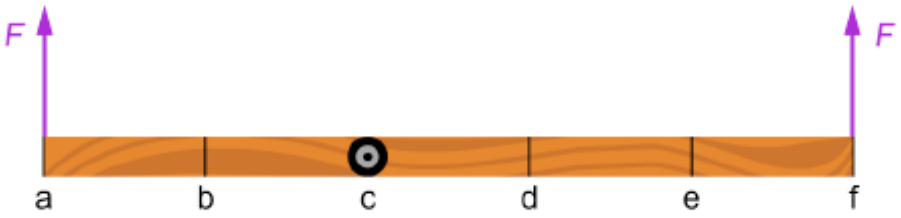
ch 12 problems

Chapter 12: Static Equilibrium and Elasticity

Conceptual problems

12.C.1 (5.00) The sketch shows a rod divided into five equal parts. The rod has negligible mass and a fixed pivot at point c. An upward force of magnitude *F* is applied at point a, and an identical force is applied at point f, as shown. At what point on the rod could you apply a third force of the same magnitude *F*, perpendicular to the rod, either upward or downward, so that the net torque on the rod is zero? Check all of the points for which this is possible.



- [ ] a
- [ ] b
- [ ] c
- [ ] d
- [ ] e
- [ ] f

12.C.2 (5.00) Use principles of equilibrium to describe how the gymnast is able to hold his body in this position.

12.C.3 (7.00) The Space Needle in Seattle, Washington is over 500 feet tall, but the center of gravity of the complete structure is only 5 feet off the ground. This is achieved with a huge concrete foundation that weighs more than the Space Needle itself. What is the advantage of having a center of gravity so low?

12.C.4 (5.00) (a) Which point is the proportionality limit? (b) Which point is the rupture point? (c) Which point is the elastic limit?

(a)
(b)
(c)

12.C.5 (5.00) Suppose you have four rods made of four different materials-aluminum, copper, steel and titanium. They all have the same dimensions, and the same force is applied to each. Order the rods from smallest to largest by how much each stretches.

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Section 1: Static equilibrium

12.1.1 (5.00) Two children sit *R* m apart on a very low-mass horizontal seesaw with a movable fulcrum. The child on the left has a mass of 29.0 kg, and the child on the right has a mass of 38.0 kg. At what distance, as measured from the child on the left, must the fulcrum be placed in order for them to balance?

m

12.1.3 (5.00) A 3.6-meter long horizontal plank is held up by two supports. One support is at the left end, and the other is 0.80 m from the right end. The plank has uniform density and has a mass of 40 kg. How close can a 70 kg person stand to the unsupported end before causing the plank to rotate?

m

12.1.4 (5.00) The mass of the sign shown is 28.5 kg. Find the weight supported by (a) the left support and (b) the right support.

(a) N

(b) N

12.1.6 (7.00) A person who weighs 620 N stands at x = 5.00 m, right on the end of a long horizontal diving board that weighs 350 N. The diving board is held up by two supports, one at its left end at x = 0, and one at the point x = 2.00 m. (a) What is the force exerted on the support at x = 0? (b) What is the force acting on the other support? (Use positive to indicate an upward force, negative for a downward force.)

(a) N

(b) N

12.1.7 (7.00) Two brothers, Jimmy and Robbie, sit 3.00 m apart on a horizontal seesaw with its fulcrum exactly midway between them. Jimmy sits on the left side, and his mass is 42.5 kg. Robbie's mass is *m* kg. Their sister Betty sits at the exact

point on the seesaw so that the entire system is balanced. If Betty is 29.8 kg, at what location should she sit? Take the fulcrum to be the origin, and right to be positive. Assume that the mass of the seesaw is negligible.

m

12.1.8 **(7.00)** If a cargo plane is improperly loaded, the plane can tip up onto its tail while it rests on the runway (this has actually happened). Suppose a plane is 45.0 m long, and weighs 1.20×10^6 N. The center of mass of the plane is located 21.0 m from the nose. The nose wheel located 3.50 m from the nose and the main wheels are 25.0 m from the nose. Cargo is loaded into the back end of the plane. If the center of mass of the cargo is located 40.0 m from the nose of the plane, what is the maximum weight of the cargo that can be put in the plane without tipping it over (that is, so that the plane remains horizontal)?

N

12.1.10 **(7.00)** The sketch shows a mobile in equilibrium. Each of the rods is 0.16 m long, and each hangs from a supporting string that is attached one fourth of the way across it. The mass of each rod is 0.10 kg. The mass of the strings connecting the blocks to the rods is negligible. What is the mass of (a) block A? (b) block B?

(a) kg

(b) kg

12.1.11 **(7.00)** Two identical 1.80 m long boards just barely balance on the edge of a table, as shown in the figure. What is the distance *x*?

m

12.1.12 **(7.00)** The wheelbarrow shown has a mass of 35.0 kg without the wheel. When it is empty, the center of mass is 0.400 m from the axle. A load with a mass of 55.0 kg is put in the wheelbarrow, 0.600 m from the axle. Olivia holds the handles of the wheelbarrow, 1.20 m from the axle. She lifts the handles so that they make a 25.0° angle with the ground. What is the upward force that Olivia applies to the handles in order to hold the wheelbarrow in that position?

N

12.1.14 **(10.00)** (a) A mobile is constructed by connecting a string to a massless rod one-third of the way from the end. A block is attached to each end of the rod. The mobile is in static equilibrium. What is the mass of the block hanging from the end of the rod farther from the string, as a fraction of the mobile's total mass *m*? (b) Suppose that the block hanging from the far end is replaced by another massless rod with two dependent blocks, having the same net mass as the single block they replace. The string supporting the lower rod is attached one-third of the way from its end. What is the mass of the block on the end of the lower rod that is farther from the supporting string, as a fraction of the mobile's total mass *m*? (c) Now suppose the mobile consists of a chain of *n* rods connected in the same manner. What is the mass of the block on the far end of the lowest rod as a fraction of the total mass? Express your answer in terms of *n*.

(a) ○ 1/9 ○ 2/9 ○ 1/3 ○ 1/2 ○ 2/3
(b) ○ 1/27 ○ 1/9 ○ 4/27 ○ 2/9 ○ 1/4
(c) ○ $1/3^n$ ○ $1/2^n$ ○ $2/3^n$ ○ $2/3^n$ ○ $1/n^3$

Section 3: Center of gravity

12.3.1 **(5.00)** A weightlifter has been given a barbell to lift. One end has a mass of 5.5 kg while the other end has a mass of *m2* kg. The bar is 0.20 m long. (Consider the bar to be massless, and assume that the masses are thin disks, so that their centers of mass are at the ends of the bar.) How far from the heavier end should she hold the bar so that the weight feels balanced?

[ ] m

12.3.2 **(5.00)** A *x* m rod with uniform mass distribution runs along the *x* axis with its left end at the origin. A 1.8 m rod with uniform mass distribution runs along the *y* axis with its top end at the origin. Find the coordinates of the center of gravity for this system.

([ ] , [ ]) m

12.3.5 **(5.00)** A woman with weight 637 N lies on a bed of nails. The bed has a weight of 735 N and a length of 1.72 m. The bed is held up by two supports, one at the head and one at the foot. Underneath each support is a scale. When the woman lies in the bed, the scale at the foot reads 712 N. How far is the center of gravity of the system from the foot of the bed of nails?

[ ] m

Section 4: Sample problem: a leaning ladder

12.4.1 **(7.00)** A ladder leans against a wall making a 55.0° angle to the floor. The ladder is 4.50 m long, and weighs 415 N. The wall is frictionless and so is the floor. A horizontal wire is attached to the base of the ladder and attached to the wall. (a) What is the tension in the wire? (b) A person who weighs 655 N stands on a rung of the ladder located 2.00 m from its lower end. What is the new tension in the wire?

(a) _____ N

(b) _____ N

Section 11: Stress and strain

12.11.1 **(5.00)** (a) Suzy the elephant weighs 65,000 N. The cross-sectional area of each foot is 0.10 m^2. When she stands on all fours, what is the average stress on her feet? (b) Suzanne the stockbroker weighs 610 N. She wears a pair of high-heeled shoes whose heels each have a cross-sectional area of 1.5×10^{-4} m^2 in contact with the floor. If she stands with all her weight on her heels, what is the stress on the heels of the shoes?

(a) _____ N/m^2

(b) _____ N/m^2

Section 12: Tensile stress

12.12.1 **(5.00)** A 85.0 kg window washer hangs down the side of a building from a rope with a cross-sectional area of 4.00×10^{-4} m^2. If the rope stretches 0.740 cm when it is let out 7.50 m, how much will it stretch when it is let out *L* m?

_____ m

Section 13: Volume stress

12.13.1 **(5.00)** The deepest point in the seven seas is the Marianas Trench in the Pacific Ocean. The pressure in the deepest parts of the Marianas Trench is 1.1×10^{8} Pa. Pressure at the surface of the ocean is 1.0×10^{5} Pa. If a mass of salt water has a volume of *V* m^3 at the surface of the ocean, what will be its volume at the bottom of the Marianas Trench?

_____ m^3

Section 14: Shear stress

12.14.1 **(5.00)** A *m* kg sculpture is attached to the wall by 4 identical bolts inserted into horizontally-drilled holes in the wall. If each bolt has a circular cross-sectional area of 5.50×10^{-5} m^2, what is the shear stress on the bolts?

_____ N/m^2

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