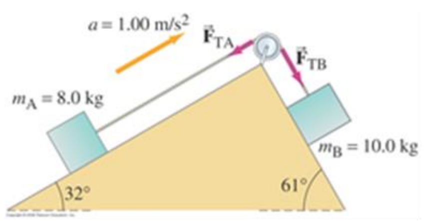
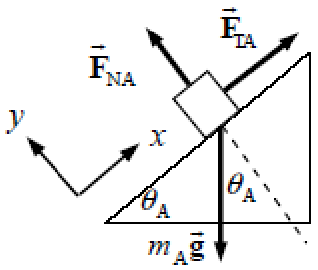
CHAPTER XI

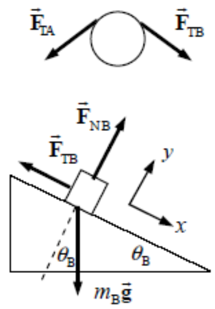
ROLLING, TORQUE AND ANGULAR MOMENTUM

PROBLEM SET

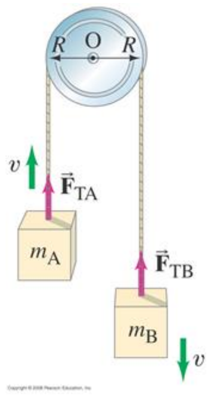
1) Two blocks are connected by a light string passing over a pulley of radius 0.15 m and moment of inertia *I*. The blocks move (towards the right) with an acceleration of 1.00 m/s^2 along their frictionless inclines (see Fig. 10–54).(*a*) Draw free-body diagrams for each of the two blocks and the pulley.(*b*)Find the net torque acting on the pulley, and determine its moment of inertia. **[Answer: a) figures below, b) $3.9\ \mathrm{m \cdot N}$, $0.59\ \mathrm{kg \cdot m^2}$]**

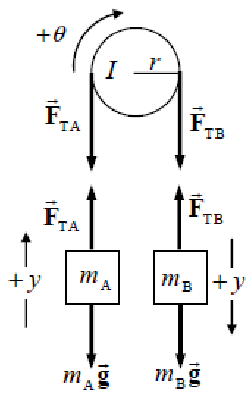






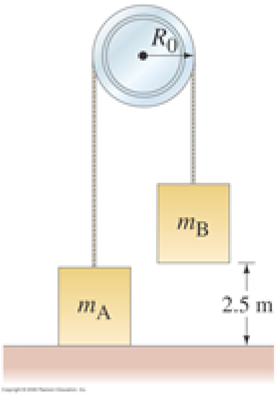
2) An *Atwood's machine* consists of two masses, m_A and m_B, which are connected by a massless inelastic cord that passes over a pulley, Fig. 10–57. If the pulley has radius *R* and moment of inertia *I* about its axle, determine the acceleration of the masses m_A and m_B, and compare to the situation in which the moment of inertia of the pulley is ignored. [*Hint*: The tensions F_{TA} and F_{TB} are not equal. We discussed the Atwood machine in Example 4–13, assuming $I = 0$ for the pulley.] **[Answer: expressions below]**





$$a = \frac{(m_B - m_A)}{(m_A + m_B + I/r^2)} g \qquad a_{I=0} = \frac{(m_B - m_A)}{(m_A + m_B)} g$$

3) *** Two masses, $m_A = 35.0\text{ kg}$ and $m_B = 38.0\text{ kg}$, are connected by a rope that hangs over a pulley (as in Fig. 10–59). The pulley is a uniform cylinder of radius 0.381 m and mass 3.1 kg. Initially m_A is on the ground and m_B rests 2.5 m above the ground. If the system is released, use conservation of energy to determine the speed of m_B just before it strikes the ground. Assume the pulley bearing is frictionless. **[Answer: 1.4 m/s]**



4) *** A ball of radius r_0 rolls on the inside of a track of radius R_0 (see Fig. 10–61). If the ball starts from rest at the vertical edge of the track, what will be its speed when it reaches the lowest point of the track, rolling without slipping?
[Answer:

$$\sqrt{\tfrac{10}{7}g\left(R_0 - r_0\right)}$$ **]**

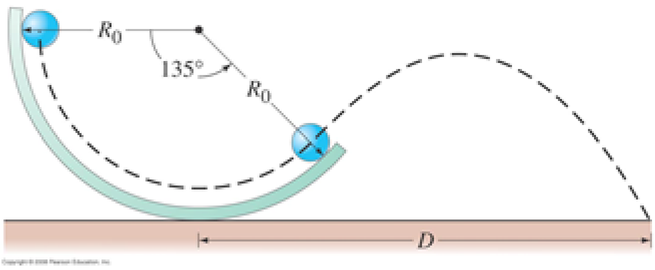
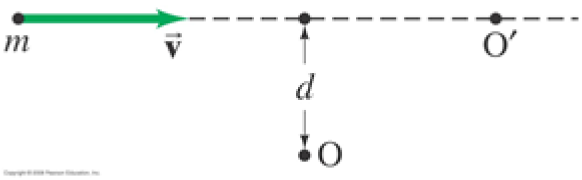


Fig. 10–61

5) A small sphere of radius $r_0 = 1.5\text{ cm}$ rolls without slipping on the track shown in Fig. 10–61 whose radius is $R_0 = 26.0\text{ cm}$. The sphere starts rolling at a height R_0 above the bottom of the track. When it leaves the track after passing through an angle of 135° as shown, (*a*) what will be its speed, and (*b*) at what distance *D* from the base of the track will the sphere hit the ground? **[Answer: a) 1.6 m/s, b)0.48 m]**

6) Calculate the angular momentum of a particle of mass *m* moving with constant velocity ***v*** for two cases (see Fig. 11–33): (*a*) about origin O, and (*b*) about O'.**[Answer: a) *d*mv, b)zero]**

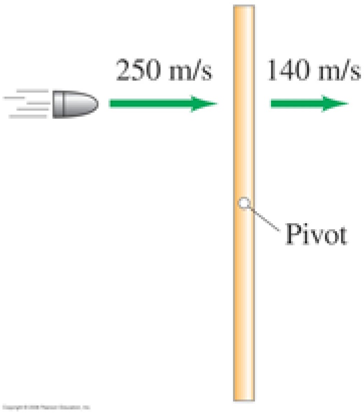


7) Determine the angular momentum of a 75-g particle about the origin of coordinates when the particle is at $x = 4.4$ m, y=-6.0 m, and it has velocity $\vec{v} = (3.2\mathbf{i} - 8.0\,\mathbf{k})\mathrm{m/s}$.

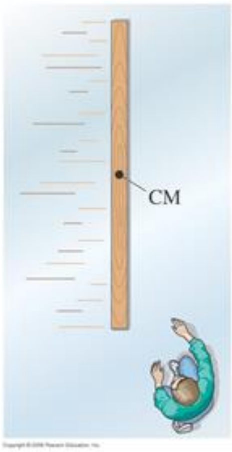
[Answer:

$$\left(3.6\hat{\mathbf{i}} + 2.6\hat{\mathbf{j}} + 1.4\hat{\mathbf{k}}\right)\mathrm{kg{\bullet}m^2/s}$$ **]**

8) A uniform stick 1.0 m long with a total mass of 270 g is pivoted at its center. A 3.0-g bullet is shot through the stick midway between the pivot and one end (Fig. 11–36). The bullet approaches at 250 m/s and leaves at 140 m/s. With what angular speed is the stick spinning after the collision? **[Answer: 3.7 rad/s]**



9) *** A 230-kg beam 2.7 m in length slides broadside down the ice with a speed of 18 m/s (Fig. 11–38). A 65-kg man at rest grabs one end as it goes past and hangs on as both he and the beam go spinning down the ice. Assume frictionless motion. (*a*) How fast does the center of mass of the system move after the collision? (*b*) With what angular velocity does the system rotate about its CM? **[Answer: a) 14 m/s, b) 5.3 rad/s]**



$$v_{\substack{\mathrm{CM}\\\mathrm{final}}} = \frac{mv}{m+M} \qquad \frac{12mv}{\ell(7m+4M)}$$

10) A thin rod of mass *M* and length ***l***, rests on a frictionless table and is struck at a point ***l*/4** from its CM by a clay ball of mass *m* moving at speed ***v*** (Fig. 11–39). The ball sticks to the rod. Determine the translational and rotational motion of the rod after the collision.
[Answer: expressions above]