Problem Set #1.

(1.1) Read the article at the following web site:

"www.memagazine.org/backissues/may97/features/mechtron/mechtron.html"

Write a 1-paragraph statement in your own words to describe "mechatronics". Imagine you are explaining it to your grandparents, none of whom have a technical background.

(1.2) Do text problem 1-2.

![Graph showing speed vs throttle](image)

Normal driver moves throttle position (via pedal) around the desired speed position. Also, there are ups and downs in the road, wind loads might vary, etc.

Inputs: road, elevation, wind conditions, desired speed

Outputs: actual speed
(1.3) Do text problem 2-3.

\[ \frac{\tau}{\omega} \text{PUMP} \frac{P}{Q} \]

Inputs: P and \( \omega \)

Outputs: Q and \( \tau \)

(1.4) Do text problem 2-8.

\[ \frac{dE}{dt} = P. \quad \text{If } P(t) \text{ is constant,} \]

\[ E = P \times t. \]

\[ 100 \times t = 10 \times 9.8 \times 30 \quad \{\text{all units} \text{ MKS}\} \]

\[ t = 29.4 \text{ s} \]

(1.5) Do text problem 2-10.

\[ \tau \cdot \omega = P \cdot Q \]

\[ w = \frac{P}{\tau} \times Q = \frac{7.0 \times 10^6 \text{ N/m}^2}{5.0 \text{ N-m}} \times Q \]

\[ w = 1.4 \times 10^6 \text{ Q} \]

[\( w \) = \( \text{rad s}^{-1} \)]
(1.6) Assume we are matching a marine engine and a propeller. "T" denotes torque; "w" denotes angular velocity. Subscript "s" denotes supply (i.e., engine); subscript "d" denotes demand (i.e., propeller).

Supply characteristic: \[ T_s = a_w^2 + b_w + c \]

Lab data show that
\[ T_s = 1000 \quad \text{at} \quad w = 100 \]
\[ T_s = 0 \quad \text{at} \quad w = 0 \]
\[ T_s = 0 \quad \text{at} \quad w = 200 \]

Demand characteristic: \[ T_d = C_d w^2 \]

Lab data show that \[ T_d = 850 \quad \text{at} \quad w = 120 \]

Where are the torque-angular_velocity operating points?

Use MATLAB to verify your solution to the problem. Include a plot of the supply and demand curves. Make a hard copy of your MATLAB results to hand in.
HW #1 PROBLEM 6: Analytical Solution.

ENGINE $\frac{T_s}{W} \rightarrow \frac{T_d}{W} \rightarrow$ PROP $T_s = T_d$

(1) Find $C_d$ from the data:

$$850 = C_d \times (120)^2 \Rightarrow C_d = 0.059$$

(2) Find $a, b, c$ from the data:

(i) $0 = a \cdot 0 + b \cdot 0 + c \Rightarrow c = 0$

(ii) $0 = a(200)^2 + b(200)$

(iii) $1000 = a(100)^2 + b(100)$

$$0 = 200a + b \quad \Rightarrow \quad a = -0.1$$
$$10 = 100a + b \quad \Rightarrow \quad b = 20$$

(3) Thus $T_d = 0.059 \times w^2$ and $T_s = -0.1w^2 + 20w$

At the operating point $T_d = T_s$, so

$w = 125.8 \ (or \ w = 0)$

and $T_d = T_s = 934$. 
% File: Marine engine / propeller matching 
% hw01 problem 6 
% 
w= [ 0:1:200 ];     % set up the speed vector (omega) 
% 
% Set up the Td vector 
Cd= 0.059       % from Cd= 850/(120^2), data given 
for i= 1:1:201 
    Td(i)= Cd*(w(i)^2); 
end 
% 
% Set up the Ts vector 
% You could use MATLAB to find coefficients a,b,c from these data 
% 1000= a*(100^2) +b*100 +c 
% 0= a*0 +b*0 +c 
% 0= a*(200^2) +b*200 +c 
% A= [ (100^2), 100, 1; 
%       0 , 0, 1; 
%     (200^2), 200, 1 ] 
% u= [ 1000, 0, 0 ]'       % note transpose to make a column vector 
% x= inv(A)*u            % solves A*x= u 
% a= x(1) 
% b= x(2) 
% c= x(3) 
% a= -0.1 
% b= 20.0 
% c= 0.0 
for i= 1:1:201 
    Ts(i)= a*(w(i)^2) +b*w(i) +c; 
end 
% 
plot(w,Ts,'k- ',w,Td,'k-- '); 
grid on; 
title('engine-propeller matching'); 
legend('Ts','Td','Location','NorthWest'); 
xlabel('w, speed'); 
ylabel('Ts, Td, torques'); 
% pause; 
% 
print table near intersection to get better data 
string1= 'w, Td, Ts' 
for i= 1:1:11 
    j= i+119; 
    v(i,1)=w(j); 
    v(i,2)=Td(j); 
    v(i,3)=Ts(j); 
end 
v 
%
Output from running the .m file:
(listed in 2 columns)

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<th>v</th>
</tr>
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