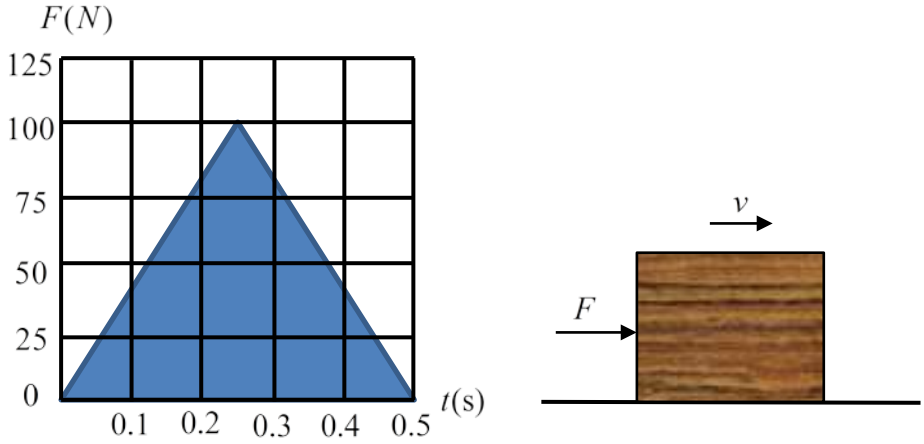
2-13. The force acting on a component of 3 kg is shown in the graph. At $t = 0\,\text{s}$, the speed of the component is $v_1 = 20\,\text{m/s}$. The coefficient of kinetic friction between the component and ground is $\mu_k \sim N(0.3, 0.03^2)$. Determine the distribution of the speed of the component when $t = 0.5\,\text{s}$.



Solution:

The friction force between the component and ground

$$F_f = N\mu_k = mg\mu_k$$

Principle of Impulse and Momentum:

$$mv_1 + \int F\ dt - \int F_f\ dt = mv_2$$

$$mv_1 + Area - mg\mu_k t = mv_2$$

$$v_2 = v_1 + \frac{Area}{m} - g\mu_k t$$

From the graph, we can get

$$Area = \frac{1}{2}(0.5)(100) = 25\ \text{N}\cdot\text{s}$$

Thus

$$\mu_{v_2} = v_1 + \frac{Area}{m} - g\mu_{\mu_k} t$$

$$= 20 + \frac{25}{3} - (9.81)(0.3)(0.5) = 26.86\ \text{m/s}$$

And $$\sigma_{v_2} = \sqrt{(-gt)^2 \sigma_{\mu_k}^2} = 0.15 \text{ m/s}$$

Therefore, $v_2 \sim N(26.86, 0.15^2)$ m/s. **Ans.**