$$m_1\ddot{\vec{r}}_1 = \frac{Gm_1m_2}{r_{12}^3}\vec{r}_{12} + \frac{Gm_1m_3}{r_{13}^3}\vec{r}_{13}$$

$$m_2\ddot{\vec{r}}_2 = -\frac{Gm_1m_2}{r_{12}^3}\vec{r}_{12} + \frac{Gm_2m_3}{r_{23}^3}\vec{r}_{23}$$

$$m_3\ddot{\vec{r}}_3 = -\frac{Gm_1m_3}{r_{13}^3}\vec{r}_{13} - \frac{Gm_2m_3}{r_{23}^3}\vec{r}_{23}$$

$$\vec{r}_{12} = \vec{r}_2 - \vec{r}_1$$

$$r_{12} = \sqrt{(x_2 - x_1)^2 - (y_2 - y_1)^2}$$

$$\ddot{x}_1 = \frac{Gm_2}{r_{12}^3}(x_2 - x_1) + \frac{Gm_3}{r_{13}^3}(x_3 - x_1)$$

$$\ddot{y}_1 = \frac{Gm_2}{r_{12}^3}(y_2 - y_1) + \frac{Gm_3}{r_{13}^3}(y_3 - y_1)$$

$$\ddot{x}_2 = -\frac{Gm_1}{r_{12}^3}(x_2 - x_1) + \frac{Gm_3}{r_{23}^3}(x_3 - x_2)$$

$$\ddot{y}_2 = -\frac{Gm_1}{r_{12}^3}(y_2 - y_1) + \frac{Gm_3}{r_{23}^3}(y_3 - y_2)$$

$$\ddot{x}_3 = -\frac{Gm_1}{r_{13}^3}(x_3 - x_1) - \frac{Gm_2}{r_{23}^3}(x_3 - x_2)$$

$$\ddot{y}_3 = -\frac{Gm_1}{r_{13}^3}(y_3 - y_1) - \frac{Gm_2}{r_{23}^3}(y_3 - y_2)$$

$$F = \frac{Gm_1m_2}{r^2}$$

$$\ddot{\vec{r}} = -\frac{G(m_1 + m_2)}{r^2}\hat{r}$$

$$\ddot{\vec{r}} = -\frac{1 + q}{r^2}\hat{r}$$

$$\ddot{x} = -\frac{1+q}{r^3}x$$

$$\ddot{y} = -\frac{1+q}{r^3}y$$

$$u_1 = x$$

$$u_2 = y$$

$$u_3 = \dot{x}$$

$$u_4 = \dot{y}$$

$$\dot{u}_1 = u_3$$

$$\dot{u}_2 = u_4$$

$$\dot{u}_3 = -\frac{1+q}{r^3}u_1$$

$$\dot{u}_4 = -\frac{1+q}{r^3}u_2$$