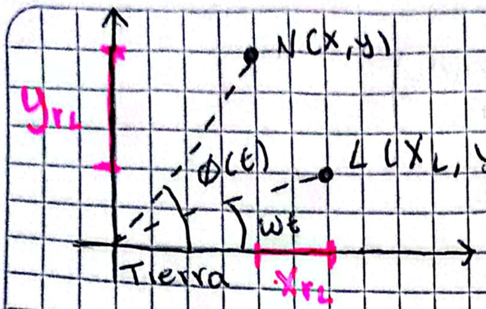

c) $X_L = d\cos(\omega t)$

$y_L = d\,\mathrm{sen}(\omega t)$

$X_N = r\cos(\phi)$

$y_N = r\,\mathrm{sen}(\phi)$

(c)

$$X_{rL} = d\cos(\omega t) - r\cos(\phi)$$
$$y_{rL} = r\,\mathrm{sen}(\phi) - d\,\mathrm{sen}(\omega t)$$

$$r_L = \left(d^2\cos^2(\omega t) - 2dr\cos(\omega t)\cos(\phi) + r^2\cos^2(\phi) + r^2\mathrm{sen}^2(\phi) - 2dr\,\mathrm{sen}(\omega t)\,\mathrm{sen}(\phi) + d^2\mathrm{sen}^2(\omega t)\right)^{1/2}$$

$$r_L = \left(d^2 + r^2 - 2dr(\cos(\omega t)\cos(\phi) + \mathrm{sen}(\omega t)\,\mathrm{sen}(\phi))\right)^{1/2}$$

$$r_L = \sqrt{d^2 + r^2 - 2r(t)\,d\cos(\phi - \omega t)}$$ $\star\ \cos(x-y) = \cos x\cos y + \sin x \sin y$

(d) $P_r = m\dot r$ $\quad P_\phi = m\dot\phi r^2$

$$L = T - U \qquad T = \frac{m\dot v^2}{2} \qquad U = -mgh$$

$$\vec r = r\cos(\phi)\hat\imath + r\sin(\phi)\hat\jmath$$

$$\dot{\vec r} = (\dot r\cos(\phi) + r(-\mathrm{sen}(\phi))\dot\phi)\hat\imath + (\dot r\sin(\phi) + r\cos(\phi)\dot\phi)\hat\jmath$$

$$\dot{\vec r}^2 = \dot r^2\cos^2(\phi) + \cancel{2\dot r r(-\mathrm{sen}(\phi))\cos(\phi)\dot\phi} + r^2\mathrm{sen}^2(\phi)\dot\phi^2 + \dot r^2\sin^2(\phi) + \cancel{2\dot r r\,\mathrm{sen}(\phi)\cos(\phi)\dot\phi} + r^2\cos^2(\phi)\dot\phi^2$$

$$\dot{\vec r}^2 = \dot r^2 + r^2\dot\phi^2$$

$$T = \frac{m(\dot r^2 + r^2\dot\phi^2)}{2}$$

$$U = -mgh = -\frac{Gmm_T}{r} - \frac{Gmm_L}{r_L}$$

$$L = \frac{m(\dot r^2 + r^2\dot\phi^2)}{2} + \left(\frac{Gmm_T}{r} + \frac{Gmm_L}{r_L}\right)$$

$$H = P_r\dot r + P_\phi\dot\phi - L$$

$$H = \frac{P_r^2 r^2}{mr^2} + \frac{P_\phi^2}{mr^2} - \left(\frac{m\dot r^2 + mr^2\dot\phi^2}{2}\right) - \left(\frac{Gmm_T}{r} + \frac{Gmm_L}{r_L}\right)$$

$$H = \frac{2P_r^2 r^2 + 2P_\phi^2 - m^2r^2\dot r^2 - m^2r^4\dot\phi^2}{2mr^2} - \left(\frac{Gmm_T}{r} + \frac{Gmm_L}{r_L}\right)$$

$$H = \frac{P_r^2 r^2 + P_\phi^2}{2mr^2} - \left(\frac{GmM_T}{r} + \frac{GmM_L}{r_L}\right)$$

$$H = \frac{P_r^2}{2m} + \frac{P_\phi^2}{2mr^2} - \frac{GmM_T}{r} - \frac{GmM_L}{r_L}$$

(e) $\dot{r} = \frac{\partial H}{\partial P_r} = \frac{2P_r}{2m} = \frac{P_r}{m}$

$$\dot{\phi} = \frac{\partial H}{\partial P_\phi} = \frac{2P_\phi}{2mr^2} = \frac{P_\phi}{mr^2}$$

$$\dot{P_r} = -\frac{\partial H}{\partial r} = -\left[-\frac{2P_\phi^2}{2mr^3} - (-1)\frac{GmM_T}{r^2} - \frac{GmM_L}{r_L^3}\left(\frac{-1}{2}\right)(2r - 2d\cos(\phi-\omega t))\right] = \frac{P_\phi^2}{mr^3} - \frac{GmM_T}{r^2} - \frac{GmM_L}{r_L^3}[r - d\cos(\phi-\omega t)]$$

$$\dot{P_\phi} = -\frac{\partial H}{\partial \phi} = -\left[-\frac{GmM_L}{r_L^3}\left(\frac{-1}{2}\right)(2rd\,\mathrm{sen}(\phi-\omega t))\right]$$

$$= -\frac{GmM_L}{r_L^3} rd\,\mathrm{sen}(\phi-\omega t)$$

(f) $\tilde{r} = \frac{r}{d}$ $\quad \tilde{P_r} = \frac{P_r}{md}$ $\quad \tilde{P_\phi} = \frac{P_\phi}{md^2}$

$\dot{r} = \frac{P_r}{m} = \tilde{P_r}\cancel{d} = \dot{\tilde{r}}\cancel{d}$ $\quad \dot{\tilde{r}} = \tilde{P_r}$ $\quad * \ \dot{\tilde{r}} = \frac{\dot{r}}{d}$

$$\dot{\phi} = \frac{P_\phi}{mr^2} = \frac{\tilde{P_\phi} d^2}{r^2} = \frac{\tilde{P_\phi} d^2}{\tilde{r}^2 d^2} = \frac{\tilde{P_\phi}}{\tilde{r}^2}$$

$\Delta = \frac{GM_T}{d^3}$ $\quad \mu = \frac{M_L}{M_T}$ $\quad \tilde{r}' = \sqrt{1 + \tilde{r}^2 - 2\tilde{r}\cos(\phi-\omega t)}$

$$\dot{P_r} = \frac{P_\phi^2}{mr^3} - \frac{GmM_T}{r^2} - \frac{GmM_L}{r_L^3}[r - d\cos(\phi-\omega t)]$$

$$\dot{\tilde{P_r}} = \frac{1}{md}\left[\left(\frac{\tilde{P_\phi}^2 m^2 d^4}{m\tilde{r}^3 d^3}\right) - \frac{GmM_T}{\tilde{r}^2 d^2} - \frac{GmM_L}{\tilde{r}_L^3}[\tilde{r}d - d\cos(\phi-\omega t)]\right]$$

$$\tilde{r}_L = \sqrt{\tilde{r}^2 d^2 + d^2 - 2\tilde{r}d^2\cos(\phi-\omega t)} = d\tilde{r}'$$

$$\dot{\tilde{P_r}} = \frac{1}{md}\left[\frac{\tilde{P_\phi}^2 md}{\tilde{r}^3} - \frac{GmM_T}{\tilde{r}^2 d^2} - \frac{GmM_L d[\tilde{r} - \cos(\phi-\omega t)]}{d^3 \tilde{r}'^3}\right]$$

$$\tilde{\dot{P}}_r = \frac{\tilde{P}_\phi^2}{\tilde{r}^3} - \frac{Gm_T}{\tilde{r}^2 d^3} - \frac{Gm_L}{\tilde{r}_1^3 d^3}\frac{m_T}{m_T}\left[\tilde{r} - \cos(\phi - \omega t)\right]$$

$$\tilde{\dot{P}}_r = \frac{\tilde{P}_\phi^2}{\tilde{r}^3} - \Delta\left[\frac{1}{\tilde{r}^2} + \frac{\mu}{\tilde{r}_1^3}\left[\tilde{r} - \cos(\phi - \omega t)\right]\right]$$

$$\dot{P}_\phi = -\frac{GmM_L}{r_L^3} rd\, sen(\phi - \omega t)$$

$$\tilde{\dot{P}}_\phi = \frac{1}{md^2}\left[-\frac{GmM_L}{d^3 \tilde{r}_1^3}\frac{m_T}{m_T}\tilde{r} d^2 \sin(\phi - \omega t)\right]$$

$$\tilde{\dot{P}}_\phi = -\frac{\Delta\mu}{\tilde{r}_1^3}\tilde{r}\sin(\phi - \omega t)$$

9) $$\tilde{P}_r^0 = \frac{x\dot{x} + y\dot{y}}{rd} = \frac{r\cos(\phi)V_0\cos(\theta) + r\,sen(\phi)V_0\,sen(\theta)}{rd}$$

$$= \frac{V_0}{d}\left(\cos(\phi)\cos(\theta) + sen(\phi)sen(\theta)\right) = \frac{V_0}{d}\cos(\theta - \phi)$$

$$\tilde{r} = \frac{r}{d} \Rightarrow V_0 = \tilde{V}_0 d$$

$$\tilde{P}_r^0 = \tilde{V}_0\cos(\theta - \phi)$$

$$\tilde{P}_\phi^0 = \frac{\tilde{r}^2}{r^2}(\dot{y}x - y\dot{x}) = \frac{\tilde{r}^2}{r^2}(V_0\sin(\theta) r\cos(\phi) - V_0\cos(\theta)$$
$$r\sin(\phi))$$

$$\tilde{P}_\phi^0 = \frac{r}{d^2}(\sin(\theta)\cos(\phi) - \cos(\theta)\sin(\phi))V_0$$

$$\tilde{P}_\phi^0 = \frac{\tilde{r}d\tilde{V}_0 d}{d^2}\sin(\theta - \phi) = \tilde{r}_0\tilde{V}_0\sin(\theta - \phi)$$