AuE824 Autonomous Driving Homework 1
Due: January 27th, 2021 – before class

Submission Rules: You should submit all your homework through Clemson Canvas. Your primary submission should be in a report format pdf file titled Firstname_Lastname_HW1.pdf. If coding is required, source codes must be submitted along with your primary submission in Canvas. Maximum securable points are 100.

Problem 1 (40 pts)

(1) Find four autonomous vehicles developed by different companies and introduce their autonomous driving functions. Determine their autonomous levels in the SAE standard and explain the reason. (10 pts)

(2) List five advantages of autonomous vehicles and explain the reasons for each. (10 pts)

(3) List four sensors in autonomous vehicles and explain what autonomous driving functions that they can be applied to. (10 pts)

(4) Describe the principles of three types distance sensors (ultrasonic, radar, and lidar). List the advantages and disadvantages of each. (10 pts)

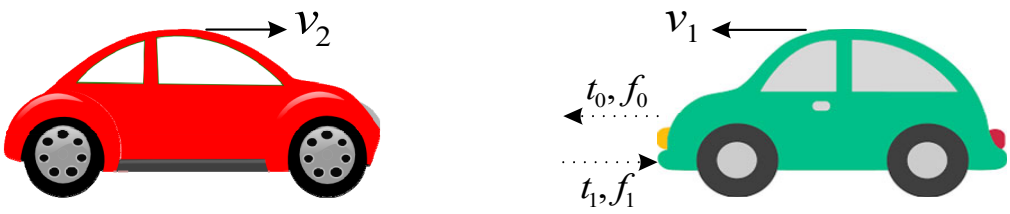
Problem 2 (30 pts)

(1) How does a radar detect distance and speed respectively? (10 pts)

(2) Two cars (a green car and a red car shown in the figure below) are driving in the opposite way with constant speeds v_1 and v_2. The green car can measure its speed v_1 using an onboard speed sensor. The green car emits a radar signal with a frequency f_0 at time t_0 and receives the reflected signal with a frequency f_1 at time t_1. Please answer the two questions with your derivation processes:

(a) What is the speed of the red car v_2? (10 pts)

(b) What is the distance between the two cars at time t_1? (10 pts)



Problem 3 (30 pts)

The position of four satellites are given in the table below in the unit of Mm (megameter).

Satellite No.	Satellite Position *x* (Mm)	Satellite Position *y* (Mm)	Satellite Position *z* (Mm)
1	101	16	207
2	52	21	302
3	17	53	350
4	-15	159	208

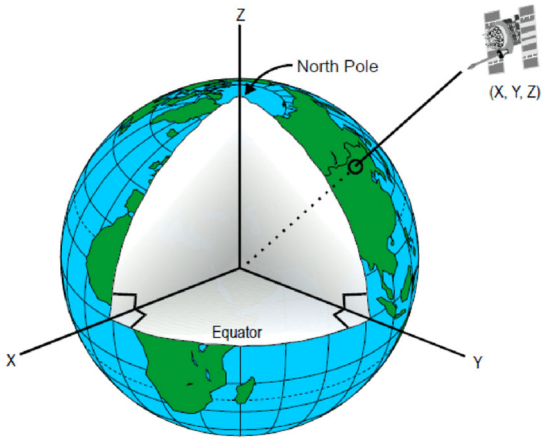
A GPS unit receives signals from the four satellites and the signals incorporate the positions of each satellite and also the following information:

- Sending times of each signal at the satellites, which are stored in file "st.mat"
- Receiving times of each signal at the GPS unit, which are stored in file "rt.mat"

Please calculate the position of the GPS unit in the unit of Mm and also the clock difference between the GPS unit clock and Satellite system clock in the unit of s (second) using numerical optimization function in Matlab. You need to submit both the solution presentation and codes.

Additional Notes:

- Use Matlab command, <load 'Name.mat'>, to load the data. For example, command <load 'st.mat'> will load a variable vector "st" and "st(1), st(2), st(3) and st (4)" will be the sending times of satellite 1, 2, 3 and 4 respectively. Do the same for "rt.mat".
- Speed of GPS radio wave: c = 300 Mm/s
- All the satellites share the same clock – satellite system clock.
- The available numerical optimization functions with examples in Matlab can be found at https://www.mathworks.com/help/optim/referencelist.html?type=function. Please explore and try different functions, such as "fminsearch", "fminumc", "fmincon", etc., to find out the best appropriate function.
- The radius of the earth is 6.378 Mm. The range of the GPS unit's position coordinates is [5, 20] Mm and the range of clock differences is [-10, 10] s. These information can be used to check the correctness of your results or set constraints for the numeric optimization functions.
- Coordinate system of the GPS system is defined as:



Homework Notes:

- **Any cheating attempts (like copying) will secure you a 0 score.**
- **If you have any questions or doubts regarding, you can ask the TA during office hours**