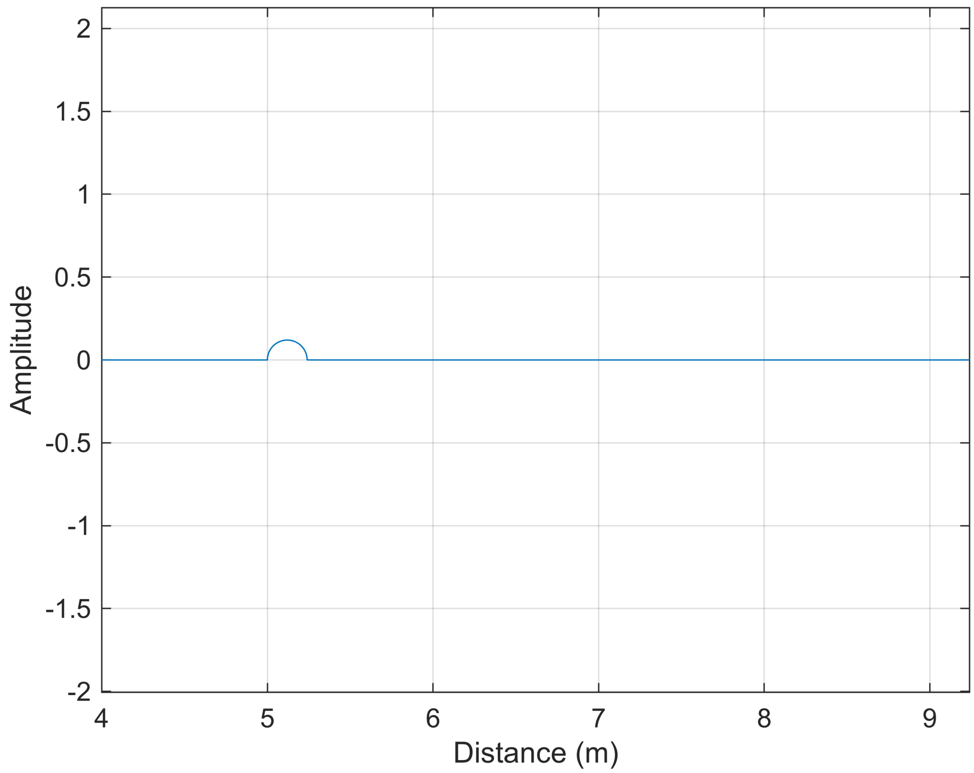
Road Profile - Generation

```
[X_r, Z_r] = bump_road_input(5,0.12,15);
```



```
% profile_length = 200;       % Length of the road profile (meters)
% sampling_rate = 50;         % Numberof points per meter
% amplitude_factor = 0.005;     % Roughness
% num_bumps = 5;              % Number of bumps
% bump_amplitude = 0.001;       % Amplitude of bumps
% bump_frequency = 0.5;       % Frequency of bumps
%
% [X_r, Z_r] = generateRoadProfileWithBumps(profile_length, sampling_rate, amplitude_factor, nu

road.X_r = X_r;
road.Z_r = Z_r;
```

Car Model

```
%Vehicle
scooter.mass = 150;
scooter.front_unsprung_mass = 15;
scooter.rear_unsprung_mass = 15;
scooter.Lateral_MOI = 20;
scooter.CG_2_Front = 0.5;
scooter.CG_2_Rear = 0.5;
```

```
stiffness.front_strut = 15000;
stiffness.rear_strut = 15000;
stiffness.tire_front = 100000;
stiffness.tire_rear = 100000;

damping.strut_front = 1000;
damping.strut_rear = 1000;

%Velocity
initial_vel = 10; %velocity in m/s
acc  = 0;
```

SOLVING

```
[displacement, velocity, acceleration] = Ride_Comfort_Analysis(scooter, stiffness, damping, roa
```

```
displacement = struct with fields:
                   z_body: [300×1 double]
         z_unsprung_front: [300×1 double]
          z_unsprung_rear: [300×1 double]
                    theta: [300×1 double]
                     time: [300×1 double]
               tire_front: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
                tire_rear: [0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
     longitudinal_pos_front: [1 1.0334 1.0669 1.1003 1.1338 1.1672 1.2007 1.2341 1.2676 1.3010 1.3344 1.3679 1.4013 1
      longitudinal_pos_rear: [0 0.0334 0.0669 0.1003 0.1338 0.1672 0.2007 0.2341 0.2676 0.3010 0.3344 0.3679 0.4013 0
velocity = struct with fields:
              v_body: [299×1 double]
    v_unsprung_front: [299×1 double]
     v_unsprung_rear: [299×1 double]
            v_thetha: [299×1 double]
                time: [299×1 double]
acceleration = struct with fields:
              a_body: [298×1 double]
    a_unsprung_front: [298×1 double]
     a_unsprung_rear: [298×1 double]
             a_theta: [298×1 double]
                time: [298×1 double]
```

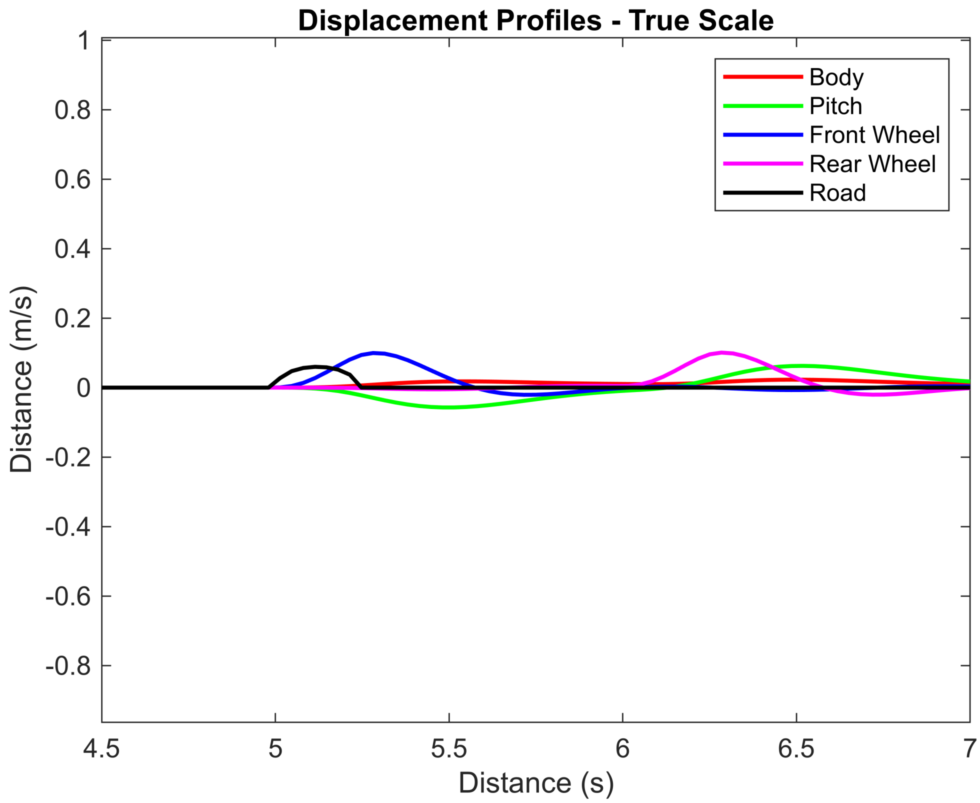
```
%ANd DONEEEEEEEE...
```

Plotting & Analyzing

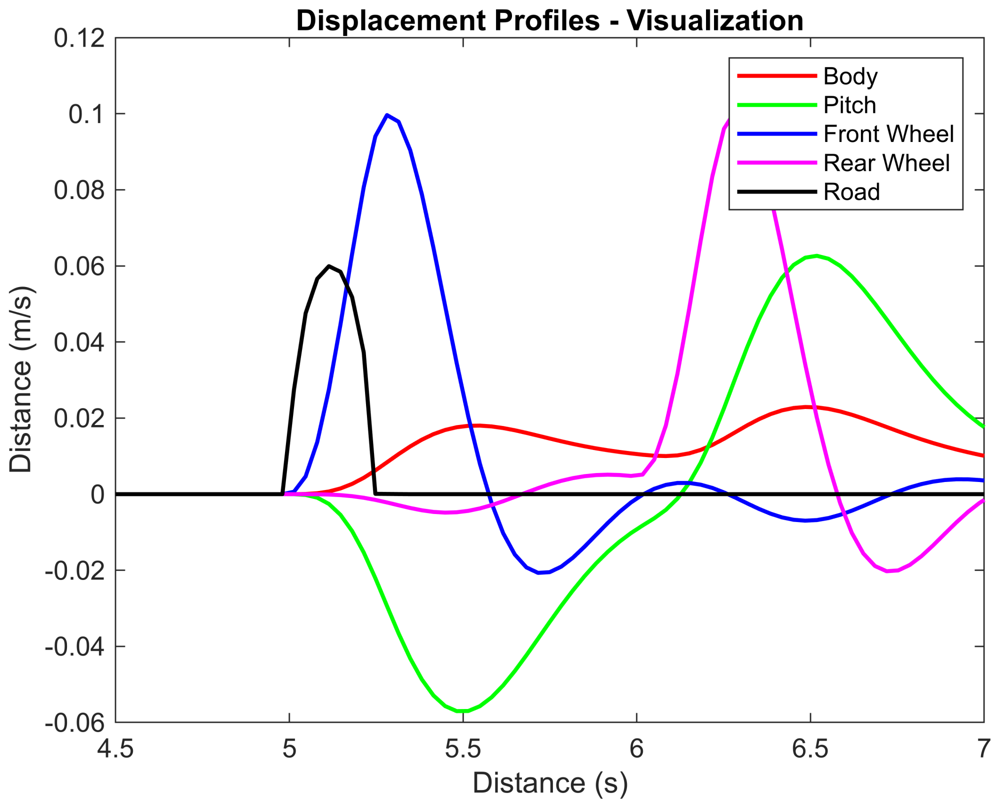
Position Based Analysis

```
figure
u = displacement.longitudinal_pos_front;
plot(u , displacement.z_body, 'r', 'LineWidth', 1.5);
hold on;
plot(u, displacement.theta, 'g', 'LineWidth', 1.5);
plot(u, displacement.z_unsprung_front, 'b', 'LineWidth', 1.5);
plot(u, displacement.z_unsprung_rear, 'm', 'LineWidth', 1.5);
plot(u, displacement.tire_front, 'k', 'LineWidth', 1.5);
xlabel('Distance (s)');
ylabel('Distance (m/s)');
```

```
legend('Body', 'Pitch', 'Front Wheel', 'Rear Wheel','Road');
title('Displacement Profiles - True Scale');
axis equal
xlim([4.5 7])
hold off
```

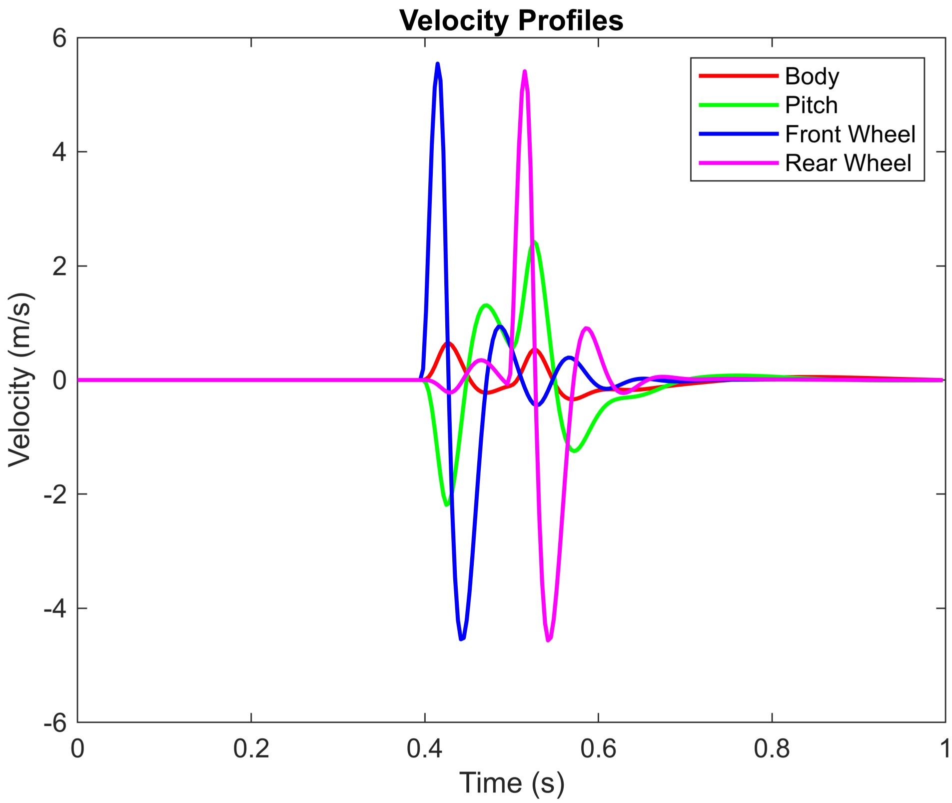



```
figure
u = displacement.longitudinal_pos_front;
plot(u , displacement.z_body, 'r', 'LineWidth', 1.5);
hold on;
plot(u, displacement.theta, 'g', 'LineWidth', 1.5);
plot(u, displacement.z_unsprung_front, 'b', 'LineWidth', 1.5);
plot(u, displacement.z_unsprung_rear, 'm', 'LineWidth', 1.5);
plot(u, displacement.tire_front, 'k', 'LineWidth', 1.5);
xlabel('Distance (s)');
ylabel('Distance (m/s)');
legend('Body', 'Pitch', 'Front Wheel', 'Rear Wheel','Road');
title('Displacement Profiles - Visualization');
xlim([4.5 7])
hold off
```

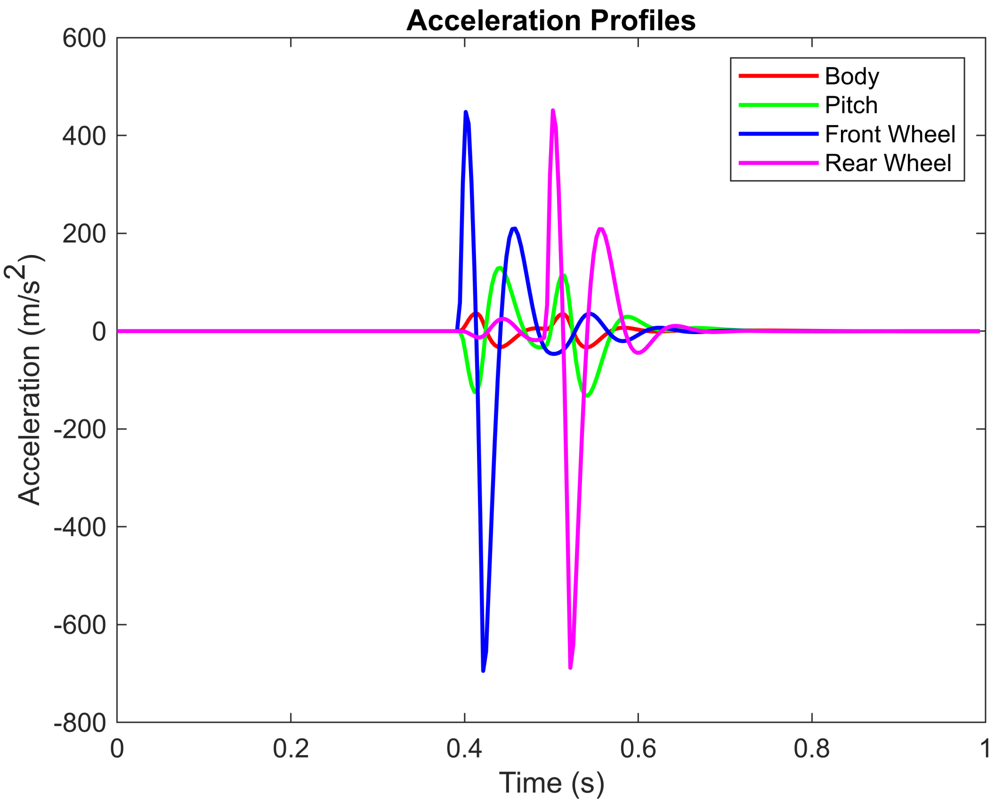


Time Based Analysis

```
figure;
plot(velocity.time, velocity.v_body, 'r', 'LineWidth', 1.5);
hold on;
plot(velocity.time, velocity.v_thetha, 'g', 'LineWidth', 1.5);
plot(velocity.time, velocity.v_unsprung_front, 'b', 'LineWidth', 1.5);
plot(velocity.time, velocity.v_unsprung_rear, 'm', 'LineWidth', 1.5);
xlabel('Time (s)');
ylabel('Velocity (m/s)');
legend('Body', 'Pitch', 'Front Wheel', 'Rear Wheel');
title('Velocity Profiles');
hold off
```




```
figure;
plot(acceleration.time, acceleration.a_body, 'r', 'LineWidth', 1.5);
hold on;
plot(acceleration.time, acceleration.a_theta, 'g', 'LineWidth', 1.5);
plot(acceleration.time, acceleration.a_unsprung_front, 'b', 'LineWidth', 1.5);
plot(acceleration.time, acceleration.a_unsprung_rear, 'm', 'LineWidth', 1.5);
xlabel('Time (s)');
ylabel('Acceleration (m/s^2)');
legend('Body', 'Pitch', 'Front Wheel', 'Rear Wheel');
title('Acceleration Profiles');
hold off
```



RIDE COMFORT QUANTIZATION

Root Mean Square Acceleration

```
%Body
RMS_Acc_Body = rms(acceleration.a_body)
```

```
RMS_Acc_Body = 9.0862
```

```
%Pitch
RMS_Acc_Pitch = rms(acceleration.a_theta)
```

```
RMS_Acc_Pitch = 34.0564
```

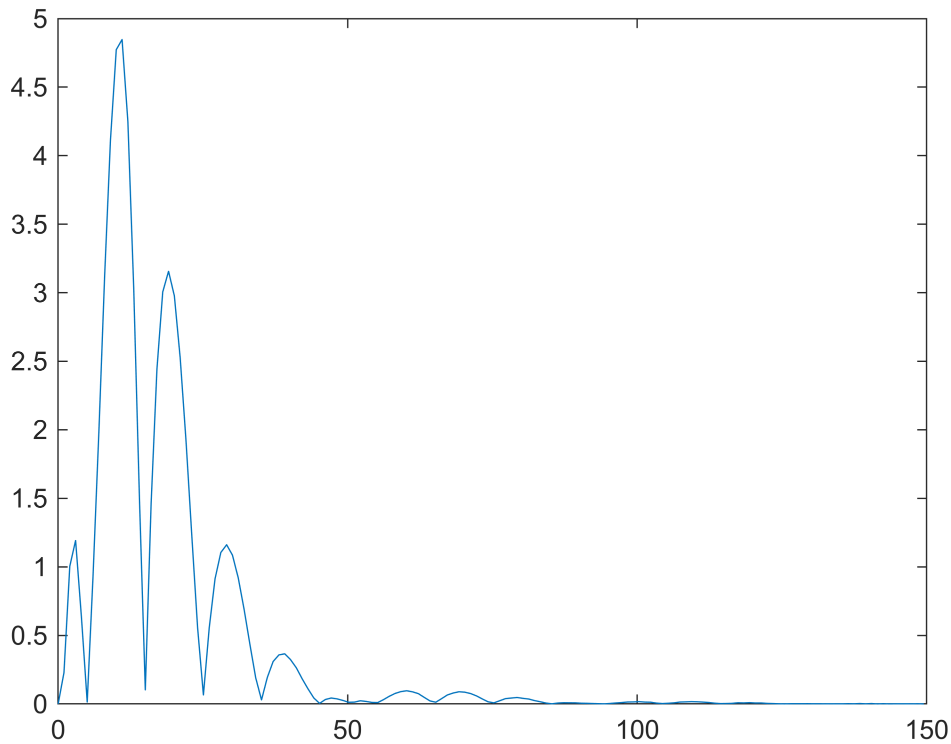
Transmissibility (acceleration based)

```
max(acceleration.a_body)/max(acceleration.a_unsprung_front)
```

```
ans = 0.0800
```

Power Spectral Density - Frequency based

```
[Weighted_PSD, frequency_arr, PSD] = Frequency_analysis(acceleration.a_body,acceleration.time);
plot(frequency_arr, PSD)
```



Total Power (PSD integral)

```
Total_Power = trapz(frequency_arr, PSD)
```

```
Total_Power = 62.4977
```

Finding Natural Frequencies

```
% Find and display the first 5 peaks in the amplitude spectrum (simple peak detection)
peaks = [];
locs = [];

for i = 2:length(frequency_arr)-1
    if PSD(i) > PSD(i-1) && PSD(i) > PSD(i+1)
        peaks = [peaks, PSD(i)];
        locs = [locs, frequency_arr(i)];
    end
end

n_modes = 5;
```

Natural Frequencies (First 5)

```
peaks = peaks(1:n_modes);
freqs = locs(1:n_modes)
```

```
freqs = 1×5
```

```
    3.0101   11.0369   19.0638   29.0973   39.1309
```

```
plot(frequency_arr, PSD)
hold on;
plot(freqs, peaks, 'ro');
hold off;
```