ENG06 Project #1

Collaboration Policy:

You may talk at a high level about the project with up to 2 other students. They are your collaborators. By high level discussions, we mean that you can say things like `We need to use a For Loop to accomplish this task'. Once you start `speaking in Matlab code', you've gone too far. Collaborators may help each other debug their code, but the only hands that should ever touch the keyboard for your project are your own. Transferring even small portions of code to each other is certainly not allowed. You must submit your own solution to the project. At the top of your submission, state the names of all your collaborators. It will be your responsibility to make sure that all your collaborators are listed.[1] ***Other than contacting the teaching assistants for clarification, you may not seek the assistance of other persons.***

Grading Criteria:

120 points total. Point distributions are shown next to each task.

No late submissions will be accepted and no resubmissions will be accepted for credit.

[1] In the grading of the assignment the listed names may be cross checked. So, if you assist someone, make sure that that person agrees to list you as one of the collaborators, and that you list the person on your list. For this reason, it may be the easiest to form collaborative teams of three, with the understanding that discussions outside of the group will not be allowed.

Project Statement:

Renewable energy is available in many forms: wind, rain, solar, bio-fuel, ocean tides, and many more. The effectiveness of a particular type of renewable energy depends on many factors, and one big factor is the geographical location. For example, installing a wind farm at a location with daily average wind speed of 1 mph is not nearly as effective as installing a wind farm at a location with daily average wind speed of 20 mph. Another example is solar panels. Using solar panel arrays at a windy and cloudy city is not cost effective and risks damages to the panels.

Your task is to investigate the feasibility of using wind versus solar as the main source of renewable energy in various cities in the United States. In particular, you'll be classifying each city according to whether solar or wind energy should be used. Topics related to precipitation will also be explored.

In order to develop your program, weather data for the United States will be used. The information that you will process is already read into MATLAB format (.mat). The steps to access the information are:

Step 1:
Place the file "weather.mat" in your *current directory*. Otherwise, Matlab won't know where to find the file.

Step 2:
In Matlab, type "load weather.mat". You'll now have seven matrices, **solar, wind, precip, area, population, city, and state. solar**, **wind**, and **precip** contain solar insolation, wind speed, and precipitation data for select cities in the United State, respectively. Each of the rows represents a different city. The city and state name can be found in the matrices **city** and **state**. See more information about each of the matrices below:

solar, wind, precip:

- Column 1 to Column 12: data for January, February, …, and December

city, state, population, area:

- **city** contains city names. Each row is a string (character array) with length 14. For city names shorter than 14 characters (including spaces), the remaining elements will be empty spaces.
- **state** contains state abbreviations. Each row is a string with length 2.
- **population** contains population for a city
- **area** contains the land area for a city (square km)

Example: The 13th row in **city** is 'Dubuque', so the 13th row in **state** is 'IA'. In addition, the 13th row in each **solar, wind,** and **precip** has the solar, wind, and precipitation data for Dubuque, respectively.

Submission Requirements:

You must follow the following submission requirements closely.

- Submit ONE script for Tasks 1 to 18. Name this script **Analyze_Weather.m**
- Submit the function you wrote for Task 17 as a separate file.
- Submit one script for Task 19.
- **ALL files above** must be submitted in one "zipped" folder. Name it as "Proj1_XXX.zip" where "XXX" are your initials.
- The "zipped" folder must be submitted through SmartSite.

It will be completely your responsibility to make sure that your zipped folder contains ***all the supporting functions,*** and are all in the same folder.

Submission Checklist: (Into a single .zip file, Proj1_XXX.zip)

- Analyze_Weather.m
- Task19.m
- output_rank.txt

Your Matlab program will need to function correctly (Task 1 to Task 18) using values for ANY DATA SET OF THE SAME FORMAT (i.e. calculate the correct numbers for your data and fill them in).

Your submissions will be graded by using a different data set from the one provided.

- You may assume that the number of columns and the designation of each will be the same.
- You may also assume that the names of the variables (**solar, wind, precip, area, population, city** and **state**) remain the same.
- You may not assume that the number of rows will stay the same.
  For example, the number of cities in **precip**, **solar** or **wind** can increase. Thus, your program will have to find which row contains a particular city. To do this, try using the following command: find(strcmp(states,'Dubuque')). For all outputs, use fprintf and make sure you display the result with 0 places after the decimal point. I suggest copying and pasting the outputs so that you don't spell anything incorrectly. Below, are sample outputs with fake numbers; your text should be the same, the numbers (or sometimes state names) different!
- In producing output you must use the fprintf (and not a series of disp(x) functions). The output to each task should start off with an output that indicates which task it is fulfilling, and then text should follow as described below. For clarity, between the different tasks output at least 3 blank lines.

Important: you may not use loop constructs unless otherwise noted.

For Task 1 to Task 18 below, answer everything with a single MATLAB script. (Analyze_Weather.m)

The database "weather.xlsx" contains solar, wind, precipitation, land area, and population data for 54 cities in the United States, which is the same data contained in "weather.mat". Open "weather.xlsx" using spreadsheet software such as Microsoft Excel and familiarize yourself with the database before moving on.

The solar, wind, and precipitation data is stored as a worksheet in the database; each worksheet has 12 columns where column 1 is January, and column 12 is December. Solar data is given in Kilowatt per square meter. Wind data is given in miles per hour. Precipitation data is given in inches. Land area and population data for each city are in sheets 'area' and 'population' – land area data is given in Kilometer square. Finally, worksheet 1 contains city information and worksheet 2 contains state information. As previously described, rows in the city and state worksheets correspond to rows in other worksheets. For example, row 20 in city and state worksheets is 'Boston' and 'MA', respectively**,** so row 20 in the solar, wind, and precip worksheets contains data for Boston.

Note: In each task below, a sample output is provided. Answers in the sample output may or may not be correct.

Task 0 (2 points): Include the lines of code below at the top of your script.

```
% Your Name
 % Your UC Davis ID Number
% Your Section Number
% Collaborators (List Full Names, maximum of two)
%
load weather.mat % load the database containing data in the given spreadsheet
```

Task 1 (4 points): In total, how many unique states (not cities!) exist in the database? You may use a loop in this task. However, 2 points extra credit for solution that does not use loop in this task.

Display your result as:
"In total, 53 unique states exist in the database"

Task 2 (4 pints): Find and display the city with the longest name. (Do not count the blank spaces. Only count upper and lower case letters) You may use a loop in this task. However, 2 points extra credit for solution that does not use loop in this task.

Display your result as:
"San Francisco has the longest name. It has 12 characters."

Wind energy problems

Task 3 (2 points): **Which city experiences the most wind in July?**
Display your result as:
"Seattle experiences the most wind in July."

Task 4 (4 points): **Which city experiences the most wind (average yearly wind speed) throughout the 12 months? The least?**
Display your result as:
"Seattle experiences the most wind while Boise experiences the least wind."

Task 5 (4 points): What percentage of cities has average yearly wind speed greater than 8 miles per hour?
Display your result as:
"35 percent of cities have yearly wind speed greater than 8 mph."

Task 6 (4 points): Which city has the highest percentage of months that have wind speed greater than 8 miles per hour? What is that percentage? You may use loops to help you solve this problem.
Display your result as:
"Billings has the highest percentage of months with wind speed greater than 8 miles per hour. 48 percent."

Solar energy problems

Task 7 (4 points): Which city experiences the greatest total amount of sunlight in a year? Which city experiences the greatest amount of sunlight in August? (Don't forget to account for land area)
Display your result as:
"Washington experiences the greatest total amount of sunlight in a year.
Boise has the least sunlight in August. "

Task 8 (4 points): Assuming 40% of the land area in a city is completely covered in 100% efficient solar panels. Which city can potentially produce the most solar energy in July?
Display your result as:
"Las Vegas can potentially produce the most solar energy in July."

Task 9 (4 points): Assuming 40% of the land area in a city is completely covered in 100% efficient solar panels. Each solar panel is 60 square meters and produces 1kW. Which city has the greatest solar power available in January?
Display your result as:
"Las Vegas can has the greatest solar power available in January."

Task 10 (4 points): Strong wind (average yearly wind speed greater than 3mph) damages solar panels. List the top three cities where solar panels are most likely to be damaged. Assume only cities with average yearly solar insolation greater than 4 kilo Watts per square meter, and have land area greater than 300 square Kilometers have solar panels installed.
Display your result as:
"In order of likeliness to damage solar panels: Birmingham, Anchorage, and Little Rock."

Rain water related problems

Task 11 (8 points): A rainwater collection system is used in each city to recycle rainwater. Assuming 5% of the land area of each city is covered with rainwater collection system, which city collects the most rain in February? How about in August?
Display your result as:
"San Francisco collects the most rain in February while New Orleans collects the most rain in August."

Task 12 (8 points): Strong wind reduces the amount of collected rainwater. Assuming monthly wind speed below 3mph reduces the amount collected that month by 5%, monthly wind speed from 3 to 5 mph reduces the collection amount by 10%, and monthly wind speed above 5 mph reduces the collection amount by 40%. Which city collect the most rain water in a year?
Display your result as:
"Accounting for loss due to strong wind, Seattle collects the most rainwater in a year"

Task 13 (12 points): Too much rain increases the probability that solar panels become damaged. Specifically, cities with monthly precipitation above 3 inches are likely to have its solar panels damaged. (Again assume only cities with average yearly solar radiation greater than 4 kilo Watt per meter square have solar panels installed)
List the top three cities where solar panels are most likely to be damaged.
Display your result as:
"In order to likeliness to have solar panels damaged due to rain: Birmingham, Anchorage, and Little Rock"

Solar to Wind Energy Comparison

Task 14 (8 points): Assume a wind turbine can produce an average of 5000 kWh of energy each month if the average wind speed that month is greater than 3 miles per hour. Each wind turbine takes up 10,000 square meters of area, and 7% of a city's land area is covered in wind turbines. Assume cities with average yearly solar radiation greater than 3 kW/square meter have 100% efficient solar panels installed in 40% of its land area. Cities with wind power greater than solar power should install wind turbines. How many cities should install wind turbines? How many cities should install solar panels?

Display your result as:
"32 cities should install wind turbines while 12 cities should install solar panels."

Task 15 (8 points): An increase in sustainable energy awareness causes the number of solar panel arrays installed per month per household to increase. If 50% of the households (assume 1 household has 3 persons) in all cities in the database decides to start utilizing solar panels for their home today, how much total power relief can be achieved in August? (Power relief is defined here to be the amount of power consumed each household, but not supplied by the power grid)
Assume each household installs an average of 40 panels, and each panel produces 200 watts. Assume the power demand of the households that utilize solar panels, is met. (They do not need to draw power from the power grid. They are 100% off the grid.)
Display your result as:
"In total, all cities together achieve a power relief of 1000 mega watts in August"

Relationship Between Solar and Precipitation

Dataset obtained from performing an experiment tells us how the experiment behaves in the past, during measurement. By calculating the mean and standard deviation, which are statistical properties, we can better understand the experiment.

Another important statistical property is correlation. Correlation indicates how one dataset behaves relative to another dataset. For example, if data values increases with time in both datasets, then the correlation between the two datasets is positive. On the other hand, if data in one dataset increases in time while data in the other dataset decreases in time, the correlation between the two datasets is negative. You will learn how to calculate correlation in the remaining tasks.

Example, dataset1=[1 2 3] and dataset2=[9 10 11] have a correlation of 1, and the two datasets c=[8 9 10] and d=[5 4 3] have a correlation of -1.

Task 16 (4 points): Write code to plot the solar and precipitation data for the 12 months, for the following three cities on the same plot. Cities: Miami, Seattle, and Boston. One would expect that cities with high precipitation experiences low sunlight.
Your plot should be formatted using the following specifications:
1) plot the solar data using dashdot style lines, and the precipitation data using dotted style lines,
2) plot data for San Francisco using the color Red, Seattle using Blue, and Boston using Magenta, and
3) for all, use line width of 2.5.

HINT: use MatLab's help command to find information on 'plot'.

Task 17 (4 points): **Create a function called 'sum_square', that takes two 1-D vectors with equal lengths as input arguments, and returns a scalar as output. This function implements the equation below. We will use this function in the next task to compute correlation.**

$$out = \sum(\mathrm{x} * \mathrm{y}) - \frac{(\sum \mathrm{x})(\sum \mathrm{y})}{\mathrm{n}} \quad where\ n\ is\ the\ number\ of\ elements\ in\ vector\ x$$

The notation, $\sum \mathrm{x}$ means the sum of all elements in vector x.
The notation, $\sum(\mathrm{x} * \mathrm{y})$ is the sum of the element-wise product of vectors x and y.

Task 18 (8 points): **The correlation between two datasets, x and y can be computed using the formula below. Write code to find the top three cities whose correlation between solar and precipitation data is closest to -1. Use the function you wrote in Task 17 to help you.**

$$correlation, r = \frac{\mathrm{sum\_square}(\mathrm{x}, \mathrm{y})}{\sqrt{\mathrm{sum\_square}(\mathrm{x}, \mathrm{x}) * \mathrm{sum\_square}(\mathrm{y}, \mathrm{y})}}$$

Task 19 (20 points): (create a new script: task19.m)

Design **a MATLAB program that sorts the given database and display the sorted results in the form of a table. The user decides (in the form of an input. Use input(), or other methods) whether to display the sorted results (see sample output table below) in terms of average yearly wind speed, solar radiation, or precipitation. Write the sorted table into a text file ("output_rank.txt"). See sample output below. You may use loops in this problem.**

Contents of *output_rank.txt* : (sorted by wind) (table below is a sample showing 10 cities, answers are NOT correct. Your output should have ALL cities in the database)

City	Solar Rank	Wind Rank	Precipitation Rank
Birmingham	4	1	10
Anchorage	6	2	4
Little Rock	10	3	3
Phoenix	5	4	1
Los Angeles	2	5	7
San Francisco	8	6	9
Denver	1	7	6
Hartford	3	8	5
Dover	9	9	8
Miami	7	10	2