Problem Set 07
Function Discovery

Instructions

1. This problem set contains paired and individual programming problems. Each problem has a set of deliverables that needs to be submitted. You are responsible for following the appropriate guidelines and instructions below. Create appropriately-named files as instructed.
2. Save all files to your Purdue career account in a folder specific to PS07.
3. Compress all deliverables into one zip folder named **PS07_yourlogin.zip**. Submit the zip file to the Blackboard drop box for PS07 before the due date.

Deliverables List

Item	Type	Deliverable
Problem 1: Earthquake Magnitude	Individual	PS07_earthquakes_*yourlogin*.xlsx
Problem 2: Beach Profiles	Paired	PS07_beach_profile_ *yourlogin1_yourlogin2*.m PS07_beach_profile_ *yourlogin1_yourlogin2*_report.pdf Any data file loaded into your code
Problem 3: Deburring Media	Individual	PS07_deburr_*yourlogin*_report.pdf PS07_deburr_*yourlogin*.m Any data file loaded into your code
Other Required Deliverables	--	histogramRight.p

`histogramRight` Command

An updated version of the `histogramRight` command is included in the Assignment Files for this problem set. Please use the new version to complete Problem 3. Include the file in your deliverables zip folder when you submit the assignment.

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Problem 1: Earthquake Magnitude

Individual Programming

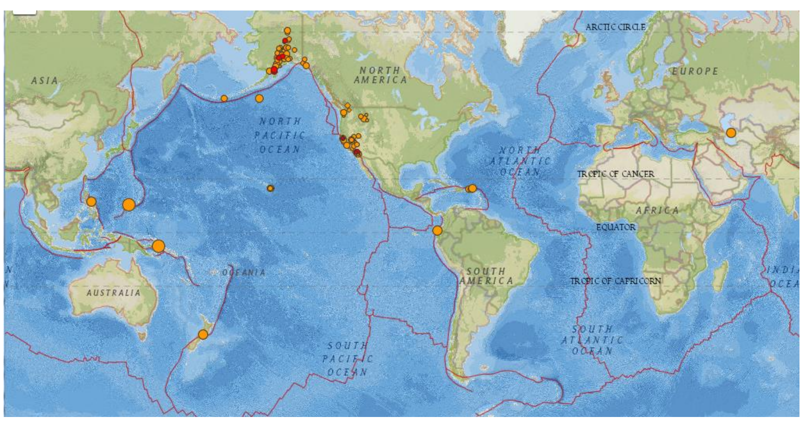
Problem Setup

Earthquakes happen every day around the world. They are reported by magnitude. There are several types of magnitude calculations, the most well-known being the Richter scale, which was developed in the 1930s. The Richter scale is limited by two key things. The scale was designed for and best suited for use in California, and its reliability decreases when magnitude values reach 7 or greater.

A newer magnitude measurement model was created in the 1970s and is more universal. It is called the moment magnitude scale, and it is the model used by the United States Geological Survey. The model uses seismographs to determine an earthquake's seismic moment and then calculates a magnitude.

Every day, there are hundreds of earthquakes worldwide. Most earthquakes are of magnitude 1 to 3, cause no damage, and are not felt by people, except by a very few and under especially favorable conditions. A few earthquakes are of magnitude 3.0 or higher. A sample list of worldwide earthquakes are listed below, with the moment given in giganewton-meters.

Table 1. Sample daily earthquake moments and magnitude



Moment (GN-m)	Magnitude
5.97E+07	5.1
3.11E+07	4.9
7.25E+06	4.6
3.54E+06	4.2
5.02E+05	3.8
2.53E+05	3.3
4.07E+00	0.4
2.12E+02	1.3
3.69E+04	3.1
8.55E+03	2.6

Civil engineers, particularly in earthquake-prone areas, need to be cognizant of earthquake intensities. You will use function discovery and data transformation to model the relationship between earthquake intensity and magnitude. You will also use your model to make appropriate predictions.

Problem Steps

1. Download the Excel template, PS07_earthquakes_template.xlsx, and fill out the appropriate header information on the ***Earthquakes*** sheet.

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2. Place the moment and magnitude data in Table 1 into Excel and save the file as **PS07_earthquakes_*yourlogin*.xlsx**. Use this file to perform function discovery.

3. Create four plots to visualize how moment affects magnitude. Plot using appropriate linear and/or log scaling. Organize your plots on the ***Earthquakes*** sheet. Be sure to label the plots for technical presentation, paying particular attention to the labels on the x- and y-axes.

    a. Plot 1: linear scale on the x- and y-axes

    b. Plot 2: log scale on the x-axis, linear scale on the y-axis

    c. Plot 3: linear scale on the x-axis, log scale on the y-axis

    d. Plot 4: log scale on the x- and y-axes

4. Use the plots to diagnose the type of function that best represents the relationship between the data. On the ***Earthquakes – Analysis*** sheet of your Excel workbook answer the following:

    Q1: Based on your plots of the data using the four different axis scaling options, which type of function do you think best represents the data? Provide a reason for your selection by making reference to the plots and the axes' scaling.

5. In the **Linearization** section of the template, linearize the data and plot it on linear x- and y- axes scales. Be sure to label the plots for technical presentation, paying particular attention to the labels on the x- and y-axes. This will be Plot 5.

6. Use Excel to add a regression line to the data on Plot 5. Show the trendline equation and r-squared value on the plot. Use clear, appropriate variable names in place of x and y in the equation.

7. On the ***Earthquakes – Analysis*** sheet of your Excel workbook answer the following:

    Q2: Determine the general form of the function you diagnosed in Q1. Show work as necessary. Manage the decimal precision of the coefficients.

    Q3: As appropriate, use your model to predict the magnitude of earthquakes with the following moments:

90 GN-m	9,000 GN-m	900,000 GN-m	9,000,000 GN-m	9,000,000,000 GN-m

Use the ***Model Calcs*** worksheet to perform your magnitude prediction calculations.

References

http://earthquake.usgs.gov/earthquakes/recenteqsww/

http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

http://earthquake.usgs.gov/learn/topics/measure.php

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Problem 2: Equilibrium Beach Profiles

Paired Programming

Problem Setup

Using measurements of water depths at different distances from shore, coastal engineers can determine an equilibrium profile for a given beach. An equilibrium beach profile is a uniform model of the ocean floor of a beach as it approaches the shoreline. By knowing a beach's equilibrium profile, the engineers can better model constructive and destructive processes that change a beach over time. Example beach profiles can be seen in the images below.

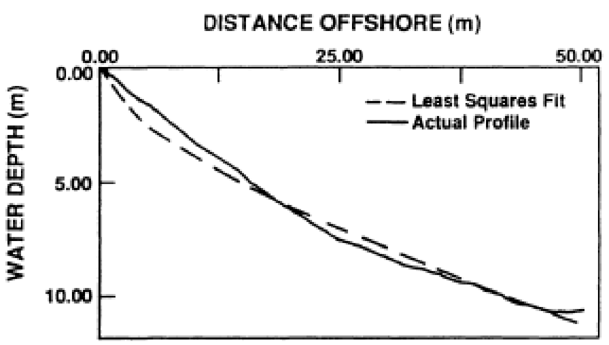

Figure 1: Rocky beach

Profile P4 from Zenkovich (1967). A boulder coast in Eastern Kamchatka.

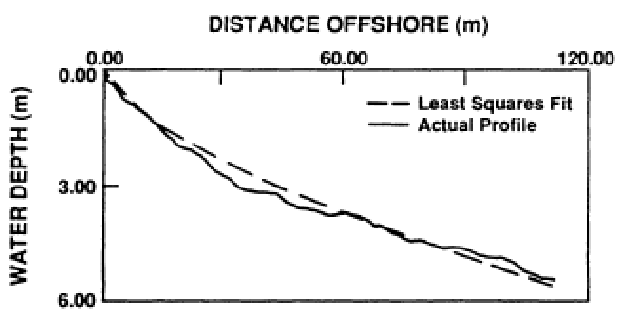

Figure 2: Whole and broken shell beach

Profile P10 from Zenkovich (1967). Near the end of a spit in western Black Sea. Whole and broken shells.

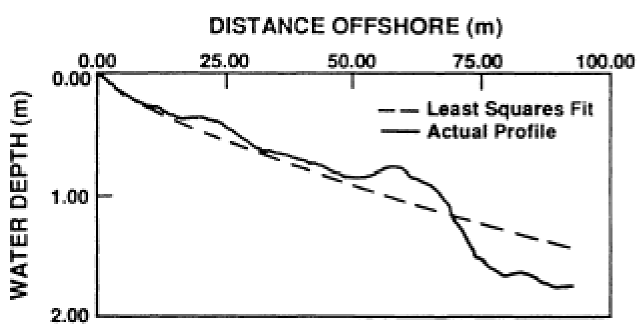

Figure 3: Sandy beach

Profile from Zenkovich (1967). Eastern Kamchatka.

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As you can see in the images, the equilibrium profile will depend on the mean size of sand and particles that comprise the beach and the water depth at various distances from shore. The equilibrium beach profile is a model that represents water depth as a function of distance from shore. Note that the beach profiles are slightly curved in each image so a linear model is not sufficient.

You have been provided with a dataset, named **Data_beach_measurements.csv**, that contains the water depth at different distances from shore for a given beach. Use this data to create a user-defined function that models the beach profile of the given beach. Your UDF will accept one input, which is the model's independent variable, and will return one output, which is the model's dependent variable. The input can be a scalar or a vector.

Problem Steps

1. Open *PS07_beach_template.m*. Complete the header and save the file as **PS07_beach_*login1_login2*.m**.
2. Import the beach measurement data.
3. In the `FUNCTION DISCOVERY SUBPLOTS` section, write the code to identify the type of function that represents the data:
    a. Create one figure with 2x2 subplots (i.e., 2 rows and 2 columns) that contains the data plotted on linear, semilogx, semilogy, and loglog scales. Be sure to label the plots for technical presentation, paying particular attention to the labels on the x- and y-axes.

       Use MATLAB to learn about the `suptitle` command. Using this command will allow you to put one overarching title on the figure window, thus permitting you to use short, scale-specific titles on each subplot.

       Hint: You can also control the font size of a title or axis label by using the FontSize property within the label. For example, to set an x-label's font size to 8-point:

       ```
       xlabel('Speed (m/s)','FontSize',8)
       ```

       NOTE: Your plots will be on standard axes, not reversed on the y-axis as shown in the examples above. For function discovery, it will be easier to use standard axes.
4. Diagnose the type of function that best represents the relationship between the data, using the plots. Then, in the `ANALYSIS` section, answer the following:

    Q1: What type of function best represents the relationship between the data? Justify your answer by making reference to the plots and the axes' scaling.
5. In the `LINEARIZED DATA` section,
    a. Linearize the data using the technique that is most appropriate for the function type you diagnosed above.
    b. Find the linearized form of the equation using least squares regression.

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c. Print the linearized form of the equation to the Command Window. Use clear, appropriate variable names in place of x and y in the equation.

d. Plot the linearized data and the function model on a single plot in a second figure window. Be sure to label the plot for technical presentation, paying particular attention to the labels on the x- and y-axes.

6. In the `BEACH PROFILE MODEL` section,

   a. Determine the general form of the equation.

   b. Print the general form of the beach profile equation to the Command Window. Use clear, appropriate variable names in place of x and y in the equation.

   c. Plot, on a single plot in a third figure window, the original data as a solid line with markers and the beach profile model as a dashed line.

   NOTE: Normally, we would plot measured data with markers only, not a line. But this particular data set is being used to represent the continuous ocean floor, so it makes more sense to make it a line in this visual representation.

   d. Reverse the y-axis to make your plot similar to those in Figures 1-3. There are several ways to reverse an axis. Try this command at the end of your plot formatting:

```
ax3 = gca;
set(ax3,'Ydir','reverse')
```

   Hint: You may want to look up the `gca` and `set` commands.

7. In the `BEACH PREDICTION` section, write code that will use your model and the UDF input to calculate the UDF output. Then, in the `ANALYSIS` section, answer the following:

   Q2: Sam McGuire is the lead engineer of a coastal engineering firm working on an oceanfront pier project for this beach. The pier plans require six primary pylons, made of concrete and equipped with both lateral and vertical load sensors, to be placed every 25 meters from 25 meters offshore to 150 meters offshore. These primary pylons will have multiple secondary pylons between them to provide full support for the pier. The firm would like to use your beach profile model to predict water depth at the **primary** pylon locations. Compose a brief email to Sam McGuire with your conclusions.

8. Publish your function as a PDF file using your pylon distance vector from Q2 and name the file **PS07_beach_*yourlogin1*_*yourlogin2*_report.pdf**

Reference: http://www.jstor.org/stable/4297805

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Problem 3: Deburring Media

Individual Programming

Problem Background

Metal cutting is a common manufacturing operation in the creation of many parts. The cut edges of a metal part can have uneven protrusions and ridges, which are called burrs. These burrs must be removed. One way to remove them is to load the cut pieces into a large tumbler with deburring media (i.e., special stones) to rub off the burrs. Over time, these media wear out and must be replaced. There are many types of deburring media, and they vary based on material, shape, and weight.

Figure 1 Tumbler machine with deburring media and parts.

Cornerstone Inc. needs you to analyze the performance (time to failure) of three different types of deburring media – New Age Stone, Triangle, and Ever Last. Utilization data have been collected for each type. These data are contained in the file **Data_DeburringMediaPerformance.csv,** and the data are the observed time (in hours) between replacements for 250 pieces of each media type.

Problem Steps

1. Open *PS07_deburr_template.m* and complete the header information.
2. Save your program with the name **PS07_deburr_*yourlogin*.m**, where *yourlogin* is your Purdue Career Account login.
3. Load the data into the `INITIALIZATION` section of your program.
4. In the `MEAN TIME TO FAILURE` section:
    a. Calculate the mean time to failure (MTTF) for each media type. The MTTF is the average of all failure times.
    b. Display the MTTF to the Command Window for each media type.

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5. In the `HISTOGRAMS & CDPS` section of your code:

    a. Create a histogram for each deburring media. Use the appropriate histogram function in preparation for creating a cumulative distribution plot (CDP).

    - Put the three histograms in a 3x1 subplot. Format each for technical presentation.
    - Create the histograms using the same bin edge vector for all three histograms. Be sure to manage the edge values so that all data for each media type are accounted for and visible.

    b. In a second figure window, create one cumulative distribution plot (CDP) that shows all three cumulative distributions. Recall that you will need to determine a number of intermediate values to create a cumulative distribution plot (CDP) for each media. Format the plot for technical presentation.

6. In the `ANALYSIS` section, answer the following questions **in brief, complete sentences**:

    Q1. For each deburring media type, use your CDP to determine the median time to failure. Explain how you arrived at your answer.

    Q2. Which deburring media type has the least variability? Explain how you arrived at your answer using your CDP.

    Q3. For each media type, use your CDP to determine the likelihood that it will perform effectively for at least 50 hours. Explain how you arrived at your answer.

    Q4. Explain why you would or would not recommend each media type.

    Hint: Apply your knowledge of descriptive statistics, cumulative plot, and distribution shape.

    Q5. What other considerations that are not represented in the CDPs and histograms might affect the decision to use a particular media type?

7. Publish the code to a word document. Save it as **PS07_deburr_*yourlogin*_report.pdf.**

Reference: [Chautauqua Machine Specialties- Secondary Operations, online image]. Retrieved from www.chautauquamachine.com