

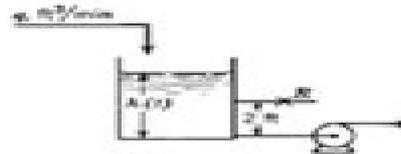
Solutions to Chapter 5 Problems

5.1 Derive the transfer function $H(s) / Q(s)$ for the liquid-level system of Fig. P5.1 when

a) The tank level operates about the steady-state value of $h_0 = 1$ ft

b) The tank level operates about the steady-state value of $h_0 = 3$ ft.

The pump removes water at a constant rate of 10 cfm (cubic feet per minute); this rate is independent of head. The cross-sectional area of the tank is 1.0 ft^2 and the resistance R is $0.5 \text{ ft}/\text{cfm}$.



a) Volume balance : $q - 10 = A \frac{dh}{dt}$

The tank level operates about the steady state value of $h_0 = 1$ ft (at this height the only outlet from the tank is through the pump)

at steady state : $q_s - 10 = 0$

after subtraction : $q - q_s = A \frac{dh}{dt}$

$$Q(s) = A \frac{dH}{dt}$$

Taking the transform : $Q(s) = AsH(s)$

Rearranging : $\boxed{\frac{H(s)}{Q(s)} = \frac{1}{As} = \frac{1}{s}}$

b) The tank level operates about the steady state value of $h_0 = 3$ ft (at this height the outlets from the tank is through the pump and through the resistance)

Volume Balance : $q - 10 - \frac{(h-2)}{R} = A \frac{dh}{dt}$

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