

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Physics

Physics 8.01X

Fall Term 2002

PROBLEM SET 6

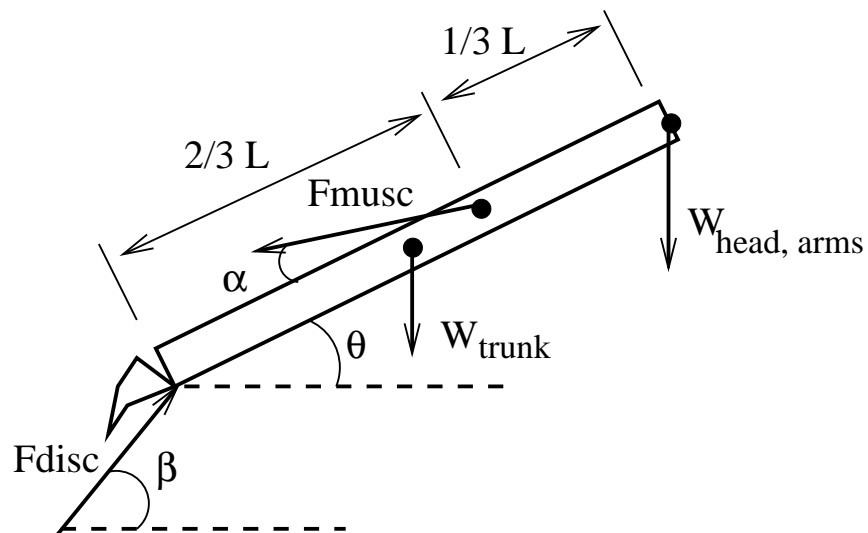
Handed out: October 11

Due: October 18 at 4 pm in 4-339B.

Please write your name, subject, **recitation number**, and the name of the recitation instructor on the top right corner of the first page of your homework solutions. The solutions should be placed in the appropriate box in room 4-339B. Note that sometimes you will be able to check your answer at the back of the book. You must always show your work for credit.

Problem 1: Young and Freedman 11-17.

Problem 2:



The human vertebral column is shown on the last page of this problem set. The sacrum is rigidly attached to the pelvis. The fifth lumbar vertebra is separated from the sacrum by a disc. In this problem we will approximate the spine as a rigid body hinged at the bottom of the lumbo-sacral disc. The top of the sacrum exerts a force \vec{F}_{disc} on the base of the lumbo-sacral disc. When a person of mass m bends over or lifts an object, the main muscles that lift the back are the erector spinae (sacrospinal muscles). These muscles act approximately as a single cord on the vertebral column and exert a force \vec{F}_{musc} at a point that is $2/3$ of the distance from the base of the spine (where the sacrum pushes on the base of the lumbo-sacral disc) to the center of gravity of the head and arms. The angle that this “cord” acts at is about $\alpha = 12$ degrees relative to the axis of the vertebral column. Assume that the mass of the head and arms is 0.2 the mass of the person. The center of mass of the trunk is one half the distance from the base of the spine to the center of gravity of the head and arms. Assume that the mass of the trunk is 0.4 the mass of the person.

Suppose that a person of mass 60 kg bends over such that the spine makes an angle of $\theta = 35$ degrees with the horizontal.

- a. Find the magnitude of the force F_{musc} that the muscles exert on the spine.
- b. Find the magnitude of the force F_{disc} on the base of the lumbo-sacral disc, and the angle β that this force makes with the horizontal.
- c. How does this force compare with the weight of the body?
- d. What is the compressive force on the disc?
- e. Suppose now the person lifts a mass equal to the mass of the head and arms, with arms hanging straight down. Assume the person is bent at the same angle of 35 degrees with the horizontal. By how much does the magnitude of the compressive force on the disc increase?
- f. Explain why you should bend your knees when you pick up an object, based on your results from this problem.

VERTEBRAL COLUMN, LATERAL VIEW

