Study Guide and Assignment 3

Suggestions for you to study the material on my web page

Modeling Software CAMPG/MATLAB

- **The Computer Aided Modeling Software CAMPG/MATLAB**
  
  Introduction to CAMPG/MATLAB. Please go over and understand the process

- **CAMPG/ACSL (Advanced Continuous Simulation Language)**
  
  This is another interface that CAMPG has to another simulation language. The format procedure of simulations is a little different than with MATLAB but the results will be the same.

Mechanical Systems

- **Systematic procedure for generating models of Mechanical Systems**
  
  This is a must learn. You need to know this steps. Please go over and redo the example so you can retain this.

- **Modeling of Mechanical Systems**
  
  Suggest go over and look at the example development

Electrical Systems

- **Systematic procedure for generating models of Electrical Systems**
  
  This too is a must learn. You need to know these steps so that you can create models of circuits on your own and from scratch.

- **Electrical Systems Simulation**
  
  Suggest go over the slides and review with the lecture notes done in class.

Computer Simulation

- **Computer Simulation using CAMPG and ACSL (Advanced Continuous Simulation Language)**
  
  Explanation on how to do a simulation using CAMPG/ACSL

Assignment.

1. – Homework 3 (Due Tuesday, March 7, 2017)

   A) Please do these on paper 4-1.4-2, 4-3, 4-4. Please scan and keep your originals.

   B) Using the systems in problems 4-1 (e) and 4-4(a)

      a) Generate a Bond Graph model
b) Write the constitutive equations of each element explicitly following the power flow and the causal marks. Include the derivatives (Differential equations)
c) Substitute and reduce the derivatives (Differential equations to single expressions, Cauchy form)
d) Generate a Block diagram for the system so that they can go in Simulink

2. - **Computer Assignment.** (Due on Tuesday March 14, 2017). Shown below is the description of a specific modeling, design and simulation problem.

   Please do not send your assignments via email, except on emergencies

3. - Plan ahead. Quiz Thursday, March 16, 2017
DESIGN OF SEAT BELTS FOR VEHICLE CRASH TEST

PROBLEM:
The dummy in the figure shown below is driving his new VW-Rabbit into a wall! Will his shock-absorbing bumper ($k_2$, $b_2$) and his seat belts ($k_1$, $b_1$) prevent him from hitting the windshield without breaking his collarbone?

DATA ON INJURIES (SAE Handbook)
Seat belts must be tested to 3000 lbs. ($1.334 \times 10^4$ N)
Chest can sustain a force of 1500 lbs. distributed over 30 in$^2$.
Seat belt effective area = 30 in$^2$
Shoulder strap-seat belt combination = 60 in$^2$

PHYSICAL PARAMETERS

\[
\begin{align*}
M &= 1500 \text{ Kg}, \quad k_1 = 1 \times 10^4 \text{ N/m}, \quad b_1 = 500 \text{ N-s/m} \\
m &= 100 \text{ Kg}, \quad k_2 = 3 \times 10^3 \text{ N/m}, \quad b_2 = 8 \times 10^4 \text{ N-s/m}
\end{align*}
\]

Shown above is an engineering model of the car, person, seat belts, bumper etc. Transform the engineering model of reality into a computer model for simulation using SIMULINK and CAMPNG/MATLAB. Perform interactive simulation and generate numerical and graphical outputs using considering the design criteria. Interpret the results make design decisions and perform simulation of several models in an interactive way.

DESIGN CRITERIA
The simulation must produce a design of the seat belts and the bumper so that it satisfies the following conditions:

1. Passenger doesn't hit the windshield if he travels at 25 and at 55 mph.

2. We must control the force acting on his chest and waist at 25 mph and at 55 mph. Compare the data on injuries and determine if chest or internal injury occurs. If so that situation must be avoided. (1) If he wears a seat belt only; (2) If he wears a seat belt and a shoulder strap. What is the force acting on his chest and waist at 25 mph and at 55 mph?
3. - What is the "critical", the maximum velocity (when no injury occurs) when impact occurs? Hitting the windshield, chest injury, internal injury, seat belt failure, and strap failure, any of these should not occur.

4. – What happens if he travels without a seat belt. How long does it take for him to hit the windshield at 25 mph, 40 mph, and 55 mph? What is the force acting on him on impact at 25 mph, 40 mph, and 55 mph?

Hints:
Understand which variables represent the displacement of the head and get values to determine if the head hit the windshield. What is its maximum displacement? Compare it to the value allowed. Display graphically the values for the force actin on his body and that on his chest. Do the values produce injury, if so, change the design of the seat belts or the bumper and run a new simulation.

Use a table similar to the sample shown below in order to appreciate the numbers and make a determination of the best design.

<table>
<thead>
<tr>
<th>INITIAL VELOCITY</th>
<th>N OF BELTS</th>
<th>BUMPER K2</th>
<th>BUMPER B2</th>
<th>SEAT BELTS K1</th>
<th>SEAT BELTS B1</th>
<th>DUMMY E1</th>
<th>DUMMY Q9</th>
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<tbody>
<tr>
<td>25</td>
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YOUR LAB REPORT:

Explain the development of your computer model, simulation and conclusions from beginning to end. You can use a series of screen shots.

1. **Bond Graph Modeling Approach:**
   a) Using the CAMPG/MATLAB system, perform a simulation and design the bumper and the seat belts so that the head of the dummy does not travel more than 100 centimeters and that the forces exerted on him by the seat belts do not exceed the limits expressed above. What is your best design? Follow the requirements and indications above.

   b) Generate enough plots to indicate clearly your solution by displaying the variables relevant to your design. Start with the parameters given and then modify them to fit the design requirements.

2. **Block Diagram Approach:**

   a) Derive (by hand) the differential equations of the system in second order form starting with a free body diagram.

   b) Using the equations in a), perform substitutions that will allow you to obtain the equations in first order form (State Space form)
c) Using the first order equations obtained on b), Generate a Simulink Model using the first order equations by transforming them into a block diagram.

d) Using the parameters values and results from your CAMP/MATLAB simulations, demonstrate that the block diagram models in SIMULINK using the equations derived from the free body diagram produce the same results as the automated bond graph model.

3. 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

4. Name your directory Yourlastname_ME171S14_SeatBelts

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

3