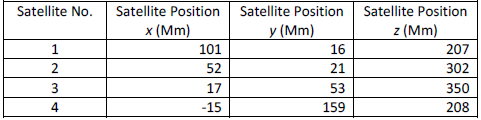
**Problem 3:**

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



The GPS location was solved using fmincon, a nonlinear programming algorithm in MATLAB, and the initial values for X, Y, Z coordinates were equal to the radius of earth and 0 for the time difference in the clock.

Equations:

Here the GPS coordinates are (x, y, z, tiv), and Satellite system coordinates are (xi, yi, zi, tic).

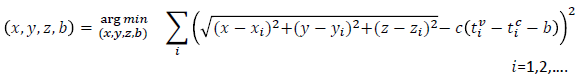
Distance between the GPS unit and one satellite is,



The difference in distance between them should be zero,



Hence, we must find the minimum value of the below-cost function to find the coordinates of the GPS,



**Output:**

The coordinates of the GPS unit are as follows:

|  |  |
| --- | --- |
| X coordinate of GPS unit | 5.185537 Mm |
| Y coordinate of GPS unit | 7.578706 Mm |
| Z coordinate of GPS unit | 8.456620 Mm |
| Clock difference between GPS and satellite | 0.299846 s |

**MATLAB script: (reference fmincon function MATHWORKS)**

%%% Author - Adithya Suresh %%%

%%% Professor - Dr. Yunyi Jia %%%

%%% Homework 1 - 3rd problem solution %%%

clear all

clc

%% Loading time data

load('st');

load('rt');

%% Data from question

x = [101,52,17,-15];

y = [16,21,53,159];

z = [207,302,350,208];

radiowave\_speed = 300;

earth\_radius = 6.378;

%% Time taken for individual satellite to receive the signal

time\_diff = rt - st;

%% Function to calculate position of GPS unit

fun = @(a)((sqrt(((a(1)-x(1)).^(2))+((a(2)-y(1)).^(2))+((a(3)-z(1)).^(2)))-(radiowave\_speed.\*(time\_diff(1)-a(4)))).^(2))...

+((sqrt(((a(1)-x(2)).^(2))+((a(2)-y(2)).^(2))+((a(3)-z(2)).^(2)))-(radiowave\_speed.\*(time\_diff(2)-a(4)))).^(2))...

+((sqrt(((a(1)-x(3)).^(2))+((a(2)-y(3)).^(2))+((a(3)-z(3)).^(2)))-(radiowave\_speed.\*(time\_diff(3)-a(4)))).^(2))...

+((sqrt(((a(1)-x(4)).^(2))+((a(2)-y(4)).^(2))+((a(3)-z(4)).^(2)))-(radiowave\_speed.\*(time\_diff(4)-a(4)))).^(2));

initial\_data = [earth\_radius,earth\_radius,earth\_radius,0];

A = [];

B = [];

C = [];

D = [];

E = [];

F = [];

func\_variable = @equation;

GPS\_position = fmincon(fun, initial\_data, A, B, C, D, E, F, func\_variable);

Local minimum possible. Constraints satisfied.

fmincon stopped because the size of the current step is less than

the value of the step size tolerance and constraints are

satisfied to within the value of the constraint tolerance.

<stopping criteria details>

%% Output

fprintf('X coordinate position of the GPS is %f Mm \n',GPS\_position(1));

X coordinate position of the GPS is 5.185537 Mm

fprintf('Y coordinate position of the GPS is %f Mm \n',GPS\_position(2));

Y coordinate position of the GPS is 7.578706 Mm

fprintf('Z coordinate position of the GPS is %f Mm \n',GPS\_position(3));

Z coordinate position of the GPS is 8.456620 Mm

fprintf('Clock difference between GPS unit clock and Satelite system clock is %f s \n',GPS\_position(4));

Clock difference between GPS unit clock and Satelite system clock is 0.299846 s

Equation function:

function [c,ceq] = equation(m)

c = [5-m(1) m(1)-20 5-m(2) m(2)-20 5-m(3) m(3)-20 -10-m(4) m(4)-10];

ceq=[];