
1.10. PRESSURE INSTRUMENTS

Atmospheric-pressure sensors are called **barometers**. Almost all barometers measure the pressure difference between atmospheric pressure on one side of the sensor, and a reference pressure on the other side. This pressure difference causes a net force that pushes against a spring or a weight. For most barometers, the reference pressure is a **vacuum** (zero pressure).

Aneroid barometers use a corrugated metallic can (the **aneroid element**) with a vacuum inside the can. A spring forces the can sides outward against the inward-pushing atmospheric-pressure force. The relative inflation of the can is measured with levers and gears that amplify the minuscule deflection of the can, and display the result as a moving needle on a barometer or a moving pen on a **barograph** (a recording barometer). The scale on an aneroid barometer can be calibrated to read in any pressure units (see Table 1-3).

Mercury (Hg) barometers (developed by Evangelista Torricelli in the 1600s) are made from a U-shaped tube of glass that is closed on one end. The closed end has a vacuum, and the other end is open to atmospheric pressure. Between the vacuum and the air is a column of mercury inside the tube, the weight of which balances atmospheric pressure.

Atmospheric pressure is proportional to the height difference Δz between the top of the mercury column on the vacuum side, and the height on the side of the U-tube open to the atmosphere. Typical Δz scales are **millimeters of mercury (mm Hg)**, **centimeters of mercury (cm Hg)**, or **inches of mercury (in Hg)**. To amplify the height signal, **contra-barometers** (developed by Christiaan Huygens in the 1600s) use mercury on one side of the U-tube and another fluid (e.g., alcohol) on the other.

Because mercury is a poison, modern **Torricelli** (U-tube) barometers use a heavy silicon-based fluid instead. Also, instead of using a vacuum as a reference pressure, they use a fixed amount of gas in the closed end of the tube. All Torricelli barometers require temperature corrections, because of thermal expansion of the fluid.

Electronic barometers have a small can with a vacuum or fixed amount of gas inside. Deflection of the can is measured by strain gauges, or by changes in capacitance between the top and bottom metal ends of an otherwise non-conductive can. **Digital barometers** are electronic barometers that include analog-to-digital circuitry to send pressure data to digital computers. More info about all weather instruments is in WMO-No. 8 *Guide to Meteorological Instruments and Methods of Observation*.

1.11. REVIEW

Pressure, temperature, and density describe the thermodynamic state of the air. These state variables are related to each other by the ideal gas law. Change one, and one or both of the others must change too. Ambient pressure decreases roughly exponentially with height, as given by the hypsometric equation. The vertical pressure gradient is balanced by the pull of gravity, according to the hydrostatic eq.

Density variation is also exponential with height. Temperature, however, exhibits three relative maxima over the depth of the atmosphere, caused by absorption of radiation from the sun. Thermodynamic processes can be classified. The standard atmosphere is an idealized model of atmospheric vertical structure, and is used to define atmospheric layers such as the troposphere and stratosphere. Atmospheric pressure is measured with mercury, aneroid, or electronic barometers.

1.11.1. Tips for Using This Book

- Take advantage of the extensive index.
- Check online for errata (corrections) to the current edition.
- Use split screens or multiple windows to view different but related items (such as homework exercises and relevant material in the body of the chapter).

1.11.2. Tips for the Homework

At the end of each chapter are four types of homework exercises:

- Broaden Knowledge & Comprehension
- Apply
- Evaluate & Analyze
- Synthesize

Each of these types are explained here in Chapter 1, at the start of their respective subsections. I also recommend how you might approach these different types of problems.

One of the first tips is in the “A SCIENTIFIC PERSPECTIVE” box. Here I recommend that you write your exercise solutions in a format very similar to the “Sample Applications” that I have throughout this book. Such meticulousness will help you earn higher grades in most science and engineering courses, and will often give you partial credit (instead of zero credit) for exercises you solved incorrectly.

Finally, most of the exercises have multiple parts to them. Your instructor need assign only one of the parts for you to gain the skills associated with that exercise. Many of the numerical problems are sim-