Whereas an arch spans a two-dimensional space, a **dome**—which is basically an arch rotated about a vertical axis—spans a three-dimensional space. The Romans built the first large domes. Their shape was hemispherical and some still stand, such as that of the Pantheon in Rome (Fig. 9–32), built 2000 years ago.

Fourteen centuries later, a new cathedral was being built in Florence. It was to have a dome 43 m in diameter to rival that of the Pantheon, whose construction has remained a mystery. The new dome was to rest on a "drum" with no external abutments. Filippo Brunelleschi (1377–1446) designed a pointed dome (Fig. 9–33), since a pointed dome, like a pointed arch, exerts a smaller side thrust against its base. A dome, like an arch, is not stable until all the stones are in place. To support smaller domes during construction, wooden frameworks were used. But no trees big enough or strong enough could be found to span the 43-m space required. Brunelleschi decided to try to build the dome in horizontal layers, each bonded to the previous one, holding it in place until the last stone of the circle was placed. Each closed ring was then strong enough to support the next layer. It was an amazing feat. Only in the twentieth century were larger domes built, the largest being that of the Superdome in New Orleans, completed in 1975.

FIGURE 9–32 Interior of the Pantheon in Rome, built in the first century. This view, showing the great dome and its central opening for light, was painted about 1740 by Panini. Photographs do not capture its grandeur as well as this painting does.

FIGURE 9–33 The skyline of Florence, showing Brunelleschi's dome on the cathedral.

EXAMPLE 9–13 **A modern dome.** The 1.2×10^6 kg dome of the Small Sports Palace in Rome (Fig. 9–34a) is supported by 36 buttresses positioned at a 38° angle so that they connect smoothly with the dome. Calculate the components of the force, F_H and F_V, that each buttress exerts on the dome so that the force acts purely in compression—that is, at a 38° angle (Fig. 9–34b).

APPROACH We can find the vertical component F_V exerted upward by each buttress because each supports $\frac{1}{36}$ of the dome's weight. We find F_H knowing that the buttress needs to be under compression so $\vec{\mathbf{F}} = \vec{\mathbf{F}}_V + \vec{\mathbf{F}}_H$ acts at a 38° angle.

SOLUTION The vertical load on *each* buttress is $\frac{1}{36}$ of the total weight. Thus

$$F_V = \frac{mg}{36} = \frac{(1.2 \times 10^6\,\text{kg})(9.8\,\text{m/s}^2)}{36} = 330{,}000\,\text{N}.$$

The force must act at a 38° angle at the base of the dome in order to be purely compressive. Thus

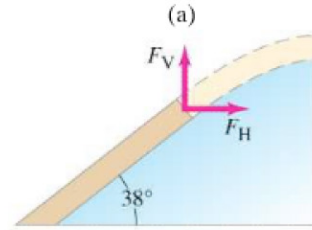
$$\tan 38^\circ = \frac{F_V}{F_H};$$

$$F_H = \frac{F_V}{\tan 38^\circ} = \frac{330{,}000\,\text{N}}{\tan 38^\circ} = 420{,}000\,\text{N}.$$

NOTE For each buttress to exert this 420,000-N horizontal force, a prestressed-concrete tension ring surrounds the base of the buttresses beneath the ground (see Problem 56 and Fig. 9–70).

FIGURE 9–34 Example 9–13. (a) The dome of the Small Sports Palace in Rome, built for the 1960 Olympics. (b) The force components each buttress exerts on the dome.

(a)



(b)