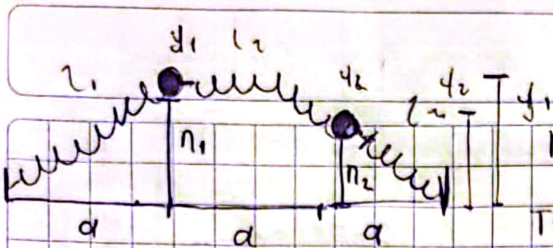


$$n_1 = y_1 \mp y_{01}$$

$$T = \frac{1}{2} m (\dot{y}_1^2 + \dot{y}_2^2)$$

$$V = 1/2\, k\left(\sqrt{a^2 + y_1^2} - a\right)^2 + 1/2\left(\sqrt{a^2 + y_2^2} - a\right)^2 + 1/2\, k\left(\sqrt{(y_1 - y_2)^2} - a\right)^2 - mg(y_1 + y_2)$$

$$V = 1/2\, k(a^2 + y_1^2) + 1/2\, k(a^2 + y_2^2) + 1/2\, k((y_1 - y_2)^2 + a^2 - mg(y_1 + y_2)$$

$$L = T - V \rightarrow 1/2\, m(\dot{y}_1^2 + \dot{y}_2^2) - 1/2\, k\left[(a^2 + y_1^2) + (a^2 + y_2^2) + (y_1 - y_2)^2 + a^2\right.$$

$$m\ddot{y}_1 + k\left[\left(\sqrt{a^2 + y_1^2} - a\right)\frac{y_1}{\sqrt{a^2 + y_1^2}} + \left(\sqrt{a^2 + (y_1 - y_2)^2} - a\right)\left(\frac{y_1 - y_2}{\sqrt{a^2 + (y_1 - y_2)^2}}\right)\right.$$

$$m\ddot{y}_1 = -k\left[(l_1 - a)\frac{y_1}{l_1} + (l_3 - a)(y_1 - y_2)\frac{1}{l_3}\right.$$

$$m\ddot{y}_1 = -k\left[\left(1 - \frac{a}{l_1}\right) y_1 + \left(1 - \frac{a}{l_3}\right)(y_1 - y_2)\right.$$

$$m\ddot{y}_2 = -k\left[\left(1 - \frac{a}{l_2}\right) y_2 + \left(1 - \frac{a}{l_3}\right)(y_1 - y_2)\right.$$

Para Pequeñas oscilaciones $l_1 \approx l_2 \approx l_3 \approx l$ $\quad n_i = y_i - y_{0i}$

$$m\ddot{n}_1 = -k\left[\left(1 - \frac{a}{l}\right) n_1 + \left(1 - \frac{a}{l}\right)(n_1 - n_2)\right] \qquad k' = k(1 - a/l)$$

$$m\ddot{n}_2 = -k\left[\left(1 - \frac{a}{l}\right) n_2 + \left(1 - \frac{a}{l}\right)(n_1 - n_2)\right]$$

$$m\ddot{n}_1 = -k' n_1 + k'(n_2 - n_1)$$

$$m\ddot{n}_2 = -k' n_2 - k'(n_2 - n_1)$$

$$n_j = a_j e^{iwt} \qquad \ddot{n}_j = -w^2 a_j e^{iwt}$$

$$\begin{pmatrix} -mw^2 \\ -mw^2 \end{pmatrix} = \begin{pmatrix} -2k' & k' \\ k' & -2k' \end{pmatrix} \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$$

$$\begin{bmatrix} -2k' & k' \\ k' & -2k' \end{bmatrix} + \begin{bmatrix} mw^2 & 0 \\ 0 & mw^2 \end{bmatrix} = \begin{bmatrix} -2k'+w^2m & k' \\ k' & -2k'+mw^2 \end{bmatrix} \begin{bmatrix} a \\ b \end{bmatrix} = 0$$

$$(-2k'+w^2m)^2 - k'^2 = 0$$

$$-2k'+w^2m = \pm k'$$

$$w^2 = \frac{2k' \pm k'}{m}$$

$$w_1 = \sqrt{\frac{3k(1-a/2)}{m}}$$

$$w_2 = \sqrt{\frac{(1-a/4)k}{m}}$$

$$(-2k'+w^2m)a_1 + k'a_2 = 0$$

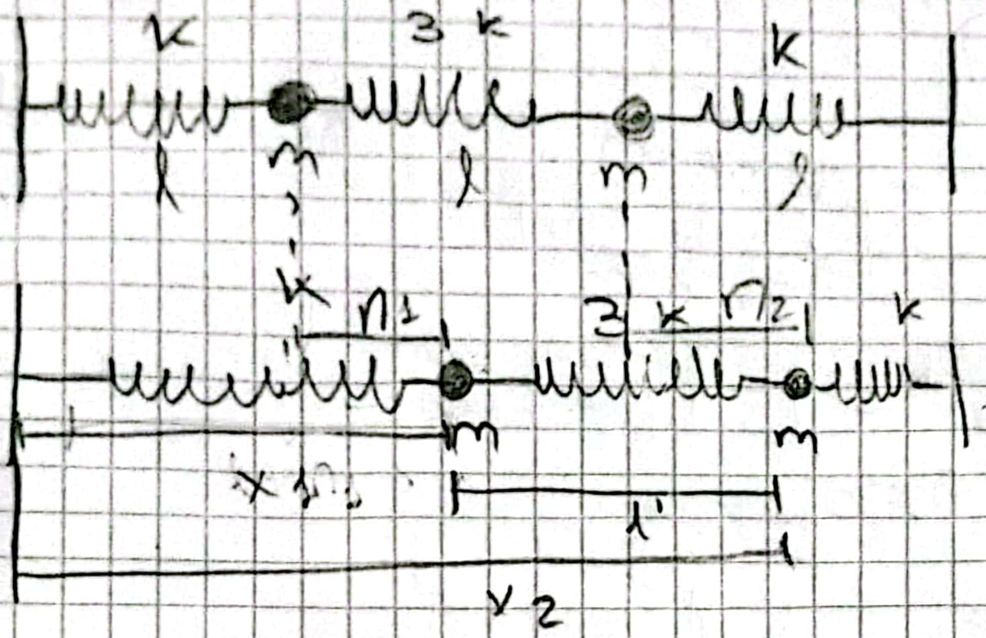
$$(-2k'+w^2m)a_2 + k'a_1 = 0$$

Para $w_1 =$ $a_1 = a_2$

$ka_1 = ka_2$

Para w_2 $a_1 = -a_2$

$-ka_1 = ka_2$



$$T = \frac{1}{2} m \dot{\eta}_1^2 + \frac{1}{2} m \dot{\eta}_2^2$$

$$V = \frac{1}{2} k \eta_1^2 + (l' - l)^2 \frac{3k}{2} + \eta_2^2 \frac{k}{2}$$

$$V = \frac{k}{2} \eta_1^2 + \frac{3}{2} k (\eta_2 - \eta_1)^2 + \eta_2^2 \frac{k}{2}$$

$$V = \frac{k}{2} \eta_1^2 + \frac{3}{2} k (\eta_2^2 - 2\eta_2 \eta_1 + \eta_1^2) + \eta_2^2 \frac{k}{2}$$

$$V = k(2\eta_1^2 - 3\eta_2 \eta_1 + 2\eta_2^2)$$

$$V = \frac{1}{2} \sum_{i,j} V_{ij} \eta_i \eta_j$$

$V_{11} = 4k \qquad V_{22} = 4k$

$V_{21} = -3k \qquad V_{12} = -3k$

$$V = \begin{pmatrix} 4k & -6k \\ -6k & 4k \end{pmatrix} \qquad T = \frac{1}{2} \sum T_{ij} \dot{r}_i \dot{r}_j$$

$$T_{11} = m \qquad T_{12} = T_{21} = 0$$

$$T = \begin{pmatrix} m & 0 \\ 0 & m \end{pmatrix} \qquad T_{22} = m$$

$$\det | V_{ij} - \omega^2 T_{ij} | = 0$$

$$\begin{vmatrix} 4k - \omega^2 m & -3k \\ -3k & 4k - \omega^2 m \end{vmatrix} = 0$$

$$(4k - \omega^2 m)^2 - (3k)^2 = 0$$

$$4k - \omega^2 m = \pm 3k$$

$$\omega^2 = \frac{4k \pm 3k}{m}$$

$$\omega_1 = \sqrt{\frac{k}{m}} \qquad \omega_2 = \sqrt{\frac{7k}{m}}$$

$$i=1: \quad (4k - \omega_k^2 m) a_1 - 3k a_2 = 0$$

$$i=2: \quad (-3k) a_1 + (4k - \omega_k^2 m) a_2 = 0$$

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Con ω_1

$(4k - k)a_1 - 3k a_2 = 0$ $\quad -(-3k)a_1 + (4k - k)a_2 = 0$

$3k a_1 - 3a_2 k = 0$ $\quad -3k a_2 + (3k)a_2 = 0$

$a_1 - a_2 = 0$ $\quad a_2(-3k + 3k) = 0$

$a_1 = a_2$ $\quad a_2 = 0$

$a_1 = 0$

Con ω_7

$(4k - 7k)a_1 - 3k a_2 = 0$

$-3k a_1 - 3k a_2 = 0$

$a_2 = -a_1$

$$2k + \frac{2\varepsilon a}{l^2} - \omega^2 m = \pm\left(k - \frac{2\varepsilon a}{l^2}\right)$$

$$\omega^2 = \left[\frac{2\varepsilon a}{l^2} + 2k \pm \left(-k - \frac{2\varepsilon a}{l^2}\right)\right]\frac{1}{m}$$

$$\omega_1^2 = \frac{3k}{m} + \frac{4\varepsilon a}{l^2 m} \qquad \omega_2^2 = \frac{k}{m}$$

$$\left(2k + \frac{2\varepsilon a}{l^2} - \omega^2 m\right)a_1 + \left(-k - \frac{2\varepsilon a}{l^2}\right)a_2 = 0$$

$$\left(-k - \frac{2\varepsilon a}{l^2}\right)a_1 + \left(2k + \frac{2\varepsilon a}{l^2} - \omega^2 m\right)a_2 = 0$$

Con $i = 1$

$$\left(2k + \frac{2\varepsilon a}{l^2} - 3k - \frac{4\varepsilon a}{l^2}\right)a_1 + \left(-k - \frac{2\varepsilon a}{l^2}\right)a_2 = 0$$

$$\left(-k - \frac{2\varepsilon a}{l^2}\right)a_1 + \left(-k - \frac{2\varepsilon a}{l^2}\right)a_2 = 0$$

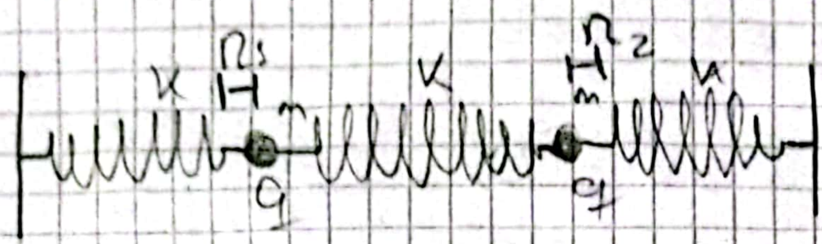
$$a_1 = -a_2$$

Con $i = 2$

$$\left(2k + \frac{2\varepsilon a}{l^2} - k\right)a_2 + \left(-k - \frac{2\varepsilon a}{l^2}\right)a_1 = 0$$

$$\left(k + \frac{2\varepsilon a}{l^2}\right)a_2 - \left(k + \frac{2\varepsilon a}{l^2}\right)a_1 = 0$$

$$a_2 = a_1$$



$$T=\frac{1}{2}m\dot{\eta}_1^2+\frac{1}{2}m\dot{\eta}_2^2$$

$$V=\underbrace{\frac{1}{2}k\eta_1^2+\frac{k}{2}(\eta_2-\eta_1)^2+\eta_2^2\frac{k}{2}}_{V^0_{res}}+\underbrace{\frac{\varepsilon q}{(\ell+\eta_2-\eta_1)}}_{V^0_{el}}$$

$$V_{(res)}=\begin{pmatrix}2k & -k\\ -k & 2k\end{pmatrix}\qquad V_{(el)}=\frac{\partial^2 V_{ij}}{\partial \eta_i\partial \eta_j}$$

$$V_{(el)}=\begin{pmatrix}\frac{2\varepsilon q}{\ell^2} & -\frac{2\varepsilon q}{\ell^2}\\ -\frac{2\varepsilon q}{\ell^2} & \frac{2\varepsilon q}{\ell^2}\end{pmatrix}$$

$$V=\begin{pmatrix}2k+\frac{2\varepsilon q}{\ell^2} & -k-\frac{2\varepsilon q}{\ell^2}\\ -k-\frac{2\varepsilon q}{\ell^2} & 2k+\frac{2\varepsilon q}{\ell^2}\end{pmatrix}$$

$$\det|V_{ij}-\omega^2T_{ij}|=0$$

$$\begin{vmatrix}\left(2k+\frac{2\varepsilon q}{\ell^2}\right)-\omega^2m & -k-\frac{2\varepsilon q}{\ell^2}\\ -k-\frac{2\varepsilon q}{\ell^2} & -\omega^2m+2k+\frac{2\varepsilon q}{\ell^2}\end{vmatrix}=0$$

$$\left(2k+2\frac{\varepsilon q}{\ell^2}-\omega^2m\right)^2-\left(-k-\frac{2\varepsilon q}{\ell^2}\right)^2=0$$