ABOUT THE LAB:

We will use a built-in Matlab solver for differential equations, ode45. We will use this to solve the inverted pendulum model for walking. Finally, we will modify this model to reflect compliance of a leg.

Exercises: The equation of motion for an inverted pendulum is

$$\frac{d^2\theta}{dt^2} = \frac{g}{L}\sin\theta$$

where $\theta(t)$ is the angular displacement, L is the length of the arm, and g is the acceleration due to gravity. (Notice that except for the sign change, this is exactly the same as the mode for the pendulum.)

(a) Download pendulum_inv.m and use this to solve the equation. (We will go through the script line by line together.) Show the angular displacement and velocity as a function of time. Describe what you see and why this is a reasonable description of walking.

(b) The total energy of the **pendulum** is given by $E = \frac{1}{2}mL^2\omega^2 - mgL\cos\omega$. Plot this function using the angular velocity, ω that we calculate. Show a figure with the total energy as a function of time on one panel and the total energy as a function of ω on the other. Is this the correct total energy function for the inverted pendulum?

(c) Now assume that the length, L of the arm of the pendulum changes according to the equation $L = L_0 - \frac{mg}{k}$ where k is the spring coefficient that describes the compliance of the arm of the pendulum. Explain what this equation means.

(d) Implement the equation in the Matlab function for the inverted pendulum. Run simulations for 5 different values of k ranging from 1000 to 10. For each simulation, look at the angular displacement and the energy function. Describe what you see.

(e) Read the article by Geyer et al (on moodle for this lab). Summarize the main points of the article and comment on how it relates to the class discussion about the models for walking and running.

(f) (COMPLETE THIS AND REMAINING PARTS IF THERE IS TIME)
Brainstorm about other plausible assumptions about how the length would change. (Hint: think about what physical quantities the length of a runner's leg would be correlated to.) Describe one of your ideas and implement it it Matlab.