ECE 111 - Homework #3

Math 105: Trigonometry. Due Tuesday, September 12th
Please submit via email, via hard copy, or on BlackBoard

Polar to Rectangular Conversions

1) Determine the final position of A: (x,y)

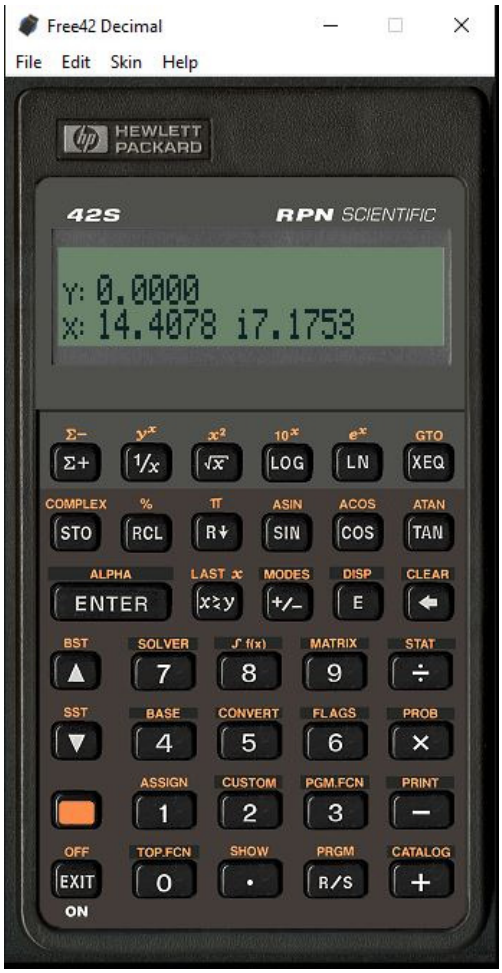
$$A = (10\angle 20^0) + (5\angle 65^0) + (3\angle -15^0)$$

Using Matlab

```
>> x1 = 10*cos(20*pi/180);
>> y1 = 10*sin(20*pi/180);
>> x2 = 5*cos(65*pi/180);
>> y2 = 5*sin(65*pi/180);
>> x3 = 3*cos(-15*pi/180);
>> y3 = 3*sin(-15*pi/180);
>> Ax = x1+x2+x3

Ax =   14.4078

>> Ay = y1 + y2 + y3

Ay =    7.1753
```

Using Free42 (HP42 calculator)

```
modes
polar
10
enter
20
complex
5
enter
65
complex
+
3
enter
-15
complex
+
modes
rectangular
```



2) Determine final position of B: (x,y)

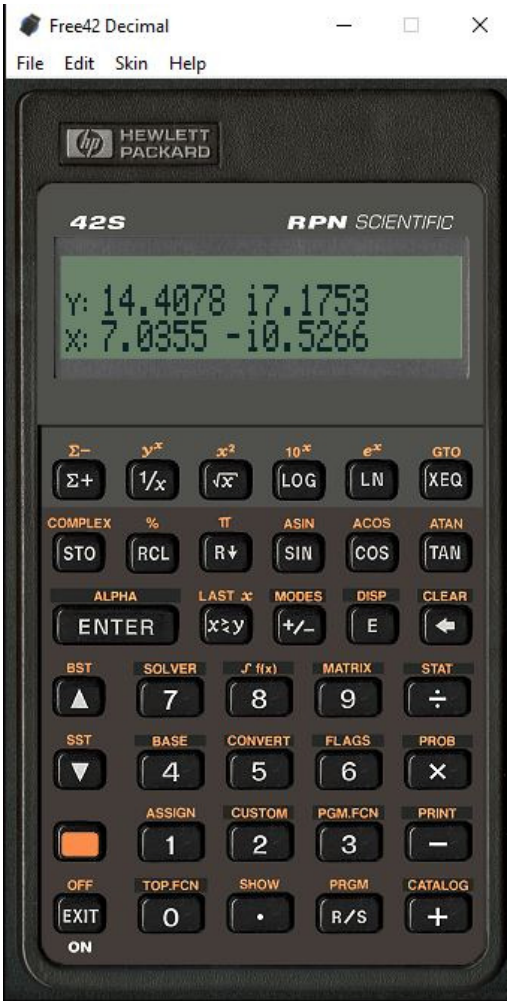
$$B = (5\angle 45^0) + (7\angle -60^0) + (2\angle 90^0)$$

In Matlab

```
>> x1 = 5*cos(45*pi/180);
>> y1 = 5*sin(45*pi/180);
>> x2 = 7*cos(-60*pi/180);
>> y2 = 7*sin(-60*pi/180);
>> x3 =2*cos(90*pi/180);
>> y3 = 2*sin(90*pi/180);
>> Bx = x1 + x2 + x3

Bx =    7.0355

>> By = y1 + y2 + y3

By =   -0.5266
```

With an HP42

```
modes
polar
5
enter
45
complex
7
enter
-60
complex
+
2
enter
90
complex
+
```



3) Where is B relative to A

- In (x,y) coordinates
- In polar coordinates

i.e. What is B - A?

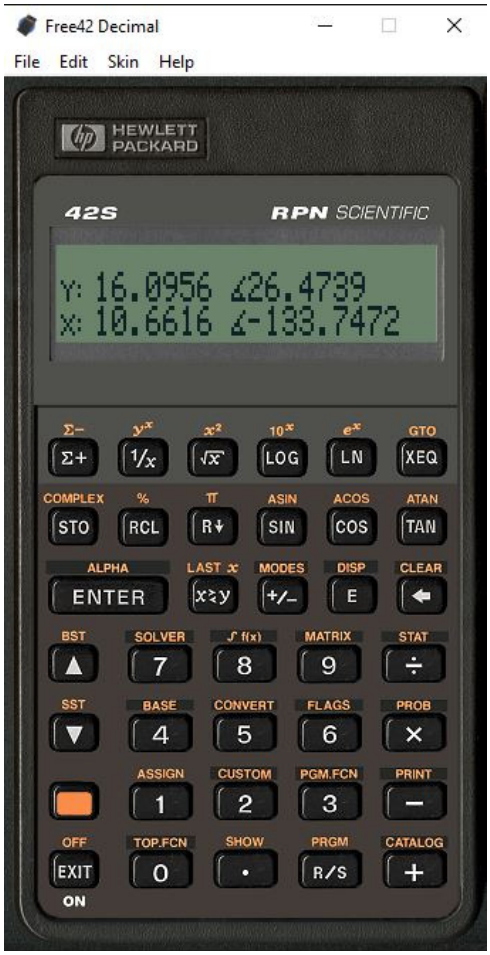
```
>> X = Bx - Ax

X =   -7.3723

>> Y = By - Ay

Y =   -7.7019
```

in polar coordinates

```
>> R = sqrt(X^2 + Y^2)

R =   10.6616

>> Q = atan2(Y,X) * 180/pi

Q = -133.7472  (degrees)
```

With an HP42

```
x<>y
-
modes
polar
```



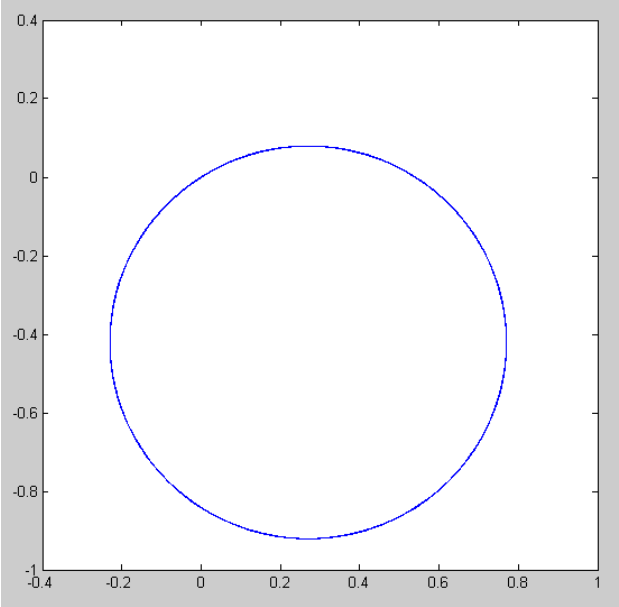
Plotting Polar Functions

4) Plot the following functions in Matlab for $0 < \theta < 6\pi$

- Note: plot() plots in cartesian coordinates. Each function needs to be converted from polar to rectangular.

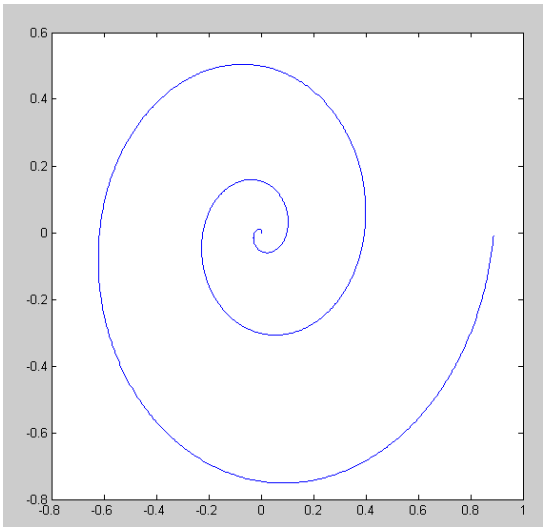
a) $r = \cos(\theta + 1)$

```
>> q = [0:0.01:6*pi]';
>> r = cos(q + 1);
>> x = r .* cos(q);
>> y = r .* sin(q);
>> plot(x,y)
>>
```



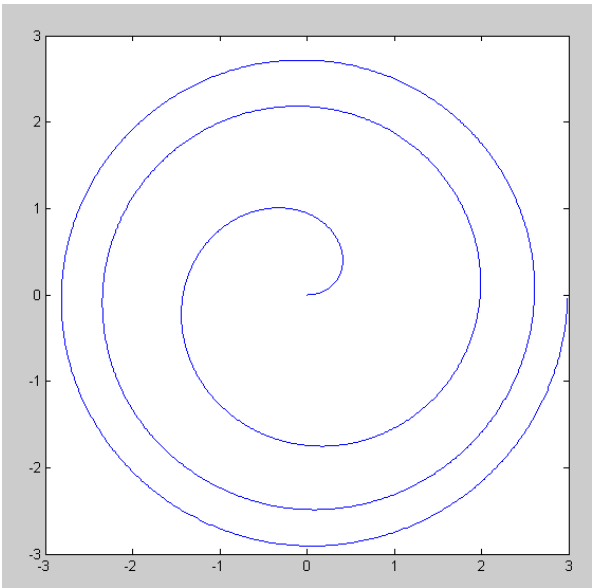
b) $r = \theta^2/400$

```
>> q = [0:0.01:6*pi]';
>> r = q.^2 / 400;
>> x = r .* cos(q);
>> y = r .* sin(q);
>> plot(x,y)
>>
```



c) $r = \ln(\theta + 1)$

```
>> q = [0:0.01:6*pi]';
>> r = log(q+1);
>> x = r .* cos(q);
>> y = r .* sin(q);
>> plot(x,y)
```



Robot Tip Position (Forward Kinematics)

A 2D robot has three arms with lengths of {1, 0.9, 0.8} meters. The final tip positionis

$$x_1 = \cos(\theta_1) \qquad y_1 = \sin(\theta_1)$$

$$x_2 = x_1 + 0.9\cos(\theta_1 + \theta_2) \qquad y_2 = y_1 + 0.9\sin(\theta_1 + \theta_2)$$

$$x_3 = x_2 + 0.8\cos(\theta_1 + \theta_2 + \theta_3) \qquad y_3 = y_2 + 0.8\sin(\theta_1 + \theta_2 + \theta_3)$$

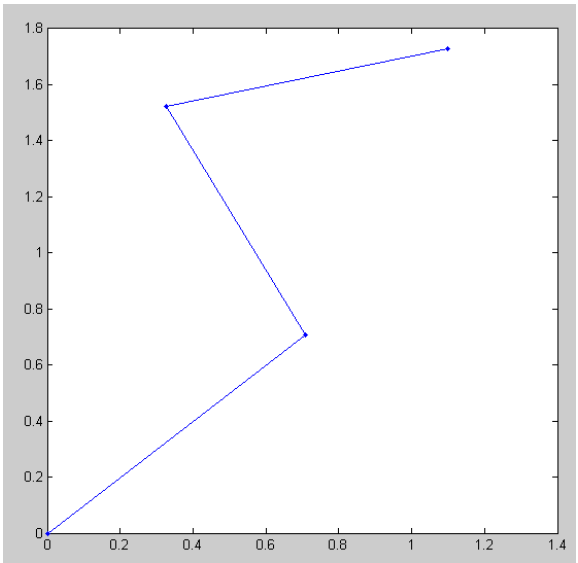
Matlab Function RRR:

```
function [x,y] = RRR(q1,q2,q3)
x0 = 0;
y0 = 0;
x1 = cos(q1*pi/180);
y1 = sin(q1*pi/180);
x2 = x1 + 0.9*cos((q1+q2)*pi/180);
y2 = y1 + 0.9*sin((q1+q2)*pi/180);
x3 = x2 + 0.8*cos((q1+q2+q3)*pi/180);
y3 = y2 + 0.8*sin((q1+q2+q3)*pi/180);

plot([x0,x1,x2,x3],[y0,y1,y2,y3],'b.-');
x = x3;
y = y3;
end
```

5) Plot robot position for

$$\theta_1 = 45^0 \quad \theta_2 = 70^0 \quad \theta_3 = -100^0$$

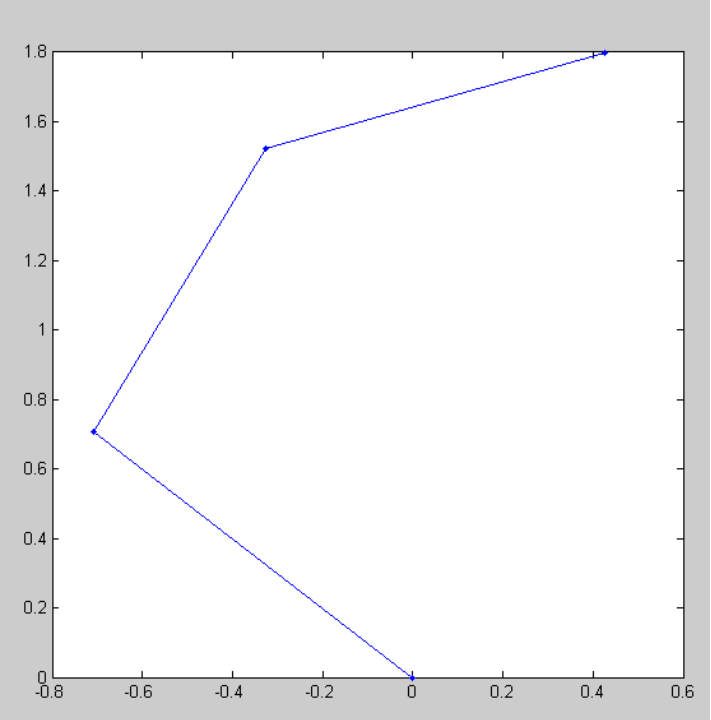
```
>> [x3,y3] = RRR(45,70,-100)

x3 =    1.0995
y3 =    1.7298
```



6) Plot robot position (x3, y3) for

$$\theta_1 = 135^0 \qquad \theta_2 = -70^0 \qquad \theta_3 = -45^0$$

```
>> [x3,y3] = RRR(135,-70,-45)

x3 =    0.4250
y3 =    1.7964
```



Robot Tip Position (Inverse Kinematics & fminsearch())

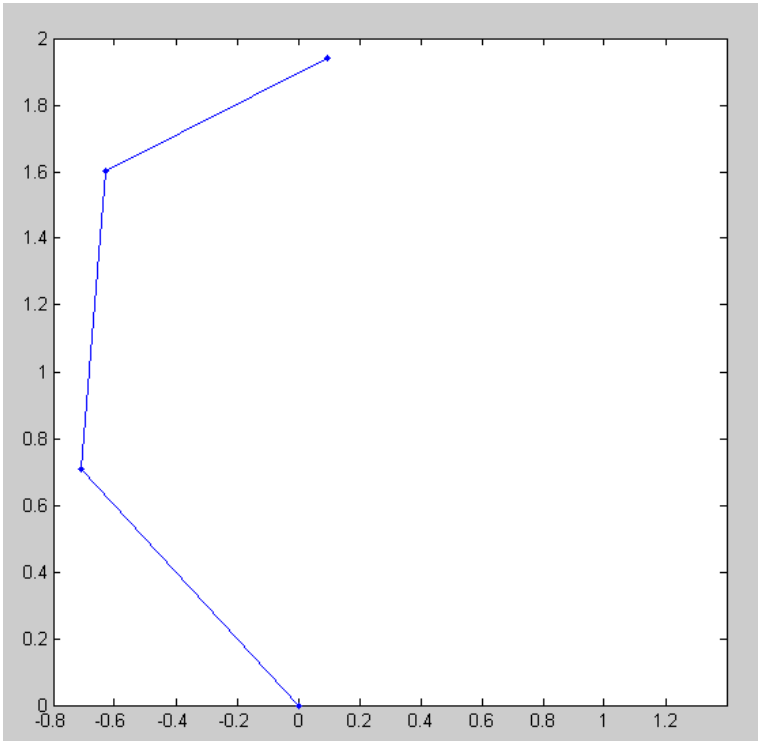
7) Write a Matlab function which

- Is passed the angles $(\theta_1, \theta_2, \theta_3)$,
- Computes the tip position, and
- Returns the distance from the tip position and point (x = 1.2, y = 1.2)

```
function [e] = Prob7(z)
q1 = z(1);
q2 = z(2);
q3 = z(3);
[x3,y3] = RRR(q1,q2,q3);
dx = x3 - 1.2;
dy = y3 - 1.2;
e = dx^2 + dy^2;
end
```

Check:

```
>> Prob7([135,-50,-60])

ans =    1.7682
```



8) Use the fminsearch() to determine the joint angles which place the robot at (x = 1.2, y = 1.2)

- Note: There are multiple solutions

```
>> [Z,e] = fminsearch('Prob7',[135,-50,-60])

       q1          q2          q3
Z =  102.8424  -63.7997  -64.3434

e =  8.4872e-017
```