approaching each other: $f_{obs} > f_{src}$

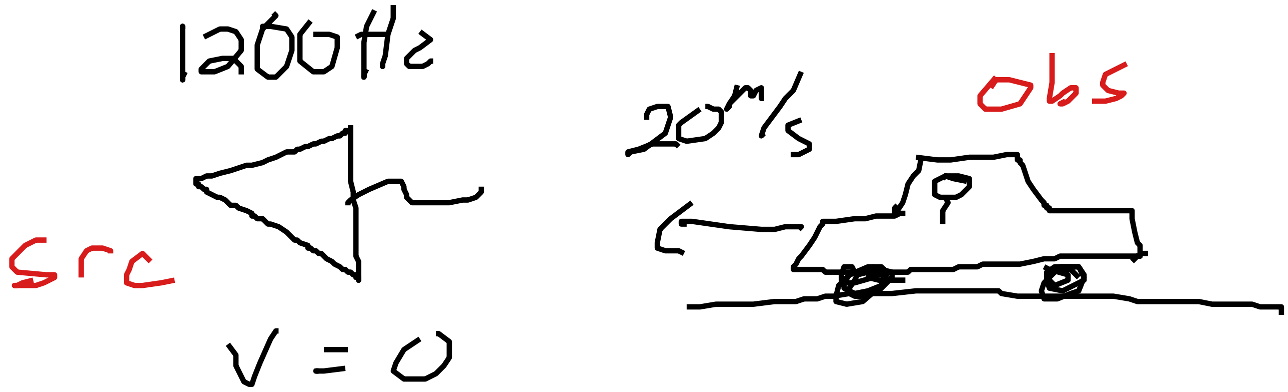
away from each other: $f_{obs} < f_{src}$

$$f_{obs} = f_{src} \frac{V_w \mp V_{obs}}{V_w \pm V_{src}}$$

eg. $V_w = 343\,m/s$ sound in 20°C air

top sign: moving apart

bottom sign: moving together

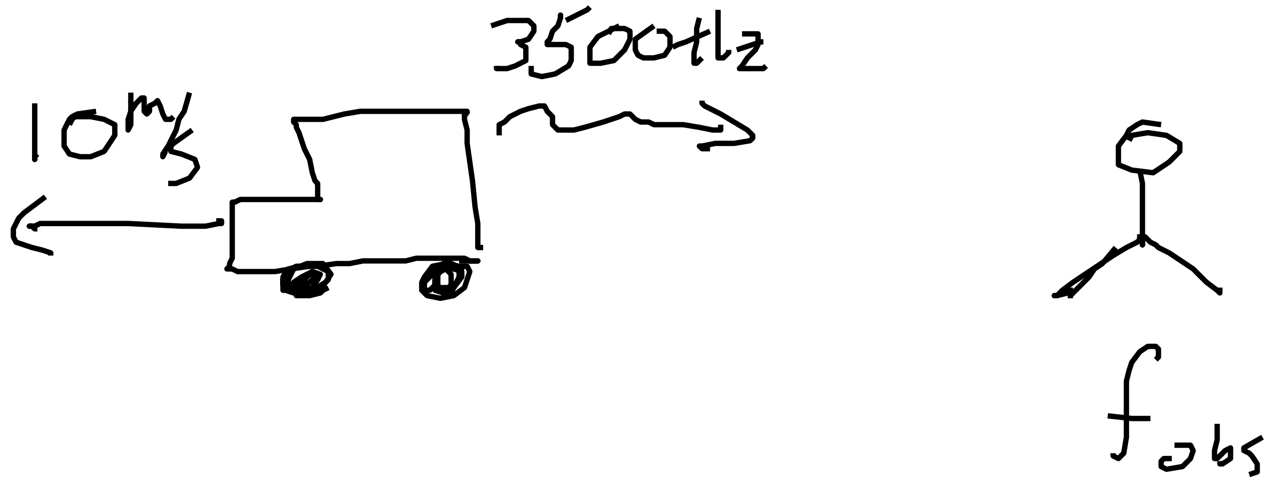


$$f_{obs} = f_{src}\,\frac{v_w \mp v_{obs}}{v_w \pm v_{src}}$$

$$(1200\,\text{Hz})\,\frac{343\,\text{m/s} + 20\,\text{m/s}}{343\,\text{m/s} - 0}$$

$$= (1200)\,\frac{363}{343}$$

$$= 1270\ \text{Hz}$$



$$f_{obs} = f_{src} \frac{V_w \mp V_{obs}}{V_w \pm V_{src}}$$

$$3500 \frac{343 - 0}{343 + 10}$$

obs. not moving

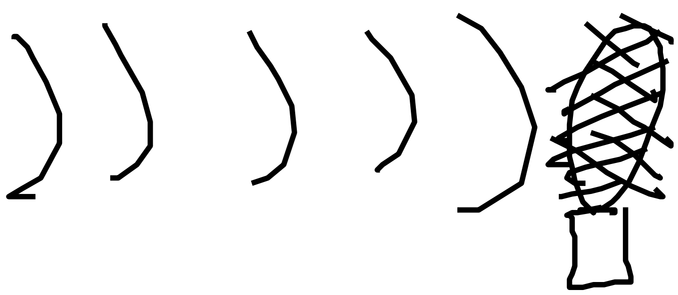
source is moving

$$= 3401 \text{ Hz} < 3500 \text{ Hz}$$

Wave Intensity

oscillator has energy $\frac{1}{2}kA^2$

wave's energy is proportional to its amplitude squared: A^2



How much energy is absorbed by this microphone?

proportional to

$$E \propto A^2$$

$E \propto$ area of microphone

$E \propto$ time of collection

Intensity I is measured in

Watts

$$\frac{\text{Joules}}{\text{seconds} \cdot m^2}$$

or

$$\boxed{\frac{W}{m^2}}$$

Sound:

threshold of hearing $I = 10^{-12}\ W/m^2$

quiet room $I = 10^{-8}\ W/m^2$

moving car $I = 10^{-4}\ W/m^2$

loud rock concert $I = 10^{0}\ W/m^2$

Our brain's scale of how loud something is, is based on exponent.

Logarithms

$$\log_{10} 10^4 = 4$$

base 10

$$\log_{10} 0.01 = -2$$

$$\log_{10} 0.1 = -1$$

$$-2 < \log_{10} 0.05 < -1$$

$\rightarrow -1.3$

base e → log

base 10 → log10

base e → ln

base 10 → log

$$\log_{10} ab = \log_{10} a + \log_{10} b$$

$$\log_{10} a^n = n \log_{10} a$$

$$\log_{10} 0.05 = \log_{10} 5 + \log_{10} 0.01$$

$$0.7 + -2$$

$$= -1.3$$

Sound Intensity Level

$10^{-12} \xrightarrow{\log} -12 + 12 = 0\,B$

$10^{-8} \rightarrow -8 + 12 = 4\,B$

$10^{-4} \rightarrow -4 + 12 = 8\,B$

$10^{0} \rightarrow 0 + 12 = 12\,B$

β measured in Bels

1 decibel = 0.1 bels

$$\beta = (10\,dB)(\log_{10} I + 12)$$

3 1 2

e1:

$$I = 3 \times 10^{-7}\ W/m^2$$

$$\beta = 10(-6.5 + 12)$$

$$\log_{10}(3 \times 10^{-7}\ W/m^2) = -6.5$$

$$\beta = 55\ dB$$

decibels