a) $\phi(x,y,t) = A\sin\left(\frac{2\pi}{L}(x-ct)\right) \underbrace{- f_0 U_y + \phi}$

$U_g = -\frac{1}{f_0}\frac{d\phi}{dy}$ $V_g = \frac{1}{f_0}\frac{d\phi}{dx}$ $\zeta_g = \frac{dV_g}{dx} - \frac{dU_g}{dy}$

$\frac{d}{dx}\left(\phi(x,y,t)\right) = \frac{d}{dx}\left(A\sin\left(\frac{2\pi}{L}(x-ct)\right)\right) - \frac{d}{dx}(f_0 U_y) + \frac{d}{dx}(\phi)$

$\frac{d}{dx}\left(A\sin\left(\frac{2\pi}{L}(x-ct)\right)\right)$

$\frac{d}{dx}\left(A\sin\left(\frac{2\pi(x-ct)}{L}\right)\right)$

$A \cdot \frac{d}{dx}\left(\sin\left(\frac{2\pi(x-ct)}{L}\right)\right)$

* chain rule

$\cos\left(\frac{2\pi(x-ct)}{L}\right)\frac{d}{dx}\left(\frac{2\pi(x-ct)}{L}\right)$

$\frac{2\pi}{L}\frac{d}{dx}(x-ct)$

$\frac{d}{dx}(x) - \frac{d}{dx}(ct)$

$1 - 0 = 1$

$A\cdot\cos\left(\frac{2\pi(x-ct)}{L}\right)\left(\frac{2\pi}{L}\right) = \frac{2\pi A\cos\left(\frac{2\pi(x-ct)}{L}\right)}{L}$

$\frac{2\pi}{L} A\cos\left(\frac{2\pi(x-ct)}{L}\right)$

$\zeta = \frac{dV}{dx} - \frac{du}{dy} = -\frac{2\pi}{L} V_0 \sin\left(\frac{2\pi}{L}(x-ct)\right)$?

$\frac{d}{dx}(f_0 U_y) \to 0$ → all constant

$\frac{d}{dx}(\phi) = \frac{d}{dx}(kx - \omega t)$

$k - 0$

$f = f_0 + \beta y$

$f_0 = f - \beta y$