

## 1 | Problem 1

$$\begin{aligned}
 KE_{total} &= \sum_{i=1}^N \frac{1}{2} m_i v_i^2 \\
 &= \sum_{i=1}^N \frac{1}{2} m_i (\vec{v}_i \cdot \vec{v}_i) \\
 &= \sum_{i=1}^N \frac{1}{2} m_i (\vec{V}_{CM}(t)^2 + 2\vec{V}_{CM}(t)\vec{v}'_i(t) + \vec{v}'_i(t)^2) \\
 \backslash [ & \\
 &= \sum_{i=1}^N \frac{1}{2} m_i (\vec{V}_{CM}(t)^2 + 2\vec{V}_{CM}(t)\vec{v}'_i(t)) + \sum_{i=1}^N \frac{1}{2} m_i (v_i'^2) \quad \backslash ] \\
 &= \frac{1}{2} M V_{CM}^2 + V_{CM} \cdot \sum_{i=1}^N m_i \vec{v}'_i + \sum_{i=1}^N \frac{1}{2} m_i (v_i'^2) \\
 &= \frac{1}{2} M v_{CM}^2 + \frac{1}{2} \sum_{i=1}^N m_i (v_i'^2)
 \end{aligned}$$