Jungjae Lee, Rohan Kumar
Professor Attaway
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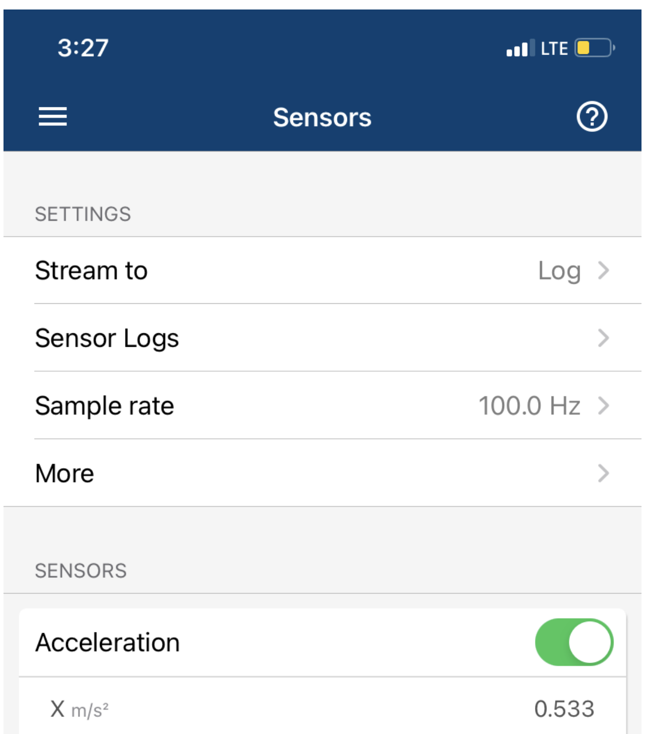
Analysis of Elevator Accelerations in Warren Towers B Tower

In this project, our goal was to document the accelerations of the different elevators in the Warren Towers dormitory. This was done specifically on the Warren B Tower, which has 3 elevators. Upon collecting that data, we then found the maximum and minimum accelerations in the vertical directions. We then compared the elevators together in a comprehensive graph that shows which elevators are most efficient at bringing students up to their floors. Finally, we created a function in our script to find the maximum forces exerted by the elevators, given the maximum accelerations. Below are the steps in sequential order.

1. In order to measure the acceleration of the elevators, we placed our phones, equipped with the MATLAB acceleration sensors, on the ground of the elevator floor, starting at floor 4, and ending at floor 18. These floors are the lowest and highest floors that the elevators go to. In the MATLAB application, we chose to take measurements at the 100 Hz frequency, which is the most measurements possible, and therefore it can be the most accurate measurements possible. Below is a screenshot of what the application appeared as before we began each trial:



2. After documenting the accelerations of each elevator, we uploaded the data into MATLAB Drive using the instructions given during the homework assignment. From there, we had 3 timetables, each with 3 columns: acceleration in the x direction, in the y direction, and in the z direction. Due to our orientation of the phone on the ground, the only acceleration that the phone experienced was in the z direction (vertical), and therefore we isolated these columns into variables named accelerationOne, accelerationTwo, and accelerationThree, using the following command:

```
% Load the data, and isolate the Z value
load('elevator1.mat')
accelerationOne = Acceleration.Z(1:3740);

load('elevator2.mat')
accelerationTwo = Acceleration.Z(1:3880);

load('elevator3.mat')
accelerationThree = Acceleration.Z(1:3781);
```

These variables each contain the acceleration data in the z direction from elevator one, two, and three, respectively.

3. After importing and isolating the data points of acceleration in the z direction, the next step was to find the maximum and minimum acceleration values. We expect the normal acceleration in the z direction to be roughly equal to the gravitational acceleration experienced by any object with mass on earth (~9.81 $m/s^2$). As the elevator initially moves in the upwards direction, the acceleration in the downwards z direction should increase, whereas as the elevators slow down to reach their destination, the acceleration should decrease. We used the maximum and minimum functions in order to complete this task:

```
% The maximum(MAX) value of acceleration
maxOne = max(accelerationOne);
maxTwo = max(accelerationTwo);
maxThree = max(accelerationThree);
```

```
% The minimum(MIN) value of acceleration
minOne = min(accelerationOne);
minTwo = min(accelerationTwo);
minThree = min(accelerationThree);
```

4. We then stored the maximum values of each in a vector labeled maxVec and minVec, where the indices correspond to the elevator (index 1 is the first elevator, etc.):

```
% Vector of maximum(MAX) value of acceleration
maxVec = [maxOne, maxTwo, maxThree];

% Vector of minimum(MIN) value of acceleration
minVec = [minOne, minTwo, minThree];
```

5. In order to plot all of the data, we used the plot function, and then subsequently used the hold function in order to layer the data onto each other. We then added labels, titles, and a legend in order to complete the graph:

```
% Plot the vector of maximum values
plot([1 2 3], maxVec, 'go', 'MarkerSize', 10);
hold on
plot([1 2 3], minVec, 'ro', 'MarkerSize', 10);
legend('Maximum Acceleration','Minimum Acceleration');
xlabel('Elevator #');
ylabel('Acceleration (m/s^2)');
title('Acceleration of Warren B Elevator');
axis([-1 5 8.5 11.5]);
```

6. Additionally, we found the maximum force that is exerted by each elevator, using a function called accelToforce that we created ourselves. The function uses the general force formula (f=ma), where f is force in Newtons, m is mass in kg, and a is acceleration in meters per second squared. We found the mass of the phone, which was 0.194 kg. The function takes a vector of maximum accelerations and returns a vector of maximum forces:

```
function force = accelToForce(x)
% Calculates force given acceleration on phone, accelToForce(x)
force = x * 0.194;
end
```

We then used the fprintf function to print out a short statement about the maximum forces of each elevator.

```
% Convert the acceleration to the force
forces = accelToForce(maxVec);
fprintf('The force exerted on the phone in elevators 1, 2 and 3 are ');
fprintf('%.2f N, %.2f N, and %.2f N, respectively\n', forces(1), forces(2), forces(3));
```

In conclusion, our final product was a multifaceted analysis of the accelerations of the elevators 1-3 on Warren B tower, where we found the maximum and minimum accelerations, compared them in a graph format, and then found the maximum forces exerted on the phone. The following pictures are the graph output and the print statement.

```
Command Window
>> project
The force exerted on the phone in elevators 1, 2 and 3 are 2.10 N, 2.12 N, and 2.11 N, respectively
>>
```