ENGINEERING BIOMECHANICS: STATICS[1]

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DIMENSIONS AND UNITS

1. A man has a weight of 188 lb and he runs 400 m in 3 minutes 23 seconds. Calculate his weight in kg and his running time in seconds.

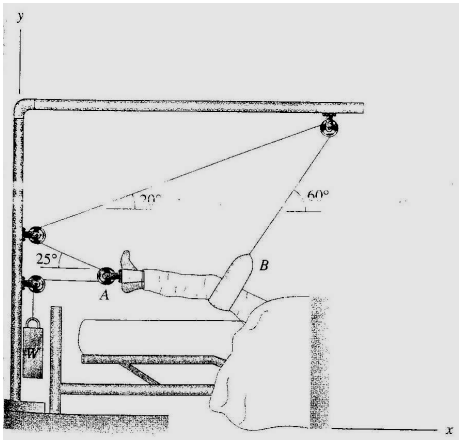
2. The weight of the person is 230 pounds. Convert his weight to Newtons.

3. If an Olympic athlete swims 100 m in 10 seconds. What is his average velocity in mi/hr?

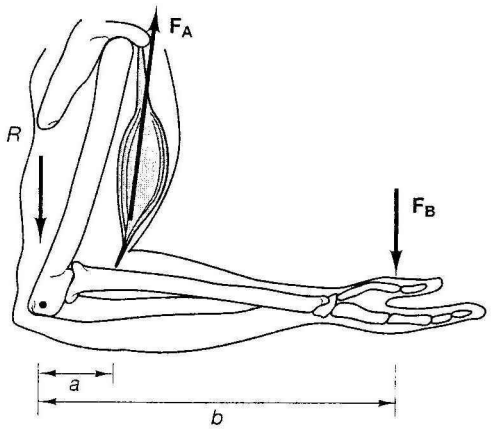
4. A person on a diet might lose 2.3 kg per week. Express the mass loss rate in milligrams per second, as if the dieter could sense the second by second loss, [Halliday and Walker 2003, 1N].

STATICS OF PARTICLES

1. The system shown is called Russell's traction. The sum of the downward forces exerted at A and B by the patient's leg is 32.2 lb. What is the weight? [Bedford and Fowler 1999, 207].



2. Draw a free body diagram of the human arm [Inman and Soutas-Little 1998, 241].



Numbers in parenthesis refer to the appended references.

[1] This problem set was prepared on May 14, 2004 for the course INGE3031: Statistics. Course Instructor: Dr. Megh R. Goyal, Professor in Agricultural and Biomedical Engineering, General Engineering Department, PO Box 5984, Mayagüez, Puerto Rico 00681-5984. For details contact: m_goyal@ece.uprm.edu or visit at: http://www.ece.uprm.edu/~m_goyal/home.htm

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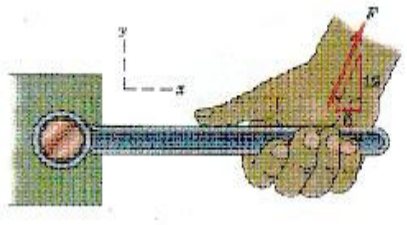
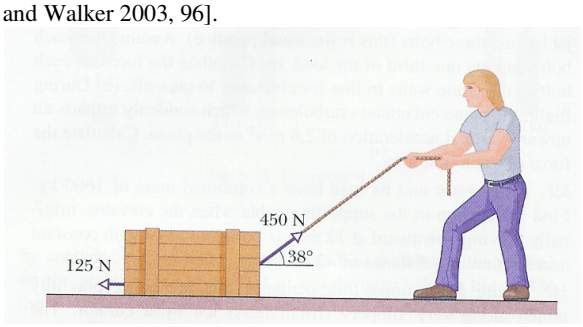
3. The y component of the force F which a person exerts on the handle of the box wrench is known to be 70 lb. Determine de x component and the magnitude of F, [Meriam and Kraige, 33].

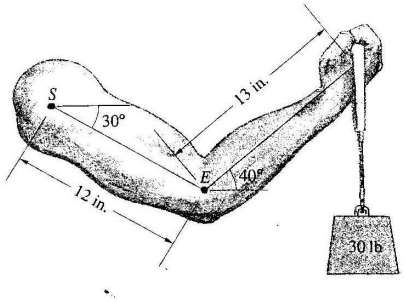


4. A worker drags a crate across a factory floor by pulling on a rope tied to a crate. The worker exerts a force of 450 N on the rope, which is inclined at 38° to the horizontal, and the floor exerts a horizontal force of 125 N that opposes the motion. Calculate the magnitude of the acceleration of the crate if (a) its mass is 320 kg and (b) its weight is 310 N, [Halliday and Walker 2003, 96].

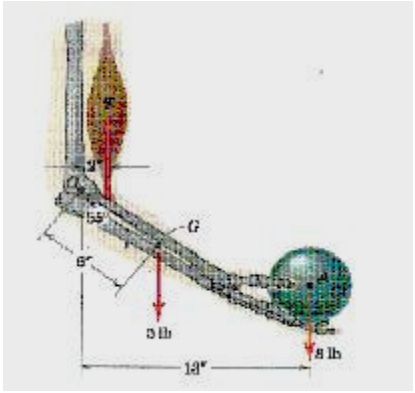


EQUIVALENT SYSTEM OF FORCES

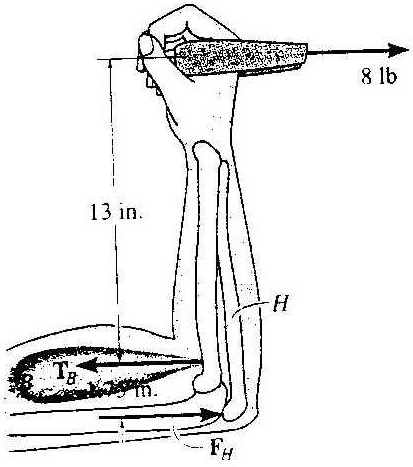
1. Determine the moment exerted by the 30 lb weight (a) about E, (b) about S, [Bedford and Fowler 1999, 134].



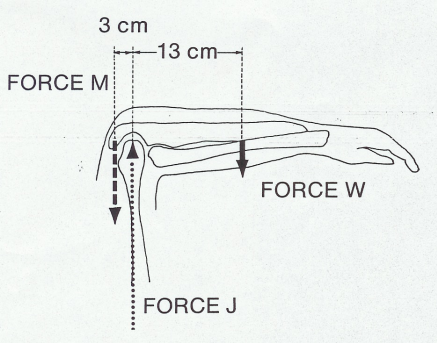
2. Elements of the lower arm are shown in the figure. The weight of the forearm is 5 lb with mass center at G. Determine the combined moment about the elbow pivot O of the weights of the forearm and the sphere. What must the biceps tension force be so that the overall moment about O is zero? [Meriam and Kraige, 43].



3. A man is pulling a load of 8 lb with one arm held as shown. Determine the force F_H this exerts on the humerus bone H, and the tension developed in the biceps muscle B. Neglect the weight of the man's arm, [Hibbeler 1995, 207].

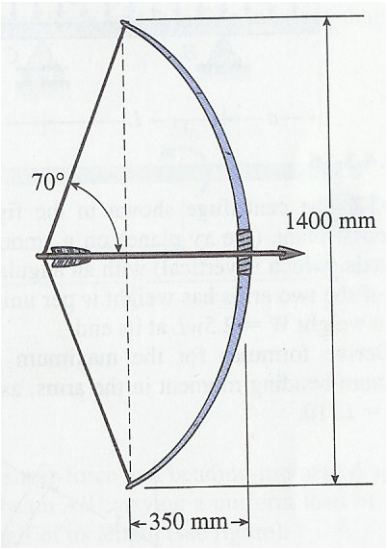


4. Determine the joint reaction force during elbow extension, [Frankel and Nordin 1989, 251].

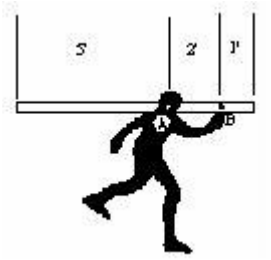


EQUILIBRIUM OF RIGID BODIES

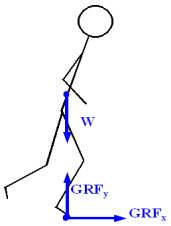
1. At full draw, an archer applies a pull of 150 N to the bowstring of the bow shown in the figure. Determine the bending moment at the midpoint of the bow, [Gere, 2001, 303].



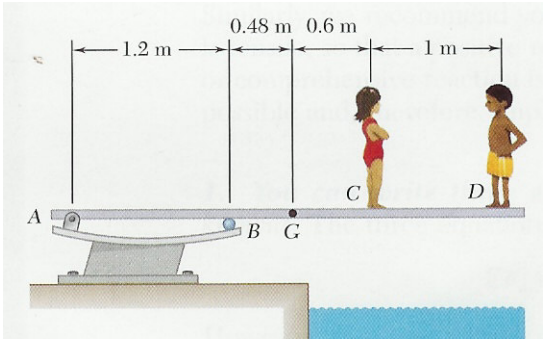
2. A carpenter carries a 12 lb, 2 x 4 inch board as shown. What downward force does he feel on his shoulder at A? [Meriam and Kraige, 124].



3. Consider a woman with mass 45 kg running. During a phase of contact with the ground her vertical (Y) and horizontal (X) ground reaction forces (GRFs) vary as shown. What is the change in velocity between the start of the contact phase (t = 0) and the end of the contact phase (t = 0.9)?

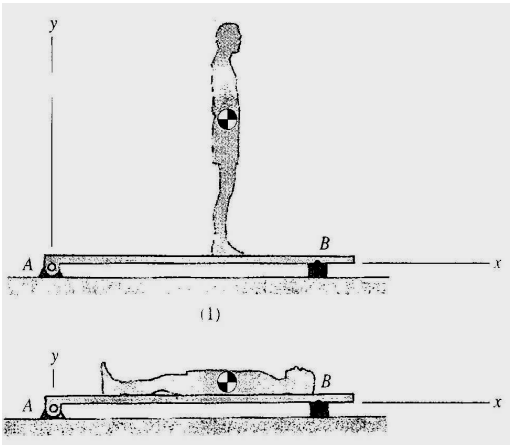


4. Two children are standing on a diving board of mass 65 kg. Knowing that the masses of the children at C and D are 28 kg and 40 kg, respectively, determine (a) the reaction at A, (b) the reaction at B, [Beer and Johnston 2003, 172].

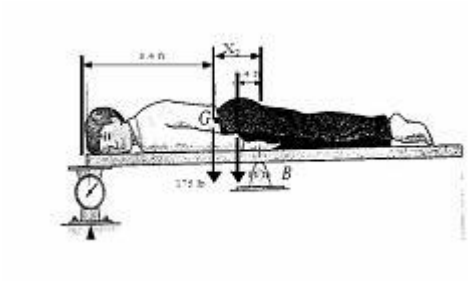


CENTROIDS AND CENTERS OF GRAVITY

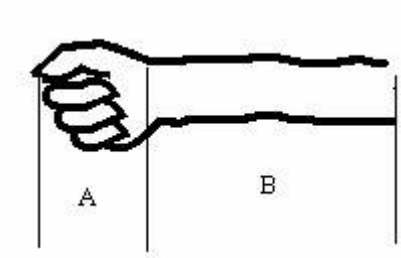
1. A horizontal board has a pin support A and rests on a scale that measures weight at B. The distance point from A to B is 90 in. When the person is not on the board, the scale measures 20 lb. When a 135-lb person is in position (1), the scale measures 98 lb. What is the x coordinate of the person's center of mass? [Bedford and Fowler 1999].



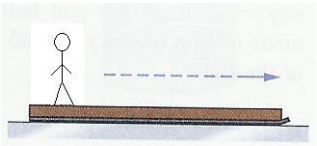
2. Determine the center of mass of a body if its weight W2 is 175 and the weight (W1) and location (X1) of the balance board are 81 lb and 5 inches respectively. X3 = 3.4 ft, X2 = 0.8 ft and S = 194 lb (S is and upward force acting at a distance X3 from the pivot), [Hibbeler 1995, 469].



3. Determine the center of mass if the length of A is 12 cm and the length of B is 30 cm.

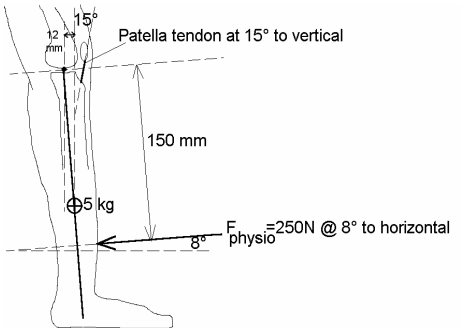


4. A person stands at the left edge of a uniform sled of length L, which lies on frictionless ice. The sled and person have equal masses. Where is the center of mass of the sled? [Modified from Halliday and Walker 2003, 187].

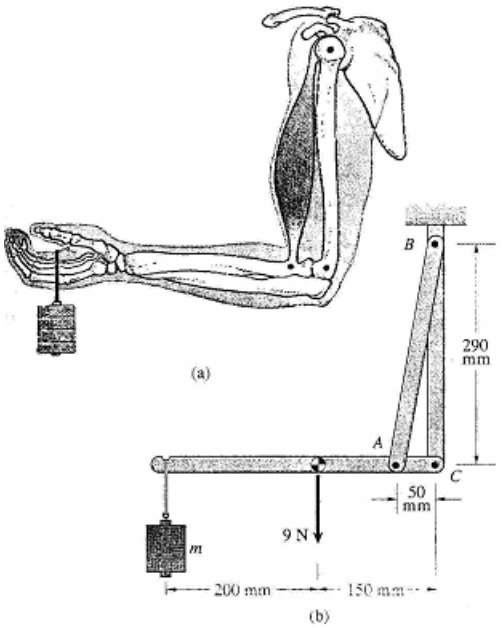


ANALYSIS OF STRUCTURES

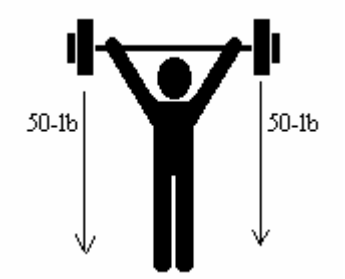
1. Consider a woman extending her knee against resistance provided by a physiotherapist. The mass of the leg (shank + foot) is 5 kg, located at the center of mass shown, which 12 mm anterior to the joint is. A force of 250 N is applied perpendicular to the leg at a distance of 150 mm from the joint, at an angle of 8° to horizontal, as shown. The quadriceps muscle has a moment arm = 25 mm (applied via the patella tendon at 15° from vertical). What is the quadriceps muscle force, and what is the knee joint (tibio-femoral) force for equilibrium? [Lee 2003].



2. Figure (a) is a diagram of the bones and biceps muscle of a person's arm supporting a mass. Tension in the biceps muscle holds the forearm in the horizontal position, as illustrated in the simple mechanical model in fig (b). The weight of the forearm is 9 N, and the mass m = 2 kg. A) Determine the tension in the point A [Bedford and Fowler 1999, 315].



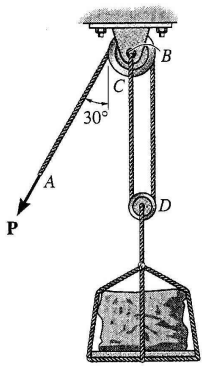
3. Determine the force applied by the man



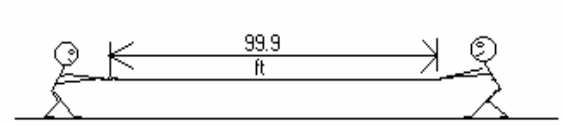
4. A 49 kg rock climber is climbing a "chimney" between two rock slabs. The static coefficient of friction between her shoes and the rock is 1.2; between her back and the rock it is 0.80. She has reduced her push against the rock until her back and her shoes are on the verge of slipping. What is her push against the rock? [Halliday and Walker 2003, 112].

FORCES IN BEAMS AND CABLE

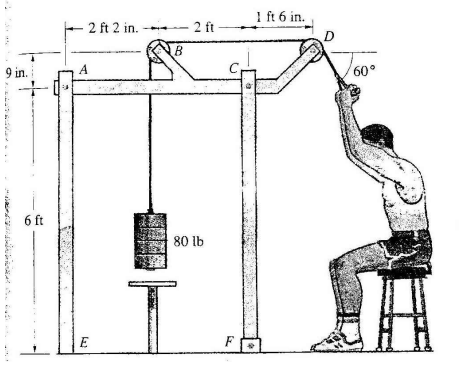
1. The cable and pulleys are used to lift the 600-lb stone. Determine the force that must be exerted on the cable at A and the magnitude of the resultant force the pulley at C must exert on pin B when the cables are in position shown, [Hibbeler 1998].



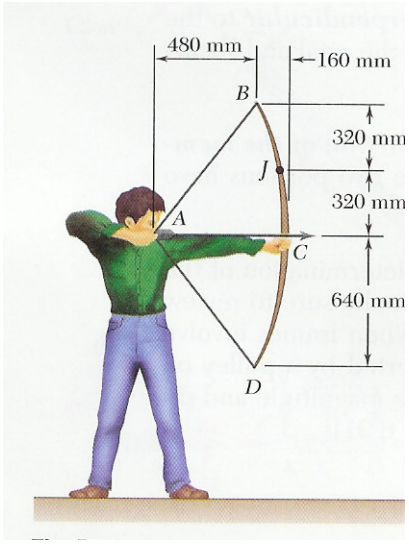
2. A steel tape used for measurement in surveying has a length of 100.0 ft and a total weight of 2 lb. How much horizontal tension must be applied to the tape so that the distance marked on the ground is 99.90 ft. The calculation should also include the effects of elastic stretching and temperature changes on the tape's length, [Hibbeler 1998, 362].



3. The man using the exercise machine is holding the 80 lb weight stationary in the position shown. What are the reaction at the built-in support E and the pin support F? A and C are pinned connections, [Bedford and Fowler 1999, 313].

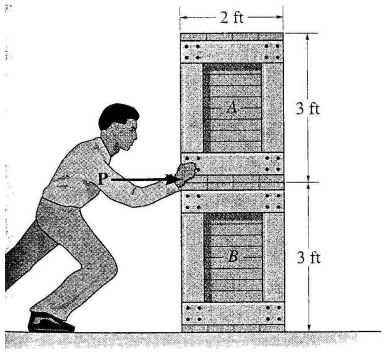


4. An archer aiming at a target is pulling with a 210 N force on the bowstring. Assuming that the shape of the bow can be approximated by a parabola, determine the internal forces at point J, [Beer and Johnston 2003, 358].

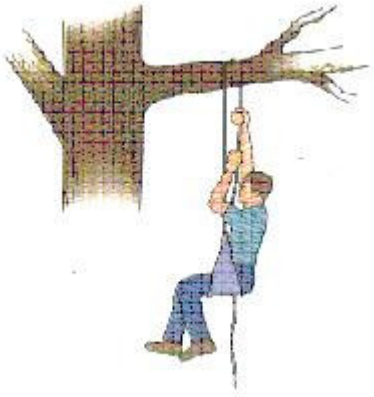


DRY FRICTION

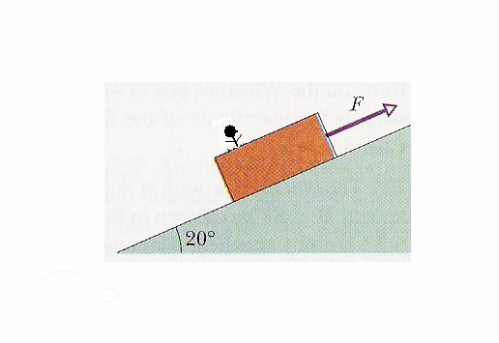
1. A man having a weight of 150 lb. pushes vertically on the bottom of crate A, which is stacked on crate B. Each crate has a weight of 100 lb. If the coefficient of static friction between each crate is $\mu_s = 0.8$ between the bottom crate, his shoes, and the floor is $\mu_s = 0.3$, determine if he can cause impending motion, [Hibbeler 1998].



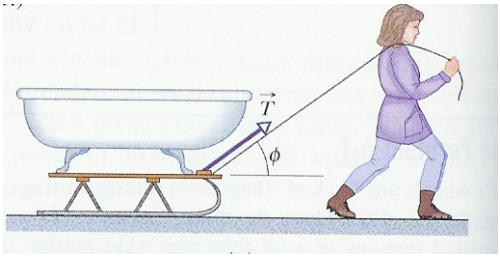
2. The 180 lb tree surgeon lowers himself with the rope over a horizontal limb of the tree. If the coefficient of friction between the rope and the limb is 0.60, compute the force with man must exert on the rope to let himself down slowly without causing mayor damage to the limb? [Meriam and Kraige, 373].



3. A loaded person sled weighing 80 N rest on an plane inclined at 20° to the horizontal. Between the sled and the plate, the coefficient of static friction is 0.15. (a) What is the minimum magnitude of the force F, parallel to the plane that will prevent the sled from slipping down the plane? (b) What is the minimum magnitude F that will start the sled moving up the plane? (c) What the value of F is required to move the sled up the plane at constant velocity? [Halliday and Walker 2003, 113].

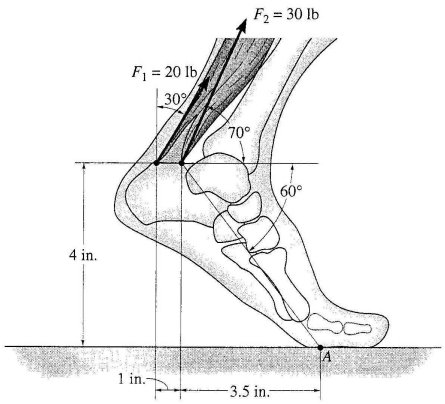


4. A woman pulls a loaded sled of mass m = 75 kg along a horizontal surface at constant velocity. The coefficient of kinetic friction μ_k between the runners and the snow is 0.10, and the angle φ is 42°. What is the magnitude of the force **T** on the sled from the rope? [Halliday and Walker 2003, 102].

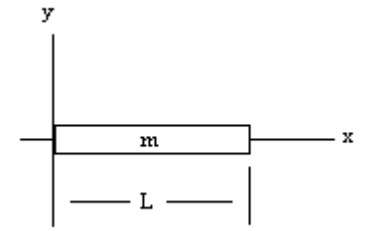


MOMENTS OF INERTIA

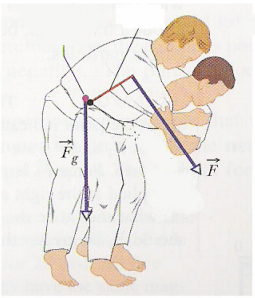
1. The foot segment is subjected to the pull of the two plantar flexor muscles. Determine the moment of each force about the point of contact A on the ground, [Hibbeler 1998].



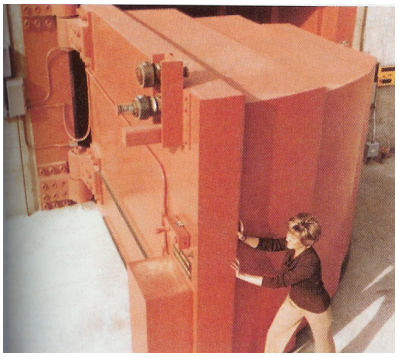
2. Determine the moment of inertia of a portion of a bone with length L and mass m with respect to an axis which is perpendicular to the bone and passes through one end of the bone.



3. To throw an 80 kg opponent with a basic judo hip throw, you intend to pull his uniform with a force F and a moment arm d_1 = 0.30 m from a pivot point (rotational axis) on your right hip. You wish to rotate him about the pivot point with an angular acceleration α of –6.0 rad/s^2. Assume that his rotational inertia I relative to the pivot point in 15 kg.m^2. (a) What must the magnitude of F be if, before you throw him, you bend your opponent forward to bring his center of mass to your hip? [Halliday and Walker 2003, 232].



4. The figure shows the massive shield door at the neutron test facility at Lawrence Livermore Laboratory; this is the world's heaviest hinged door. The door has a mass of 44,000 kg, a rotational inertia about a vertical axis through its huge hinges of 8.7 x 10^4 kg - m^2, and a (front) face width of 2.4 m. Neglecting friction, what steady force, applied at its outer edge and perpendicular to the plane of the door, can move it from rest through an angle of 90° in 30 s [Halliday and Walker 2003, 243].



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