## PRACTICE B

### Pressure

**1.** In a car lift, compressed air exerts a force on a piston with a radius of 5.00 cm. This pressure is transmitted to a second piston with a radius of 15.0 cm.

**a.** How large a force must the compressed air exert to lift a $1.33 \times 10^4$ N car?

**b.** What pressure produces this force? Neglect the weight of the pistons.

**2.** A 1.5 m wide by 2.5 m long water bed weighs 1025 N. Find the pressure that the water bed exerts on the floor. Assume that the entire lower surface of the bed makes contact with the floor.

**3.** A person rides up a lift to a mountaintop, but the person's ears fail to "pop"—that is, the pressure of the inner ear does not equalize with the outside atmosphere. The radius of each eardrum is 0.40 cm. The pressure of the atmosphere drops from $1.010 \times 10^5$ Pa at the bottom of the lift to $0.998 \times 10^5$ Pa at the top.

**a.** What is the pressure difference between the inner and outer ear at the top of the mountain?

**b.** What is the magnitude of the net force on each eardrum?



### Pressure varies with depth in a fluid

As a submarine dives deeper in the water, the pressure of the water against the hull of the submarine increases, so the hull must be strong enough to withstand large pressures. Water pressure increases with depth because the water at a given depth must support the weight of the water above it.

Imagine a small area on the hull of a submarine. The weight of the entire column of water above that area exerts a force on the area. The column of water has a volume equal to $Ah$, where $A$ is the cross-sectional area of the column and $h$ is its height. Hence the mass of this column of water is $m = \rho V = \rho Ah$. Using the definitions of density and pressure, the pressure at this depth due to the weight of the column of water can be calculated as follows:

$$P = \frac{F}{A} = \frac{mg}{A} = \frac{\rho Vg}{A} = \frac{\rho Ahg}{A} = \rho hg$$

This equation is valid only if the density is the same throughout the fluid.

The pressure in the equation above is referred to as *gauge pressure.* It is not the total pressure at this depth because the atmosphere itself also exerts a pressure at the surface. Thus, the gauge pressure is actually the total pressure minus the atmospheric pressure. By using the symbol $P_0$ for the atmospheric pressure at the surface, we can express the total pressure, or *absolute pressure,* at a given depth in a fluid of uniform density $\rho$ as follows: