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CE 520 HW6

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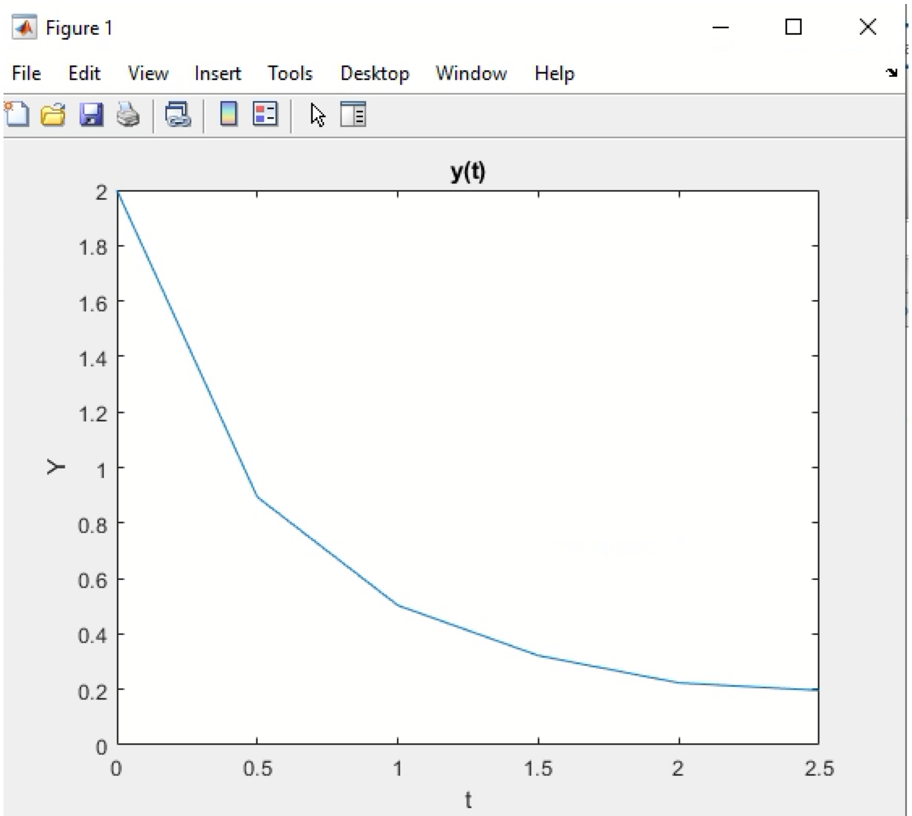
Problem1
%This script uses the 4th order Adam's method
slope = @(t,y) (-2*y)/(1+t);
y(1)=2; %Initial value
h = .5;
i=0;
%RK4 starter
for t = 0:h:1.5
i = i+1;
k1 = slope(t,y(i));
k2 = slope(t+(1/2)*h, y(i) + (1/2)*k1*h);
k3 = slope(t+(1/2)*h, y(i) + (1/2)*k2*h);
k4 = slope(t+h, y(i)+ k3*h);
y(i+1) = y(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end
%%4th Order Adams
%Predictor
yp = y(4) + (h/24)*(55*slope(1.5,y(4)) - 59*slope(1,y(3)) + ...
    37*slope(0.5, y(2)) -9*slope(0,y(1)));
%Evaluate using predictor
fpe = slope(2.5, yp);
%Corrector
yc = y(4) + (h/24)*(9*fpe + 19*slope(1.5,y(4)) - 5*slope(1,y(3))...
    + slope(0.5, y(2)));
%Plotting
Y = [y, yc];
t = [0:.5:2.5];
plot(t,Y)
xlabel ('t')
ylabel ('Y')
title ('y(t)')

%Table
tfinal=transpose(t);
yfinal=transpose(Y);
result = table(tfinal,yfinal)
```



6x2 table

	1 tfinal	2 yfinal
1	0	2
2	0.5000	0.8933
3	1	0.5029
4	1.5000	0.3219
5	2	0.2236
6	2.5000	0.1965

Problem 2a

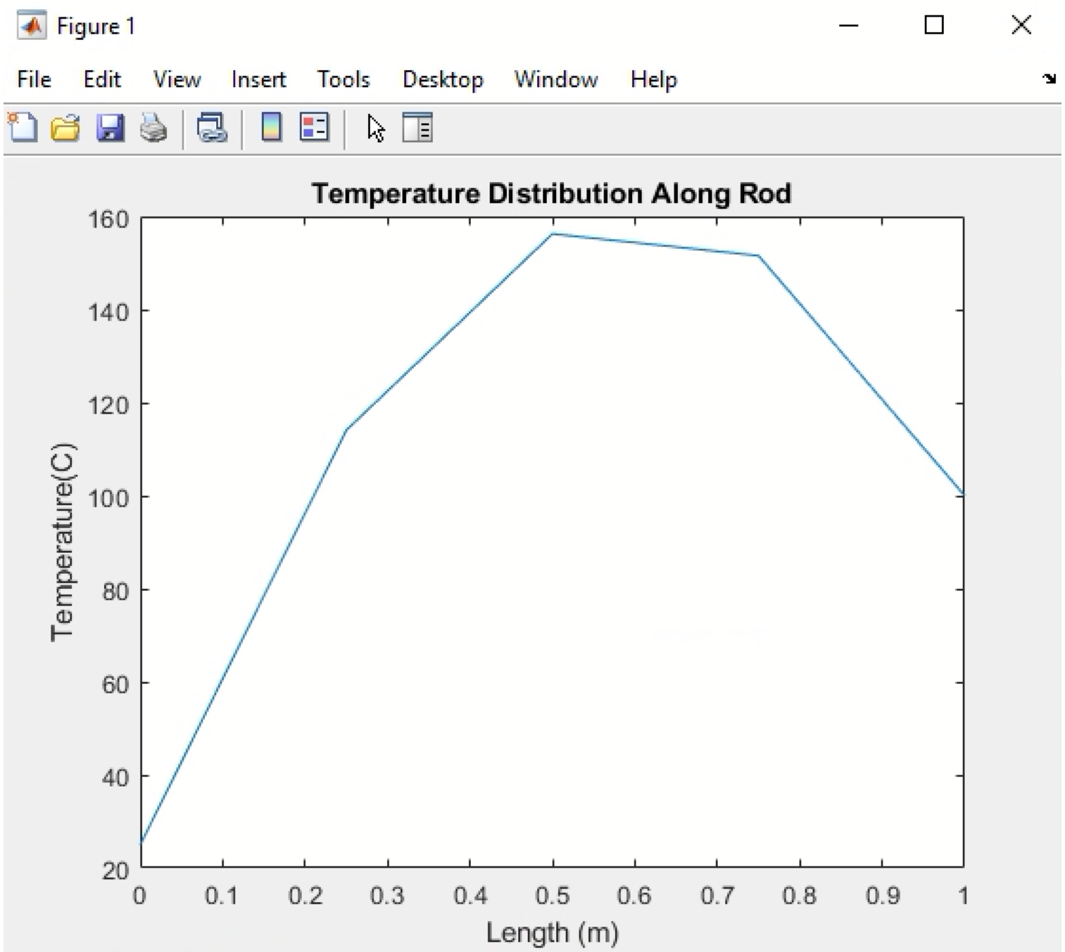
```
%This script uses the Shooting method
%Initial parameters
slope = @(x,T) -750*x + 450;
xo = 0;
x1 = 1;
to = 25;
t1 = 100;
h = 0.25;
i=0;
Ta(1) = 10; %1st guess
A = Ta(1);
%RK4 starter
for x = 0:h:0.75
i = i+1;
k1 = slope(x,Ta(i));
k2 = slope(x+(1/2)*h, Ta(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Ta(i) + (1/2)*k2*h);
k4 = slope(x+h, Ta(i)+ k3*h);
Ta(i+1) = Ta(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end

%RK4 starter
Tb(1) = 26; %2nd guess
B = Tb(1);
h = 0.25;
i = 0;
for x = 0:h:0.75
i = i+1;
k1 = slope(x,Tb(i));
k2 = slope(x+(1/2)*h, Tb(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Tb(i) + (1/2)*k2*h);
k4 = slope(x+h, Tb(i)+ k3*h);
Tb(i+1) = Tb(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end
%Interpolate
Ti = A + (B-A)/(Tb(5) - Ta(5)) * (t1 - Ta(5));

%RK4 starter
Ti(1) = Ti; %3rd guess
h = 0.25;
i = 0;
for x = 0:h:0.75
i = i+1;
k1 = slope(x,Ti(i));
k2 = slope(x+(1/2)*h, Ti(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Ti(i) + (1/2)*k2*h);
k4 = slope(x+h, Ti(i)+ k3*h);
Ti(i+1) = Ti(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end

%Plotting
Y = [Ti];
X = [0:.25:1];
plot(X,Y)
```

```
xlabel ('Length (m)')
ylabel ('Temperature(C)')
title ('Temperature Distribution Along Rod')
```



Problem 2 b

```
%This script uses the finite difference method
%Using Central Differencing
%Initial Parameters
fun = -750;
xo = 0;
x1 = 1;
to = 25;
t1 = 100;
h = 0.2;
z = [-2 1 0 0; 1 -2 1 0; 0 1 -2 1; 0 0 1 -2];
b = [fun*(h.^2)-to; fun*(h.^2); fun*(h.^2); fun*(h.^2)-t1];
T = inv(z)*b;

%Plotting
Y = [to T' t1];
X = [0:.2:1];
plot(X,Y)
xlabel ('Length (m)')
ylabel ('Temperature(C)')
title ('Temperature Distribution Along Rod')

%Spectral Norm
SpecNorm = norm(z);

%Condition number
CondNum = cond(z);
```

From script, spectral norm = 3.618

Condition number = 9.4721

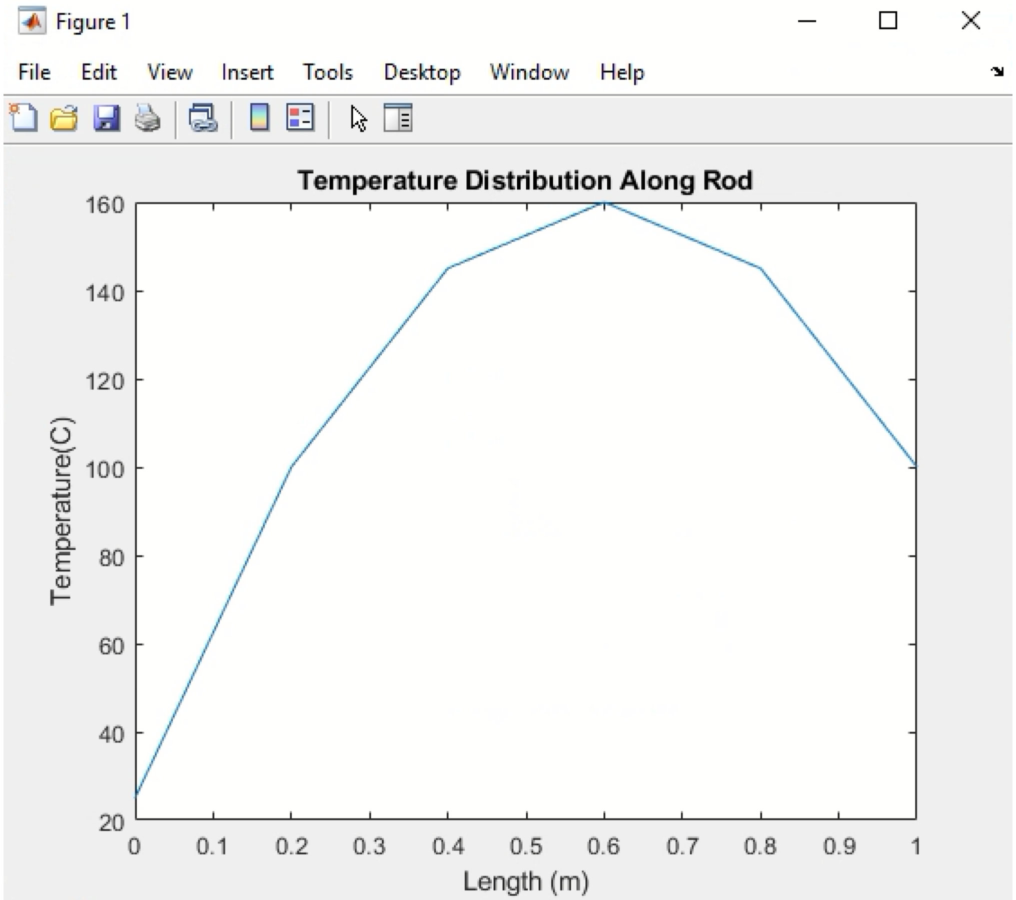


Figure 1
File Edit View Insert Tools Desktop Window Help
Temperature Distribution Along Rod
Temperature(C)
160
140
120
100
80
60
40
20
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Length (m)

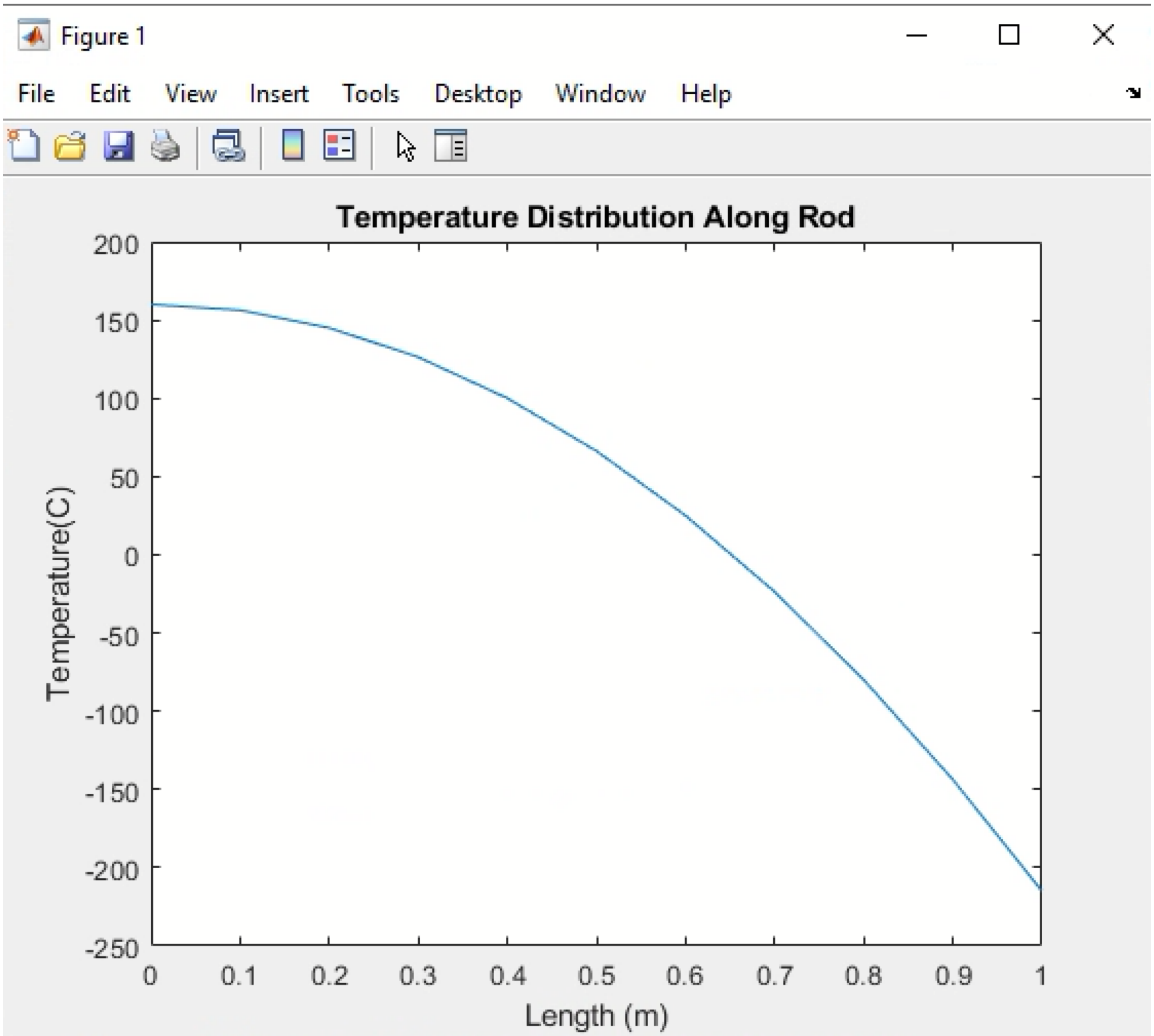
```
Problem 3 a
%This script uses the Shooting method
%with fully insulated left boundary
%Initial parameters
slope = @(x,T) -750*x;
xo = 0;
x1 = 1;
to = 25;
t1 = 100;
h = 0.1;
i=0;
Ta(1) = 10; %1st guess
A = Ta(1);
%RK4 starter
for x = 0:h:0.9
i = i+1;
k1 = slope(x,Ta(i));
k2 = slope(x+(1/2)*h, Ta(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Ta(i) + (1/2)*k2*h);
k4 = slope(x+h, Ta(i)+ k3*h);
Ta(i+1) = Ta(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end

%RK4 starter
Tb(1) = 26; %2nd guess
B = Tb(1);
h = 0.1;
i = 0;
for x = 0:h:0.9
i = i+1;
k1 = slope(x,Tb(i));
k2 = slope(x+(1/2)*h, Tb(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Tb(i) + (1/2)*k2*h);
k4 = slope(x+h, Tb(i)+ k3*h);
Tb(i+1) = Tb(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end
%Interpolate
Ti = A + (B-A)/(Tb(5) - Ta(5)) * (t1 - Ta(5));

%RK4 starter
Ti(1) = Ti; %3rd guess
h = 0.1;
i = 0;
for x = 0:h:0.9
i = i+1;
k1 = slope(x,Ti(i));
k2 = slope(x+(1/2)*h, Ti(i) + (1/2)*k1*h);
k3 = slope(x+(1/2)*h, Ti(i) + (1/2)*k2*h);
k4 = slope(x+h, Ti(i)+ k3*h);
Ti(i+1) = Ti(i) + (1/6)*(k1 +2*k2+2*k3+k4)*h;
end

%Plotting
Y = [Ti];
X = [0:.1:1];
plot(X,Y)
```

```
xlabel ('Length (m)')
ylabel ('Temperature(C)')
title ('Temperature Distribution Along Rod')
```



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Problem 3b
%This script uses the finite difference method, fully insulated LB
%Using Central Differencing
%Initial Parameters
fun = -750;
xo = 0;
x1 = 1;
to = 475;
t1 = 100;
h = 0.1;
z = [-2 1 0 0 0 0 0 0 0;...
    1 -2 1 0 0 0 0 0 0;...
    0 1 -2 1 0 0 0 0 0;...
    0 0 1 -2 1 0 0 0 0; ...
    0 0 0 1 -2 1 0 0 0;...
    0 0 0 0 1 -2 1 0 0; ...
    0 0 0 0 0 1 -2 1 0; ...
    0 0 0 0 0 0 1 -2 1;...
    0 0 0 0 0 0 0 1 -2];
b = [fun.*(h.^2)-to; fun.*(h.^2); fun.*(h.^2); ...
    fun.*(h.^2); fun.*(h.^2); fun.*(h.^2);...
    fun.*(h.^2); fun.*(h.^2); fun.*(h.^2)-t1];
T = inv(z)*b;

%Plotting
Y = [to T' t1];
X = [0:.1:1];
plot(X,Y)
xlabel ('Length (m)')
ylabel ('Temperature(C)')
title ('Temperature Distribution Along Rod')

%Spectral Norm
SpecNorm = norm(z);

%Condition number
CondNum = cond(z);
```

From script above, spectral norm = 3.9021

Condition number = 39.8635

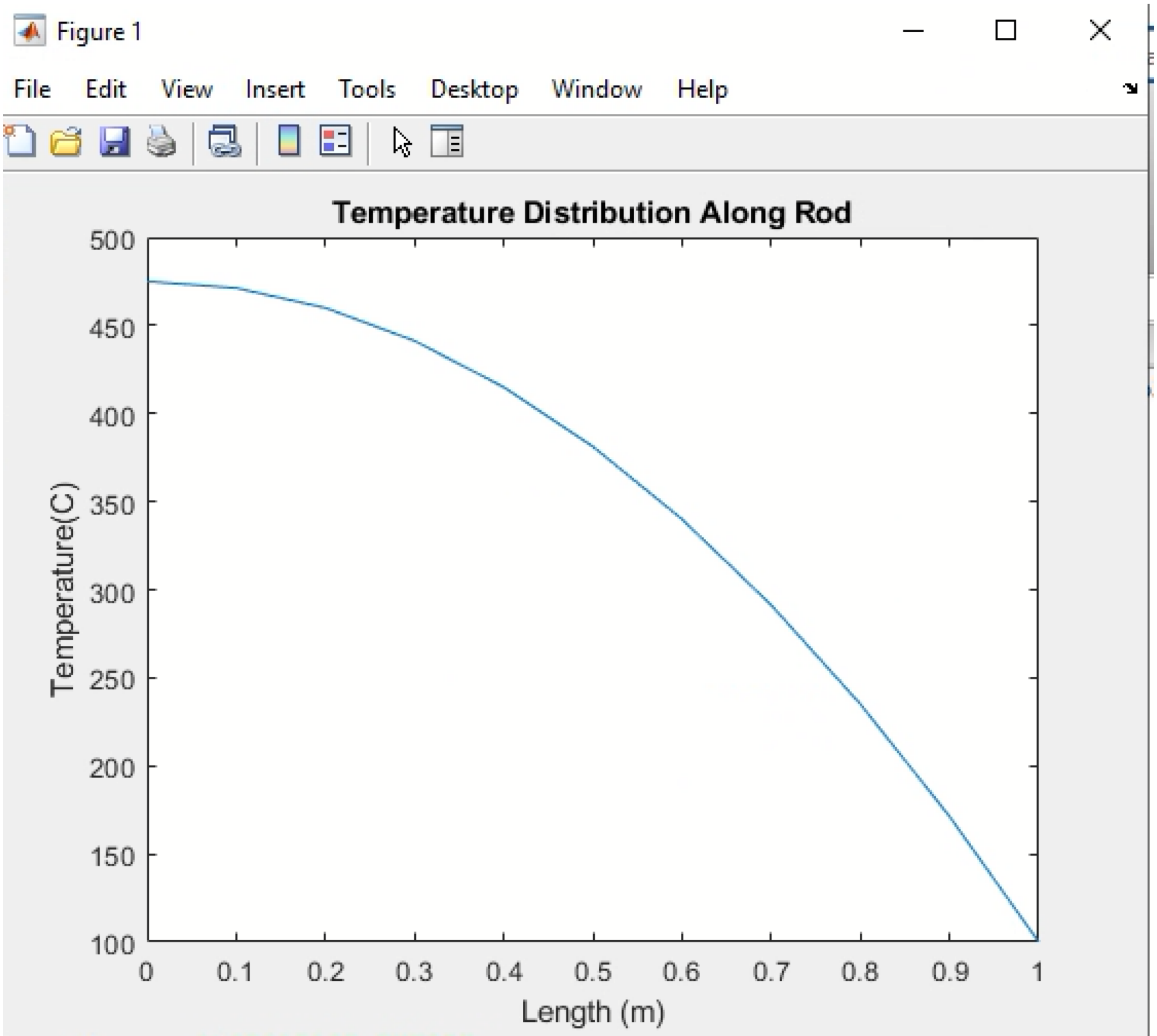
Figure 1
File Edit View Insert Tools Desktop Window Help
Temperature Distribution Along Rod
Temperature(C)
500
450
400
350
300
250
200
150
100
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Length (m)

Problem 2 Sample Calcs

$$\frac{d^2T}{dx^2} = -f(x) = -750 \quad , \quad T(0)=25$$
$$T(1)=100$$

$$\frac{dT}{dx} = -750x + C_1$$

$$T(x) = -\frac{750x^2}{2} + C_1x + C_2$$

$$T(0) = C_2 = 25$$

$$100 = -375(1)^2 + C_1(1) + 25$$

$$C_1 = 450$$

$$\rightarrow \frac{dT}{dx} = -750x + 450 = Z$$

prob 3 b

$T(0)=0$
$T(1)=100$

$$\overset{90}{\cancel{\frac{dT}{dx}}} = -\overset{90}{\cancel{750}}x + C_1 \rightarrow C_1 = 0$$

$$T(x) = -\frac{750x^2}{2} + \overset{90}{\cancel{C_1}}x + C_2$$

$$100 = -375(1)^2 + C_2 \rightarrow C_2 = 475 = T_0$$

$$\begin{bmatrix} -2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & -2 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -2 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & -2 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & -2 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & -2 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & -2 \end{bmatrix}_{9\times 9} \times \begin{bmatrix} T(1) \\ T(2) \\ T(3) \\ T(4) \\ T(5) \\ T(6) \\ T(7) \\ T(8) \\ T(9) \end{bmatrix}$$

$$= \begin{bmatrix} -750h^2 - T(0) \\ -750h^2 \\ \vdots \\ -750h^2 \\ -750h^2 - T(1) \end{bmatrix}$$