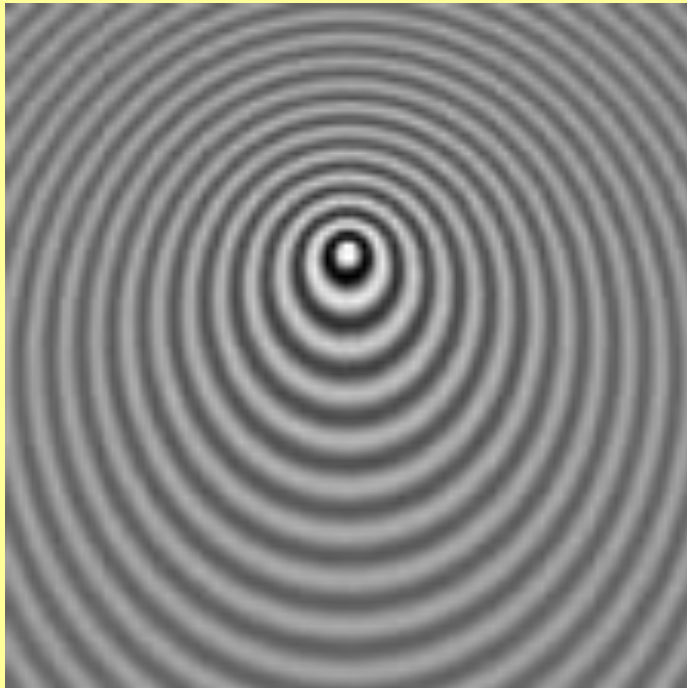


# The Doppler Effect



# Frequency and Pitch

- Pitch is the characteristic of a sound that depends on the frequency the ear receives. Pitch is associated principally with the fundamental frequency of the sound wave.

# The Doppler Effect

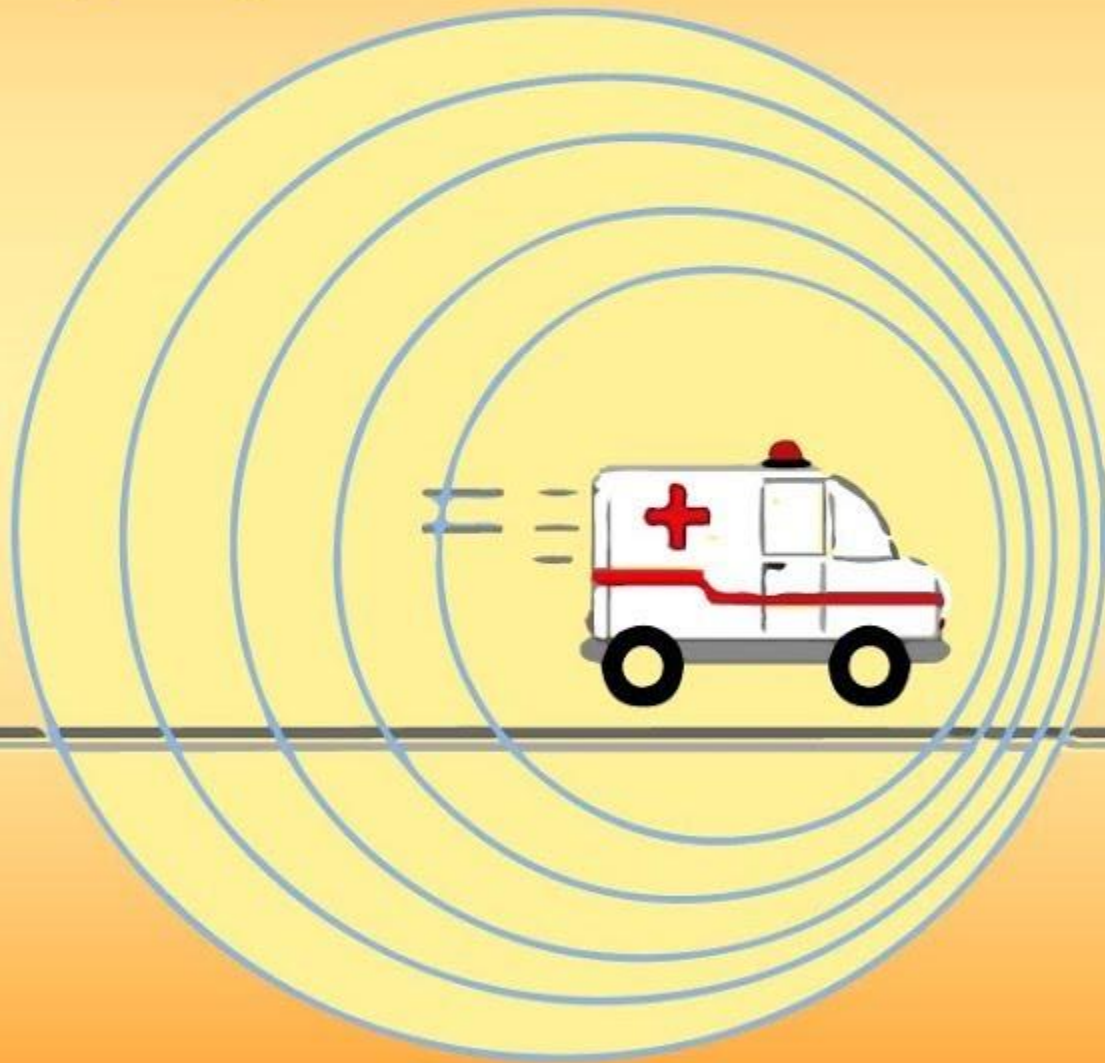
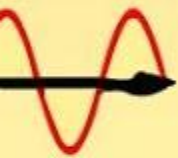
- Named for Christian Johann Doppler who lived from 1803 to 1853
- In general, a Doppler Effect is experienced whenever there is relative motion between the source and the observer.

- When the source and observer are moving toward each other, the frequency heard by the observer is higher than the frequency of the source.

- When the source and observer are moving away from each other, the frequency heard by the observer is lower than the frequency of the source.

# Doppler Effect

Low Frequency



# Formula

- + observer toward source
- observer away from source

$$f = f_o \left( \frac{v \pm v_o}{v \mp v_s} \right)$$

- source toward observer
- + source away from observer



$v$  : velocity of sound

1. A sound source with a frequency of 790Hz moves away from a stationary observer at a rate of 15m/s. What frequency does the observer hear? The speed of sound is 340m/s.

In this scenario the Doppler effect is described by the following equation.

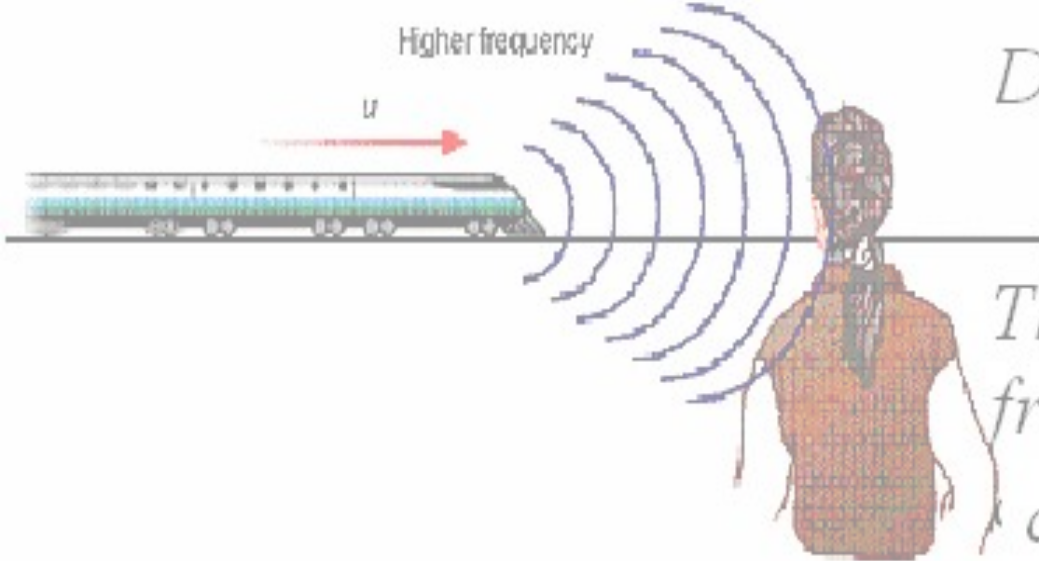
$$f_o = f_s \left( \frac{v + v_o}{v + v_s} \right)$$

Using the values from the problem, we know that  $v_o$  is zero and  $v_f$  is 15m/s.  $v$  is 340m/s and  $f_s$  is 790Hz.

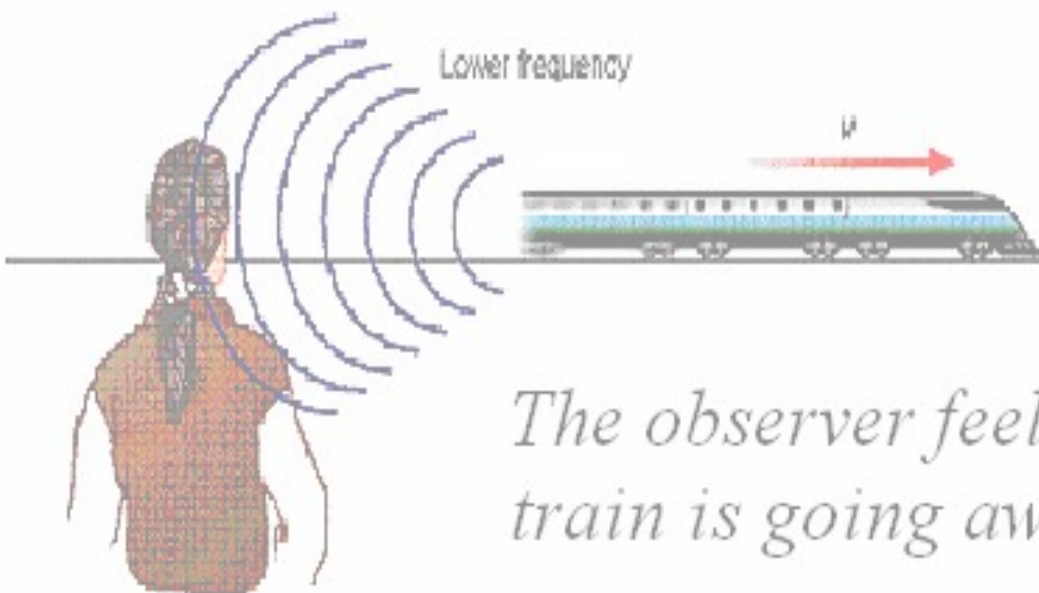
$$\text{substituting } f_o = 790 \text{ Hz} / (340 \text{ m/s} + 0 \text{ m/s}) / (340 \text{ m/s} + 15 \text{ m/s}) = 757 \text{ Hz}$$



## Doppler Effect



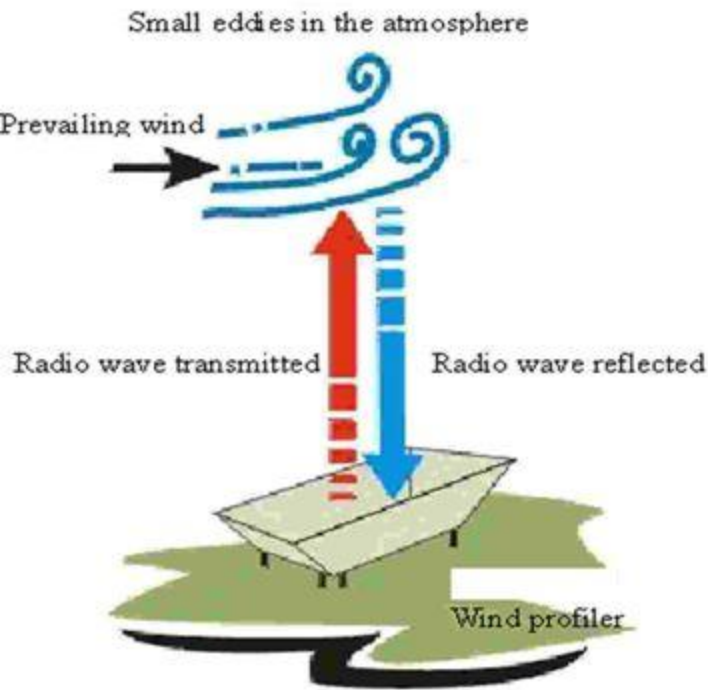
*The observer feel higher frequency ,when the train is coming to the observer.*



*The observer feel lower frequency when the train is going away from the observer.*

# Applications of Doppler Effect

## ➤ Radar Guns



Working principle of wind profiler



## Doppler measurement of wind speed

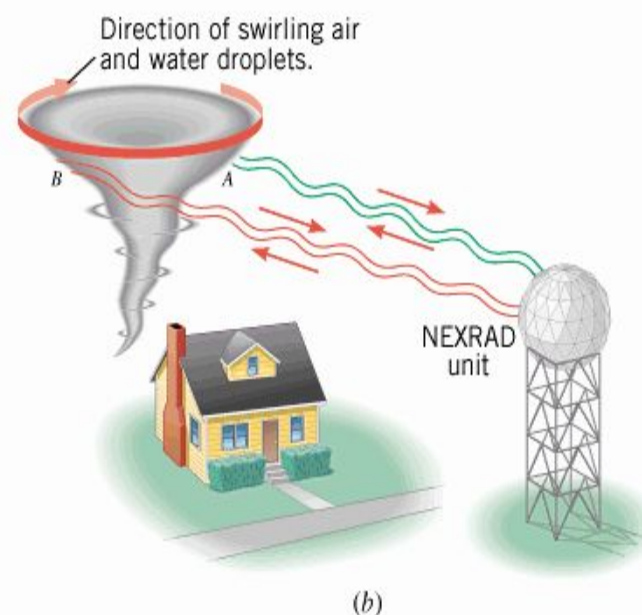


# Application of Doppler Effect

## Nexrad: Next Generation Weather Radar



(a)



(b)

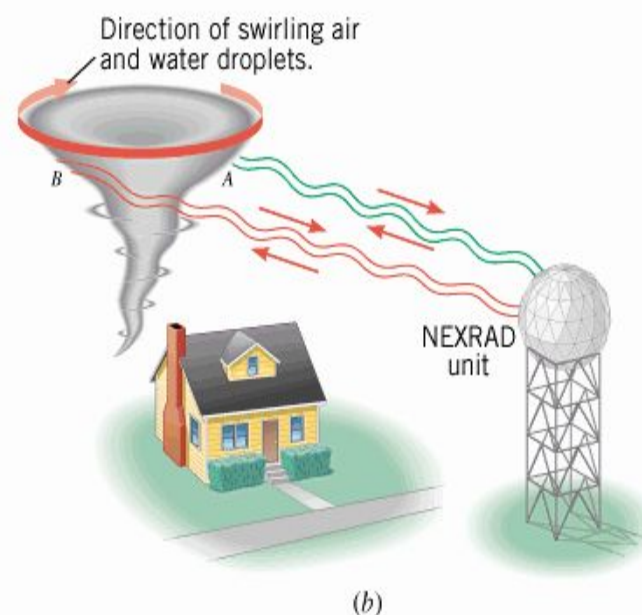


# Application of Doppler Effect

## Nexrad: Next Generation Weather Radar

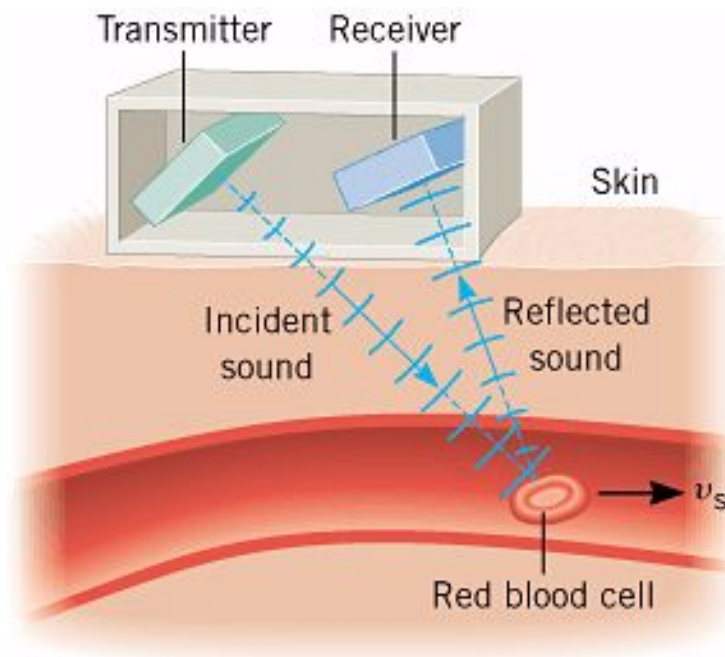


(a)



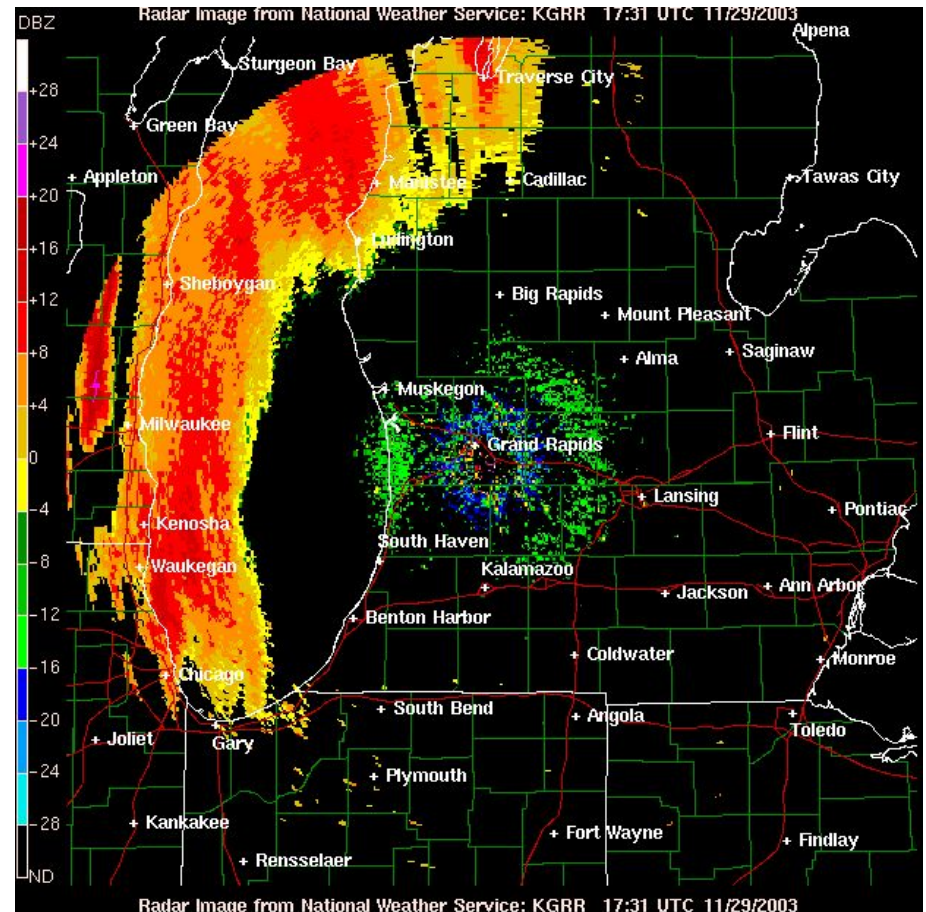
(b)

# Doppler Flow Meter



A Doppler flow meter measures the speed of red blood cells.

# Application: weather radar



Both humidity (reflected intensity) and speed of clouds (doppler effect) are measured.

# Applications of Doppler Effect (Radar Speed Trap)

- The police monitor the speeds of vehicles with radar gun. The radar gun send microwaves towards the car. The wave reflected back to the gun have a higher frequency because of the Doppler effect.
- The microwave receiver in the radar gun detects the difference in frequency  $\Delta f$  between the emitted signal and the received signal.
- The speed of the car is calculated from this, and displayed automatically on a screen.



*A speed trap in action.*