```matlab
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Project #2
% Jason Rodriguez, Ethan Swan-Begnaud, Ian Coble, Nicolas Kudr, Marlon Coates
% ME 2543--Simulations Methods
% Spring 2023
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

clear; clc; % Clear the variable list and the command window.

% Constants
R = 287;                                        % J/kg/K Ideal Gas Constant
T0 = 300;                                       % K
V1 = 8.4*(5*(10^-5));                           % m^3
P0 = 1.013e+5;                                  % Pa
M = ((P0.*V1)./(T0.*R));                        % Mass is a constant in problem 1

Y = [(1.013*(10^5)); 0];                        % Y(P0, W0)

theta = [pi 3*pi];                              % Our independent variable

[Theta,stats] = ode45(@gPiston1,theta,Y);       % Solving P and Wout when h=0 and C=0
[Theta2,stats2] = ode45(@gPiston2,theta,Y);     % Solving P and Wout when h=50, C=0.8, and w=50
[Theta3,stats3] = ode45(@gPiston3,theta,Y);     % Solving P and Wout when h=50, C=0.8, and w=100

% Storing multiple Theta arrays is not neccessary; they are all the same.
% That's just how our code worked out.

P = stats(:,1);                                 % Storing P when h=0 and C=0
P2 = stats2(:,1);                               % Storing P when h=50, C=0.8, and w=50
P3 = stats3(:,1);                               % Storing P when h=50, C=0.8, and w=100
W = stats(:,2);                                 % Storing Wout when h=0 and C=0
W2 = stats2(:,2);                               % Storing Wout when h=50, C=0.8, and w=50
W3 = stats3(:,2);                               % Storing Wout when h=50, C=0.8, and w=100
V = vol(Theta);                                 % Solving V when h=0 and C=0
V2 = vol(Theta2);                               % Solving V when h=50, C=0.8, and w=50
V3 = vol(Theta3);                               % Solving V when h=50, C=0.8, and w=100
T = ((P.*V)./(R.*M))+T0;                        % Solving T when h=0 and C=0
T2 = ((P2.*V2)./(R.*mass2(Theta2)))+T0;         % Solving T when h=50, C=0.8, and w=50
T3 = ((P3.*V3)./(R.*mass3(Theta3)))+T0;         % Solving T when h=50, C=0.8, and w=100

% PLOTTING OUR RESULTS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

figure(1)                                               % Storing the four plots in one figure window

subplot(2,2,3)                                          % Placing Volume curve in the assigned subplot
plot(Theta,V,'-','Marker','.','Color','#e31425')        % Plotting the Volume curve
hold on                                                 % Allow us the plot multiple lines on the same subplot
plot(Theta2,V2,'-','Marker','.','Color','#146ae3')      % Plotting the w=50 Volume curve
plot(Theta3,V3,'-','Marker','.','Color','#db9a16')      % Plotting the w=100 Volume curve
xlabel('Crank Angle (Rad)')                             % Label the X axis
xticks([pi 1.5*pi 2*pi 2.5*pi 3*pi])                    % correct the X axis ticks to make it consistent with our domain
xticklabels({'\pi','1.5\pi','2\pi','2.5\pi','3\pi'})    % Label the corrected x axis ticks
ylabel('Volume (m^3)')                                  % Label the Y axis
title("Volume")                                         % Name the subplot
legend('c = 0, h = 0','w = 50','w = 100')               % Label the legends
grid on                                                 % Turn on the grid

subplot(2,2,2)                                          % Placing Work out curve in the assigned subplot
plot(Theta,W,'-','Marker','.','Color','#e31425')        % Plotting the Work out curve
hold on                                                 % Allow us the plot multiple lines on the same subplot
plot(Theta2,W2,'-','Marker','.','Color','#146ae3')      % Plotting the w=50 Work out curve
plot(Theta3,W3,'-','Marker','.','Color','#db9a16')      % Plotting the w=100 Work out curve
ylabel('Work (J)')                                      % Label the Y axis
xlabel('Crank Angle (Rad)')                             % Label the X axis
xticks([pi 1.5*pi 2*pi 2.5*pi 3*pi])                    % correct the X axis ticks to make it consistent with our domain
xticklabels({'\pi','1.5\pi','2\pi','2.5\pi','3\pi'})    % Label the corrected x axis ticks
title("Work out")                                       % Name the subplot
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legend('c = 0, h = 0','w = 50','w = 100')                 % Label the legends
grid on                                                   % Turn on the grid

subplot(2,2,1)                                            % Placing the Pressure curve in the assigned subplot
plot(Theta,P,'-','Marker','.','Color','#e31425')          % Plotting the pressure curve
hold on                                                   % Allow us the plot multiple lines on the same subplot
plot(Theta2,P2,'-','Marker','.','Color','#146ae3')        % Plotting the w=50 pressure curve
plot(Theta3,P3,'-','Marker','.','Color','#db9a16')        % Plotting the w=100 pressure curve
ylabel('Pressure (Pa)')                                   % Label the Y axis
xlabel('Crank Angle (Rad)')                               % Label the X axis
xticks([pi 1.5*pi 2*pi 2.5*pi 3*pi])                      % correct the X axis ticks to make it consistent with our domain
xticklabels({'\pi','1.5\pi','2\pi','2.5\pi','3\pi'})      % Label the corrected x axis ticks
title("Pressure")                                         % Name the subplot
legend('c = 0, h = 0','w = 50','w = 100')                 % Label the legends
grid on                                                   % Turn on the grid

subplot(2,2,4)                                            % Placing the Temperature curve in the assigned subplot
plot(Theta,T,'-','Marker','.','Color','#e31425')          % Plotting the Temperature curve
hold on                                                   % Allow us the plot multiple lines on the same subplot
plot(Theta2,T2,'-','Marker','.','Color','#146ae3')        % Plotting the w=50 Temperature curve
plot(Theta3,T3,'-','Marker','.','Color','#db9a16')        % Plotting the w=100 Temperature curve
ylabel('Temperature (K)')                                 % Label the Y axis
xlabel('Crank Angle (Rad)')                               % Label the X axis
xticks([pi 1.5*pi 2*pi 2.5*pi 3*pi])                      % correct the X axis ticks to make it consistent with our domain
xticklabels({'\pi','1.5\pi','2\pi','2.5\pi','3\pi'})      % Label the corrected x axis ticks
title("Temperature")                                      % Name the subplot
legend('c = 0, h = 0','w = 50','w = 100')                 % Label the legends
grid on                                                   % Turn on the grid

% FUNCTIONS %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%

function ODE = gPiston3(theta,Y)                           % function for solving for pressure and Wout when h=50, C=0.8, and w=100
    dM = dmass3(theta);         % kg
    V = vol(theta);             % Calling the volume function
    dV = dvol(theta);           % Calling the derivative volume function
    dX = dbBy(theta);           % Calling the derivative X function
    R = 287;                    % J/kg/K Ideal Gas Constant
    M = mass3(theta);           % kg
    T = Y(1)*V/(R*M);           % K
    b = 0.09;                   % m
    Aw = (4.*V)/b;              % m^2
    y = 1.4;                    % Unitless specific heat ratio of the gas
    qin = 2.8e+6;               % J/kg
    h = 50;                     % W/(m^2*K)
    w = 100;                    % rad/sec
    ODE = [((-y./V).*Y(1).*dV) + (((y-1).*((M.*qin)./V)).*dX) - (((y-1).*h.*Aw*(T-300))./(V.*w)) - y.*dM.*(Y(1)./M);
        Y(1).*dV];
end


function ODE = gPiston2(theta,Y)                          % function for solving for pressure and Wout when h=50, C=0.8, and w=50
    dM = dmass2(theta);         % kg
    V = vol(theta);             % Calling the volume function
    dV = dvol(theta);           % Calling the derivative volume function
    dX = dbBy(theta);           % Calling the derivative X function
    R = 287;                    % J/kg/K Ideal Gas Constant
    M = mass2(theta);           % kg
    T = Y(1)*V/(R*M);           % K
    b = 0.09;                   % m
    Aw = (4.*V)/b;              % m^2
    y = 1.4;                    % Unitless specific heat ratio of the gas
    qin = 2.8e+6;               % J/kg
    h = 50;                     % W/(m^2*K)
    w = 50;                     % rad/sec
    ODE = [((-y./V).*Y(1).*dV) + (((y-1).*(M.*qin)./V).*dX) - (((y-1).*h.*Aw*(T-300))./(V.*w)) - y.*dM.*(Y(1)./M);
        Y(1).*dV];
end
```
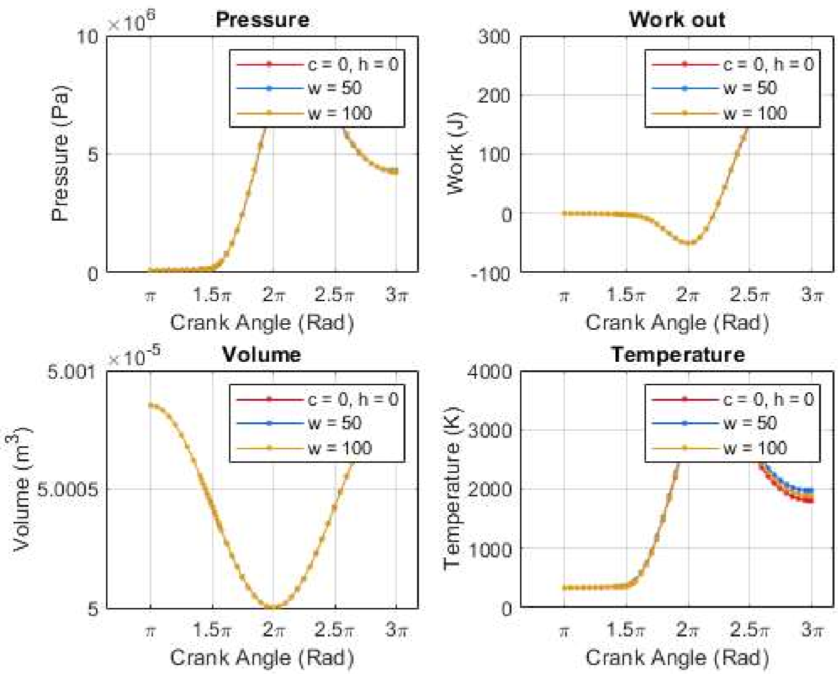

```matlab
function ODE = gPiston1(theta,Y)                        % function for solving for pressure and Wout when h=0 and C=0
    dM = 0;                     % M is a constant here, so its derivative is 0
    V = vol(theta);             % Calling the volume function
    dV = dvol(theta);           % Calling the derivative volume function
    dX = dbBy(theta);           % Calling the derivative X function
    R = 287;                    % J/kg/K Ideal Gas Constant
    T0 = 300;                   % K
    V1 = 8.4*(5*(10^-5));       % m^3
    P0 = 1.013e+5;              % Pa
    M = ((P0.*V1)./(T0.*R));    % kg
    y = 1.4;                    % Unitless specific heat ratio of the gas
    qin = 2.8e+6;               % J/kg

    ODE = [((-y./V).*Y(1).*dV) + (((y-1).*(M.*qin)./V).*dX) - y.*dM.*(Y(1)./M);
        Y(1).*dV];
end


function M = mass2(theta)
    R = 287;                    % J/kg/K Ideal Gas Constant
    C = 0.8;                    % empirical proportionaity constant
    w = 50;                     % rad/s
    T0 = 300;                   % K
    V1 = 8.4*(5*(10^-5));       % m^3
    P0 = 1.013e+5;              % Pa
    M = ((P0.*V1)./(T0.*R)).*exp(-(C./w).*(theta-pi));
end


function dM = dmass2(theta)
    % Dirivative of mass2(theta)
    dM = -(18230782191871*exp((2*pi)/125 - (2*theta)/125))/2305843009213693952;
end


function M = mass3(theta)
    R = 287;                    % J/kg/K Ideal Gas Constant
    C = 0.8;                    % empirical proportionaity constant
    w = 100;                    % rad/s
    T0 = 300;                   % K
    V1 = 8.4*(5*(10^-5));       % m^3
    P0 = 1.013e+5;              % Pa
    M = ((P0.*V1)./(T0.*R)).*exp(-(C./w).*(theta-pi));
end


function dM = dmass3(theta)
    % Dirivative of mass3(theta)
    dM = -(18230782191871*exp(pi/125 - theta/125))/4611686018427387904;
end


function V = vol(theta)
    S = 0.08;                   % m
    l = 0.12;                   % m
    r = 8.4;                    % Unitless Compression Ratio
    e = S/2*l;                  % Heat Transfer Parameter
    V0 = 5*(10^-5);             % m^3

    V = (V0).*(1+((r-1)./2.*e).*(1+e.*(1-cos(theta))-(1-(e.^2).*(sin(theta).^2)).^(1./2)));
end


function dV = dvol(theta)
    % Derivative of voll(theta)
    dV = (37.*sin(theta))./1800000 + (37.*cos(theta).*sin(theta))./(5400000.*(1 - sin(theta).^2./9).^(1./2));
end
```

```
function dX = dbBy(theta)
    % Derivative of bBy(theta) (Unused)
    thetas=(3*pi)/2;
    thetab=pi;
    if (pi <= theta) && (theta < thetas)
        dX = 0;
    elseif (thetas <= theta) && (theta <= (thetas+thetab))
        dX = sin(((3*pi)/2 - pi*theta)/pi)/2;
    else
        dX = 0;
    end
end
```



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