

MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
Department of Physics

Physics 8.01T

Fall Term 2004

**In-Class Problems 17-19: Static Equilibrium**

Section \_\_\_\_\_ Table and Group Number \_\_\_\_\_

Names \_\_\_\_\_

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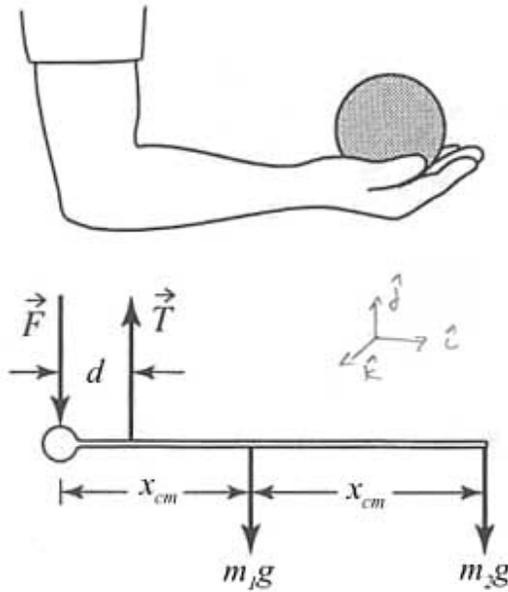
**Hand in one solution per group.**

We would like each group to apply the problem solving strategy with the four stages (see below) to answer the following two problems.

- I. Understand – get a conceptual grasp of the problem**
- II. Devise a Plan - set up a procedure to obtain the desired solution**
- III. Carry out your plan – solve the problem!**
- IV. Look Back – check your solution and method of solution**

### In-Class-Problem 17 Static Equilibrium: Forearm

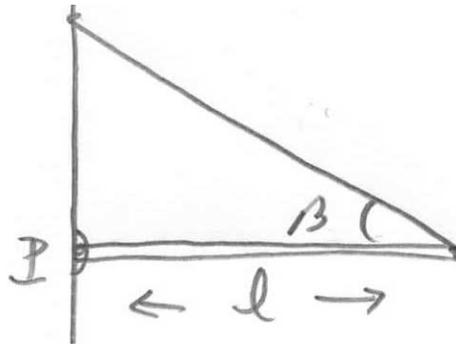
The human forearm (including the hand) can be regarded as a lever pivoted at the joint of the elbow with a downward force  $\vec{F}$  acting on the forearm at the elbow. The forearm is pulled upward by the tendon of the biceps  $\vec{T}$  which connects to the forearm a distance  $d$  from the joint. The tendon  $\vec{T}$  makes an angle of  $90^\circ$  with the horizontal. The forearm and hand have a mass of  $m_1$ . Assume the center of mass of the forearm and hand is a distance  $x_{cm}$  from the joint. Suppose an object of mass  $m_2$  rests in the hand a distance  $2x_{cm}$  away from the joint of the elbow. See the accompanying figure.



- What are the equations for static equilibrium of the forces?
- About point will you choose to analyze the torques? What are the equations for static equilibrium of the torques?
- What upward force  $\vec{T}$  must the tendon exert to keep the forearm horizontal?
- What is the downward force  $\vec{F}$  on the forearm at the elbow joint?

### In-Class-Problem 18 Static Equilibrium: Suspended Beam

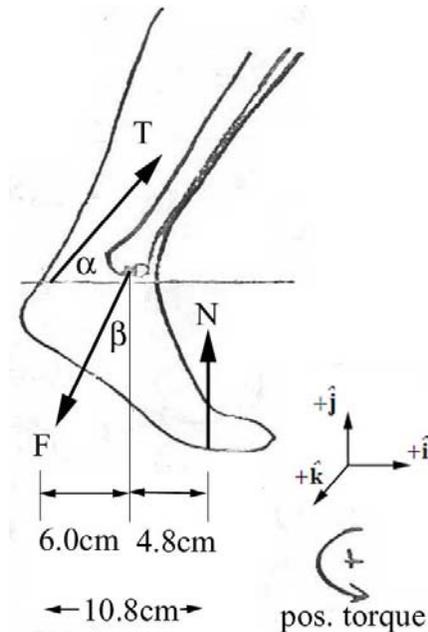
A rod of length 2.0 m and mass 4.0 kg is hinged to a wall at one end and suspended from the wall by a cable which is attached to the other end of the rod at an angle of  $\beta = 30^\circ$  to the rod (see sketch). Assume the cable is massless. There is a pivot force acting on the beam. The magnitude and direction of this force is unknown. One of the most difficult parts of these types of problems is to introduce an angle for the pivot force and then solve for that angle if possible. In this problem you will solve for the magnitude of the tension in the cable and the direction and magnitude of the pivot force.



- Draw a free body force diagram for the beam. Clearly indicate your choice of angle for the pivot force.
- What are the equations for static equilibrium of the forces?
- About point will you choose to analyze the torques? What are the equations for static equilibrium of the torques?
- What is the tension in the cable?
- What angle does the pivot force make with the beam?
- What is the magnitude of the pivot force?

### In-Class-Problem 19 Static Equilibrium: The Ankle

A person of mass  $m = 75 \text{ kg}$  is crouching with his/her weight evenly distributed on both tiptoes. The forces on the skeletal part of the foot are shown in the diagram. In this position, the Achilles tendon is under considerable tension,  $\vec{T}$ , and makes an angle of  $\alpha = 37^\circ$  with the horizontal. The tendon acts on the ankle a horizontal distance  $d = 10.8 \text{ cm}$  from the point where the foot contacts the floor. The tibia acts on the foot with magnitude,  $F \equiv |\vec{F}|$  and makes an angle  $\beta$  with the vertical. This force acts on the ankle a horizontal distance  $s = 4.8 \text{ cm}$  from the point where the foot contacts the floor. You may ignore weight of the foot.



- Find the magnitude of the tension in the Achilles tendon,  $T \equiv |\vec{T}|$ .
- Find the magnitude,  $F \equiv |\vec{F}|$ , and the angle,  $\beta$ , of the tibia force on the ankle.