16.

<u>Problem 12.6E (HRW)</u>

An automobile has a total of mass of 1700 kg. *It accelerates from rest to* 40 km / h *in* 10 s. *Assume each wheel is a uniform* 32 kg *disk. Find, for the end of the* 10 s *interval,* (a) *the rotational kinetic energy of each wheel about its axle,* (b) *the total kinetic energy of each wheel, and* (c) *the total kinetic energy of the automobile.*

<u>Solution:</u>

(a)

Let m be the mass and r be the radius of each wheel. Assuming that each wheel is a uniform disk, the rotational inertia of each wheel will be given by the expression $I_{wheel} = \frac{1}{2}mr^2$. Let v be the speed of the car after 10 s starting from rest.

$$v = \frac{40 \times 10^3}{3600}\ \text{m s}^{-1} = 11.11\ \text{m s}^{-1}.$$

As the car is moving normally that is without slipping the angular speed of each wheel will be

$\omega = {}^{v}\!/_{r}$.

The rotational kinetic energy of each wheel will, therefore, be

$$KE_{rot-wheel} = \frac{1}{2} I_{wheel} \omega^2 = \frac{1}{2} \times \frac{1}{2} mv^2,$$

$$= 8 \times 11.11^2 \text{ J} = 987.6 \text{ J} .$$

(b)

As the centre of mass of each wheel is moving with speed *v*, the kinetic energy of translation of each wheel will be

$$KE_{trans-wheel} = \frac{1}{2} mv^2 = 1975.3 \text{ J} .$$

The total kinetic energy of each wheel will be

$$KE_{rot-wheel} + KE_{trans-wheel} = 2963 \text{ J} .$$

(c)

The total kinetic energy of the automobile will be the sum of the translational kinetic energy of the automobile and the rotational kinetic energy of the 4 wheels. Therefore,

$$KE_{automobile} = (\frac{1}{2} \times 1700 \times 11.11^2 + 4 \times 987.6) \text{ J} ;\ 1.1 \times 10^5 \text{ J} .$$