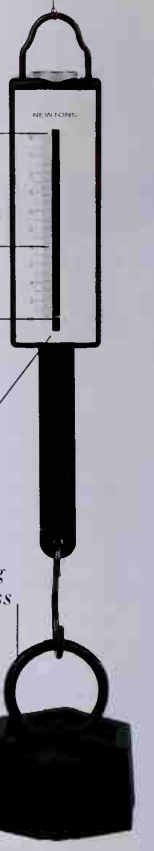
Measurement and experiment

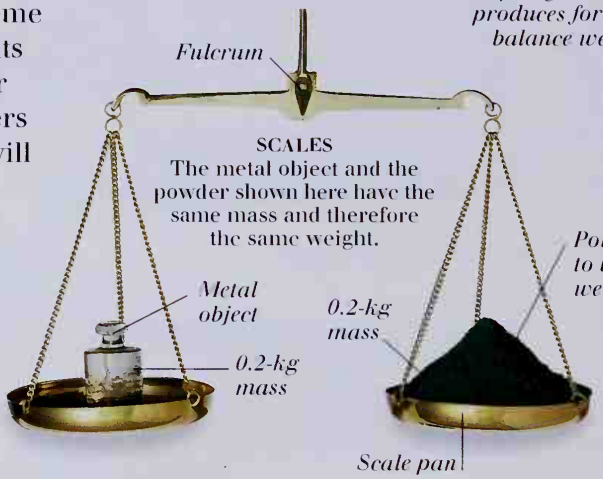
THE SCIENCE OF PHYSICS IS BASED on the formulation and testing of theories. Experiments are designed to test theories and involve making measurements: of **mass**, length, time, or other quantities. In order to compare the results of various experiments, standard units are necessary. The kilogram (kg), the meter (m), and the second (s) are the fundamental units of a system called **SI units** (Système International). Physicists use a variety of instruments for making measurements. Some, like the Vernier callipers, traveling microscopes, and thermometers are common to many laboratories, while others will be made for a particular experiment. The results of measurements are interpreted in many ways, but most often as graphs. Graphs provide a way of illustrating the relationship between two measurements involved in an experiment. For example, in an experiment to investigate falling objects, a graph can show the relationship between the duration and the height of the fall.

MASS AND WEIGHT

Mass is the amount of matter in an object, and is measured in kilograms. **Gravitational force** gives the mass its **weight**. Weight is a force, and is measured in newtons (see pp.10–11), using a newton meter like the one shown on the right. It is common to speak of weight being measured in kilograms, but in physics this is not correct.

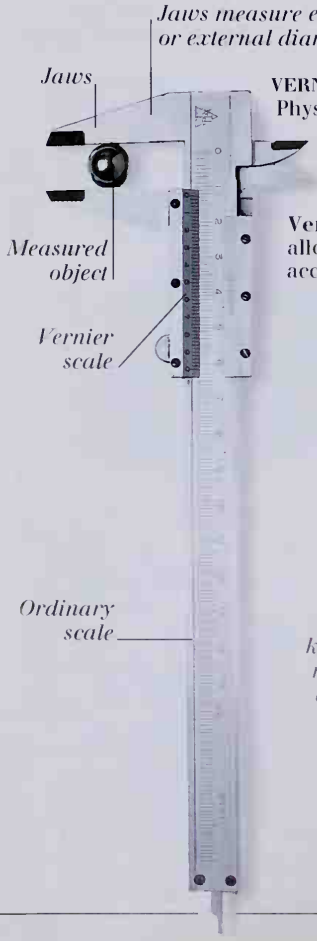


NEWTON METER AND KILOGRAM MASS

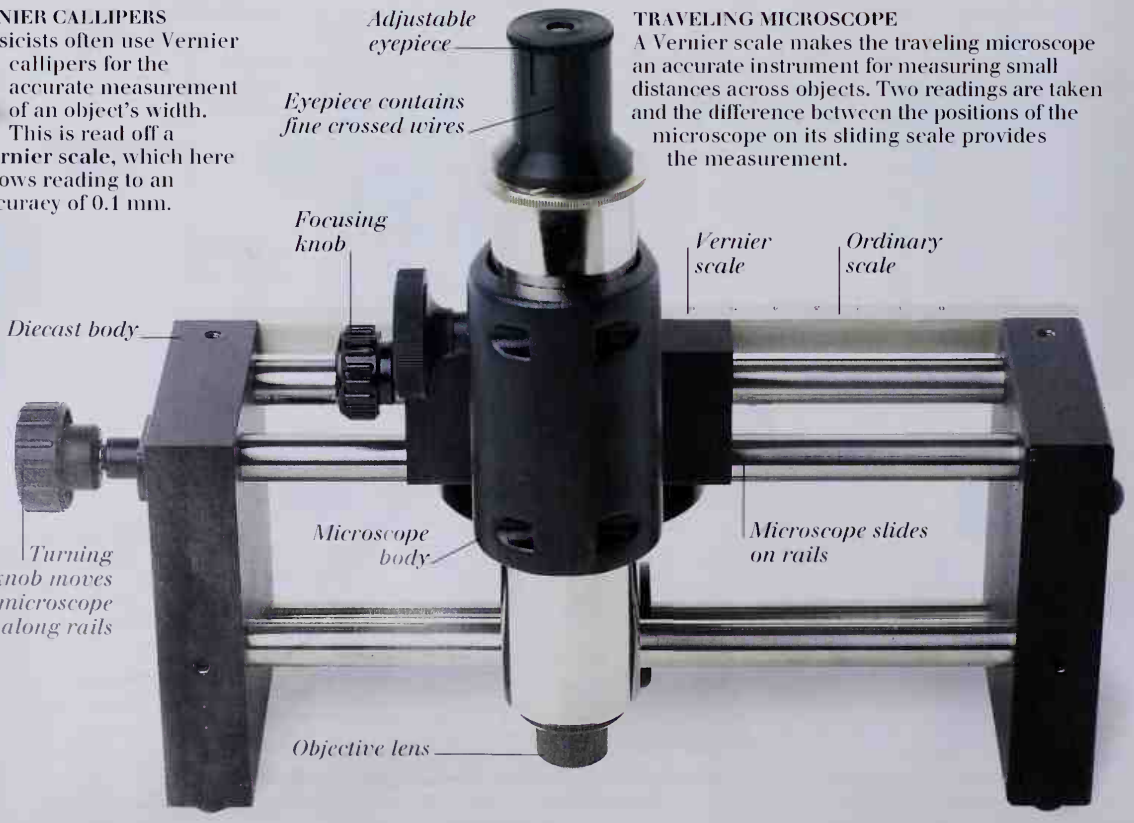


SCALES
The metal object and the powder shown here have the same mass and therefore the same weight.

MEASURING DISTANCE



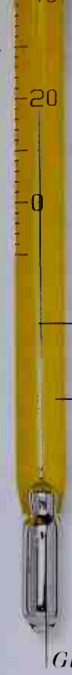
VERNIER CALLIPERS
Physicists often use Vernier callipers for the accurate measurement of an object's width. This is read off a **Vernier scale**, which here allows reading to an accuracy of 0.1 mm.



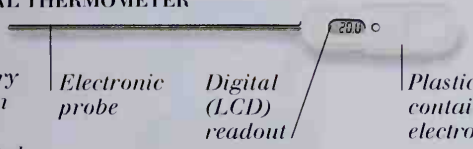
TRAVELING MICROSCOPE
A Vernier scale makes the traveling microscope an accurate instrument for measuring small distances across objects. Two readings are taken and the difference between the positions of the microscope on its sliding scale provides the measurement.

THERMOMETERS

There are two types of thermometer commonly used in modern physics. The mercury thermometer has a glass bulb containing mercury that expands as the temperature rises, while the digital thermometer contains an electronic probe and has a digital readout.

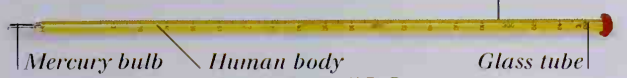


DIGITAL THERMOMETER



Mercury column
Electronic probe
Digital (LCD) readout
Plastic case contains electronics
Glass tube

MERCURY THERMOMETER



Scale
Mercury bulb
Human body temperature (37°C)
Glass tube

MAGNIFIED VIEW OF MERCURY THERMOMETER

Glass bulb

INTERPRETING DATA

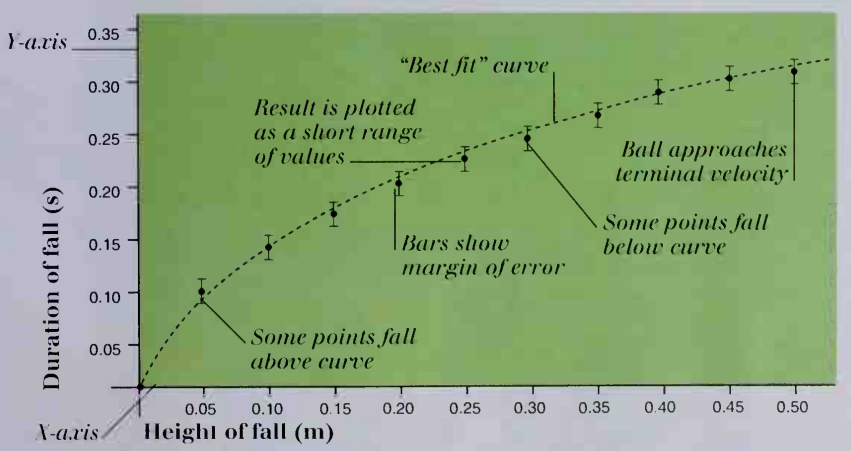
TABLE OF RESULTS FOR A FREEFALL EXPERIMENT

A steel ball is dropped from a variety of heights and the duration of each fall is timed. The results of these measurements are entered into a table.

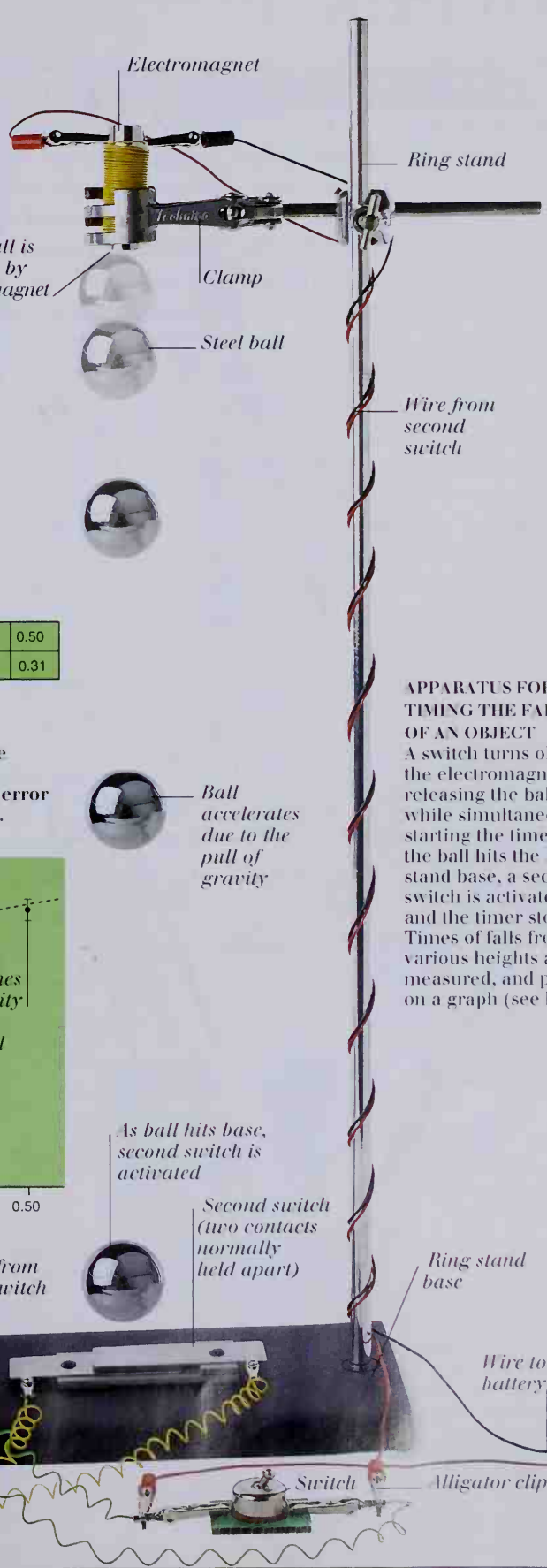
HEIGHT (m)	0	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50
TIME (s)	0	0.10	0.14	0.17	0.21	0.22	0.24	0.26	0.27	0.30	0.31

RESULTS OF A FREEFALL EXPERIMENT IN GRAPH FORM

A **graph** allows us to identify visually the relationship between the time and the height of the fall. There is an element of uncertainty or error in every result obtained, so each is plotted on the graph as a short range of values forming an **error bar** instead of a point. The curve is drawn so that it passes through all the bars.



FREEFALL EXPERIMENT



APPARATUS FOR TIMING THE FALL OF AN OBJECT

A switch turns off the electromagnet, releasing the ball while simultaneously starting the timer. As the ball hits the ring stand base, a second switch is activated, and the timer stops. Times of falls from various heights are measured, and plotted on a graph (see left).