Torque Problems

1. What is the torque on a bolt if you are pulling with a force of 200 N directed perpendicular to a wrench of length 25 cm? How does the torque change for a wrench of twice the length?
   (Answers: 50 Nm; 100 Nm)

2. In cycling, the torque generated about the crank axis depends on the magnitude of the force applied to the pedal and also the angle between the crank arm and the force vector. In the diagram below, an 800 N vertical force applied to the pedal will create a counter-clockwise torque of 140 Nm when the crank is at 90 degrees (where greatest torque is generated).

   How much torque will the same force generate when the crank is at 75 degrees and at 105 degrees? What torque will that same vertical force generate when the crank is at 180 degrees?
   (Answers: at 75 and 105 degrees, torque = 135.2 Nm, at 180 degrees, torque = 0)
3. What is the torque about the shoulder if the arm is held in an abducted position at
60 degrees from the body in the frontal plane while holding a 10 kg dumbbell? Assume that the mass of the arm is 6 kg, its center of mass is located 38 cm from the shoulder joint center, and the arm's total length is 80 cm.

(Answers: torque of dumbbell = -69.3 Nm; torque of arm weight = -19.7 Nm; Torque at the shoulder = 89 Nm)

4. Short Essay Response: The torque you can apply to the rear wheel of your mountain bike depends on which gear you are using. Explain how and why the gearing of the back wheel affects torque.

5. A 35 N hand and forearm are held at a 45° angle to the vertically oriented humerus. The center of gravity of the forearm and hand is located at a distance of 15 cm from the joint center at the elbow, and the elbow flexor muscles attach at a distance of 3 cm from the joint center (assume that the muscles attach at an angle of 45° to the axis of the forearm).
   a. How much force must be exerted by the forearm muscles to maintain this position? (answer: 175 N)
   b. How much force must the forearm flexors exert if a 50 N weight is held in the hand at a distance along the arm of 25 cm? (Answer: 591.7 N)

6. A hand exerts a force of 90 N on a scale at 32 cm from the joint center at the elbow. The triceps attach to the ulna at a 90° angle, and at a distance of 3 cm from the joint center. The weight of the forearm and the hand is 40 N with the forearm/hand center of gravity located 17 cm from the elbow joint center. Considering these conditions, how much force is being exerted by the triceps? Remember that you are interested in the forces acting on the forearm system. (answer: 733.3 N)

7. A therapist applies a lateral force of 80 N to the forearm at a distance of 25 cm from the elbow joint center. The biceps attaches to the radius at a 90° angle and at a distance of 3 cm from the elbow.
   a. How much force is required of the biceps to stabilize the arm in position? (answer: 666.7 N)
   b. What is the magnitude of the reaction force exerted by the humerus on the ulna? (answer: 586.7 N)