The Longitude Problem
Using a Marine Chronometer

Marine chronometers are precise, specialized clocks for finding longitude at sea. They serve as portable time standards.

Local time established by angle of the sun

12 Noon Local time

Greenwich

12 Noon Ships Chronometer

12 Noon Ships Chronometer

10 AM Local time

1 hour = 15° of longitude
Simultaneous observations

- If two observers see where the stars (or sun) are above the eastern horizon at the same time, they can determine their longitude.

- But all measurements of the day (stars, sun) are local.

  - Can be rephrased as difference in local time provides difference in longitude.

- Problem is how to know observations are happening simultaneously.
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12 Noon Ship's Chronometer

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Things that almost work
Wait for a lunar eclipse
Lunar eclipse

- Was used in ancient times
- Too rare for use at sea
- Hard to use accurately (when did it start, etc.)
Galilean moons
Galilean moons

- Works great on land
- Widely used to make land maps
- Predictable eclipses (speed of light…)

🌟
Cook transit of venus 1778
Problems of sea

• Jupiter is not visible all the time

• Can’t see the moons on a pitching deck

• Need a simple observation (bright star, etc.), and need to know the time
Two approaches

- Lunar distance to stars
  - Requires calculating in **advance** where the moon will be

- A better clock
  - A clock that can accurately keep time on a moving ship
John Harrison & Longitude

Arnold chronometer
The full process
Observing stars to measure local time
Time ball to tell ships the time
Finding local longitude
Technical state of the art ~1780s

- Pushed what could be done, invention of caged ball bearings & bimetallic strip
- Arnold, Earnshaw, Emery, Brequet, worked to make chronometers in ‘production’
- Expensive but crucial instrumentation
Trains and time zones
Train chronometer

- Trains used time to avoid collisions (!)
- Keeping accurate time became important
- Set up time zones (initially in Canada)
- Transition from local time (stars) being primary to a transferred time being paramount
For your grandparents

- Time defined by spin of the earth and observations of the stars

- Time at another location can be transmitted. Either by a precision mechanical watch, radio signals, or telegraph/telephone
To understand GPS, we need to understand light. Next week, what is light, introduction to quantum mechanics...