The Sun Is a Gas

The sun is a ball of gas—a special kind of gas to be sure. It is so hot in some regions in the interior that the atoms have come apart completely to form a state of matter known as a plasma—an electrically charged gas. To understand the physical processes that cause stars, like the sun, to shine and to understand how and why stars evolve, we must learn something about the behavior of gases. A quantity that is quite useful in describing the state of a fluid (gas or liquid) is the pressure. We define the average pressure $\bar{P}$ on a small area $\Delta A$ in a fluid as $(\Delta F)_\perp$, the component of the force exerted perpendicular to the area, divided by the area,

$$ \bar{P} = \frac{(\Delta F)_\perp}{\Delta A}. $$

(17.1)

As the area around a given point becomes very small, this ratio approaches the value for the pressure at the point. Note that the pressure is a scalar quantity. To make this notion of pressure intuitively clear, let’s consider a liquid (e.g., water) in an open container as illustrated in Fig. 17.1. We focus our attention on a small,
horizontal circular area $A$ at a depth $h$ in the liquid. The force exerted on this area is due to the weight of the fluid directly above it, that is, a fluid column of cross-sectional area $A$ consisting of a cylindrical volume of liquid of height $h$ and a cylindrical column of air extending from the surface of the liquid all the way to the top of the atmosphere.

From Eq. (17.1), we find that

$$P = \frac{\text{weight of liquid column} + \text{weight of air column}}{\text{area of column}}$$

$$= \frac{(\rho h A)g}{A} + P_{\text{atm}} = \rho hg + P_{\text{atm}}$$

where $\rho$ is the density of the liquid, $g$ is the acceleration due to gravity, and $P_{\text{atm}}$ is the pressure of the atmosphere at the top of the liquid.

### 17.1 Boyle’s Law

Let’s begin with a very simple gas—the air in the room. Suppose we trap a small volume of air in a sealed glass cylinder fitted with an airtight piston. By pushing the piston in or drawing it out, we can change the volume that the gas occupies. Since the system is tightly sealed, we assume no air leaks in or out.

To measure the pressure of the gas trapped in our glass cylinder, a pressure gauge is connected to the cylinder by means of a small, flexible tube as illustrated in Fig. 17.2. The volume of gas is obtained from the inside diameter of the cylinder and the distance from the end of the cylinder to the piston.

Let us attempt a graphical analysis of the data collected from these measurements. First, we make the straightforward plot of pressure versus volume shown...