The Flying-Chardonnay Final Challenge (replacing the Exam)

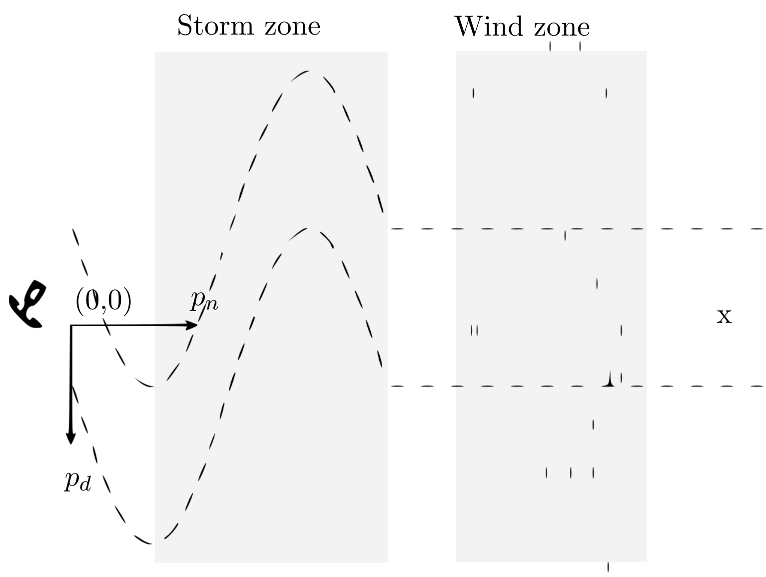
Due date: January 31, 2023

Exercise 1

This exercise is the endgame of a series of activities leading to the implementation of an interactive MIMO control law for the `Flying-Chardonnay`, an automatic drink delivery device. This exercise exploits the MATLAB model implemented previously, and follows the following configuration its parameters (in S.I. units):

$m_d = 1 \pm 5\%$	$m_c = 1 \pm 5\%$	$l = 1 \pm 5\%$	$l_d = 1 \pm 5\%$	$J = 0.1 \pm 5\%$	$C_D = 0.1$	$g = 10$

The challenge support MATLAB files are available at the course LMS page (Lecture 6), under the tag `[Exercise Support] The Flying-Chardonnay Final Challenge`. After download, run the `main.m` script to execute the challenge with an example design (see Figure below). A correct execution will display an animation at the end (and also record a `animation.avi` video file), and print the final drink level percentage to the command window.



The objective is to design a MIMO controller that will drive the drink delivery device from its initial position all the way to the `x` spot without violating strict trajectories boundaries. The winner of this challenge will be the design which gets to the finish line with the most percentage of drink. These are the mechanisms in which drink might spill:

1. Inclination of cup spills drink;
2. There's a drink leakage rate of 1.5% per second;
3. Out-of-bounds violation empties the cup.

Additionally, the controller should be tolerant to noise and constant wind disturbances. To model noise, the simulator adds to all sensors output a sine signal of frequency 1KHz while in the *Storm Zone*. To model constant wind disturbance, the simulator adds external downward wind (2m/s) at the *Wind Zone*. Finally, your controller should also be robust against parameters uncertainty as given in the table above.

Do not modify the Simulink `Chardonnay Dynamics` block unless you want to test robustness towards parameters variation (e.g., mass m, inertia J, pendulum length l)!

Feel free to modify the Reference Trajectory and Controller systems as you will! Any control design technique is allowed, or you can use Eigenstructure Assignment as taught in class.

1. **(20pts)** Design a controller that performs the mission with a final percentage of drink larger than 65%.

In your written report, add the design choices you made, as well as MIMO margins (ST-disk and multiloop), and σ-plots of closed-loop and sensibility transfer matrices. Please also add the percentage of drink associated with your final design on nominal conditions. Additionally, please post your final simulation video on the LMS link under the tag `[Challenge Submission] Submit your video here!`.

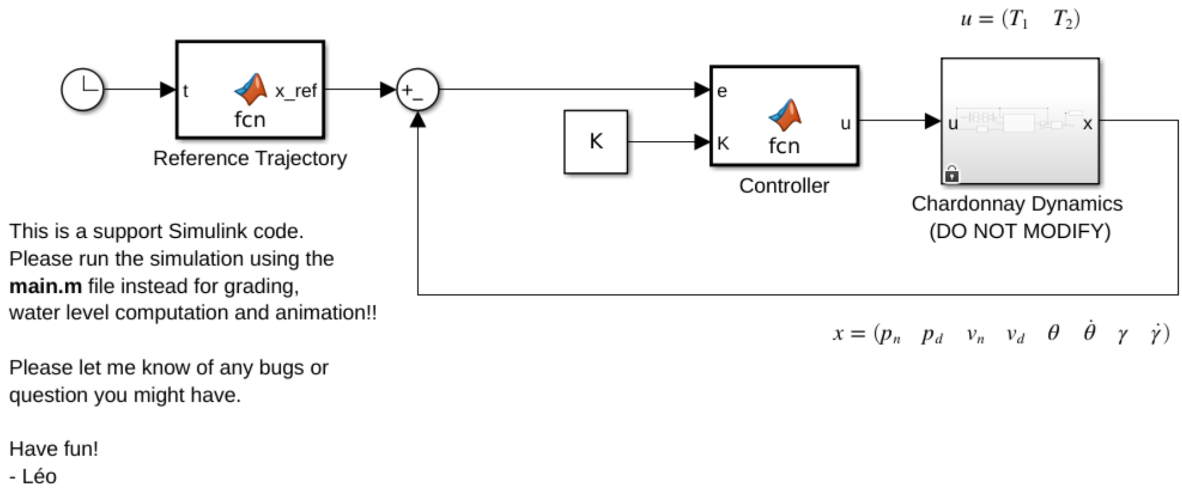


Figure 1: Simulink file to be modified: `chardonnay_simulinkR2018a.slx`.

Hint: Remember that you are designing a linear controller for a nonlinear plant! Therefore, the simulation might be unstable even if your linearized design is stable! To avoid that, make sure deflections from trimmed states are not excessively large.