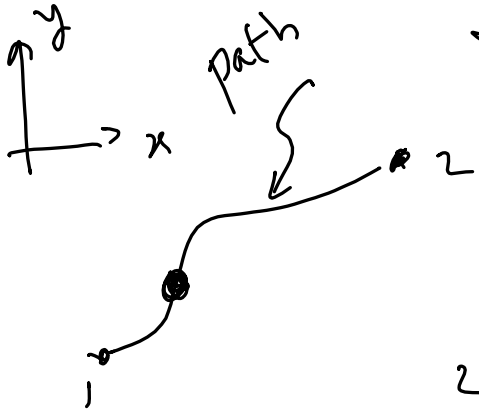
$w_1 = w_2 = w_3$



$\vec{F}_g = -mg\,\hat{j}$

$mg \quad d\vec{r} = dx\,\hat{i} + dy\,\hat{j}$

$$U_{12} = \int_1^2 \vec{F} \cdot d\vec{r}$$

$$= \int_1^2 (-mg\,\hat{j}) \cdot (dx\,\hat{i} + dy\,\hat{j})$$

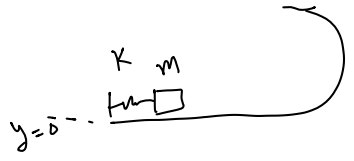
$$U_{12} = \int_1^2 -mg\,dy$$

$$= -mg\,(y_2 - y_1)$$

$$U_{12} = T_2 - T_1$$

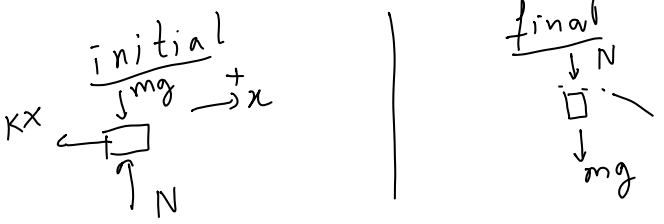
$$-mg(y_2 - y_1) = T_2 - T_1$$

$$\Rightarrow \quad T_2 + mgy_2 = T_1 + mgy_1$$



find min δ_s so that mass m does not come off track

1) $\omega_N = 0$, as $N \perp ds$ always



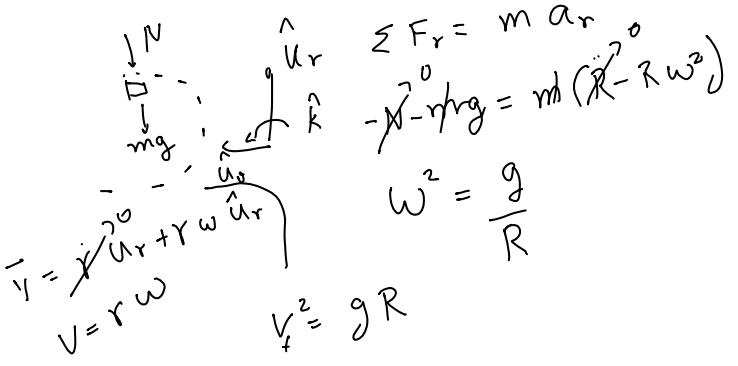
$$V_{s_i} = \frac{1}{2} k \delta_s^2, \quad T_i = 0, \quad V_{g_i} = 0$$

$\omega_N = 0$

$$V_{f_{i,g}} = mg(2R), \quad V_{f_s} = 0$$

$$T_f = \frac{1}{2} m V_f^2$$

$$\frac{1}{2} k \delta_s^2 = \frac{1}{2} m V_f^2 + 2mgR$$



$$\Sigma F_r = m a_r$$

$$-\cancel{N}^{0} - mg = m(\cancel{\ddot{R}}^{0} - R\omega^2)$$

$$\omega^2 = \frac{g}{R}$$

$$V_f^2 = gR$$

$$\frac{1}{2} k \delta_s^2 = \frac{1}{2} m V_f^2 + 2mgR$$

$$= \frac{1}{2} mgR + 2mgR$$

$$\boxed{\delta_s = \sqrt{\frac{5mgR}{k}}}$$