16.3: Pressure

Pressure is force per unit area, or, more precisely,

$$\rho = \lim_{\delta A \to 0} \frac{\delta F}{\delta A}. \tag{16.3.1}$$

There is no particular direction associated with pressure – it acts in all directions – and it is a scalar quantity. The SI unit is the *pascal* (Pa), which is a pressure of one newton per square metre (N m^{-2}). Blaise Pascal (1623-1662) was a French mathematician and philosopher who contributed greatly to the theory of conic sections and to hydrostatics. He showed that the barometric pressure decreases with height – hence the famous examination question: "Explain how you would use a barometer to measure the height of a tall building" – to which the most accurate answer is said to be: "I would drop it out of the window and time how long it took to reach the ground."

The CGS unit of pressure is dyne cm^{-2}, and 1 Pa = 10 dyne cm^{-2}.

Some other silly units for pressure are often seen, such as psi, bar, Torr or mm Hg, and atm.

A psi or "pound per square inch" is all right for those who define a "pound" as a unit of force (US usage) but is less so for those who define a pound as a unit of mass (UK usage). A psi is about 6894.76 Pa and a bar is 10^5 Pa or 100 kPa.

> *[The "British Engineering System", as far as I know, is used exclusively in the U.S. and is not and never has been used in Britain, where it would probably be unrecognized. In the "British" Engineering System, the pound is defined as a unit of force, whereas in Britain a pound is a unit of mass.]*

A Torr is a pressure under a column of mercury 760 mm high. This may be convenient for casual conversational use where extreme precision is not expected in laboratory experiments in which pressure is actually indicated by a mercury barometer or manometer. To find out exactly what the pressure in Pa under 760 mm Hg is, one would have to know the exact value of the local gravitational acceleration and also the exact density of mercury, which varies with temperature and with isotopic constitution. A Torr is usually given as 133.322 Pa. Evangelista Torricelli (1608 – 1647) is regarded as the inventor of the mercury barometer. He succeeded Galileo as professor of mathematics at the University of Florence.

An atm is 760 torr or about 14.7 psi or 101 325 Pa. That is to say, 1.013 25 bar

As usual, the use of a variety of different units, and knowing the exact definitions and conversion factors between all of them and carrying out all the tedious multiplications, is an unnecessary chore that is inflicted upon all of us in all branches of physics.