HRW pp. 301–302, #51, 58, 61, 66

NAME: KEY

51 In Fig. 11-50, two skaters, each of mass 50 kg, approach each other along parallel paths separated by 3.0 m. They have opposite velocities of 1.4 m/s each. One skater carries one end of a rotating pole of negligible mass, and the other skater grabs the other end as she passes. The skaters then rotate around the center of the pole. Assume that the friction between skates and ice is negligible. What are (a) the radius of the circle, (b) the angular speed of the skaters, and (c) the kinetic energy of the two-skater system? Next, the skaters pull along the pole until they are separated by 1.0 m. What then are (d) their angular speed and (e) the kinetic energy of the system? (f) What provided the energy for the increased kinetic energy?

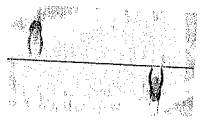

FIG. 11-50 Problem 51.

(51) (a) $r = 1.5\ m$

(b) $L_{before} = L_{after}$

$m_1 v r + m_2 v r = 2mvr$

$2mvr = 2mvr \rightarrow v = 1.4\ m/s$

$v = \omega r \rightarrow \omega = v/r = 1.4/1.5 = \boxed{0.93\ rad/s}$

(c) $2\left(\frac{1}{2} I \omega^2\right) = I_1 \omega^2 = \left(\frac{1}{2} m r^2\right)\omega^2 = \frac{194.6\ J}{2}$

(d) $L_{before} = L_{after}$ $\quad \omega_1 = 1.4/1.5$

$I_1 \omega_1^2 = I_2 \omega_2^2 \rightarrow \omega_2 = \frac{\omega_1 r_1^2}{r_2^2} = \boxed{8.4\ rad/s}$

(e) $2\left(\frac{1}{2} m v_2^2\right) = 2\left(\frac{1}{2}(50)(\quad)^2\right) = \boxed{882\ J}$

(f) work done by skaters

58 In Fig. 11-54, a 1.0 g bullet is fired into a 0.50 kg block attached to the end of a 0.60 m nonuniform rod of mass 0.50 kg. The block–rod–bullet system then rotates in the plane of the figure, about a fixed axis at *A*. The rotational inertia of the rod alone about that axis at *A* is 0.060 kg · m². Treat the block as a particle. (a) What then is the rotational inertia of the block–rod–bullet system about point *A*? (b) If the angular speed of the system about *A* just after impact is 4.5 rad/s, what is the bullet's speed just before impact?

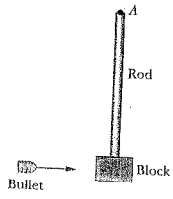

FIG. 11-54 Problem 58.

(58) (a) $I_{system} = I_{block} + I_{rod} = m_B l^2 + I_{rod} = \boxed{0.24\ kg \cdot m^2}$

(b) ang. mom. cons.

$(I_{bullet}\omega_{bullet})_{before} = (I_{sys}\omega_{sys})_{after}$

$(m_{bullet} l^2 \omega_{bullet}) = I_{sys}\omega_{sys} \qquad \omega_{bullet} = \frac{v_{bullet}}{r}$

$m_B l^2\left(\frac{v_{bullet}}{l}\right) = I_{sys}\omega_{sys}$

$v_{bullet} = \frac{I_{sys}\omega_{sys}}{m_B l} = \frac{0.24(4.5)}{(0.001)(0.6)} = \boxed{1800\ m/s}$

61 In Fig. 11-55 the uniform rod (length 0.60 m, mass 1.0 kg) rotates in the plane of the figure about an axis through one end, with a rotational inertia of 0.12 kg · m². As the rod swings through its lowest position, it collides with a 0.20 kg putty wad that sticks to the end of the rod. If the rod's angular speed just before collision is 2.4 rad/s, what is the angular speed of the rod–putty system immediately after collision?

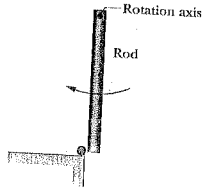

FIG. 11-55 Problem 61.

(61) ang. mom. cons.

$I_1\omega_1 = (I_1 + I_{putty})\omega_2 \qquad I_{putty} = ml^2 = 0.072\ kg \cdot m^2$

$\omega_2 = \frac{I_1\omega_1}{(I_1 + I_{putty})} = \frac{0.12(2.4)}{(0.12 + 0.072)} = \boxed{1.5\ rad/s}$

66 In Fig. 11-59, a small 50 g block slides down a frictionless surface through height $h = 20$ cm and then sticks to a uniform rod of mass 100 g and length 40 cm. The rod pivots about point *O* through angle θ before momentarily stopping. Find θ.

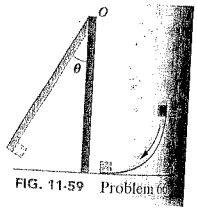

FIG. 11-59 Problem 66.