37.

<u>Problem 12.53E (HRW)</u>

A wheel is rotating freely with an angular speed of 800 rev/min *on a shaft whose rotational inertia is negligible. A second wheel, initially at rest and twice the rotational inertia of the first, is suddenly coupled to the same shaft. We have to find* (a) *the angular speed of the resultant combination of the shaft and the two wheels;* (b) *the fraction of the original rotational kinetic energy lost in the process.*

<u>Solution:</u>

Let the rotational inertia of the first wheel be *I*. Its angular speed $\omega = 800 \text{ rev min}^{-1}$. Therefore, the angular momentum of the shaft and the wheel system is $I\omega$. The initial rotational energy of the system is

$$E_i = \frac{1}{2} I\omega^2.$$

When the second wheel of rotational inertia 2*I*, is coupled to the shaft let the two wheels and the shaft rotate with angular speed ω'. From conservation of angular momentum, we find the changed angular speed ω' of the system,

$$(I + 2I)\omega' = I\omega,$$

or

$$\omega' = \omega/3 = 266.6 \text{ rev min}^{-1}.$$

Rotational energy of the system when both wheels are attached with the shaft is

$$E_f = \frac{1}{2} \times 3I \times \omega'^2 = \frac{1}{6} I\omega^2 = \frac{1}{3} E_i.$$

Fractional loss of rotational energy is

$$f = \frac{E_i - E_f}{E_i} = \frac{2}{3}.$$