Physics I

Doppler Effect

For a detector moving directly towards a stationary emitter use the + sign (– if moving away).

$$f_{\text{detected}} = f_{\text{emitter}}\left(1 \pm \frac{v_{\text{detector}}}{v_{\text{sound}}}\right)$$

For an emitter moving directly towards a stationary detector use the – sign (+ if moving away).

$$f_{\text{detected}} = \frac{f_{\text{emitter}}}{\left(1 \mp \frac{v_{\text{emitter}}}{v_{\text{sound}}}\right)}$$

For electromagnetic waves, if the detector is directly approaching the emitter (or vice versa).

$$f_{\text{detected}} = f_{\text{emitter}}\sqrt{\frac{1+\beta}{1-\beta}} \qquad \text{where} \quad \beta = \frac{v}{c} = \frac{v}{3\times10^8\,\text{m/s}}$$

If the detector is moving directly away from the emitter, you change the signs.

Problem 1.- A bat (flying mammal, not baseball) emits an ultrasonic wave of frequency 48.5 kHz while moving towards an ultrasonic microphone at 7 m/s. Calculate the frequency measured by the instrument.

Problem 2.- A source of radio waves emits radiation of wavelength λ = 0.21061m Find the wavelength observed on Earth if the source approaches us at v = 335×10^3 m/s.

Problem 3.- Two speakers separated by 100m emit sound at a frequency of 1,500 Hz simultaneously. You are at the middle point between the two speakers and run towards one of them (and away from the other) at a speed of 5m/s. Calculate the frequency of the resulting beats. Take the speed of sound as 343m/s.

Problem 4.- In studying a star you notice that the Hα spectral line (whose normal wavelength in the lab is 659.8 nm), is shifted to 658.4 nm.

(A) Is it approaching us or moving away from us?

(B) What is the speed of the star?

Problem 5.- At what frequency do you hear a police car siren that emits a frequency of 500Hz and is approaching you at 22m/s?

Problem 6.- A bat at rest sends a sound wave with a frequency of 45.0 kHz and receives it returning from an object moving directly away from it with a frequency of 42.4 kHz. Find the speed of the object.
Speed of sound = 343m/s