ME EN 534
Homework #3

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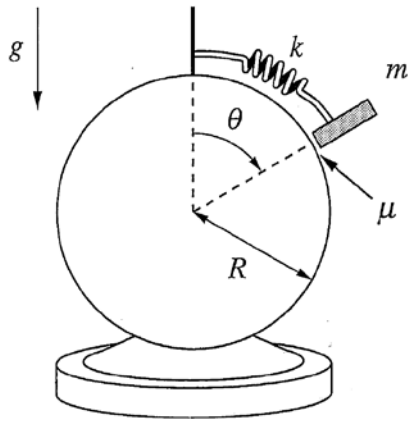
1. Complete Problem 2.28 from the text. Express your answer in the *XYZ* frame, which rotates with the vertical shaft, as shown in Figure 2.42.b. The *x'y'z'* frame is attached to arm *OB*: *x'* is directed from *B* to *C*, *y'* is directed from *O* to *B*, and *z'* is perpendicular to *x'* and *y'*. Ignore Figure 2.42.c.

2. Complete Problem 2.40 from the text. Express your answers in the *xyz* frame attached to the oscillating tube, with *y* directed as shown and $\dot{\theta}$ occurring about the positive *x* axis.

3. Find the equation of motion in terms of θ for the mass sliding with Coulomb friction over a disk of radius *R*, as shown below. A spring connects the mass with the top of the disk. The spring is unstretched when $\theta = 0$.



4. A rigid wire rotates in the horizontal plane with a constant angular velocity of 10 rad/s about the *z*-axis. A bead of mass *m* on this wire is released from rest at a radial distance 5 cm from the *z*-axis at time $t = 0$. If the coefficient of friction between the bead and the wire is $\mu = 0.5$, determine the time it takes for the particle to move to a point on the wire 30 cm from the *z*-axis.

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5. A speed governor consists of a block of mass m that slides within a smooth groove in a horizontal housing. The spring, of stiffness k, is unstretched when the block is at $s = 0$. The system rotates about the vertical axis at an angular speed ω.

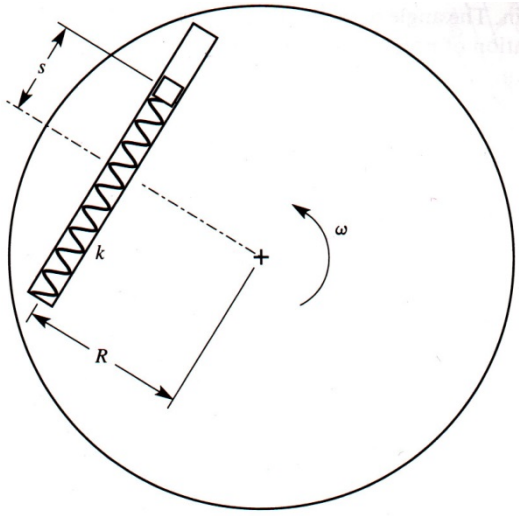
a. Derive the differential equation describing s as a function of time in the case where ω is an arbitrary function of time.

b. Derive an expression for the normal force N exerted by the groove wall on the block in terms of ω and s.

c. Solve the differential equation found in part a for a single revolution of the housing, using the values $m = 0.75$ kg, $k = 25$ N/m, $R = 1$ m, and $\omega = 5\sin t$. Plot $s(t)$, $N(t)$, $s(\theta)$, and $N(\theta)$, where θ is the angle of rotation of the housing. Assume that the block is at rest at $s = 0$ when $t = 0$. Specify the method that you used to obtain the solution, including the step size (if applicable).

d. What is the maximum absolute value of s during the first revolution of the housing?

e. What is the maximum absolute value of N during the first revolution of the housing?



6. A pendulum consists of a particle of mass m and a massless string of length $2R$. As the deflection angle θ increases, the string wraps around one of two fixed cylinders of radius R adjacent to the support point O.

a. Obtain the equation of motion in terms of θ, where θ is assumed to be positive. You do not need to solve the equation of motion.

b. Assuming the initial conditions $\theta(0) = 0, \dot{\theta}(0) = \left({}^{g}/_{2R}\right)^{1/2}$, find θ_{max}.