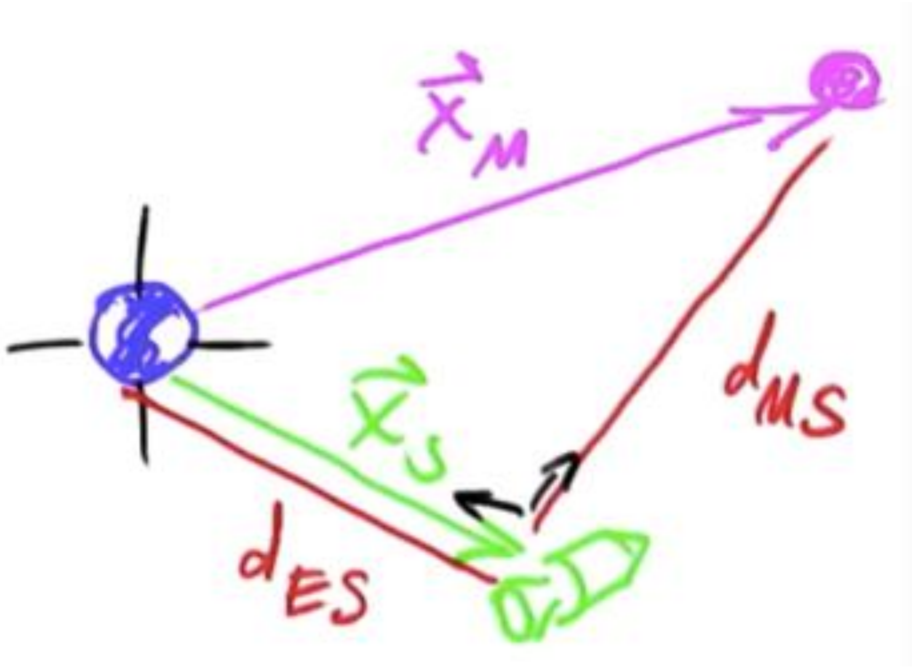

E stands for earth (blue object)
M stands for moon (pink object)
S stands for satellite (green object)

For S, according to Newton’s Second Law and Newtonian Gravity:

$$m_s\overrightarrow{a_s} = \frac{Gm_E m_S}{{d_{ES}}^2}\overrightarrow{e_{SE}} + \frac{Gm_M m_S}{{d_{MS}}^2}\overrightarrow{e_{SM}}$$

Where mS, mE, mM are the mass of satellite, earth, moon respectively, G is the gravitational constant, dES, dMS are the distance from earth to satellite and distance from moon to satellite, $\overrightarrow{a_s}$ is the vector of acceleration of satellite, $\overrightarrow{e_{SE}}, \overrightarrow{e_{SM}}$ are the unit vectors from satellite to earth and to moon.

$$\overrightarrow{e_{SE}} = \frac{-\overrightarrow{x_S}}{d_{ES}} = \frac{-\overrightarrow{x_S}}{||\overrightarrow{x_S}||}$$

$$\overrightarrow{e_{SM}} = \frac{\overrightarrow{x_M} - \overrightarrow{x_S}}{||\overrightarrow{x_M} - \overrightarrow{x_S}||}$$

Finally:

$$\frac{d^2\vec{x}}{dt^2} = \overrightarrow{a_s} = G[\frac{-m_E}{||\overrightarrow{x_S}||^3}\overrightarrow{x_S} + \frac{m_M}{||\overrightarrow{x_M} - \overrightarrow{x_S}||^3}(\overrightarrow{x_M} - \overrightarrow{x_S})]$$

Obviously, this PDE is non-linear.