CEE 3804 Exam2 (Spring 2023)

Computer Applications in Civil Engineering

Open Book and Notes (Take Home - Due April 26, 2023)

Your Name _____

Your Signature * _____

* The answers in this exam are the product of my own work. I certify that I have not received nor I have provided help to others while taking this examination.

Directions:

Solve the problems. Copy and paste the VBA code and solutions such as graphs in a Word Document and convert to a single PDF file. **Make sure your code is not too small for me to be able to read it.** Minimum font size 10.

Problem 1 (40 points)

Civil engineering undergraduate students collected airport noise data as part of a study abroad program (see Figure 1). Airport noise is important to mitigate environmental impacts around airports.

Figure 1. Virginia Tech students collecting airport noise data at the Punta Cana International Airport.

The data collected near the old Air Traffic Control tower at the Punta Cana airport is included in a companion Excel file. Three teams of students collected data independently using three noise sensors. The data collection started simultaneously for a time period of 11 hours. The data file includes the time measured from 8:00 AM of day of the recording (in decimal hours) and the A-weighted Sound Pressure Level (SPL) in decibels - a measure of instantaneous noise produced by the aircraft or ground vehicles in the ramp area. Figure 2 shows a screen capture of the data provided.

a) Create a Matlab script to read the data. Label the variables appropriately and include their units if applicable as part of the variable name.

b) Add code the Matlab script created in part (a) to make a single plot the SPL noise levels (in the y-axis) and time (x-axis) collected at three different locations. Use different colors to distinguish each run. Add a legend to the plot as well to identify the data sets.

c) Add code to item (b) to calculate the mean difference between all three data sets. Calculate the difference between data sets 1-2 and 1-3. Plot the difference as a function of time. Find the mean difference for each time recorded.

	A	B
1	**Time (s)**	**SPL (dBA)**
2	1	69.7
3	2	68.8
4	3	70.4
5	4	71.2
6	5	70.9
7	6	78.5
8	7	74.5
9	8	71.0
10	9	70.7
11	10	69.4
12	11	70.8
13	12	70.5

Figure 2. Noise Data Collected Near the Old Air Traffic Control Tower.

d) Add code to the script created in part (c) to find the number of times (in the recording period) that SPL exceeded 65 dBA.

A quantity used in transportation noise studies is the so-called Equivalent Continuous Sound Pressure Level (L_{eq}). L_{eq} is calculated using the following equation. Note that noise levels are additive via a logarithmic function.

$$L_{eq} = 10log(\sum_{i=1} \frac{1}{T} 10^{SPL_i/10})$$

Where:

L_{eq} is the equivalent noise level over a period of time T

T is the total time in seconds of the recording period

SPL_i is the sound pressure level measured at time i

To illustrate the use of the formula above consider adding two SPL values of 88 dBA over two seconds ($T = 2$). The value of the Equivalent Noise Level (L_{eq}) is 91 dBA.

e) Add Matlab code to the script to estimate the value of L_{eq} for all three data sets. Report the values of L_{eq} for each data set.

f) Comment on the observed differences in the three data sets.

Problem 2 (30 points)

Review the Kicker with angle table VBA code demonstrated in class. The partial code is reproduced Figure 3.

```
' Estimates the hang time and the distance traveled by the ball
' Uses simple equations learned in Physics

vx0 = initialSpeed * Cos(initialAngle * pi / 180)     ' initial horizontal velo
vy0 = initialSpeed * Sin(initialAngle * pi / 180)     ' initial vertical velocity

hangtime = 2 * vy0 / g
Distance = hangtime * vx0
```

Figure 3. Kicker Calculations in VBA.

a) Convert the VBA code into a Matlab function to estimate the hang time and distance traveled by the soccer ball. The function should accept two inputs: 1) initial speed and 2) angle of kick. The function produces two outputs: 1) hang time and distance traveled.

b) Write a separate Matlab script to test the function created in part (a). In the script create a vector of angles ranging from 0-90 degrees and produce the solutions of the kicker problem when the initial speed is 30 m/s.

c) Plot the results of part (b). Label the plot accordingly.

d) Comment on the differences between VBA and Matlab.

Problem 3 (30 points)

The Logan company makes $156 for every steel doubler using in construction. The company makes $185 for every titanium doubler using in construction. The company would like to maximize the revenue via an optimization problem with the following formulation:

$$Z = 156x_1 + 185x_2$$

$$4.1x_1 + x_2 <= 10200$$

$$-1.3x_1 + x_2 <= 1500$$

$$3.5x_1 + x_2 <= 9200$$

$$x_1 <= 2000$$

$$x_1 >= 0 \text{ and } x_2 >= 0$$

a) Convert the problem into **standard (canonical) form** to be solved by hand using the Simplex Method. Write down the transformed equations and add slack variables as needed.

b) Find the optimal solution to the problem using the manual Simplex Method (tables and row operations) explained in class. Indicate the numerical values of all decision variables in every table. Indicate the value of the objective function Z in every table. This task requires calculations and row operations and you need to show me your row operations clearly.

c) Solve the problem using Excel Solver. Verify the solution obtained in part (a).

d) Show a graphical solution to the problem indicating the corner points. In the plot also show me the line representing the objective function for the highest Z value.