ME 563-Fall 2024

Homework No. 1

Due: September 6, 2024 11:59 pm on Gradescope

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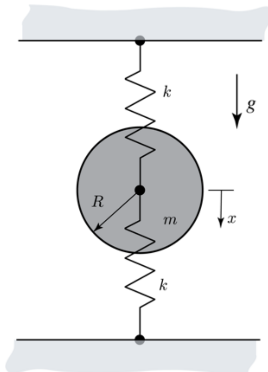
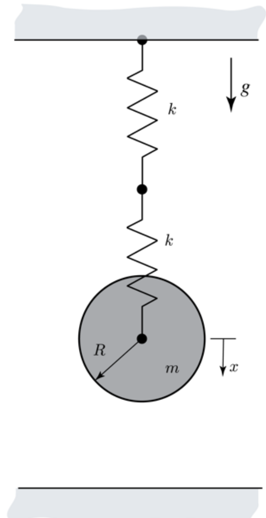
Homework Problem 1.1

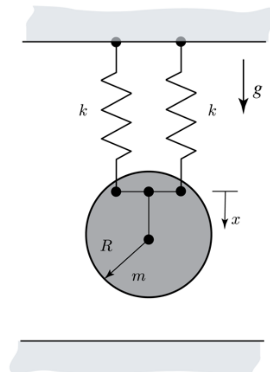
Consider each one-degree-of-freedom system shown below consisting of springs of stiffnesses k, and cylinders of masss m.



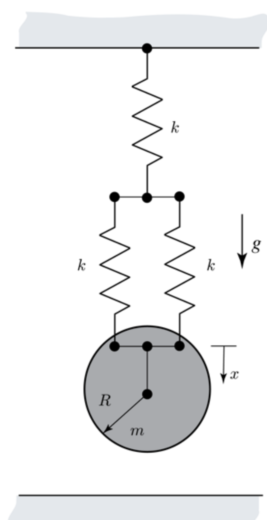
(a)



(b)



(c)



(d)

a) Determine the equivalent spring stiffness for each system. Do this by drawing a FBD of each mass and spring as needed.

b) Determine the equilibrium position of the system, x_{st}, for each system. Which system deflects the most due to gravity?

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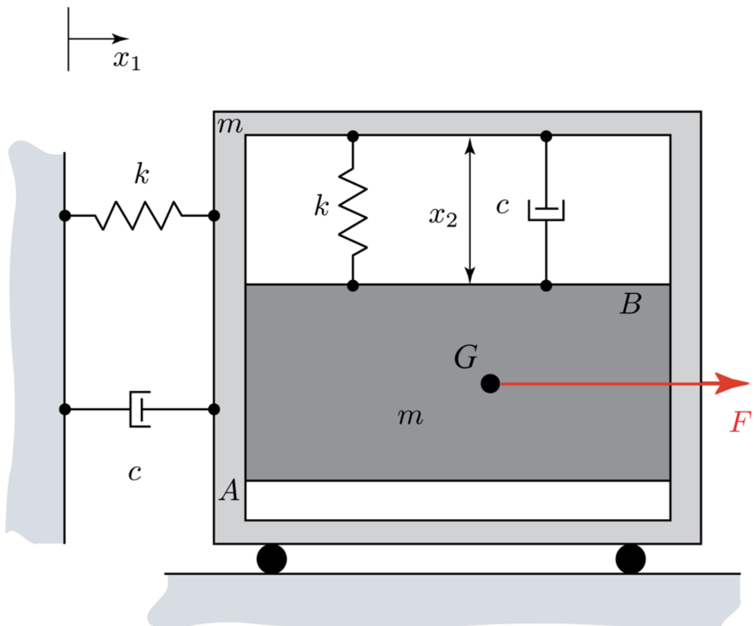
Homework Problem 1.2

Consider the two-degree-of-freedom system shown below made up of two particles *A*, and *B*, each of mass m, with system moving within a horizontal plane. Let x_1, describe the absolute motion of particle *A*, x_2 describe the motion of paticle *B* relative to *A*. All the springs are unstretched when $x_1=x_2=0$. Assume all surfaces to be smooth and neglect gravity.



Horizontal Plane

a) Draw individual free body diagrams of each particle.

b) Use the Newton- Euler formulation to derive three differential equations of motion for the system. Your final equations should not include any forces of reaction

c) Write the equations of motion derived in b) in matrix form. Identify the mass, damping, and stiffness matrices in these equations

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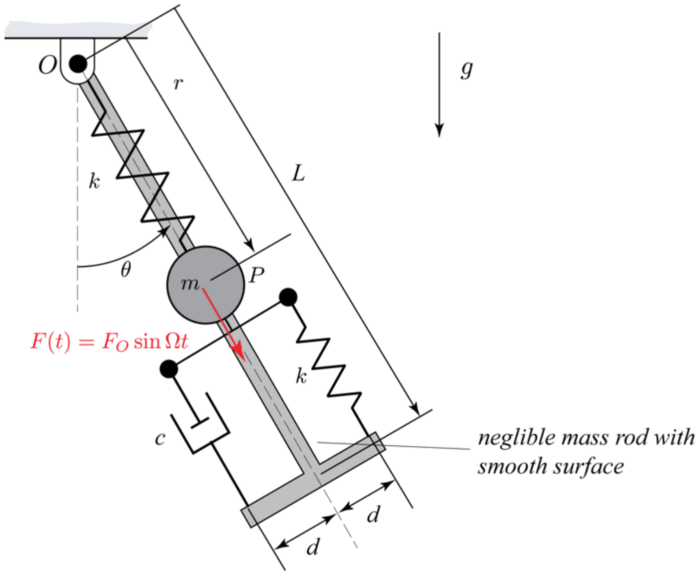
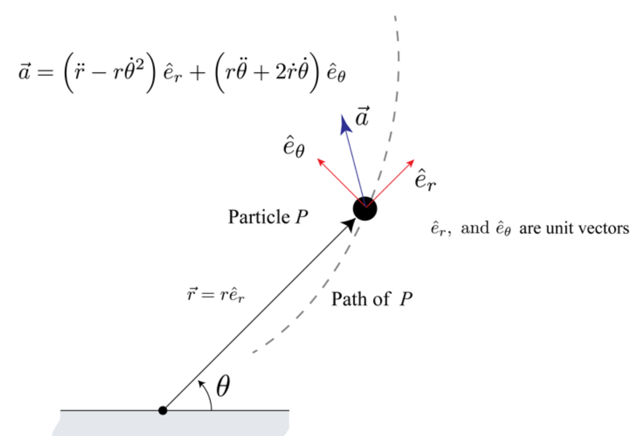
Homework Problem 1.3



A mass m is able to slide along a smooth, *thin massless rod*. A force $F(t) = F_o \sin\omega t$ is applied to mass along with a spring of stiffness k attached to the rod at pt. *O,* with a spring of stiffness K k attached at pt. *A.* *,* and a damper with damping coefficient c attached at pt. *B.* The position of the mass along the rod is defined as r, and the angular the rod makes with the ground is defined θ. The distance from the cente of the rod to the outer spring and damper is d. The inner spring is unstretched at $r=0$, and the outer spring is unstretched at $r=L$.

a) Draw free body diagrams of the mass and the rod.

b) Use Newton's 2nd Law to derive two equations of motion in terms of r, and θ. Hint: It may be easier to use Newton's Equations using polar coordinates. The forumla for the acceleration in polar coordinate system and configuration for polar coordinates is shown in the figure at right.



c) In class, it was stated that it is typical to have one degree of freedom if you have one mass. This is typical for a system of mass and carts. Here we have one mass and two degrees of freedom, explain in words why one needs two degrees of freedom to describe the motion.

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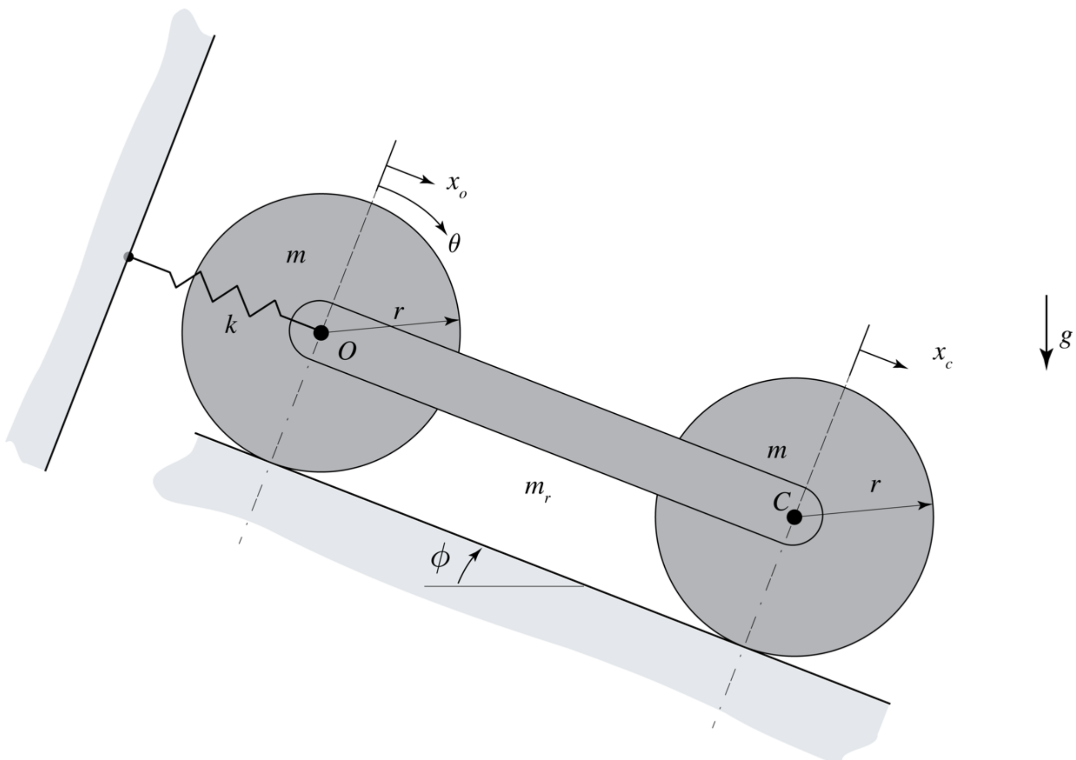
Homework Problem 1.4

Consider the system below: It consist of two homogeneous circular cylinders, each of mass m and a centroidal mass moment of inertia, $I=1/2mr^2$, and rod AB of mass m_r and length l. The cylinders, which have radius r are assumed to roll without slipping. Due to the rolling conditions, the velocities of the centers of mass of they cylinders are equal. The system in on an incline and attached to wall by a spirng of constant k at point A.



a) Using the <u>power equation formulation</u>, determine the equations of motion for the system using the coordinate θ. Draw a free body diagram of the entire system before writing down the power equation. <u>Don't forget your datum.</u>