ENGIN 112: Homework 8

Due date: 11/15/22 5:00 p.m.

Please submit your answers via Gradescope as a single PDF file. You can write your answers electronically or by hand and submit a scan or photo.

Question 1

Please answer the following questions about measurement errors.

(a) List three metrics (with units) that you may measure in daily life and two potential sources of error for each. For example: "distance (meters): error due to inaccurate alignment of zero value of measurement tape on one side of distance; error due to variation in manufacturing of measurement tape."

(b) The precision of a measurement determines how much variation you observe when measuring the same metric repeatedly. With everyday tools available to you, how much variation would you expect when measuring the following quantities: 1 minute of time, room temperature, 1 cup of water. Your answer should state a reasonable range of values that you would expect. For example, when measuring 1 meter of distances, it is reasonable to expect that you can measure it within: "1 meter $\pm$ 2 millimeter"

Question 2

Please answer the following questions using MATLAB.

(a) The following MATLAB command generates a vector with 10 random "measurements":
`x = normrnd(50,0.01,[10 1])`
Each vector element has an expected value of 50. (The parameter 0.01 indicates the level of variation between different measurements and can be left unchanged for this problem.) Use the `mean` function to calculate the mean of `x`. What result do you get? Explain how this result does or does not match your expectation.

(b) Repeat the above experiment with larger vectors of sizes 100 and 1000. When calculating the mean of those larger vectors, what do you observe? Explain how this result does or does not match your expectation.

Note: Every time you run `x = normrnd(50,0.01,[10 1])` in MATLAB, a new set of random values are assigned to the components of `x`.

Question 3

[Note: I realize that this is not an Electrical and Computer Engineering question *per se*. However, since we cover positioning in class, I want to make sure that you have determined latitude at least once. Also, this is a weather-dependent homework assignment – it may work or not. Try to do the assignment, but if it does not work out for you, then just write a brief statement why.]

Please answer the following question regarding determining the latitude of your position. To answer this question, you need to be outside at night so you can see the stars (particularly towards the north).

(a) Look at a star map and determine where Polaris (i.e, the north star) is. (You can get a program to display a current star map at `http://www.stellarium.org/` – make sure to set your location correctly.) Describe how you found Polaris in the night sky.

(b) Measure the angle between Polaris and the horizon. You may use any approach to measure that angle. (A rule of thumb is that the width of your thumb as seen with your fully stretched out arm appears to cover one degree; the width of your fist as seen with your fully stretched out arm appears to cover ten degrees.) Based on this measurement, what is the latitude of your position?

Question 4

Please answer the following question about propagation delay in signals.

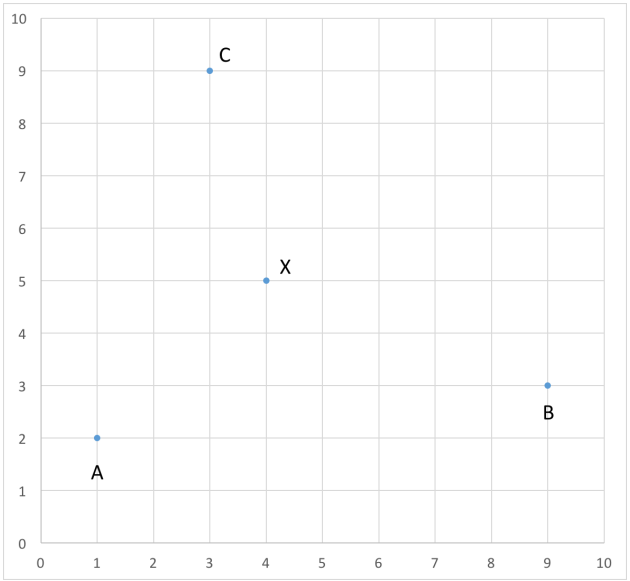
(a) Assume you have two microphones that are placed 0.2 meters apart. What is the maximum difference in reception time of a sound wave on the two microphones (i.e., the maximum phase shift between the microphones expressed in time)?

(b) Repeat the above calculation, but assume that you are using electromagnetic waves instead of sound waves (i.e., a radio receiver instead of a microphone and a radio signal instead of a sound wave).

(c) Assume you can choose to do beamforming with sound or with electromagnetic signals. Based on the results from (a) and (b), discuss which beamforming approach is easier to implement and why.

Question 5

Consider the location of three beacons, A, B, and C, and the location of an object, X, in the following 2-D plane (1 unit = 1 km):



(a) What are the distances between each beacon and X?

(b) Assuming that all beacons send a synchronized radio signal at time $t = 0$. At what time do the signals from the beacons arrive at X? (Please order your answer in order of arrival time.)

(c) Assume that X moves to the right. How do you expect the arrival order to change (if it does change)? If you expect multiple changes in order, list each change.

Question 6

If technology was available to implement GPS-style positioning that works indoors with accuracy and precision of a few inches, what useful application could you envision implementing? Your answer should be 4-5 sentences.