

A (very) brief history of control

The buzzwords you need to know

Material from F.L. Lewis, “*Applied Optimal Control and Estimation*”, Prentice-Hall, 1992.

The Greeks

Naturally, the Greeks were first:



In -270, [Ktesibios](#) invented a float regulator for water clocks

Gadgets

- Float regulator used by [Philon](#) of Byzantium in -250 to keep constant level of oil in a lamp.
- [Heron of Alexandria](#) (100 AD) developed float regulators for water clocks.

Uses:

- Automatic dispensing of wine
- Opening of temple doors
- Etc

First “gadgets”: Ideas looking for an application!

Darkness

From 300-1500, nothing happened.

The mechanical clock was invented \Rightarrow no more water to control.

It starts moving again

Windmill control:

- The fantail (1745) by blacksmith E. Lee:
Small fan mounted to main wheel \Rightarrow pointed it into the wind.
- The mill-hopper regulated the flow of grain, depending on speed of millstone.
- The millwrights developed rotation speed sensors.
Led to self-regulating windmill sails.

Industrial revolution

- **J. Watt** invented steam engine 1769.
Not quite true:
- **T. Newcomen** built one in 1712, but no automatic control.

Watt's automatic control system made it usable.

Classic control applications

A number of inventions were made:

- Temperature regulator: For making gold, hatching chickens and heating water.
- Float regulator: For steam engines.
- Pressure regulator.
- Centrifugal governor.

Mathematics come into play

1840, **G.B. Airy**, developed a feedback device for pointing a telescope \Rightarrow oscillations introduced.

Used differential equations for analysis [Airy 1840].

The theory was well developed by I. Newton (1642-1727), G.W. Leibniz (1646-1716), the Bernoullis (late 1600's and early 1700's), J.F. Riccati (1676-1754), and others.

Stability theory

J.C. Maxwell analyzed the stability of Watt's flyball governor [Maxwell 1868].

Linearize the differential equations, check characteristic equation.

Proved that all poles in LHP \Rightarrow stable!

E.J. Routh found numerical method to see if characteristic equation has stable roots [Routh 1877].

Deeper understanding

The time was now ripe for Black, Nyquist, and Bode.