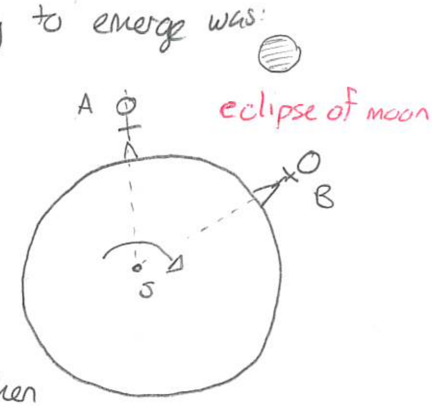
Mon: HW 5

Weds: Read – Mondsch 110 – 117
Barnett 95 – 110

Longitude and navigation

The question of determining longitude had arisen in ancient Greece with various proposals for accomplishing this. Even at that point it was connected with time differences. The earliest possibility to emerge was:



1) observe the same event at two locations and record the local time (time according to local noon) at which the event occurs. For example if an eclipse of the moon is observed by Alice at 9:28pm and by Bob at 10:58 pm then we know that their local noons differ by 1 hr 30 min. Using

$15^\circ \rightsquigarrow 1$ hr
$1^\circ \rightsquigarrow 4$ min

we get that their locations differ by $1 \times 15^\circ + \frac{1}{2} \times 15^\circ = 22.5^\circ$. Thus the difference in longitudes differ by 22.5°

Q: What would practical problems with this be?

We will see that more sophisticated variants of this emerged during the 1600s and 1700s ~~1750n~~

This method was used in 1675 by Charles Boucher to establish the longitude difference between Greenwich and a location in the middle of Jamaica reducing the inaccuracy from about 5° to 0.5°.

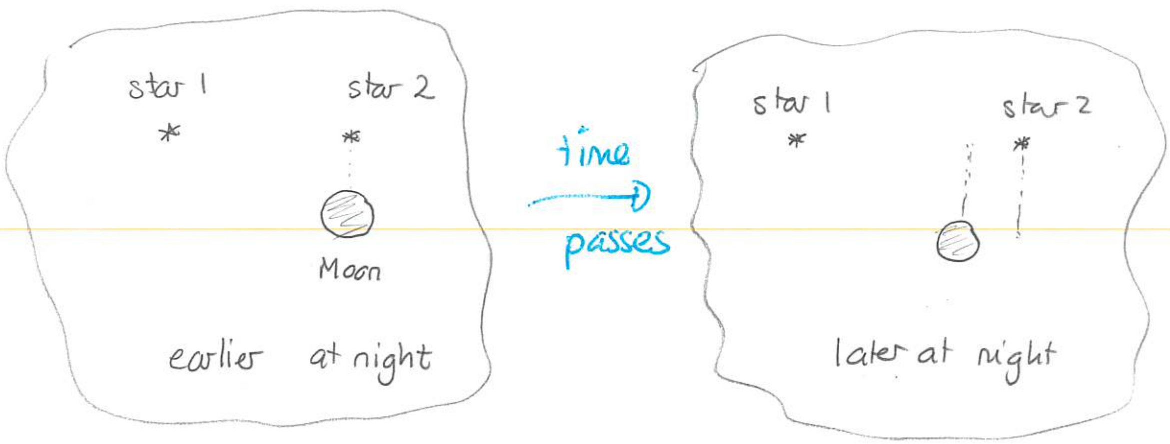
~~Q: What practical problems?~~

~~How much time passes?~~

After the middle ages ended the problem of determining longitude resurfaced. Two new methods emerged:

1) A celestial method observing Moon's position (the lunar distance method).

The idea here is to use the relatively rapid motion of the Moon relative to the stars. So we have



So we just need to know where Moon is compared to the stars to track the passage of time through the night. Two observers at two locations could note the local times at which Moon lines up with star 2 and Moon. Then again the difference in local times will give the difference in longitude.

A key aspect of this is that Moon only moves relative to stars at a rate of about 0.5° per hour.

Q: Suppose one wanted to use this in the open ocean to determine longitude with respect to a distant port. What would one need / need to know?

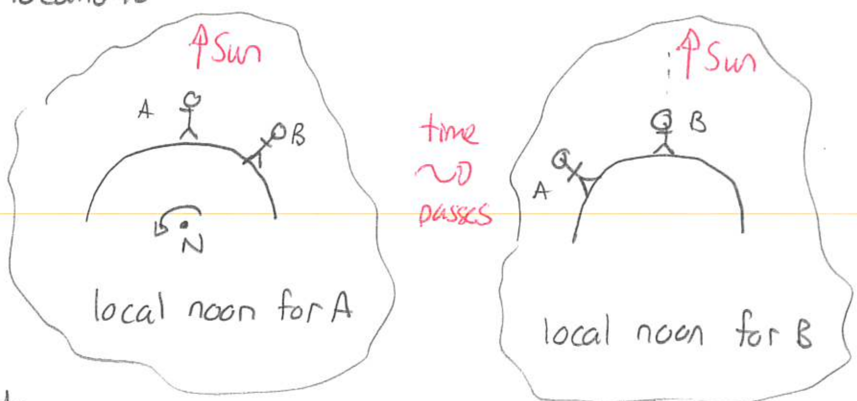
* an instrument to measure sufficiently precisely.
* a table of the positions of the Moon that tells where it will be at different times in the distant port
* accurate information about the relative positions of the stars.

The lunar distance method was first proposed by Johann Werner in 1514. The necessary tables (Nautical Almanac) only first became available in 1760s.

2 A timekeeping method involving synchronized clocks.

Another possibility would be to determine the time difference between local noon at two locations

If we can determine how much time passes between the two local noons then we can again translate into longitude difference via



15° ~> 1 hr   or   1° ~> 4 min

If the two parties are not in close communication then how could they establish time differences?

Q: What strategy might work to establish time differences in the absence of any communication?

The strategy is for the two parties to each have a clock that is synchronized to the other. Before describing the strategy consider how it might be used.

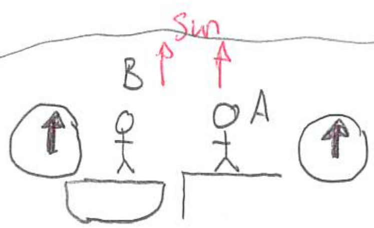
Example: Ana stays in Lisbon (Portugal). Bob sails west from Lisbon. A few days later he wants to know his longitude and finds that local noon occurs 2hr and 40min later than in Lisbon. He knows that the longitude of Lisbon is 9.15°W. What is his longitude?

Answer: $2hr\ 40min = 2\ hr + \frac{2}{3} hr$

$$2 \times 15^\circ + \frac{2}{3} \times 15^\circ = 40^\circ$$

The longitude difference is 40°. Thus his longitude is 49.15°W ∎

The strategy for finding the time difference is



Bob parties synchronize their clocks. They do this in the same location

→

Later Bob observes local noon and at that moment records the time on his synchronized clock → e.g. 2:40pm

Bob knows that this is the time that Alice records at the same instant. He then knows the time difference between local noon at his location and Alices location → ~~e.g. 2:40~~ 2hr 40min e.g.

→ Now use

1° → 4min

to determine longitude difference

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This method was first proposed in 1530 by Gemma Frisius who described all the details. The first known English translation was in 1555.

Q What practical issues would arise with this method from Alice's perspective?

Q What practical issues would arise with this method from Bob's perspective?

Both parties need to be able to track time and also measure when local noon occurs.

* Alice actually has no difficulties except that when she + Bob observe local noon, they get this correct.
* Alice does not even need a clock.
* Bob needs a clock that will
  - run uniterrupted for months or years
  - run accurately for months or years.

In the period during 1500 - 1700 the issue of determining longitude was extremely important but its resolution appeared impeded by many practical difficulties.

<u>Demo</u>: Hogarth Illustration