


m/2 m/2

a.  $\vec{F}_i = -k\vec{y}_i$   
 $\Sigma \vec{F} = 0, \quad \Sigma \vec{N} = 0$  about any point.

$\Sigma \vec{y}_i = 0$   
 $Mg - k \sum_{i=1}^N y_i = 0$



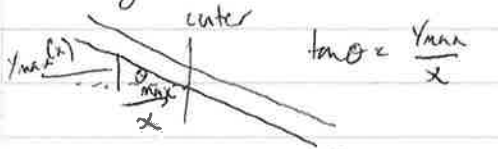
torque about CM ( $x=0$ ):  $\sum_{i=1}^N x_i (-ky_i) = 0 \rightarrow \sum_{i=1}^N x_i y_i = 0.$

or explicitly,  $Mg - k \sum_{i \neq j}^N y_i - ky_j = 0 = \sum_{i \neq j}^N x_i y_i + x_j y_j$   
 $y_j (-k - x_j) = \frac{\sum_{i \neq j}^N (x_i + k) y_i - Mg}{k + x_j}$   
 $y_j = \frac{Mg - \sum_{i \neq j}^N (x_i + k) y_i}{k + x_j}$

and  $F_j = -ky_j$

b. nontwisting mode -  ~~$\Sigma \vec{F} = 0$  still,  $\Sigma \vec{N} = 0$  still, though  $\Sigma \vec{F} \neq 0$ .~~  
 guess  $y_i = A \cos \omega t$ , then no torque condition becomes  
 $\sum x_i y_i = 0 \rightarrow \sum x_i = 0.$

twisting mode,  $\Sigma \vec{F} = 0$ , though  $\Sigma \vec{N} \neq 0.$



$\tan \theta = \frac{y_{\max}}{x}$  so guess  $y_i(x_i) = A(x) \cos \omega t$  (includes sign)  
 $y_i(x_i) = x_i \tan \theta_{\max} \cos \omega t + \frac{Mg}{kN}$   
 no net force  $\rightarrow Mg - k \tan \theta_{\max} \cos \omega t \sum x_i \tan \theta + Mg = 0$   
 $\rightarrow \sum x_i = 0$  again.