Cornerstone of Engineering
Fall 2020
Northeastern University
College of Engineering
Programming Lab 5
Due: November 20, 2020

Programming Homework (need m-files)

1. **Measurements of the fuel efficiency** of a car F_E at various speeds v are shown in the table.

v (mi/h)	5	15	25	35	45	55	65	75
F_E (mpg)	11	22	28	29.5	30	30	27	23

a) Curve-fit the data with the second-order polynomial. Use the polynomial to estimate the fuel efficiency at 60 mi/h. make a plot of the points and polynomial.
b) Curve-fit the data with the third-order polynomial. Use the polynomial to estimate the fuel efficiency at 60 mi/h. make a plot of the points and polynomial.

2. **The ideal gas equation** relates the volume, pressure, temperature, and the quantity of a by:

$$V = \frac{nRT}{P}$$

Where V is the volume in liters, P is the pressure in atm, T is the temperature in kelvins, n is the number of moles, and R is the gas constant.

An experiment is conducted for determining the value of the gas constant R. In the experiment, 0.05 mol of gas is compressed to different volumes by applying pressure to the gas. At each volume, the pressure and temperature of the gas are recorded. Using the data given below, determine R by plotting V versus T/P and fitting the data point with a linear equation.

V (L)	0.75	0.65	0.55	0.45	0.35
T (^{0}C)	25	37	45	56	65
P (atm)	1.63	1.96	2.37	3.00	3.96

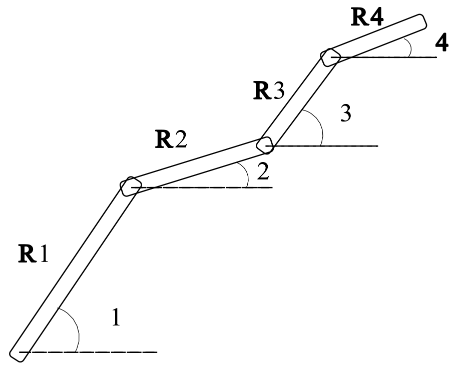
3. **Robotic Arm**

In robotics, one is often concerned with the position of the end of a robot manipulator; that is, the location of the end of the final link in a robot arm. A four-link robot manipulator arm is show in Figure 1, where θ_i is the angle from the horizontal and R_i is the length of the *i*th link of the robot's arm.

In vector notation, the position of the end of the arm is given by:

$$\mathbf{R} = \mathbf{R_1} + \mathbf{R_2} + \mathbf{R_3} + \mathbf{R_4}$$

where , $\boldsymbol{R_i} = R_i \cos(\theta_i) + R_i\ \mathrm{sing}\ (\theta_i)$



In MATLAB we can express this vector as a two component row vector: $[x_i\ y_i]$.
The rules of addition of vectors in MATLAB are precisely the rules for addition of vector components:

If

»R1=[x1 y1];
»R2=[x2 y2];
»R3=[x3 y3];
»R4=[x4 y4];

then

»Re=R1+R2+R3+R4 results in:
»*Re=[xe,ye]=[x1+x2+x3+x4, y1+y2+y3+y4]*

So if we convert the link vectors **R** from magnitude and angle notation into two-component MATLAB vectors, we can find the x- and y-components of the end of the arm as follows:

```
»R1=L1*[cosd(a1) sind(a1)];
»R2=L2*[cosd(a2) sind(a2)];
»R3=L3*[cosd(a3) sind(a3)];
»R4=L4*[cosd(a4) sin(da4)];
»Re=R1+R2+R3+R4;
»xe=Re(1)
»ye=Re(2)
```

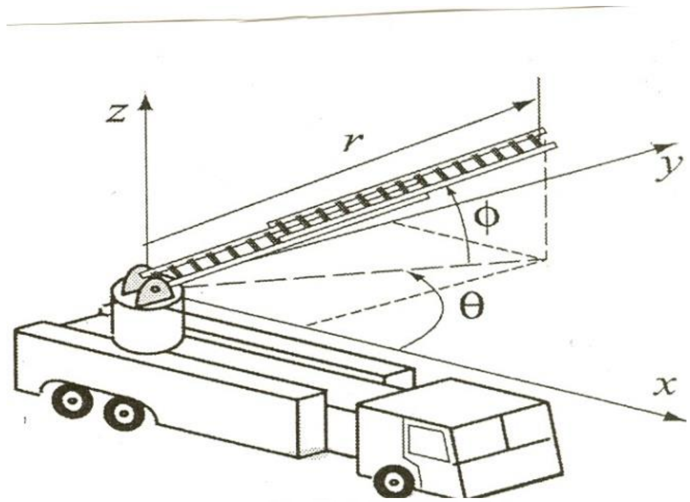
Exercise:
A 4-link robot arm is being operated 8 feet from the wall in a room with 8-foot ceilings. The fourth arm segment is designed to rotate 360^o while in operation. The length of the arm links are: R_1=4 ft, R_2=3 ft, R_3=2 ft, R_4=1 ft. The first and second links are fixed at 60^o and 45^o respectively. Is there a danger of the end of the arm hitting either the wall or the ceiling if the third link is at 0^o, 30^o, 60^o, or 90^o?

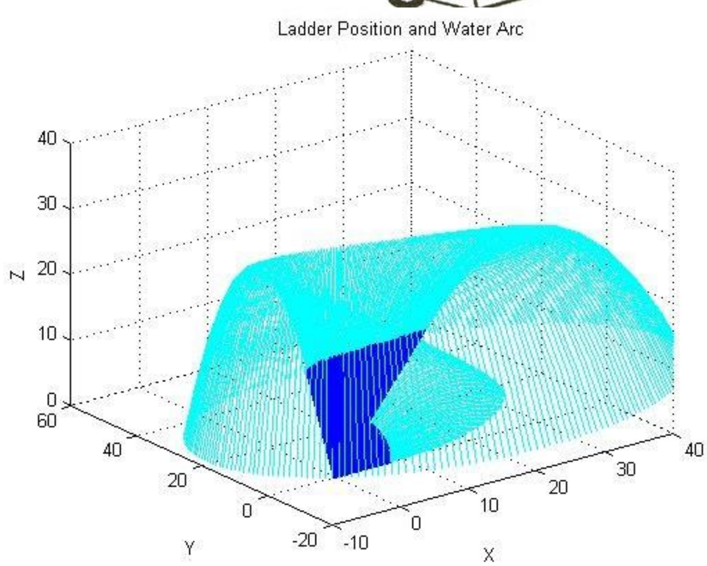
Use a MATLAB for loop to find the *x*- and *y*-components of the end of the arm for the angle of the last link between 0 and 360^o. Prepare a plot as at right to show the range of the end of the arm. Use the axis command to set both axes from 0 to 8 feet.

4. **Fire Truck and Water Flow**

The ladder of a fire truck can be elevated (increase of angle ϕ), rotated about the z axis (increase of angle θ), and extended (increase of r). Initially the ladder rest on the truck, $\phi = 0$, $\theta = 0$, r = 8.25 m. The ladder is moved to position by raising the ladder at a range of $\varphi' = 5.00$ deg/s, rotating of $\theta' = 7.50$ deg/s, and extending the ladder at a rate of $r' = 0.50$ m/s.

a) Determine and plot the position of the tip of the ladder for 25 second.
b) If the water leaves the fire hose at a speed of 18.5 m/s, determine and plot the trajectory of the water flow.





To Turn In via Blackboard:

1. Word file with Cover page, outputs, answers to any questions, and Results and Discussion
2. Source code e-file (upload to the blackboard, the source code should be saved as phw51_xxx.m, phw52_xxx.m, …etc., where xxx is your initial)