Name_____

MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) What condition or conditions are necessary for rotational equilibrium? 1) _____
    A) $\Sigma F_x = 0$ B) $\Sigma F_x = 0, \Sigma F_y = 0$
    C) $\Sigma T = 0$ D) $\Sigma F_x = 0, \Sigma T = 0$

Answer: C

2) What condition or conditions are necessary for static equilibrium? 2) _____
    A) $\Sigma T = 0$ B) $\Sigma F_x = 0, \Sigma F_y = 0, \Sigma T = 0$
    C) $\Sigma F_x = 0, \Sigma F_y = 0$ D) $\Sigma F_x = 0$

Answer: B

3) A book weighs 6 N. When held at rest above your head the net force on the book is 3) _____
    A) 9.8 N. B) -6 N. C) 6 N. D) 0 N.

Answer: D

4) A rocket moves through outer space with a constant velocity of 9.8 m/s. What net force acts on it? 4) _____
    A) a force equal to the gravity acting on it
    B) a force equal to its weight on Earth, mg
    C) The net force is zero.
    D) cannot be determined without more information

Answer: C

5) A person weighing 800 N stands with one foot on each of two bathroom scales. Which statement is 5) _____
definitely true?
    A) If one scale reads 500 N, the other will read 300 N.
    B) Each scale will read 400 N.
    C) Each scale will read 800 N.
    D) None of the above is definitely true.

Answer: A

6) A heavy boy and a light girl are balanced on a massless seesaw. If they both move forward so that 6) _____
they are one-half their original distance from the pivot point, what will happen to the seesaw?
    A) The side the boy is sitting on will tilt downward.
    B) Nothing, the seesaw will still be balanced.
    C) The side the girl is sitting on will tilt downward.
    D) It is impossible to say without knowing the masses and the distances.

Answer: B

7) Muscles that tend to bring two limbs closer together are called 7) _____
    A) extensors. B) tendons. C) insertions. D) flexors.

Answer: D

8) Muscles that act to extend a limb outward are called 8) _____
    A) flexors. B) insertions. C) extensors. D) tendons.

Answer: C

9) A sphere hanging freely from a cord is in
    A) stable equilibrium.
    C) positive equilibrium.
    B) unstable equilibrium.
    D) neutral equilibrium.

Answer: A

9) _____

10) A cone balanced on its small end is in
    A) unstable equilibrium.
    C) stable equilibrium.
    B) positive equilibrium.
    D) neutral equilibrium.

Answer: A

10) _____

11) A cube resting on a horizontal tabletop is in
    A) stable equilibrium.
    C) neutral equilibrium.
    B) positive equilibrium.
    D) unstable equilibrium.

Answer: C

11) _____

12) Consider two identical bricks, each of dimensions 20.0 cm × 10.0 cm × 6.0 cm. One is stacked on the other, and the combination is then placed so that they project out over the edge of a table. What is the maximum distance that the end of the top brick can extend beyond the table edge without toppling?
    A) 7.5 cm   B) 15 cm   C) 12.5 cm   D) 10 cm

Answer: B

12) _____

13) A 36-kg round table is supported by three legs placed equal distances apart on the edge. What minimum mass, placed in the middle between two supports on the table's edge, will cause the table to overturn?
    A) 36 kg   B) 12 kg   C) 24 kg   D) 48 kg

Answer: A

13) _____

14) Stress is
    A) the same as force.
    C) the ratio of the change in length.
    B) the strain per unit length.
    D) applied force per cross-sectional area.

Answer: D

14) _____

15) Strain is
    A) the applied force per unit area.
    B) the stress per unit area.
    C) the ratio of stress to elastic modulus.
   D) the ratio of the change in length to the original length.

Answer: D

15) _____

16) A mass is hung from identical wires made of aluminum, brass, copper, and steel. Which wire will stretch the least?
    A) steel
    B) copper
    C) brass
    D) aluminum
    E) all the same

Answer: A

16) _____

17) A copper wire is found to break when subjected to minimum tension of 36 N. If the wire diameter were half as great, we would expect the wire to break when subjected to a minimum tension of

    A) 36 N.   B) 18 N.   C) 108 N.   D) 9.0 N.

17) _____

Answer: D

18) The horizontal component of the buttressing force at the base of a pointed arch is

    A) greater than that of a rounded arch.   B) less than that of a rounded arch.
    C) equal to that of a rounded arch.   D) zero in magnitude.

18) _____

Answer: B

19) A lever is 5.0 m long. The distance from the fulcrum to the weight to be lifted is 1.0 m. If a worker pushes on the opposite end with 400 N, what is the maximum weight that can be lifted?

    A) 2000 N   B) 100 N   C) 1600 N   D) 80 N

19) _____

Answer: C

20) A lever is 5.0 m long. The distance from the fulcrum to the weight to be lifted is 1.0 m. If a 3000 N rock is to be lifted, how much force must be exerted on the lever?

    A) 600 N   B) 12000 N   C) 3000 N   D) 750 N

20) _____

Answer: D

21) A boy and a girl are balanced on a massless seesaw. The boy has a mass of 75 kg and the girl's mass is 50 kg. If the boy sits 2.0 m from the pivot point on one side of the seesaw, where must the girl sit on the other side?

    A) 3.0 m   B) 2.5 m   C) 2.3 m   D) 1.3 m

21) _____

Answer: A

22) Two children sit on opposite ends of a uniform seesaw which pivots in the center. Child A has mass 60 kg and sits 2.0 m from the center. Child B has mass 40 kg. How far from the center must child B sit for the seesaw to balance?

    A) 1.3 m
    B) 3.0 m
    C) 2.5 m
    D) cannot be determined without knowing the seesaw's mass

22) _____

Answer: B

23) A uniform board of weight 40 N supports two children weighing 500 N and 350 N, respectively. If the support is at the center of the board and the 500-N child is 1.5 m from the center, what is the position of the 350-N child?

    A) 2.1 m   B) 1.1 m   C) 1.5 m   D) 2.7 m

23) _____

Answer: A

24) A 10-m uniform beam of weight 100 N is supported by two ropes at the ends. If a 400-N person sits at 2.0 m from the left end of the beam, what is the tension in the left rope?

    A) 370 N   B) 500 N   C) 130 N   D) 250 N

24) _____

Answer: A

25) A 10-m uniform beam of weight 100 N is supported by two ropes at the ends. If a 400-N person sits at 2.0 m from the left end of the beam, what is the tension in the right rope?

    A) 130 N   B) 370 N   C) 500 N   D) 250 N

25) _____

Answer: A

26) A massless scaffold is held up by a wire at each end. The scaffold is 12 m long. A 300-N box sits 4.0   26) _____
m from the left end. What is the tension in each wire?
   A) left wire = 2700 N; right wire = 900 N   B) left wire = 900 N; right wire = 2700 N
   C) left wire = 200 N; right wire = 100 N   D) left wire = 100 N; right wire = 200 N

Answer: C

27) A 200-N scaffold is held up by a wire at each end. The scaffold is 18 m long. A 650-N box sits 3.0   27) _____
m from the left end. What is the tension in each wire?
   A) left wire = 640 N; right wire = 210 N   B) left wire = 195 N; right wire = 975 N
   C) left wire = 520 N; right wire = 130 N   D) left wire = 295 N; right wire = 1000 N

Answer: A

28) A uniform meter stick is supported by a knife edge at the 50-cm mark and has masses of 0.40 kg   28) _____
and 0.60 kg hanging at the 20-cm and 80-cm marks, respectively. Where (at what mark) should a
third mass of 0.30 kg be hung to keep the stick in balance?
   A) 25 cm   B) 70 cm   C) 30 cm   D) 20 cm

Answer: C

29) A 500-N person stands on a uniform board of weight 100 N and length 8.0 m. The board is   29) _____
supported at each end. If the support force at the right end is three times that at the left end, how
far from the right end is the person?
   A) 1.6 m   B) 4.0 m   C) 6.4 m   D) 2.0 m

Answer: A

30) Two scales are separated by 2.00 m, and a plank of mass 4.00 kg is placed between them. Each   30) _____
scale is observed to read 2.00 kg. A person now lies on the plank, after which the right scale reads
30.0 kg and the left scale reads 50.0 kg. How far from the right scale is the person's center of gravity
located?
   A) 1.20 m   B) 1.30 m   C) 1.26 m   D) 1.23 m

Answer: C

31) Two telephone poles are separated by 40 m and connected by a wire. A bird of mass 0.50 kg lands   31) _____
on the wire midway between the poles, causing the wire to sag 2.0 m below horizontal. Assuming
the wire has negligible mass, what is the tension in the wire?
   A) 25 N   B) 12 N   C) 50 N   D) 6.2 N

Answer: A

4

2.5 cm

30.0 cm

Elbow joint

$\vec{F}_M$

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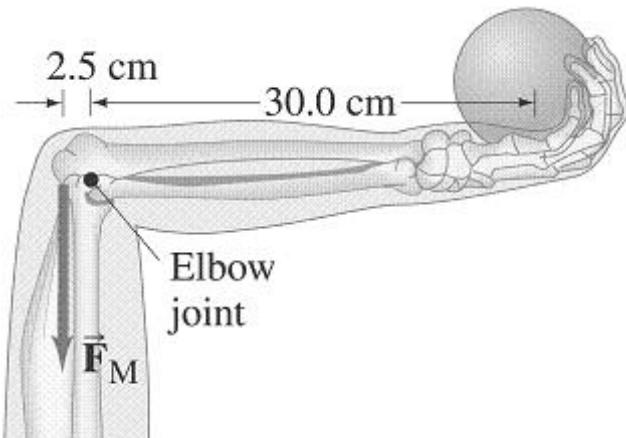
FIGURE 9-1

32) Assuming the lower arm has a mass of 2.8 kg and its CG is 12 cm from the elbow-joint pivot, how much force must the extensor muscle in the upper arm exert on the lower arm to hold a 7.5 kg shot put (Fig. 9-1)?

    A) 1500 N   B) 500 N   C) 100 N   D) 1000 N

32) _____

Answer: D

33) A passenger van has an outer wheel base width of 2.00 m. Its center of gravity is equidistant from the sides, and positioned 1.20 m above the ground. What is the maximum sideways angle at which it can be inclined without tipping over?

    A) 50.2°   B) 39.8°   C) 32.6°   D) 57.3°

33) _____

Answer: B

34) The Leaning Tower of Pisa is 55 m tall and about 7.0 m in diameter. The top is 4.5 m off center. How much farther can it lean before it becomes unstable?

    A) 0.5 m   B) 1.5 m   C) 3.5 m   D) 2.5 m

34) _____

Answer: D

35) A 5000-N force compresses a steel block by 0.0025 cm. How much force would be needed to compress the block by 0.0125 cm?

    A) 5000 N   B) 2500 N   C) 1000 N   D) 25000 N

35) _____

Answer: D

36) A cable is 100-m long and has a cross-sectional area of 1 mm^2. A 1000-N force is applied to stretch the cable. The elastic modulus for the cable is 1.0×10^{11} N/m^2. How far does it stretch?

    A) 10 m   B) 1.0 m   C) 0.01 m   D) 0.10 m

36) _____

Answer: B

37) A steel lift column in a service station is 4.0 m long and 0.20 m in diameter. Young's modulus for steel is 20×10^{10} N/m^2. By how much does the column shrink when a 5000-kg truck is on it?

    A) 7.8×10^{-6} m   B) 3.1×10^{-5} m   C) 3.2×10^{-6} m   D) 8.0×10^{-7} m

37) _____
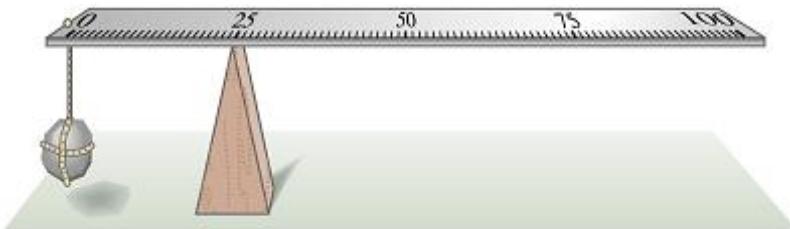
Answer: B

38) A wire of diameter 0.20 mm stretches by 0.20% when a 6.28-N force is applied. What is the elastic modulus of the wire?

    A) 2.5×10^{10} N/m^2 B) 1.0×10^{12} N/m^2

    C) 2.5×10^{12} N/m^2 D) 1.0×10^{11} N/m^2

38) _____

Answer: D

39) A mass of 50 kg is suspended from a steel wire of diameter 1.0 mm and length 11.2 m. How much will the wire stretch? The Young's modulus for steel is 20×10^{10} N/m^2.

    A) 2.5 cm   B) 1.5 cm   C) 3.5 cm   D) 4.5 cm

39) _____

Answer: C

40) Suppose that an 80-kg person walking on crutches supports all his weight on the two crutch tips, each of which is circular with a diameter of 4.0 cm. What pressure is exerted on the floor?

    A) 312 kPa   B) 624 kPa   C) 156 kPa   D) 78 kPa

40) _____

Answer: A

41) A bridge piling has an area of 1.250 m^2. It supports 1875 N. Find the stress on the column.

    A) 1875 N/m^2 B) 1875 N   C) 2344 N/m^2 D) 1500 N/m^2

41) _____

Answer: D

42) An aluminum wire 2.0 m in length and 2.0 mm in diameter supports a 10.0-kg mass. What is the stress in the wire? (The Young's modulus for aluminum is 7.0×10^{10} N/m^2)

    A) 1.2×10^8 N/m^2 B) 6.2×10^7 N/m^2 C) 3.1×10^7 N/m^2 D) 9.3×10^7 N/m^2

42) _____

Answer: C

43) An aluminum wire 2.0 m in length and 2.0 mm in diameter supports a 10.0-kg mass. What is the elongation of the wire? (The Young's modulus for an aluminum is 7.0×10^{10} N/m^2)

    A) 0.33 mm   B) 0.22 mm   C) 0.89 mm   D) 0.11 mm

43) _____

Answer: C

44) A shear force of 400 N is applied to one face of an aluminum cube with sides of 30 cm. What is the resulting relative displacement? (The shear modulus for aluminum is 2.5×10^{10} N/m^2)

    A) 1.9×10^{-8} m   B) 8.2×10^{-8} m   C) 5.3×10^{-8} m   D) 4.4×10^{-8} m

44) _____

Answer: C

45) At a depth of about 1030 m in the sea the pressure has increased by 100 atmospheres (to about 10^7 N/m^2). By how much has 1.0 m^3 of water been compressed by this pressure? The bulk modulus of water is 2.3×10^9 N/m^2.

    A) 2.3×10^{-3} m^3 B) 3.3×10^{-3} m^3 C) 5.3×10^{-3} m^3 D) 4.3×10^{-3} m^3

45) _____

Answer: D

46) A 55-cm brass rod has a diameter of 30 cm. The compressive strength of steel is 250×10^6 N/m^2. What is the compression force that would break the rod?

    A) 4.5×10^8 N   B) 1.8×10^7 N   C) 2.4×10^8 N   D) 1.4×10^8 N

46) _____

Answer: B

ESSAY. Write your answer in the space provided or on a separate sheet of paper.

47) A ladder, leaning against a wall, makes a 60° angle with the ground. When is it more likely to slip: when a person stands on the ladder near the top or near the bottom? Explain.

Answer: When the person stands near the top, the ladder is more likely to slip. The force of the person pushing down on the ladder causes a clockwise torque about the contact point with the ground. The only force causing a counterclockwise torque about that same point is the reaction force of the wall on the ladder. While the ladder is in equilibrium, the force due to the wall will be the same magnitude as the frictional force at the ground. Since the frictional force due to the ground has a maximum value, the force due to the wall will have the same maximum value, and so the force due to the wall will have a maximum counterclockwise torque that it can exert. As the person climbs the ladder, his lever arm gets longer and so the torque due to his weight gets larger. Eventually, if the torque caused by the person is larger than the maximum torque caused by the force due to the wall, the ladder will start to slip—it will not stay in equilibrium.

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FIGURE 9-37

48) A uniform meter stick supported at the 25 cm mark is in equilibrium when a 1 kg rock is suspended at the 0 cm end (as shown in Fig. 9-37). Is the mass of the meter stick greater than, equal to, or less than the mass of the rock? Explain your reasoning.

Answer: The mass of the meter stick is equal to that of the rock. For purposes of calculating torques, the meter stick can be treated as if all of its mass were at the 50 cm mark. Thus the CM of the meter stick is the same distance from the pivot point as the rock, and so their masses must be the same in order to exert the same torque.

49) Can the sum of the torques of an object be zero while the net force on the object is nonzero? Explain.

Answer: If the sum of the forces on an object are not zero, then the CM of the object will accelerate in the direction of the net force. If the sum of the torques on the object are zero, then the object has no angular acceleration. Some examples are:
(a) A satellite in a circular orbit around the Earth.
(b) A block sliding down an inclined plane.
(c) An object that is in projectile motion but not rotating
(d) The startup motion of an elevator, changing from rest to having a non-zero velocity.
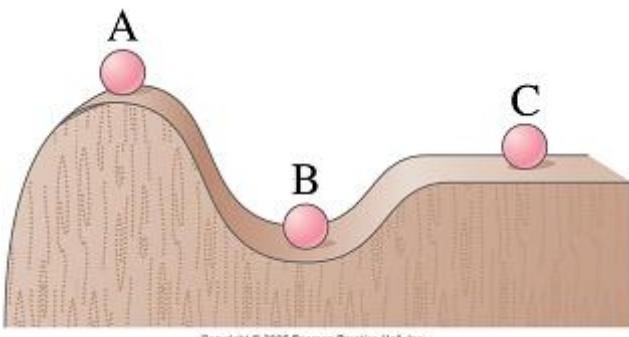
50) Why do you tend to lean backward when carrying a heavy load in your arms?

Answer: When walking, you must keep your CG over your feet. If you have a heavy load in your arms, your CG is shifted forward, and so you must lean backwards to re-align your CG over your feet.

51) Why is it not possible to sit upright in a chair and rise to your feet without first leaning forward?

Answer: When you start to stand up from a normal sitting position, your CM is not over your point of support (your feet), and so gravity will exert a torque about your feet that rotates you back down into the chair. You must lean forward in order that your CM be over your feet so that you can stand up.

7
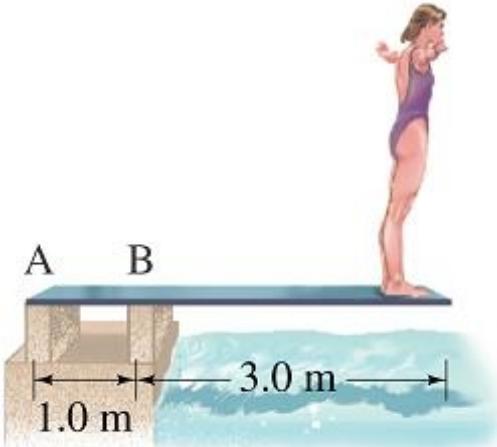
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FIGURE 9-40

52) Name the type of equilibrium for each position of the ball in Fig. 9-40.

Answer: Position "A" is unstable equilibrium, position "B" is stable equilibrium, and position "C" is neutral equilibrium.
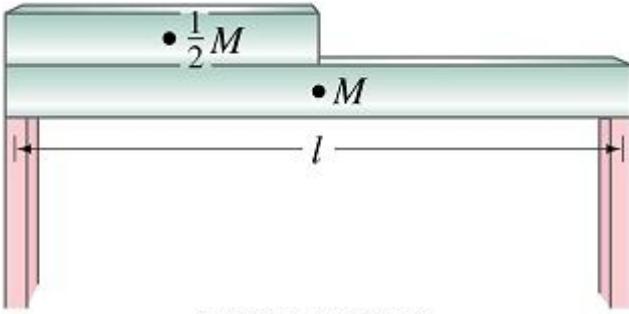

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FIGURE 9-42

53) Calculate the forces F_A and F_B that the supports exert on the diving board of Fig. 9-42 when a 58 kg person stands at its tip. (a) Ignore the weight of the board. (b) Take into account the board's mass of 35 kg. Assume the board's CG is at its center.

Answer: (a) 1.7×10^3 N, 2.3×10^3 N
(b) 2.0×10^3 N, 3.0×10^3 N
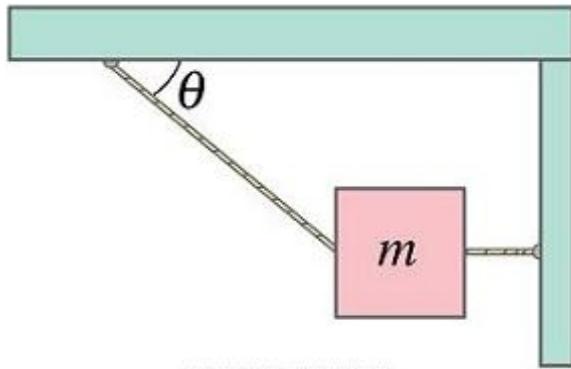
FIGURE 9-44

54) A uniform steel beam has a mass of 940 kg. On it is resting half of an identical beam, as shown in Fig. 9-44. What is the vertical support force at each end?

Answer: 8.1×10^3 N, 5.8×10^3 N

55) A 75-kg adult sits at one end of a 9.0 m long board. His 25-kg child sits on the other end. (a) Where should the pivot be placed so that the board is balanced, ignoring the board's mass? (b) Find the pivot point if the board is uniform and has a mass of 15 kg.

Answer: (a) 2.3 m from the adult
         (b) 2.5 m from the adult
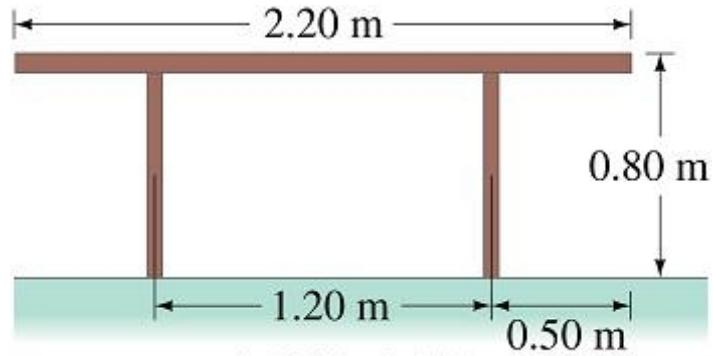
FIGURE 9-45

56) Find the tension in the two cords shown in Fig. 9-45. Neglect the mass of the cords, and assume that the angle θ is 33° and the mass m is 170 kg.

Answer: 3.1×10^3 N, 2.6×10^3 N

2.20 m

0.80 m

1.20 m

0.50 m
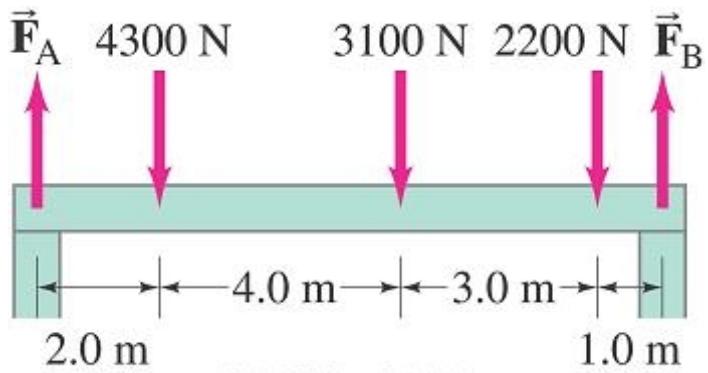
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FIGURE 9-47

57) How close to the edge of the 20.0-kg table shown in Fig. 9-47 can a 66.0-kg person sit without tipping it over?

Answer: 0.32 m

$\vec{F}_A$ 4300 N   3100 N 2200 N $\vec{F}_B$

←—4.0 m—→←—3.0 m—→←→

2.0 m   1.0 m

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FIGURE 9-49

58) Calculate F_A and F_B for the beam shown in Fig. 9-49. The downward forces represent the weights of machinery on the beam. Assume the beam is uniform and has a mass of 250 kg.

Answer: 6.1×10^3 N, 5.9×10^3 N

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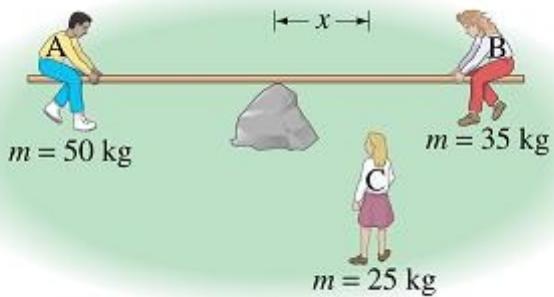
FIGURE 9-50

59) Three children are trying to balance on a seesaw, which consists of a fulcrum rock, acting as a pivot at the center, and a very light board 3.6 m long (Fig. 9-50). Two playmates are already on either end. Boy A has a mass of 50 kg, and girl B a mass of 35 kg. Where should girl C, whose mass is 25 kg, place herself so as to balance the seesaw?

Answer: 1.1 m to the right of the fulcrum rock

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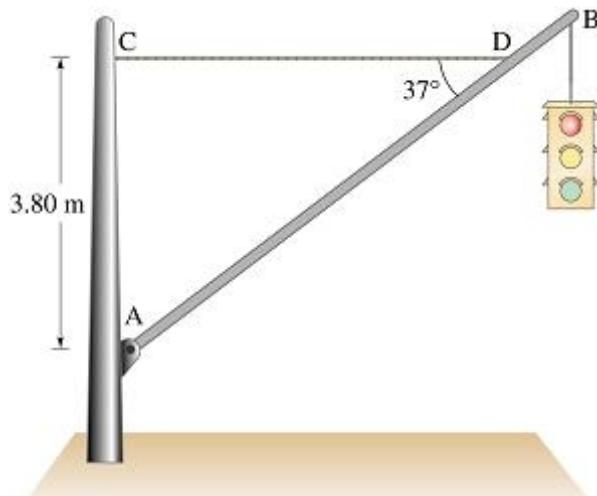
FIGURE 9-55

60) A traffic light hangs from a pole as shown in Fig. 9-55. The uniform aluminum pole AB is 7.50 m long and has a mass of 12.0 kg. The mass of the traffic light is 21.5 kg. Determine (a) the tension in the horizontal massless cable CD, and (b) the vertical and horizontal components of the force exerted by the pivot A on the aluminum pole.

Answer: (a) 4.25×10^2 N

(b) 3.28×10^2 N, 4.25×10^2 N

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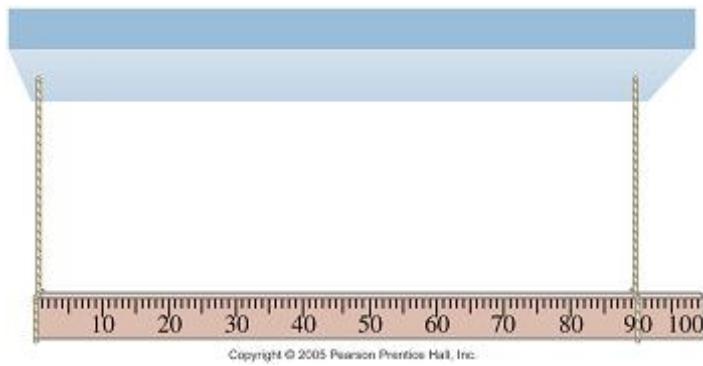
FIGURE 9-57

61) A uniform meter stick with a mass of 180 g is supported horizontally by two vertical strings, one at the 0 cm mark and the other at the 90 cm mark (Fig. 9-57). What is the tension in the string (a) at 0 cm? (b) at 90 cm?

Answer: (a) 0.78 N
          (b) 0.98 N

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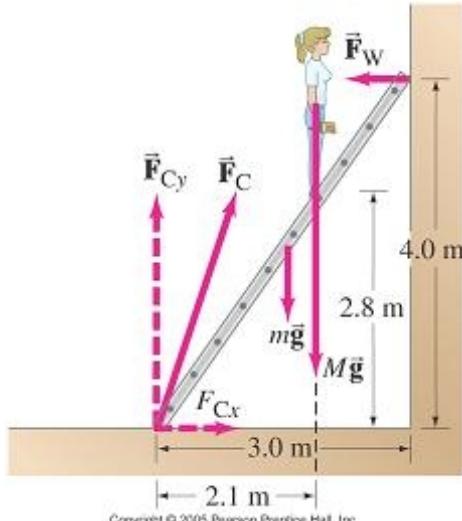
FIGURE 9-61

62) Consider a ladder with a painter climbing up it (Fig. 9-61). If the mass of the ladder is 12.0 kg, the mass of the painter is 55.0 kg, and the ladder begins to slip at its base when her feet are 70% of the way up the length of the ladder, what is the coefficient of static friction between the ladder and the floor? Assume the wall is frictionless.

Answer: 0.50
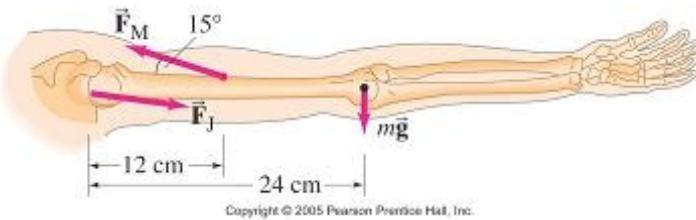
FIGURE 9-65

63) (a) Calculate the force, F_M, required of the "deltoid" muscle to hold up the outstretched arm shown in Fig. 9-65. The total mass of the arm is 3.3 kg. (b) Calculate the magnitude of the force F_3 exerted by the shoulder joint on the upper arm.

Answer: (a) 2.5×10^2 N

          (b) 2.4×10^2 N
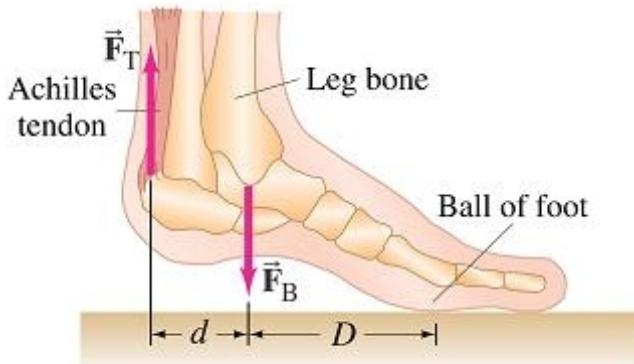
FIGURE 9-66

64) The Achilles tendon is attached to the rear of the foot as shown in Fig. 9-66. When a person elevates himself just barely off the floor on the "ball of one foot," estimate the tension F_T in the Achilles tendon (pulling upward), and the (downward) force F_B exerted by the lower leg bone on the foot. Assume the person has a mass of 72 kg and D is twice as long as d.

Answer: 1.4×10^3 N, 2.1×10^3 N

65) The Leaning Tower of Pisa is 55 m tall and about 7.0 m in diameter. The top is 4.5 m off center. Is the tower in stable equilibrium? If so, how much farther can it lean before it becomes unstable? Assume the tower is of uniform composition.

Answer: The tower is in stable equilibrium. 2.5 m

66) A 15-cm long tendon was found to stretch 3.7 mm by a force of 13.4 N. The tendon was approximately round with an average diameter of 8.5 mm. Calculate the Young's modulus of this tendon.

Answer: 9.6×10^6 N/m^2

67) How much pressure is needed to compress the volume of an iron block by 0.10%? Express your answer in N/m^2, compare it to atmospheric pressure (1.0×10^5 N/m^2).

Answer: 9.0×10^7 N/m^2, 9.0×10^2

68) A scallop forces open its shell with an elastic material called abductin, whose Young's modulus is about 2.0×10^6 N/m^2. If this piece of abductin is 3.0 mm thick and has a cross-sectional area of 0.50 cm^2, how much potential energy does it store when compressed 1.0 mm?

Answer: 1.7×10^{-2} J

69) (a) What is the minimum cross-sectional area required of a vertical steel cable from which is suspended a 320 kg chandelier? Assume a safety factor of 7.0. (b) If the cable is 7.5 m long, how much does it elongate?

Answer: (a) 4.4×10^{-5} m^2

(b) 2.7×10^{-3} m

70) An iron bolt is used to connect two iron plates together. The bolt must withstand shear forces up to about 3200 N. Calculate the minimum diameter for the bolt based on a safety factor of 6.0.

Answer: 1.2×10^{-2} m

71) How high must a pointed arch be if it is to span a space 8.0 m wide and exert one-third the horizontal force at its base that a round arch would?

Answer: 12 m