# Analog Devices

A brief discussion of continuous state computational devices spanning the centuries

James Tam

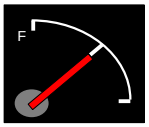
## Digital Vs. Analog

- In this context (from Williams)
  - Digital devices are classified as having a finite number of states.


off


on

  - This is in contrast with analog devices (a continuum of possible states)

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Images: James Tam

## Astrolabe

- An old computing device used to solve problems related to time and navigation.
- It's a projection of the map of the sky (a dome) on a 2D surface.
- Timeframe:
  - It was clearly used in the Arab empire (~600 AD up to ~1600 AD)
  - There are hints of earlier usage but the evidence is not definitive (Williams)


https://commons.wikimedia.org

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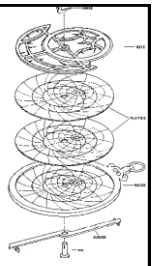
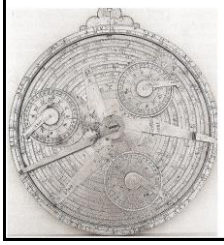
## Astrolabe: Parts



Images: copyright unknown

- Outer backing: mater/"mother"
- Metal: plates/ "climate" or "tympanum"
- Cut-away disk: rete/"net/network?"



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## Astrolabe: Some Common Uses

www.astrolabes.org

- Time keeping (given the sun's position when at the following latitude it is the XYZ time of day).
- Determining the current latitude (navigation)

For more specific details of the astrolabe (based on positions of stars) see the references at the end of these notes.

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## Astrolabe: Video

- Ted talk: Tom Wujec (last accessed Jan. 2024)
  - https://www.ted.com/talks/tom_wujec_learn_to_use_the_13th_century_astrolabe

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## Astrolabe: Today

- The development of more accurate mechanical clocks (such as Galileo's conceived pendulum clock ~1600s) reduced the need for the astrolabe.
- Mostly it's viewed as a historical curiosity but souvenir versions can still be purchased cheaply.

Images:
www.amazon.com

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## For More Information: Astrolabe

- Refer to the following article"
  - "**The Astrolabe**" (Scientific American 1974: J.D. North)
  - A link to a PDF can be found via the UC library if you login via the university portal.
  - There's also a persistent web link in the article itself:
    - https://www.jstor.org/stable/24949987

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## The Antikythera Device: Discovery

- Discovered in 1900 by Greek sponge fisherman who found a shipwreck near the island of Antikythira.


Generated with: www.bing.com

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## The Antikythera Device: Discovery (2)

- They took shelter from a storm and divers were sent after it blew over.
- Instead of finding sponges a ship wreak was found.
- It contained Greek statues and artifacts from the time of Christ.
- Included in those artifacts was a lump of encrusted bronze.

http://historicmysteries.com

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## The Antikythera Device: Uses

- Due to the deteriorated condition (years in salt water) the exact use is unknown.
- It's speculated to be the device reported by the Roman philosopher Cicero (~1st century BC) and used to reproduce the positions of the sun, the moon and some of the planets. (Williams).

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## The Antikythera Device: Videos

- History and background (last accessed Jan. 2024):
  - https://www.youtube.com/watch?v=4eUibFQKJqI

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## The Antikythera Device: Additional Details

- Books and even research publications can be accessed via the UC library website (www.ucalgary.ca/library) – authentication required.
- The course instructor hasn't had time to evaluate the following publications but they are all peer reviewed and you can request access via the library website:
  - "A Model of the Cosmos in the ancient Greek Antikythera Mechanism"
  - "Long-lost piece of Antikythera mechanism found"
  - "The dark shades of the Antikythera Mechanism"

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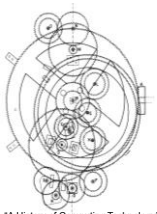
## Antikythera Device: Significance

- The Antikythera device originated from Roman times yet contained gearing mechanism that did not reappear in Europe until much later in ~1500 years. (Similar to an automobile: Williams).



"A History of Computing Technology" by Williams

Encyclopedia Wikipedia

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## Differential Analyzer

- Manually determining the area under a curve is cumbersome and inaccurate ("Using cutouts": Williams).
  - This has many applications (last accessed Jan. 2024):
  - http://www.intmath.com/applications-integration/applications-integrals-intro.php
- Early attempts to devise mechanical mechanisms (e.g., Lord Kelvin) for solving these problems were hindered by the limited ability to obtain accurately machined parts.
- Vannevar Bush (MIT) was the first to actually produce a working machine (Late 1920s, early 1930s: publication 1931).

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## Differential Analyzer: Videos

- (Last accessed Jan. 2024):
  - http://web.mit.edu/klund/www/analyzer/

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## Differential Analyzer: Programming

- Because it relied heavily on mechanical movement to generate results, 'programming' and debugging the computational device was challenging.

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"A History of Computing Technology" by Williams

## Other Differential Analyzers

- The mechanical method of solving differential equations was so successful that at least 5 copies were made.
- Example: Manchester university


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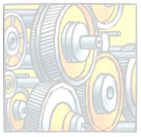
Hartree and Porter: From http://www.marshall.edu

## Differential Analyzer: A Military Application

- Ballistics research (artillery and rocket trajectories)
- World War II Norway: Shortly after the successful German invasion
  - Oslo University



Colourbox.com

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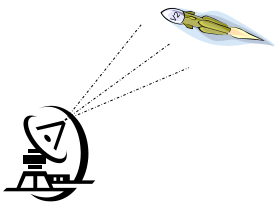
## Differential Analyzer: A Military Application (2)

- World War II MIT:
  - Differential Analyzer was used to solve ballistic trajectories
  - (Yet the range of the 'shell' by far exceeded any artillery piece at the time).



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## After This Section You Should Now Know

- The time period during which the astrolabe was used
- Some of the common uses of the astrolabe
- The general appearance and major parts of the astrolabe
- The date and circumstances under which the Antikythera device was found
- The appearance and general condition of the Antikythera device
- The date of creation and the significance of the Antikythera device
- The approximate creation date and use of the Differential Analyzer

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## After This Section You Should Know (2)

- Some of the key people and events behind the original Differential Analyzer and its copies
  - MIT
  - Manchester
  - Oslo

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## References


- "A history of computing technology", Williams M.R., IEEE Computer Society.
- "Time and the astrolabe in the Canterbury tales", Osborn M., OU Press.
- Astrolabes dot org (last accessed January 2, 2012):
  - http://www.astrolabes.org
- MIT: Differential analyzer
  - http://web.mit.edu/klund/www/analyzer/


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