Lagrangian Dynamics Project

Rigid-Body Spring Pendulum

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By:

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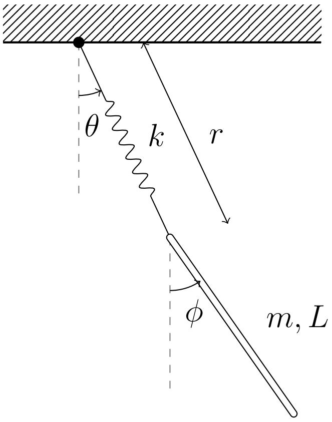
1 Conceptualize the Problem



The pendulum system consists of a rigid bar pinned to the free end of a linear spring, which rotates about its opposite end at a fixed point; there are three degrees of freedom, since each bar has an individual rotation with respect to the vertical, as well as the radial distance the bar is from the point of rotation.

1.1 Constants and Assumptions

Constants:		Assumptions:
Bar Mass:	$m = 1$ kg	No Losses
Bar Length:	$L = 1$ m	Released from Rest
Gravity:	$g = 9.81 m/s^2$	Slender Bar
Linear Spring:		Planar
Spring Coefficient:	$k = 25\ N/m$	Rigid-Body Dynamics
Unstretched Length:	$L = 0.5$ m	

We are asked to determine the following:

1. The Equations of Motion for the system via the Lagrangian method.

2. Integrate the Equations of Motion using various initial conditions and plot the behavior of the system for 10 seconds.

   (a) $\theta_o = 0\ rad, \quad \phi_o = 0\ rad$
   (b) $\theta_o = \pi/18\ rad, \quad \phi_o = \pi/9\ rad$
   (c) $\theta_o = \pi/6\ rad, \quad \phi_o = \pi/3\ rad$

3. Plot the total energy versus time for all 3 cases.

4. Repeat 2. and 3. using a '`RelTol`' of 1e-6 and '`AbsTol`' of 1e-9 for the `ode45` integration tolerances.

2 Free Body Diagram

3 Coordinate Frame

4 Sum of Forces

5 Constraints

6 Solve for the Equations of Motion

7 Solve the Equations of Motion

8 Does it Make Sense?

8.1 Units

Checking with the MATLAB symbolic units tool (from Section 9.3):

8.2 Magnitude

9 Appendix

9.1 Attributions

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Thorne Wolfenbarger
Trey Dufrene
Joint Effort

9.2 Analytical Solution

9.3 Numerical Solution