Pendulum Wave in Matlab Math 320 Prof. Leise

Basics of Matlab

1. Start up Matlab.
2. Type `1:10` in the command window and press return.
3. Try `1:2:10` and `1:1/2:10`.
4. We want to plot a few sine functions, so define a vector of time points, `t=0:0.01:2`. Use a semi-colon ; to suppress output, so you don't get a gazillion numbers after pressing return.
5. Next define a vector of corresponding sine values: `x=sin(2*pi*t);`
6. Open a figure window by typing `figure`
7. Plot the sine: `plot(t,x)`
8. You can adjust the color and linestyle: `plot(t,x,'r-.')`
9. Add more plots to the same figure window by typing `hold on`
10. Add sines with higher frequencies:
    `plot(t,sin(2*pi*2*t),'b',t,sin(2*pi*3*t),'k--')`
11. How many times does `sin(2*pi*f*t)` oscillate on the interval [0,1]?

Scripts in Matlab

1. Create a new script, either using the File menu or by clicking on the New Script icon at the upper left of the Matlab window.
2. In the Editor window, type the following:

```
t=0:0.01:3;
figure;hold on
xlim([t(1) t(end)])
ylim([-1.1 1.1])
for f=1:6
     plot(t,sin(2*pi*f*t));
end
```

   The for-loop will run through the 6 frequencies and plots each one. The axis command fixes the x-axis to be shown from the first value of the time vector, t(1), through the last value, t(end). The y-axis is set to the interval [-1.1 1.1].

3. Save the file with a name like SinePlot.m that ends in ".m". You may want to create a new folder for your Math 320 scripts. After creating the folder, update the Current Folder at the top of the Matlab window to that folder by clicking the button with 3 dots at the top right and choosing your new folder.

4. Press the green arrow on the Editor window to run the new script (or type the name of the script without the .m in the command window and press return).

Notice that a pattern repeats with all sine curves passing through the same point at certain times.

The neat wave patterns appearing in the wave pendulum video www.youtube.com/watch?v=yVkdfJ9PkRQ are related to the patterns in the sine plot. The frequency of a pendulum is inversely proportional to the square root of its length (if we ignore friction). To construct a series of pendula with frequencies, say, 5 through 15, we would take 11 weights and hang them on strings of lengths proportional to $\frac{1}{5^2}, \frac{1}{6^2}, \ldots, \frac{1}{15^2}$. Now we'll make a Matlab simulation to explore whether this simple idea of a series of pendula with different frequencies can generate the patterns seen in the video.

Plotting pendula

1. To keep things simple, we'll graph the position of the weights as seen by someone looking straight down at the pendula from above. Create a new script and save it as something like "PendulumWave.m".

2. It's generally a good idea to start a new script with `clear all` to prevent accidentally using an old variable value that you didn't intend.

3. Next choose a range of frequencies to using in your simulated pendula, e.g.,

```
freqs=5:16;
```

4. Have the script open a figure window and plot the pendula at rest:

```
pendula=plot(zeros(size(freqs)),freqs,'k.','MarkerSize',25);
```

5. Fix the x-limits to be [-1.1 1.1] and y-limits to cover the smallest to largest frequency in your `freqs` vector.

6. Make a for-loop to repeatedly update the plot over time:

```
for t=0:0.001:1
     x = sin(2*pi*freqs*t);
     set(pendula,'XData',x);
     drawnow; pause(0.03)
end
```

7. Save your script and run it. Feel free to adjust various numbers and experiment. Notice that the pendulum with frequency 15 oscillates three times as often as the pendulum with frequency 5. Adjust the value in the pause command to speed up or slow down the movie.