EE3004: Control Engineering - Section ESB350 July - Nov 2018

Tutorial & Homework #1 Due: 9 August 2018

Note: Before attempting problems 1, 2, 3 consider reviewing the case study from [NN] Antenna Azimuth - An Introduction to Position Control Systems (Chapter 1, page 12)

1. A Segway Personal Transporter (PT) shown in Figure 1 is a two-wheeled vehicle in which the human operator stands vertically on a platform. As the driver leans left, right, forward, or backward, a set of sensitive gyroscopic sensors sense the desired input. These signals are fed to a computer that amplifies them and commands motors to propel the vehicle in the desired direction. One very important feature of the PT is its safety: The system will maintain its vertical position within a specified angle despite road disturbances, such as uphills and downhills or even if the operator overleans in any direction. Draw a functional block diagram of the PT system that keeps the system in a vertical position. Indicate the input and output signals, intermediate signals, and main subsystems.

Figure 1: The Segway Personal Transporter (PT)

2. During a medical operation an anesthesiologist controls the depth of unconsciousness by controlling the concentration of isoflurane in a vaporized mixture with oxygen and nitrousoxide. The depth of anesthesia is measured by the patient's blood pressure. The anesthesiologist also regulates ventilation, fluid balance, and the administration of other drugs. In order to free the anesthesiologist to devote more time to the latter tasks, and in the interest of the patient's safety, we wish to automate the depth of anesthesia by automating the control of isoflurane concentration. Draw a functional block diagram of the system showing pertinent signals and subsystems

3. A university wants to establish a control system model that represents the student population as an output, with the desired student population as an input. The administration determines the rate of admissions by comparing the current and desired student populations. The admissions office then uses this rate to admit students. Draw a functional block diagram showing the administration and the admissions office as blocks of the system. Also show the following signals: the desired student population, the actual student population, the desired student rate as determined by the administration, the actual student rate as generated by the admissions office, the dropout rate, and the net rate of influx.

4. Solve the following differential equations using classical methods and the given initial conditions.

   a) $\frac{dx}{dt} + x = e^{2t},\ x(0) = 2$

   b) $\frac{dx}{dt} + 7x = 5\cos(2t),\ x(0) = 0$

   c) $\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 3x = e^{2t},\ x(0) = 1, \frac{dx}{dt}(0) = 1$

   d) $\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + 2x = \sin(2t),\ x(0) = 2, \frac{dx}{dt}(0) = -3$

   e) $\frac{d^2x}{dt^2} + 2\frac{dx}{dt} + x = 5e^{-2t} + t,\ x(0) = 2, \frac{dx}{dt}(0) = 1$

   f) $\frac{d^2x}{dt^2} + 4x = t^2,\ x(0) = 1, \frac{dx}{dt}(0) = 2$