Lecture 36

Mon: HW by 5pm

Weds: Read B 145 - 153

Mon after break: Term paper - see syllabus pg 5-7.
1st draft - single topic → classification what? when?
- analysis why?

Later developments in pendulum clocks

Pendulums and balance springs, incorporated into clocks in the late 1600s, continued to provide the basic regulators in all mechanical clocks until the early 1900s. These included clocks used for

* everyday timekeeping purposes
* chronometers for navigation (superseded by telegraph signals)
* timekeepers that sent precise timekeeping signals to railroads, telegraph companies and so on.

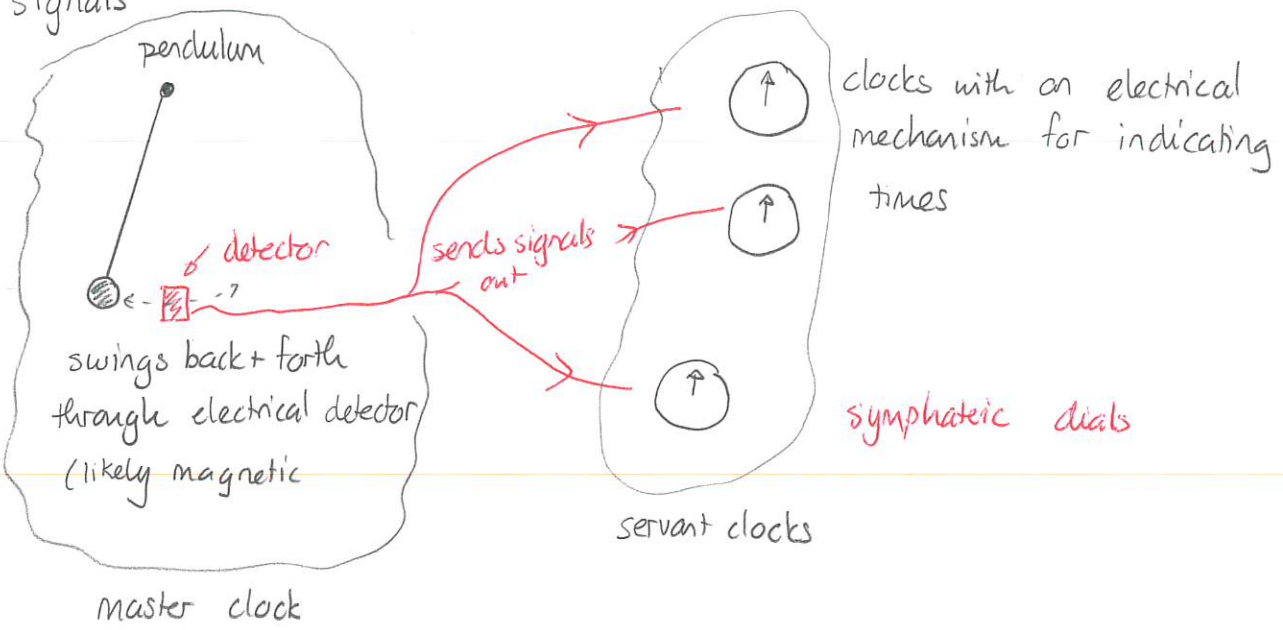
Various technical developments reduced the inaccuracies in such clocks

* pendulums that were better under a range of temperatures
* reduced friction and air drag
* improved escapements

By this stage the available clock accuracies were:

* typical mechanical wristwatch (mid 1900s) ~ 15s / day
* railroad watch ~ 5s/day.

There was still specialized need for more accurate timing by specialists, and for distribution of time signals. This promoted the development of clocks which incorporated electrical mechanisms and used these to transmit signals



Demo: Shepherd clock RMG site

This type of clock represented the time standard for an entire country. In the United States the most important versions of such clocks in use were:

→ NIST image

* Riefler pendulum regulator ~ 0.010s/day (German)
* Shortt clock ~ 0.0002s/day (UK)

→ NIST image

These used the same type of electrical signalling to distribute precise time signals. Clearly such clocks were not intended for everyday use.

Where would such precise timing be needed?

1 Watch and clock accuracy

We will consider the limitations that the accuracies of various timing devices impose. A typical mechanical wristwatch loses 15s per day (86400s). The best scientific pendulum clock loses 0.0002s per day. Suppose that you need to time events (e.g. a race) to a certain accuracy. We want to determine how long that event could last before the inaccuracies of the clock that you use render your timing inaccurate.

a) Determine how much time passes before each device loses one second.

mechanical $\frac{86400}{15} = 5760s = 1hr\ 36min$

best clock $\frac{86400}{0.0002s} = 432000000s = 5000days$

b) Suppose that you need to time an event *to an accuracy* of within 5s. What type of event might this be? Do you have any examples of such an event?

Long race?

For each type of device, what is the minimum duration of the event such that the device's inaccuracy does not interfere (i.e. the minimum amount of time that must pass before the device loses 5s)?

mechanical $5 \times 5760s = 5 \times (1hr\ 36min) = 8hr$

best $5 \times 5000\ days = 25000\ days$

If the event lasted 5hrs, which of the devices would be accurate enough to time the event to within an accuracy of 5s?

Both would work.

c) Suppose that you need to time an event *to within an accuracy* of 0.01s. What type of event might this be? Do you have any examples of such an event?

short race.

For each type of device, what is the minimum duration of the event such that the device's inaccuracy does not interfere (i.e. the minimum amount of time that must pass before the device loses 0.01s) ?

mechanical $0.01 \times 5760s = 57.6s \sim 1min$

best $0.01 \times 5000day = 50 days$

If the event lasted 3min, which of the devices would be accurate enough to time the event to within an accuracy of 0.01s?

only the best!