EEE4119F – practical 1

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Tip: don't forget that you can get help by typing

```
>> help <function name>
```

in the Command Window if the tutors are busy with other students.

If C and F are the Celsius and Fahrenheit temperatures, the relationship is given as follows:

$$F = \frac{9C}{5} + 32$$

1. Use the matlab command line to convert from a temperature of 37 degrees C to Fahrenheit

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37C = 98.6F
```

2. Set up a vector N with elements [1,2,3,4,5]. Use the matlab array operations on the vector to set up the following four vectors, each with five elements:

   a. $2,\ 4,\ 6,\ 8,\ 10$
   b. $½,\ 1,\ 3/2\ ,\ 2,\ 5/2$
   c. $1,\ ½,\ 1/3,\ ¼,\ 1/5$
   d. $1, \frac{1}{2^2}, \frac{1}{3^2}, \frac{1}{4^2}, \frac{1}{5^2}$

```
a = 2*N;
b = 0.5*N;
c = 1./N;
d = 1./N.^2;
```

3. An alternating sign series is given by:

$$1 - \frac{1}{2} + \frac{1}{3} - \frac{1}{4} + \frac{1}{5} - \ldots$$

   Write a matlab script to calculate the series for the first 1000 terms. You may use **for** loops. Your answer should sum to $log\ (2)$

```
0.3074
```

4. Write a script which computes the first 100 members of the sequence:

$$x_n = \frac{a\, x_{n-1}}{n} \qquad x_0 = 1$$

   and then displays every tenth member of the series. Use a value of 10 for a. Hint: the **rem** function may help

5. Without the use of if statements, plot the following function over the interval 0 to 3π:

$$y(x) = \{sin\ (x)\ \ for\ \ sin\ (x)\ > 0,\quad 0\ otherwise\}$$

6. To simulate throwing a dice, we can generate a vector of random numbers. Use the function **rand** to do this and determine the probability of landing on a 6 by generating 20 rolls. Do this without a **for** loop. Increase the number of rolls to 1000 and see that the probability converges to $1/6$

7. Given b (right) provide a matlab expression that uses only a single matrix multiplication to obtain:

$$b = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ 9 & 7 & 5 & 3 & 1 & -1 & -3 \\ 4 & 8 & 16 & 32 & 64 & 128 & 256 \end{bmatrix}$$

   a. The sum of columns 5 and 7 of b
   b. The last row of b
   c. A version of b with rows 2 and 3 swapped

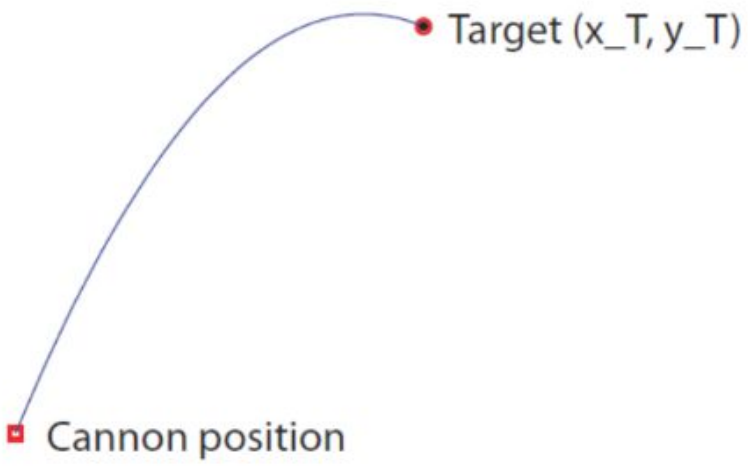
   Hint: start by thinking about the dimensions of the desired output matrix, and then think about what dimension the input must be to get that

8. Give a matlab expression that multiplies two vectors to obtain:

   a. $\begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 1 & 2 & 3 & 4 & 5 \\ 1 & 2 & 3 & 4 & 5 \end{bmatrix}$

   b. $\begin{bmatrix} 0 & 0 & 0 \\ 1 & 1 & 1 \\ 2 & 2 & 2 \\ 3 & 3 & 3 \\ 4 & 4 & 4 \end{bmatrix}$

9.



A canon is fired at a target at position [1000m, 1250m]. We would like to determine the optimal initial velocity [vx0, vy0] is to hit the target in 10s.

We can solve this problem using a Brute Force Search where we seek to minimize the distance between the cannonball and the target.

a) First, we need to write a function which takes in the target position, time of flight and initial velocity of the cannonball. This function must then return how far from the target the cannonball is after the time of flight specified. The equations are:

$$x_{miss} = v_{x0}\, t - x_T$$

$$y_{miss} = v_{y0} t - \frac{1}{2} g t^2 - y_T$$

b) A Brute Force search works by trying every possible value on some interval. Write a script which calls your cannonball trajectory function, for varying initial velocities. The outcome must be a three column matrix of row length n x n. Where n is the length of your velocity vectors. For a start use velocity vectors of v_x from 50 to 100m/s and v_y from 100 to 200 m/s.

c) Using your answer, plot a graph of velocity x, velocity y and miss distance. You should see a clear minimum. You can use the **`surf`** function.

d) Use the Matlab function **`min`** to determine which velocities yield the minimum miss distance.

10. A noisy sine wave is described by the following equation:

$$y = \sin(t) + w(t)$$

Where w(t) is a Gaussian White Noise (normally distributed random variable) with zero mean and variance of 1.

a) Write a Matlab script to plot the function with its noise. Assume the wave is sampled at 0.02s for 10s.

b) Using a first order filter, smooth the data using a time constant of 0.02s, 0.5s and 1s. Use a plot to compare these to the original signal

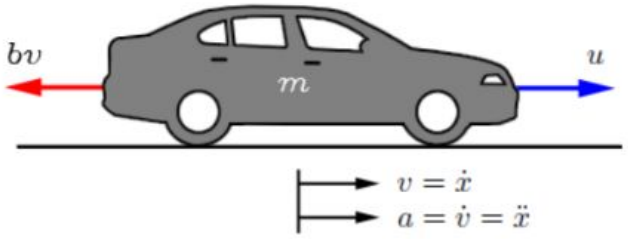
(Tip: start by typing **`help filter`**, and if that's not enough info, look at https://www.mathworks.com/help/matlab/ref/filter.html)

11.

You have been given a .csv file of a high-speed robot's IMU logged data at 10Hz.

a) Use uiimport to import the .csv file as column vectors, then plot the 'GndSpeed' variable as function of time. *Note, time is not one of the logged variables. You need to create your own time vector.*
b) Programmatically determine the max velocity obtained by the robot and determine the time at which this occurs. Check out **`max`** function.
c) Calculate the average acceleration experienced from the start of experiment to the point at which max velocity was experienced.

12.



Automatic cruise control is an excellent example of a feedback control system found in many modern vehicles.

We consider here a simple model of the vehicle dynamics, shown in the free-body diagram (FBD) above. The vehicle, of mass m, is acted on by a control force, u. The force u represents the force generated at the road/tire interface in Newtons. The resistive forces, bv, due to rolling resistance and wind drag, are assumed to vary linearly with the vehicle velocity, v, and act in the direction opposite the vehicle's motion.

The differential equation representing the motion of the system is shown below:

$$m\dot{v} + bv = u$$

Write a script to simulate the motion of the system velocity of the car for 120s. Assume you are starting from rest and the car's accelerator input is held at 500N. The car's mass is 1000kg and the damping force (bv) is 50.