Make sure to review the double pendulum example problem on pages 291-294. This is a model for any kind of rotational movement involving 2 axes of rotation. For instance, such a model can be used to calculate the velocity of a foot about the hip, considering that you are also extending the leg at the knee.

1. A windmill style softball pitcher executes a pitch in 0.65 seconds. If her pitching arm is 0.7 m long, what are the magnitudes of the tangential and centripetal accelerations on the ball at ball release, when tangential ball speed is 20 m/s? Assume the ball is released in the horizontal direction. What are the magnitude of the resultant acceleration at that point, and the angle of the resultant acceleration in comparison to the horizontal direction? A drawing of the acceleration vectors may help you here. (Answer: \( a_t = 30.8 \text{ m/s}^2 \); \( a_c = 571.4 \text{ m/s}^2 \); \( a = 572.2 \text{ m/s}^2 \); angle of release = 3.1 degrees)

2. A speed skater increases his speed from 10 m/s to 12.5 m/s over a period of 3 seconds while coming out of a curve of 20 m radius. What are the magnitudes of his tangential, centripetal, and resultant accelerations as he leaves the curve? (Answer: \( a_t = 0.83 \text{ m/s}^2 \); \( a_c = 7.81 \text{ m/s}^2 \); \( a = 7.85 \text{ m/s}^2 \))

3. A kicker’s extended leg is swung for 0.4 seconds in a counter-clockwise direction while accelerating at 200 deg/s\(^2\). What is the angular velocity of the leg at the instant of contact with the ball? (Answer: 80 deg/s or 1.4 rad/s)

4. A 1.2 m golf club is swung in a planar motion by a right-handed golfer with an arm length of 0.76 m. If the initial velocity of the golf ball is 35 m/s, what was the angular velocity of the left shoulder at ball contact? Assume that the left arm and golf club form a straight line and that the initial ball velocity is the same as the linear velocity of the club head at impact. (Answer: 17.86 rad/s)
1. A pitched ball with a mass of 1 kg reaches a catcher's glove traveling at a velocity of 28 m/s.
   a. How much momentum does the ball have?
   b. How much impulse is required to stop the ball?
   c. If the ball is in contact with the catcher's glove for 0.5 seconds during the catch, how much average force is applied by the glove?
      (Answer: a. 28 kg m/s; b. 28 Ns; c. 56 N)

2. A 108-cm, 0.73 kg golf club is swung for 0.5 seconds with a constant acceleration of 10 rad/s². What is the linear momentum of the club head when it impacts the ball?
   (Answer: 3.9 kg m/s)

3. A volleyball player's 3.7-kg arm moves at an average angular velocity of 15 rad/s during the execution of a spike. If the average moment of inertia of the extending arm is 0.45 kg m², what is the average radius of gyration for the arm during the spike?
   (Answer: 0.35 m)

4. The patellar tendon attaches to the tibia at a 20 ° angle, 3-cm from the axis of rotation at the knee. If the tension in the tendon is 400 N, what is the resulting angular acceleration of the 4.2 kg lower leg and foot given a radius of gyration of 30 cm for the lower leg/foot with respect to the axis of rotation at the knee?
   (Answer: 10.8 rad/s²)

5. Lineman A has a mass of 100 kg and is traveling with a velocity of 4 m/s when he collides head-on with Lineman B, who has a mass of 90 kg and is traveling at 4.5 m/s. If both players remain on their feet, what will happen? (Answer: B will push A backward with a velocity of 0.03 m/s)

6. Two skaters gliding on ice run into each other head-on. If the two skaters hold onto each other and continue to move as a unit after the collision, what will be their resultant velocity? Skater A has a velocity of 5 m/s and a mass of 65 kg. Skater B has a velocity of 6 m/s and a mass of 60 kg. (Answer: v = 0.28 m/s in direction originally taken by B)

7. A 60 kg diver is positioned so that his radius of gyration is 0.5 m as he leaves the board in a layout position with an angular velocity of 4 rad/s. What is the diver’s angular velocity when he assumes a tuck position, altering his radius of gyration to 0.25 m²? (Answer: ω = 16 rad/s)
8. The knee extensors insert on the tibia at an angle of 30 degrees (from the longitudinal axis of the tibia), at a distance of 3 cm from the axis of rotation at the knee. How much force must the knee extensors exert to produce an angular acceleration at the knee of 1 rad/s$^2$, given a mass of the lower leg and foot of 4.5 kg, and a radius of gyration of 23 cm? (Answer: $F = 15.9$ N)

9. Calculate the impulse associated with this force-time graph. Force is expressed in Newtons, and time is expressed in seconds. (Answer: 180 Ns)