Homework 2, ECE 1675/2570 Robotic Control, Spring 2022
(Due Wednesday Feb. 9)

Problem 1. Please read Chapters 10-18 of the textbook by Mataric (The Robotics Primer) and submit a table summarizing the approximate amount of time that you spent in reading each chapter.

Problem 2. Please derive the nonlinear state-space equation for the Harrier "jump jet" system described on Slide 32 of Lecture 2. Consider the following definitions of input, state, and output variables:

$$u_1 = F_1, u_2 = F_2;$$
$$x_1 = 2x, x_2 = \dot{x}, x_3 = 3y, x_4 = \dot{y}, x_5 = 4\theta, x_6 = \dot{\theta};$$
$$y_1 = x, y_2 = y, y_3 = \theta.$$

Problem 3. Consider the motion dynamics of a bicycle (see Fig. 1), which can be described by

$$J\frac{d^2\varphi}{dt^2} - \frac{Dv_0}{b}\frac{d\delta}{dt} = mgh\sin\varphi + \frac{mv_0^2 h}{b}\delta$$

where δ is the steering angle, φ the tilt angle, J the moment of inertia of the bicycle body with respect to the ξ–axis, v_0 the velocity of the bicycle at the rear wheel, m the total mass of the system, g the gravitational acceleration, $D = mah$, and a, b, and h are explained in Fig. 1.

(a) Please derive the nonlinear state-space equation for the bicycle motion with the following definitions of input, state, and output variables:

$$u = \delta;\;\; x_1 = \varphi,\; x_2 = \dot{\varphi} - \frac{Dv_0}{bJ}\delta;\;\; y = \varphi.$$

(b) Please linearize the equation obtained in (a) for small φ.

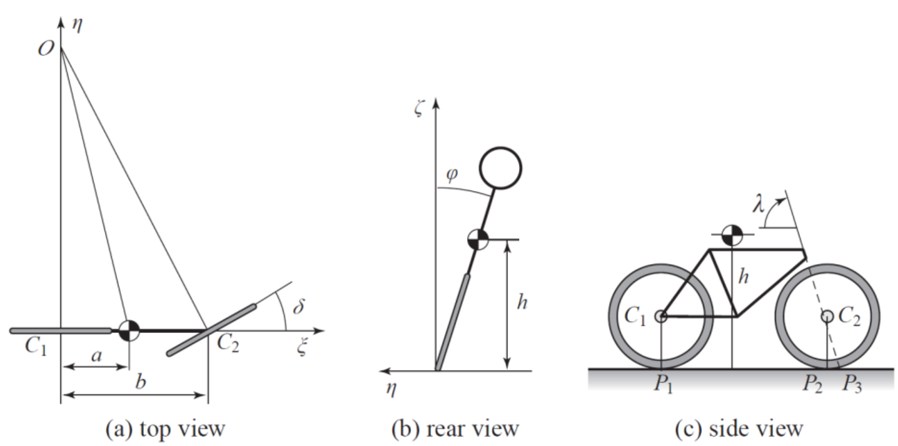

Figure 1. Schematic views of a bicycle.