

Hipparchus

Hipparchus (c. 190 BCE – c. 120 BCE) was a Greek astronomer, geographer, and mathematician. The appearance of a nova in the constellation Scorpius inspired him to investigate how stars are born and die. With only the power of his eyes, he created the first accurate star map, a catalogue of 1,080 stars, giving their position and relative brightness. In comparing his chart with one compiled by Timocharis and Aristyllus of Alexandria 150 years earlier, Hipparchus discovered that the earth's axis is *precessing*, or wobbling, slowly like a top. His calculation of the inclination of the ecliptic, its equation, and his estimate of the annual precession of the equinoxes were all remarkably accurate. He determined the perigee and mean motion of the sun and of the moon, and he calculated the extent of the shifting of the plane of the Moon's motion. Hipparchus' star catalogue was used for over 1600 years, and his system of star magnitudes is still in use. His main contribution to geography was in applying rigorous mathematical principles in determining the location of places on the earth's surface, being the first to do so by specifying a position's latitude and longitude. In the *Almagest*, Ptolemy made use of a catalogue of stars, whose position Hipparchus had fixed by calculating celestial angular measurements, corresponding to latitude and longitude on earth.



Recognizing that the earth was round, he constructed the first globe and was the first to divide a circle into 360 degrees. Hipparchus invented an improved type of astrolabe, which he used to determine accurately the celestial coordinates of stars and a planisphere that allowed stereographic projections (also invented by Hipparchus), making it possible to tell time at night from stellar projections. He calculated the length of the year as 365.24667 days, correct to within 6.5 minutes and by making observations of eclipses, found the distance to the Moon. It isn't known who discovered that the

noontime shadow of an upright rod (called a *gnomon*, derived from the Greek word for “one who knows or examines”) is longest at the winter solstice and shortest at the summer solstice. It is known that the Egyptians used the sundial as early as 1500 BCE, and the Greeks learned of it from the Babylonians. The L-shaped figure comprised of the upright rod of a sundial and its shadow is often referred to as a gnomon. By keeping a record of the number of days that elapsed while the shadow of a gnomon passed from its shortest to its greatest length and then back to its shortest length, ancient people learned to measure the length of the year.

Hipparchus was born in Nicaea (now Iznik) in Bithynia (now Turkey). He probably spent some years in Alexandria but settled in Rhodes where he made most of his observations. What set him apart from other ancient astronomers was that he collected data based on careful observations and then formed theories to fit the observed facts. Except for a short commentary on an astronomical poem by Arastus, all of Hipparchus works are lost. Most of what is known about him comes from the writings of Strabo of Amaseai (fl. c. CE 21) and Ptolemy’s *Almagest*, written in the 2nd century CE, which was based on Hipparchus’ findings. Hipparchus’ contributions to astronomy were the most important before the time of Copernicus in the early sixteenth century.

Most scientific historians credit Hipparchus with founding trigonometry. The word is derived from two Greek words, *trigonum*, meaning “triangle,” and *metron*, meaning, “measure,” combining to mean “measurement of triangles.” In ancient times there was no name for trigonometry, which was not considered a branch of mathematics, merely a collection of techniques and formulas ancillary to astronomy. Hipparchus introduced trigonometric functions in the form of a table of chord arcs used to solve the problem of the computation of specific positions from geometric models. This table is practically the same as that of natural sines. It is likely that he had some means of solving triangles in spherical trigonometry. It is also suspected that Ptolemy’s Theorem, which gives the necessary and

sufficient conditions that a convex quadrilateral be inscribable in a circle, is due to Hipparchus. The theorem implicitly gives formulas for the sines and cosines of the sum and difference of angles, from which all trigonometric relations can be deduced.

Quotation of the Day: “Even if he did not invent it, Hipparchus is the first person of whose systematic use of trigonometry we have documentary evidence.” – T. L. Heath

[The time the professor alluded to must have been 9:36 p.m. A quarter of the time since noon is 2 hr. 24 min., and a half of the time till noon the next day is 7 hr. 12 min. Together these give us 9 hr. 36 min. This is the answer to the puzzle, but how was the solution found?]