A rocket ship travels at a relativistic velocity $\vec{v} = v_0 \begin{pmatrix} \cos \theta \\ \sin \theta \\ 0 \end{pmatrix}$ with respect to an observer O in the x-y coordinate frame. A photon of frequency $\omega'$ is emitted from the rocket along the $y'$ axis in the rocket's frame of reference.

(a) Calculate the angle, $\alpha$ with respect to the x-axis, of the photon in the observer's frame of reference.

(b) Calculate the frequency $\omega$ of the photon in the observer's frame of reference.

The Lorentz transformation of a four-vector $(A_x, A_y, A_z, A_4)$ with velocity $v = \beta c$ with respect to a stationary observer's x-axis is:

$$B_x = \gamma (A_x + \beta A_4), \quad B_y = A_y, \quad B_z = A_z, \quad B_4 = \gamma (A_4 + \beta A_x)$$

where $\gamma = 1/\sqrt{1 - \beta^2}$. 