**25.**

**Problem 12.58E (HRW)**

*With centre and spokes of negligible mass, a certain bicycle wheel has a thin rim of radius* 1.14 ft *and weight* 8.36 lb*; it can turn on its axle with negligible friction. A man holds the wheel above his head with the axle vertical while he stands on a turntable free to rotate without friction; the wheel rotates clockwise, as seen from above, with an angular speed of* 57.7 rad $s^{-1}$, *and the turntable is initially at rest. The rotational inertia of* ***wheel*** *+* ***man*** *+* ***turntable*** *about the common axis of rotation is* 1.54 slug $ft^2$. *The man's free hand suddenly stops the rotation of the wheel* (relative to the turntable). *Determine the angular velocity* (magnitude and direction of the system).

**Solution:**

In this problem data has been given in the British fps system. In this system of units the basic unit of mass is slug, of length is ft, and of force is lb. Slug and lb are

connected by the relation that a mass of 1 slug under acceleration of 32 ft $s^{-2}$ experiences a force of 1 lb. There is no external torque on the system about the direction of the vertical axis. Therefore, angular momentum is a constant of motion.

Radius of the bicycle wheel $= 1.14$ ft.

Weight of the wheel =8.36 lb.

Therefore, mass of the wheel = $8.36/32.17$ slug

$= 0.259$ slug.

Moment of inertia of the wheel, $I = mr^2$

$= 0.259 \times 1.14^2$ slug $ft^2$

$= 0.337$ slug $ft^2$

Wheel is spinning with speed, $\omega = 57.7$ rad $s^{-1}$.

Angular momentum of the wheel, which is also the angular momentum of *wheel+ man+ turntable,*

$L = I\omega = 0.337 \times 57.7$ slug $ft^2 s^{-1} = 19.48$ slug $ft^2 s^{-1}$.

Rotational inertia of *wheel+ man+ turntable*

$I_{sys} = 1.54$ slug $ft^2$

As no external torque is exerted on the system when the rotation of the wheel is stopped by the man using his free- hand (*relative to turntable*), the angular momentum

of the system will be $L$. The rotational angular speed of the system can now be calculated using the definition

$$\omega = \frac{L}{I_{sys}} = \frac{19.48}{1.54} \text{ rad s}^{-1} = 12.65 \text{ rad s}^{-1}.$$

The direction of rotation will continue to remain clockwise when seen from top.