# CECS 552 Programming Assignment 2, Fall 2016

Dr. Todd Ebert

## Due Date: 6:30pm on Tuesday, October 25th

## Presenting Your Work.

Submit via email a single R script named `assign2-StudentFirstName.R`. For example, if your first name is Nitesh, then you would submit the file `assign1-Nitesh.R`. Line 1 of the file should include your full name as a comment. Also, for each block of code that pertains to some exercise, say Exercise 1, preface the code with the comment (all in caps)

```
#EXERCISE 1
```

Each function should be named exactly as it appears in the exercise, and have an input signature that follows the order specified in the exercise. Your email submission should be postmarked no later than the time shown on the due date. Submissions received after that time, but on the same day will lose one letter grade. Submissions emailed on a later day will either not be accepted, or will lose two letter grades.

## Plagiarism

Plagiarism is defined for this assignment as the practice of taking someone else's code and passing it off as one's own. However, you are welcome to use the functions in the posted R-scripts as starting points for developing your own functions. Although it is OK to discuss this assignment with other students, in the end each student must implement his or her own source code based on his or her own coding style, and way of seeing the solution. Students suspected of plagiarism will receive an automatic course grade of "F".

# Acme Energy Consortium

Acme Energy Consortium consists of 15 power stations that operate in and serve a county that consists of 20 cities. Each station has a number of generators, with each station generator being capable of producing a uniform number of megawatts (MW) per day. Also, each generator has a uniform probability $p$ of not operating on a given day. The table below provides this information for each station.

| Station | Generators | Megawatts per generator | Non-operation probability |
|---|---|---|---|
| 1 | 1 | 13.60 | 0.16 |
| 2 | 1 | 12.00 | 0.16 |
| 3 | 1 | 5.60 | 0.14 |
| 4 | 9 | 0.76 | 0.02 |
| 5 | 6 | 0.65 | 0.01 |
| 6 | 6 | 1.12 | 0.02 |
| 7 | 1 | 5.53 | 0.17 |
| 8 | 3 | 5.53 | 0.17 |
| 9 | 2 | 7.35 | 0.12 |
| 10 | 8 | 0.78 | 0.02 |
| 11 | 11 | 1.09 | 0.02 |
| 12 | 8 | 0.78 | 0.02 |
| 13 | 18 | 1.45 | 0.02 |
| 14 | 6 | 7.74 | 0.02 |
| 15 | 4 | 0.95 | 0.01 |

Note that all generator non-operations are assumed to occur independently.

Each city has a daily demand (in megawatts) for energy, as shown in the following table.

| **City** | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| **Demand** | 6.04 | 7.15 | 9.04 | 10.12 | 5.80 | 5.40 | 6.20 | 6.06 | 7.97 | 6.52 |
| **City** | K | L | M | N | O | P | Q | R | S | T |
| **Demand** | 9.05 | 5.37 | 3.99 | 6.69 | 5.85 | 5.88 | 4.86 | 5.86 | 7.00 | 8.30 |

For this reason it has contracts with some of the power stations, where a contract requires a station to commit a fixed percentage of its output to that city. As a result, for each station, the distribution of its generated power to each city is fixed, and shown in the matrix $A$ below, where $a_i j$ is the percent of energy that station $i$ has committed to city $j$. Note that stations 14 and 15's distributions do not sum to 100, since they have contracts with cities in a neighboring county.

$$A = \begin{pmatrix}
30 & 20 & 15 & 0 & 0 & 21 & 14 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 8 & 0 & 20 & 0 & 0 & 41 & 0 & 15 & 0 & 7 & 0 & 0 & 0 & 9 & 0 & 0 & 0 & 0 \\
0 & 10 & 0 & 0 & 0 & 0 & 10 & 0 & 25 & 5 & 10 & 0 & 10 & 0 & 10 & 0 & 0 & 10 & 10 & 0 \\
0 & 0 & 0 & 80 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 20 & 0 & 0 & 0 & 0 \\
20 & 0 & 0 & 0 & 0 & 0 & 10 & 0 & 0 & 15 & 0 & 10 & 0 & 0 & 0 & 10 & 10 & 10 & 0 & 15 \\
0 & 10 & 10 & 0 & 0 & 15 & 0 & 0 & 7 & 8 & 0 & 0 & 0 & 0 & 9 & 6 & 20 & 0 & 15 & 0 \\
3 & 6 & 9 & 0 & 15 & 0 & 11 & 7 & 0 & 10 & 0 & 12 & 0 & 0 & 14 & 0 & 0 & 0 & 0 & 13 \\
7 & 5 & 6 & 8 & 4 & 5 & 5 & 5 & 5 & 8 & 4 & 10 & 5 & 5 & 4 & 4 & 2 & 2 & 3 & 3 \\
3 & 3 & 2 & 2 & 4 & 4 & 5 & 5 & 10 & 4 & 8 & 5 & 5 & 5 & 5 & 4 & 8 & 6 & 5 & 7 \\
10 & 10 & 10 & 10 & 0 & 0 & 0 & 0 & 10 & 0 & 15 & 0 & 0 & 15 & 0 & 0 & 0 & 0 & 0 & 20 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 14 & 21 & 0 & 0 & 15 & 20 & 30 \\
0 & 0 & 20 & 0 & 8 & 0 & 0 & 15 & 0 & 0 & 41 & 0 & 9 & 0 & 0 & 0 & 0 & 7 & 0 & 0 \\
6 & 6 & 6 & 6 & 6 & 6 & 6 & 6 & 8 & 6 & 0 & 6 & 0 & 6 & 0 & 6 & 4 & 6 & 4 & 6 \\
5 & 7 & 8 & 6 & 5 & 4 & 5 & 5 & 8 & 5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 10 & 10 & 10 & 10 & 0 & 15 & 0 & 10 & 0 & 0 & 15 & 0 & 20 & 0 & 0 & 0
\end{pmatrix}$$

# Exercises

1. Implement the zero-input R function `daily_power` that returns the total generated power for a random day. Also, implement the zero-input R function `daily_surplus` that returns the difference between the total power demand and the power supply for a random day. Note: if the demand exceeds the supply, then a negative number should be returned.

2. A day for which daily_surplus $< 0$ is called a **blackout day**, meaning that parts of the county will experience temporary loss of power. Use `daily_surplus` to implement `blackout`, which is the same as `daily_surplus`, but returns 1 for a blackout day, and zero otherwise. Use `estimate_bernoulli` from Programming-Assignment 1 with inputs

$$\texttt{estimate\_bernoulli}(\texttt{blackout}, 0.95, 0.005)$$

   to estimate probability $p_b$, the probability of a blackout. Modify your `estimate_bernoulli` function so that, as a side effect, it prints the confidence interval for $p_b$, the number of required samples. and the mean time between blackout days.

3. There are a number of (both very warm and cold) days in the year when the overall countywide demand for energy increases by 20%. Estimate $p_b$ for this increased demand using $n = 1000$ random days. Note: you do not need a confidence interval for this exercise.

4. Implement `daily_power2` which is the same as `daily_power`, except that now it accepts the inputs i) station number $s$, and ii) a probability $p$ that is the new probability that a generator at station $s$ will fail.

5. The energy consortium is interested in upgrading one of its stations. This upgrade would have the effect of cutting in half the probability that a generator does not operate on a given day. It will perform the upgrade if it can be shown that the mean time between blackout days is extended by at least four days. Implement the zero-input void R function `consortium_report`

that has the effect of printing the following information for each station: i) station number, ii) estimate of $p_b$ if this is the station that is upgraded, iii) 0.95-confidence interval for $p_b$, and iv) mean time between blackout days if this station is upgraded.

6. Do you recommend the consortium perform the upgrade based on their criteria? If so, which station should be upgraded? If not why?