

Homework Exercise 4

Submission is in pairs only.

Submission deadline: 10/6/2021, 23:59

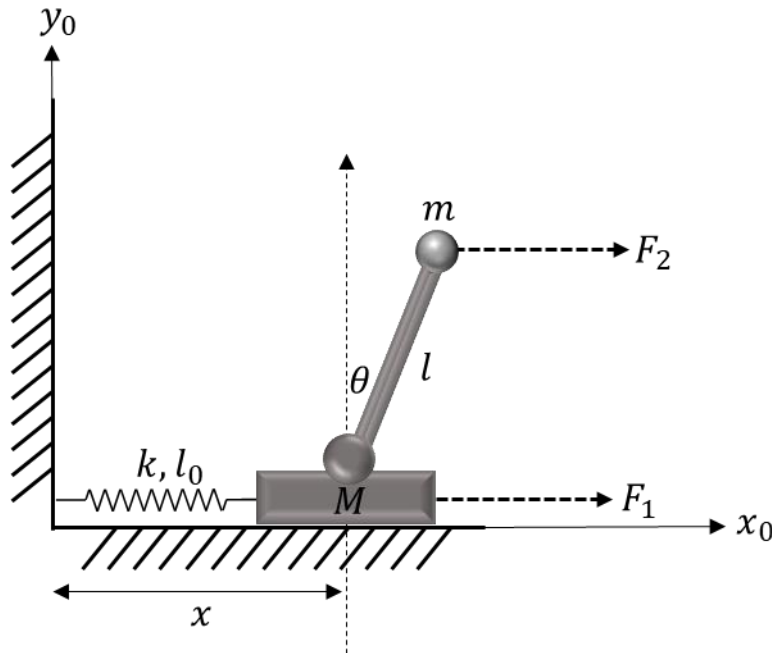
Question 1

The below physical system is composed of a rigid body whose mass is M which slides without any friction along the x_0 axis and a massless rod of length l to which a point mass m is attached. The rod is attached at the center of mass of the rigid body M by a revolute axis.

The mass M is constrained by a spring that is fixed in $x_0 = 0$ and whose stiffness is k and rest length is l_0 .

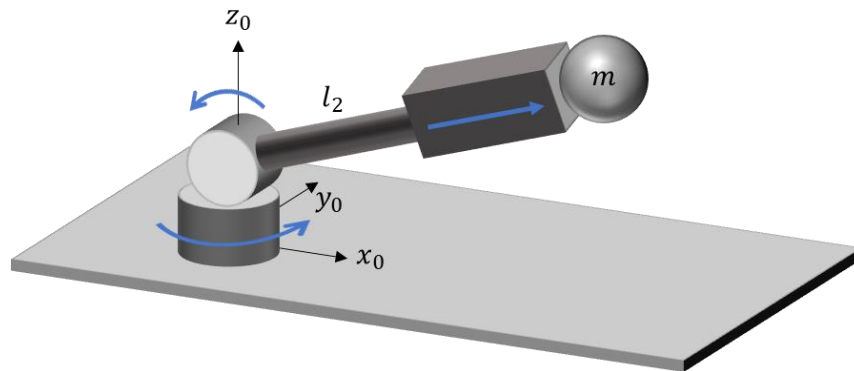
The force F_1 is constantly applied on the mass M and the force F_2 is constantly applied on the mass m . Both forces are in the direction of $+\hat{x}_0$.

Use x, θ depicted below as the generalized coordinates of this system to find its equations of motion.



Question 2

Consider the revolute-revolute-prismatic arm which was discussed in tutorial 8:



You may use the results developed in class.

1. Write the explicit expressions for the matrices $D(q)$, $C(q, \dot{q})$, $G(q)$ where $q = [\vartheta_1 \quad \vartheta_2 \quad d_3]^T$.
2. Assume m is no longer a point mass but a ball of radius R and uniform density ρ . How would the Lagrangian change?
3. Now assume that the arm is operating in an imaginary world in which the gravity field is in the direction of \hat{y}_0 . How would the Lagrangian change?