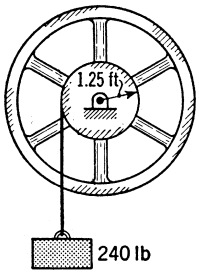
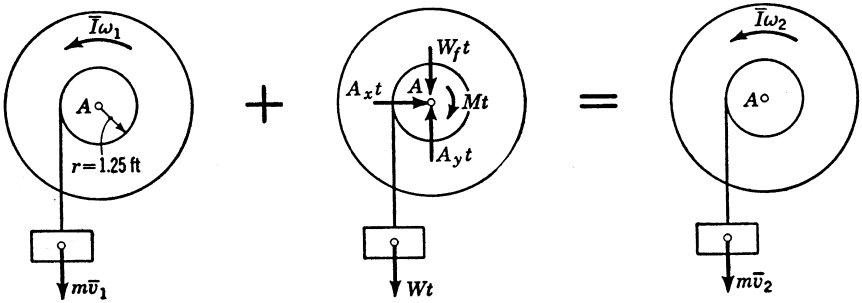
SAMPLE PROBLEM 18.2



A 240-lb block is suspended from an inextensible cable which is wrapped around a drum of radius 1.25 ft rigidly attached to a flywheel. The drum and flywheel have a combined moment of inertia $\bar{I} = 10.5$ lb-ft-sec^2. At the instant shown, the velocity of the block is 6 ft/sec directed downward. Knowing that the bearing at A is poorly lubricated and that the bearing friction is equivalent to a couple of moment $M = 60$ lb-ft, determine the velocity of the block 2 sec later.

Solution. We consider the system formed by the flywheel and the block. Forces external to this system consist of the weight W_f of the flywheel, the weight W of the block, the reaction at A, and the friction couple M. Since the magnitude and line of action of each force are constant, the impulse of each force is equal to the product of the force and of the time interval t. Likewise, since the friction couple is constant, its angular impulse is Mt.

Principle of Impulse and Momentum. The systems of initial momenta, impulses, and final momenta are shown in three separate sketches.



$$\text{Syst Momenta}_1 \overset{+}{\rightarrow} \text{Syst Ext Imp}_{1\rightarrow 2} = \text{Syst Momenta}_2$$

$+\circlearrowleft$ moments about A: $\bar{I}\omega_1 + m\bar{v}_1 r + Wtr - Mt = \bar{I}\omega_2 + m\bar{v}_2 r$

We note that $\bar{v} = r\omega$ and write

$$\bar{v}_1 = 6 \text{ ft/sec} \qquad \omega_1 = \frac{\bar{v}_1}{r} = \frac{6}{1.25} = 4.80 \text{ radians/sec} \qquad \omega_2 = \frac{\bar{v}_2}{r} = \frac{\bar{v}_2}{1.25}$$

Substituting these expressions together with the known values of W, $\bar{I}$, r, M, and t into the above equation, we obtain

$$(10.5)(4.80) + \frac{240}{32.2}(6)(1.25) + (240)(2)(1.25) - (60)(2) = (10.5)\frac{\bar{v}_2}{1.25} + \frac{240}{32.2}\bar{v}_2(1.25)$$

$$\bar{v}_2 = +33.1 \text{ ft/sec} \qquad \bar{v}_2 = \mathbf{33.1 \text{ ft/sec} \downarrow}$$