lecture 5

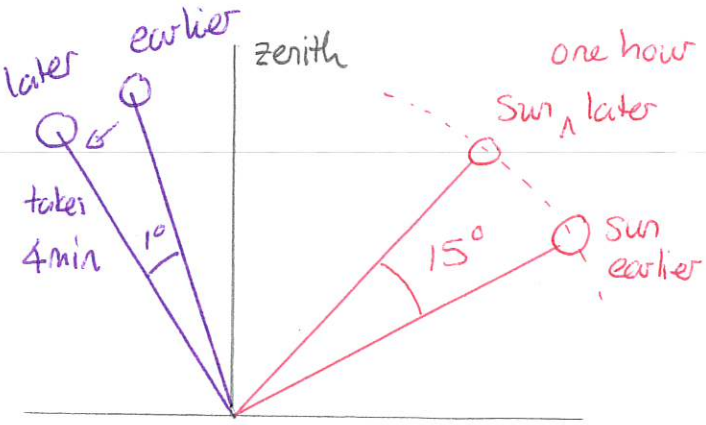
Friday: Cover Barrett. Ch2.

Monday: HW by 5pm

Returned HW - Solutions to most problems on D2L
- Grades updated in D2L
- D2L does not yet include attendance/participation

Local apparent solar time

We have seen that the passage of Sun across the sky can be used to measure the time of day. Specifically we can attempt to measure the angle of Sun from the zenith. To illustrate the principle consider the special case where the Sun passes directly overhead. We calculated that

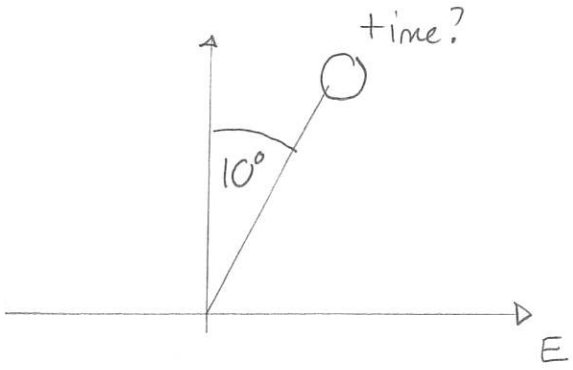


During one hour the angle between the Sun and the zenith changes by 15°

and

When the angle between the Sun and zenith changes by 1° then 4 minutes have passed

So, if we have the illustrated situation then we could use the angle to tell the time.



Q. What time would it be?

A. $10° \rightsquigarrow 10° \times 4\text{min}/1° \equiv 40\text{min}$ before noon

11:20 am.

Sundials

How can we measure the angle that the Sun makes with respect to the vertical? We could try to observe the Sun by looking at it or pointing an instrument at it. This is generally not very practical.

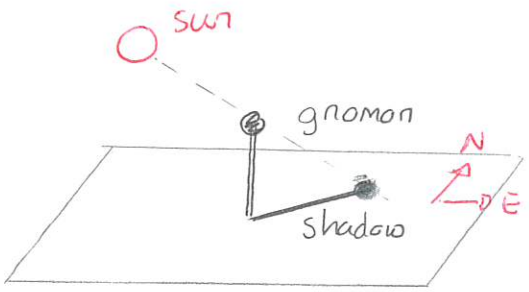
Q. What could we do to measure Sun's angle that does not require looking directly at the Sun?

We could use an object that casts a shadow and then use the shadow to calculate the hour. This is the basic idea behind sundials. We will see that this has advantages:

1) it is easier to observe the shadow
2) observing the shadow can be done with a precision that could tell time fairly accurately.

Basic principles of a sundial

The simplest sundial consists of a vertical object (the gnomon) that casts a shadow onto a surface where the shadow's position can be recorded.

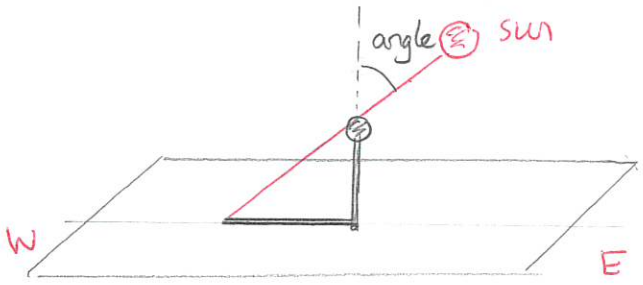


As time passes Sun appears to move and the position of the shadow changes.

Demo: Video by Daniel Douch → basic concept

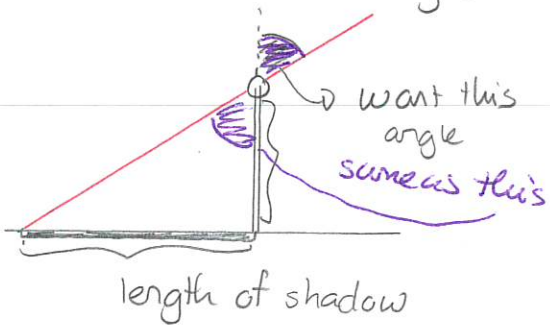
How might this be used? Again consider the day when the Sun passes directly overhead.

Suppose that the gnomon is vertical (along zenith) and the surface onto which it projects a shadow is horizontal.



Then geometry gives that the shadow produced by the gnomon will lie along the E-W line. Rather than measure the angle we could do

1) measure length of shadow
2) use length of shadow and height of gnomon and trigonometry to get angle.



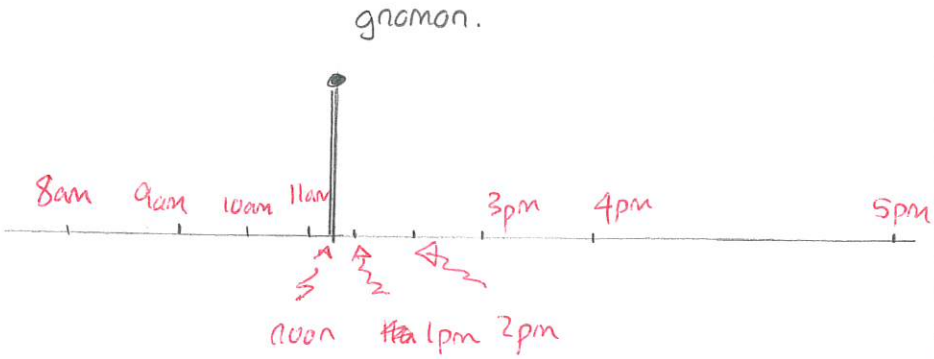
In practice a sundial user does not actually go through all of this mathematics.

Q How could we make it easy for an ordinary person to use such a sundial?

For ordinary users it would be better to have an expert who can do the geometry and mathematics to calibrate the sundial.

For our special situation sundial, we could make marks along the ground corresponding to hours.

In other situations, the process of calibration would be much more complicated.



Demo: Natweclip Time Lapse Sundial

The video shows a typical sundial with a calibrated edge that indicates the time.

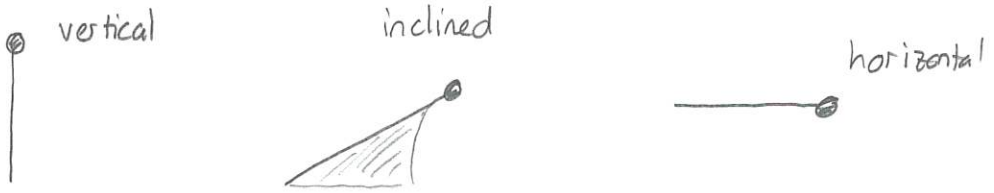
Demo Diptych Dial. History of Science Museum.

The video shows a portable sundial and there were clearly adjustments needed for various latitudes.

Types of Sundials

The primary variations in sundials have to do with:

1) orientation of the gnomon



2) orientation of the dial - surface onto which the shadow is projected.

For each choice there will be a way in which to calibrate the dial

Demo EAAE History of Sundials

- show vertical dial horiz gnomon
- " tilted gnomon equatorial dial

Demo: British Sundial Society

- British Dials Online
  * Vertical St James Church Bytham
  * Horizontal Trelavour Peazey, St Dennis
- search by Condition - excellent
  - Chumber Park
  - Commandery
  - Bowes Museum

The calibration of such dials requires tricky geometry and trigonometry since the angle of the shadow will vary throughout the year in many cases

Demo: Animated Shadows on Virtual Stone

* Winter Solstice - animation
  - images

* Spring Equinox

Note the different trajectories. With a vertical gnomon this will vary during the days of the year. The same will be true for a horizontal gnomon. Is there a better way?

Q What might be a better way to angle the k gnomon?