# Assignment 1

Tarun N
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## Problem Statement

52. Many systems are piece-wise linear. That is, over a large range of variable values, the system can be described linearly. A system with amplifier saturation is one such example. Given the differential equation

$$\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x = f(x)$$

assume that $f(x)$ is as shown in Figure P2.32.

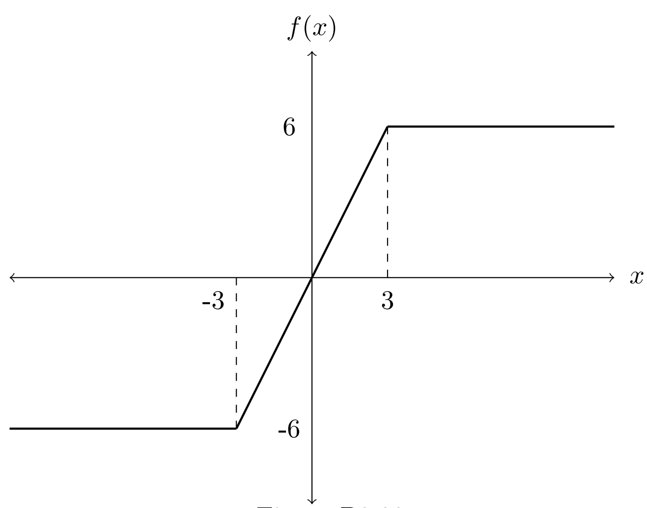

Figure P2.32

Write the differential equation for each of the following ranges of x:

- **a.** $-\infty < x < -3$
- **b.** $-3 < x < 3$
- **c.** $3 < x < \infty$

## Solution

The function $f(x)$ displayed in Figure P2.32 can be written as the following piece-wise function:

$$f(x) = \begin{cases} -6 & -\infty < x < -3 \\ 2x & -3 < x < 3 \\ 6 & 3 < x < \infty \end{cases}$$

Substitute the value of $f(x)$ in the interval $-\infty < x < -3$. The resulting differential equation is

$$\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x = -6$$

$$\boxed{\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x + 6 = 0} \tag{1}$$

Substitute the value of $f(x)$ in the interval $-3 < x < 3$. The resulting differential equation is

$$\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x = 2x$$

$$\boxed{\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 48x = 0} \tag{2}$$

Substitute the value of $f(x)$ in the interval $3 < x < \infty$. The resulting differential equation is

$$\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x = 6$$

$$\boxed{\frac{d^2x}{dt^2} + 17\frac{dx}{dt} + 50x - 6 = 0} \tag{3}$$