

KIN 412/512 Biomechanics of the Skeletal System

Problem Set 1 (One knee problem with many parts)

Due Tuesday November 4, 2003 10:40 AM

**Instructions:** Show **all** your work including the equations used.

1. Patrick is rehabilitating an injured right knee. He is performing isokinetic (constant velocity) knee extensions against resistance provided by a Cybex machine. At the instant in question, his thigh is horizontal and knee is flexed  $80^\circ$ . The Cybex machine exerts an external force of 250 N perpendicular to the calf long axis at a distance of 58.5 cm from the knee joint center. The weight of his calf + foot is 50 N. Assume the center of mass of the calf + foot is halfway between the knee joint center and the point of application of the external force from the Cybex machine. The angle of pull of the patellar ligament on the tibia is  $4^\circ$ . The moment arm of the patellar ligament force about the knee joint center is 4.75 cm. From the information given, complete the following:
  - (a) Draw a complete free body diagram (FBD) of the calf + foot.
  - (b) Compute the magnitude of the patellar ligament force (T).
  - (c) Compute the compressive and shear components of the tibiofemoral joint force ( $J_T$ ). Be sure to draw the force  $J_T$  and label the appropriate components on the diagram.
  - (d) Compute the magnitude of  $J_T$  and its direction ( $\phi$ ) relative to the long axis of the tibia.
  - (e) Is the shear component of  $J_T$  being sustained by the ACL or PCL? Explain.
  - (f) Compute the quadriceps muscle force (Q) knowing the patellar ligament force (T) and an appropriate T/Q ratio from the literature for this situation. Cite the source of your information and your rationale for choosing that particular value of T/Q.
  - (g) Assuming the angle between Q and T is  $84^\circ$  (see diagram), draw a complete FBD of the patella and compute the magnitude of the patellofemoral joint force ( $J_P$ ). Be sure to draw and label the force  $J_P$  on your FBD.
  - (h) Compute and label the direction ( $\alpha$ ) of the force  $J_P$ . Show the appropriate angle in your diagram.

