Chapter 7 Problems

1. A tennis racket has a mass of 0.350 kg. The radius of gyration of the racket about its longitudinal (twist) axis is 7.2 cm, and its radius of gyration about its swing axis is 20 cm.
   a. What is the moment of inertia of this racket about its longitudinal axis?
   b. What is the moment of inertia of this racket about its swing axis?

2. The moment of inertia of the club head is a design consideration for a driver in golf. A larger moment of inertia about the vertical axis parallel to the club face provides more resistance to twisting of the club face for off-center hits. The mass of one club head is 200 g and its moment of inertia is 5000 g cm². What is the radius of gyration of this club head?

3. A 1 kg baseball bat has a moment of inertia around a transverse axis through its center of gravity of 650 kg·cm². What is the moment of inertia of the bat about an axis through the handle of the bat if this axis is 50 cm from the center of gravity of the bat?

4. The moment of inertia of the lower leg and foot about an axis through the knee joint is 0.20 kg·m². What is the moment of inertia of the leg and foot about the knee joint if a 0.50 kg shoe is worn on the foot? Assume that the shoe’s mass is all concentrated in one point 45 cm from the knee joint.
5. Lily is a 50 kg diver. At the instant of takeoff, her angular momentum about her transverse axis is 20 kg·m²/s. Her radius of gyration about the transverse axis is 0.4 m at this instant. During the dive, Lily tucks and reduces her radius of gyration about the transverse axis to 0.2 m.
   
   a. At takeoff, what is Lily’s moment of inertia about her transverse axis?
   
   b. At takeoff, what is Lily’s angular velocity about the transverse axis?
   
   c. After Lily tucks, what is her moment of inertia about her transverse axis?
   
   d. After Lily tucks, what is her angular velocity about the transverse axis?

6. Kristen is spinning on the ice at 20 rad/s about her longitudinal axis when she abducts her arms and doubles her radius of gyration about her longitudinal axis from 30 cm to 60 cm. If her angular momentum is conserved, what is her angular velocity about her longitudinal axis after she increases her radius of gyration?

7. The average net torque Justin exerts on a discus about its axis of spin is 100 Nm during a throw. The mass of the discus is 2 kg, and its radius of gyration about the spin axis is 12 cm. If the discus is not spinning at the start of Justin’s throwing action, and the throwing action lasts for 0.20 s, how fast is the discus spinning when Justin releases it?

8. Tom’s leg angularly accelerates $3000^\circ/s^2$ around the hip joint during a roundhouse kick in the transverse plane. The moment of inertia of the leg around the axis of rotation for this kick is $0.75 \text{ kg}\cdot\text{m}^2$. How large is the torque that produces this acceleration?

9. Doug is driving a golf ball off the tee. His downswing takes 0.50 s from the top of the swing until ball impact. At the top of the swing, the club’s angular velocity is zero; at the instant of ball impact, the club’s angular velocity is 30 rad/s. The swing moment of inertia of the club about the grip is $0.220 \text{ kg}\cdot\text{m}^2$. What average torque does Doug exert on the golf club during the downswing?

10. Sarah’s twist angular momentum increases from 0 to $50 \text{ kg}\cdot\text{m}^2/\text{s}$ in 0.25 s as she initiates a twisting jump on the ice. During this 0.25 s, her moment of inertia about her twist axis is $2.2 \text{ kg}\cdot\text{m}^2$.

   a. How large is the average torque that produces this change in angular momentum?

   b. How fast is Sarah’s twist angular velocity at the end of the 0.25 s?