CS 322: Problem Set 1

Due: Thursday, June 27, 2002 (In Lecture)

The policies for this homework assignment are as follows:

- You must work individually on Questions 1 and 2. You may work with at most one other person on Questions 3 and 4. Consult the course website for the Academic Integrity rules.
- The writing exercises will be graded on content as well as on grammar, spelling, punctuation, etc.
- Points will be deducted on the Matlab questions for poorly commented code and inefficient code/redundant computations.
- For the Matlab questions, you should hand-in the appropriate plot(s) and the script/functions necessary to generate the plot(s).
- Submit your assignment in two different parts (Part 1 for Questions 1 and 2 and Part 2 for Questions 3 and 4). Every student should submit Part 1. At the top of the first page for Part 1, write your name, the course number, the problem set number, Part 1, your e-mail address, your student ID number, and the date. Each team of up to two students should submit Part 2 jointly. The information at the top of Part 2 should be the same, except there should be up to two names at the top of the paper, and Part 1 should be replaced with Part 2.

1. (10 points) **Applications in Scientific Computing:** This question will help you become acquainted with the types of problems people in Scientific Computing are interested in. Using the internet, find 3 application problems in scientific computing that people are working on. Write one paragraph describing each problem in your own words. You will want to give a brief description of the problem being addressed, a general idea of the types of numerical methods being used to address the problem, and the groups of people interested in this particular application. Be sure to include the websites where you found the information. If you are having trouble finding websites containing this information, be sure to consult the "Applications" section of the "Interesting Links" website. You can reach this page from the course homepage.

2. (10 points) **Careers in Scientific Computing:** This exercise will help you learn about careers in Scientific Computing. You will use the internet to find several people employed in the field of scientific computing and give a short description of their careers. More specifically, find 2 people employed in each of the following 3 categories: academics, government labs, and industry, and list their name, title, place of employment, educational background (if you can find it), and 3-4 sentences describing what this person does at their job. You might want to discuss which types of problems they work on, the types of software they write, the proofs they work on, the students they teach, etc. Be sure to include the websites where you found this information. If you are having trouble finding websites containing this information, be sure to see the link to "Careers" on the "Interesting Links" website. You can reach this page from the course homepage.

3. (10 points) **MATLAB Basics:** You have been hired by the *ABC Graphics Company* to make a high quality mesh for an animation for one of their customers. The company is providing you with a poor quality mesh with which to start. A poor quality mesh, for our purposes, is one with many long, skinny triangles. We will define a property of the triangle called the *aspect ratio* to determine exactly which triangles are of poor quality. Your task is to make the mesh smoother so that it can be used by the animation team at *ABC Graphics Company.* You will do this as follows:

   (a) Download the file mesh.txt from the "Homework" page. You can get there from the course website. You will note that the file has the following format. On the top line, the first number represents the number of nodes in the mesh. The second number gives the number of triangles. The next several lines give the node number, the x and y coordinates of the node, and a 1 if the node is on the boundary or a 0 if the node is on the interior. There should be one of these lines for each node. The last several lines give the number of the triangle and its three vertices.

(b) Use **textread** to read **mesh.txt** into Matlab. You will want to store the nodal information in one array and the triangle information in another. Store the nodal information in an array called coords; store the triangle information in an array called tris.

(c) Use the **plot** command to draw all of the triangles in one figure, i.e., plot the mesh. (It's not necessary to draw the vertices. Just plot the triangles.) Write a function to do this and make use of it throughout this question.

(d) Compute the aspect ratio of all of the triangles in the mesh according to the following formula. Let a, b, and c be the lengths of the three sides of the triangle and denote its aspect ratio by AR. Define

$$s := \frac{1}{2}(a + b + c).$$

Then,

$$\begin{aligned} AR &:= \tfrac{CR}{IR}, \text{ where} \\ CR &:= \tfrac{abc}{4\sqrt{s(s-a)(s-b)(s-c)}}, \text{ and} \\ IR &:= \sqrt{\tfrac{(s-a)(s-b)(s-c)}{s}}. \end{aligned}$$

Write a function called **aspectratio** to do this and use it throughout this question.

(e) Use the **fill** command to color the triangles with bad aspect ratio green. For our purposes, these are the triangles with an aspect ratio greater than 4. These are the triangles that will need smoothing. This should be a separate plot from the one above.

(f) Download the smoother from the "Homework" page.

(g) Run the smoother on the initial mesh. To do this, you will need to pass it the mesh and the numbers of the triangles will bad aspect ratio. Be sure to save the mesh that it returns.

(h) Plot the final mesh.

(i) Compute the aspect ratio of the triangles in the final mesh.

(j) Use the **fprintf** command to write out the initial and final aspect ratio of each of the triangles that has been smoothed. Write out this data in **mesh.aspectratio**. Organize the data in a table with appropriately labeled columns.

(k) Write a few sentences describing what the smoother tried to accomplish and how you think it performed based upon the aspect ratio data and the pictures of the meshes.

4. (10 points) **3D Plotting with MATLAB:** Let $z = x\exp(-x^2 - y^2)$ define a mountain and an inverse mountain. We will hereby refer to the mountain and inverse mountain collectively as "the terrain". Make the four plots listed below and plot them all in the same figure using the subplot command.

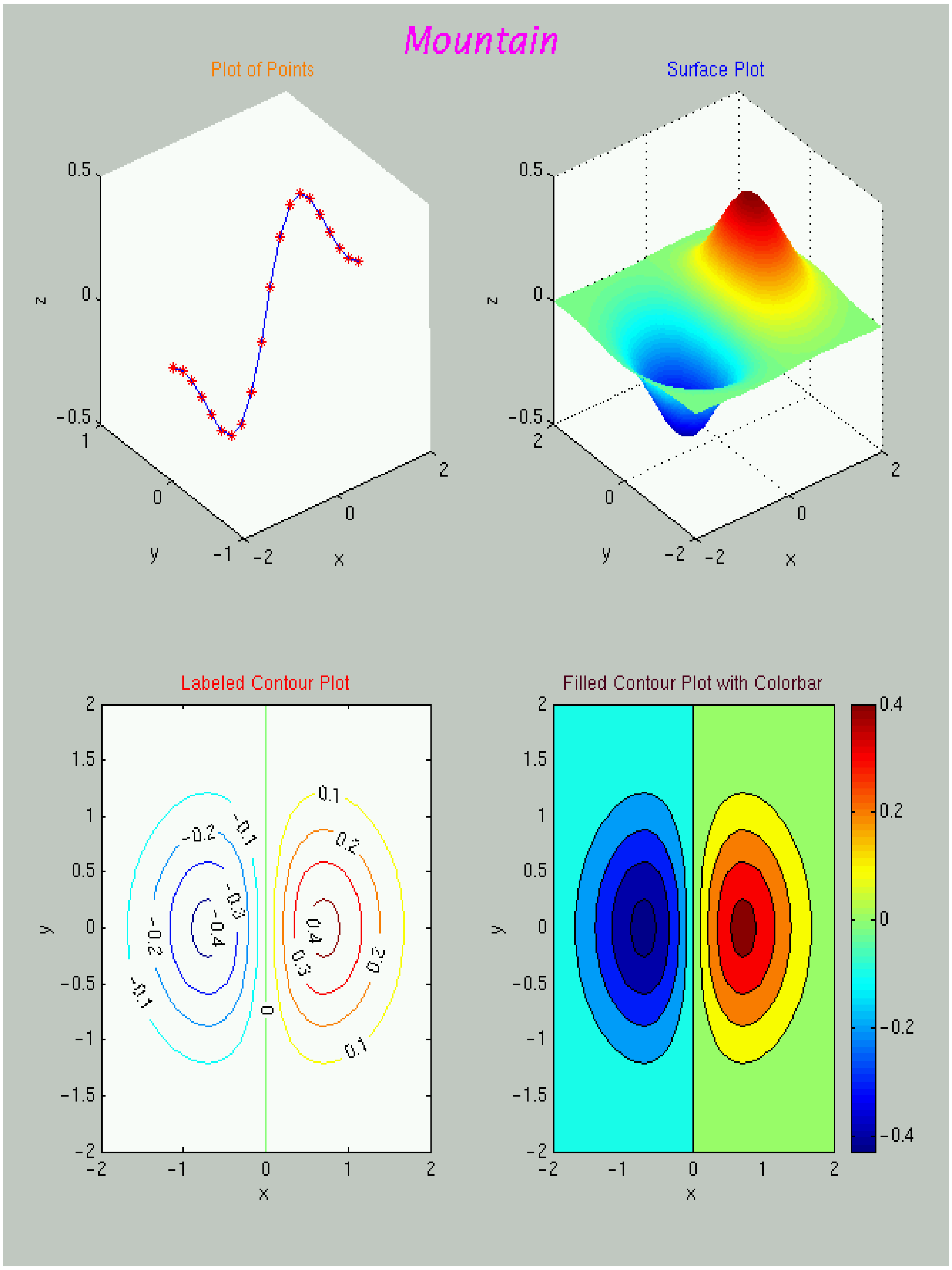
(a) Use plot3 to plot the slice of the terrain passing through $y = 0$. Plot the data as a blue line and then plot it using red asteriks. Label the x, y, and z axes. Make an appropriate title in orange. Since orange is not one of Matlab's standard colors, you will need to figure out how to create orange as an RGB-triple.

(b) Use meshgrid and surf to make a surface plot of the terrain. Use "interp" for the shading smooth. Label the x, y, and z axes, and make a blue title for the plot.

(c) Use contour and clabel to make a labeled contour plot of the terrain. You should use the default number of contour lines. Label the x and y axes, and make a red title for the plot.

(d) Use contourf and colorbar to make a filled contour plot of the terrain with a vertical colorbar. Label the x and y axes. Make a brown label for the plot. Since brown is not one of Matlab's standard colors, you will need to figure out how to create brown as an RGB-triple.

Finally, use gtext to position the title "Mountain" at the top center of the figure. The title should be in magenta, use 18 pt Lucida for the font, and be in italics. See the last page of the handout for sample output.


Mountain
Plot of Points
Surface Plot
Labeled Contour Plot
Filled Contour Plot with Colorbar
x
y
z