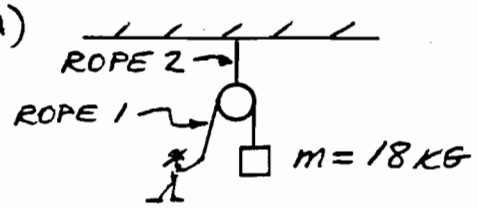
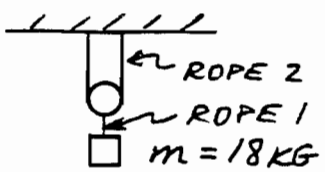
EQUILIBRIUM OF A PARTICLE — NO MOTION.

1. FIND THE TENSION IN EACH ROPE.

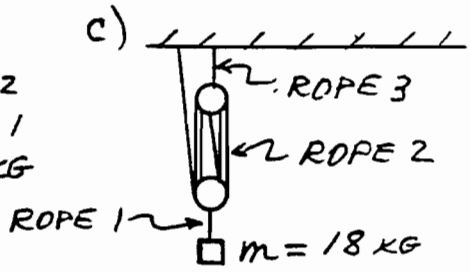
A)



B)



C)



(180, 360, 180, 90, 180, 30, 150 N)

2. A VERY WISE WILD TURKEY IS PERCHED ON A TELEPHONE WIRE. THE TENSION IN ROPE 1 IS 40N.

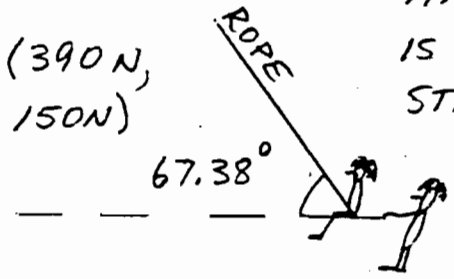
A) USE THE X-EQUATION TO FIND THE TENSION IN ROPE 2.

B) USE THE Y-EQUATION TO FIND THE WEIGHT AND MASS OF THE BIRD.

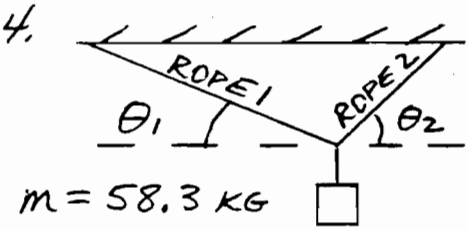
(68N, 84N, 8.4 KG)

3. THE PLAYGROUND! A YOUNG GIRL, m = 36 KG, IS HELD BY HER MOTHER, WHO IS PULLING STRAIGHT BACK. A) USE THE Y-EQUATION TO FIND THE TENSION IN THE ROPE. B) USE THE X-EQUATION TO FIND THE HORIZONTAL FORCE OF MOM.

(390 N, 150N)



4.

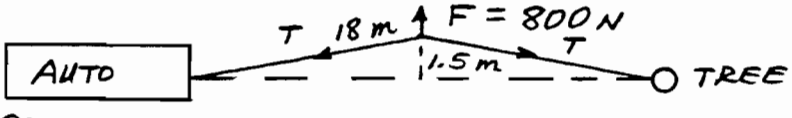


$\theta_1 = 30.51°$ $\theta_2 = 48.89°$

SOLVE THE X AND Y EQUATIONS SIMULTANEOUSLY TO FIND THE TENSION IN ROPE 1 AND IN 2. (390N, 511N)

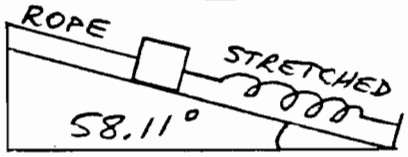
5. CHAD'S CAR IS STUCK IN THE MUD. SO, HE TIES A ROPE 36 m LONG VERY TIGHTLY BETWEEN HIS CAR AND A TREE. AT THE CENTER OF THE ROPE, HE PUSHES SIDEWAYS WITH A FORCE OF 800N AS THE ROPE MOVES SIDEWAYS 1.5 m.

LOOKING DOWN ON THEM:



USE THE Y-AXIS TO FIND THE TENSION IN THE ROPE. (4800N)

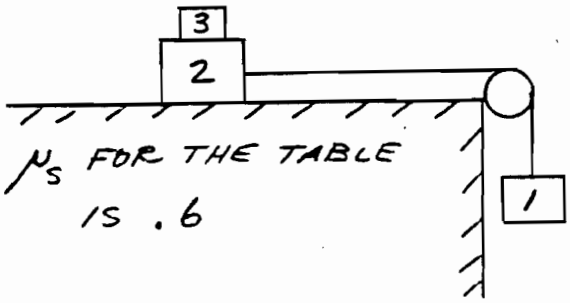
6.



m = 106 KG F_T IN THE ROPE = 1500N

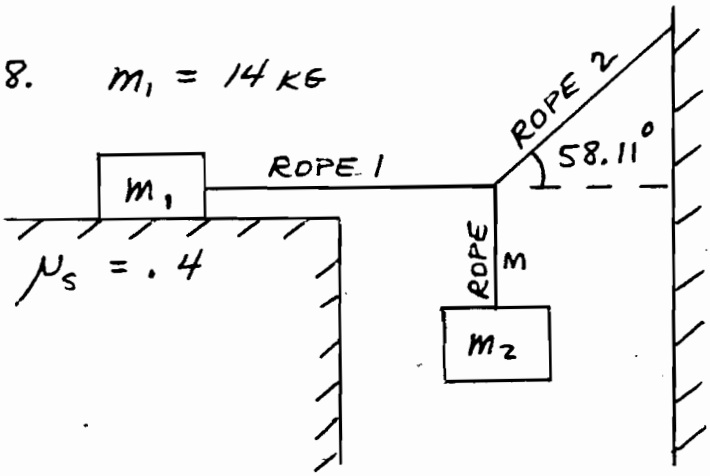
FIND: A) F_{SPRING} (600N)

B) F_N (560N)

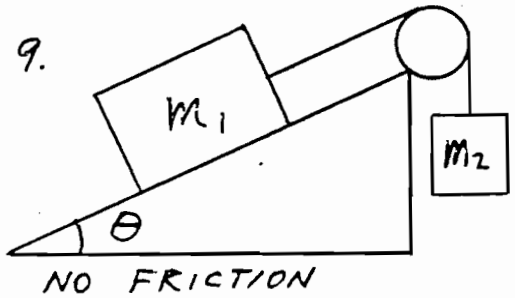
7. 

$m_1 = 30\,KG$
$m_2 = 42\,KG$

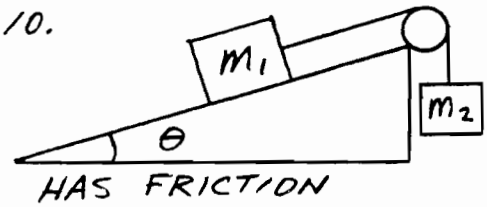
FIND THE MASS OF BRICK THREE SO THAT THE ENTIRE SYSTEM IS STATIONARY. (8 KG)

8. $m_1 = 14\,KG$ 

BRICK TWO HAS THE MAXIMUM AMOUNT OF MASS SUCH THAT THE SYSTEM CAN REMAIN STATIONARY. DETERMINE THE TENSION IN EACH ROPE AND THE MASS OF BRICK 2.
($T_1 = 56$, $T_2 = 106$, $T_3 = 90N$, $m_2 = 9\,KG$)

9. 

$m_1 = 700\,KG$ $m_2 = 401.5\,KG$
FIND THE ANGLE θ SO THAT THE MASSES ARE STATIONARY. FIND THE ROPE'S TENSION. (35°, 4015)

10. 

$\theta = 36.87°$ $m_2 = 162\,KG$ $\mu = .1875$
FIND THE MAXIMUM AND THE MINIMUM VALUES FOR m_1 SO THAT m_1 IS STATIONARY.
(216 KG, 360 KG)

TORQUE $\tau = rF\sin\theta$

1. CALCULATE THE TORQUE PRODUCED BY EACH OF THE FOLLOWING FORCES.

a) AXIS, 2 m, 40 N

b) 40 N, 3 m, AXIS

c) 40 N, 4 m, AXIS

d) AXIS, 5 m, 40 N

e) AXIS, 10 N, 2 m, 5 m, 40 N

f) AXIS, 40 N, 10 m, 30 m, 20 N

g) AXIS, 5 m, 15 m, 20 N, 12 N

h) 5 N, 36.87°, AXIS, 20 m

i) 15 N, 36.87°, 50 m, AXIS

j) $F_\perp = 56$ N, $F = 106$ N, θ, 4 m, AXIS

k) $F = 34$ N, $F_\perp = 30$ N, θ, 4 m, AXIS

l) 50 N, θ, $r_\perp = 48$ m, 73 m, AXIS

m) 80 N, AXIS, 3 m, 2 m

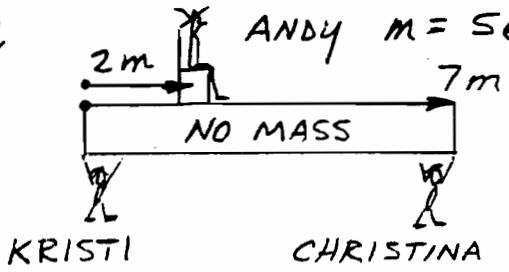
(80; −120; 160; −200; −50, −80; 400, 600; 180, −100, 60, 450, 224, 120, −2400, 400)

2. JULIAN USES A TIRE IRON TO TIGHTEN THE LUG NUTS ON THE TIRES OF HIS FERRARI. THE WRENCH IS .18m LONG. WHAT FORCE MUST HE SUPPLY ON THE END OF THE WRENCH TO CREATE A TORQUE OF 45 Nm. (250 N)

3. KENDRA, WORKING ON THE ENGINE OF HER BMW, HAS A TORQUE WRENCH, EIGHT INCHES LONG, WHICH READS 28 ft·lbs. WHAT FORCE DOES SHE APPLY ON THE END OF THE WRENCH? (42 lbs)

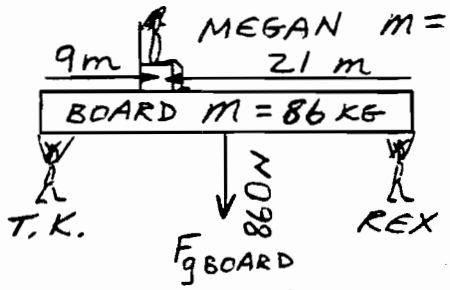
EQUILIBRIUM OF SOLID OBJECTS

1. ANDY $m = 56$ KG



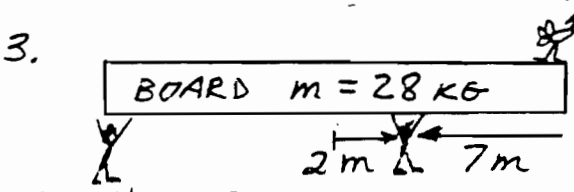
FIND THE FORCE SUPPLIED BY EACH WOMAN.
($F_K = 400$ $F_C = 160$ N)

2. MEGAN $m = 51$ KG



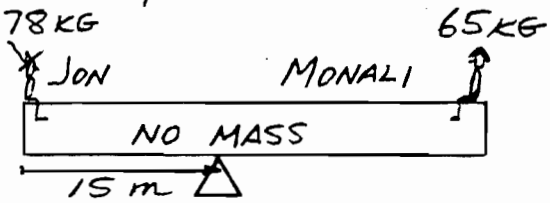
FIND THE FORCE SUPPLIED BY EACH MAN.
($F_{T.K.} = 787$ $F_R = 583$)

3. TURKEY $m = 41$ KG



JUSTIN STANDS TWO METERS FROM THE BOARD'S CENTER. FIND EACH MAN'S FORCE.
($F_H = -210$ N, $F_J = 900$N)

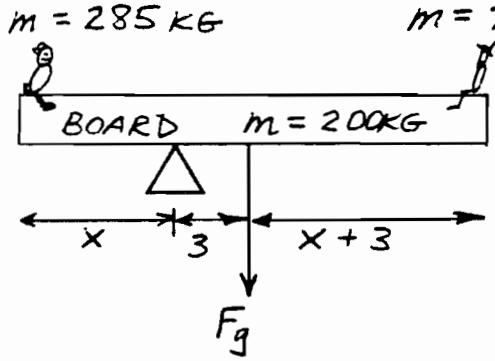
4. A PLAYGROUND TEETER-TOTTER!



A) FIND THE DISTANCE FROM MONALI TO THE FULCRUM SO THAT THEY ARE PERFECTLY BALANCED. (18 m)

B) FIND THE UPWARD FORCE SUPPLIED BY THE FULCRUM. (1430N)

5. GAVIN IS RIDING A TEETER-TOTTER WITH A BLACK BEAR.



THE FULCRUM IS THREE METERS FROM THE CENTER OF THE BOARD. FIND:

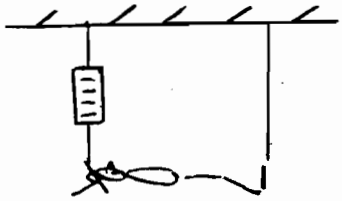
A) THE UPWARD FORCE EXERTED BY THE FULCRUM. (5600N)

B) THE DISTANCE FROM THE BEAR TO THE FULCRUM. (5)

C) THE DISTANCE FROM GAVIN TO THE FULCRUM. (11)

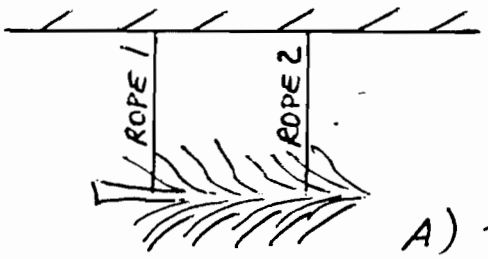
D) THE TOTAL LENGTH OF THE BOARD (16 m)

6. IAN, $m = 56\,kg$, $L = 147\,cm$, DOES YOGA AND HANGS HORIZONTALLY BETWEEN TWO ROPES. A SPRING SCALE IN THE LEFT ROPE READS A TENSION OF 320N. FIND: (240N)



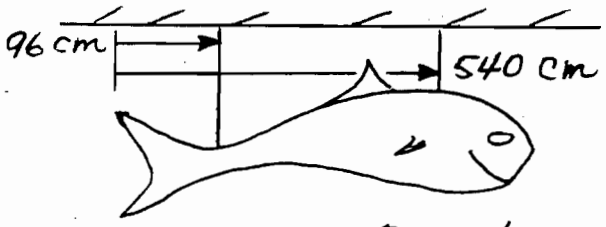
A) THE TENSION IN THE RIGHT ROPE.
B) THE DISTANCE FROM HIS HEAD TO HIS CENTER OF GRAVITY. (63 cm)
C) THE DISTANCE FROM HIS FEET TO HIS CENTER OF GRAVITY. (84cm)

7. A NEWTON FIR TREE IS HUNG HORIZONTALLY FROM TWO ROPES. ROPE 1 HAS A TENSION OF 90N; ROPE 2 HAS 60N. ROPE 1 IS TIED TO THE TREE AT 35 cm FROM THE STUMP. THE DISTANCE BETWEEN THE ROPES IS 80 cm. FIND:



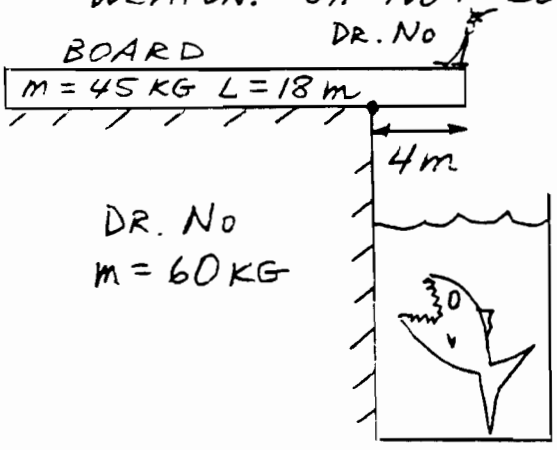
A) THE WEIGHT AND MASS OF ISAAC'S TREE. (150N, 15KG) B) THE DISTANCE FROM THE STUMP TO THE CENTER OF GRAVITY. (67cm)

8. SHAMU, $m = 1575\,kg$, IS HUNG FROM TWO ROPES FOR CLEANING. THE RIGHT ROPE HAS FIVE TIMES GREATER TENSION THAN THE LEFT. FIND: (2625, 13125N)



A) THE TENSION IN EACH ROPE.
B) THE DISTANCE FROM THE END OF THE ORCAS' TAIL TO ITS CENTER OF GRAVITY. (466 cm)

9. JAMES BOND AND DR. NO ARE ENGAGED IN FISTICUFFS ON A BOARD OVERHANGING A POOL. DR. NO NOW PULLS OUT HIS WEAPON. OH NO! BOND IS IN TROUBLE AGAIN. UNARMED, BOND QUICKLY CALCULATES THE TORQUES AND LEAPS OFF THE LEFT END OF THE BOARD LEAVING DR. NO ON THE RIGHT. IS BOND SAFE? THAT IS, DOES NO FEED THE FISH? HINT, PUT THE PIVOT ON THE EDGE OF THE BUILDING.



(NO IS ANCHOVIES BY .25 m) TOO FAR OUT
OR (NO IS ANCHOVIES BY 150 Nm) TOO MUCH TORQUE
OR (NO IS BAIT BY 3.75 KG) HE HAS TOO MUCH MASS

✓**5-B16** The center of gravity of an empty automobile is 3 ft ahead of the rear axle, and the empty car weighs 1500 lb. A 100 lb driver sits 5 ft ahead of the rear axle, and three 200 lb passengers sit 2 ft ahead of the rear axle. How far from the rear axle is the c.g. of the loaded car? (2.82 FT)

✓**5-B17** A collapsible fishing pole consists of three sections, each 50 cm long and uniform. The sections weigh 6 N, 4 N, and 2 N, respectively. When assembled with the 4 N section in the middle, how far from the heavy end is the c.g. of the system? (58.3 cm)

5-B18 Tom and Dick are carrying their young friend Harry on a uniform horizontal plank 8 m long that weighs 150 N. Harry, who weighs 400 N, is sitting 5 m from Tom and 3 m from Dick. How much weight does each man support?

5-B19 A 200 lb movie stunt man walks out to the end of a uniform horizontal plank that projects perpendicularly over the edge of a roof. The plank is 20 ft long and weighs 100 lb. How far from the roof can the plank overhang?

5-B20 The lever of Fig. 5-32 is a flat piece of metal in a vertical plane. The lever weighs 20 lb with its c.g. at *C*. What horizontal force applied at *B* will hold the 15 lb load at *A* in equilibrium?

5-B21 What vertical force applied at *B* in Fig. 5-32 (replacing the horizontal one) will hold the 15 lb load at *A* in equilibrium? Is the required force upward or downward?

5-B22 A trunk weighing 500 N is on a frictionless inclined plane that rises 60 cm for every 100 cm measured along the plane. A force of 400 N is applied, directed upward along the plane. (*a*) Calculate the net force along the plane. (*b*) What is the acceleration of the trunk? (*c*) What is the normal push of the plane upon the trunk?

5-B23 A sledge weighing 400 lb is being dragged along a rough road, for which the coefficient of kinetic friction is 0.6. The forward tension in the rope is 340 lb. Compute the resultant force on the sledge. Is the sledge in equilibrium? If not, what is its acceleration?

✓**5-B24** A mountain climber weighing 800 N is held on a 60° slope by a rope attached to a tree at the top of the peak. The tension in the rope is 500 N. Compute (*a*) the normal force on the climber; (*b*) the magnitude and direction of the force of friction on the climber. ($F_N = 400N$, $F_f = 193N$ UPSLOPE)

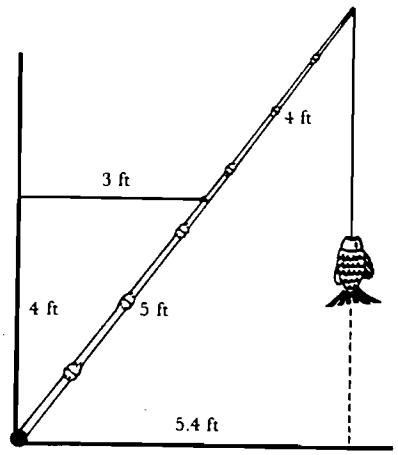


Figure 5-33

5-B25 A box of mass 80 kg is on a rough horizontal pavement for which the coefficient of kinetic friction is 0.3. The box is acted on by gravity and by a horizontal rope in which the tension is 400 N. How far does the box move in 3 s, starting from rest?

5-B26 A box of mass 80 kg is on a rough horizontal pavement for which the coefficient of kinetic friction is 0.3. The box is acted on by gravity and by a rope in which the tension is 400 N. The rope makes an angle of 30° with the horizontal. How far does the box move in 3 s, starting from rest?

✓**5-B27** A light bamboo fishing pole 9 ft long is supported by a horizontal string as shown in Fig. 5-33. A 10 lb fish hangs from the end of the pole, and the pole is pivoted at the bottom. What is the tension in the supporting string, and what are the components of the force of the pivot on the pole? ($T = 13.5$, $F_x = 13.5$, $F_y = 10$)

5-B28 A 150 lb cylindrical barrel of diameter 26 in. is lying on a pavement with its curved surface snugly against a curb 8 in. high. (*a*) Make a careful diagram, and use the Pythagorean theorem to find the distance from the foot of the curb to the bottom of the barrel. (*b*) What force, applied horizontally at the top of the barrel, is needed to just ease it up off the pavement, so that the barrel is pivoted on the edge of the curb?

✓**5-B29** A gardener using a hoe 6 ft long applies with one hand a horizontal force of F lb at the top of the handle, and with the other hand he applies a force of 10 lb perpendicular to the handle and 2 ft from the top (Fig. 5-34). The handle makes an angle of 65° with the ground. (*a*) What is the value of *F*? (*b*) What is the horizontal (useful) component of the force exerted on the ground by the hoe? (Ignore the weight of the hoe.) Is the force on the ground a push or a pull? c) FIND F_N

5-B30 A housewife holds a 2 kg carton of milk at arm's length (Fig. 5-35). What force B must be exerted by the brachialis muscle? (Ignore the weight of the forearm.)

✓**5-B31** A uniform pole 6 m long weighs 200 N and is attached at one end to a vertical wall. A load of 500 N hangs from the other end of the pole, and a horizontal guy wire attached to the outer end of the pole holds it at an angle of 30° above the horizontal. (*a*) Find the tension in the guy wire. (*b*) What is the resultant force of the wall on the pole? ($T = 1039$, $F_{WALL} = 1253$ AT 34°)

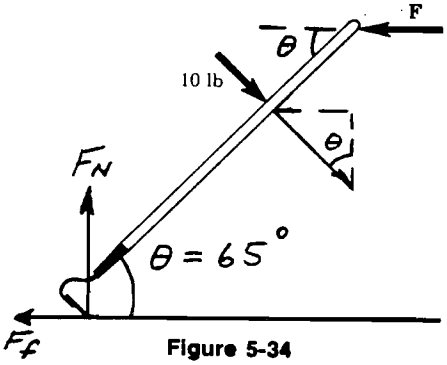


Figure 5-34

($F = 7.36$, $F_f = 1.71$, $F_N = 4.23$)

5-B34
$F_N = 800\,N$
$F_f = 360\,N$
$F_N' = 360\,N$
$B = 1.9\,m$

5-B35
$F_N = 80\,lbs$
$F_N' = 27.7$
$F_f = 27.7$
$\mu = .3464$

5-B32 A yogini seeking to locate her center of gravity supported herself in a horizontal supine position with her head on one chair and her heels on a spring scale on another chair. The two points of contact were 65 in. apart, and a friend observed the scale to read 39 lb. Later the yogini stood upright on the scale, which then read 110 lb. How far from her heels was her center of gravity?

5-B33 A patient 200 cm tall weighs 500 N and his center of gravity is 70 cm from the top of his head. He is carried on a uniform stretcher 200 cm long, of weight 200 N. What upward force must each stretcher bearer exert?

✓ **5-B34** A uniform ladder 5 m long weighing 200 N is leaning against a smooth vertical wall with its base 3 m from the wall. The coefficient of static friction between the bottom of the ladder and the ground is 0.45. How far, measured along the ladder, can a 600 N man climb before the ladder starts to slip? (3.16 m)

✓ **5-B35** A ladder 20 ft long weighs 80 lb, with its c.g. 4 ft from the lower end. The ladder leans against a smooth wall and makes a 30° angle with the horizontal. What coefficient of static friction is needed to keep the ladder from slipping? (*Hint:* First compute the components of the force exerted by the ground on the ladder.)

5-B36 A 100 lb block rests on a rough table for which the coefficient of static friction is 0.40 and the coefficient of kinetic friction is 0.30. The block is counterbalanced as shown, by a 75 lb weight and a weight W (Fig. 5-36). (*a*) What is the force of friction if $W = 60$ lb? (*b*) For what range of values for W can the system remain at rest?

5-B37 In Fig. 5-36, assume the weight W to be 25 lb and the coefficient of kinetic friction between the 100 lb block and the table to be 0.30. What speed will the system acquire after moving 4 ft, starting from rest?

5-B38 A uniform rectangular sign 4 ft tall and 8 ft wide weighing 120 lb is held in a vertical plane, perpendicular to a wall, by a horizontal pin through the top inside corner, and by a guy wire that runs from the outer top corner of the sign to a point on the wall 6 ft above the pin. (*a*) Calculate the tension in the wire. (*b*) Calculate the magnitude and direction of the force on the pin.

✓ **5-B39** A sign in the form of a uniform rectangular board 1 m wide and 0.6 m high weighs 200 N. The sign is hung as shown in Fig. 5-37 from a horizontal uniform pole 2 m long that weighs 300 N, and a guy wire CD makes a 30° angle with the horizontal. Calculate (*a*) the tension in the guy wire; (*b*) the horizontal and vertical components of the force exerted by the wall at A. (*Hint:* Each vertical rope at B and C supports half the weight of the sign.) ($T = 600$, $F_x = 520$, $F_y = 200$)

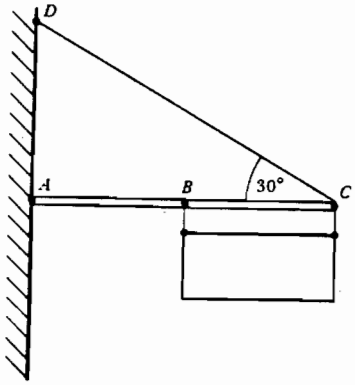
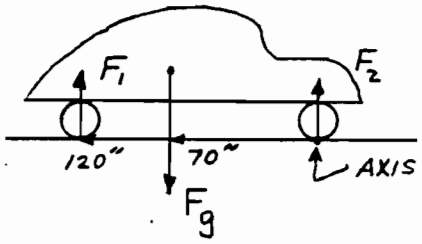


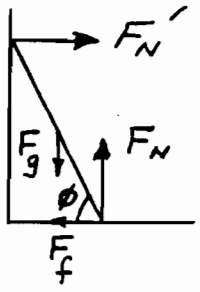
Figure 5-37

✓ **5-B40** An automobile weighing 3000 lb has a wheel base of 120 in. Its center of gravity is located 70.0 in. behind the front axle. Determine (*a*) the force exerted on each of the front wheels (assumed the same) and (*b*) the force exerted on each of the back wheels (assumed the same) by the level ground.

(625, 875)



✓ **5-C4** A uniform ruler of length L and weight W leans without slipping against a smooth vertical wall at an angle θ with the vertical, with its base on a rough table. Show that the coefficient of static friction between the table top and the ruler must be at least equal to $\frac{1}{2}\tan\theta$. Interpret your result in the limiting cases as $\theta \to 0$, and as $\theta \to 90°$.

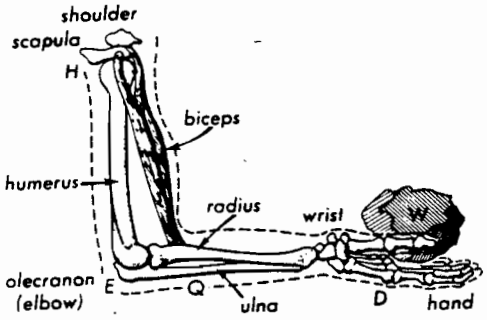


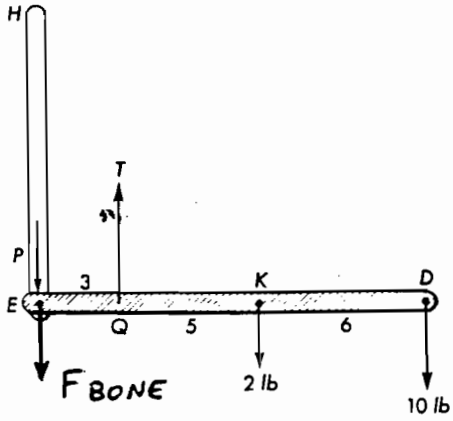
RECALL: FUNCTION OF AN ANGLE EQUALS THE COFUNCTION OF ITS COMPLEMENTARY ANGLE.

The Physics of Muscles

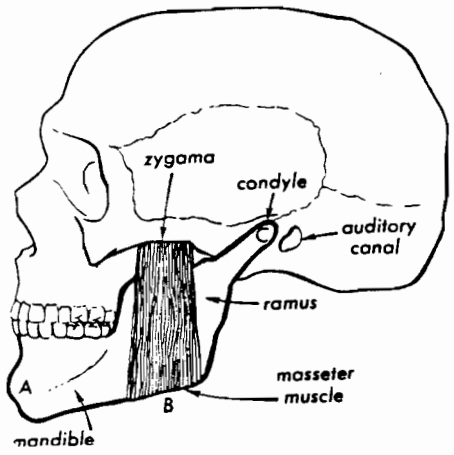
OBJECTIVE: TO DETERMINE THE TREMENDOUS FORCES THAT MUSCLES MUST EXERT TO PERFORM ORDINARY TASKS.

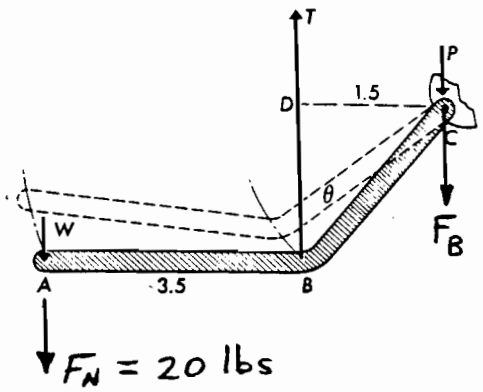
1. MR. HARVIE, WHOSE ARM IS FLEXED IN THE HORIZONTAL POSITION, IS HOLDING A 10lb CHUNK OF GNEISS IN HIS HAND. HIS FOREARM WEIGHS 2 lbs. FIND THE TENSION THE THE BICEP AND THE COMPRESSIONAL FORCE IN THE HUMERUS. (52 lbs, 40 lbs)





2. MR. HARVIE IS EATING A MAHI-MAHI SANDWICH WITH SPINACH AND TOMATOES ON WHOLE WHEAT. AS HE BITES THE SANDWICH, HIS LOWER FRONT TEETH FEEL A DOWNWARD F_N OF 20 lbs. FIND THE TOTAL TENSION EXERTED BY THE TWO MASSETERS AND THE FORCE EXERTED ON THE CONDYLES. (67 lbs, 47 lbs)

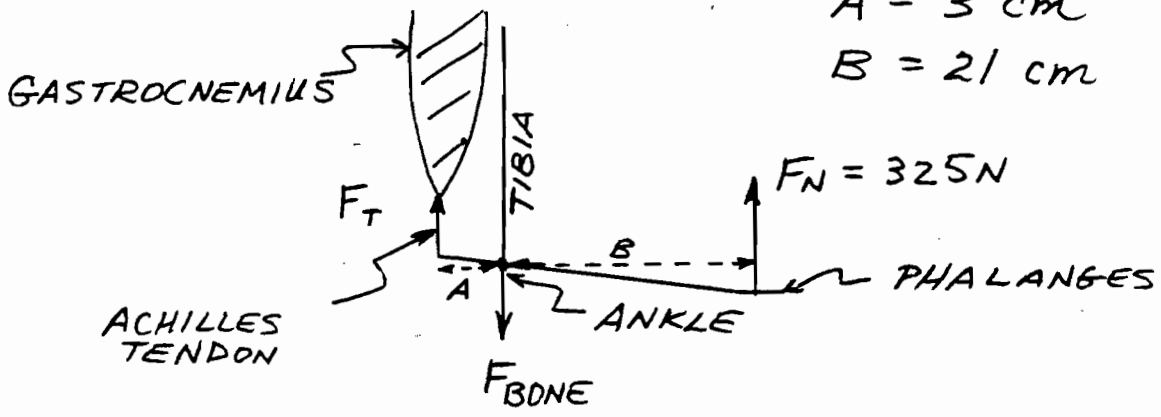




3. VEJAS, WHOSE MASS IS 65 KG, STANDS ON HIS TOES AS HE AWAITS THE START OF THE RACE. HALF OF HIS TOTAL WEIGHT IS SUPPORTED BY EACH FOOT. FIND THE TENSION IN THE ACHILLES TENDON AND THE DOWNWARD FORCE EXERTED BY THE TIBIA.

$A = 3$ cm

$B = 21$ cm



(2275 N, 2600 N)