Hydraulic Systems

- **Systematic procedure for generating models of Hydraulic Systems**  This is a must learn. You need to know this steps to create a model and follow them in an structured and ordely fashion. Please go over the write up procedure for the hydraulic systems on this link and redo the example so you can retain this.

- **Hydraulic Systems Simulation using Bond Graph Modeling**. Go over the slides and see how the model is constucted. Concentrate how the geometry and the set of elements is put together. Then go over how the water squeezer used to stop a plane on an aricraft carrier is represented.

- **Hydraulic Systems Modeling and Simulation using Block Diagrams**. This is a link for materials background on how to do models of hydraulic systems using the block diagram approach. You should review this and use it as a reference for your lab report.

State Space Models

- You must know the concept of State Space form of the differential equations of a mechatronics system. You must know how to obtain the A, B, C, D matrices.
  - Using the first order differential equations, rearrange them into matrix form to produce the A and B matrices.
  - Using the output equations rearrage them to produce the C and D matrices. If you do not have this clear beyond the explanation in class please ask me in class or in office hours.

Assignments

1. **Homework.** (Due Tuesday, April 4, 2017)
   Please do the following problems from your textbook 4-7, 4- 8, 4- 9, 4-10, 4-11, 4-15.
   For problems 4-10, 4-11, 4-15. Develop the state space form using CAMPG and generate the block diagrams from the first order equations.

   Please scan, transfer them over and keep your originals.
3. - **Computer Assignment.** (Due on Tuesday April 11, 2017). Shown below is the description of a specific simulation problem.

4.- **Next Quiz.** Thursday April 13, 2017
Please do not send your assignments via email, except on emergencies
ME171 Lab  
CAMP-G/MATLAB – Hydroelectric Power Plant with Surge Tanks

POWER PLANT
A hydroelectric power plant has a turbine that delivers power when the flow, Qo, is 1 cubic meter per second. When the generator trips off the line, Qo is reduced to zero in 0.1 seconds, to prevent over speeding and destruction of the turbine. There are two surge tanks to prevent excessive pressures in the standpipe once the gate/valve at the turbine is closed when the generator goes off line.

OBJECTIVES:
1. Design the tanks so that the areas will be such that no overflowing will occur when Qo is shut down.
2. Generate graphical displays using the computer and show the levels of water in the tanks and the corresponding pressures in the standpipe segments.
3. Also use tabular displays to show the peak pressure in the standpipes and the peak height is the tanks.

Model of Physical System
DESIGN CRITERIA

Careful consideration must go into the modeling of this system when the water flow is cut to zero. This is a nonlinear operation as it induces a switch or discontinuity.

It is necessary to create a function or a set of conditional statements that will fully represent the nonlinearity for the flow source Qo. In SIMULINK, this can be done by creating an input function using the built in sources and adding them together. While, in MATLAB this can be done by using a set of conditional statements.

ADDITIONAL RELATIONS

The equations for this system are as follows:

\[ C = \frac{A}{(g \cdot rho)} \quad \text{Tank capacitance} \]
\[ I = \frac{(rho \cdot L)}{A} \quad \text{Pipe Inertia} \]
\[ R = 10^5 \frac{(H/m^2)/(m^3/sec)} \quad \text{Pipe internal resistance} \]
\[ \delta P_1 = rho \cdot g \cdot H_1 \quad \text{Variation in Pressure} \]
\[ \delta P_2 = rho \cdot g \cdot H_2 \quad \text{Variation in Pressure} \]

Seen below in the Figure, is the bond graph model for this system.

The bond graph from the previous Figure, above, is input into CAMPG as done in earlier methods and then interfaced with Matlab. This is seen below.
EQUATIONS
The equations for this system are as follows:

\[ C = \frac{A}{g \rho} \]
\[ I = \frac{\rho L}{A} \]
\[ R = 10^5 \frac{(H/m^2)}{(m^3/sec)} \]
\[ \Delta P_1 = \rho g H_1 \]
\[ \Delta P_2 = \rho g H_2 \]

For your lab report:

1. Using your computer simulation results, design the tanks so that there will not be overflows when \( Q_0 \) is shut down at the turbine. Try several standpipe diameters. What are the areas and the diameter of the standpipes that fulfill this requirement?

2. Generate graphical displays using the computer and show the levels of water in the tanks and the corresponding pressures in the standpipe segments from beginning to end. Generate enough plots to indicate clearly your solution. Start with the parameters given and then modify them to fit the design requirements.
2. Using tabular displays show the peak pressure in the standpipes and the peak height is the tanks.

4. Using the first order equations produced by CAMPG (use campgsym.m)
   - Generate the State Space form for the state variables and the outputs.
   - From the first order equations, generate a block diagram in SIMULINK.
   - Using the parameters values and results from your CAMP/MATLAB simulations, demonstrate that the block diagram simulation will produce the same answers in SIMULINK.

EXTRA CREDIT (Turn it in separately)

If you solve the same problem in MATLAB/SIMULINK using the block diagram approach and add a report to show:
   - Equations of Motion
   - State Space Form
   - SIMULINK Block Diagram
   - You verify your BG model results; you can get, apart from the lab grade:
     - 3 points towards improving your past quiz grades. (Individual work please.)

Since this is a consultation activity, you can use the approach suggested on the link on the web page or you can use ANY OTHER textbook or source to guide yourself. Keep in mind that you already know the answers and the basic structure from you lab work and what you are trying to do is to understand the mechanics of the other method, to compare it and to verify your answers.

WHAT TO TURN IN:
Please turn in a directory by creating and transferring files that contain:
   - A PowerPoint or Word Files explaining and describing what you did and the steps you follow to solve the problem described. You may want to take screen shots of the work and paste them in your document as you go on.
   - The CAMPG (.bg), MATLAB (.m), SIMULINK (.mdl) files used

Name your directory Yourlastname_ME171F16_Hydraulic_System

Please turn electronically to the path indicated on Voyager
   …\voyager\faculty\granda\me171