Instructor's Supplement Problems

Chapter 01

1. An aircraft's attitude varies in roll, pitch, and yaw as defined in Figure I-1.1. Draw a functional block diagram for a closed-loop system that stabilizes the roll as follows: The system measures the actual roll angle with a gyro and compares the actual roll angle with the desired roll angle. The ailerons respond to the roll-angle error by undergoing an angular deflection. The aircraft responds to this angular deflection, producing a roll angle rate. Identify the input and output transducers, the controller, and the plant. Further, identify the nature of each signal (Section 1.4: Introduction to a Case Study).

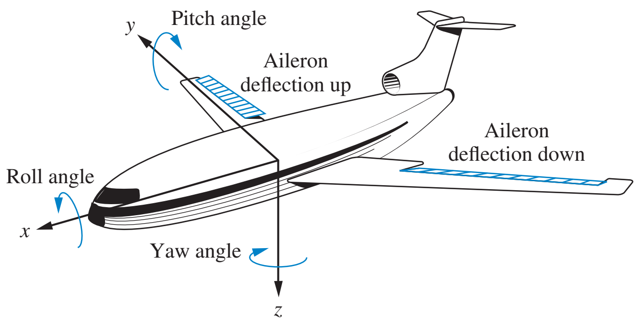

FIGURE I-1.1 Aircraft attitude defined

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 nitrous oxide. 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 (*Meier*, *1992*) (Section 1.4: Introduction to a Case Study).

3. You are given a high-speed proportional solenoid valve. A voltage proportional to the desired position of the spool is applied to the coil. The resulting magnetic field produced by the current in the coil causes the armature to move. A push pin connected to the armature moves the spool. A linear voltage differential transformer (LVDT) that outputs a voltage proportional to displacement senses the spool's position. This voltage can be used in a feedback path to implement closed-loop operation (*Vaughan*, *1996*). Draw a functional block diagram of the valve, showing input and output positions, coil voltage, coil current, and spool force (Section 1.4: Introduction to a Case Study).

4. Some skillful drivers can drive and balance a four-wheeled vehicle on two wheels. To verify that a control system can also drive a car in this fashion, a prototype using an RC (remote-controlled) car is equipped with a feedback control system (*Arndt*, *2011*). In a simplified system model, the roll angle at which the car balances was calculated a priori and found to be 52.3°. This value was used as the desired input. The desired input is compared with the actual roll angle and the difference is fed to a controller that feeds a servomotor indicating the desired wheel steering angle that controls the vehicle's roll angle on two wheels. The car's actual roll angle is measured using a hinged linkage that rolls along the ground next to the vehicle and is connected to a potentiometer. Draw a block diagram indicating the system functions. Draw blocks for the system controller, the steering servo, and the car dynamics. Indicate in the diagram the following signals: the desired roll angle, the steering wheel angle, and the actual car roll angle.

5. In the Case Study of Section 1.4, an antenna azimuth angle is controlled, and its corresponding block diagram is shown in Figure 1.8(*d*) in the text. There, the sensor used to measure the antenna's azimuth angle is a potentiometer.

   a. Modify the block diagram if the sensor used to measure the antenna's angle is an accelerometer.

   b. Modify the block diagram if the sensor used to measure the antenna's angle is a gyroscope.

Bibliography

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