CEE/MAE M20
Introduction to Computer Programming with MATLAB

HOMEWORK 1

Due: Tuesday, April 10, 2018, 11:55 pm

Formatting Reminder: Using the naming convention presented in the syllabus, submit **two** separate files to the CCLE course website: (1) a .pdf of your written report and (2) a .zip file containing all of the MAT-LAB files written for the assignment. Remember to use good coding practices by keeping your code organized, choosing suitable variable names, and commenting where applicable. Any of your MATLAB .m files should contain a few comment lines at the top to provide the name of the script, a brief description of the function of the script, and your name and UID.

0. **Reading Assignment.**
   Read section 1.1 of ITC

1. **Polyhedron Properties.**
   Complete problem 1.1.5 from ITC. Follow the problem statement in the book, except for the following:

   - Print the values in your table using only 6 decimal places as opposed to 15.
   - Use only `fprintf` along with formatting codes to organize the results into a table (as opposed to any more advanced, built-in MATLAB function).
   - Textbook erratum: In the example below the table of formulae, the divisor for calculating `Vol20` should be 12, not 4

     ```
     Vol20 = ((15 + 5*sqrt(5))/12)*E^3;
     ```

   What patterns do you notice in the columns of your table and how can this help you check the reasonableness of your answer? Are there any exceptions to these trends?

2. **Ellipse Calculations.**
   Complete problem 1.1.6 from ITC. Your script must prompt for the value of a *first* and b *second*. Print your results using the format shown below. (Your code should print all 8 results plus the value of h):

   ```
   P1 = 1.234
   P2 = 1.234
      .
      .
      .
   P8 = 1.234
   h = 1.234
   ```

   You'll need to decide how many significant figures to display so that discrepancies between approximations (if they exist) are clearly revealed. As the ellipse becomes "flatter", what happens to these predictions? Do all the perimeter values agree with each other? Can you propose a method to determine which approximation is the *most* accurate?

3. **Circle-Circle Intersections.**

   In this problem, we'll calculate the area of the lens formed by two intersecting circles. Consider the two overlapping circles shown in Figure 1.
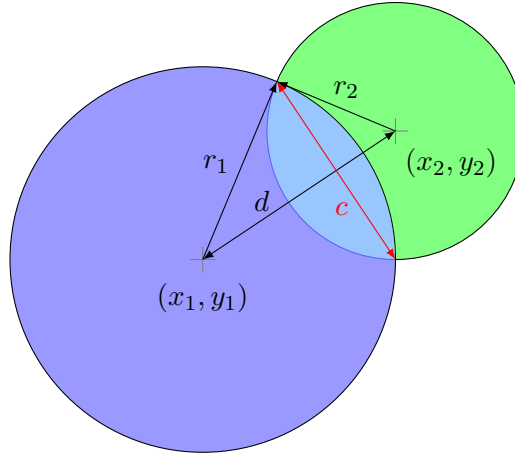
Figure 1: The intersected area (in light blue) formed by Circles 1 and 2.

Circle 1 is centered at (x_1, y_1) while Circle 2 is centered at (x_2, y_2); r_1 and r_2 are their respective radii. We'll define d as the separation distance between the two centers and c as the length of the chord defined by the intersection points. We can calculate the area of the intersection using the following expression:

$$\text{Area} = r_1^2 \cos^{-1}\left(\frac{d^2 + r_1^2 - r_2^2}{2dr_1}\right) + r_2^2 \cos^{-1}\left(\frac{d^2 - r_1^2 + r_2^2}{2dr_2}\right) - \left(\frac{d}{2}\right)c \tag{1}$$

where the chord length, c, is given by:

$$c = \frac{1}{d}\sqrt{(-d + r_1 + r_2)(d - r_1 + r_2)(d + r_1 - r_2)(d + r_1 + r_2)} \tag{2}$$

and the separation distance between the two circles, d, can be obtained by applying the Pythagorean theorem: $d = \sqrt{\Delta x^2 + \Delta y^2}$.

Write a script that prompts the user to input the six parameters governing the calculation in exactly the following order: x_1, y_1, r_1, x_2, y_2, and r_2. You may find it helpful to break the above equations into smaller, intermediate calculations to avoid typos (especially misplaced parentheses) while keeping your code readable and organized. When printing your results, use the exact format shown below:

```
x1 = 0.00
y1 = 0.00
r1 = 4.00
x2 = 3.00
y2 = 4.00
r2 = 3.00

Area = 6.6417
```

What is the theoretical area of the intersection for two circles with non-zero radii separated by a distance $d = r_1 + r_2$? Does your code recover this result exactly? Why or why not? Examine the Variable Workspace to determine what happens to your area calculation when $d + r_1 < r_2$ and $d \neq 0$, for example $(x_1, y_1, r_1) = (0, 0, 1.5)$ and $(x_2, y_2, r_2) = (2, 2, 5)$. To understand this result, think about what this inequality means geometrically; what should the correct area of intersection be in this case?