EE362 HW#1 SPRING ?

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NAME: *EMMETT BROWN*

STUDENT NUMBER: 1244453

Change your .m file name to the following: name_surname_ID_hw1.m

```
% Most of the operations are already given to you for simplicity.
% Uncomment the already given solutions to use them, i.e, Delete the
 "%" in
% front of such lines.

% Use "fprintf" function to display results
% Do not display the results of long arrays!!!

% Please add axis names, legends, titles etc. in all your plots

% Use the already defined variable names whenever possible

% Show the unit for each variable

% Examine the whole template before you start

% Delete the hints, guidelines etc. given in this template when you
 prepare
% your solution. Please submit a clean version without any unnecessary
 parts.

% Note that:
% Indexes in MATLAB start at 1, not 0
% Elementwise operations:
% http://www.mathworks.com/help/matlab/matlab_prog/array-vs-matrix-
operations.html
```

Q1)

```
%At same reason you want to buy 100hp (135kW) Y-connected 460V three-
phase 4-pole 50-Hz induction
%machine via Alibaba
%Link => https://bit.ly/2HBiWE2
%Of course, as a smart engineer you never blind buy anything at the
 internet
%you request some test result from the company.

%No-load Test
P_nl=1.22*10^3; %Watts
V_nl=448; %line to line voltage
I_nl=32.1; %Ampere

%Locked Rotor Test for 50 Hz
P_lr=143*10^3; %Watts
V_lr=450; %line to line voltage
I_lr=727; %Ampere

%Per stator phase dc resistance
R_s=29.2*10^-3;

%Other Parameters
Vs=460; %Rated supply voltage (line to line)
q = 3; % Number of phases
fe = 50; %Hz
poles = 4;
```

PART A

```
%Calculate ac resistance of stator per phase for 50-Hz
R_s_ac = 1.1*R_s;
fprintf('Stator ac resistance is %d Ohm.\n', R_s_ac);

%Windage and friction losses are 82W. Find the core loss.
P_fw=82;
P_core=P_nl-P_fw-q*I_nl^2*R_s_ac;
fprintf('Core loss is %d Watts.\n', P_core);

%Find R_core and X_m,  clearly indicate your assumption
R_c = q*(V_nl^2)/P_core
G = I_nl/V_nl
Y_c=1/R_c;
B_sq =G^2+Y_c^2;
Xm=1/sqrt(B_sq)
fprintf('Core resistance is %d ohm and core reactance is j%d.\n',
 R_c,Xm);

%State your assumptions here
```

Stator ac resistance is 3.212000e-02 Ohm.
Core loss is 1.038710e+03 Watts.

```
R_c =

  579.6730


G =

    0.0717


Xm =

   13.9523

Core resistance is 5.796730e+02 ohm and core reactance is j1.395234e
+01.
```

```
%I assume that impedance of stator winding is much less than core
 impedence.

%Find winding paramaters X_1, X_2 and R_2. Assume X_1 = X=2
P_phase = P_lr/q
R_2=P_phase/I_lr^2-R_s_ac
Z=V_lr/I_lr
X_2sq = Z^2-R_2^2;
X_2 = sqrt(X_2sq);
X_1=X_2;
fprintf('X_1 = ,%d X_2 = %d, R_2 = %d\n', X_1,X_2,R_2);

%Calculate ns both rpm and rad/sec
omegas= 4*pi*fe/poles;
ns = 120*fe/poles;
fprintf('ns is %d rpm and omegas is %d rad/sec.\n', ns, omegas)

%Find the thevenin equivalent parameters
Z1eq = j*Xm*(R_s_ac+j*X_1)/(R_s_ac+j*(X_1+Xm));
R1eq = real(Z1eq);
X1eq = imag(Z1eq);
V1eq = abs(Vs*j*Xm/(R_s_ac+j*(X_1+Xm)));
fprintf('Equivalent impedance is %d, resistance %d ohm \n, reactance
 %d ohm \n, voltage, %d volts', Z1eq, R1eq, X1eq, V1eq)
```

```
P_phase =

   4.7667e+04


R_2 =

    0.0581


Z =
```

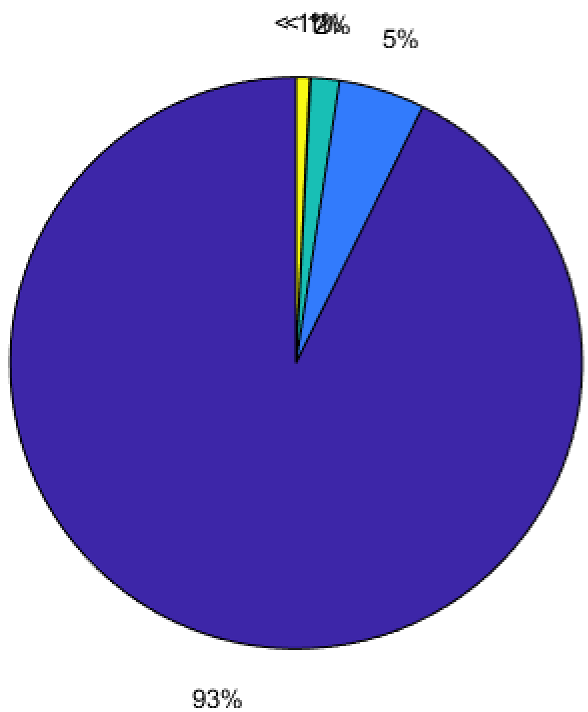
```
    0.6190

X_1 = ,6.162524e-01 X_2 = 6.162524e-01, R_2 = 5.806742e-02
ns is 1500 rpm and omegas is 1.570796e+02 rad/sec.
Equivalent impedance is 2.945997e-02, resistance 2.945997e-02 ohm
, reactance 5.902499e-01 ohm
, voltage, 4.405409e+02 volts
```

Part B

```
Now you know every circuit parameter of the induction machine.Calculate
all the losses and build an pie-
diagram when s = 0.05 at rated voltage and power.
Assume current on magnetizing branch is negligible small.

s=0.05;
P_rated = 135*10^3;
%Stator cupper loss
I2=abs(V1eq./(Z1eq+j*X_2+R_2./s));
P_cu1=I2^2*R_s_ac
%Air-gap power
P_gap=P_rated-P_cu1-P_core-P_fw;
%Rotor cupper loss
P_cu2=s*P_gap;
%Mechanical power
P_mech=(1-s)*P_gap;

%Do not forget MATLAB pie function takes array as argument. First you
%should define an array that consist of data that you used.
Data = [P_mech,P_cu2,P_cu1,P_fw,P_core]
figure;
legend('Mechanical Output','Rotor Cupper Loss','Stator Cupper
 Loss','Friction and Windage Loss','Core Loss')
pie(Data);

%Calculate the efficency, Now change the slip to 0.1 then 0.2. Comment
 on
%change. Comment relationship between slip and efficiency
```

```
P_cu1 =

   2.1693e+03


Data =

   1.0e+05 *

    1.2512    0.0659    0.0217    0.0008    0.0104

Warning: There is no axes with which to associate a legend.
```

```
ans =

  0×0 empty GraphicsPlaceholder array.
```



Comment here

```
%With increasing slip efficiency drop
```

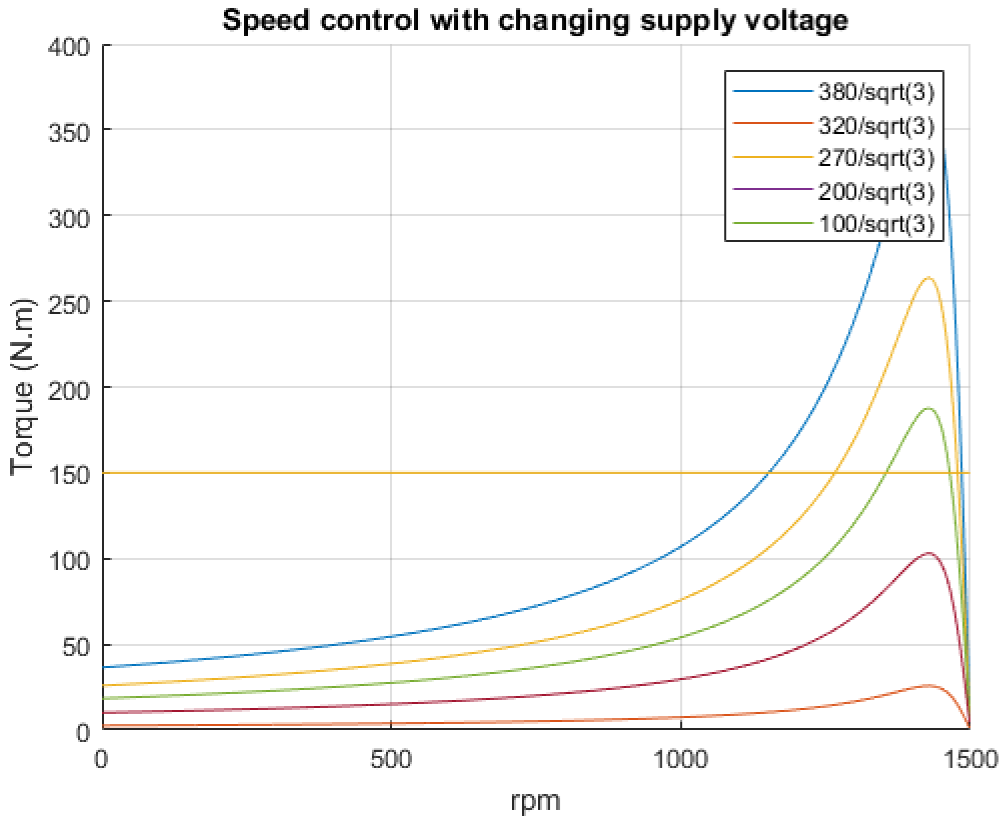
Q2)

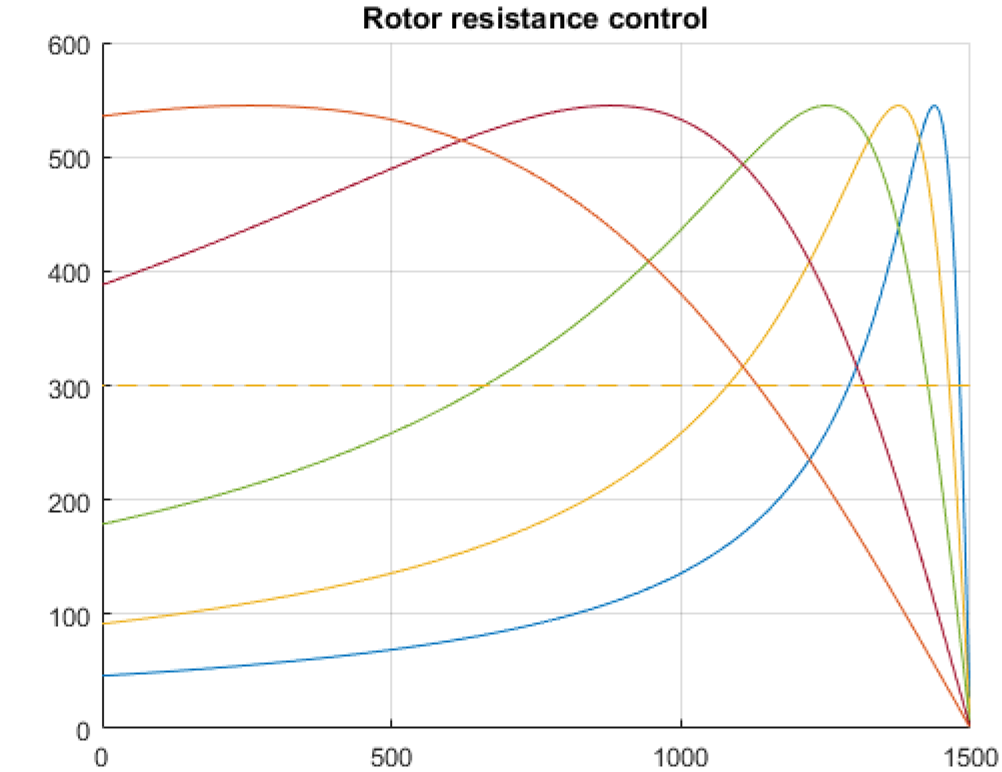
Plot torque vs speed graph with different thevenin voltages (Not supply voltages

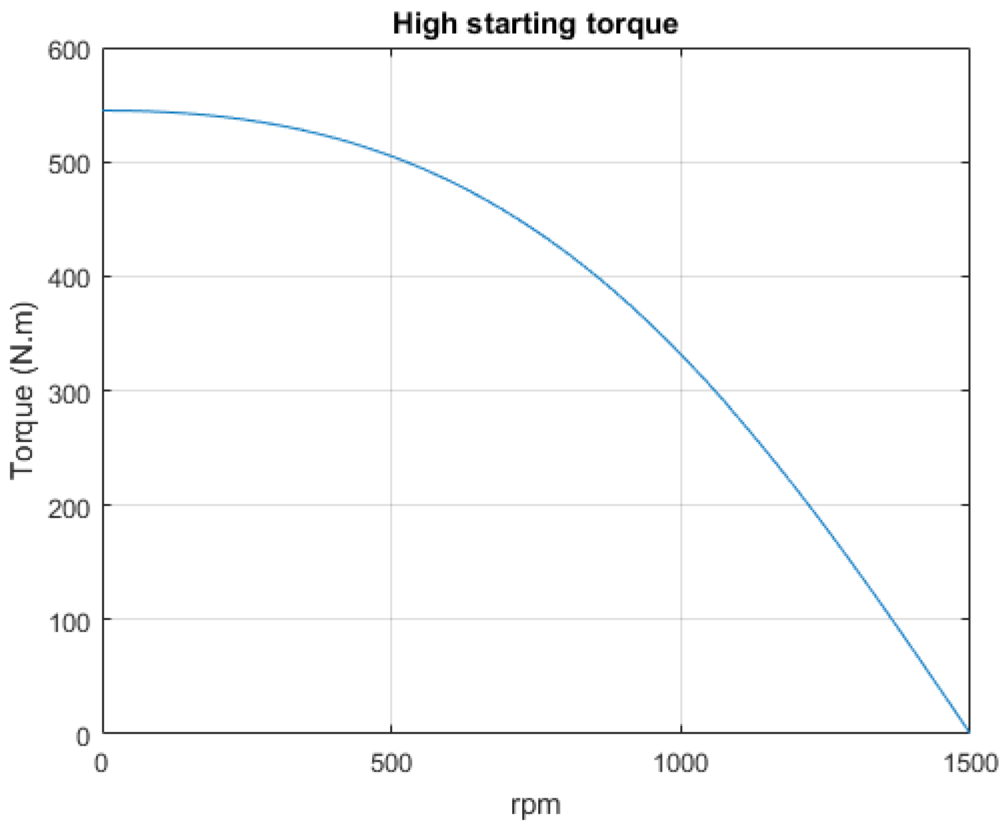
```
%you can use variable that you found Q1). For loop can be helpful. Use
 1000 data points slip vector.
%Give
% Vs_vector = [380/sqrt(3),320/sqrt(3),270/sqrt(3),200/sqrt(3),100/
sqrt(3)]
figure;
hold on;
load_linear(1:1000) = 150;
for m = 1:5
    if m == 1;
        V1eq=380/sqrt(3)
    end
    if m == 2;
```

```
        V1eq=320/sqrt(3)
    end
    if m == 3;
        V1eq=270/sqrt(3)
    end
    if m == 4;
        V1eq=200/sqrt(3)
    end
    if m == 5;
        V1eq=100/sqrt(3)
    end
    s = .001:.001:1; %slip
    rpm = ns*(1-s);
    I2=abs(V1eq./(Z1eq+j*X_2+R_2./s));
    T = q*(I2.^2)*R_2./(s*omegas);
    plot(rpm,T,rpm,load_linear)
    hold on;
    grid on;
end
title('Speed control with changing supply voltage')
legend('380/sqrt(3)','320/sqrt(3)','270/sqrt(3)','200/sqrt(3)','100/
sqrt(3)')
xlabel('rpm')
ylabel('Torque (N.m)')
hold off;

%Plot torque vs speed graph with differents R_2 (0.1,0.2,0.5,1,1.5)
%For loop may help you.
load_linear(1:1000) = 300;
figure;
hold on;
Vleq=460/sqrt(3) %uncomment
for m = 1:5
    if m == 1;
        R_2=0.05;
    end
    if m == 2;
        R_2=0.1;
    end
    if m == 3;
        R_2=0.2;
    end
    if m == 4;
        R_2=0.5;
    end
    if m == 5;
        R_2=1.0;
    end
    s = .001:.001:1; %slip
    rpm = ns*(1-s);
    I2=abs(Vleq./(Z1eq+j*X_2+R_2./s));
    T = q*(I2.^2)*R_2./(s*omegas);
    grid on;
    plot(rpm,T,rpm,load_linear,'--');
```

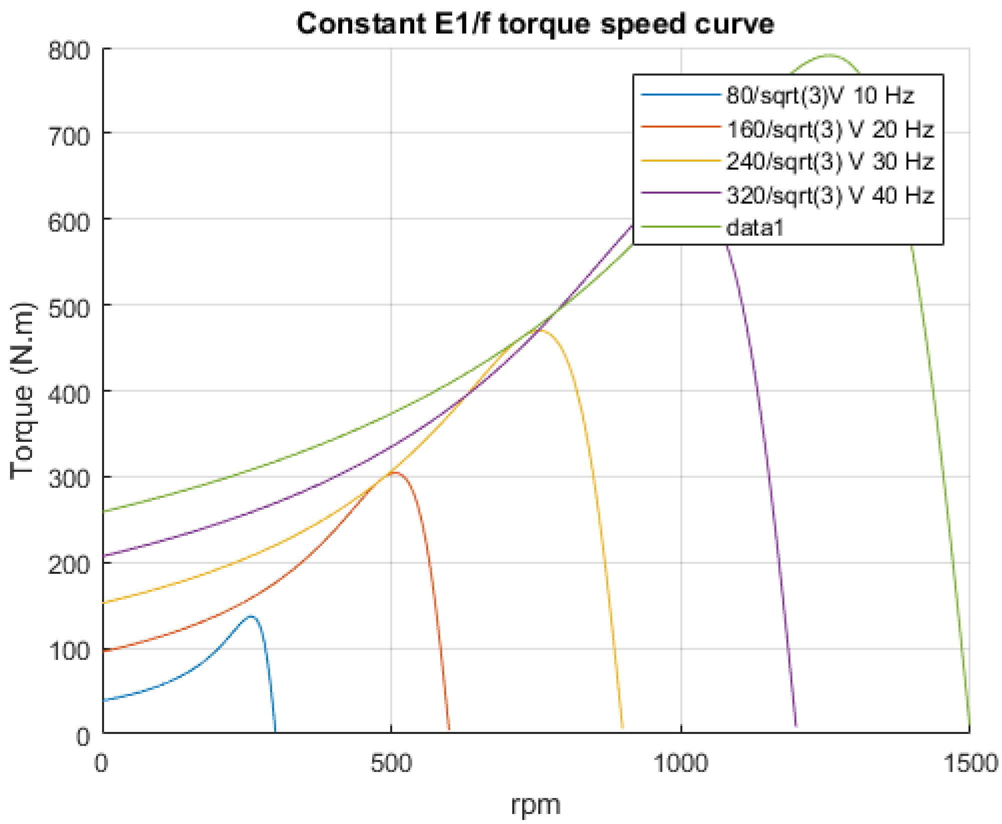
```
    title('Rotor resistance control');
end
hold off;

% Now you want to change your machine operation characteristic such as
 you
% want a high starting torque. Change the necessary parameter and plot
 new
% torque-speed graph
% I increased the rotor resistance by adding extra resistance to
 rotor.
figure;
R_2=1.2;
s = .001:.001:1; %slip
rpm = ns*(1-s);
I2=abs(Vleq./(Z1eq+j*X_2+R_2./s));
T = q*(I2.^2)*R_2./(s*omegas);
plot(rpm,T);
title('High starting torque');
ylabel('Torque (N.m)')
xlabel('rpm');
grid on;
%Plot torque vs speed graph using constant v/f topology. Take R_2 as
 0.05 ohm%


V1eq =

  219.3931


V1eq =

  184.7521


V1eq =

  155.8846


V1eq =

  115.4701


V1eq =

   57.7350


Vleq =

  265.5811
```


Speed control with changing supply voltage
400
350
300
250
200
150
100
50
0
Torque (N.m)
0
500
1000
1500
rpm
380/sqrt(3)
320/sqrt(3)
270/sqrt(3)
200/sqrt(3)
100/sqrt(3)


Rotor resistance control
600
500
400
300
200
100
0
0
500
1000
1500

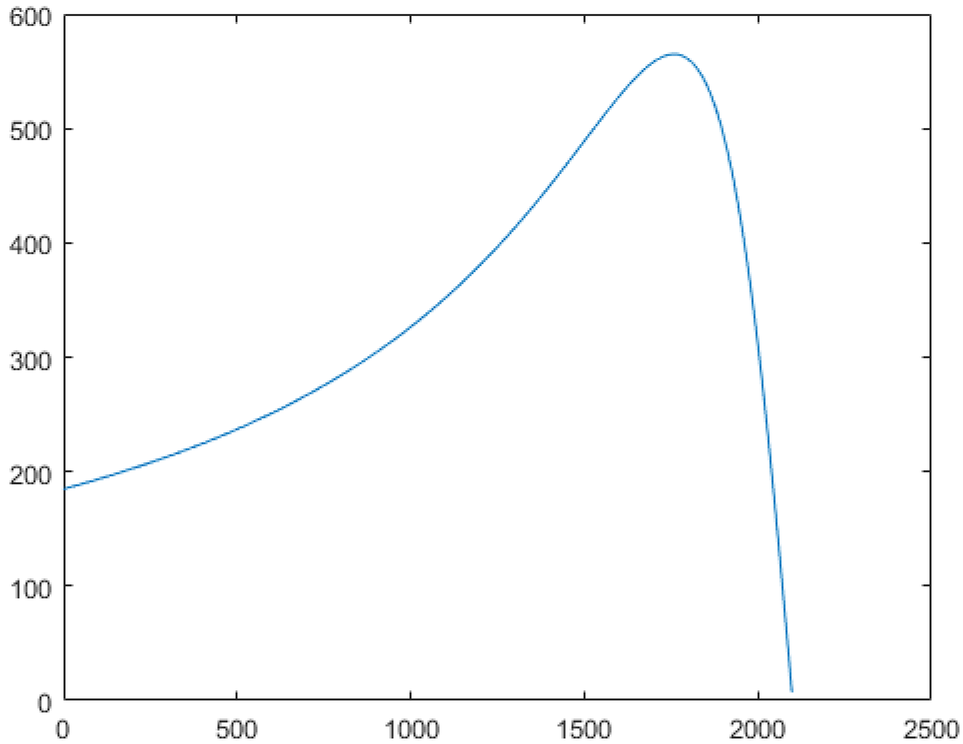

High starting torque
Torque (N.m)
600
500
400
300
200
100
0
0
500
1000
1500
rpm

```
R_2=0.1;
figure;
hold on;
for m = 1:5
    if m == 1;
        fe=10;
        V1eq = 80/sqrt(3);
    end
    if m == 2;
        V1eq = 160/sqrt(3);
        fe=20;
    end
    if m == 3;
        V1eq = 240/sqrt(3);
        fe=30;
    end
    if m == 4;
        V1eq = 320/sqrt(3);
        fe=40;
    end
    if m == 5;
        V1eq = 400/sqrt(3);
        fe=50;
    end
    hold on;
    grid on;
    s = .001:.001:1; %slip
    omegas= 4*pi*fe/poles;
    ns = 120*fe/poles;
    rpm = ns*(1-s);
    X_2 = X_2*m/5;
    I2=abs(V1eq./(Z1eq+j*X_2+R_2./s));
    T = (q*(I2.^2)*R_2)./(s*omegas);
    title('Constant E1/f torque speed curve');
    xlabel('rpm');
    ylabel('Torque (N.m)');
    legend('80/sqrt(3)V 10 Hz','160/sqrt(3) V 20 Hz','240/sqrt(3) V 30
 Hz','320/sqrt(3) V 40 Hz','400/sqrt(3) V 50 Hz')
    plot(rpm,T)
end
hold off;

Warning: Ignoring extra legend entries.
Warning: Ignoring extra legend entries.
Warning: Ignoring extra legend entries.
Warning: Ignoring extra legend entries.
Warning: Ignoring extra legend entries.
```




```
%Comment on all control method considering the linear load?
%Compare them briefly?

%Now you want to increase machine speed above the synchronous speed.
%Propose a method. Obtain 2000 rpm speed where 0<s<0.05. Plot torque-speed
%curve.
fe = 70;
Vleq = 460/sqrt(3);
omegas= 4*pi*fe/poles;
ns = 120*fe/poles;
rpm = ns*(1-s);
I2=abs(V1eq./(Z1eq+j*X_2+R_2./s));
T = (q*(I2.^2)*R_2)./(s*omegas);
figure;
plot(rpm, T);
speed = ns*(1-0.05);
fprintf('Speed at s=0.05 is %d, ns is %d therefore 2000 rpm in this
 slip range',speed,ns)
```

Speed at s=0.05 is 1995, ns is 2100 therefore 2000 rpm in this slip range



After you finished

Run the following command from Matlab terminal (command window) Generate a report of your .m file as pdf and ONLY upload the PDF file to ODTUClass.

```
% publish('name_surname_ID_hw1.m','pdf')
```

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