36.2: Problems

Translational Problem

Consider the following translational problem: a body of mass $m = 3.0\text{ kg}$ is initally at rest; then a force of $F = 5.0\text{ N}$ is applied to it for time $t = 7.0$ seconds. What is the final velocity v of the body?

Solution. Given the force, we can find the acceleration; knowing the acceleration and time, we can find the velocity. The applicable equations are

$$F = ma \tag{36.2.1}$$

$$v = at + v_0. \tag{36.2.2}$$

Solving Eq. $36.2.1$ for a and substituting into Eq. $36.2.2$, we have

$$v = \left(\frac{F}{m}\right) t + v_0 \tag{36.2.3}$$

Substituting the given values of F, m, and t, and using $v_0 = 0$, we have

$$v = \left(\frac{5.0\text{ N}}{3.0\text{ kg}}\right)(7.0\text{ s}) \tag{36.2.4}$$

or

$$v = 11.67\text{ m/s} \tag{36.2.5}$$

Rotational Problem

Now consider the following similar rotational problem, which can be solved using the same method: a body of moment of inertia $I = 3.0\text{ kg m}^2$ is initially at rest (not rotating); then a torque of $\tau = 5.0\text{ N m}$ is applied to it for time $t = 7.0$ seconds. What is the final angular velocity ω of the body?

Solution. Given the torque, we can find the angular acceleration; knowing the angular acceleration and time, we can find the angular velocity. The applicable equations are analogous to those used for the translational problem:

$$\tau = I\alpha \tag{36.2.6}$$

$$\omega = \alpha t + \omega_0. \tag{36.2.7}$$

Solving Eq. $36.2.6$ for α and substituting into Eq. $36.2.7$, we have

$$\omega = \left(\frac{\tau}{I}\right) t + \omega_0 \tag{36.2.8}$$

Substituting the given values of τ, I, and t, and using $\omega_0 = 0$, we have

$$\omega = \left(\frac{5.0\text{ N m}}{3.0\text{ kg m}}\right)(7.0\text{ s}) \tag{36.2.9}$$

or

$$\omega = 11.67\text{rad/s} \tag{36.2.10}$$