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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 9.02" length data processing

```
clc
clear
close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from the Excel Files'

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 4.47','B5:B12');
Display_ForceN_902 = xlsread('Drag Data A-Train Trailer','A-Train 9.02','E17:E24');
Display_ForceN_745 = xlsread('Drag Data A-Train Trailer','A-Train 7.45','E28:E35');
Display_ForceN_667 = xlsread('Drag Data A-Train Trailer','A-Train 6.67','E17:E24');
Display_ForceN_526 = xlsread('Drag Data A-Train Trailer','A-Train 5.26','E17:E24');
Display_ForceN_447 = xlsread('Drag Data A-Train Trailer','A-Train 4.47','E17:E24');
```

Applying the scaling factor to the drag forces

```

Scale_ForceN_902 = (Display_ForceN_902 - 0.0036) ./ 0.9944;
Scale_ForceN_745 = (Display_ForceN_745 - 0.0036) ./ 0.9944;
Scale_ForceN_667 = (Display_ForceN_667 - 0.0036) ./ 0.9944;
Scale_ForceN_526 = (Display_ForceN_526 - 0.0036) ./ 0.9944;
Scale_ForceN_447 = (Display_ForceN_447 - 0.0036) ./ 0.9944;

```

%% Defining the Relationship between Frequency Drive and Wind Velocity

```

m_Vel = 1.2081; % (m/s) / Hz
b_Vel = -1.0632; % m/s

for n = 1:length(Frequency)
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s
end

V_mph = 2.23694*V;

```

Calculating the Coefficient of Drag on the Trailer

Constants

```

rho = 1.225; % kg/m^3
mu = 1.846e-5; % kg/m*s
w = 0.0650; % m (2.560 inches)
h = 0.0518; % m (2.039 inches)
A = w*h; % m^2

% Calculation
C_DragN_902 = (2*abs(Scale_ForceN_902)) ./ (rho*(V.^2)*A);
C_DragN_745 = (2*abs(Scale_ForceN_745)) ./ (rho*(V.^2)*A);
C_DragN_667 = (2*abs(Scale_ForceN_667)) ./ (rho*(V.^2)*A);
C_DragN_526 = (2*abs(Scale_ForceN_526)) ./ (rho*(V.^2)*A);
C_DragN_447 = (2*abs(Scale_ForceN_447)) ./ (rho*(V.^2)*A);

```

Determining the average Cd for each model

```

C_Drag_AvgN_902 = mean(C_DragN_902);
C_Drag_AvgN_745 = mean(C_DragN_745);
C_Drag_AvgN_667 = mean(C_DragN_667);
C_Drag_AvgN_526 = mean(C_DragN_526);
C_Drag_AvgN_447 = mean(C_DragN_447);

```

Percent Changes in Drag Coefficient w.r.t base model

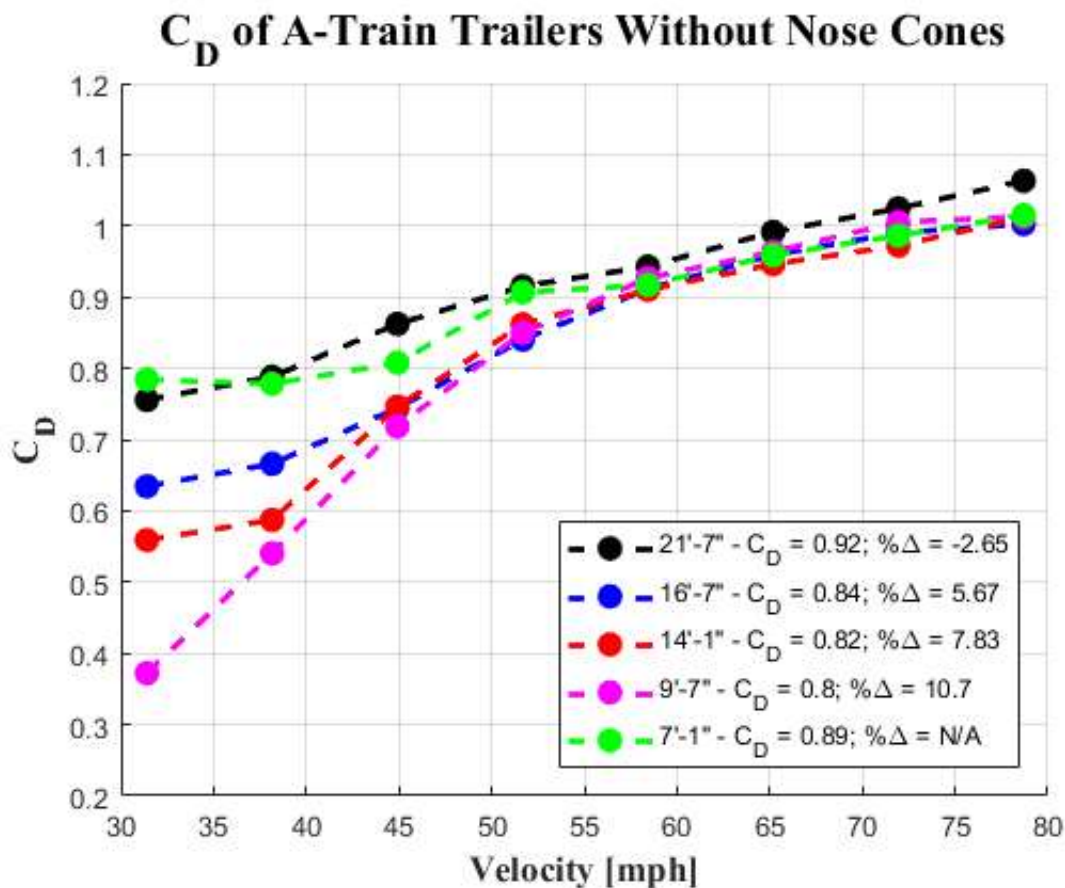
```

ChangeN_902 = (C_Drag_AvgN_447 - C_Drag_AvgN_902) / C_Drag_AvgN_447 * 100;
ChangeN_745 = (C_Drag_AvgN_447 - C_Drag_AvgN_745) / C_Drag_AvgN_447 * 100;
ChangeN_667 = (C_Drag_AvgN_447 - C_Drag_AvgN_667) / C_Drag_AvgN_447 * 100;
ChangeN_526 = (C_Drag_AvgN_447 - C_Drag_AvgN_526) / C_Drag_AvgN_447 * 100;

```

Plotting Results

```
figure(1)
set(gcf,'color','w')
plot(V_mph,C_DragN_902,'k--','Linewidth',2,'MarkerSize',30)
hold on
plot(V_mph,C_DragN_745,'b--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragN_667,'r--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragN_526,'m--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragN_447,'g--','Linewidth',2,'MarkerSize',30)
title('C_{D} of A-Train Trailers Without Nose Cones','Fontname','Times',...
      'Fontweight','bold','FontSize',16)
xlabel('Velocity [mph]','Fontname','Times','Fontweight','bold','FontSize',13)
ylabel('C_{D}','Fontname','Times','Fontweight','bold','FontSize',13)
ylimlimits = [0.2 1.2];
ylim(ylimlimits)
legend('Location','southeast',['21'-7" - C_{D} = ',num2str(C_Drag_AvgN_902,2),...
      '; %{\Delta} = ',num2str(ChangeN_902,3)],['16'-7" - C_{D} = ',...
      num2str(C_Drag_AvgN_745,2),'; %{\Delta} = ',num2str(ChangeN_745,3)],...
      ['14'-1" - C_{D} = ',num2str(C_Drag_AvgN_667,2),'; %{\Delta} = ',...
      num2str(ChangeN_667,3)],['9'-7" - C_{D} = ',num2str(C_Drag_AvgN_526,2),...
      '; %{\Delta} = ',num2str(ChangeN_526,3)],['7'-1" - C_{D} = ',...
      num2str(C_Drag_AvgN_447,2),'; %{\Delta} = N/A'])
grid on
box off
```



Emission Calculations

```

C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;           %Weight Reduction
h_48 = 1.99;        %m
w_48 = 2.49;        %m
A_ATrain = h_48*w_48; %m^2

e_CO2_N_745 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgN_902 - C_Drag_AvgN_745)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_N_667 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgN_902 - C_Drag_AvgN_667)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_N_526 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgN_902 - C_Drag_AvgN_526)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_N_447 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgN_902 - C_Drag_AvgN_447)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile

FC_N_745 = (e_CO2_N_745/10180)*1000 %gal_diesel/1000ton-mile
FC_N_667 = (e_CO2_N_667/10180)*1000 %gal_diesel/1000ton-mile
FC_N_526 = (e_CO2_N_526/10180)*1000 %gal_diesel/1000ton-mile
FC_N_447 = (e_CO2_N_447/10180)*1000 %gal_diesel/1000ton-mile

```

e_CO2_N_745 =

120.8055

e_CO2_N_667 =

119.8987

e_CO2_N_526 =

118.6944

e_CO2_N_447 =

123.1858

FC_N_745 =

11.8669

FC_N_667 =

11.7779

FC_N_526 =

11.6596

FC_N_447 =

12.1008

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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 9.02" length data processing

```
clc
% clear
% close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from the Excel Files'

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 4.47','B5:B12');
Display_ForceC_902 = xlsread('Drag Data A-Train Trailer','A-Train 9.02','K17:K24');
Display_ForceC_745 = xlsread('Drag Data A-Train Trailer','A-Train 7.45','K28:K35');
Display_ForceC_667 = xlsread('Drag Data A-Train Trailer','A-Train 6.67','K17:K24');
Display_ForceC_526 = xlsread('Drag Data A-Train Trailer','A-Train 5.26','K17:K24');
Display_ForceC_447 = xlsread('Drag Data A-Train Trailer','A-Train 4.47','K17:K24');
```

Applying the scaling factor to the drag forces

```

Scale_ForceC_902 = (Display_ForceC_902 - 0.0036) ./0.9944;
Scale_ForceC_745 = (Display_ForceC_745 - 0.0036) ./0.9944;
Scale_ForceC_667 = (Display_ForceC_667 - 0.0036) ./0.9944;
Scale_ForceC_526 = (Display_ForceC_526 - 0.0036) ./0.9944;
Scale_ForceC_447 = (Display_ForceC_447 - 0.0036) ./0.9944;

```

%% Defining the Relationship between Frequency Drive and Wind Velocity

```

m_Vel = 1.2081; % (m/s) / Hz
b_Vel = -1.0632; % m/s

for n = 1:length(Frequency)
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s
end

V_mph = 2.23694*V;

```

Calculating the Coefficient of Drag on the Trailer

Constants

```

rho = 1.225;          % kg/m^3
mu = 1.846e-5;       % kg/m*s
w = 0.0650;          % m (2.560 inches)
h = 0.0518;          % m (2.039 inches)
A = w*h;              % m^2

% Calculation
C_DragC_902 = (2*abs(Scale_ForceC_902)) ./ (rho*(V.^2)*A);
C_DragC_745 = (2*abs(Scale_ForceC_745)) ./ (rho*(V.^2)*A);
C_DragC_667 = (2*abs(Scale_ForceC_667)) ./ (rho*(V.^2)*A);
C_DragC_526 = (2*abs(Scale_ForceC_526)) ./ (rho*(V.^2)*A);
C_DragC_447 = (2*abs(Scale_ForceC_447)) ./ (rho*(V.^2)*A);

```

Determining the average Cd for each model

```

C_Drag_AvgC_902 = mean(C_DragC_902);
C_Drag_AvgC_745 = mean(C_DragC_745);
C_Drag_AvgC_667 = mean(C_DragC_667);
C_Drag_AvgC_526 = mean(C_DragC_526);
C_Drag_AvgC_447 = mean(C_DragC_447);

```

Percent Changes in Drag Coefficient w.r.t base model

```

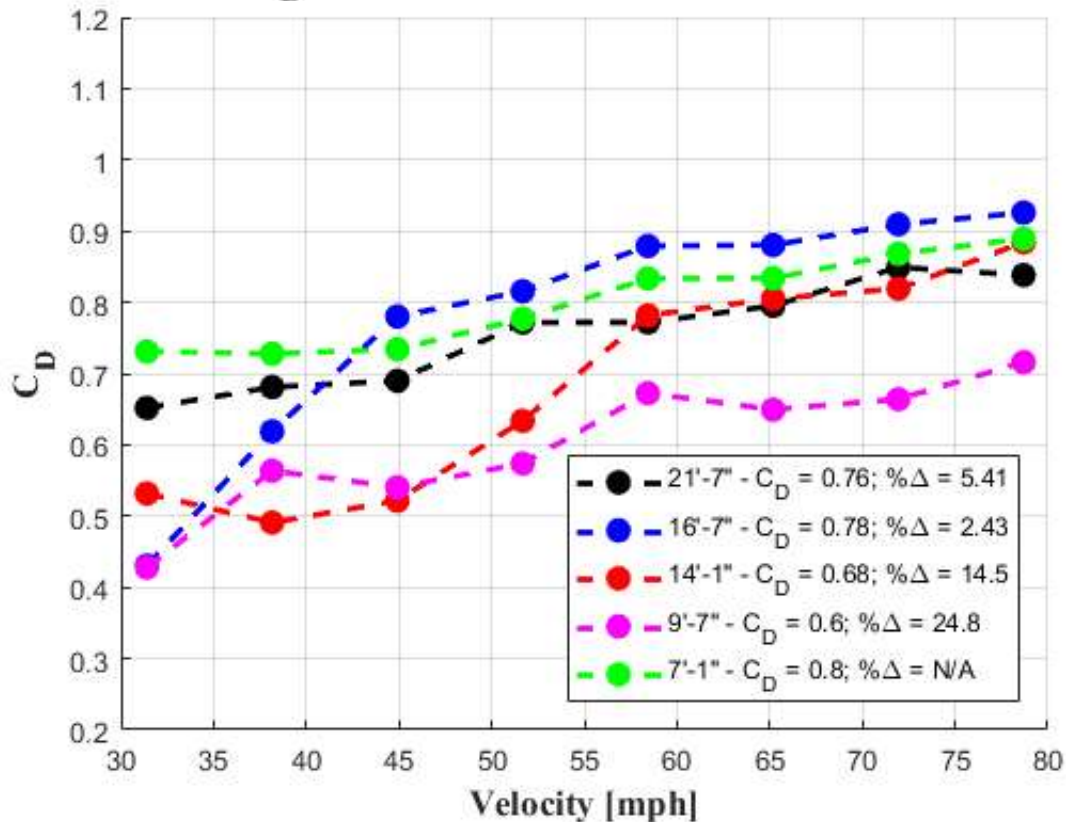
ChangeC_902 = (C_Drag_AvgC_447 - C_Drag_AvgC_902) / C_Drag_AvgC_447 * 100;
ChangeC_745 = (C_Drag_AvgC_447 - C_Drag_AvgC_745) / C_Drag_AvgC_447 * 100;
ChangeC_667 = (C_Drag_AvgC_447 - C_Drag_AvgC_667) / C_Drag_AvgC_447 * 100;
ChangeC_526 = (C_Drag_AvgC_447 - C_Drag_AvgC_526) / C_Drag_AvgC_447 * 100;

```

Plotting Results

```
figure(2)
set(gcf,'color','w')
plot(V_mph,C_DragC_902,'k.--','Linewidth',2,'MarkerSize',30)
hold on
plot(V_mph,C_DragC_745,'b.--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragC_667,'r.--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragC_526,'m.--','Linewidth',2,'MarkerSize',30)
plot(V_mph,C_DragC_447,'g.--','Linewidth',2,'MarkerSize',30)
title('C_{D} of A-Train Trailers Nose Cones','Fontname','Times',...
      'Fontweight','bold','FontSize',16)
xlabel('Velocity [mph]','Fontname','Times','Fontweight','bold','FontSize',13)
ylabel('C_{D}','Fontname','Times','Fontweight','bold','FontSize',13)
ylimlimits = [0.2 1.2];
ylim(ylimlimits)
legend('Location','southeast',['21'-7" - C_{D} = ',num2str(C_Drag_AvgC_902,2),...
      '; %{\Delta} = ',num2str(ChangeC_902,3)],['16'-7" - C_{D} = ',...
      num2str(C_Drag_AvgC_745,2),'; %{\Delta} = ',num2str(ChangeC_745,3)],...
      ['14'-1" - C_{D} = ',num2str(C_Drag_AvgC_667,2),'; %{\Delta} = ',...
      num2str(ChangeC_667,3)],['9'-7" - C_{D} = ',num2str(C_Drag_AvgC_526,2),...
      '; %{\Delta} = ',num2str(ChangeC_526,3)],['7'-1" - C_{D} = ',...
      num2str(C_Drag_AvgC_447,2),'; %{\Delta} = N/A'])
grid on
box off
```

C_D of A-Train Trailers Nose Cones



Emission Calculations


```

C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;           %Weight Reduction
h_48 = 1.99;        %m
w_48 = 2.49;        %m
A_ATrain = h_48*w_48; %m^2

e_CO2_C_745 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgC_902 - C_Drag_AvgC_745)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C_667 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgC_902 - C_Drag_AvgC_667)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C_526 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgC_902 - C_Drag_AvgC_526)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C_447 = (C1 + C2*TRRL + C3*(abs(C_Drag_AvgC_902 - C_Drag_AvgC_447)*A_ATrain)...
  + C4*WR)*C5 %gCO2/ton-mile

FC_C_745 = (e_CO2_C_745/10180)*1000 %gal_diesel/1000ton-mile
FC_C_667 = (e_CO2_C_667/10180)*1000 %gal_diesel/1000ton-mile
FC_C_526 = (e_CO2_C_526/10180)*1000 %gal_diesel/1000ton-mile
FC_C_447 = (e_CO2_C_447/10180)*1000 %gal_diesel/1000ton-mile

```

e_CO2_C_745 =

123.1764

e_CO2_C_667 =

120.8885

e_CO2_C_526 =

117.0134

e_CO2_C_447 =

122.2648

FC_C_745 =

12.0998

FC_C_667 =

11.8751

FC_C_526 =

11.4944

FC_C_447 =

12.0103

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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train Trends length data processing

```
clc
clear
close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Frequency

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 4.47','B5:B12');
```

%% Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz
b_Vel = -1.0632; % m/s

for n = 1:length(Frequency)
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s
end

V_mph = 2.23694*V;
```

Overall Trendlines for A-Train Trailers

```
yN = 0.0066*v_mph + 0.55;   %No Nose Cone
yC = 0.0043*v_mph + 0.52;   %Nose Cone
```

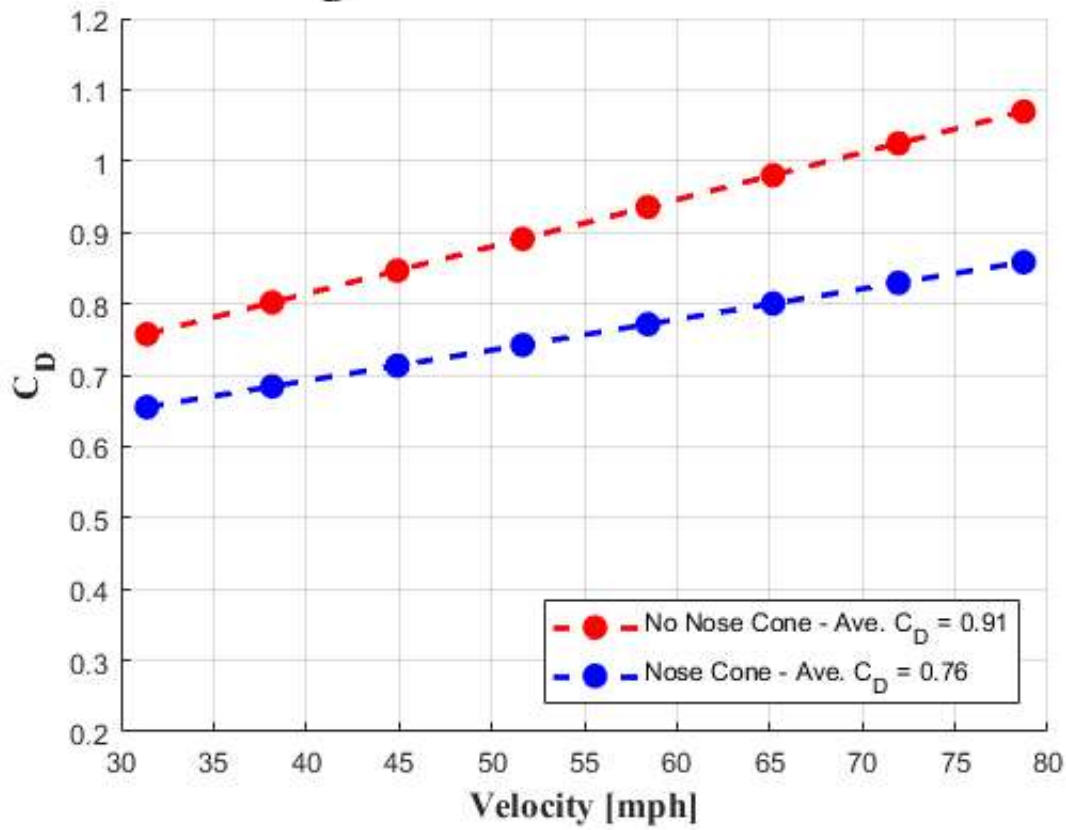
Average Drag Coefficient

```
C_Drag_AvgN = mean(yN);
C_Drag_AvgC = mean(yC);
```

Plotting

```
figure(1)
set(gcf, 'color', 'w')
plot(V_mph, yN, 'r.--', 'Linewidth', 2, 'MarkerSize', 30)
hold on
plot(V_mph, yC, 'b.--', 'Linewidth', 2, 'MarkerSize', 30)
title('C_{D} Trends of A-Train Trailers', 'Fontname', 'Times', ...
      'Fontweight', 'bold', 'FontSize', 16)
xlabel('Velocity [mph]', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylabel('C_{D}', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylimlimits = [0.2 1.2];
ylim(ylimlimits)
legend('Location', 'southeast', ['No Nose Cone - Ave. C_{D} = ', num2str(C_Drag_AvgN, 2)], ...
      ['Nose Cone - Ave. C_{D} = ', num2str(C_Drag_AvgC, 2)])
grid on
box off
```

C_D Trends of A-Train Trailers



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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 4.47" length data processing

```
clc
clear
% close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from .xlsx files

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 4.47','B5:B12');
Display_ForceN = xlsread('Drag Data A-Train Trailer','A-Train 4.47','E17:E24');
Display_ForceC = xlsread('Drag Data A-Train Trailer','A-Train 4.47','K17:K24');
```

Applying the scaling factor to the drag forces

```
Scale_ForceN = (Display_ForceN - 0.0036)./0.9944;  
Scale_ForceC = (Display_ForceC - 0.0036)./0.9944;
```

Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz  
b_Vel = -1.0632; % m/s  
  
for n = 1:length(Frequency)  
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s  
end  
  
V_mph = 2.23694*V;
```

Calculating the Coefficient of Drag on the Trailer

Constants

```
rho = 1.225; % kg/m^3  
mu = 1.846e-5; % kg/m*s  
w = 0.0650; % m (2.560 inches)  
h = 0.0518; % m (2.039 inches)  
A = w*h; % m^2  
  
% Calculation  
C_DragN = (2*abs(Scale_ForceN))./(rho*(V.^2)*A);  
C_DragC = (2*abs(Scale_ForceC))./(rho*(V.^2)*A);
```

Determining the average Cd for each model

```
C_Drag_AvgN = mean(C_DragN);  
C_Drag_AvgC = mean(C_DragC);
```

Percent Changes in Drag Coefficient w.r.t base model

```
ChangeC = (abs(C_Drag_AvgN - C_Drag_AvgC)/C_Drag_AvgN)*100;
```

Uncertainty Analysis

```
U_FD = 0.00454; % N  
U_V = 1; % m/s  
U_rho = 0.0001; % kg/m^3  
U_A = 0.00001; % m^2  
CD_FD = 1/((1/2)*rho*A*V.^2);  
  
%No Nose Cone  
CD_rho_N = (-Scale_ForceN)./((1/2)*rho^2*A*V.^2);  
CD_A_N = (-Scale_ForceN)./((1/2)*rho*A^2*V.^2);  
CD_V_N = (-2*Scale_ForceN)./((1/2)*rho*A*V.^3);
```

```

U_CD_N = ((CD_FD*U_FD).^2 + (CD_rho_N*U_rho).^2 + (CD_A_N*U_A).^2 + (CD_V_N*U_V).^2).^(1/2);

%Nose Cone
CD_rho_C = (-Scale_ForceC)/((1/2)*rho^2*A*V.^2);
CD_A_C = (-Scale_ForceC)/((1/2)*rho*A^2*V.^2);
CD_V_C = (-2*Scale_ForceC)/((1/2)*rho*A*V.^3);
U_CD_C = ((CD_FD*U_FD).^2 + (CD_rho_C*U_rho).^2 + (CD_A_C*U_A).^2 + (CD_V_C*U_V).^2).^(1/2);

```

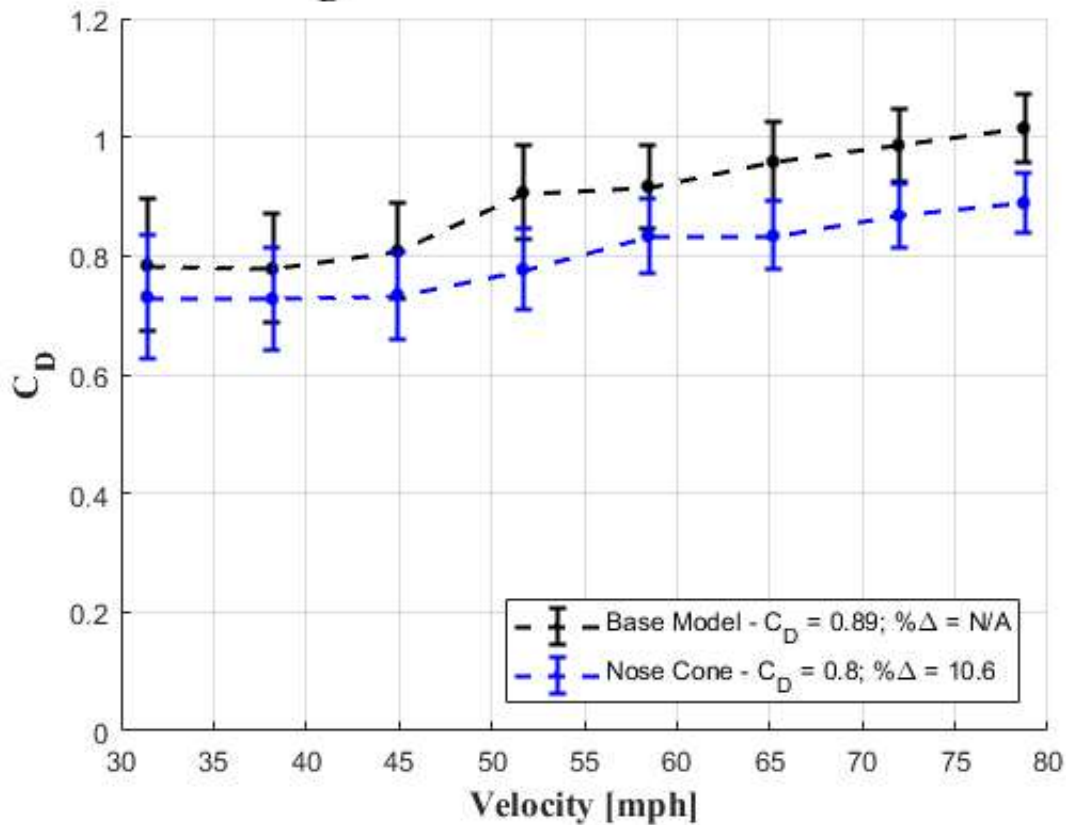
Plotting Results

```

figure(1)
set(gcf,'color','w')
% plot(V_mph,C_DragN,'k.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragN,U_CD_N(:,1),'k.--','Linewidth',1.5,'MarkerSize',15)
hold on
% plot(V_mph,C_DragC,'b.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragC,U_CD_C(:,1),'b.--','Linewidth',1.5,'MarkerSize',15)
title('C_{D} of A-Train Trailers at 7''-1"', 'Fontname', 'Times', ...
      'Fontweight', 'bold', 'FontSize', 16)
xlabel('Velocity [mph]', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylabel('C_{D}', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylimits = [0 1.2];
ylim(ylimits)
legend('Location', 'southeast', ['Base Model - C_{D} = ', num2str(C_Drag_AvgN, 2), ...
    '; %{\Delta} = N/A'], ['Nose Cone - C_{D} = ', num2str(C_Drag_AvgC, 2), ...
    '; %{\Delta} = ', num2str(ChangeC, 3)])
grid on
box off

```


C_D of A-Train Trailers at 7'-1"



Emission Calculations

```

CD_902NNC = 0.9179;
C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;           %Weight Reduction
h_48 = 1.99;        %m
w_48 = 2.49;        %m
A_ATrain = h_48*w_48; %m^2

e_CO2_N = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgN)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgC)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile

FC_N = (e_CO2_N/10180)*1000 %gal_diesel/1000ton-mile
FC_C = (e_CO2_C/10180)*1000 %gal_diesel/1000ton-mile
    
```

e_CO2_N =

123.1866

e_CO2_C =

118.7304

FC_N =

12.1008

FC_C =

11.6631

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- B: Bull Nose
- Reading Data from .xlsx files
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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 5.26" length data processing

```
clc
clear
close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from .xlsx files

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 5.26','B5:B12');
Display_ForceN = xlsread('Drag Data A-Train Trailer','A-Train 5.26','E17:E24');
Display_ForceC = xlsread('Drag Data A-Train Trailer','A-Train 5.26','K17:K24');
```

Applying the scaling factor to the drag forces

```
Scale_ForceN = (Display_ForceN - 0.0036)./0.9944;  
Scale_ForceC = (Display_ForceC - 0.0036)./0.9944;
```

Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz  
b_Vel = -1.0632; % m/s  
  
for n = 1:length(Frequency)  
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s  
end  
  
V_mph = 2.23694*V;
```

Calculating the Coefficient of Drag on the Trailer

Constants

```
rho = 1.225; % kg/m^3  
mu = 1.846e-5; % kg/m*s  
w = 0.0650; % m (2.560 inches)  
h = 0.0518; % m (2.039 inches)  
A = w*h; % m^2  
  
% Calculation  
C_DragN = (2*abs(Scale_ForceN))./(rho*(V.^2)*A);  
C_DragC = (2*abs(Scale_ForceC))./(rho*(V.^2)*A);
```

Determining the average Cd for each model

```
C_Drag_AvgN = mean(C_DragN);  
C_Drag_AvgC = mean(C_DragC);
```

Percent Changes in Drag Coefficient w.r.t base model

```
ChangeC = (abs(C_Drag_AvgN - C_Drag_AvgC)/C_Drag_AvgN)*100;
```

Uncertainty Analysis

```
U_FD = 0.00454; % N  
U_V = 1; % m/s  
U_rho = 0.0001; % kg/m^3  
U_A = 0.00001; % m^2  
CD_FD = 1/((1/2)*rho*A*V.^2);  
  
%No Nose Cone  
CD_rho_N = (-Scale_ForceN)./((1/2)*rho^2*A*V.^2);  
CD_A_N = (-Scale_ForceN)./((1/2)*rho*A^2*V.^2);  
CD_V_N = (-2*Scale_ForceN)./((1/2)*rho*A*V.^3);
```

```

U_CD_N = ((CD_FD*U_FD).^2 + (CD_rho_N*U_rho).^2 + (CD_A_N*U_A).^2 + (CD_V_N*U_V).^2).^(1/2);

%Nose Cone
CD_rho_C = (-Scale_ForceC)/((1/2)*rho^2*A*V.^2);
CD_A_C = (-Scale_ForceC)/((1/2)*rho*A^2*V.^2);
CD_V_C = (-2*Scale_ForceC)/((1/2)*rho*A*V.^3);
U_CD_C = ((CD_FD*U_FD).^2 + (CD_rho_C*U_rho).^2 + (CD_A_C*U_A).^2 + (CD_V_C*U_V).^2).^(1/2);

```

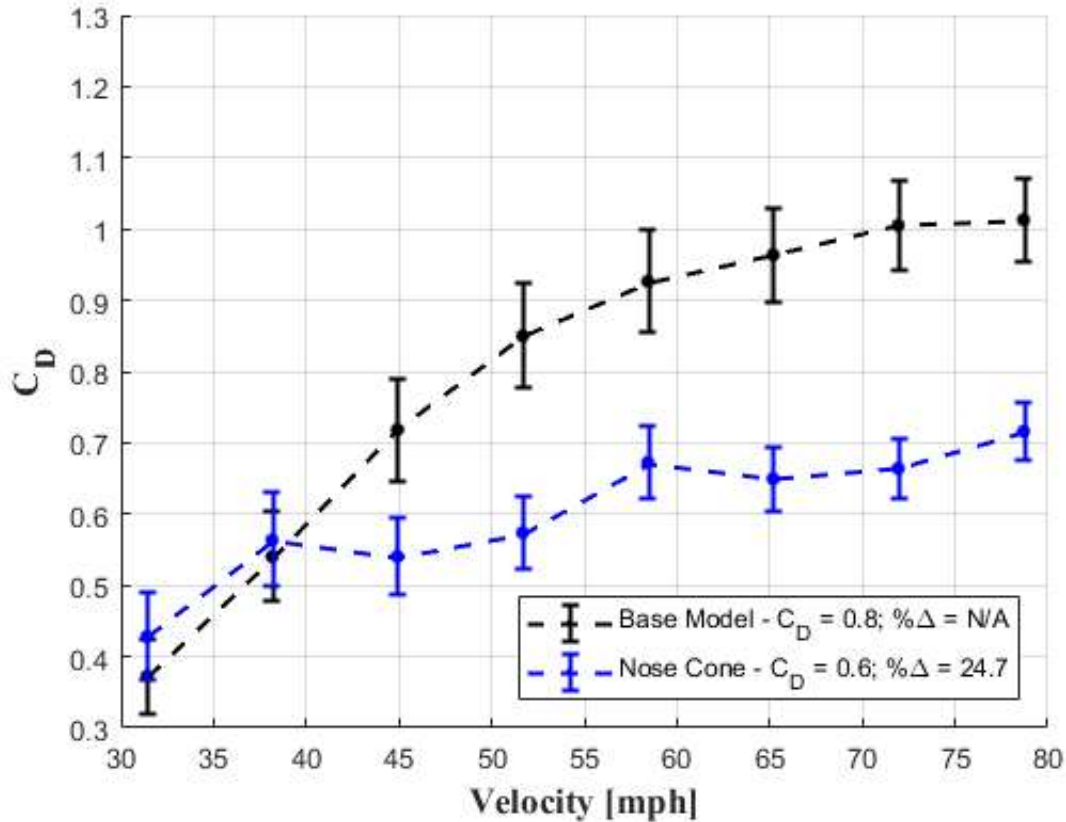
Plotting Results

```

figure(1)
set(gcf,'color','w')
% plot(V_mph,C_DragN,'k.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragN,U_CD_N(:,1),'k.--','Linewidth',1.5,'MarkerSize',15)
hold on
% plot(V_mph,C_DragC,'b.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragC,U_CD_C(:,1),'b.--','Linewidth',1.5,'MarkerSize',15)
title('C_{D} of A-Train Trailers at 91-7','Fontname','Times',...
      'Fontweight','bold','FontSize',16)
xlabel('Velocity [mph]','Fontname','Times','Fontweight','bold','FontSize',13)
ylabel('C_{D}','Fontname','Times','Fontweight','bold','FontSize',13)
ylimits = [0.3 1.3];
ylim(ylimits)
legend('Location','southeast',['Base Model - C_{D} = ',num2str(C_Drag_AvgN,2),...
      '; %{\Delta} = N/A'], ['Nose Cone - C_{D} = ',num2str(C_Drag_AvgC,2),...
      '; %{\Delta} = ',num2str(ChangeC,3)])
grid on
box off

```

C_D of A-Train Trailers at 9'-7"



Emission Calculations

```

CD_902NNC = 0.9179;
C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;          %Weight Reduction
h_48 = 1.99;       %m
w_48 = 2.49;       %m
A_ATrain = h_48*w_48; %m^2

e_CO2_N = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgN)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgC)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile

FC_N = (e_CO2_N/10180)*1000 %gal_diesel/1000ton-mile
FC_C = (e_CO2_C/10180)*1000 %gal_diesel/1000ton-mile
    
```

e_CO2_N =

118.6952

e_CO2_C =

109.4124

FC_N =

11.6597

FC_C =

10.7478

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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 6.67" length data processing

```
clc
clear
close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from .xlsx files

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 6.67','B5:B12');
Display_ForceN = xlsread('Drag Data A-Train Trailer','A-Train 6.67','E17:E24');
Display_ForceC = xlsread('Drag Data A-Train Trailer','A-Train 6.67','K17:K24');
```

Applying the scaling factor to the drag forces

```
Scale_ForceN = (Display_ForceN - 0.0036)./0.9944;  
Scale_ForceC = (Display_ForceC - 0.0036)./0.9944;
```

Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz  
b_Vel = -1.0632; % m/s  
  
for n = 1:length(Frequency)  
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s  
end  
  
V_mph = 2.23694*V;
```

Calculating the Coefficient of Drag on the Trailer

Constants

```
rho = 1.225; % kg/m^3  
mu = 1.846e-5; % kg/m*s  
w = 0.0650; % m (2.560 inches)  
h = 0.0518; % m (2.039 inches)  
A = w*h; % m^2  
  
% Calculation  
C_DragN = (2*abs(Scale_ForceN))./(rho*(V.^2)*A);  
C_DragC = (2*abs(Scale_ForceC))./(rho*(V.^2)*A);
```

Determining the average Cd for each model

```
C_Drag_AvgN = mean(C_DragN);  
C_Drag_AvgC = mean(C_DragC);
```

Percent Changes in Drag Coefficient w.r.t base model

```
ChangeC = (abs(C_Drag_AvgN - C_Drag_AvgC)/C_Drag_AvgN)*100;
```

Uncertainty Analysis

```
U_FD = 0.00454; % N  
U_V = 1; % m/s  
U_rho = 0.0001; % kg/m^3  
U_A = 0.00001; % m^2  
CD_FD = 1/((1/2)*rho*A*V.^2);  
  
%No Nose Cone  
CD_rho_N = (-Scale_ForceN)./((1/2)*rho^2*A*V.^2);  
CD_A_N = (-Scale_ForceN)./((1/2)*rho*A^2*V.^2);  
CD_V_N = (-2*Scale_ForceN)./((1/2)*rho*A*V.^3);
```

```

U_CD_N = ((CD_FD*U_FD).^2 + (CD_rho_N*U_rho).^2 + (CD_A_N*U_A).^2 + (CD_V_N*U_V).^2).^(1/2);

%Nose Cone
CD_rho_C = (-Scale_ForceC)/((1/2)*rho^2*A*V.^2);
CD_A_C = (-Scale_ForceC)/((1/2)*rho*A^2*V.^2);
CD_V_C = (-2*Scale_ForceC)/((1/2)*rho*A*V.^3);
U_CD_C = ((CD_FD*U_FD).^2 + (CD_rho_C*U_rho).^2 + (CD_A_C*U_A).^2 + (CD_V_C*U_V).^2).^(1/2);

```

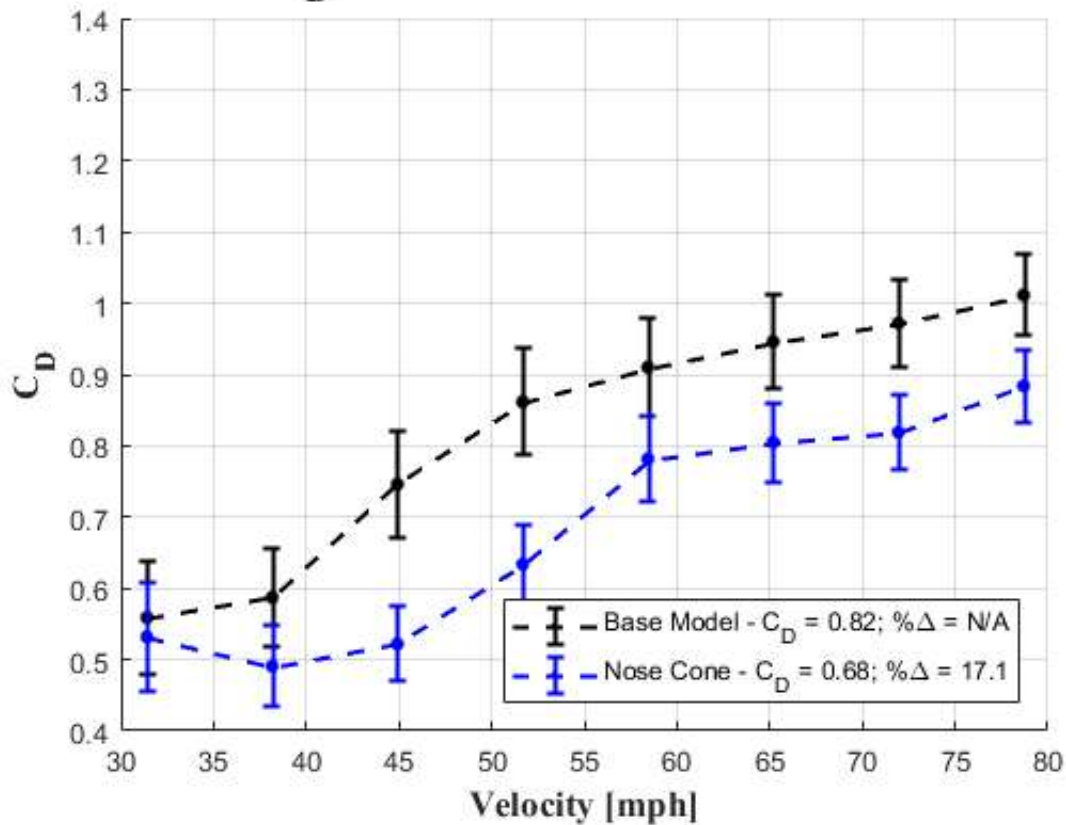
Plotting Results

```

figure(1)
set(gcf,'color','w')
% plot(V_mph,C_DragN,'k.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragN,U_CD_N(:,1),'k.--','Linewidth',1.5,'MarkerSize',15)
hold on
% plot(V_mph,C_DragC,'b.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragC,U_CD_C(:,1),'b.--','Linewidth',1.5,'MarkerSize',15)
title('C_{D} of A-Train Trailers at 14''-1"', 'Fontname', 'Times', ...
      'Fontweight', 'bold', 'FontSize', 16)
xlabel('Velocity [mph]', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylabel('C_{D}', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylimits = [0.4 1.4];
ylim(ylimits)
legend('Location', 'southeast', ['Base Model - C_{D} = ', num2str(C_Drag_AvgN, 2), ...
    '; %{\Delta} = N/A'], ['Nose Cone - C_{D} = ', num2str(C_Drag_AvgC, 2), ...
    '; %{\Delta} = ', num2str(ChangeC, 3)])
grid on
box off

```

C_D of A-Train Trailers at 14'-1"



Emission Calculations

```

CD_902NNC = 0.9179;
C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;          %Weight Reduction
h_48 = 1.99;       %m
w_48 = 2.49;       %m
A_ATrain = h_48*w_48; %m^2

e_CO2_N = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgN)*A_ATrain) ...
          + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgC)*A_ATrain) ...
          + C4*WR)*C5 %gCO2/ton-mile

FC_N = (e_CO2_N/10180)*1000 %gal_diesel/1000ton-mile
FC_C = (e_CO2_C/10180)*1000 %gal_diesel/1000ton-mile
    
```

e_CO2_N =

119.8996

e_CO2_C =

113.2875

FC_N =

11.7780

FC_C =

11.1284

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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 7.45" length data processing

```
clc
clear
close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from .xlsx files

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 7.45','B5:B12');
Display_ForceN = xlsread('Drag Data A-Train Trailer','A-Train 7.45','E28:E35');
Display_ForceC = xlsread('Drag Data A-Train Trailer','A-Train 7.45','K28:K35');
```

Applying the scaling factor to the drag forces

```
Scale_ForceN = (Display_ForceN - 0.0036)./0.9944;  
Scale_ForceC = (Display_ForceC - 0.0036)./0.9944;
```

Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz  
b_Vel = -1.0632; % m/s  
  
for n = 1:length(Frequency)  
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s  
end  
  
V_mph = 2.23694*V;
```

Calculating the Coefficient of Drag on the Trailer

Constants

```
rho = 1.225; % kg/m^3  
mu = 1.846e-5; % kg/m*s  
w = 0.0650; % m (2.560 inches)  
h = 0.0518; % m (2.039 inches)  
A = w*h; % m^2  
  
% Calculation  
C_DragN = (2*abs(Scale_ForceN))./(rho*(V.^2)*A);  
C_DragC = (2*abs(Scale_ForceC))./(rho*(V.^2)*A);
```

Determining the average Cd for each model

```
C_Drag_AvgN = mean(C_DragN);  
C_Drag_AvgC = mean(C_DragC);
```

Percent Changes in Drag Coefficient w.r.t base model

```
ChangeC = (C_Drag_AvgN - C_Drag_AvgC)/C_Drag_AvgN*100;
```

Uncertainty Analysis

```
U_FD = 0.00454; % N  
U_V = 1; % m/s  
U_rho = 0.0001; % kg/m^3  
U_A = 0.00001; % m^2  
CD_FD = 1/((1/2)*rho*A*V.^2);  
  
%No Nose Cone  
CD_rho_N = (-Scale_ForceN)./((1/2)*rho^2*A*V.^2);  
CD_A_N = (-Scale_ForceN)./((1/2)*rho*A^2*V.^2);  
CD_V_N = (-2*Scale_ForceN)./((1/2)*rho*A*V.^3);
```

```

U_CD_N = ((CD_FD*U_FD).^2 + (CD_rho_N*U_rho).^2 + (CD_A_N*U_A).^2 + (CD_V_N*U_V).^2).^(1/2);

%Nose Cone
CD_rho_C = (-Scale_ForceC)/((1/2)*rho^2*A*V.^2);
CD_A_C = (-Scale_ForceC)/((1/2)*rho*A^2*V.^2);
CD_V_C = (-2*Scale_ForceC)/((1/2)*rho*A*V.^3);
U_CD_C = ((CD_FD*U_FD).^2 + (CD_rho_C*U_rho).^2 + (CD_A_C*U_A).^2 + (CD_V_C*U_V).^2).^(1/2);

```

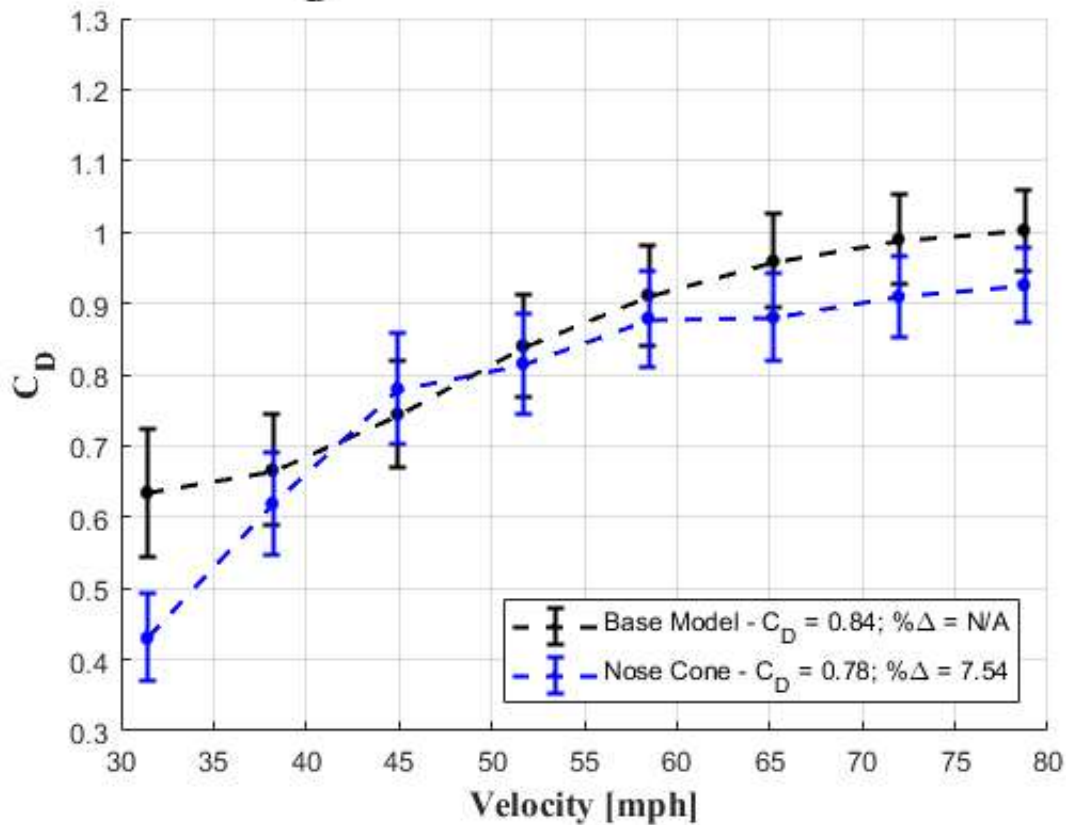
Plotting Results

```

figure(1)
set(gcf,'color','w')
% plot(V_mph,C_DragN,'k.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragN,U_CD_N(:,1),'k.--','Linewidth',1.5,'MarkerSize',15)
hold on
% plot(V_mph,C_DragC,'b.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragC,U_CD_C(:,1),'b.--','Linewidth',1.5,'MarkerSize',15)
title('C_{D} of A-Train Trailers at 16'-7'', 'Fontname','Times',...
      'Fontweight','bold','FontSize',16)
xlabel('Velocity [mph]', 'Fontname','Times','Fontweight','bold','FontSize',13)
ylabel('C_{D}', 'Fontname','Times','Fontweight','bold','FontSize',13)
ylimits = [0.3 1.3];
ylim(ylimits)
legend('Location','southeast',['Base Model - C_{D} = ',num2str(C_Drag_AvgN,2),...
    '; %{\Delta} = N/A'], ['Nose Cone - C_{D} = ',num2str(C_Drag_AvgC,2),...
    '; %{\Delta} = ',num2str(ChangeC,3)])
grid on
box off

```

C_D of A-Train Trailers at 16'-7"



Emission Calculations

```

CD_902NNC = 0.9179;
C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;          %Weight Reduction
h_48 = 1.99;       %m
w_48 = 2.49;       %m
A_ATrain = h_48*w_48; %m^2

e_CO2_N = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgN)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgC)*A_ATrain) ...
           + C4*WR)*C5 %gCO2/ton-mile

FC_N = (e_CO2_N/10180)*1000 %gal_diesel/1000ton-mile
FC_C = (e_CO2_C/10180)*1000 %gal_diesel/1000ton-mile
    
```

e_CO2_N =

120.8064

e_CO2_C =

117.8188

FC_N =

11.8670

FC_C =

11.5736

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Trailer Park Boys

Senior Capstone Design - Western Trailer

Dr. Beyerlein

A-Train 9.02" length data processing

```
clc
clear
% close all
```

Note - N: No Nose Cone

C: Nose Cone

B: Bull Nose

Reading Data from .xlsx files

```
Frequency = xlsread('Drag Data A-Train Trailer','A-Train 9.02','B5:B12');
Display_ForceN = xlsread('Drag Data A-Train Trailer','A-Train 9.02','E17:E24');
Display_ForceC = xlsread('Drag Data A-Train Trailer','A-Train 9.02','K17:K24');
```

Applying the scaling factor to the drag forces

```
Scale_ForceN = (Display_ForceN - 0.0036)./0.9944;  
Scale_ForceC = (Display_ForceC - 0.0036)./0.9944;
```

Defining the Relationship between Frequency Drive and Wind Velocity

```
m_Vel = 1.2081; % (m/s) / Hz  
b_Vel = -1.0632; % m/s  
  
for n = 1:length(Frequency)  
    V(n,1) = m_Vel*Frequency(n,1) + b_Vel; % m/s  
end  
  
V_mph = 2.23694*V;
```

Calculating the Coefficient of Drag on the Trailer

Constants

```
rho = 1.225; % kg/m^3  
mu = 1.846e-5; % kg/m*s  
w = 0.0650; % m (2.560 inches)  
h = 0.0518; % m (2.039 inches)  
A = w*h; % m^2  
  
% Calculation  
C_DragN = (2*abs(Scale_ForceN))./(rho*(V.^2)*A);  
C_DragC = (2*abs(Scale_ForceC))./(rho*(V.^2)*A);
```

Determining the average Cd for each model

```
C_Drag_AvgN = mean(C_DragN);  
C_Drag_AvgC = mean(C_DragC);
```

Percent Changes in Drag Coefficient w.r.t base model

```
ChangeC = (C_Drag_AvgN - C_Drag_AvgC)/C_Drag_AvgN*100;
```

Uncertainty Analysis

```
U_FD = 0.00454; % N  
U_V = 1; % m/s  
U_rho = 0.0001; % kg/m^3  
U_A = 0.00001; % m^2  
CD_FD = 1/((1/2)*rho*A*V.^2);  
  
%No Nose Cone  
CD_rho_N = (-Scale_ForceN)./((1/2)*rho^2*A*V.^2);  
CD_A_N = (-Scale_ForceN)./((1/2)*rho*A^2*V.^2);  
CD_V_N = (-2*Scale_ForceN)./((1/2)*rho*A*V.^3);
```

```

U_CD_N = ((CD_FD*U_FD).^2 + (CD_rho_N*U_rho).^2 + (CD_A_N*U_A).^2 + (CD_V_N*U_V).^2).^(1/2);

%Nose Cone
CD_rho_C = (-Scale_ForceC)/((1/2)*rho^2*A*V.^2);
CD_A_C = (-Scale_ForceC)/((1/2)*rho*A^2*V.^2);
CD_V_C = (-2*Scale_ForceC)/((1/2)*rho*A*V.^3);
U_CD_C = ((CD_FD*U_FD).^2 + (CD_rho_C*U_rho).^2 + (CD_A_C*U_A).^2 + (CD_V_C*U_V).^2).^(1/2);

```

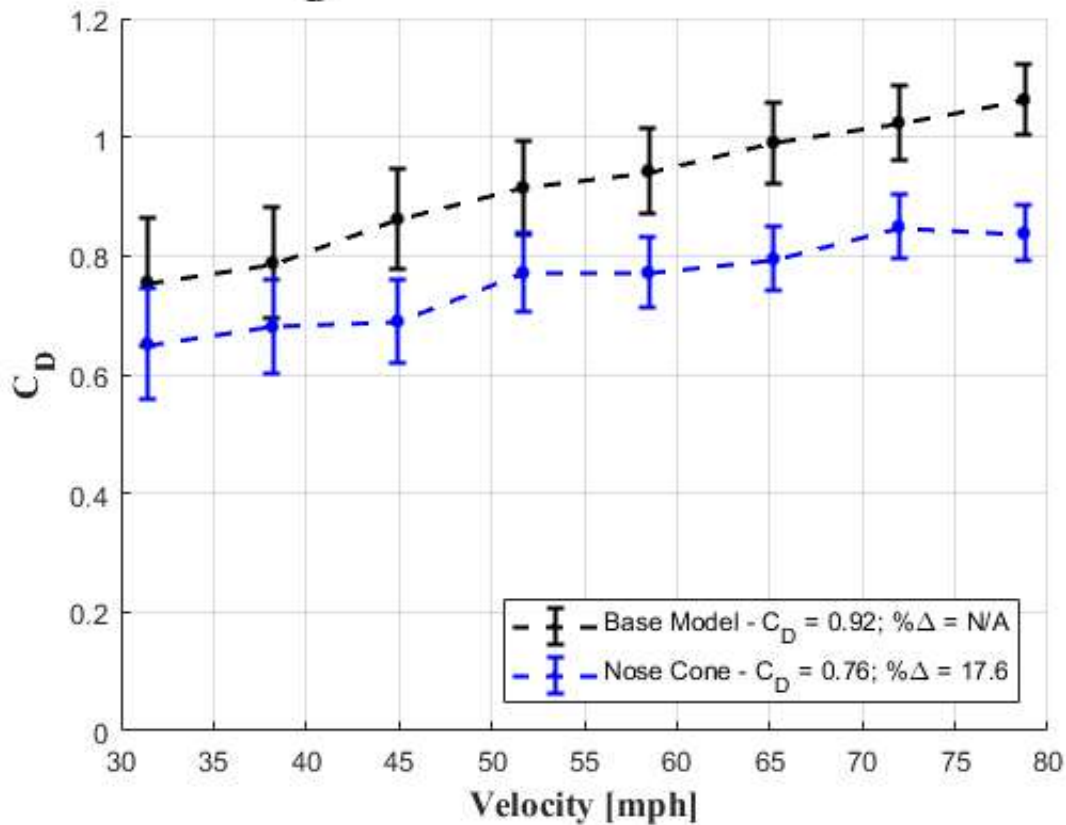
Plotting Results

```

figure(2)
set(gcf,'color','w')
% plot(V_mph,C_DragN,'k.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragN,U_CD_N(:,1),'k.--','Linewidth',1.5,'MarkerSize',15)
hold on
% plot(V_mph,C_DragC,'b.--','Linewidth',2,'MarkerSize',30)
errorbar(V_mph,C_DragC,U_CD_C(:,1),'b.--','Linewidth',1.5,'MarkerSize',15)
title('C_{D} of A-Train Trailers at 21'-7"', 'Fontname', 'Times', ...
      'Fontweight', 'bold', 'FontSize', 16)
xlabel('Velocity [mph]', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylabel('C_{D}', 'Fontname', 'Times', 'Fontweight', 'bold', 'FontSize', 13)
ylimits = [0 1.2];
ylim(ylimits)
legend('Location', 'southeast', ['Base Model - C_{D} = ', num2str(C_Drag_AvgN, 2), ...
    '; %{\Delta} = N/A'], ['Nose Cone - C_{D} = ', num2str(C_Drag_AvgC, 2), ...
    '; %{\Delta} = ', num2str(ChangeC, 3)])
grid on
box off

```

C_D of A-Train Trailers at 21'-7"



Emission Calculations

```

CD_902NNC = 0.9179;
C1 = 117.8;
C2 = 1.78;
C3 = -9.48;
C4 = -0.00258;
C5 = 1.00;           %Tire Inflation System
TRRL = 4.6;         %Tire Rolling Resistance Level
WR = 655;           %Weight Reduction
h_48 = 1.99;        %m
w_48 = 2.49;        %m
A_ATrain = h_48*w_48; %m^2

% e_CO2_N = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgN)*A_ATrain)...
%           + C4*WR)*C5 %gCO2/ton-mile
e_CO2_C = (C1 + C2*TRRL + C3*(abs(CD_902NNC - C_Drag_AvgC)*A_ATrain)...
           + C4*WR)*C5 %gCO2/ton-mile

% FC_N = (e_CO2_N/10180)*1000 %gal_diesel/1000ton-mile
FC_C = (e_CO2_C/10180)*1000 %gal_diesel/1000ton-mile
    
```

e_CO2_C =

116.6971

FC_C =

11.4634

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