Pendulum Simulation Lab

July 7, 2023

You are given a material with unknown properties, and you wish to find its density ρ. You are also given a light string with density $\lambda = 0.0016$ kg/m. You can only make spheres of radius $1.0 < r < 10.0$ (cm) and cut strings of length $1.0 < l < 250.0$ (cm). In order to determine the material's density, you decide to make a pendulum as pictured on the next page. Assume the apparatus is built such that the bob never slams the top of the apparatus. You do not know g.

In the program, you may choose the length of the string, the initial amplitude θ_0 ($1^\circ < \theta_0 < 150^\circ$) of the pendulum, and the radius of the bob. Given these parameters, the program will return the period T of the subsequent oscillations. All input uncertainties are half of the last digit of the constraints; that is, the uncertainty in radius and length is 0.05 cm, and the uncertainty in amplitude is half a degree. The output uncertainty is similarly half of the last reported digit, or 0.005 s.

1. Determine g.
2. Determine the density ρ of the material.
3. The period of oscillations is roughly independent of amplitude for small oscillations. Say that for a certain combination of l and r, this period of small oscillations is T_0. Then the period T for larger amplitudes, holding l and r fixed, to the leading order correction is $T = T_0(1 + \alpha\theta_0^2)$, where α is a numerical constant. Determine α.

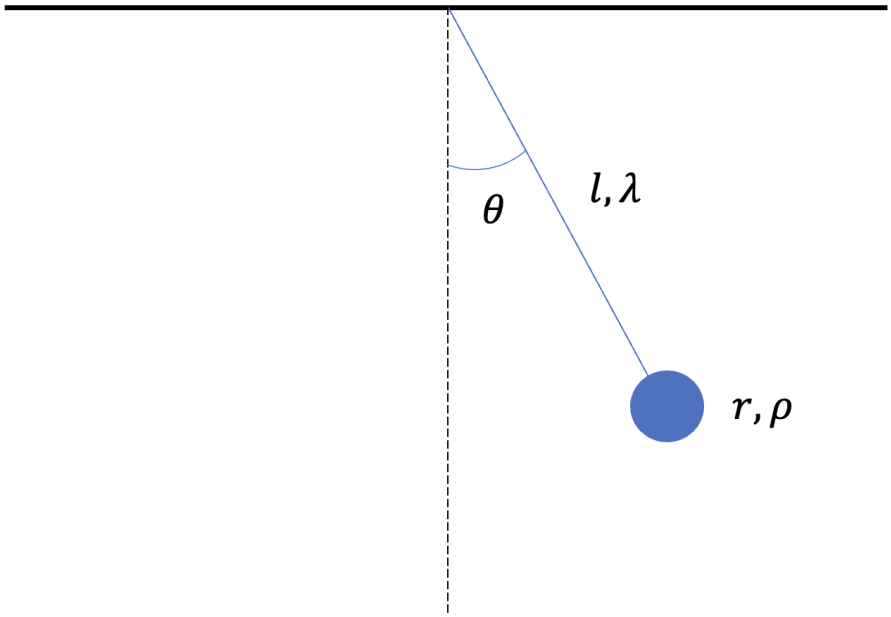

Figure 1: Pendulum