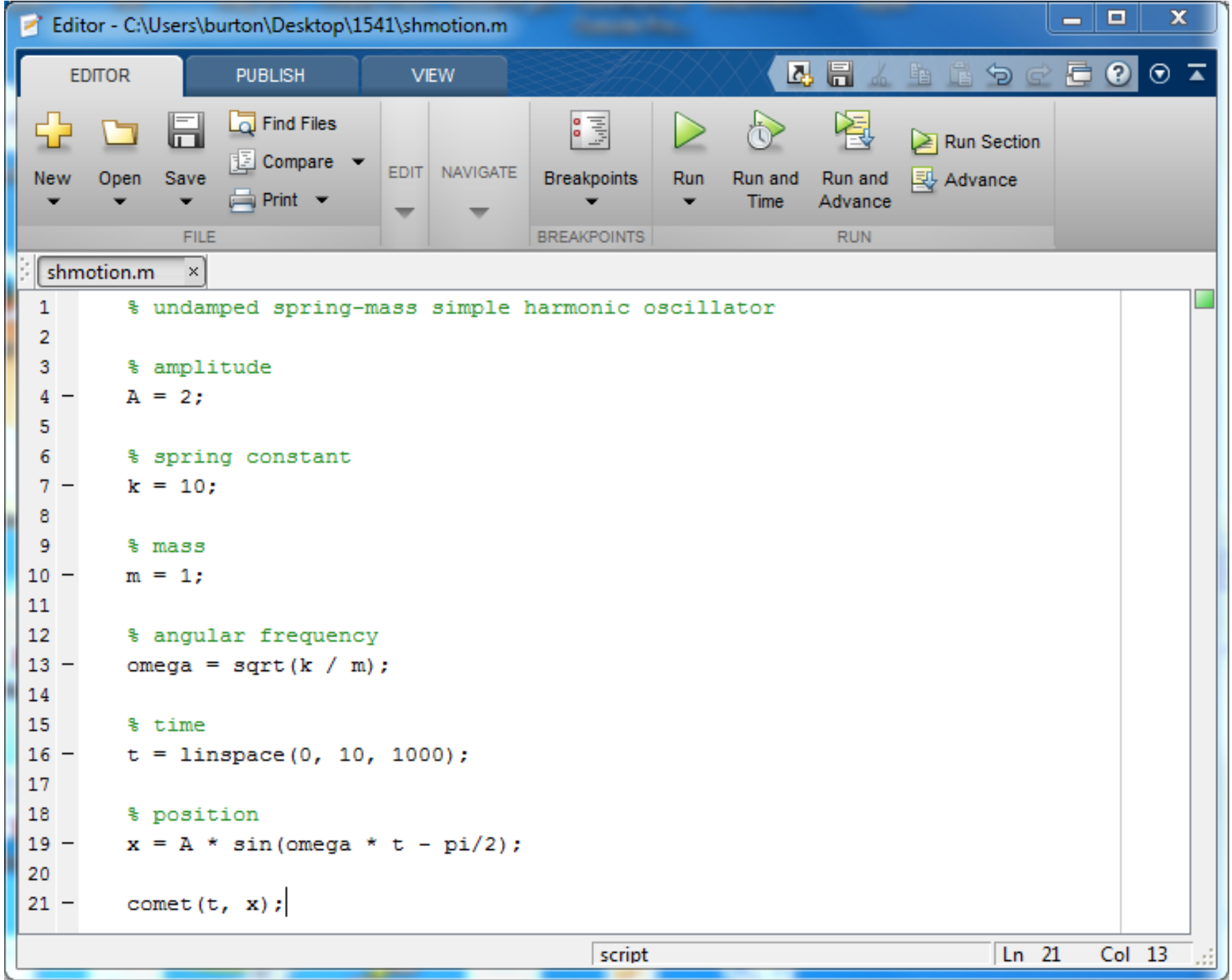
User-defined functions

Recall the script example from Day 5

- an undamped spring-mass system is an example of a simple harmonic oscillator
- the position of the mass is given by

$$x(t) = A \sin\left(\sqrt{\frac{k}{m}}t - \frac{\pi}{2}\right)$$


Editor - C:\Users\burton\Desktop\1541\shmotion.m
EDITOR
PUBLISH
VIEW
New
Open
Save
Find Files
Compare
Print
FILE
EDIT
NAVIGATE
Breakpoints
BREAKPOINTS
Run
Run and Time
Run and Advance
Run Section
Advance
RUN
shmotion.m
1 % undamped spring-mass simple harmonic oscillator
2
3 % amplitude
4 A = 2;
5
6 % spring constant
7 k = 10;
8
9 % mass
10 m = 1;
11
12 % angular frequency
13 omega = sqrt(k / m);
14
15 % time
16 t = linspace(0, 10, 1000);
17
18 % position
19 x = A * sin(omega * t - pi/2);
20
21 comet(t, x);
script
Ln 21
Col 13

User-defined functions

- scripts are useful but:
  - the variables used in the script appear in the current workspace
  - the values of the variables used in the script are fixed

- contrast this to a user-defined MATLAB function
  - the variables used in the function do not appear in the current workspace
  - the user of the function can specify the input values to the function

User-defined functions

- a user-defined function is usually a plaintext file having a filename with the following form:

`yourFunctionName.m`

where **`yourFunctionName`** must be a valid MATLAB variable name

  - i.e., must begin with a letter and may only contain letters and spaces and underscores
    - no spaces or symbols!

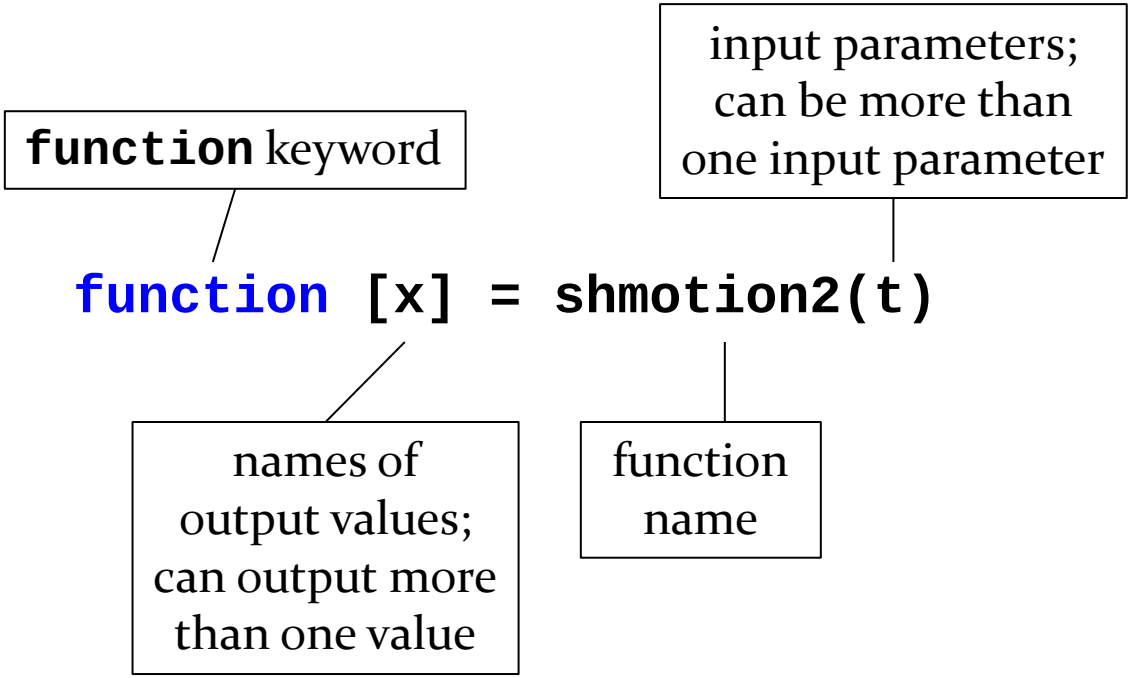
User-defined functions

- let's replace the script that calculates the position of an undamped spring-mass system with a function
- the position of the mass is given by

$$x(t) = A \sin\left(\sqrt{\frac{k}{m}}t - \frac{\pi}{2}\right)$$

User-defined functions

- the first line of a MATLAB function is called the function header:



User-defined functions

- the block of comments immediately following the header is the help documentation for the function
  - the help comments are not required but very useful
  - you may have noticed that in the functions that come with MATLAB, the function name, names of the output values, and names of the input parameters are written in uppercase in the help comments
    - this is so that these names are more apparent in the Command Window
    - you don't have to do this, and there are good arguments against using this convention

User-defined functions

```
function [x] = shmotion2(t)
%SHMOTION2
%   X = SHMOTION2(T) returns the position X
%   of a simple harmonic oscillator evaluated
%   at each time in the vector T


end
```

User-defined functions

- you might prefer adding documentation in the same style that appears in the Help browser
  - you can use Cell-mode style comments like you have been doing in the labs

User-defined functions

```
function [x] = shmotion2(t)
%% shmotion2
% Position of a simple harmonic oscillator.
%% Syntax
%  x = shmotion2(0:0.1:5);
%% Description
% |x = shmotion(t)| for vector |t| computes the position |x|
% for each element in |t|
%% Examples
%  x = shmotion2(0:0.1:0.5)
%  x =
%     -2.0000   -1.9008   -1.6132   -1.1655   -0.6023    0.0207

end
```

User-defined functions

- the body of the function appears after the help comments
- the body contains MATLAB statements that are interpreted in a separate workspace
  - i.e., variables that appear in the body do not appear in the user workspace, and
  - variables in the user workspace are not visible to the function

User-defined functions

```
function [x] = shmotion2(t)
% help comments not shown

% amplitude
A = 2;

% spring constant
k = 10;

% mass
m = 1;

% angular frequency
omega = sqrt(k / m);

% position
x = A * sin(omega * t - pi/2);

end
```

you must assign a value for every output variable!

User-defined functions

- to use the function, it must be in a folder on the current MATLAB path
- you call (or invoke) the function in the usual way:

```
>> t = 0:0.01:5;
>> x = shmotion2(t);
>> comet(t, x)
```

User-defined functions

- so far our function is a function of time only
  - i.e., the amplitude of oscillation, spring constant, and mass are still fixed
- it would probably be useful to allow the user of the function to change these other parameters

$$x(t, A, k, m) = A \sin\left(\sqrt{\frac{k}{m}}t - \frac{\pi}{2}\right)$$

User-defined functions

```
function [x] = shmotion2(t, A, k, m)
% help comments not shown

% angular frequency
omega = sqrt(k / m);

% position
x = A * sin(omega * t - pi/2);

end
```

User-defined functions

- can you generalize our function even more?

User-defined functions

- write a function that computes the magnitude of force given by Newton's law of gravity

$$F = \frac{Gm_1m_2}{r^2}$$

User-defined functions

- write a function that computes the total energy, potential energy, and kinetic energy of a free falling mass at a height *y* above the earth's surface with instantaneous velocity *v*

$$E = mgy + \frac{1}{2}mv^2$$