Tutorial 6°
Modeling of a Segway

The Segway, Figure 1, is a two-wheeled, self-balancing, battery-powered electric vehicle. When powered on, computers and motors in the base of the device keep the Segway balancing upright, being able to reach a speed of 20 km/h. This is not the single specimen of this kind that is being marketed today; other devices such as iBOT, Figure 2, and others have implemented similar functionalities.

Figure 1. Segway I2

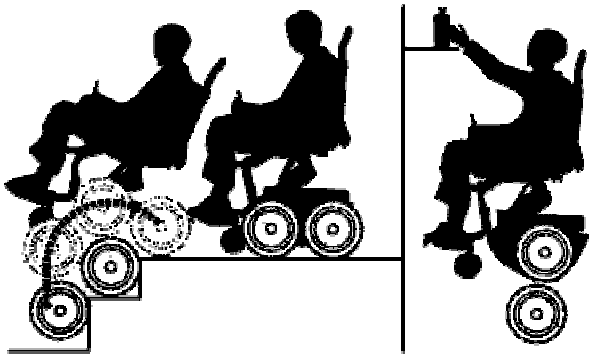

Figure 2. iBOT the weelchair that climbs stairs

The dynamics of the Segway is similar to a classical control problem – the inverted pendulum. In order to control it, the engineers need the model of the system. Thus, during this tutorial we will try to establish the dynamical model of the system. For educational purpose, the study will be conducted on an intentionally simplified schematic, given in Figure 3, in which the platform will be omitted. The parameters to be used in the model are:

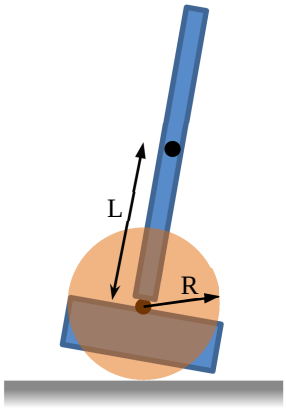

Figure 3. Simplified Schematic of the Segway

- J_w and J_h inertia of the wheel and the handlebar plus the pilot;
- M_w and M_h mass of the wheel and the handlebar;
- L the distance from the center of rotation to the center of mass of the handlebar;
- R radius of the wheel;
- C_r rolling resistance coefficient between the wheel and the ground;
- C the torque developed by the motor on the wheel.

1. Propose the generalized coordinates to be used in this problem.
2. Define the potential and the kinetic energy of the system.
3. Find the equations of motion of the system.
4. Propose a Simulink model in order to simulate the nonlinear system.