Lab 6. "Segway" Motion Control Contest.

Deliverables: **Each lab group must, as usual, submit a *short* (~2-3 page) Lab Report, for work done in Labs 5 and 6, combined. This is due by 5pm Friday, Dec. 7 (in the dropbox).** Include the following:

1. Document your overall controller to stabilize and to drive the robot forward. Include the following: gains used, a explanation and/or diagram demonstrating how wheels are controlled to stay synchronized, and a plot of the reference trajectory you used (for wheel velocity). Also, describe briefly the process you used to tune gains. (e.g., LQR Q and R matrices used, or any overall scaling to the K gains you may have tried, etc.)

2. In your report, include plots of body angle and wheel angle(s) over time, including response to an external perturbation, e.g., from an impulse response, where you tap the robot and then let it recover. (Hopefully, you already have adequate data for this, from Lab 5.) Show work to identify the dominant poles of the actual closed-loop system, *based on this experimental data*.

3. Also include a plot (on the same axes as part 2 is preferred, but not required) of an impulse response for your *predicted* closed-loop system *based on your linearized model*, using MATLAB. How do the actual and predicted closed-loop responses compare to one another? (e.g., how do the damped natural frequency and damping ratio compare?0

<u>Overview and Contest Description</u>

This week, your task is to control the robot both to remain upright and to move along a prescribed trajectory as quickly as possible. Being able to stay upright while also being able to drive is a good test of your controller.

For fun, as with previous robot projects, we will hold an in-class contest, with rules and scoring to be announced by the TA's. The winning team will receive extra credit. Winners from the 3 lab contests this quarter will be announced in class the last day of lecture.

Specific suggested tasks to work on are open-ended and include the following:

1. Continue to tune your state space controller for the inverted pendulum robot.
2. Implement additional control to synchronous wheel rotations with one another.
3. Implement motion control, to command desired velocity for the wheels over time.
4. Smooth your reference trajectory (for velocity as input above), to go from A to B quickly.

TA's can help in designing a simple wheel synchronization strategy. Reference tracking can be implemented much as it was for the omnibot. Another option is to command wheel velocity and include an integrator in your model to calculate desired wheel position. This will result in reference trajectories for both wheel position and wheel velocity.

<u>Grading and creativity guidelines</u>

For your report, the only new requirement is the control for wheel synchronization; otherwise, data from Lab 5 may be sufficient. However, you can likely improve your controller in other ways, too, and are encouraged to do so. *Please be concise and efficient in your presentation; well-labeled plots are always appreciated – and often can be much more effective in communicating details than excessive text.*