Appendix C

Matlab Codes

C1: S-N Data and Curve-Fit of Aluminum 1100

C2: S-N Data and Curve-Fit of Aluminum 3003-0

C3: S-N Data and Curve-Fit of Aluminum 6061-T6

C4: S-N Data and Curve-Fit of Nickel 200

C5: 2-D Vertical Piping Span Shear and Moment Evaluation

C1: Aluminum 1100

```
clear all;
close all;

% SN curve of AL 1100 using NASA D-1574 technical document

N=[5
   11
   27
   73
   282
   784
   2120
   6320
   12800
   104000
   205000
   417000
   1000000];

% longitudinal elastic strain range
del_el=[0.0042
   0.0042
   0.0036
   0.003
   0.0024
   0.0021
   0.0018
   0.0018
   0.0017
   0.0015
   0.0015
   0.0015
   0.0014];

logn=[0.699
1.041
1.431
1.863
2.450
2.894
3.326
3.801
4.107
5.017
```

```
5.312
5.620
6.000];

Slog2=[4.3
4.3
4.3
4.2
4.1
4.0
4.0
4.0
3.9
3.9
3.9
3.9
3.8];

Sa=[21210.0
21210.0
18180.0
15150.0
12120.0
10605.0
9090.0
9090.0
8585.0
7575.0
7575.0
7575.0
7070.0];

% old best fit data curve
S_old_Best=[2480351.494
1672254.94
1067377.364
649142.874
330279.5897
198086.3107
120463.2437
69772.20755
49029.18102
17205.16424
12256.61799
8595.800321
5553.28874];
figure;
```

```
loglog(N,Sa,'o')
hold on;grid;
loglog(N, S_old_Best)
xlabel('Number of Cycles, N')
ylabel('Allowable Stress,      , in ksi')
title('Allowable Stress vs. Cycles Using of Criteria
Document Best-Fit Curve on AL 1100')
legend('Sa of AL 1100, Tension-Compression Strain-Based
Data', 'Criteria Document Best-Fit Equation Curve Fit of AL
1100')
axis([0 10e6 10e2 10e6])

figure;
Sbest=[19538.8
18143.0
16674.5
15186.1
13374.5
12148.8
11064.3
9984.6
9343.8
7673.6
7199.4
6734.5
6203.0];

Sm=[19538.8
18143.0
16674.5
15186.1
13374.5
12148.8
11064.3
9984.6
9343.8
7673.6
6921.9
6110.8
5288.4];

loglog(N,Sa,'o')
hold on;
grid
loglog(N, Sbest,'k');
hold on;
loglog(N,Sm,'r')
```

```
hold on;
loglog(N,Sm/2,'m')
hold on;
loglog(N/20,Sm,'g')

legend('Sa of AL 1100, TC Strain-based', 'First order,
curve fit', 'ASME Mean stress Adjustment', 'Mean stress
adjustment, Sm/2', 'N/20');
axis([0 10e7 10e2 10e4])
xlabel('Number of Cycles');ylabel('Sa, Stress Amplitude,
ksi');
title('1st order fit Aluminum 1100 using NASA D-1574')

figure;

Slog1=[4.3
4.3
4.3
4.2
4.1
4.0
4.0
4.0
3.9
3.9
3.9
3.9
3.8];

Sres1=[4.29089682
4.258709088
4.222051806
4.181447651
4.126276584
4.08453429
4.043924429
3.999332595
3.970522263
3.884998866
3.857295137
3.828307211
3.7926];

logfit1=[4.29089682
4.258709088
4.222051806
4.181447651
```

```
4.126276584
4.08453429
4.043924429
3.999332595
3.970522263
3.884998866
3.857295137
3.828307211
3.7926];

subplot(2,1,1);plot(logn, Slog2,'o',logn, logfit1)
legend('Plot of Log(S) vs Log(N)', '3rd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')


residual1=Slog1-Sres1;
subplot(2,1,2);plot(residual1, 'o');
title('Residuals of Log(S) and Log(N) vs. 1st Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

text(7, 0.050, 'STN =83.89')
STN=83.89742621 % taken from excel-> max of
log(s)/STEYX(array)

% second order fit



Sfit2=[4.440485373
4.472571691
4.559381255
4.718024646
5.038831882
5.362131928
5.743274802
6.237466804
6.598881738
7.866508453
8.339613447
8.867382627
9.5635];
```

```
residual2=Slog2-Sfit2;
figure;

logfit2=[4.440485373
4.472571691
4.559381255
4.718024646
5.038831882
5.362131928
5.743274802
6.237466804
6.598881738
7.866508453
8.339613447
8.867382627
9.5635];

subplot(2,1,1);plot(logn, Slog2,'o',logn, logfit2)
legend('Plot of Log(S) vs Log(N)', '3rd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')


subplot(2,1,2);plot(residual2,'o');
title('Residuals of Log(S) and Log(N) vs. 2nd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(2, -2, 'STN =46.75')
STN=46.75016666; % taken from excel-> max of
log(s)/STEYX(array)

figure;
Sbest2=[23072.7
19988.8
17173.2
14725.3
12241.7
10844.4
9787.2
8898.3
8449.0
7576.7
7419.9
7314.3
```

```
7262.7]

Sm2=[23072.65736
19988.81703
17173.19032
14725.30397
12241.72231
10844.38075
9787.152976
8898.308831
8448.986539
7576.727817
7341.570088
7137.53072
7040.015346]


loglog(N,Sa,'o')
hold on;
grid

loglog(N,Sbest2);
hold on;

loglog(N,Sm2,'r')
hold on;

loglog(N,Sm2/2,'m')

hold on;
loglog(N/20,Sm2,'g')

legend('Sa of AL 1100, TC Strain-based', 'Second order,
curve fit', 'ASME Mean stress Adjustment', 'Mean stress
adjustment, Sm2/2', 'N/20');
axis([0 10e7 10e2 10e4])
xlabel('Number of Cycles');ylabel('Sa, Stress Amplitude,
ksi');
title('2nd Order Fit of Aluminum 1100 using NASA D-1574')

%3rd order fit

residual3=[-0.032
0.026
0.022
0.008
-0.008
```

```
-0.011
-0.031
0.013
0.012
0.008
0.016
0.021
-0.009];

figure;
subplot(2,1,1);

logfit3=[4.358
4.300
4.237
4.172
4.091
4.037
3.990
3.946
3.921
3.872
3.863
3.858
3.859];


plot(logn, Slog2,'o',logn, logfit3)
legend('Plot of Log(S) vs Log(N)', '3rd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 3rd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')


subplot(2,1,2);plot(residual3,'o');
title('Residuals of Log(S) and Log(N) vs. 3rd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(2, 0, 'STN =216.32')
STN=216.324208; % taken from excel-> max of
log(s)/STEYX(array)

figure;
Sbest3=[22821.54
19967.26
```

```
17273.97
14858.92
12334.28
10880.51
9766.07
8822.51
8345.73
7443.69
7298.27
7218.53
7222.71];

Sm3=[22821.54
19967.26
17273.97
14858.92
12334.28
10880.51
9766.07
8822.51
8345.73
7388.21
7107.10
6957.42
6965.19];

loglog(N,Sa,'o')
hold on;
grid
loglog(N,Sbest3);
hold on;
loglog(N,Sm3,'r')
hold on;
loglog(N,Sm3/2,'m')
hold on;
loglog(N/20,Sm3,'g')

legend('Sa of AL 1100, TC Strain-based', 'Third order,
curve fit', 'ASME Mean stress Adjustment', 'Mean stress
adjustment, Sm2/2', 'N/20');
axis([0 10e7 10e2 10e4])
xlabel('Number of Cycles');ylabel('Sa, Stress Amplitude,
ksi');
title('3rd Order Fit of Aluminum 1100 using NASA D-1574')
figure
loglog(N,Sa,'o')
hold on;
```

```
grid
loglog(N,Sbest3);
hold on;
legend('Sa of AL 1100, Tension-Compression Strain-Based
Data', 'Least Squares to the Logarithms Curve Fit of AL
1100');
axis([0 10e6 10e2 10e4])
xlabel('Number of Cycles');ylabel('Allowable Stress,    ,
in ksi');
title('Allowable Stress vs. Cycles Using Least Squares to
the Logarithms Curve Fit on AL 1100')
```

C2: Aluminum 3003-0

```
clear all,
close all;

% test case verification of curve B in appendix 5 from ASME
% boiler and pressure vessel code, section VIII

N=[1000
10000
100000
1000000
10000000
100000000];



S=[20.0
17.0
14.5
13.4
11.0
10.0];


Logs=[1.30
1.23
1.16
1.13
1.04
1.00];

LogN=[3
4
5
6
7
8];

% ===============================================
Sbest1=[19.68
17.13
14.91
12.98
11.30
```

```
9.84];

Sm1=[19.679
17.132
14.914
12.984
9.606
6.359];

Logs1=[1.29
1.23
1.17
1.11
1.05
0.99];

figure;
subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs1)
legend('Plot of Log(S) vs Log(N)', '1st order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 1st Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual1=Logs-Logs1;
subplot(2,1,2);plot(residual1,'o')
title('Residuals of Log(S) and Log(N) vs. 1st Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(3.5, 0, 'STN = 107.46')

figure;
loglog(N,S,'o')
hold on;
grid;

loglog(N,Sbest1,'m')
hold on;

loglog(N,Sm1,'b')
hold on;

loglog(N/20,Sm1,'r')
hold on;
```

```
loglog(N,Sm1/2,'k')

legend('Sa data for 3003-0', '1st order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')

xlabel('Number of Cycles')
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for 3003-0 TC-Axial strain data. 1st order
fit with Aplliction of 2/20 Method')

% ==============================2nd order fit
Sbest2=[19.89
17.08
14.77
12.85
11.26
9.92];

Sm2=[19.888
17.084
14.771
12.853
9.471
6.499];

Logs2=[1.30
1.23
1.17
1.11
1.05
1.00];

figure;
subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs2)
legend('Plot of Log(S) vs Log(N)', '2nd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual2=Logs-Logs2;
subplot(2,1,2);plot(residual2,'o')
```

```
title('Residuals of Log(S) and Log(N) vs. 2nd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(3.5, 0, 'STN = 115.056')

figure;
loglog(N,S,'o')
hold on;
grid;

loglog(N,Sbest2,'m')
hold on;

loglog(N,Sm2,'b')
hold on;

loglog(N/20,Sm2,'r')
hold on;

loglog(N,Sm2/2,'k')

legend('Sa data for 3003-0', '2nd order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')

xlabel('Number of Cycles')
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for 3003-0 TC-Axial strain data. 2nd order
fit with Aplliction of 2/20 Method')


% ==============================3rd order fit==========

Sbest3=[19.94
17.03
14.76
12.93
11.38
10.01];

Sm3=[19.94343674
17.0255049
14.76386278
12.93302151
9.838982608
```

```
6.648141313];

Logs3=[1.30
1.23
1.17
1.11
1.06
1.00];

figure;
subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs3)
legend('Plot of Log(S) vs Log(N)', '3rd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual3=Logs-Logs3;
subplot(2,1,2);plot(residual3,'o')
title('Residuals of Log(S) and Log(N) vs. 3rd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(3.5, 0, 'STN = 116.16')

figure;
loglog(N,S,'o')
hold on;
grid;

loglog(N,Sbest3,'m')
hold on;
loglog(N,Sm3,'b')
hold on;
loglog(N/20,Sm3,'r')
hold on;
loglog(N,Sm3/2,'k')
legend('Sa data for 3003-0', '3rd order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')
xlabel('Number of Cycles')
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for 3003-0 TC-Axial strain data. 3rd order
fit with Aplliction of 2/20 Method')
```

C3: Aluminum 6061-T6

```
clear all ;
close all;

N=[10
20
50
100
200
500
1000
2000
5000
7750
10000
20000
50000
100000
200000
500000
1000000
2000000
5000000
10000000
100000000
200000000
500000000
1000000000
2000000000
5000000000];


Sa=[ 678078.31
 483574.28
 310984.85
 224000.00
 162492.42
 107914.86
 80407.83
 60957.43
 43698.48
 37854.40
 35000.00
 28849.24
 23391.49
```

```
 20640.78
 18695.74
 16969.85
 16100.00
 15484.92
 14939.15
 14664.08
 14210.00
 14148.49
 14093.91
 14066.41
 14046.96
 14029.70 ];

sm=[ 678078.31
 483574.28
 310984.85
 224000.00
 162492.42
 107914.86
 80407.83
 60957.43
 43698.48
 36524.86
 20000.00
 8774.93
 5028.13
 3865.46
 3208.98
 2711.91
 2486.49
 2336.02
 2208.23
 2145.76
 2045.34
 2031.99
 2020.19
 2014.26
 2010.08
 2006.37];

sm_best=[ 339039.154
241787.138
155492.424
112000.000
81246.212
53957.428
```

```
40203.915
60957.428
43698.485
30478.714
26684.174
3636.364
1056.423
543.995
405.455
330.900
276.105
251.710
235.581
221.979
215.361
204.766
203.362
202.121
201.498
201.059];


figure;

loglog(N,Sa,'m')
hold on;
loglog(N,sm);grid; hold on;
%% apply the 2/20
loglog(N/20, sm, 'r'); hold on;
loglog(N, sm/2, 'g');

SN1=[ sm(5:17,:),   N(5:17)/20];
SN2=[sm(13:26,:)/2, N(13:26)];
SN=[SN1(:,1), SN1(:,2); SN2(:,1), SN2(:,2)]

SN2(6:10,1)
hold on;loglog(SN(:,2), SN(:,1),'k')

hold on;
SNN=[10
25
50
100
250
387.5
500
1000
```

```
2500
5000
10000
25000
50000
100000
200000
500000
1000000
2000000
5000000
10000000
100000000
200000000
500000000
1000000000
2000000000
5000000000];

SSN=[162490.0000
107910.0000
80410.0000
60960.0000
43700.0000
36525.0000
20000.0000
8775.0000
5028.0000
3865.0000
3209.0000
2711.9000
2486.5000
1932.7000
1604.5000
1356.0000
1243.2000
1168.0000
1104.1000
1072.9000
1022.7000
1016.0000
1010.1
1007.1
1005
1003.2];

loglog(SNN,SSN,'k');
```

```
axis([10 10e8 10e1 10e6])

legend('"Best-Fit" Curve Fit of TC-Axial Based Data', 'Mean
Stress Equation Applied to ASME Best-Fit Equation', 'Number
of Cycles/20', 'Allowable Stress/2', 'Final ASME adjusted
curve');
title('Aluminum 6061-T6 Fatigue Curve with Applied Mean
Stress Adjustment');

xlabel('Number of Cycles'); ylabel('Allowable Stress,   ,
in ksi');
```

```
clear all,
close all;

% nickel 200 from McAdams and Inconel

N=[100000
1000000
10000000
100000000
1000000000
10000000000];

S=[109
84
63
52
50
50];

LogN=[5
6
7
8
9
10];

Logs=[2.04
1.92
1.80
1.72
1.70
1.70];

% ================================================

Sbest1=[97.23
82.76
70.44
59.95
51.03
43.43
];

Sm1=[97.23
```

```
82.76
70.44
59.95
51.03
39.77
];

Logs1=[1.99
1.92
1.85
1.78
1.71
1.64
];

figure;
subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs1)
legend('Plot of Log(S) vs Log(N)', '1st order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 1st Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual1=Logs-Logs1;
subplot(2,1,2);plot(residual1,'o')
title('Residuals of Log(S) and Log(N) vs. 1st Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(3.5, 0, 'STN = 36.46')

figure;
loglog(N,S,'o')
hold on;grid;
loglog(N,Sbest1,'m');hold on;
loglog(N,Sm1,'b');hold on;
loglog(N/20,Sm1,'r');hold on;
loglog(N,Sm1/2,'k')

legend('Sa data for Nickel 200', '1st order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')

xlabel('Number of Cycles')
```

```
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for Nickel 200 TC-Axial strain data. 1st
order fit with Apliction of 2/20 Method')

% ==============================2nd order
fit================================================

Sbest2=[111.35
80.41
63.02
53.62
49.51
49.62
];

Sm2=[111.35
80.41
63.02
53.62
49.51
49.18
];

Logs2=[2.05
1.91
1.80
1.73
1.69
1.70
];

figure;
subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs2)
legend('Plot of Log(S) vs Log(N)', '2nd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual2=Logs-Logs2;
subplot(2,1,2);plot(residual2,'o')
title('Residuals of Log(S) and Log(N) vs. 2nd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
```

```
text(3.5, 0, 'STN = 159.92')

figure;
loglog(N,S,'o')
hold on;
grid;

loglog(N,Sbest2,'m')
hold on;

loglog(N,Sm2,'b')
hold on;

loglog(N/20,Sm2,'r')
hold on;

loglog(N,Sm2/2,'k')

legend('Sa data for Nickel 200 ', '2nd-Order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')

xlabel('Number of Cycles')
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for Nickel 200  TC-Axial strain data. 2nd
order fit with Apliction of 2/20 Method')


% ==============================3rd order
fit==================================================

Sbest3=[108.97
80.95
62.47
51.50
46.61
47.62
];

Sm3=[108.97
80.95
62.47
51.50
44.42
45.97
];
```

```
Logs3=[2.04
1.91
1.80
1.71
1.67
1.68
];

figure;subplot(2,1,1);

subplot(2,1,1);plot(LogN, Logs,'o',LogN, Logs3)
legend('Plot of Log(S) vs Log(N)', '3rd order Curve Fit');
title('Plot of Log(S) vs. Log(N) Compared to 2nd Order
Curve Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')

residual3=Logs-Logs3;
subplot(2,1,2);plot(residual3,'o')
title('Residuals of Log(S) and Log(N) vs. 3rd Order Curve
Fit')
xlabel('Log(N), units Log(cycles)')
ylabel('Log(S), units Log(ksi)')
text(3.5, 0.02, 'STN = 189.82')

figure;
loglog(N,S,'o')
hold on;grid;
loglog(N,Sbest3,'m')
hold on;
loglog(N,Sm3,'b')
hold on;
loglog(N/20,Sm3,'r')
hold on;
loglog(N,Sm3/2,'k')

legend('Sa data for Nickel 200', '3rd order Best-Fit
Curve','Best-Fit Adjusted for Mean Stress', ...
         'Number of Cycles/20', 'Adjusted Mean stress
curve, Sm/2')

xlabel('Number of Cycles')
ylabel('Allowable stress, Sa (ksi)')
title('Sa vs N for Nickel 200 TC-Axial strain data. 3rd
order fit with Apliction of 2/20 Method')
```

C5: 2-D Vertical Piping Span Shear and Moment Evaluation

```
% Chris Comeau, 01/27/2001
% Test program for Shear and Maximum moment for 3-D beam
clear all
close all

% Initialize varibles
y=0;
y_distance=0;
x_distance=0;

Pipe_Type= 0.45;    % in lbs/ft
Fluid_Weight=.05;
Pipe_Type=5.88      %Pipe_Type+Fluid_Weight
We=0.167;       % weight of elbow

%Pipe_Type=Pipe_Type*12; % Convert from lbs/in to lbs/ft

L1 = 10                        % Length of first pipe
L2 = 9                         % Length of vertical pipe
L3 = 7
% Length of second pipe

L_Total = L1 + L3;              % Total length of both
horizontal pipes

Distance1=.5*L1;               % Distance from end of pipe to
valve
Distance2=L2;                  % Distance from end of pipe to
valve
Distance3=L1+.5*L3;            % Distance from end of pipe to
valve
Distance4=L3/2;

F1 = 0                          % lbs of valve
F2 = 0% Lbs
F3 = 0% lbs
                                % calculate the reaction forces

R2 = (F1*Distance1 + Pipe_Type*L1*Distance1 + (F2+4*We)*L1
+ Pipe_Type*Distance2*L1 ...
    + F3*Distance3 + Pipe_Type*L3*(Distance3))/(L1+L3); %
Find reaction force R2
```

```
R1 = 4*We+F1+F2+F3+Pipe_Type*L1+Pipe_Type*L2+Pipe_Type*L3-
R2; % Find reaction force R1

V1=R1;
V2=V1-Pipe_Type*Distance1;    % NEED TO make sure that when
you evaluate at different
V3=V2-F1;                   % F1 distances along the pipe,
that you account for the
V4=V3-Pipe_Type*Distance1;   % same distance, difference
on the shear equations
V5=V4-F2-2*We-Pipe_Type*L2;
V6=V5-Pipe_Type*Distance4;
V7=V6-F3;
V8=V7-Pipe_Type*Distance4;

% Calculate the slope of each pipe section
     Slope1=(V2-V1)/(Distance1-0);
     Slope2=(V4-V3)/(L1-Distance1);
      Slope3=(V6-V5)/(Distance3-L1);
      Slope4=(V8-V7)/((L3+L1)-Distance3);
     Slope5=(V8-V7)/((L3+L1)-Distance3);


V2_V1=linspace(V1,V2, 100);      % need linspace to
properly plot
V3_V2=linspace(V2,V3, 100);      % the variables across the
figure
V4_V3=linspace(V3,V4, 100);
V5_V4=linspace(V4,V5, 100);
V6_V5=linspace(V5,V6, 100);
V7_V6=linspace(V6,V7, 100);
V8_V7=linspace(V7,V8, 100);

X1=linspace(0, Distance1, 100);
X2=linspace(L1/2, L1, 100);
X3=linspace(L1,L1+L3/2, 100);
X4=linspace(L1+L3/2,(L1+L3), 100);
X5=linspace(L1, L3, 100);

Y1=linspace(-2500, 2500);       % create a vertical line


if V4>=0
   if V5<=0

      % create the shear and moment diagrams
```

```
      figure;                         % draw the shear
diagrams
     subplot(2,1,1);              % Plot the shear diagram
     plot(0,V1); hold on;          % plot V1
     plot(X1, V2_V1,'b'); hold on;  % plot decay curve for
first half of L1
     plot(Distance1, V3_V2,'b'); hold on;% plot the line
for the first valve, F1, at its location
     plot(X2, V4_V3); hold on;      % plot decay curve for
second half of L1
     plot(L1, V5_V4,'b');  hold on; % Plot the line for
center pipe and valve
     plot(X3, V6_V5); hold on;
     plot(Distance3, V7_V6,'b'); hold on;
     plot(X4, V8_V7); hold on;
     plot(L1+L3, V8); hold on;     % draw the last shear
line, back to zero
     L_Total2=linspace(0,L1+L3);    % make a red line at
zero for length of pipe
     plot(L_Total2, 0, 'k:'); hold on % make a zero line
across both pipes
     plot(L1, Y1, 'k:')    % make a vertical line for the
V=0 crossing
      legend('k:', 'Shear = 0, Maximum Moment')
     title('Shear Diagram for Vertical Pipe Run');
     ylabel('Shear, (lbs)')'
     axis([0, L1+L3, V8*1.5, V1*1.5]);

      M1=linspace(0, Distance1, 100);
     M2=linspace(0, L1-Distance1, 100);
      M3=linspace(0, Distance3-L1, 100);
     M4=linspace(0, L3, 100);
      M5=linspace(0, L3/2, 100);

      Function1=Slope1/2*M1.^2 + V1*M1;
     Function2=Slope2/2*M2.^2 + V3*M2 + max(Function1);
     Function3=Slope3/2*M3.^2 + V5*M3 + max(Function2);
      Function5=Slope5/2*M5.^2 + min(Function3)+V7*M5;

      subplot(2,1,2);
      plot(X1, Function1, 'b', X2, Function2, 'b', X3,
Function3, 'b', X4, Function5, 'b');
      hold on;
      plot(L1, Y1, 'k:')     % make a vertical line for
the V=0 crossing
      xlabel('Length of Pipe Run, (ft)');
      ylabel('Moment, (Lbs-ft)');
```

```
      title('Moment Diagram for Vertical Pipe Run');
       axis([0, L1+L3, 0, max(Function2)*1.5]);
      legend( 'Maximum Moment');
  end
end

if V3>=0
   if V4<=0

      % This section is used for when V=0.% Before the
center of pipe run
      x1span=V3/Pipe_Type;      % Find the x value where
V=0
      x2span=L1/2 + x1span;    % Find the x value where
V=0
      x3span=V4/Slope4% End check x value's ---------------
---------------------------

      % Creat figure and make shear and moment diagrams
      figure;                              % draw the shear
diagrams
     subplot(2,1,1);                % Plot the shear diagram
     plot(0,V1); hold on;            % plot V1
     plot(X1, V2_V1,'b'); hold on;  % plot decay curve for
first half of L1
     plot(Distance1, V3_V2,'b'); hold on;% plot the line
for the first valve, F1, at its location
     plot(X2, V4_V3); hold on;      % plot decay curve for
second half of L1
     plot(L1, V5_V4,'b');  hold on; % Plot the line for
center pipe and valve
     plot(X3, V6_V5); hold on;
     plot(Distance3, V7_V6,'b'); hold on;
     plot(X4, V8_V7); hold on;
     plot(L1+L3, V8); hold on;     % draw the last shear
line, back to zero
     L_Total2=linspace(0,L1+L3);    % make a red line at
zero for length of pipe
     plot(L_Total2, 0, 'k:'); hold on % make a zero line
across both pipes
     plot(x2span, Y1, 'k:')     % make a vertical line for
the V=0 crossing
      legend('k:', 'Shear = 0, Maximum Moment')
     title('Shear Diagram for Vertical Pipe Run');
     ylabel('Shear, (lbs)')'
     axis([0, L1+L3, V8*1.5, V1*1.5]);
```

```
      M1=linspace(0, Distance1, 100);
      M2=linspace(0, x1span, 100);
      M3=linspace(0, V3/Slope3, 100);
      M4=linspace(0, Distance3-L1, 100);
     M5=linspace(0, L3+L1 - Distance3, 100);

      Function1=Slope1/2*M1.^2 + V1*M1;
     Function2=Slope2/2*M2.^2 + V3*M2 + max(Function1);
      Function3=Slope3/2*M3.^2 + max(Function2);
      Function4=Slope4/2*M4.^2 + min(Function3) + V4*M4;
     Function5=Slope5/2*M5.^2 + V8*M5 + min(Function4);

      subplot(2,1,2);
      plot(M1, Function1, 'b', M2+L1/2, Function2,'b',
x1span + M3 + L1/2, Function3, 'b' ...
         , X3, Function4, 'b', X4, Function5, 'r');

      hold on;
      plot(x2span, Y1, 'k:')    % make a vertical line for
the V=0 crossing
      xlabel('Length of Pipe Run, (ft)');
      ylabel('Moment, (Lbs-ft)');
      title('Moment Diagram for Vertical Pipe Run');
      axis([0, L1+L3, 0, max(Function2)*1.5]);
      legend('k:', 'Shear = 0, Maximum Moment')
    end
end

  if V5>0
     if V6<0

      % This section is used for when V=0.% Before the
center of pipe run
      x1span=V5/Pipe_Type;      % Find the x value where
V=0
      x2span=L1 + x1span;       % Find the x value where
V=0
      x3span=V4/Slope4% End check x value's ----------
      Y1=linspace(-250, 250);    % create a vertical line

      % Create figure and make shear and moment diagrams
      figure;                            % draw the shear
diagrams
     subplot(2,1,1);                % Plot the shear diagram
     plot(0,V1); hold on;            % plot V1
     plot(X1, V2_V1,'b'); hold on;  % plot decay curve for
first half of L1
```

```
     plot(Distance1, V3_V2,'b'); hold on;% plot the line
for the first valve, F1, at its location
     plot(X2, V4_V3); hold on;      % plot decay curve for
second half of L1
     plot(L1, V5_V4,'b');  hold on; % Plot the line for
center pipe and valve
     plot(X3, V6_V5); hold on;
     plot(Distance3, V7_V6,'b'); hold on;
     plot(X4, V8_V7); hold on;
     plot(L1+L3, V8); hold on;     % draw the last shear
line, back to zero
     L_Total2=linspace(0,L1+L3);    % make a red line at
zero for length of pipe
     plot(L_Total2, 0, 'k:'); hold on % make a zero line
across both pipes
     plot(x2span, Y1, 'k-')    % make a vertical line for
the V=0 crossing
      legend('k:', 'Shear = 0, Maximum Moment')
     title('Shear Diagram for Vertical Pipe Run');
     ylabel('Shear, (lbs)')'
     axis([0, L1+L3, V8*1.5, V1*1.5]);

      M1=linspace(0, Distance1, 100);
      M2=linspace(0, L1/2, 100);
      M3=linspace(0, x1span, 100);
      M4=linspace(0, L3/2-x1span, 100);
      M5=linspace(0, L3/2, 100);

      X1=linspace(0, Distance1, 100);
     X2=linspace(L1/2, L1, 100);
     X3=linspace(L1,L1+x1span, 100);
     X4=linspace(L1+x1span,L1+L3/2, 100);
     X5=linspace(L1+L3/2, L3+L1, 100);

      % Calculate the slope of each pipe section
     Slope1=(V2-V1)/(Distance1-0);
     Slope2=(V4-V3)/(L1-Distance1);
      Slope3=(0-V5)/(x1span)
      Slope4=(V6-0)/(L3/2-x1span);
     Slope5=(V8-V7)/(L3/2);

      Function1=Slope1/2*M1.^2 + V1*M1;
     Function2=Slope2/2*M2.^2 + V3*M2 + max(Function1);
      Function3=Slope3/2*M3.^2 + V5*M3 + max(Function2);
      Function4=Slope4/2*M4.^2 + max(Function3);
     Function5=Slope5/2*M5.^2 + min(Function4)+V7*M5;
```

```
      subplot(2,1,2);
      plot(X1, Function1, 'b', X2, Function2,'b', M3+L1,
Function3, 'b' ...
          , X4, Function4, 'b', X5, Function5, 'b');

      hold on;
      plot(x2span, Y1, 'k-')   % make a vertical line for
the V=0 crossing
      xlabel('Length of Pipe Run, (ft)');
      ylabel('Moment, (Lbs-ft)');
      title('Moment Diagram for Vertical Pipe Run');
      axis([0, L1+L3, 0, max(Function3)*1.5]);
     legend('k:', 'Shear = 0, Maximum Moment')


     end
  end

  if V4>=0
   if V5<=0

      % create the shear and moment diagrams
      figure;                        % draw the shear
diagrams
     subplot(2,1,1);             % Plot the shear diagram
     plot(0,V1); hold on;          % plot V1
     plot(X1, V2_V1,'b'); hold on;  % plot decay curve for
first half of L1
     plot(Distance1, V3_V2,'b'); hold on;% plot the line
for the first valve, F1, at its location
     plot(X2, V4_V3); hold on;      % plot decay curve for
second half of L1
     plot(L1, V5_V4,'b');  hold on; % Plot the line for
center pipe and valve
     plot(X3, V6_V5); hold on;
     plot(Distance3, V7_V6,'b'); hold on;
     plot(X4, V8_V7); hold on;
     plot(L1+L3, V8); hold on;     % draw the last shear
line, back to zero
     L_Total2=linspace(0,L1+L3);    % make a red line at
zero for length of pipe
     plot(L_Total2, 0, 'k:'); hold on % make a zero line
across both pipes
     plot(L1, Y1, 'k:')    % make a vertical line for the
V=0 crossing
      legend('k:', 'Shear = 0, Maximum Moment')
     title('Shear Diagram for Vertical Pipe Run');
```

```
     ylabel('Shear, (lbs)')'
       axis([0, L1+L3, V8*1.5, V1*1.5]);

      M1=linspace(0, Distance1, 100);
     M2=linspace(0, L1-Distance1, 100);
      M3=linspace(0, L1, 100);
     M4=linspace(0, L3, 100);
      M5=linspace(0, L3/2, 100);

      Function1=Slope1/2*M1.^2 + V1*M1;
     Function2=Slope2/2*M2.^2 + V3*M2 + max(Function1);
     Function3=Slope3/2*M3.^2 + V5*M3 + max(Function2);
      Function5=Slope5/2*M5.^2 + min(Function3)+V7*M5;

      subplot(2,1,2);
      plot(X1, Function1, 'b', X2, Function2, 'b', X3,
Function3, 'b', X4, Function5, 'k');
      hold on;
      plot(L1, Y1, 'k:')     % make a vertical line for
the V=0 crossing
      xlabel('Length of Pipe Run, (ft)');
      ylabel('Moment, (Lbs-ft)');
      title('Moment Diagram for Vertical Pipe Run');
       axis([0, L1+L3, 0, max(Function2)*1.5]);
      legend('k:', 'Shear = 0', 'Maximum Moment');
  end
end
```