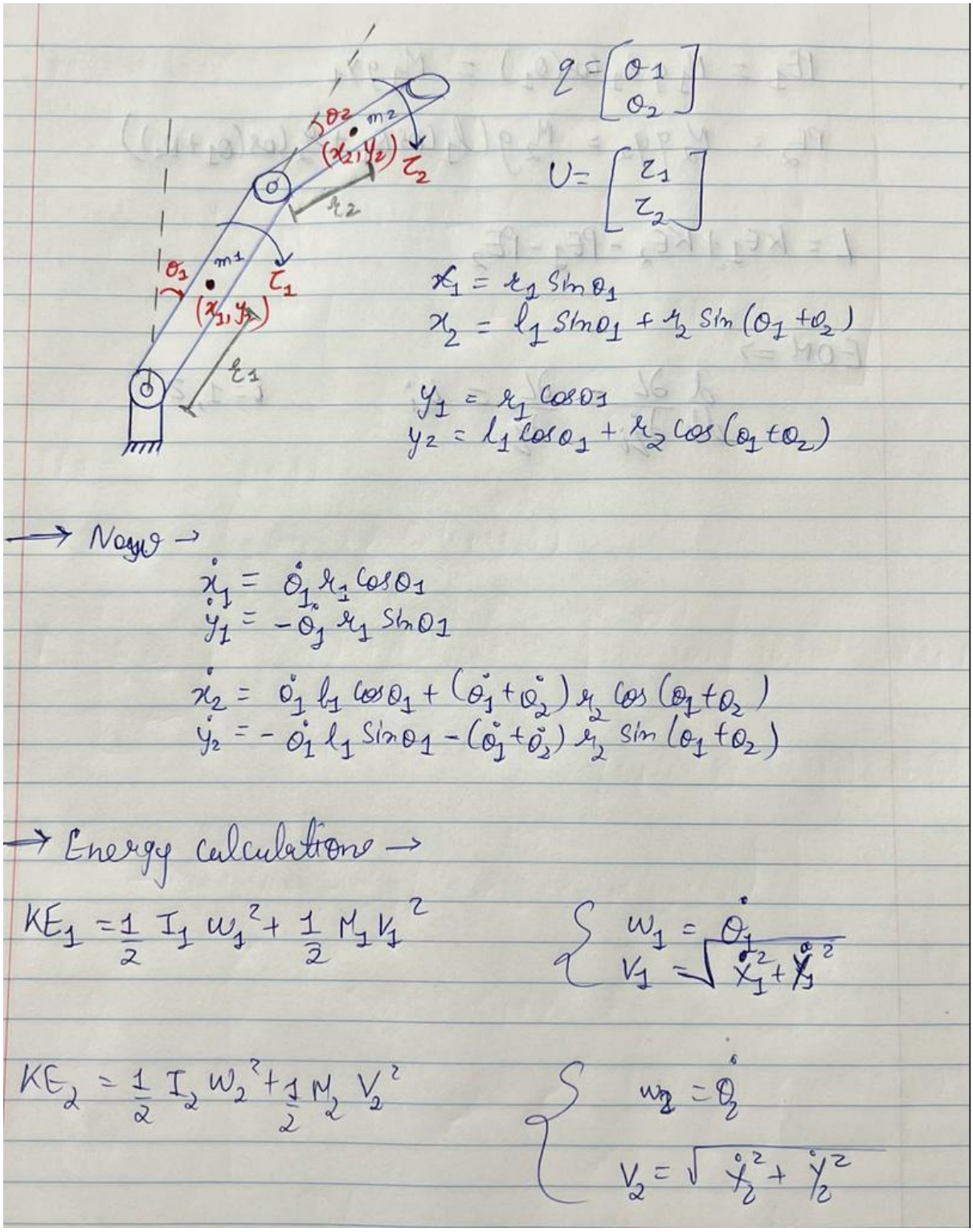
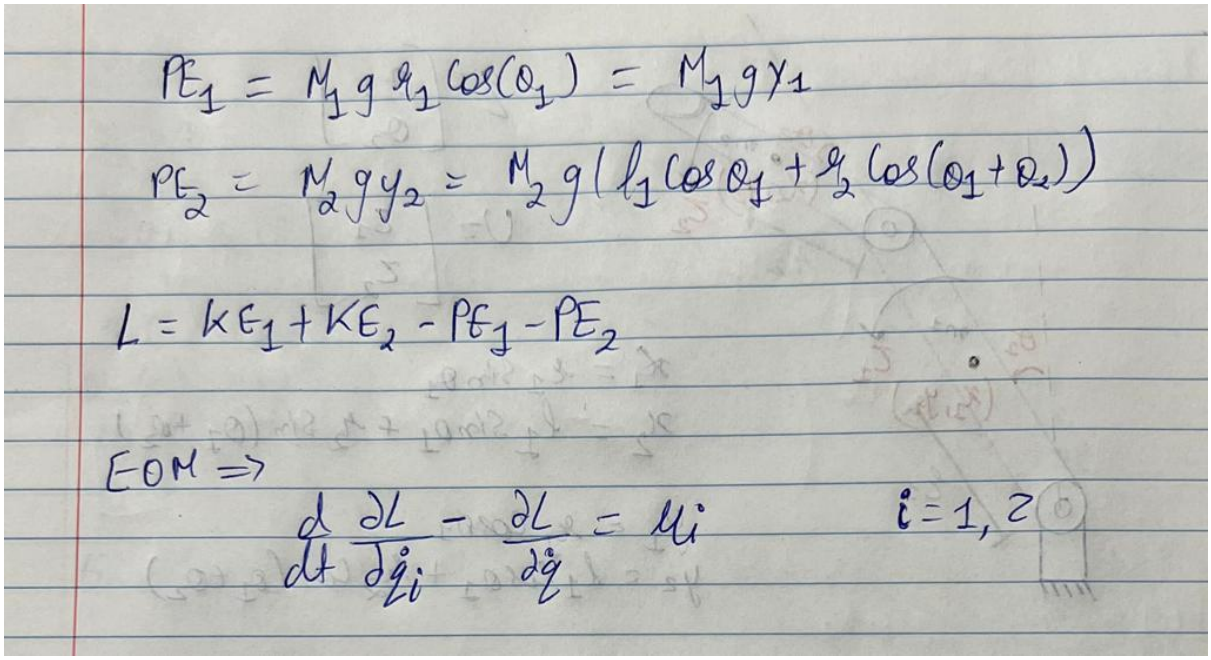
Problem a: Equations of Motion





Equations of Motion –

$$\boldsymbol{tau1} = \mathrm{I1} * \mathrm{theta1}_{\mathrm{ddot}} + \mathrm{L1}^2 * \mathrm{M2} * \mathrm{theta1}_{\mathrm{ddot}} + \mathrm{M1} * \mathrm{r1}^2 * \mathrm{theta1}_{\mathrm{ddot}} + \mathrm{M2} * \mathrm{r2}^2 * \mathrm{theta1}_{\mathrm{ddot}} + \mathrm{M2} * \mathrm{r2}^2 * \mathrm{theta2}_{\mathrm{ddot}} - \mathrm{M2} * \mathrm{g} * \mathrm{r2} * \sin(\mathrm{theta1} + \mathrm{theta2}) - \mathrm{L1} * \mathrm{M2} * \mathrm{g} * \sin(\mathrm{theta1}) - \mathrm{M1} * \mathrm{g} * \mathrm{r1} * \sin(\mathrm{theta1}) - \mathrm{L1} * \mathrm{M2} * \mathrm{r2} * \mathrm{theta2}_{\mathrm{dot}}^2 * \sin(\mathrm{theta2}) + 2 * \mathrm{L1} * \mathrm{M2} * \mathrm{r2} * \mathrm{theta1}_{\mathrm{ddot}} * \cos(\mathrm{theta2}) + \mathrm{L1} * \mathrm{M2} * \mathrm{r2} * \mathrm{theta2}_{\mathrm{ddot}} * \cos(\mathrm{theta2}) - 2 * \mathrm{L1} * \mathrm{M2} * \mathrm{r2} * \mathrm{theta1}_{\mathrm{dot}} * \mathrm{theta2}_{\mathrm{dot}} * \sin(\mathrm{theta2})$$

$$\boldsymbol{tau2} = I2 * theta2_{ddot} + M2 * r2^2 * theta1_{ddot} + M2 * r2^2 * theta2_{ddot} - M2 * g * r2 * \sin(theta1 + theta2) + L1 * M2 * r2 * theta1_{dot}^2 * \sin(theta2) + L1 * M2 * r2 * theta1_{ddot} * \cos(theta2)$$

Problem b: State Space Representation of E.O.M

Here states $X(1) = theta1,\ X(2) = theta2,\ X(3) = theta1_{dot},\ X(4) = theta2\_dot$

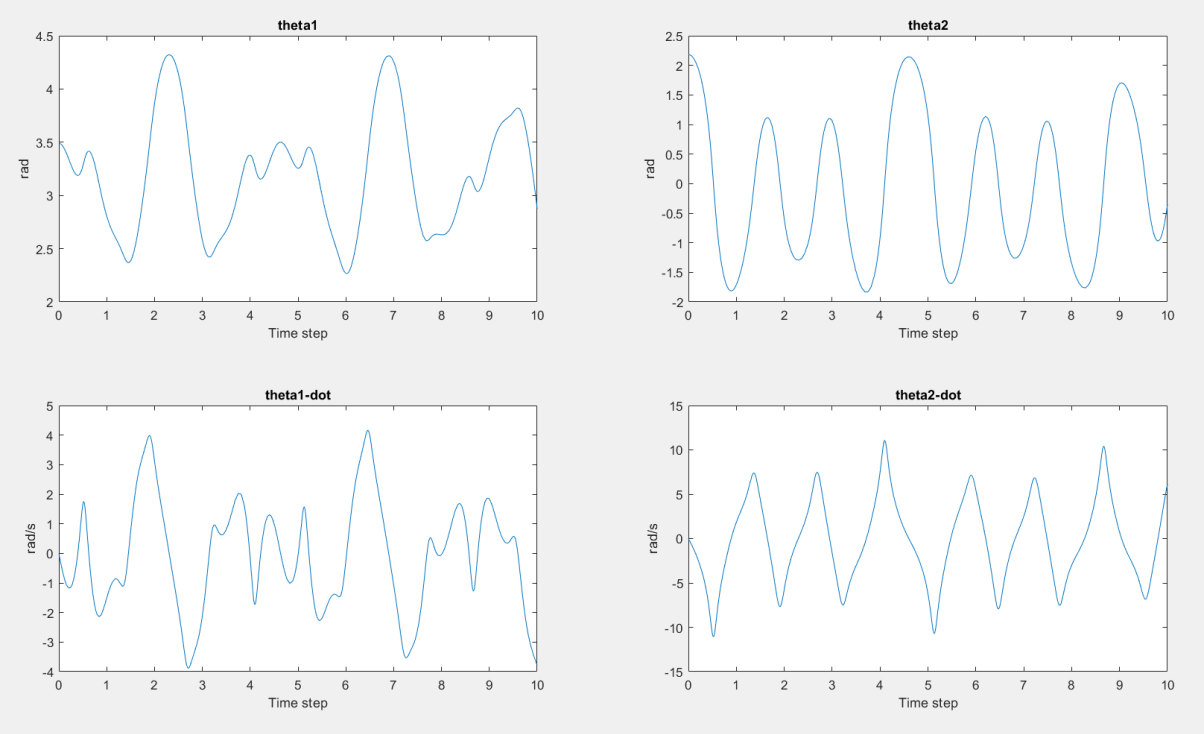
$$X(1)_{dot} = X(3) = theta1_{dot}$$

$$X(2)_{dot} = X(4) = theta2_{dot}$$

$$X(3)_{dot} = \frac{\begin{array}{c} I2 * tau1 + M2 * r2^2 * tau1 - M2 * r2^2 * tau2 + \\ L1 * M2^2 * g * r2^2 * \sin(theta1) + \\ I2 * M2 * g * r2 * \sin(theta1 + theta2) + \\ I2 * L1 * M2 * g * \sin(theta1) \\ + \frac{L1^2 * M2^2 * r2^2 * theta1_{dot}^2 * \sin(2 * theta2)}{2} + \\ I2 * M1 * g * r1 * \sin(theta1) - \\ L1 * M2 * r2 * tau2 * \cos(theta2) + \\ L1 * M2^2 * r2^3 * theta1_{dot}^2 * \sin(theta2) + \\ L1 * M2^2 * r2^3 * theta2_{dot}^2 * \sin(theta2) - \\ L1 * M2^2 * g * r2^2 * \sin(theta1 + theta2) * \cos(theta2) + \\ I2 * L1 * M2 * r2 * theta2_{dot}^2 * \sin(theta2) + \\ M1 * M2 * g * r1 * r2^2 * \sin(theta1) + \\ 2 * L1 * M2^2 * r2^3 * theta1_{dot} * theta2_{dot} * \sin(theta2) + \\ 2 * I2 * L1 * M2 * r2 * theta1_{dot} * theta2_{dot} * \sin(theta2) \end{array}}{\begin{array}{c} I1 * I2 + L1^2 * M2^2 * r2^2 + I2 * L1^2 * M2 + I2 * M1 * r1^2 + \\ I1 * M2 * r2^2 + I2 * M2 * r2^2 + \\ M1 * M2 * r1^2 * r2^2 - L1^2 * M2^2 * r2^2 * \cos^2(theta2) \\ + 2 * I2 * L1 * M2 * r2 * \cos(theta2) \end{array}}$$

$$X(4)_{dot} = -\frac{\begin{array}{c} M2 * r2^2 * tau1 - L1^2 * M2 * tau2 - \\ M1 * r1^2 * tau2 - I1 * tau2 - \\ M2 * r2^2 * tau2 - L1^2 * M2^2 * g * r2 * \sin(theta1 + theta2) \\ + L1 * M2^2 * g * r2^2 * \sin(theta1) - \\ I1 * M2 * g * r2 * \sin(theta1 + theta2) + \\ L1^2 * M2^2 * r2^2 * theta1_{dot}^2 * \sin(2 * theta2) \\ + \frac{L1^2 * M2^2 * r2^2 * theta2_{dot}^2 * \sin(2 * theta2)}{2} + \\ L1 * M2 * r2 * tau1 * \cos(theta2) - \\ 2 * L1 * M2 * r2 * tau2 * \cos(theta2) + \\ L1 * M2^2 * r2^3 * theta1_{dot}^2 * \sin(theta2) + \\ L1^3 * M2^2 * r2 * theta1_{dot}^2 * \sin(theta2) + \\ L1 * M2^2 * r2^3 * theta2_{dot}^2 * \sin(theta2) - \\ L1 * M2^2 * g * r2^2 * \sin(theta1 + theta2) * \cos(theta2) + \\ L1^2 * M2^2 * g * r2 * \cos(theta2) * \sin(theta1) - \\ M1 * M2 * g * r1^2 * r2 * \sin(theta1 + theta2) + \\ I1 * L1 * M2 * r2 * theta1_{dot}^2 * \sin(theta2) + \\ M1 * M2 * g * r1 * r2^2 * \sin(theta1) + \\ L1^2 * M2^2 * r2^2 * theta1_{dot} * theta2_{dot} * \sin(2 * theta2) + \\ 2 * L1 * M2^2 * r2^3 * theta1_{dot} * theta2_{dot} * \sin(theta2) + \\ L1 * M1 * M2 * r1^2 * r2 * theta1_{dot}^2 * \sin(theta2) + \\ L1 * M1 * M2 * g * r1 * r2 * \cos(theta2) * \sin(theta1) \end{array}}{\begin{array}{c} I1 * I2 + L1^2 * M2^2 * r2^2 + I2 * L1^2 * M2 + \\ I2 * M1 * r1^2 + I1 * M2 * r2^2 \\ + I2 * M2 * r2^2 + M1 * M2 * r1^2 * r2^2 \\ - L1^2 * M2^2 * r2^2 * \cos^2(theta2) + \\ 2 * I2 * L1 * M2 * r2 * \cos(theta2) \end{array}}$$

Problem b: Simulation



Please toggle the visualization flag on line 3 of main.m file in the submission to “true” see the RRbot (the two-link robot) in action. !!!