Essl 290 2021

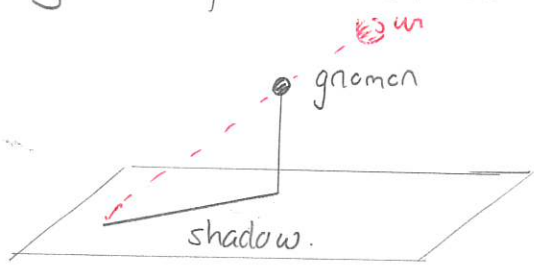
Lecture 6

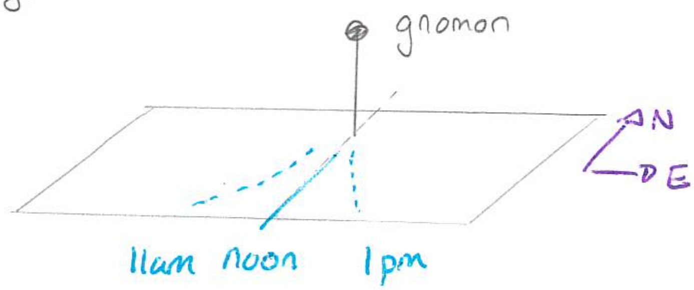
Mon: HW by 5pm – note reading

Mon: Read: Barnett Ch2

Sundial operation

Recall that sundials operate by recording the position of a shadow cast by a gnomon. In order to be practical the sundial needs to be calibrated so that the hour can be read without any complicated calculation.





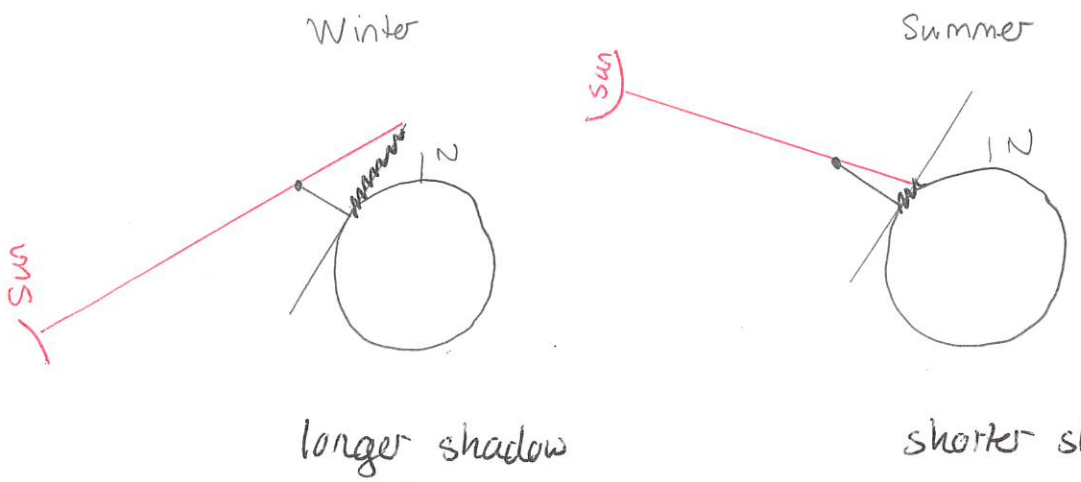
In general this can be very complicated to calculate, since the shadow caste by Sun depends on: → Q: On what might the shadow depend?

1) location of observation
2) day of the year

The location of observation issue arises because of the curvature of Earth

Same instants
different shadows at different locations

The day of year issue arises because of the tilt of Earth's rotation that results in different angles of apparent orbit



These can be illustrated via the following animation:

Animation: Animated Shadows on Virtual Stone

* Show winter solstice

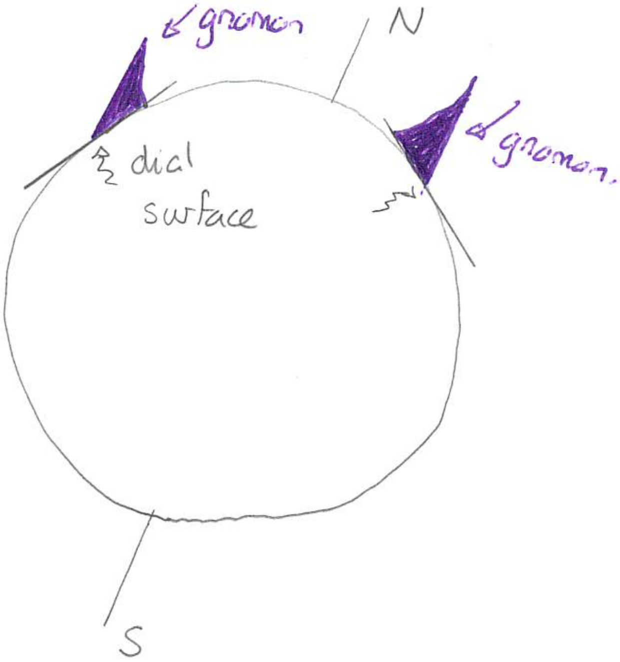
* Show spring equinox.

The animation shows that the tip of the shadow follows different trajectories on different days of the year. The same would be true for a horizontal gnomon / vertical dial sundial.

Is there a way that results in a more convenient calibration

Q: How might the sundial (with a flat dial) be arranged so that the calibration might be easier ~~that~~ than the vertical / horizontal dials?

Gnomon along Earth's axis



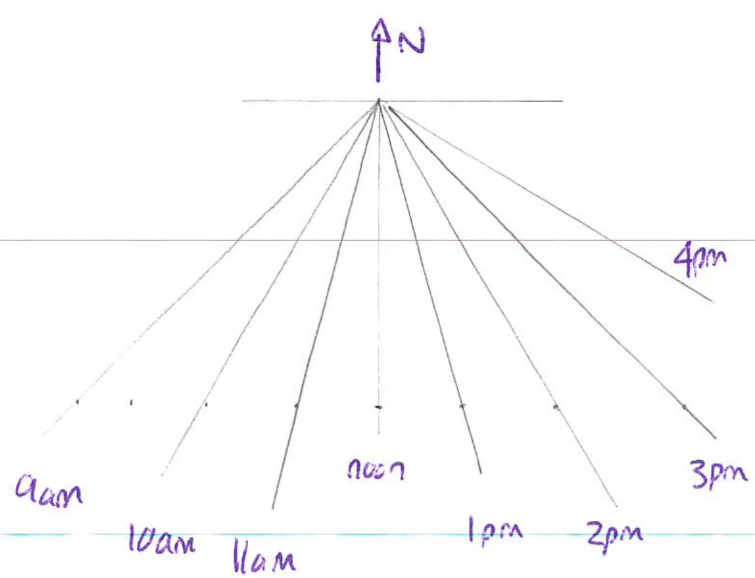
One special way to arrange a sundial is for the gnomon to point parallel to the Earth's axis

We can see that this would require the angle between the gnomon edge and the horizontal dial surface to depend on the location of the sundial. When this is done it emerges that one can calibrate the dial with straight lines that work:

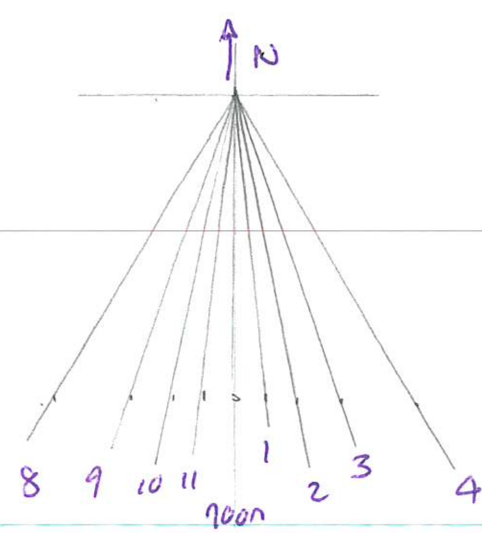
- on all days of the year at one latitude
- only at that latitude.

If we measure angles we get:

At latitude 90°



At latitude 20°



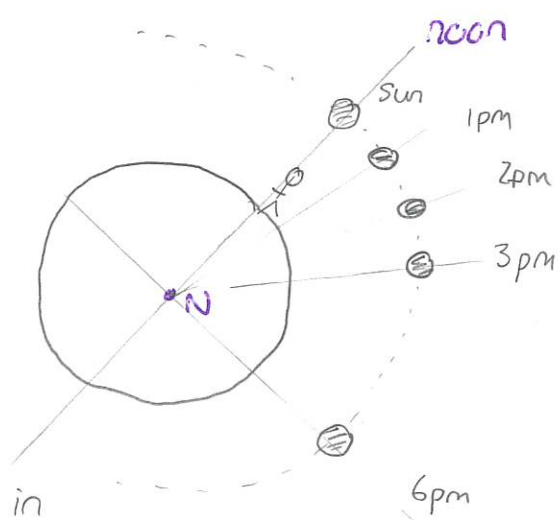
This means that

> A sundial with a gnomon and dial arranged to tell the time at one latitude will not work (without mathematical corrections to the dial) at a different latitude.

Temporal and equal hours

So far we have worked in a system where time in hours reflects the apparent rotation of the Sun as it apparently orbits Earth. So we have

> In every hour the Sun moves through the same angle (15°)



This is called the <u>equal hour</u> system because in this system the time elapsed in one hour is approximately the same at all locations and on all days.

This is not how hours were defined in ancient times. In ancient Babylon, Greece and Roman, it was common for ordinary purposes (not astronomy), to use a <u>temporal hour</u> system

> 1 temporal hour = $\frac{1}{12}$ time from sunrise to sunset.

1 Temporal Hours

The method of measuring time using temporal hours involves dividing the period of time from sunrise to sunset into twelve equal parts. Each part is one temporal hour. Suppose that classes were scheduled for one temporal hour each. We can determine how long each class will last on various days in Grand Junction.

a) On September 25 sunrise will be at 7:05am and sunset at 7:05pm. How long would one temporal hour be on that day?

b) On December 4 sunrise will be at 7:17am and sunset at 4:51pm. How long would one temporal hour be on that day?

c) On May 14 sunrise will be at 6:01am and sunset at 8:19pm. How long would one temporal hour be on that day?

d) If classes were scheduled in this way do you think that you would find the Fall semester or the Spring semester easier to manage?

Answer:

a) On this day there are exactly 12 hours, so

1 temporal hour = $\frac{12\text{ hr}}{12}$ = 1 (equal) hr (1 equal hr)

b) Need total time from 7:17am → 4:51pm.

7:17am → 8am = 43 min

8am → 4pm = 8 hr = 480 min

4pm → 4:51pm = 51 min

Total time is 574 min. Thus

1 temporal hour = $\frac{574\text{ min}}{12}$ = 48 m (48 (equal) min)

c) Until noon 5 hr 59 m = 359 min

noon → sunset 8 hr 19 min = 499 min

} total 858 min

1 temporal hour = $\frac{858\text{ min}}{12}$ = (71.5 (equal) min)

d) Depends (discussion)