EEE-101 - Control System Engineering

Tutorial - 1

1. With proper mathematical justification, identify the "static" and "dynamic" systems:

(a) $y(t) = \sqrt{\sin\left[(u(t))^2\right]}$,

(b) $\ddot{y}(t) + \dot{y}(t) + y(t) = u(t)$.

2. With proper mathematical justification, identify the "causal" and "non-causal" systems:

(a) $y(t) = 3u(t^2)$,

(b) $y(t) = u(t-a), \quad a \neq 0$,

(c) $y(t) = \cos(3t+1)u(t-1)$.

3. With proper mathematical justification, identify the "time-invariant" and "time-varying" systems:

(a) $y(t) = \int_{-\infty}^{t} u(2\tau)d\tau$,

(b) $y(t) = 2u(t-1) + u(t+2)$.

4. With proper mathematical justification, identify the "linear" and "nonlinear" systems:

(a) $(y(t))^2 = u(t) + 3$,

(b) $y(t) = u(t) \cdot \int_{-\infty}^{t} u(\tau)d\tau$,

(c) $\ddot{y}(t) + 2\dot{y}(t) + 3y(t) = 5u(t)$.

5. Consider a water storage tank in which the control objective is to keep the water level at a specified reference while water is continuously discharged through an outlet tap at the bottom. Propose a suitable control mechanism to achieve this objective. Illustrate the proposed system using a schematic diagram. Additionally, represent the system using a block diagram and clearly identify the components that function as sensors, actuators, and controllers.

6. Consider the inverted pendulum shown in the following figure. Sketch the block diagram of a feedback control system. Identify the process, sensor, actuator, and controller. The objective is keep the pendulum in the upright position, that is to keep $\theta = 0$, in the presence of disturbances.

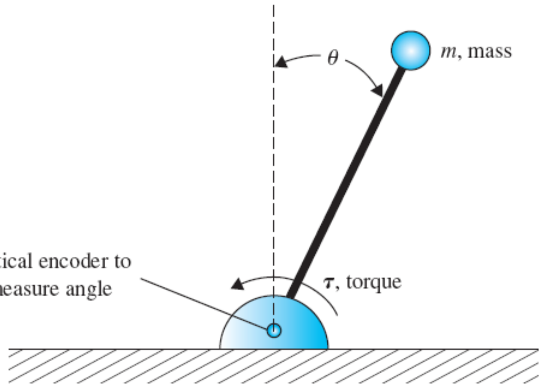

Figure 1

7. Some high-speed rail systems are powered by electricity supplied through a pantograph on the train's roof from a catenary overhead, as shown in the below figure. The force applied by the pantograph to the catenary is regulated to avoid loss of contact due to excessive transient motion. A proposed method to regulate the force uses a closed-loop feedback system, whereby a force, F_{up}, is applied to the bottom of the pantograph, resulting in an output force applied at the catenary at the top. The contact between the head of the pantograph and the catenary is represented by a spring. The output force is proportional to the displacement of this spring, which is the difference between the catenary and pantograph head vertical positions. Draw a functional block diagram showing the following signals: the desired output force as the input; the force, F_{up}, applied to the bottom of the pantograph; the difference in displacement between the catenary and pantograph head; and the output contact force. Also, show blocks representing the input transducer, controller, actuator generating F_{up}, pantograph dynamics, spring described above, and output sensor. All forces and displacements are measured from equilibrium.

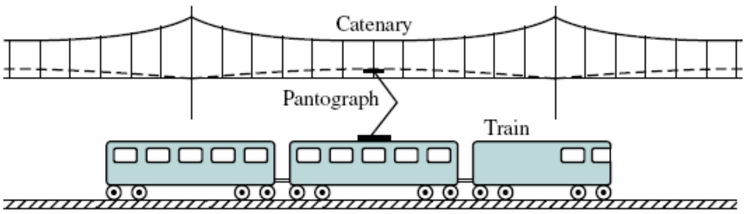

Figure 2

8. For the negative feedback control system shown in Fig. 1, find the equivalent transfer function from $R(s)$ to $\begin{bmatrix} Y(s) \\ U(s) \\ E(s) \end{bmatrix}$.

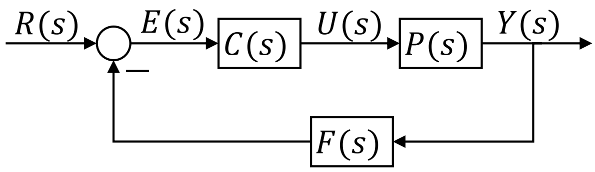

Figure 3

9. For the control system shown in Fig. 2, find the equivalent transfer function from $U(s)$ to $Y(s)$.

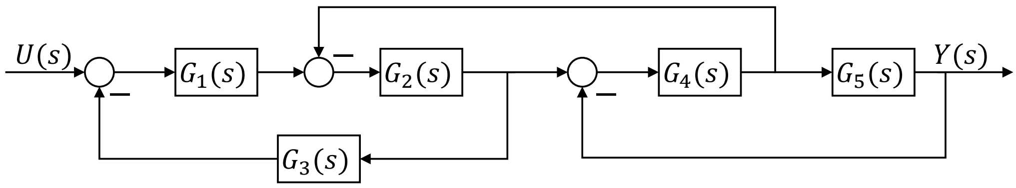

Figure 4