Magnetism underlies much of modern technology — computer information storage, medical imaging, motors — and may soon revolutionize electronics. This tutorial will give researchers and metrologists an introduction to magnetic materials, instruments and measurements, and units of measure.

Magnetism has captured the imagination over the centuries. The force exerted by a lodestone on iron, as described by William Gilbert in 1600, and the induction of current by changing magnetic fields, discovered by Michael Faraday in 1831, are fundamental magnetic phenomena, but they run counter to intuition. The designs of many perpetual motion machines, despite their violation of the laws of thermodynamics, invoke magnetic force and induction.

Hard ferromagnets retain significant magnetization in the absence of an applied magnetic field; the most important of these permanent magnets are made of neodymium-iron-boron. Soft ferromagnets have little residual magnetization; examples include electrical transformer steels, amorphous magnetic alloys, and alloys used for magnetic shielding. Other kinds of magnetic materials are antiferromagnetic, ferrimagnetic, diamagnetic, paramagnetic, and superparamagnetic.

Magnetic materials are usually characterized by measurements of their magnetization as a function of applied magnetic field and temperature. Static and low frequency measurements may be made with instruments based on electromagnetic induction, force or torque, and magneto-optics. High frequency measurements may be based on radio-frequency fields and magnetic resonance.

Magnetics is one field that has resisted full adoption of the International System of Units (SI). Many magneticians employ units in both SI and the centimeter-gram-second (CGS) system. Conversions are often confusing because the SI is rationalized: irrational factors of $4\pi$ do not appear in the constitutive electromagnetic equations.