

Milestone: Timekeeping: Homework 5

Due: 18 October 2021

1 Clock accuracy

Consider a verge and foliot clock which loses 15min of time every 24hr.

- a) How much time does this clock lose in one hour?
- b) How many seconds does this clock lose in one minute?
- c) How many seconds does this clock lose in one second?

Now consider a pendulum clock which loses 15s of time every 24hr.

- d) How much time does this clock lose in one hour?
- e) How many seconds does this clock lose in one minute?
- f) How many seconds does this clock lose in one second?
- g) Imagine a sporting event which lasts for about three minutes and in which the winner is decided by 0.50s. Which, if either, of these clocks would be accurate enough to time this race correctly?

2 Pendulums and balance springs

Compare the use of a balance spring versus a pendulum as a regulator in a clock. What are the advantages and disadvantages of each?

3 Clock search

One way of finding evidence about the existence of early clocks is to search for records of such objects in museums. The purpose of this exercise will be to find clocks with various mechanisms that were produced in the period 1650-1700. The pendulum anchor escapement and balance spring escapement were invented during this period and any existing examples would be among the earliest.

The British Museum in London, England has an extensive collection which can be searched. The search tool is found at:

<https://www.britishmuseum.org/collection>

Enter clock into the search box and then refine the search by adjusting “Production Date” to 1650 to 1700.

- a) Find at least one weight-driven clock. Describe who made it and when it was made.
- b) Find at least one spring-driven clock. Describe who made it and when it was made.

- c) Find at least one clock with an anchor escapement (the search can be further refined by escapements). Describe who made it and when it was made.
- d) Find at least one clock with an balance spring escapement (some of these are called pre-balance spring verge escapements). Describe who made it and when it was made.
- e) Would the collection suggest that at that point there was already a large demand for and range of uses of clocks and watches. Did it seem to take very long after the invention of these new timekeeping techniques to incorporate them in clocks and watches available to the public? Explain your answers.

4 Earth's rotation and longitude

In the following “local noon” means the moment at which the Sun is highest in the sky at any particular location on Earth.

- a) The eastern border of Colorado is at longitude 102.05° W and the 109.05° W. How much time passes from the instant when the Sun is highest in the sky at the eastern border to when it is highest in the sky at the western border? Explain your answer.
- b) Grand Junction is located at 108.57° W. Look up the longitude of Glenwood Springs, CO and use this information to determine the amount of time that passes from local noon at Glenwood Springs to local noon at Grand Junction. Explain your answer.
- c) How far away in degrees of longitude is a location whose local noon is only one minute later than the local noon at Grand Junction? At this latitude one degree of longitude difference corresponds to a distance of about 54miles. How far west would this location be? Explain your answers.

5 Invention of the pendulum clock

The original idea for using a pendulum to regulate a clock appears to have come from Galileo. However, a practical working pendulum clock was first constructed after Galileo's death. Credit for this is generally given to Christiaan Huygens. This is described in some detail in (amongst others):

- D. S. Landes, *Revolution in Time*, Chapter 7, Harvard University Press (2000).
- R. McEvoy, *Introducing the precision pendulum clock*, in *Harrison Decoded: Towards A Perfect Pendulum Clock*, eds. R. McEvoy and J. Betts, Oxford University Press (2020).
- N. Howard, *Marketing Longitude: Clocks, Kings, Courtiers, and Christiaan Huygens*, Book History, Vol. 11, pp. 59-88 (2008)

You should consult these to answer the following questions about the origins of pendulum clocks and the controversies surrounding them.

- a) What evidence is presented as the first detailed description of a working pendulum clock? Where does this evidence appear? Is any evidence presented that such a clock was actually constructed by Huygens or his collaborators?

- b) Was the fact that Huygens was the first person credited with constructing a pendulum clock accepted at the time? What were the criticisms of this? How valid do they appear?
- c) When compared to the clock apparently proposed by Galileo, there is one important difference in the pendulum construction. Identify this and describe why it was an important development for timekeeping.
- d) How did Huygens disseminate the information about his pendulum clocks?