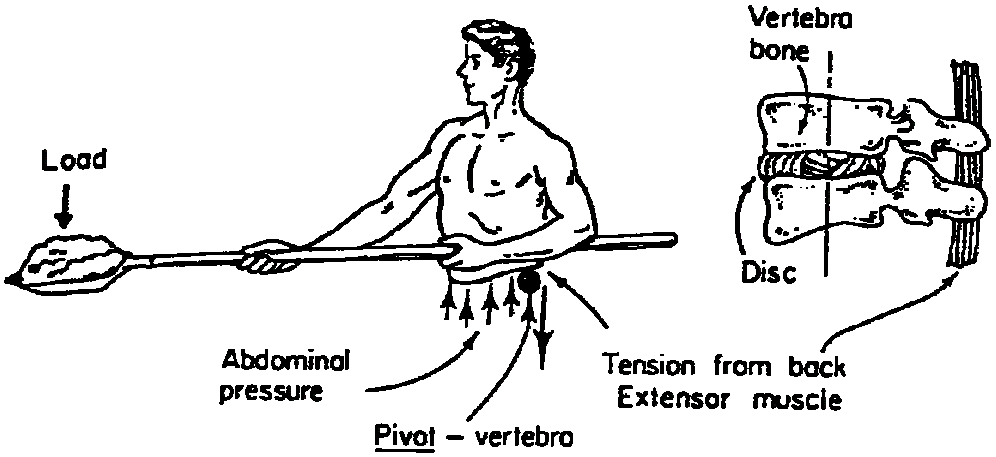
KIN 412/512 Problem Set 2
Fall 2005

Instructions: Show all your work including the equations used.

Due: Tuesday December 6 at 10:40 AM (last class day). Late papers will be accepted until Wednesday December 7 at 10:40 AM at which time the solutions will be posted on the class web page. Be sure to **make a copy of your problem set before you turn it in** so that you can compare it to the solutions.

1. J.J. is working hard shoveling dirt in his garden and stops long enough to pose for us. All we can see over the fence is his upper body. An *incomplete* free body diagram (FBD) is shown below. The dirt and shovel combination weighs 95 N and has a center of mass located 1.45 m from the L2-L3 disc of his lumbar spine. Assume his upper body (above the disc) weighs 550 N and its line of gravity falls 9.3 cm anterior to the disc. Also assume that the disc itself cannot resist moments. Hence the flexion moment of the weight of his upper body and that of the dirt and shovel has to be resisted by the back extensor muscles (assumed to be one muscle acting vertically downward with a moment arm of 5.2 cm posterior to the disc).
   a. Under these circumstances, compute the tension in his back muscle (E) as well as the joint force in his spine (J). Draw a complete FBD first.
   b. Now assume that he tenses up his abdominal muscles and develops an intra-abdominal pressure (IAP) that provides some upward supporting force on the abdomen (see diagram). If the center of this pressure lies 7.5 cm anterior to the disc and provides an overall upward force of 60 N, what happens to the values for E and J above (i.e., how much did they change)? Draw a new FBD including the 60 N force from the IAP.



2. Examine the woman performing a rowing exercise in the figure below. She is pulling back on the handgrips with a combined force of 170 N. The reaction to this force (the forward force on her hands from the grips) tends to flex her torso with a moment arm about the L3/L4 disc of 50 cm. The weight of her superincumbent body (above L3/L4, including arms) is 375 N and its line of gravity passes 8 cm anterior to the L3/L4 disc. Assume that the erector spinae muscles are the only spine extensor muscles active and that their line of action is normal to the disc surface (i.e., the erector spinae muscle force, E, acts in the compressive direction). Their moment arm about the L3/L4 disc is 5.5 cm. The inclination of the disc is –30º with the horizontal (see figure). Assuming the motion is "quasi-static" (i.e., the accelerations are negligible), compute the magnitude of the muscle force (E). Also compute the magnitude (J) and direction (ϕ) of the L3/L4 joint force. Draw an appropriate free body diagram first.