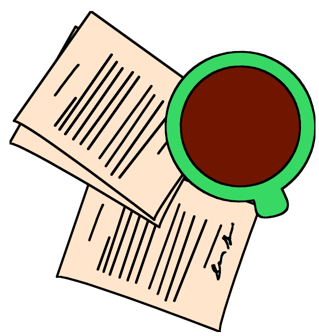
Cold Coffee

Vectors and plotting

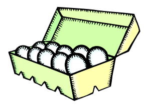
CS112 Scientific Computation
Department of Computer Science
Wellesley College

Cold, funny-tasting coffee

Time(min)	Temperature (°C)
0	93.5
1	90.6
2	87.7
3:30	83.9
7	76.6
10	71.3
18	61.5
26	65.8
34	49.2
52	41.9
113	29.1
166	25.5
191	25.0



Vectors



- A **vector** is an ordered collection of numbers

```
times = [0  1  2  3.5  7]
temps = [93.5  90.6  87.7  83.9  76.6]
```

times	0	1	2	3.5	7

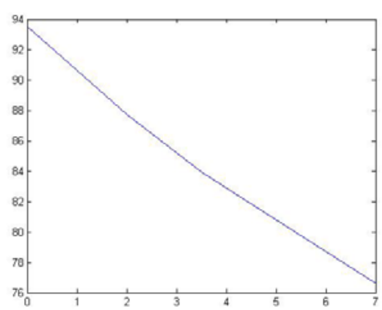
temps	93.5	90.6	87.7	83.9	76.6

Plotting data: Round 1

- Create a **2D graph** with the **plot** function

```
times = [0  1  2  3.5  7]
temps = [93.5  90.6  87.7  83.9  76.6]
```

vector of
x coordinates
↓
plot(times, temps)
↑
vector of
y coordinates



Computations on collections of data

- Perform the same arithmetic operation on each element of vector

```
>> times = [0  1  2  3.5  7]
```

times					
	0	1	2	3.5	7

```
>> times = 60 * times
```

times					
	0	60	120	210	420

Time-out exercise

- Write an assignment statement to convert temperature from Celcius to Fahrenheit*

```
>> temps = [93.5  90.6  87.7  83.9  76.6]
```

temps					
	93.5	90.6	87.7	83.9	76.6

```
>> ...
```

temps					
	200.3	195.08	189.86	183.02	169.88

* Hint: F = 32 + (9/5)C

More vector magic

- Perform **element-by-element computations** on two vectors, e.g. average the two data samples*

```
>> sample1 = [3.2  1.1  4.7  2.1  6.2]
>> sample2 = [3.0  1.2  4.4  2.4  6.1]
```

sample1	3.2	1.1	4.7	2.1	6.2

sample2	3.0	1.2	4.4	2.4	6.1

* **Hint:** How do you calculate the average of two single numbers **sample1** and **sample2**?

The envelope please

- Element-by-element average:

```
>> sample1 = [3.2  1.1  4.7  2.1  6.2]
>> sample2 = [3.0  1.2  4.4  2.4  6.1]
>> average = (sample1 + sample2) / 2
```

sample1	3.2	1.1	4.7	2.1	6.2

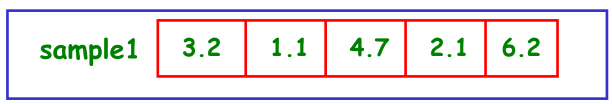
sample2	3.0	1.2	4.4	2.4	6.1

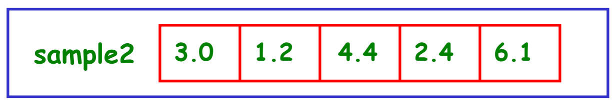
average	3.1	1.15	4.55	2.25	6.15

Let's try that one again

- Perform element-by-element computations on two vectors, e.g. **multiply corresponding values** in the two data samples*

```
>> sample1 = [3.2  1.1  4.7  2.1  6.2]
>> sample2 = [3.0  1.2  4.4  2.4  6.1]
```



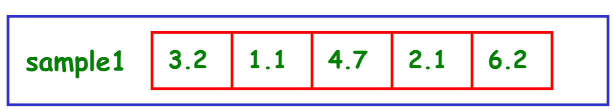


* oops…

Still more magic

- Compute a single value from the contents of a vector

```
>> sample1 = [3.2 1.1 4.7 2.1 6.2]
```




```
>> totalSum = sum(sample1)
>> totalProd = prod(sample1)
>> sampleSize = length(sample1)
>> minValue = min(sample1)
>> maxvalue = max(sample1)
>> avgValue = mean(sample1)
```

Creating sequences

- Often you will want to create a sequence of evenly spaced numbers*
- Use **colon notation**

end

```
>> nums = 1:2:9
```

start step

nums	1	3	5	7	9

* Trust me, you really will want to do this someday!

Creating evenly spaced sequences

- Use the **linspace** function:

  linspace(start, end, num)

  to create a vector of **num** evenly spaced numbers from **start** to **end**

```
>> nums = linspace(0, 10, 5)
```

nums	0.0	2.5	5.0	7.5	10.0

* Write an assignment statement that stores a sequence of 5000 evenly spaced numbers from 1 to 1000

Plotting data: Round 2

- Adjust the appearance of lines and markers with a third input to the **plot** function:

```
plot(times,temps,'g--*');
```

- Third input is a string of 1 to 4 characters in single quotes:

color: b g r c m y k w
marker: . o x + * s d v ^ < > p h
linestyle: - : -. --

- Add text labels:

```
xlabel('Time, minutes')
ylabel('Temperature, Celcius')
title('Cooling a Cup of Coffee')
```

Newton's Law of Cooling

- An object's rate of cooling depends on the difference between object's temperature and ambient temperature
- Temperature decreases exponentially over time
- According to Newton:

$$T(t) = T_{env} + (T(0) - T_{env})e^{-kt}$$

where
$T(t)$ is object temperature at time **t**
$T(0)$ is initial temperature of object
T_{env} is environment temperature
k depends on material (for coffee **k ~ 0.0426**)

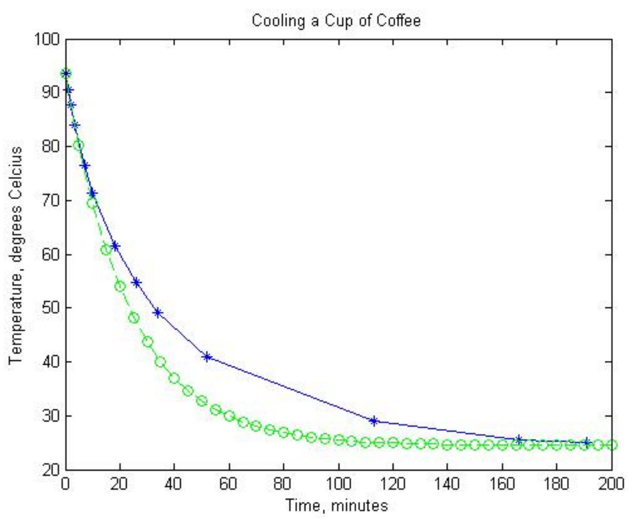
Coffee break

```
% cooling.m
% compares the direct measurement of cooling of coffee with
% the cooling rate predicted by Newton's Law of Cooling

timeData = [0  1  2  3.5  7  10  18  34  52  113  166  191];
tempData = [93.5  90.6  87.7  83.9  76.6  71.3  61.5  54.8 ...
            49.2  41.0  29.1  25.5  25.0];
plot(timeData, tempData, 'b-*')
xlabel('Time, minutes')
ylabel('Temperature, degrees Celcius')
title('Cooling a Cup of Coffee')

timeSamples = 0:5:200;
tempLaw = 24.5 + 69 * exp(-0.0426 * timeSamples);
hold on
plot(timeSamples, tempLaw, 'g--o')
hold off
```


Ta Da!

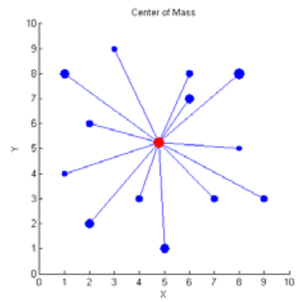


Exercise: Center of Mass

```
% coordinates and masses of particles
xcoords = [1  7  6  8  3  5  9  2  8  6  2  4  1];
ycoords = [8  3  7  5  9  1  3  6  8  8  2  3  4];
masses = [11  8  10  4  5  11  6  7  12  8  9  6  5];
% calculate the center of mass of the particles
xcenter =


ycenter =


% print center of mass coordinates using disp
```



$$x = \frac{\sum_i m_i x_i}{\sum_i m_i} \qquad y = \frac{\sum_i m_i y_i}{\sum_i m_i}$$