

Applied Engineering Problem Solving (CHEN.3170)

Homework Assignment #2b -- Fall 2017

2D Function Evaluation and Plotting in Matlab

Problem #1: Planetary Orbits

The orbit of the planets around the sun can be modeled approximately by the following expression,

$$r = \frac{\epsilon P}{1 - \epsilon \cos \theta}$$

where P is known as the parameter of the orbit and ϵ is the eccentricity of the orbit. Here, r is the radial distance from the sun and θ is the angle of rotation around the sun.

The values of the constants, P and ϵ , are given for four of the planets as follows:

Planet	P (10 ⁶ km)	ϵ
Mercury	269.2	0.206
Venus	15913	0.00677
Earth	8964	0.0167
Mars	2421	0.0934

- Using the above information, compute the value of r as a function of θ and the planet of interest. Store this information in a single 2-D array. For example, $r(i,j)$ would refer to the distance of planet j from the sun associated with the i^{th} angle, θ_i .
- Once the data array has been generated, plot all four curves (for the four planets listed above) on a single axis using two different methods:
 - Plot radial distance vs. θ for the four cases using Matlab's *polar* command. Note that, since *polar* will only let you plot one curve at a time, you can do this within a *for ... end* loop using the *hold on* command. Also, because the grid does not get resized with the subsequent plots, you should plot the orbit with the largest radius first. Finally, also be sure to use the *legend* command (or something equivalent) to identify the various curves.
 - Convert the r,θ polar coordinates to x,y Cartesian coordinates using $x = r \cos \theta$ and $y = r \sin \theta$, and plot the same profiles using Matlab's *plot* command.

Do the two plots look similar? Which style is easier to use? Which do you prefer? Do the planets' orbits make sense to you? You know that the earth has a nearly circular orbit with a radius of about 93 million miles -- is this consistent with your plots? **Hint:** To answer this last question, determine the average radius from your calculations, convert the units properly, and compare to the known value of about 93 million miles...

Problem #2: Minima of a Function -- Graphical Representation

Consider the following function of two variables,

$$f(x, y) = 100(y - x^2)^2 + (1 - x)^2$$

over the domain given by

$$-2 \leq x \leq 2 \quad \text{and} \quad -2 \leq y \leq 2$$

Our goal is to find the minima of this function. This is the objective of a whole class of optimization methods -- that is, “What are the values of x and y that minimize the so-called objective function, $f(x,y)$?”. There are formal mathematical techniques for doing this (e.g. taking the partial derivatives with respect to x and y and solving the resultant nonlinear equations). Although we may attempt some of these formal numerical methods later in the semester, our goal now is simply to plot $f(x,y)$ versus x and y to visualize the functional behavior, and to find, by inspection of the plots, the desired minima for the given function.

As you know, Matlab has several built-in routines for generating a variety of different visualizations of the same function. As part of your study of the function given here, you might try a few options (see the *meshgrid*, *surf*, and *contour* commands, for example) -- and don't hesitate to be a little creative here. In the end, however, be sure to present one or more plots that clearly show the approximate locations of any minima of $f(x,y)$ in the given portion of the x - y plane. Be sure to also tabulate the value of any minima you observe and the x,y locations of these points. Overall, in your opinion, which is the best presentation format for this problem? Explain...

Documentation

Documentation for this assignment should include a listing of the Matlab script files, the resultant Matlab plots, and a brief description of the data and results of your analyses for each problem. As usual, please keep each problem separate for ease of evaluation! An overall professional job is expected here!!!

See HW#1 for a description of the expected format -- every HW in this course should follow these basic instructions...