 600 m?
1. 3 sec
2. 6 sec
3. 9 sec
4. 12 sec

An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the sending and receiving of the wave is 1.6sec. What is the depth of the sea, if the velocity of sound in the seawater is 1400m/sec?

1. 1120 m
2. 560 m
3. 1400 m
4. 112 m

Which of the following quantities is transferred during wave propagation?

1. Speed
2. Mass
3. Matter
4. Energy

If a vibrator strikes the water 10 times in one second, then the frequency of wave is _____.

1. 10 Hz
2. 0.5 Hz
3. 5 Hz
4. 0.1 Hz