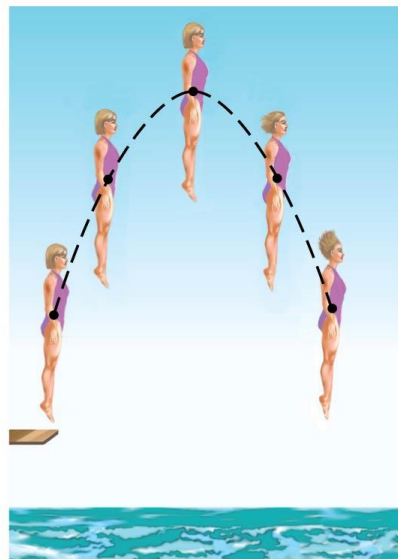# Chapter 7
Linear Momentum
(center of mass only)

Center of Mass

In (a), the diver's motion is pure translation; in (b) it is translation plus rotation.

There is one point that moves in the same path a particle would take if subjected to the same force as the diver. This point is called the center of mass (CM).
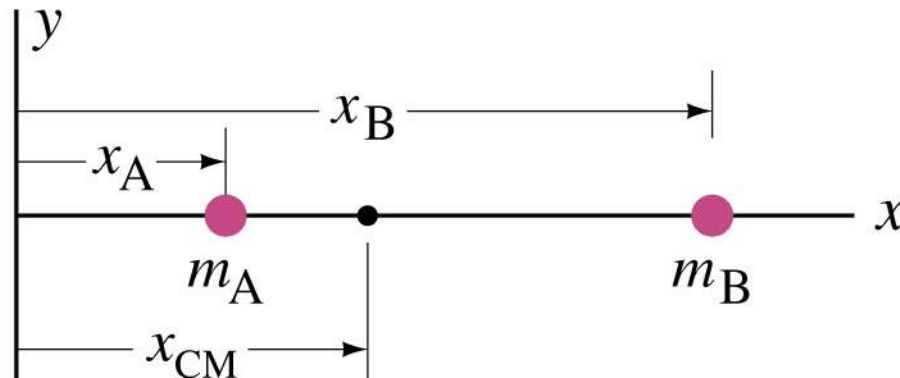

(a)   (b)

For two particles, the center of mass lies closer to the one with the most mass:

$$x_{CM} = \frac{m_A x_A + m_B x_B}{m_A + m_B} = \frac{m_A x_A + m_B x_B}{M},$$

where M is the total mass.

EXAMPLE 7–12 **CM of three guys on a raft.** On a lightweight (air-filled) "banana boat," three people of roughly equal mass m sit along the x axis at positions $x_A = 1.0$ m, $x_B = 5.0$ m, and $x_C = 6.0$ m, measured from the left-hand end as shown in Fig. 7–23. Find the position of the CM. Ignore the mass of the boat.


0   1.0 m   5.0 m 6.0 m x
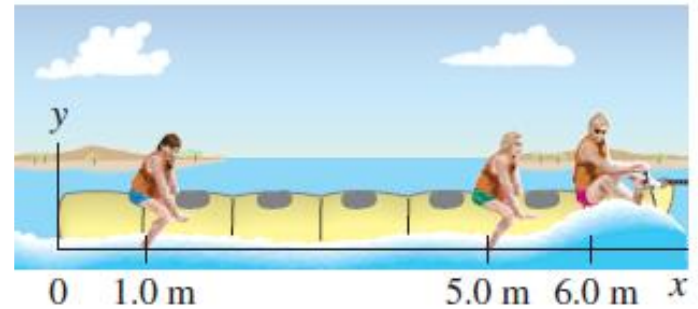
7-9 CM for the Human Body

The x's in the small diagram mark the CM of the listed body segments.

TABLE 7–1 Center of Mass of Parts of Typical Human Body, given as %
(full height and mass = 100 units)

| Distance of Hinge Points from Floor (%)	Hinge Points (•) (Joints)	Center of Mass (×) (% Height Above Floor)		Percent Mass
91.2%	Base of skull on spine	Head	93.5%	6.9%
81.2%	Shoulder joint	Trunk and neck	71.1%	46.1%
	elbow 62.2%‡	Upper arms	71.7%	6.6%
	wrist 46.2%‡	Lower arms	55.3%	4.2%
52.1%	Hip joint	Hands	43.1%	1.7%
		Upper legs (thighs)	42.5%	21.5%
28.5%	Knee joint	Lower legs	18.2%	9.6%
4.0%	Ankle joint	Feet	1.8%	3.4%
		Body CM =	58.0%	100.0%
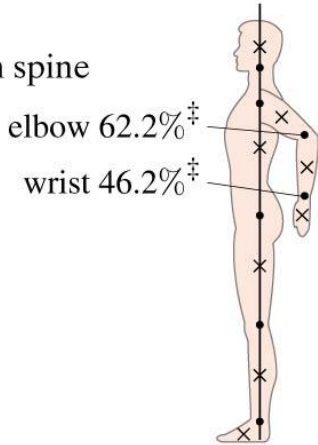
‡ For arm hanging vertically.

© 2016 Pearson Education, Ltd.

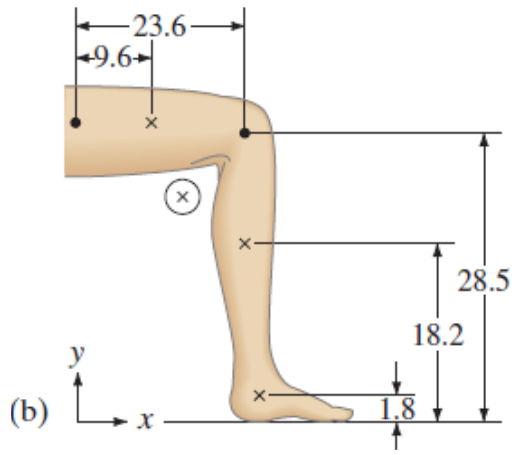# 7-9 CM for the Human Body
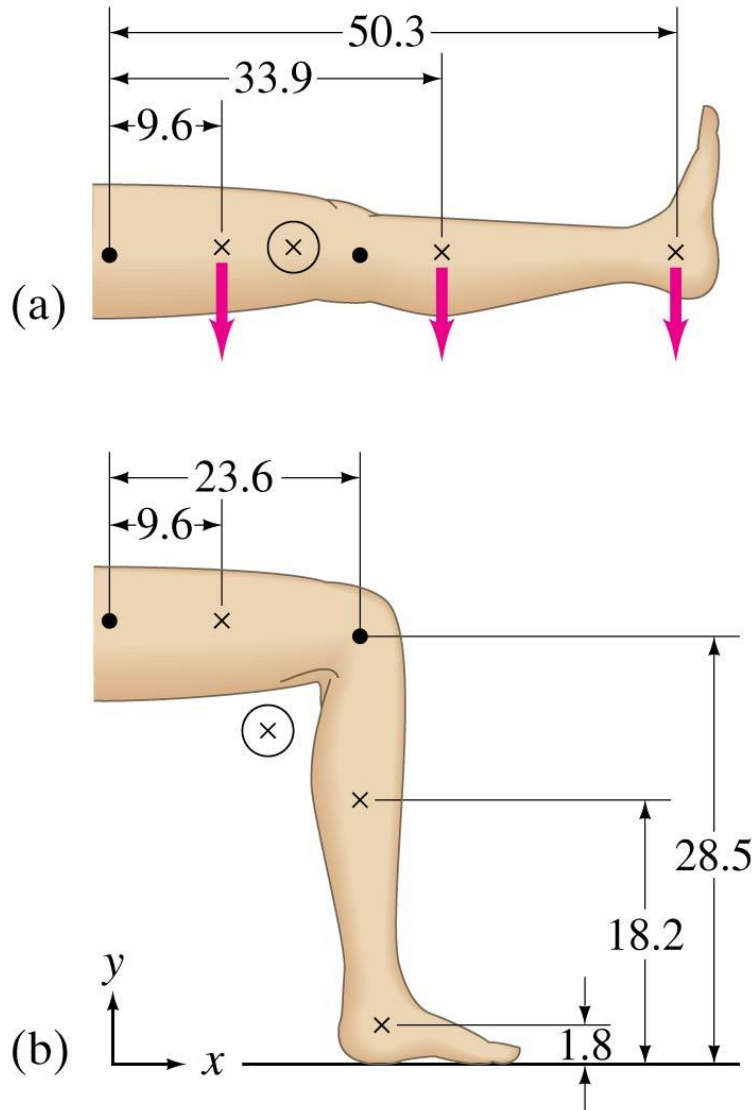
The location of the center of mass of the leg (circled) will depend on the position of the leg.

CM for the Human Body

(a)

23.6

9.6

28.5

18.2

1.8

y

(b)

x
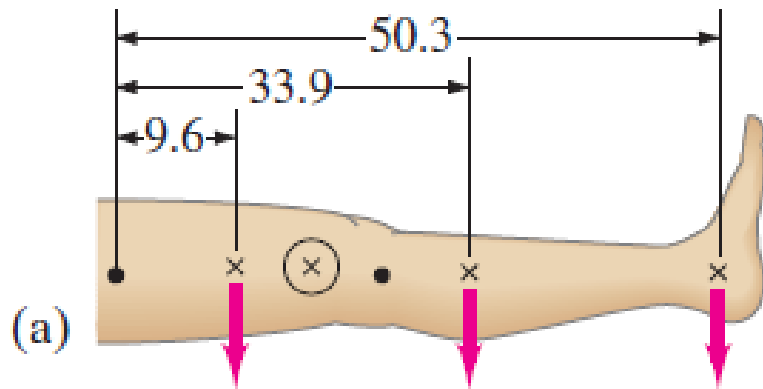
48. (II) Three cubes, of side ℓ_0, $2\ell_0$, and $3\ell_0$, are placed next to one another (in contact) with their centers along a straight line as shown in Fig. 7–38. What is the position, along this line, of the CM of this system? Assume the cubes are made of the same uniform material.
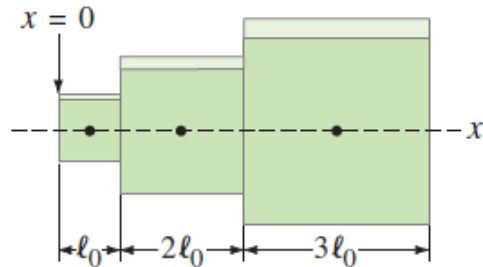

FIGURE 7–38
Problem 48.

50. (III) Determine the CM of the uniform thin L-shaped construction brace shown in Fig. 7–40.
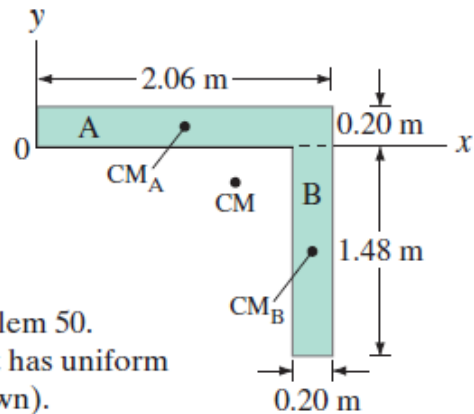

FIGURE 7–40 Problem 50. This L-shaped object has uniform thickness d (not shown).

*53. (II) Use Table 7–1 to calculate the position of the CM of an arm bent at a right angle. Assume that the person is 155 cm tall.