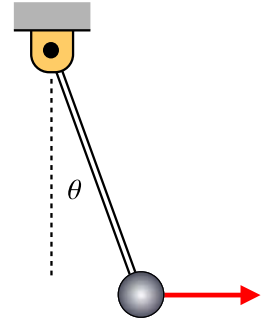## Exercises for Day 35

Exercise 1. A simple robotic arm can be modeled as a pendulum, as in the picture to the right. Let θ be the angular displacement of the pendulum counterclockwise from the downward position, and denote the angular velocity by ω. There is damping in the pivot, and a force F is applied horizontally to the lumped mass at the end of the pendulum.

The equations governing the behavior of a particular pendulum are as follows:

$$\frac{d\omega}{dt} = -0.4\,\omega - 20\sin(\theta) + F\cos(\theta)$$

$$\frac{d\theta}{dt} = \omega$$

where the units for θ and ω are rad and rad/s, respectively, and time t is in seconds. Suppose the applied force F is such that

$$F = 0 \text{ when } \omega \geq 0$$

$$F = 2 \text{ when } \omega < 0.$$

The initial conditions for the pendulum are

$$\omega(0) = 4 \text{ rad/s}$$

$$\theta(0) = 0 \text{ rad}.$$

Complete the following:

a) Use MATLAB to plot the pendulum's angular displacement θ as a function of time t, starting at $t = 0$ s and ending at $t = 4$ s. Use a time step $\Delta t = 0.01$ s. Be sure to properly label your axes and to include a title.

b) Determine the values of θ and ω at $t = 1.74$ s. Print these values to a text file using the following format:

```
Angular displacement at t = 1.74 s is  X.XXX rad.
Angular velocity at t = 1.74 s is  X.XXX rad/s.
```

Exercise 2.
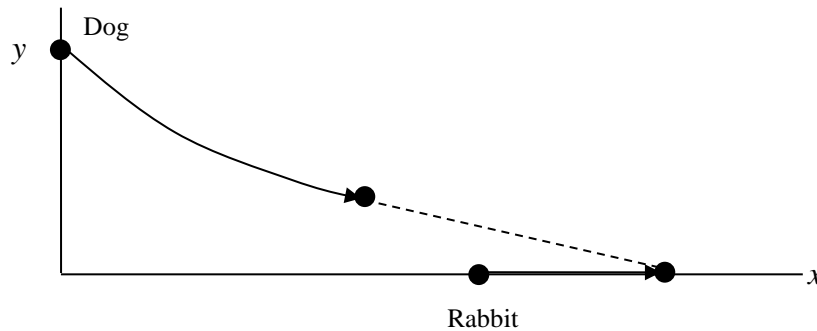
A dog, whose initial location is on the y-axis, spots a rabbit, initially located on the x-axis. The chase begins, with the rabbit running straight along the x-axis with a speed v_R. The dog, running at a constant speed of v_D, follows a "curve of pursuit," meaning that he is running straight towards the rabbit from his present position. Your job is to generate the curve of pursuit from the beginning of the chase until the time the dog captures the bunny, or the bunny gets away.

The distance d between the dog and rabbit at any given moment is given by

$$d = \sqrt{\left(x_R - x_D\right)^2 + y_D^{\,2}}$$

The dog's x-position, x_D, varies according to

$$\frac{d\,x_D}{d\,t} = \frac{v_D\left(x_R - x_D\right)}{d}.$$

The dog's y-position, y_D, varies as follows:

$$\frac{d\,y_D}{d\,t} = -\frac{v_D\,y_D}{d}.$$

The rabbit's x-position, x_R, varies according to

$$\frac{d\,x_R}{d\,t} = v_R.$$

Let's say that the dog can run at 35 ft/sec for 9 seconds before tiring out. He starts at $y = 100$ ft. The rabbit starts at $x = 100$ ft and can run on and on at 20 ft/sec. If the dog gets within $d = 2$ ft, he catches the rabbit. Using the Euler method and a time step of 0.05 seconds, solve this problem. Generate and plot the curve of pursuit. Have your program print out to a text file whether or not the dog captures the rabbit, and if he does, how long it took.

Hint: To test your program, just try giving the rabbit zero speed – you can figure out what happens! Turn in the plot, your m-files, and the printout of whether the dog caught the rabbit.