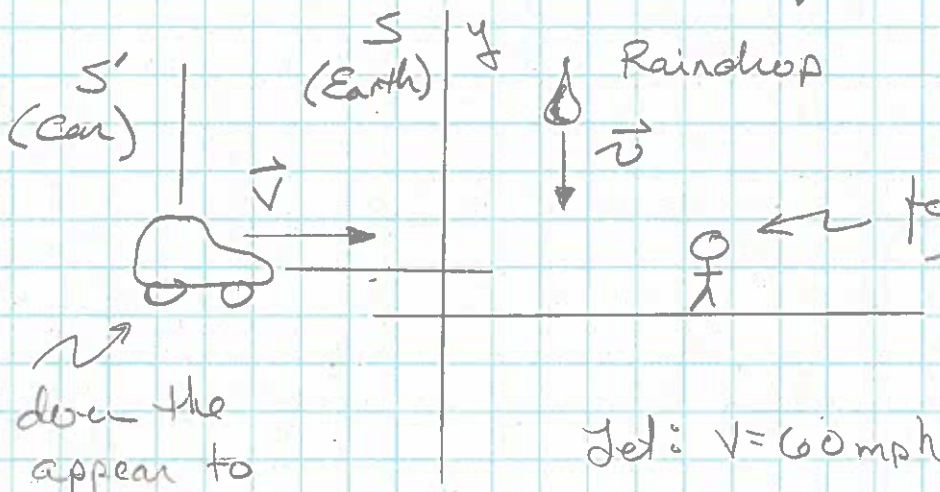
Let's do something real simple that you've all experienced:

Driving in the Rain – where does the rain come from



Let: $v = 60$ mph (S' rel. to S)

$v = 10$ mph (drop rel. to S)

So: $\vec{V} = 60\hat{i}$ mph

$\vec{v} = -10\hat{j}$ mph

So: Gal. transformation:

$$\vec{v}' = \vec{v} - \vec{V}$$

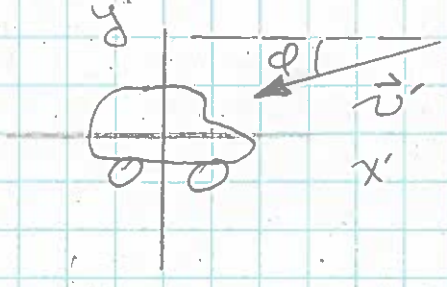
$$v_x' = v_x - V_x = 0 - 60 = -60 \text{ mph}$$

$$v_y' = v_y - V_y = -10 + 0 = -10 \text{ mph}$$

So: $\vec{v}' = -60\hat{i} - 10\hat{j}$ mph $\quad v' = \sqrt{v_x'^2 + v_y'^2}$

$= 60.83$ mph

Dn S':



$$\phi = \tan^{-1}\left(\frac{|v_y'|}{|v_x'|}\right) = 9.46^\circ$$ below horizontal.