Homework 1

Name: Jackson Lee

Due Date: 1/30/23

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```
clear, clc
```

Problem #1 - Charge on capacitor: measured vs. theoretical

a) Set up measured data (No output)

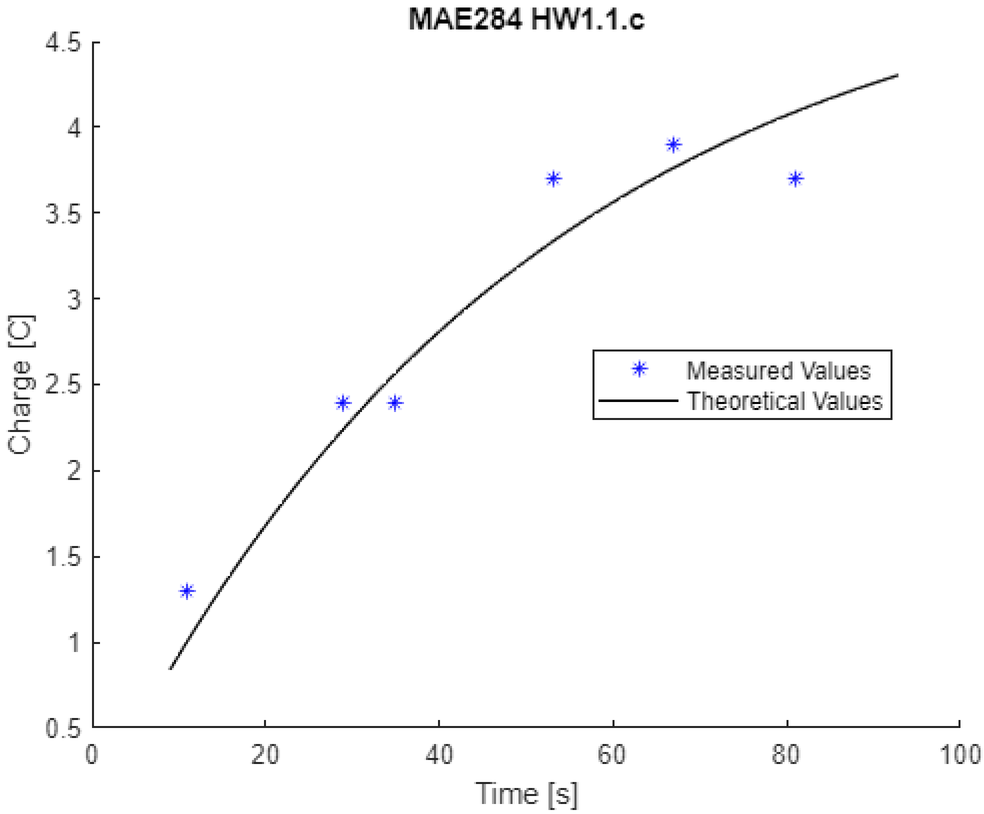
```
t_m = [11,29,35,53,67,81];
Q_m = [1.3,2.4,2.4,3.7,3.9,3.7];
```

b) Set up theoretical values (No output)

```
t_t = 9:1:93;
Q_t = 5.1 .* (1-(exp((-t_t)./50)));
```

c) Plot

```
hold on
xlabel("Time [s]");
ylabel("Charge [C]");
plot(t_m,Q_m,"b*",t_t,Q_t,"k-")
title("MAE284 HW1.1.c")
legend("Measured Values","Theoretical Values","location","best")
hold off
```



Problem #2 - Uniform beam with distributed load

```
% Set up variables
L=2000;
E=10000;
I=13000;
w0=170;
x=0:16:L;
```

a) Displacement, $y(x)$

Formula: $y = \frac{w_0}{120EIL}(2L^2x^3 - xL^4 - x^5)$

```
% Displacement code
y=((w0)./(120.*E.*I.*L).*((2*(L^2).*(x.^3))-(x.*(L^4))-(x.^5)));
```

b) Slope, $\theta(x) = \frac{dy}{dx}$

Formula: $\theta = \frac{w_0}{120\text{EIL}}(6L^2x^2 - L^4 - 5x^4)$

```
% Slope code
```

```
dy=((w0)./(120.*E.*I.*L).*((6*(L^2).*(x.^2))-(L^4)-(5.*(x.^4))));
```

c) Moment, $M(x) = EI\,\dfrac{d^2y}{dx^2}$

Formula: $M = \left(\dfrac{w_0}{120L}(12L^2x - 20x^3)\right)$

```
% Moment code
M=(w0/(120*L))*(((12*(L^2))*x)-(20*(x.^3)));
```

d) Shear, $V(x) = EI\,\dfrac{d^3y}{dx^2}$

Formula: $V = \left(\dfrac{w_0}{120\mathrm{IL}}(12L^2 - 60x^2)\right)$

```
% Shear code
V=(((w0)/(120*L))*((12*(L^2))-(60*(x.^2))));
```

e) Plot a-d versus distance along the beam

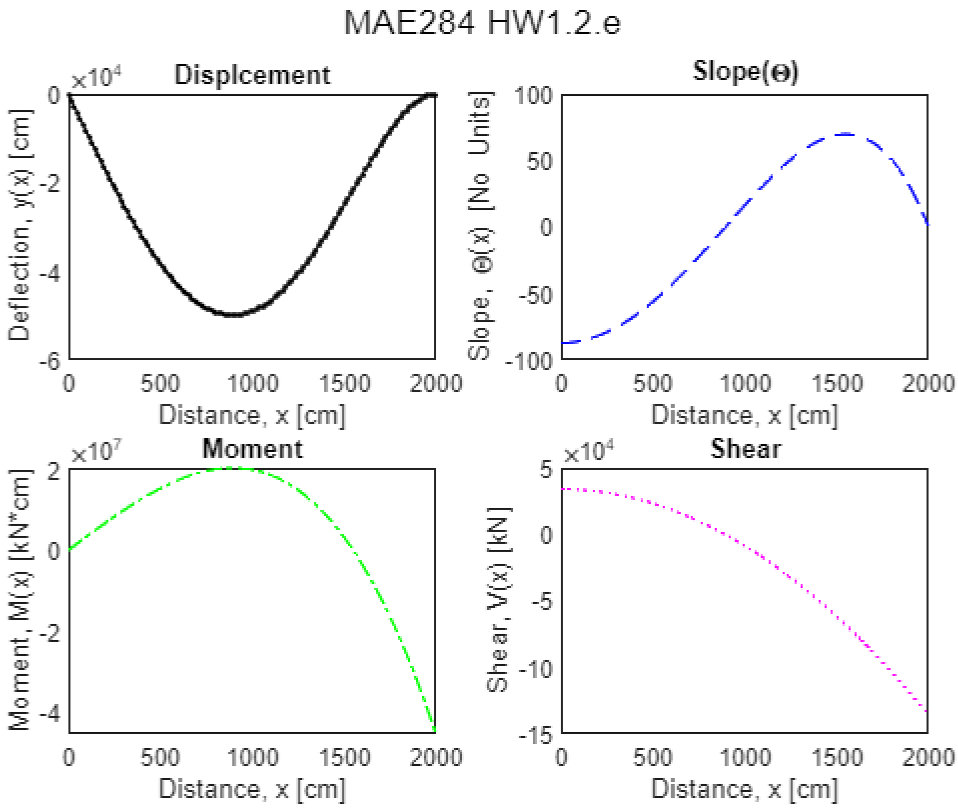
```
subplot(2,2,1);
plot(x,y,"k.-")
title("Displcement")
xlabel("Distance, x [cm]")
ylabel("Deflection, y(x) [cm]")

subplot(2,2,2);
plot(x,dy,"b--")
title("Slope(\Theta)")
xlabel("Distance, x [cm]")
ylabel("Slope, \Theta(x) [No Units]")

subplot(2,2,3);
plot(x,M,"g-.")
title("Moment")
xlabel("Distance, x [cm]")
ylabel("Moment, M(x) [kN*cm]")

subplot(2,2,4);
plot(x,V,"m:")
title("Shear")
xlabel("Distance, x [cm]")
ylabel("Shear, V(x) [kN]")

sgtitle("MAE284 HW1.2.e")
```

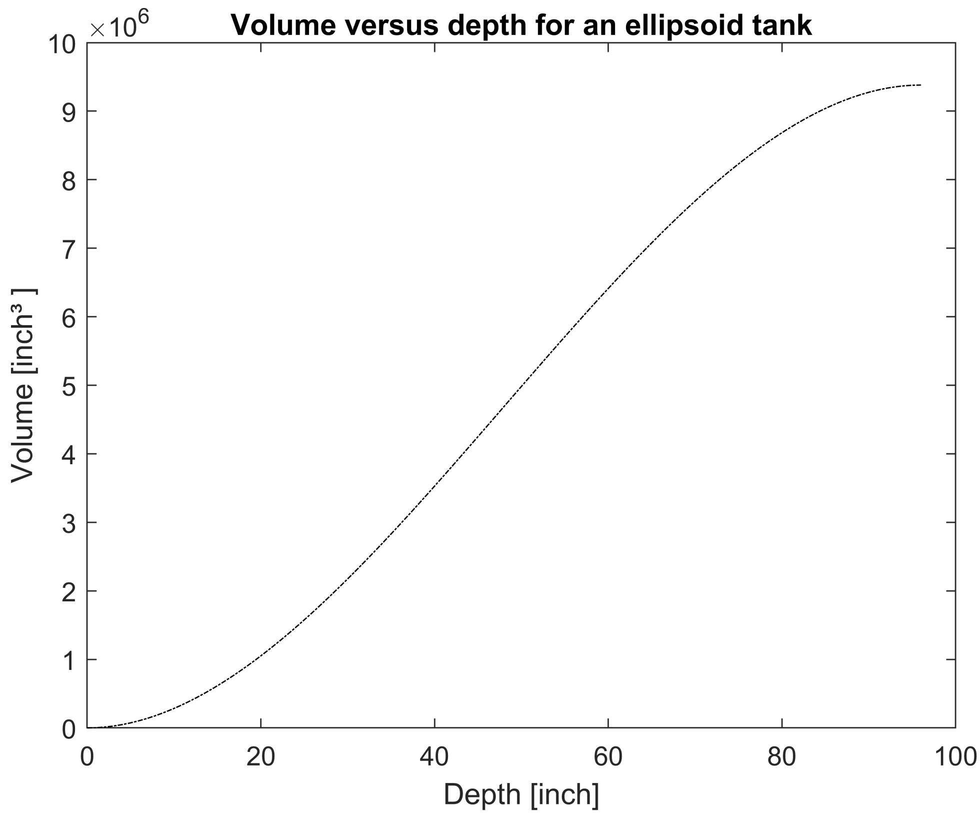



```
figure()
```

Problem #3 - Ellipsoid tank

a) Test #1 - Provide title and units, no return value

```
% Test #1 code
plot_title  = 'Volume versus depth for an ellipsoid tank';
ellipsoid_volume(48,216,plot_title,'inch')
```



b) Test #2 - Use defaults, return volume

```
% Test #2 code
V = ellipsoid_volume(10,2);
fprintf("The volume of the tank is %.4f m³", V)
```

```
The volume of the tank is 167.5516 m³
```

Problem #4 - Manning's equation

a) Display D matrix

```
D = [.028, .0011, 21, 6.4;
     .033, .0001, 9, 3.3;
     .031, .0004, 20, 16.1;
     .021, .0006, 22, 12.6;
     .017, .0004, 14, 7.7;
     .022, .0008, 7, 14.9];
D(:,5) = (D(:,3) .* D(:,4)) ./ (D(:,3) + 2 * D(:,4))
```

```
D = 6×5
    0.0280    0.0011   21.0000    6.4000    3.9763
    0.0330    0.0001    9.0000    3.3000    1.9038
    0.0310    0.0004   20.0000   16.1000    6.1686
    0.0210    0.0006   22.0000   12.6000    5.8729
    0.0170    0.0004   14.0000    7.7000    3.6667
    0.0220    0.0008    7.0000   14.9000    2.8342
```

b) Calculations for V using single line of code and display V vector

```
V = ((1./D(:,1)).*sqrt(D(:,2)).*(D(:,5).^(2/3)))
```

```
V = 6×1
    2.9730
    0.4655
    2.1700
    3.7969
    2.7974
    2.5748
```

c) Calculations for V using single line of code in a loop

```
for n = 1:length(D(:,1))
    v = (1/D(n,1))*sqrt(D(n,2))*(D(n,5)^(2/3));
    fprintf("Channel %1.0f velocity = %.5f m/s\n", n, v)
end
```

```
Channel 1 velocity = 2.97299 m/s
Channel 2 velocity = 0.46549 m/s
Channel 3 velocity = 2.16999 m/s
Channel 4 velocity = 3.79685 m/s
Channel 5 velocity = 2.79745 m/s
Channel 6 velocity = 2.57482 m/s
```

Problem #5 - Approximation and error

```
% Code for problem #5 here
termEst = zeros(1,7);
x = pi/3;

for k = 1:7
    if k == 1
        fprintf("# of terms      Estimate      True Error          MAPRE\n" + ...
                "---------- ------------- -------------- --------------\n")
        %10 13 14 14
    end

    termEst(k) =  ((-1)^(k-1))*((x^(2*k-1))/factorial(2*k-1));
    currentEst = sum(termEst(1:k));
    MAPRE = abs((currentEst-sum(termEst(1:(k-1))))/currentEst)*100;
    if k == 1
        fprintf("%10d %13.10f %14.10f %14s\n", k, currentEst, (sin(x)-currentEst), "N/A")
    else
        fprintf("%10d %13.10f %14.10f %14.10f\n", k, currentEst, (sin(x)-currentEst), MAPRE)
    end

end
```

```
# of terms      Estimate      True Error          MAPRE
---------- ------------- -------------- --------------
         1  1.0471975512  -0.1811721474            N/A
```

```
2  0.8558007816   0.0102246222  22.3646406681
3  0.8662952838  -0.0002698800   1.2114232200
4  0.8660212717   0.0000041321   0.0316403464
5  0.8660254451  -0.0000000413   0.0004819077
6  0.8660254035   0.0000000003   0.0000048043
7  0.8660254038  -0.0000000000   0.0000000338
```

Problem #6 - Taylor series

a) Calculate $f_a(x)$ display in fprintf statement

```
f = @(x) 5*x.^4 - 3*x - 7;
df_dx = @(x) 20*x.^3 - 3;
df2_d2x = @(x) 60*x.^2;

a = 1;

n_1 = df2_d2x(a)/factorial(2);
n_2 = (df_dx(a) - 2*a*(df2_d2x(a)/factorial(2)));
n_3 = f(a)-a*df_dx(a) +a^2*(df2_d2x(a)/factorial(2));

f_a = @(x) n_1*x.^2 + n_2*x + n_3;

fprintf("f_a(x) = %.4fx² + %.4fx + %.4f", n_1, n_2, n_3)
```

```
f_a(x) = 30.0000x² + -43.0000x + 8.0000
```

b) Display exact answer and estimate the value of the function at the new value of x

```
x = 2.5;
f_app = f_a(x);
f_ex = f(x);
fprintf("The exact value of f(%.1f) is %7.4f", x, f_ex)
```

```
The exact value of f(2.5) is 180.8125
```

```
fprintf("The approximate value of f(%.1f) if %7.4f", x, f_app)
```

```
The approximate value of f(2.5) if 88.0000
```

Calculating Error

```
MTPRE = abs(((f_ex-f_app)/f_ex)*100)
```

```
MTPRE = 51.3308
```

```
n = 2;
maxErr = 0.5*10.^(2-n)
```

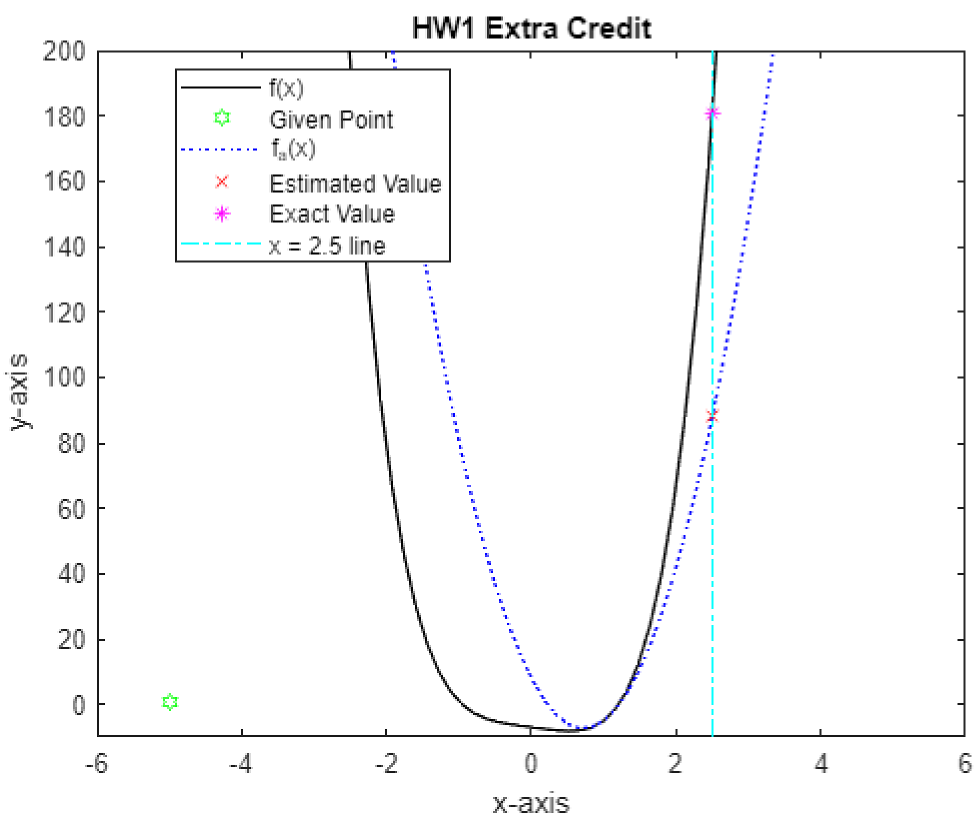
```
maxErr = 0.5000
```

c) Is this a reasonable approximation? Why or why not?

No, because the MTPRE is 51.33%, and we defined in class using the Scarborough tolerance that with 2 significant digits the acceptable error tolerance would be 0.5%, which is over 2 orders of magnitude less than the error in this estimation.

d) (Extra Credit)

```
x_ = linspace(-10,6);
figure()
plot(x_,f(x_), "k-", -5, 1, "gh", x_, f_a(x_), "b:", x, f_app, "rx", x, f_ex, "m*", linspace(2
xlim([-6,6])
ylim([-10, 200])
legend('f(x)','Given Point', 'f_a(x)','Estimated Value', 'Exact Value', 'x = 2.5 line','locatio
xlabel("x-axis")
ylabel("y-axis")
title("HW1 Extra Credit")
```



ellipsoid_volume function from problem 3

```
function  V = ellipsoid_volume(a,b,plot_title,units)
%  Calculate the volume of horizontal ellipsoidal tank
%
%  Syntax:
%     ellipsoid_volume(a,b,plot_title,units) - creates plot
%     V = ellipsoid_volume(a,b) - calculates total tank volume
```

```
%     V = ellipsoid_volume(a,b,plot_title,units) - does both
%
%  Inputs:
%     a           - vertical semi-axis
%     b           - horizontal radius
%     plot_title - string holding plot title
%     units      – optional inits string, default = ‘m’.
%
%  Output:
%     V - total volume of the tank

if nargin == 2
    V = (4/3)*pi*a*b^2;
elseif nargin > 2
    h = linspace(0,2*a);
    volume = (pi/3).*(3*a-h).*((b^2.*h.^2)./a^2);
    plot(h,volume,"k-.")
    title(plot_title)

    if nargin == 4
        xstr = strcat("Depth [",units,"]");
        ystr = strcat("Volume [",units,"³ ]");

        ylabel(ystr)
        xlabel(xstr)
    else
        ylabel("Volume [m² ]")
        xlabel("Depth [m]")
    end
else
    error("Please input a Valid Command")
end
end
```