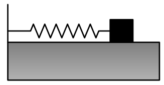
Homework 1

Chapters 12 and 13

Problem 1. *A frictionless block-spring system oscillates with amplitude A. If the mass of the block is doubled without changing the amplitude, (a) does the total energy change? (b) does the frequency of oscillation change?*



Problem 2. *A thin, rigid rod $L = 8.4$ m long pivots freely about one end. The rod is initially deflected $\theta_i = 6.4°$ from the vertical with an angular velocity of $\dot{\theta}_i = 2.7°/s$. (a) Determine the time dependence $\theta(t)$. (b) By what angle is the rod deflected at $t = 8.9$ s?*
Hint: you might want to review torque and moments of inertia in Chapter 10.

Problem 3. *Hydraulic shock absorbers typically consist of a piston in an oil filled reservoir (see http://en.wikipedia.org/wiki/Shock_absorber). Orifices in the piston allow oil to flow from one side of the piston to the other, so piston movement stirs the oil. The stirring transforms the piston's mechanical and kinetic energy into heat, damping any piston oscillation.*
You are asked to design a shock absorber for a motor-unicycle (suspended by a single shock and spring). With a rider the motor-unicyle weighs $m = 140$ kg and is sprung with a $k = 2.0$ kN/m spring.
(a) Determine the undamped resonant frequency in Hz. (b) Determine the damping coefficient for critical damping.
Hint: treat the shock absorber as a damped simple harmonic oscillator.

Problem 4. *Show that the all functions of the form $y(x,t) = f(x \pm vt)$ for any function $f(z)$ satisfy the linear wave equation (Equation 13.19)*

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2} \,. \tag{1}$$

Problem 5. *Jack and Jill are broadcasting kazoo music from their treehouse to a picnic below using a tin can telephone (http://en.wikipedia.org/wiki/Tin_can_telephone). Their transmitting string weighs $m = 140$ g, is $L = 30$ m long, and is stretched to a tension of $T = 45$ N. At what amplitude must Jack and Jill vibrate their end of the string to drive the far can at $P = 1$ W while playing the musical note A at $f = 440$ Hz?*

Problem 6. BONUS PROBLEM. *Find the resonant frequency in Hz of the sprung pendulum for small θ on both Earth and the Moon. The mass of the bob is $m = 2.3$ kg, the length of the light rod is $r = 3.0$ m, and the spring constant is $k = 1.4$ N/m. The system is at equilibrium when the pendulum rod is vertical.*
Hints: drawing a free body diagram may help determine the restoring forces. You will need to use the small angle approximation.