Essl 290 2021

Lecture 9

Mon: * Lecture by Doug O'Roark.

* HW by 5pm

- note reading is more involved - only one section of Hannah article

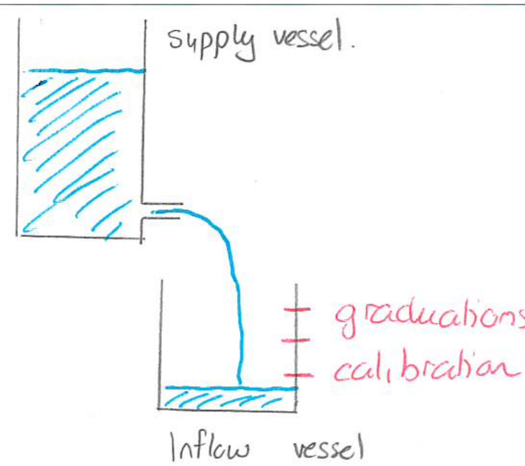
Weds: Mondschein pg 39 - 44

Burnett Ch 4.

Inflow water clocks

In an outflow clock, water leaves a graduated vessel. As the level drops the graduations indicate the time that has passed. The complication is that, as the water level drops the rate of flow reduces and this means that the calibration becomes complicated.

A technical way around this is to let the water flow into a graduated vessel. If this can be arranged so that the water flows at a constant rate, then the water height will rise at a constant rate in the last vessel.

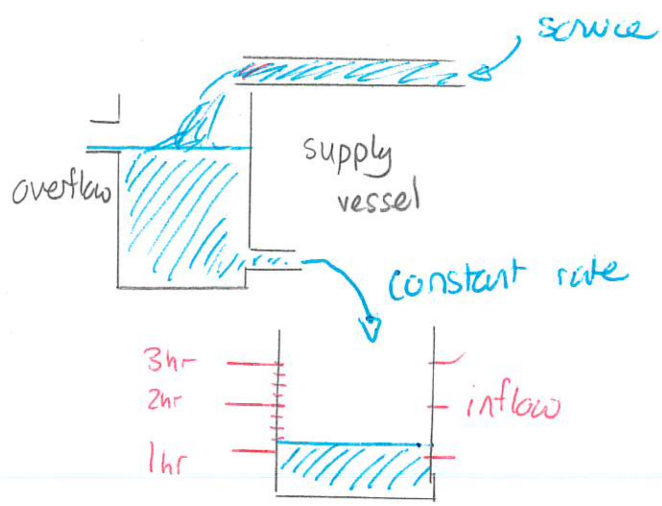


This is called an inflow water clock

The remaining challenge with such an inflow water clock is to ensure that the flow rate remain constant.

This can be accomplished by ensuring that the water level in the supply vessel remains constant. (the water level is called the "head")

There are various ways to accomplish this. A simple method is to equip the supply vessel with an overflow and to feed it so that the level remains at the overflow. This will ensure that water enters the inflow vessel at a constant rate



Therefore the water rises at a constant rate and the inflow vessel can easily be graduated in hours or subdivisions of hours

Demo: Constructed Water Clock.

Demo: Jospin video first minute

This invention is often attributed to Ctesibius (~300BC) but there were several important modifications that his clock included.

Q What would one issue with running such a clock be?

The inflow vessel will need to be emptied once it is full. Ctesibius arranged a syphon mechanism to accomplish this.

Demo: History of Physics Video

Demo: ~~Rest~~ Jospin video ~50s → 1:10min

Timekeeping via water clocks

Suppose that an inflow clock has been designed so that

1) the sides of the container are vertical
2) the inflow rate remains constant.

We can then ask how it keeps time. Will the hours be temporal or equal?

1 Water clock timing

Consider an inflow water clock with vertical sides. Water enters the vessel at a constant rate. Suppose that the vessel is large enough that it takes a day to fill.

a) How does the height that the water rises from 10:00am to 11:00am compared to that from 3:00pm to 4:00pm?

It flows at a constant rate so these would be the same

b) How does the height that the water rises during one hour on any given day compare to that on any other given day?

The same. Constant flow rate.

c) Does the clock appear to measure temporal hours, which were those commonly used in the ancient Classical world?

No, it appears to measure equal hours. The duration of a temporal hour varies from day to day. The clock has no such variation.

d) How might one adjust the clock so that it would measure temporal hours? Would your suggestion be easy to accomplish?

One would have to use some sort of calibration that varies from day to day. Maybe insert a different scale each day. This would reduce the automation.

e) In any timekeeping or measurement scheme there is usually some sort of ultimate authority or "master." This ultimate authority is always trusted and is used as the reference for any other timekeeping scheme. What would be the "master" in a timekeeping scheme that uses sundials? Is it natural or man-made? What would be the "master" in a scheme based on a water clock? What sort of fundamental shift would moving from a sundial-based scheme to a water clock-based scheme require?

In a sundial scheme the Sun and Earth's rotation are the master. These are "natural."

In a water clock scheme the device is the master. We might have to settle on one particular device. This would be a man-made device.

Shift from a "natural" realm to a "man-made" realm.

The exercise illustrates the fact that a water clock naturally measures equal hours rather than temporal hours. Recall

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

↳ vary with seasons

equal hour = same duration regardless of day

There are various possibilities that could have water clocks provide temporal hours: 1) variable dial calibration

Demo: Jospin video 2) variable flow rate

Demo: Landel's article - show calibration scale

- show flow ~~dya~~ ~~dig~~ diagrams

Water clock usage

Water clocks were clearly used in ancient Egypt, Greece, Rome and various other parts of the world. They often served as timers. Their use persisted into the middle ages.

There are several important general aspects of water clock usage.

1) unlike other timing devices they do not rely on repetition.

2) they represent a break from timekeeping which regards the cosmos (Sun, Earth) as a correct reference for time keeping.

3) they represent increasing usage of machinery.

Water clocks as mechanical devices + machines

Inflow water clocks almost always use machinery to move dials, pointers, sound bells and so on. This represents a fundamental change from timekeeping using celestial bodies - sundials, for example, do not use machinery.

Demo: Ancient Mechanical Clocks Video

Demo: Striking Clepsydras (Borugak Clepsydra)

Demo: Archimedes Water Clock