RO2102: Dynamics and Simulation

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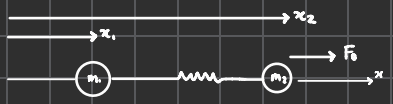
Homework-7

Problem 20 **Due** : 22-Mar-2025 **Time Spent** : 2 Hours

Sketch:



To Find: (a) EoM of Particles

(b) Prove $F = (m_1 + m_2)\, a_G$

(c) For high k, $x_1 \approx x_2 \approx x_G$

Given: k, l_0, m_1, m_2

$F(t) = F_0\, u(t)$

$x_1(0) = 0$, $x_2(0) = l_0$

(a) Apply LMB,

$$\{\Sigma_i \vec{F}_{ext} = m\vec{a}\} \cdot \hat{i}$$

$$\Rightarrow T = m_1 \ddot{x}_1 \quad \text{——— (1)}$$

FBD: mass m_1

Apply LMB on m_2,

$$\{\Sigma_i \vec{F}_{ext} = m\vec{a}\} \cdot \hat{i}$$

$$\Rightarrow F - T = m_2 \ddot{x}_2 \quad \text{——— (2)}$$

FBD: mass m_2

From constraint,

$$T = k(x_2 - x_1 - l_0)$$

$$\begin{bmatrix} -m_1 & 0 & -1 \\ 0 & m_2 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \\ T \end{bmatrix} = \begin{bmatrix} 0 \\ F \\ k(x_2 - x_1 - l_0) \end{bmatrix}$$

(b) Define x_{cm} s.t., $m_{tot} x_{cm} = m_1 x_1 + m_2 x_2$

FBD:

$m_{tot} \ddot{x}_{cm} = m_1 \ddot{x}_1 + m_2 \ddot{x}_2$

For a single particle: $\vec{F} = m\vec{a}$

For a system of particles:

$$\sum_i \vec{F}_i = \sum m_i a_i$$

$$\Rightarrow \cancel{\sum_i \vec{F}_i^{int}}^{\,0} + \sum_i \vec{F}_i^{ext} = \sum m_i a_i$$

$$\Rightarrow \sum_i \vec{F}_i^{ext} = \sum_i m_i a_i$$

From our case

$$\Rightarrow F = m_1 \ddot{x}_1 + m_2 \ddot{x}_2$$

$$\boxed{F = m_{tot} \ddot{x}_{cm}}$$