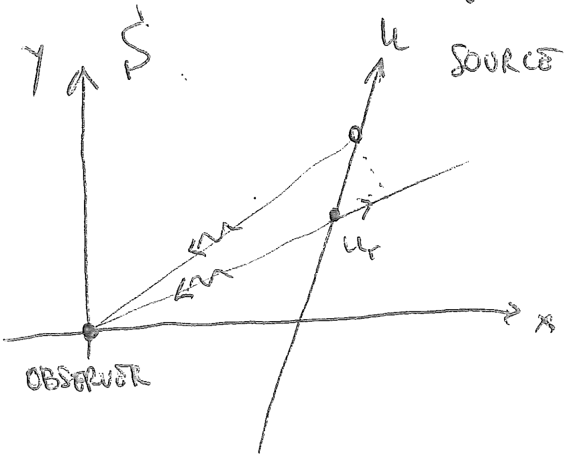
5.3

FIRST let us review the orignal case:
In the usual case of the Doppler effect we have a source moving and an observer at rest in an inertial frame.
In this case, if ν_0 is the freq. in the source frame the internal between two pulses is $\Delta t_0 = 1/\nu_0$ in the source frame.



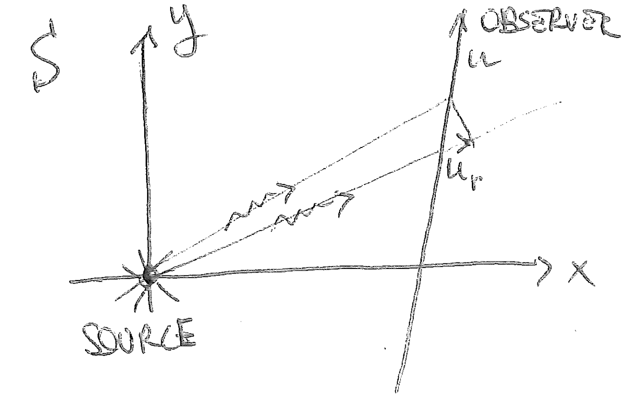
In the observer's frame S this becomes $\Delta t_S = \gamma(u)\,\Delta t_0$ by Lorentz timedilation.
The internal Δt between two pulses received by the observer at the origin is

$$\Delta t = \gamma(u)\Delta t_0 + \underbrace{\frac{u_r}{c}\gamma(u)\Delta t_0}_{\text{extra distance}} \equiv \left(1+\frac{u_r}{c}\right)\Delta t_S.$$

$\Rightarrow$ in units $c=1$ and recalling $\nu_0 = \frac{1}{\Delta t_0}$, $\nu = \frac{1}{\Delta t}$

$$\nu_0 = \gamma(u)(1+u_r)\,\nu$$

Now we have the opposite case:
Source at rest at origin of S and observer travelling:



As before, Δt_0 is the time between two pulses in the source rest frame (now S). Working still in S, the time interval in which they are received is given by $\Delta t_S = \Delta t_0 + u_r \Delta t_S$.

In the observer's frame we must also dilate: $\Delta t = \frac{1}{\gamma(u)} \Delta t_S \quad (< \Delta t_S)$.

$$\Rightarrow \Delta t = \frac{(1-u_r)^{-1}}{\gamma(u)} \Delta t_0$$

$$\Rightarrow \nu = \gamma(u)(1-u_r)\nu_0.$$

Note: it's DIFFERENT from the "Doppler's formula" (different u_r's). But STILL called Doppler.

Putting in the values in the problem:

$$V = V_0 \frac{1 - 1/3}{\sqrt{1-(1/2)^2}} = 0{,}77\, V_0 .$$