21.

Problem 12.39 (HR)

A meter stick is held vertically with one end on the floor and is then allowed to fall. We have to find the speed of the other end when it hits the floor, assuming that the end on the floor does not slip.

Solution:

The moment of inertia of a stick of length *l* and mass *m* about an axis passing through one of its end is $ml^2/3$. The centre of gravity of a stick of length *l* standing vertically will be at a height $l/2$ from its base. Therefore, the potential energy of the stick standing vertically will be $mgl/2$. Let the angular speed of the top end of the stick when it hits the ground be ω. By applying the principle of conservation of energy we can obtain an equation that gives the angular speed of the stick as it hits the ground. It is

$$\frac{ml^2\omega^2}{6} = \frac{mgl}{2},$$

or

$$\omega^2 = \frac{3g}{l}.$$

The speed of the end of the stick of length l when it touches the ground on falling with one of its ends remaining fixed will be

$$v = \sqrt{3gl}.$$

As, $l = 1.0$ m, $v = 5.42$ m s^{-1}.