

THE DOPPLER EFFECT - NOTES

Johann Doppler (1803-1853)

$$f_o = \frac{v \pm v_o}{v \pm v_s} f_s$$

Let v_o = the **observer's speed** with respect to the propagating medium

Let v_s = the **speed of source** of the wave with respect to the propagating medium

Let v = the **speed of the wave** in the propagating medium

Let f_o = the observed frequency of the wave

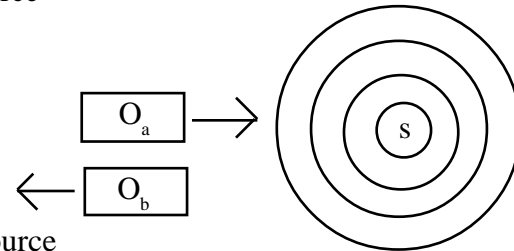
Let f_s = the frequency of the wave from the source

Case (1) Stationary source ($v_s = 0\text{m/s}$) Recall $d = vt \Rightarrow \lambda = vT \Rightarrow \lambda = v \frac{1}{f_s} \Rightarrow v = f_s \lambda$ $v = f_s \lambda$

(a) the observer is moving toward the source

Now here, the speed of the wave front is $v+v_o$ (since the observer is plowing into the wave fronts).

$$v + v_o = f_o \lambda \Rightarrow v + v_o = f_o (v/f_s) \Rightarrow f_o = \frac{v + v_o}{v} f_s$$



(b) the observer is moving away from the source

Here, the speed of the wave front is slower with respect to the observer: $v-v_o$ (Assume $v_o < v$ that the observer is not "outrunning" the wave fronts.)

$$v - v_o = f_o \lambda \Rightarrow v - v_o = f_o (v/f_s) \Rightarrow f_o = \frac{v - v_o}{v} f_s$$

$$f_o = \frac{v \pm v_o}{v} f_s$$

Case (2) Stationary observer ($v_o = 0\text{m/s}$)

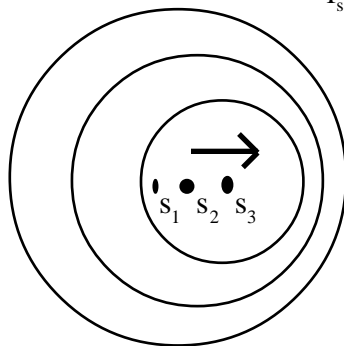
(a) source is moving away from the observer

Here, the length of the waves is greater because the source moved away from s_1 to s_2

before making the second wave front, so that $\lambda_a = d_1 + d_2$ where $d_1 = vT = \frac{v}{f_s}$ and $d_2 = v_s T = \frac{v_s}{f_s}$

$$\lambda_a = d_1 + d_2 = \frac{v + v_s}{f_s} \Rightarrow f_o = \frac{v}{\lambda_a} = \frac{v}{v + v_s / f_s} = \frac{v}{v + v_s} f_s$$

O_a



O_b

(b) source is moving toward the observer

Here, the length of the wave is less because the source moved toward the observer "b" from s_1 to s_2 , so that:

$$\lambda_b = d_1 - d_2 = \frac{v - v_s}{f_s} \Rightarrow f_o = \frac{v}{\lambda_b} = \frac{v}{v - v_s / f_s} = \frac{v}{v - v_s} f_s$$

$$f_o = \frac{v}{v \pm v_s} f_s$$

Let the 3 black dots represent: $s_1, s_2,$ and s_3 (3 successive positions of the swimming bug or wave source). The 3 waves shown have emanated outward with each of these points as their respective centers.