The capital of the Holy Roman Empire was at that time in Prague. Tycho Brahe was called to Prague as 'imperial mathematicus' and Kepler managed to become his assistant in 1599. Brahe put Kepler to work on the orbit of Mars, which deviated from a circle more than any other planetary orbit did. Two years later, Brahe died, and Kepler succeeded him as imperial mathematicus. His job description included casting horoscopes for the emperor. Kepler expressed his views on astrology in *Tertius Interveniens*, asserting that it is all very well for philosophers to criticize the 'daughter' of astronomy, without realizing that 'the daughter must support the mother by her charms'. He pointed out that an astronomer could not make a living, unless he encouraged people in the belief that they could learn the future from the stars.

With the help of Brahe's magnificent data, Kepler was able to formulate his three laws of planetary motion:

1. Each planet describes an ellipse with the sun at one focus.

2. The line joining the sun to the planet sweeps out equal areas (bounded by the ellipse) in equal times.

3. The square of the period of revolution of each planet (its 'year') is proportional to the cube of the major axis of its orbit.

Kepler's third law came in 1619, about ten years after the first two. These three laws were later to confirm Newton's theory of universal gravitation.

After the job in Prague petered out, owing to political events and a shortage of funds in the imperial treasury, Kepler supported himself by casting horoscopes. He used mathematics even in his private life, making a careful calculation to decide which eligible woman to choose as his second wife.

There was to be one occasion when Kepler's connection to the court in Prague proved useful. When jealous neighbours had accused his mother of witchcraft, a very serious accusation in those days, he managed to get the case dismissed.

Exercises

1. How should Napier have had his particle moving to get logs to the base e?

2. Suppose we have perfectly accurate values for $\log(u^a v^b)$ and $\log(u^{a-1}v^b)$. Suppose $u^a v^b < x < u^{a-1}v^b$, and suppose we calculate the value of $\log x$ from the values of the two given logs, using linear interpolation. What is the maximum error possible?

3. You have been stranded on a desert island without your calculator. Being very bored, you calculate 2^{1000}, doubling 999 times but keeping only five significant figures (leaving a trail of zeros at the right of the calculation). You find that $2^{1000} = 1.0715... \times 10^{301}$. By what easy way can you now find $\log_{10} 2$, accurate to three decimal places?

4. Briggs calculated logs using square roots. He found $10^{1/2}, 10^{1/4}, 10^{1/8}$ etc. He then found numbers such as $10^{3/8} = 10^{1/4}10^{1/8} = 2.37....$ This gave him the $\log_{10} 2.37....$ Use Briggs's method, together with linear interpolation, to get a value for $\log_{10} 2.37....$

5. According to Kepler's initial model, what is the ratio of the radius of Saturn's orbit to the radius of Jupiter's orbit?

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The Seventeenth Century in France

The 17th century saw a blossoming of mathematical activity in France. Some of the important mathematicians were:

- Marin Mersenne (1588–1648),
- Gerard Desargues (1591–1661),
- René Descartes (1596–1650),
- Pierre de Fermat (1601–1665),
- Blaise Pascal (1623–1662).

Mersenne was a friar belonging to the Minim order. In the chapter on perfect numbers, we learned about primes of the form $2^n - 1$, which are named after him. His main importance lies in the fact that he corresponded with all the other French mathematicians, keeping them in touch with each other's ideas.

Desargues was the discoverer of projective geometry, the part of the geometry which deals entirely with incidence and ignores distance. Parallel lines are presumed to meet at a point 'at infinity'. In retrospect, it appears that the theorem of Pappus was also a theorem in projective geometry. Desargues's famous theorem is this:

> If two triangles, in the same plane or not, are so situated that lines joining pairs of corresponding vertices are concurrent (if