What is an Astrolabe?

The astrolabe is a very ancient astronomical computer for solving problems relating to time and the position of the Sun and stars in the sky. Several types of astrolabes have been made. By far the most popular type is the *planispheric astrolabe*, on which the celestial sphere is projected onto the plane of the equator. A typical old astrolabe was made of brass and was about 6 inches (15 cm) in diameter, although much larger and smaller ones were made.
Astrolabes are used to show how the sky looks at a specific place at a given time. This is done by drawing the sky on the face of the astrolabe and marking it so positions in the sky are easy to find. To use an astrolabe, you adjust the moveable components to a specific date and time. Once set, the entire sky, both visible and invisible, is represented on the face of the instrument. This allows a great many astronomical problems to be solved in a very visual way. Typical uses of the astrolabe include finding the time during the day or night, finding the time of a celestial event such as sunrise or sunset and as a handy reference of celestial positions. Astrolabes were also one of the basic astronomy education tools in the late Middle Ages. Old instruments were also used for astrological purposes. The typical astrolabe was not a navigational instrument although an instrument called the *mariner's astrolabe* was widely used. The mariner's astrolabe is simply a ring marked in degrees for measuring celestial altitudes.
The history of the astrolabe begins more than two thousand years ago. The principles of the astrolabe projection were known before 150 B.C., and true astrolabes were made before A.D. 400. The astrolabe was highly developed in the Islamic world by 800 and was introduced to Europe from Islamic Spain (Andalusia) in the early 12th century. It was the most popular astronomical instrument until about 1650, when it was replaced by more specialized and accurate instruments. Astrolabes are still appreciated for their unique capabilites and their value for astronomy education.

Origins of Astrolabe Theory

The origins of the astrolabe were in classical Greece. Apollonius (ca. 225 BC), the great codifier of conic sections, probably studied the astrolabe projection. The most influential individual on the theory of the astrolabe projection was Hipparchus who was born in Nicaea in Asia Minor (now Iznik in Turkey) about 180 BC but studied and worked on the island of Rhodes. Hipparchus, who also discovered the precession of the equinoxes and was influential in the development of trigonometry, redefined and formalized the projection as a method for solving complex astronomical problems without spherical trigonometry and probably proved its main characteristics. Hipparchus did not invent the astrolabe, but he did refine the projection theory.
The earliest evidence of use of the stereographic projection in a machine is in the writing of the Roman author and architect, Marcus Vitruvius Pollio (ca. 88 - ca. 26 BC), who in *De architectura* describes an anaphoric clock (probably a clepsydra or water clock) in Alexandria. The clock had a rotating field of stars behind a wire frame indicating the hours of the day. The wire framework (the spider) and

the star locations were constructed using the stereographic projection. Similar constructions dated from the first to third century and have been found in Salzburg and northeastern France, so such mechanisms were apparently fairly widespread among Romans. See the page on the anaphoric star disk for a description of a modern recreation of the anaphoric clock.
The first major writer on the projection was the famous Claudius Ptolemy (ca. AD 150) who wrote extensively on it in his work known as the *Planisphaerium*. There are tantalizing hints in Ptolemy's writing that he may have had an instrument that could justifiably be called an astrolabe. Ptolemy also refined the fundamental geometry of the Earth-Sun system that is used to design astrolabes.

Early Astrolabes

No one knows exactly when the stereographic projection was actually turned into the instrument we know today as the astrolabe. Theon of Alexandria (ca. 390) wrote a treatise on the astrolabe that was the basis for much that was written on the subject in the Middle Ages. Synesius of Cyrene (378-430) apparently had an instrument constructed that was arguably a form of astrolabe. This is plausible since Synesius was a student of Hypatia, Theon's daughter. The earliest descriptions of actual instruments were written by John Philoponos of Alexandria (a.k.a. Joannes Grammaticus) in the sixth century and a century later by Severus Sebokht, Bishop of Kenneserin, Syria, although it is likely that Sebokht's work was derivative from Theon. It is certain that true astrolabes existed by the seventh century.

The Astrolabe in Islam

The astrolabe was introduced to the Islamic world the mid-eighth century. The astrolabe was fully developed during the early centuries of Islam. Arab treatises on the astrolabe were published in the ninth century and indicate a long familiarity with the instrument (the oldest existing instruments are Arabic from the tenth century, and there are nearly 40 instruments from

the 11th and 12th centuries). The astrolabe was inherently valuable in Islam because of its ability to determine the astronomically defined prayer times and as an aid in finding the direction to Mecca (the *qibla*). It must also be noted that astrology was a deeply imbedded element of early Islamic culture and astrology was one of the principle uses of the astrolabe. The picture is from a larger painting of the observatory at Istanbul in the 16th century.

Persian astrolabes became quite complex, and some were genuine works of art. There are a number of interesting stylistic differences between astrolabes from the eastern Islamic areas (the Mashriq), Northern Africa (the Maghrib) and Moorish Spain (al-Andalus). The astrolabe was also used in Mughal India in a somewhat less elaborate style.

The Astrolabe in Europe

The astrolabe moved with Islam through North Africa into Spain (al-Andalus) where it was introduced to European culture through Christian monasteries in northern Spain. It is likely that information about the astrolabe was available in Europe as early as the 11th century, but European usage was not widespread until the 13th and 14th centuries. The earliest astrolabes used in Europe were imported from Moslem Spain with Latin words engraved alongside the original Arabic. It is likely that European use of Arabic star names was influenced by these imported astrolabes. By the end of the 12th century there were at least a half dozen competent astrolabe treatises in Latin, and there were hundreds available only a century later. European makers

extended the plate engravings to include astrological information and adapted the various timekeeping variations used in that era. Features related to Islamic prayers were not used on European instruments.
The clock in the picture is on the Prague, Czech Republic, town hall and was originally constructed in about 1410. Click on the picture for a more complete description.
The astrolabe was widely used in Europe in the late Middle Ages and Renaissance, peaking in popularity in the 15th and 16th centuries, and was one of the basic astronomical education tools. A knowledge of astronomy was considered to be fundamental in education and skill in the use of the astrolabe was a sign of proper breeding and education. Their primary use was, however, astrological. Geoffrey Chaucer thought it was important for his son to understand how to use an astrolabe, and his 1391 treatise on the astrolabe demonstrates a high level of astronomical knowledge.

Now imagine that you wanted to take the three-dimensional celestial sphere and project it onto a flat, two-dimensional surface. This was the fundamental problem that confronted scholars like Hipparchus, who was born in Nicaea in 180 B.C. Hipparchus kept meticulous records of 850 stars, an activity that led to the discovery of **precession** (wobbling of Earth on its axis) and to a unique way of describing a star's position. The Greek astronomer was able to construct a map by imagining a perpendicular line connecting each star to a point on a plane corresponding to the plane of the Earth's equator. The map, which preserved the angular relationships among the stars, may have been the first example of **stereographic**

projection.
Claudius Ptolemy drew heavily from Hipparchus as he prepared his magnum opus, the "Almagest," and other books. In "Planisphaerium," published in 150 A.D., Ptolemy provides a complete description, almost certainly based on ideas from Hipparchus, of the mathematical techniques required to project points on the celestial sphere. The book seemed to be a handbook to construct a working instrument, but no evidence exists suggesting he actually built an astrolabe. He did, however, design and build the **armillary sphere**, a complex predecessor of the astrolabe

The first authoritative account of what would become the modern, much-easier-to-use astrolabe came from Theon of Alexandria in 390 A.D. OK, so Theon didn't actually build an astrolabe, but historians think he did provide a full blueprint.

When Islamic astronomers picked up Theon's treatise on astrolabes, they saw their value immediately. They began making and using the instruments -- and composing their own manuals. The first astrolabe guides written in Arabic appeared in the eighth century. By the 11th century, the devices began appearing in Muslim Spain. From there, it was hop, skip and a jump into Christian Europe, where astrolabes helped astronomers -- and even gifted poets like Chaucer -- bring order and stability to the night sky. They were an indispensable tool throughout

the Middle Ages, until they became supplanted by newer, more specialized technologies, such as telescopes, sextants and pendulum clocks.