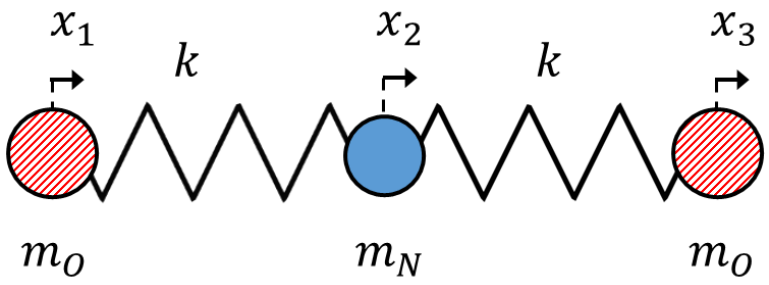
CMA Consider the linear triatomic molecule NO_2. A simple classical mechanical model of this molecule is sketched below:



The masses of the atoms are m_N for the nitrogen atom and m_0 for each oxygen atom. The covalent chemical bonds between the nitrogen and oxygen are modeled as springs with a spring constant k.

a) Suppose that the motion of the atoms can take place in **all three** dimensions. There will therefore be *nine* normal modes. Without calculating anything, describe each of these modes by means of a sketch, and label each normal mode as vibration, rotation, or translation.

For the rest of this problem we will restrict ourselves to considering motion only in the x direction so there are precisely *three* normal modes.

b) Write down the Lagrangian of the system using as coordinates the displacement x_i, $i = 1, 2, 3$, of each atom from its equilibrium position.

c) Determine the frequencies of all three distinct normal modes of longitudinal motion. Express your answers in terms of m_N, m_O, and k.

d) Find the corresponding eigenvectors of the normal-mode problem.

e) All atoms are initially at rest in their equilibrium positions. At time $t = 0$ the left-most oxygen atom is given a small amount of momentum p_x. Find the subsequent displacements $x_1(t)$, $x_2(t)$, $x_3(t)$ of the three atoms from their equilibrium positions.