Essl 290 Spring 2021

Lecture 4

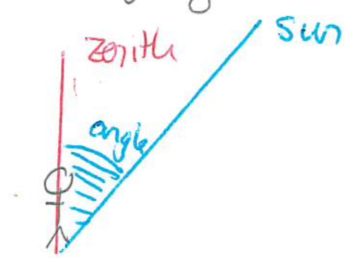
Weds: Will cover Barnett - pgs 14 – 18

~~Next Ch~~ Plus outside exercise.

Today: HW by 5pm.

Local apparent solar time

We can chart the time during the day by measuring the angle that Sun makes with respect to the zenith, an imaginary vertical line at the observer's location.



We will agree that

Noon (Local solar noon) ≡ instant at which Sun is highest

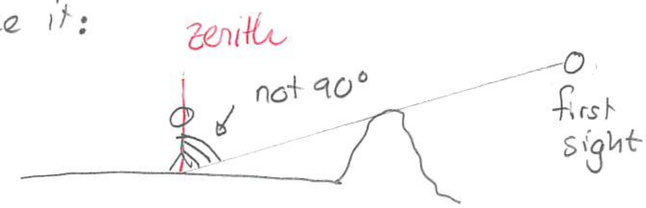
≡ instant during day when angle from Zenith is smallest

Technically we could define two other terms:

Sunrise ≡ instant when Sun is 90° from the zenith to East

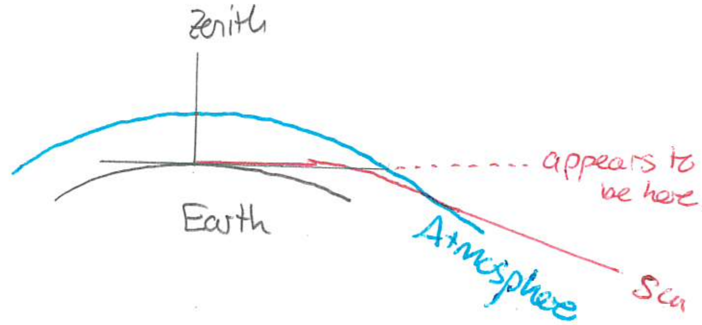
Sunset ≡ " " " " 90° " " " to West

For various reasons these do not coincide with the actual position of Sun when we first see it:



1) there can be ostacles

2) light bends as it travels from empty space into the atmosphere



Demo: Wikipedia page Sunrise.
- note minor details.

Ignoring the latter minor issue, we can focus on the special case:

- a location on Earth and a day such that the Sun passes directly overhead (smallest angle with Zenith will be exactly zero).

We want to relate the angle to a time in hours, minutes and seconds. On this special day we require:

1) the period between sunrise and sunset is divided into exactly twelve hours.

2) during any hour the change in angle is same as that during any other hour.

3) an hour is subdivided into 60 minutes, each spanning the same angle

4) a minute is divided into 60 seconds, each spanning the same angle.

5) a day consists of two such twelve hour periods (between successive noons).

We can use this to subdivide the motion of Sun, measured in terms of angle to the local zenith and arrive at the number of degrees per minute, etc, ... on this particular day.

1 **Sun motion during an equatorial equinox**

Consider observing Sun's location from a location on the equator an a day on which Sun passes directly overhead.

a) What is the angle through which Sun moves from sunrise to sunset?

b) If this period is divided into exactly twelve hours, then through what angle (measured from the local zenith) does the Sun appear to move in one hour?

c) If one hour is divided into exactly 60 minutes, then through what angle (measured from the local zenith) does the Sun appear to move in one minute?

d) If one minute is divided into exactly 60 seconds, then through what angle (measured from the local zenith) does the Sun appear to move in one second?

e) How much time passes as the angle measured from the zenith changes by exactly 1°?

a) Exactly 180°

b) Divide 180° into 12 parts

$\frac{180^\circ}{12} = 15^\circ \Rightarrow$ 15° per hour

c) Divide 15° into 60 parts $\Rightarrow \frac{15^\circ}{60}$ per minute

$\Rightarrow \frac{1}{4}^\circ =$ 0.25° per minute

d) Divide 0.25° into 60 parts $\Rightarrow \frac{0.25^\circ}{60} =$ 0.0042° per second.

e) There are twelve hours in 180°

$\Rightarrow$ 12×60 min in 180°

$\Rightarrow$ 720 min in 180° $\Rightarrow \frac{720 \text{ min}}{180^\circ} =$ 4 min per degree.

This is reasonable when Sun passes directly overhead. What if it does not pass directly overhead?

Demo: Motions of Sun Simulator

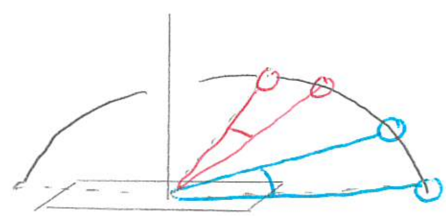
a) ~~direct~~ equator - equinox = equal angles along circle
= equal angles from zenith

~~b) equator~~

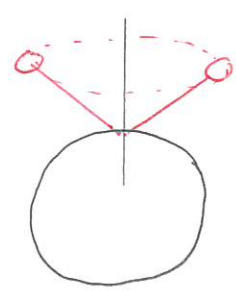
b) equator - solstice = ~~equ~~ equal angles along circle
≠ equal angles from zenith.

c) equinox - high latitude. - start at 6am
- note that speed of rotation of shadow changes - slowest at noon

We can see that on days when the Sun does not pass directly overhead, a change in Sun's position by equal angle gives different changes in zenith angle depending on how high or low Sun is.



An extreme of this is at one of the poles on any day. The Sun appears to circle at the same angle from the zenith all day long. So here zenith angle will not work.



Defining a unit of time

When we measure times for events we do so using various units. Normally the basic units are seconds. So when we keep records for a 100m race, they are quoted in seconds. We could use (except at the poles) the Suns motion by requiring that:

> The number of seconds from one instance of noon (on one day) to the next (on the next day) is
>
> $$24\text{hr} \times \frac{60\text{min}}{1\text{hr}} \times \frac{60\text{s}}{1\text{min}} = 86400\text{s}$$

So

> One second is $\frac{1}{86400}$ of the period from one local solar noon to the next (at the same location)

Will this always give the same second?

Q What would have to be true about the observed motion of Sun in order for this to always give same notion of a second day after day and year after year at all locations?