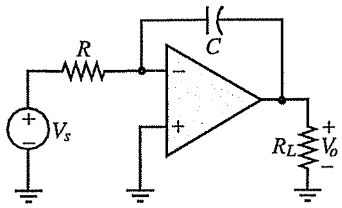
Tutorial Problems 1: Analog Computer Simulation

1. The circuit shown in Figure 1(a) will give an output voltage which is the integral of the supply voltage shown in Figure 1(b) multiplied by some gain.

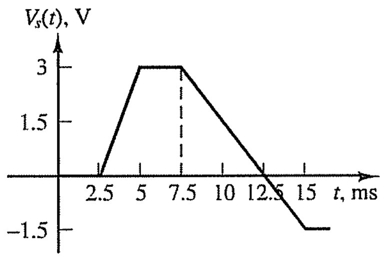
   Determine:

   a. An expression for the output voltage.
   b. The value of the output voltage at $t = 5, 7.5, 12.5, 15$, and 20 ms and a plot of the output voltage as a function of time if

   $C = 1\ \mu\text{F}$ $\qquad$ $R = 10\ \text{k}\Omega$ $\qquad$ $R_L = 1\ \text{k}\Omega$



(a)



(b)

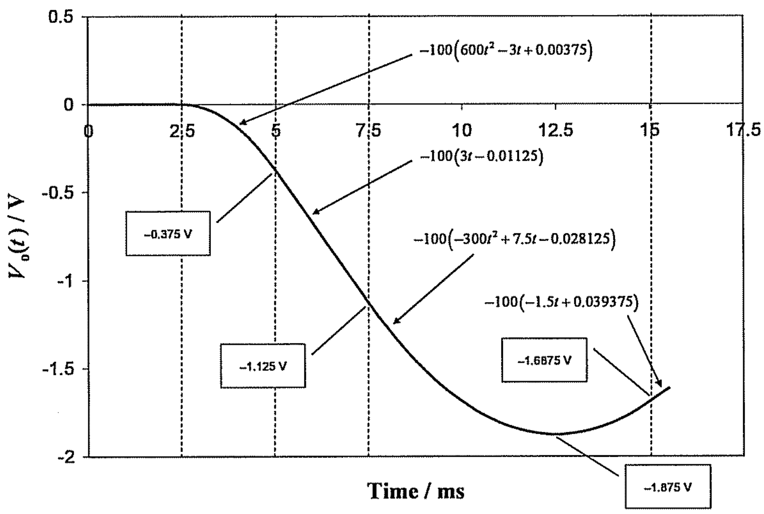
Figure 1

Solution:

(a)

$$V_o(t) = -\frac{1}{RC}\int V_S(t)\,dt$$
$$= -100\int V_S(t)\,dt$$

(b)



2. Derive the differential equation corresponding to the analog computer simulation circuit of Figure 2.

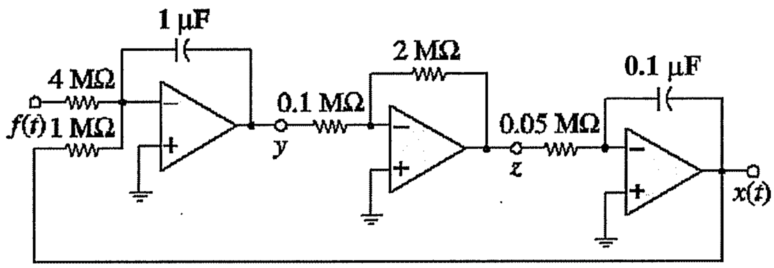


Figure 2

Solution:

$$x(t) = -200\int z(t)\ dt \Rightarrow z(t) = -\frac{1}{200}\frac{dx}{dt}$$

$$z(t) = -20y(t) \Rightarrow y(t) = -\frac{1}{20}z(t) = \frac{1}{4000}\frac{dx}{dt} \qquad ...(1)$$

And

$$y(t) = -\frac{1}{4}\int f(t)\ dt - \int x(t)\ dt \Rightarrow \frac{dy}{dt} = -\frac{1}{4}f(t) - x(t) \qquad ...(2)$$

Combining (1) and (2) gives:

$$\frac{1}{4000}\frac{d^2x}{dt^2} = -\frac{1}{4}f(t) - x(t)$$

$$\frac{d^2x}{dt^2} + 4000x(t) = -1000f(t)$$

3. Construct the analog computer simulation corresponding to the following differential equation:

$$\frac{d^2x}{dt^2}+100\frac{dx}{dt}+10x=-5f(t)$$

Solution: