Of course, it is now easy to calculate other logs. For example, if $0 < t < 1/2$, we can calculate $\log t$ by finding an integer m such that $1/2 < 2^m t < 1$. Given such an m, we have $\log t = \log(2^m t) + m \log 1/2$. The log of 2 (to our base $1/e$) is just $-\log 1/2$.

Henry Briggs (1561–1631) travelled to Edinburgh in 1615 to discuss logarithms with Napier. They agreed that there were many advantages to having logs to the base 10. In 1617 Napier died, but Briggs continued the work, publishing tables for logs to the base 10 in 1624. It was Briggs who introduced the terms 'mantissa' and 'characteristic'. The practical advantage of base 10 is of course that the logarithm of numbers such as 173, 17.3, 1.73, 0.173 and 0.0173 all have the same mantissa, which can be found in the table, while their characteristics $2, 1, 0, -1$, and -2 are seen by inspection. Briggs persuaded many of his contemporaries, including Kepler, of the importance of logarithms.

(4) **Mechanics and astronomy**

Nicholas Copernicus (1473–1543) was of Polish origin. He conjectured that the earth and the other planets move around the sun. At any rate, he said that this assumption gives a simpler explanation of what is going on. He did not assert that the planets move in circles with the sun at the center. He could only describe the orbits as epicycles, as did Ptolemy, whose observational data he used.

Simon Stevin (1548–1620) lived in the Netherlands (which included what is now Belgium). He was one of the earliest expositors of the theory of decimal fractions, which he compared to an unknown island 'having beautiful fruits, pleasant plains, precious minerals' (see page 21 in Smith's *A Source Book in Mathematics*). Stevin is perhaps best known for his *Statics and Hydrostatics*, published in 1586. In this book he discusses the triangle of forces, resolution of forces, stable and unstable equilibrium and pressure. He was the first to advance beyond Archimedes in these subjects. He also wrote on algebra and geometry.

Galileo Galilei (1564–1642) is often regarded as the father of modern physics. There is a story that, instead of paying attention to the church service, he used his pulse to time the oscillations of a lamp swinging from the church roof. He discovered that the period of oscillation does not depend on its amplitude. This discovery was to be exploited for constructing pendulum clocks. Galileo disrupted his medical studies to devote himself to mathematics. After publishing a book on hydrostatics and centers of gravity, he was appointed professor. Everyone has heard the story about his experimenting with falling bodies on the leaning tower of Pisa. Whatever the truth of this story, he found that a falling body undergoes a uniform ac-

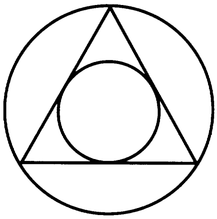

FIGURE 26.1. Kepler's solar system

celeration which is independent of its weight. He checked these conclusions by studying bodies sliding on inclined planes.

Galileo is most famous as an astronomer. He was the first to use the recently invented telescope to study the heavens and was rewarded by discovering, among other things, the moons of Jupiter (in 1610). These seemed to confirm the Copernican hypothesis which Galileo advocated. It is well-known that, in 1633, the Inquisition forced him to recant the Copernican view.

Johann Kepler (1571–1630) studied in Tübingen (Germany) and became a professor in Grätz (Austria). His early espousal of the Copernican system led him to seek an explanation of the distances of the various planets from the sun. His first idea was to construct an equilateral triangle with its vertices on the orbit of Saturn — it was assumed that this orbit was circular — and then to inscribe another circle in this triangle (Figure 26.1).

This second circle was supposed to be the orbit of Jupiter, and, indeed, this construction gave more or less the correct ratio for the distances of Saturn and Jupiter from the sun. Kepler tried to extend this idea by constructing a square with its vertices on the orbit of Jupiter, and inscribing a circle in this square for the orbit of Mars. Here, however, the observed facts did not confirm to the theoretical model.

Undiscouraged, Kepler then replaced the circles by spheres and the regular polygons by regular polyhedra. Remarkably, there were five intervals between the known planetary orbits to account for and five Platonic solids to explain them. Using the observational data of Ptolemy, Kepler made his model fit the facts more or less, and he published his findings in his *Cosmic Mystery*, a book which owed much to Pythagorean number mysticism. Today we do not attribute any significance to these speculations.

Kepler knew that, in order to check his theories, he had to use more recent observational data than those recorded by Ptolemy. It so happened that very accurate observations of celestial phenomena were being made by the Danish astronomer Tycho Brahe (1546–1601), who was, however, reluctant to part with his data, hoping to save them for his own theory, which was a modification of Ptolemy's.