1 | **Problem 1**

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