Time Measure 1
Greek Sundials

Alena Šolcová

Faculty of Information Technology

Czech Technical University

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Gnomon and shadow

- **The easiest way of determining the time (instead of using a gnomon) is**
  to measure one's own shadow with one's feet
  - knowing that

> **the body is about seven times as high as the foot is long.**

- **Herodotus (490-425 B.C.) writes that it is from the Babylonians that the Greeks became acquainted with the gnomon and acquired other astronomical knowledge.**
- **Anaximander of Miletus (610-547 B.C.), a pupil of Thales, was probably the first Greek man to determine the solstices with a gnomon.**

Vitruvius and Egypt Ideas

- **Vitruvius (died 25 B.C.) described the making of sundials.**
- **He discussed different types of small portable sundials but also monumental sundials (constructed for a particular latitude) which were based on Egyptian ideas.**
- **About 100 Hellenistic sundials have been excavated.**

The Emperor Augustus and Obelisk

- **The Roman emperor Augustus ordered a 6th-century-B.C. obelisk to be brought from Heliopolis in Egypt to Rome where it was erected on the Campus Martius.**
- **The final construction, due to the mathematician Facundus Novius, is called the Horologium Augusti. The hours were marked with gilt bronze lines on the stone plates, as was reported by the Roman writer Pliny the Elder (Naturalis Historiae 36, 72).**

- **In 1980 parts of the meridian line were discovered.**

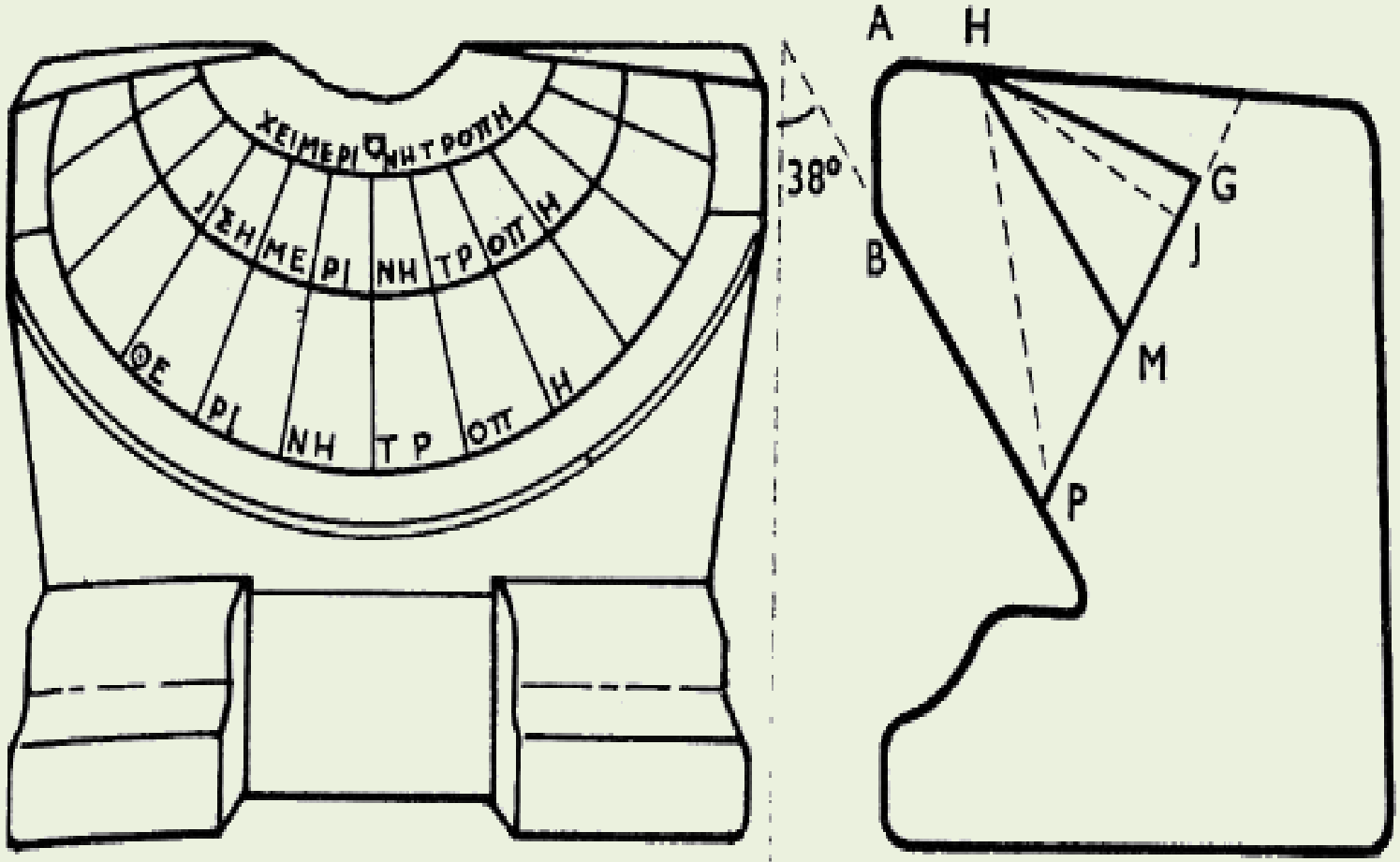
Scaphe

- **The sundials of antiquity were fundamentally different from our more recent sundials, e.g. on churches.**
- **On the plane surface of modern sundials the end point of the shadow moves at a variable speed.**
- **This is the reason why in ancient times one preferred to use spherical surfaces, on which the shadow moved at a constant rate.**
- **This hollow-sphere sundial is called a scaphe.**
- **The top of the gnomon was in the centre of the sphere.**
- **During each day, the shadow cast on the scaphe follows a path which is different for the different months of the year.**

Scaphe - hollow-sphere sundial - construction principles

Island Samos,

reconstructed in 1957

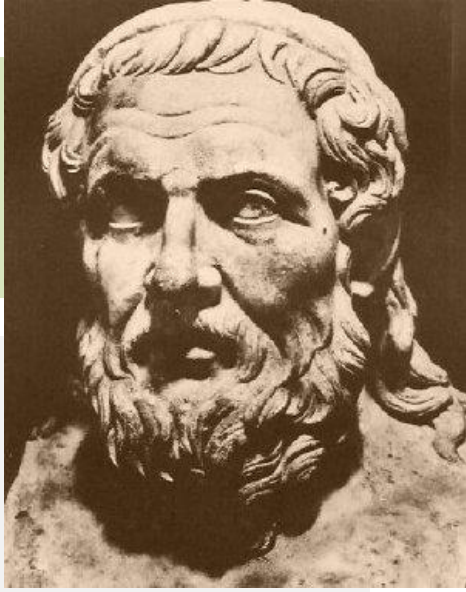


Scaphe as calendar

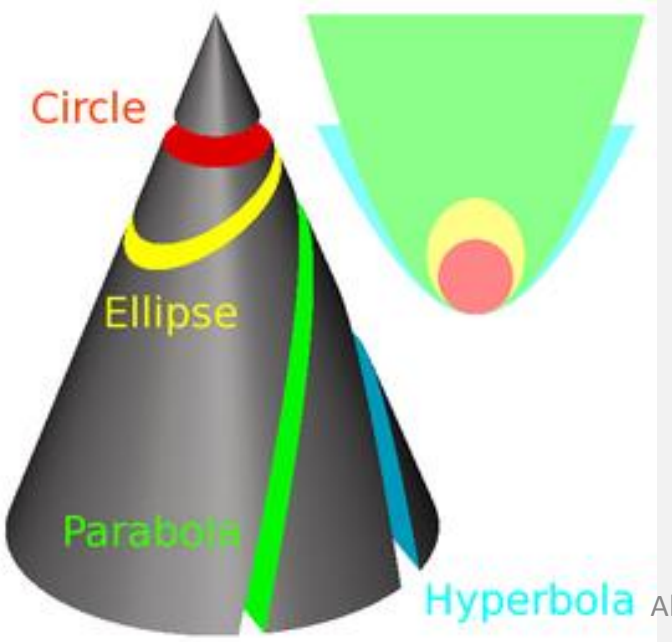
- **With such sundials one could read not only the time of day, as with the Egyptian sundials, but also the date of the year; i.e. the scaphe also represents a calendar.**
- **The time of day could be read from the direction of the shadow in the hollow sphere,**
- **the date from the position of the end point of the shadow on a circle which represents a month**

  (the position of the sun during the year is marked by the 'length' of the shadow).

Apollonius of Perga



The construction of such sundials was rather complicated and it is not astonishing that famous mathematicians like Apollonius of Perga were often among the makers.



Apollonius of Perga [**Pergaeus**]
(Ancient Greek: Ἀπολλώνιος)
ca. 262 BC – ca. 190 BC
was a Greek geometer and astronomer noted
for his writings on conic sections.
His innovative methodology and terminology, especially in the field of conics, influenced many later scholars including **Ptolemy, Francesco Maurolico, Johannes Kepler, Isaac Newton, and René Descartes.**

Aristarchos of Samos (320-250 B.C.)

suggested that

- **the Earth turns around the sun in a tilted plane;**
- **the angle between these planes - the equator and the ecliptic - can be determined with a sundial.**

Aristarchos is said to have constructed the first plane sundial.

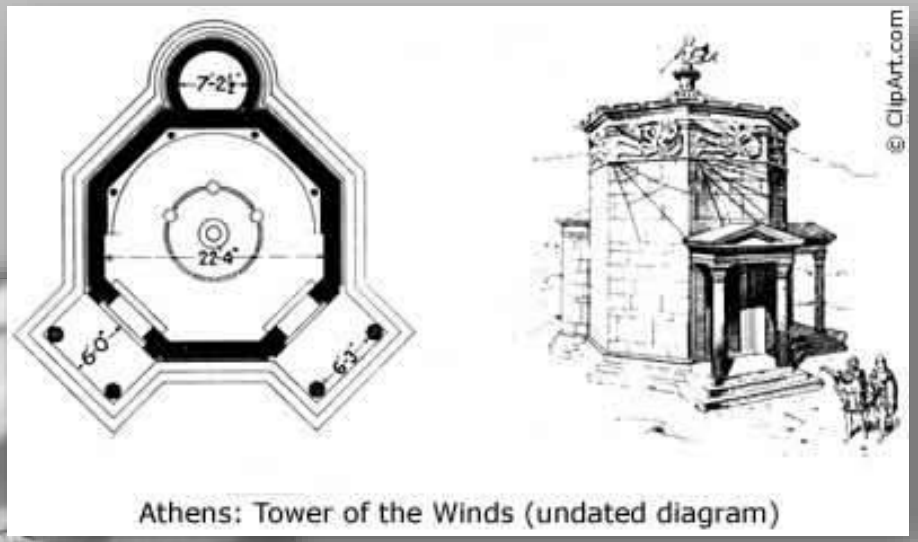
- **Otto Neugebauer even proposed that the development of the plane sundial promoted the discovery of the conic sections (Apollonius of Perga).**

Tower of the Winds

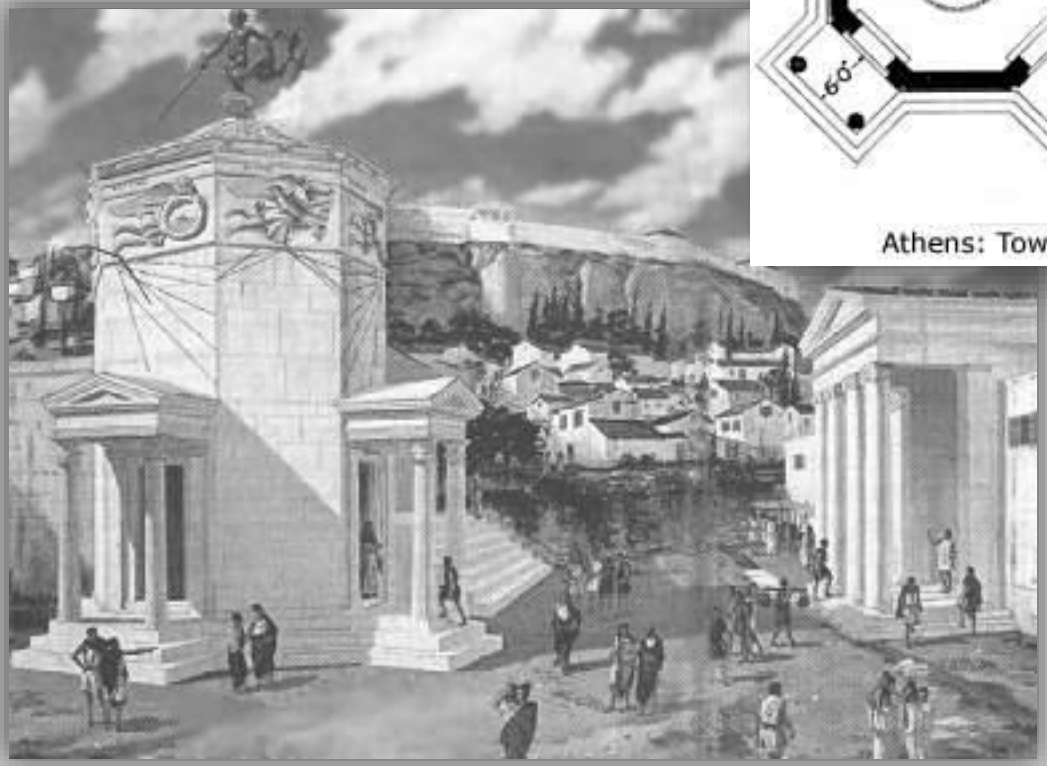
- **Inside the octagonal Tower of the Winds in Athens –**
- **there was a water clock (clepshydra), and on each of the sides a plane sundial.**
- **The tower built in 75 B.C. by the Macedonian surveyor A. Kyrrhestes**

- **According to Vitruvius the sundials were constructed by the Macedonian astronomer Andronicus.**

Tower of the Winds



Athens: Tower of the Winds (undated diagram)



Conclusion

- **Vitruvius described ten different sundials in his work 'De architectura' (25 B.C.).**
- **The first sundial in Rome was set up in 293 B.C.;**
- **Thirty years later, in 263 B.C., another sundial came to Rome from Catania in Sicily, thanks to Consul Valerius Messala.**
- **This confiscated Greek sundial was erected on the Campus Martius without recognizing the error due to the difference in latitude of 4.5°.**
- **The number of sundials did not increase until 164 B.C.**
- **Most were of Greek origin as the inscriptions indicate.**
- **Also at this time there existed portable pocket sundials for travel, called viatoria, and sundials on necklaces.**