Essl 290 Sp 2021

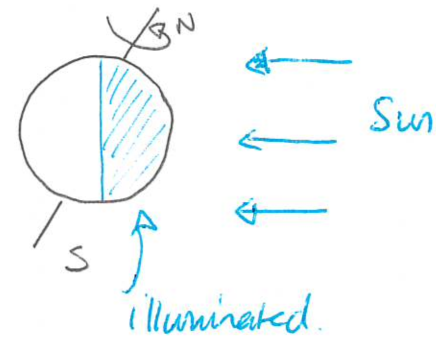
Lecture 3

Monday: Class covers Mondschein

HW due by 5pm → link to assignment on website
→ link to article on D2L.
→ answers on separate sheet.

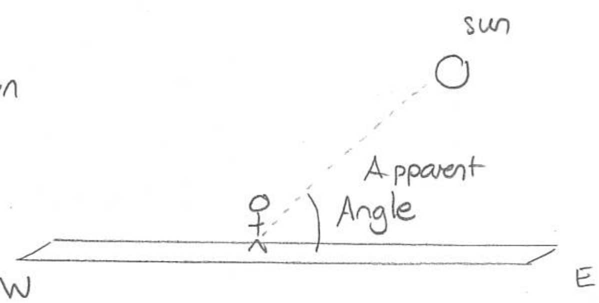
Systematized Solar Timekeeping

One method for keeping time would be to use the apparent motion of the Sun during the day. The reason behind this apparent motion is that Earth rotates on its axis and various locations pass through the illuminated portion.



Demo: Globe

We can mostly ignore that actual motion and consider the apparent motion. We could describe time in terms of the angle that Sun makes. In



the previous exercise we did this in a situation where the Sun passed directly overhead and measured the angle from the horizon. There will be several issues with this:

Q list possible issues with the previous scheme of ~~so~~ measuring Suns angle.

Possible issues are:

1) angle measurement accuracy
2) need two horizons that are 180° apart
3) need sun to move directly overhead.

We will eventually want a system that is more uniformly applicable. Such a system will have:

1) a well defined prescription for deciding Sun's angle at all locations and on all days.
2) a method of measuring angles accurately and calculating the hour from these, regardless of day.
3) a method for dividing the day into hours, minutes and seconds (preferably such that all users will agree on the results).

Solar angle measurements

The horizon is highly dependent on location. For example, in any city the immediate horizon is probably the rooftops of buildings. Thus it will be a poor choice as a basis from which to measure Sun's angle.

Q What might be a better choice?

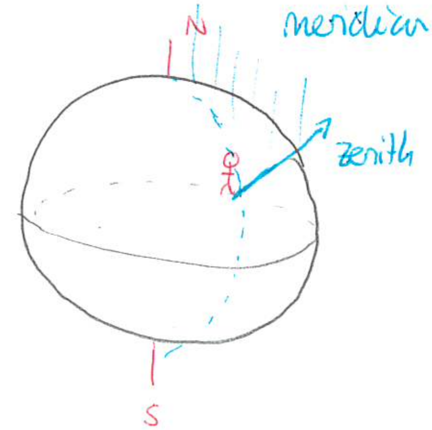
A much better choice against which to do measurements of Sun's position is the zenith.

Zenith – line passing directly vertically at any location.

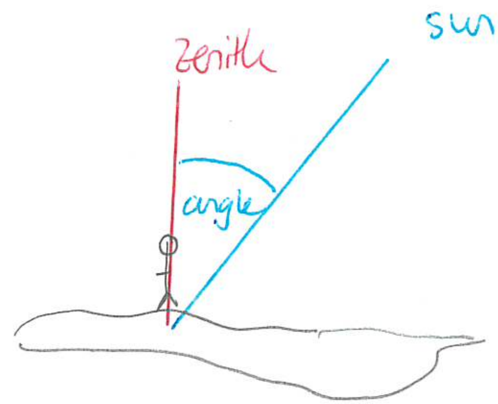
An associated entity is the

meridian

Meridian – plane passing through Zenith and N-S axis



Any observer can easily construct a zenith and then measure the angle of the sun from the zenith. We can then use information about this angle to quantify the time of day. This is the basis of



apparent solar time

Apparent solar time

Apparent solar time refers to a system which uses the angle of the Sun as measured from the Zenith. One easily identifiable point during this motion will be when the Sun is closest to the Zenith. This point is called noon.

Noon – instant at which Sun is highest in sky
≡ makes smallest angle from Zenith.

This will depend on:

1) location of observation (major issue)

2) day of year. (smaller issue)

Q: How could one easily observe when noon occurs (without having a clock)?

We can observe shadows cast by a vertical object and record when the shadow is smallest

Demo: Stand / flashlight and shadow.

Demo: Motions of Sun Simulator

- place location between tropics
- adjust day to have Sun pass over head

How do we subdivide the day into hours? There were actually various strategies:

1) require that sunrise occur at 6 am and sunset occur at 6 pm regardless of location and day of year. (used for more that 1000 yrs).
2) require that the time from one observation of noon until the next is exactly 24 hr (not quite accurate and later modified).

These two coincide on the day when the Sun passes directly overhead. This can only happen at locations between the tropics and on those locations only twice per year.

1 Local apparent solar time

Consider a day on which the Sun passes directly above the equator. Two people, Alice and Bob are at different locations along the equator. Bob is located 15° further east of Alice.

a) Alice observes that the Sun makes an angle of 45° east of the zenith. According to her what time of day will it be?

b) Geometry shows that at the same instant, Bob observes that the Sun makes an angle of 30° east of the zenith. According to him, what time of the day will it be?

Some time passes and they repeat their observations at the same later instant.

c) At this later instant Alice observes that the Sun makes an angle of 30° east of the Zenith and Bob observes 15° east of the zenith. According to each what will the time be?

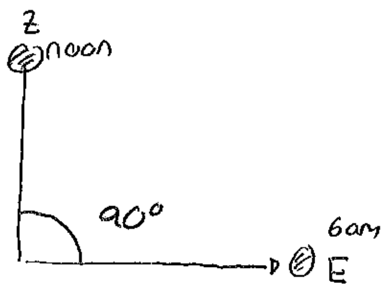
d) Do Alice and Bob agree on the time at any instant?

e) Do Alice and Bob agree on how much time passes between the instants?

Answer: a) 6 hrs

⇝ 90°

⇒ 3 hrs ⇝ 45°



So it would be three hours before noon **9 am**

b) 6 hrs ⇝ 90°

Then $1° ⇝ \frac{6\text{hrs}}{90°}$

$⇒ 30° ⇝ \frac{6\text{hrs}}{90°} \times 30° =$ 2hrs before noon **10am**

c) By Bobs previous calculation Alice says 10am

Bob now has $15° ⇝ \frac{6\text{hr}}{90°} \times 15° =$ 1hr before noon 11am

d) No

e) Yes it's one hour for each.

In this scheme, the time depends on the location of the observer, and the appearance of Sun. Thus it is called local apparent solar time.

Now what if Sun does not pass directly overhead?

Demo: Motions of Sun Simulator
- longer + shorter day.

We could use a system where we still divide the period from sunrise to sunset into twelve hours. During much of antiquity and the middle ages, this was the scheme.

Q. How will one such "hour" ~~compare to~~ measure in summer compare to one such "hour" measured in the same location in the winter?