CONTROL I

ELEN3016

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2015

Overview

- Why Control?
- Prerequisites
- Textbook & Notes
- Lectures, Tutorials & Labs
- Introduction to Control (Terminology etc.)
- Everyday Examples
- Brief History of Classical Control
- Q&A

Why Control?

- Can we do without Control?
  - Filter design is about the analysis and design of linear systems for specific spectral/time responses.
  - Can you adapt a given existing linear system to obtain a specific spectral/time response?

Why Control?

- Can we do without Control?
  - Filter design is about the analysis and design of linear systems for specific spectral/time responses.
  - Can you adapt a given existing linear system to obtain a specific spectral/time response?

... Control includes this and much much more!!

Prerequisites

- Past Courses
  - Signals & Systems I

    Continuous-Time Linear Systems Theory; Laplace transforms; LTI ODEs and solutions; Zero-input response; Zero-state response; System stability; MATLAB simulation.

  - Signals & Systems IIA

    Fourier series & transforms; Continuous-time filter design; Bode plots; State space techniques in time/frequency domains; System stability.

Textbook & Notes

- Textbook

Roland S. Burns, *Advanced Control Engineering*, Butterworth Heinemann, 2001.

- Notes

Supplementary notes may be supplied at the discretion of the lecturer. (Refer to the CB&O.)

Lectures, Tutorials & Labs

- Lectures

  Mathematical subjects can be taught in <u>one and only one</u> way: Talk & Chalk

- Tutorials

  To assimilate the work it is important to solve problems.

- Labs

  Labs demonstrate theoretical concepts.

Labs

- Lectures → Tutorials → Labs

  Labs should follow after lectures and tutorials on the related matter.

- Computer-based Labs vs. Experimental Labs
  - Computer-based labs are more versatile
  - Experimental labs provide practical experience
- Computer / Experimental Labs??
  - Inverted pendulum?

Terminology

- System
  Group of interrelated, interdependent or interacting elements forming a collective entity
- System Inputs
  Stimuli to the system
- System Outputs
  Responses by the system
- Examples
  Electric motor, aircraft, water tank, …

What is Control?

- Control

  Act of commanding, directing or regulating a “system”

- Controller

  Another system/human that controls the “system”

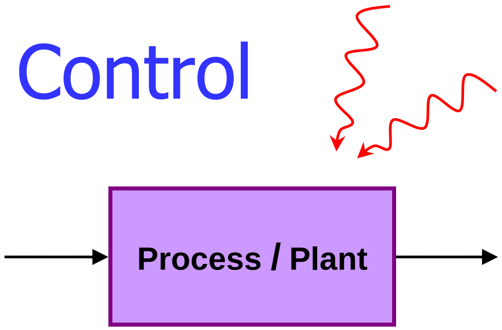
- Manual vs Automatic Control

  Manual control → Human controller

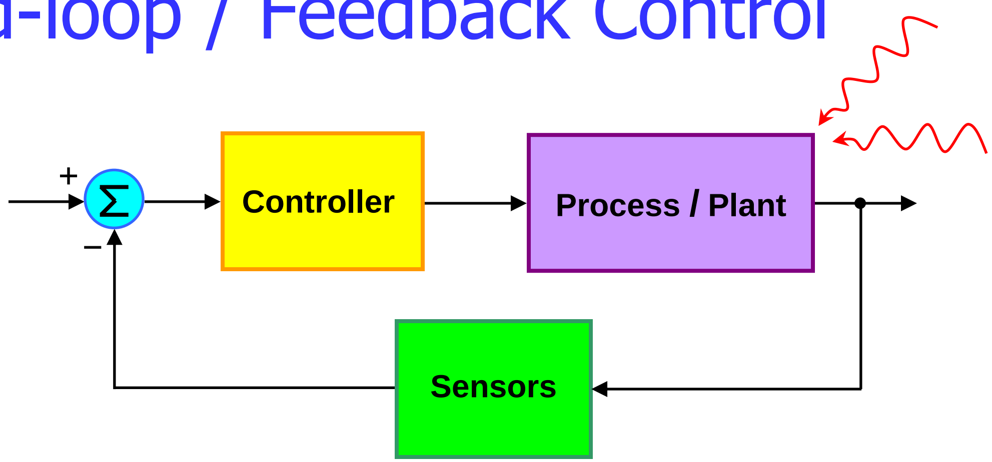
- Open-loop vs Closed-loop Control

Open- vs Closed-loop Control

- Open-loop Control

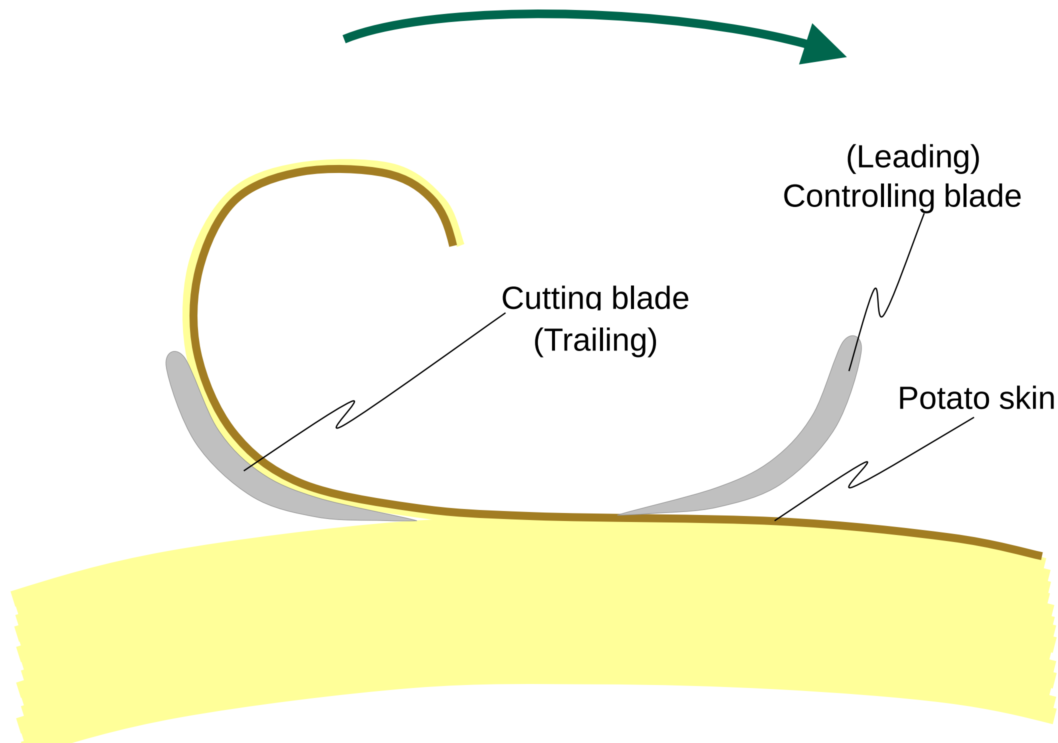


- Closed-loop / Feedback Control



Everyday Examples

- Potato Peeler



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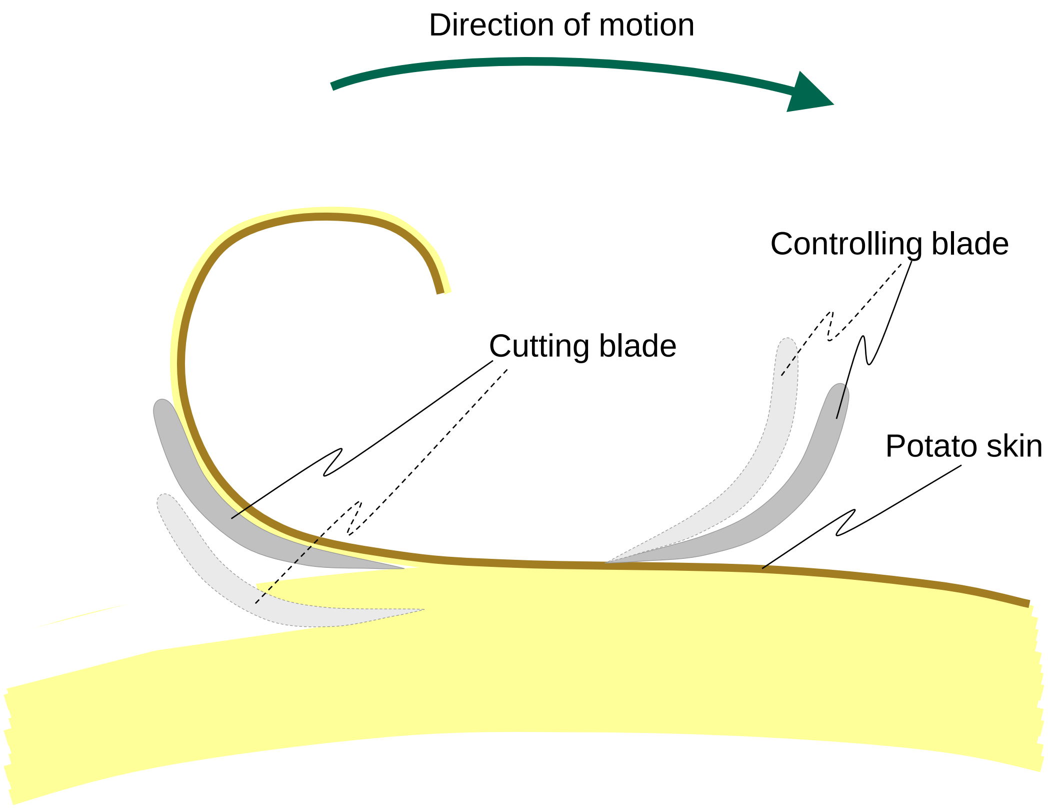
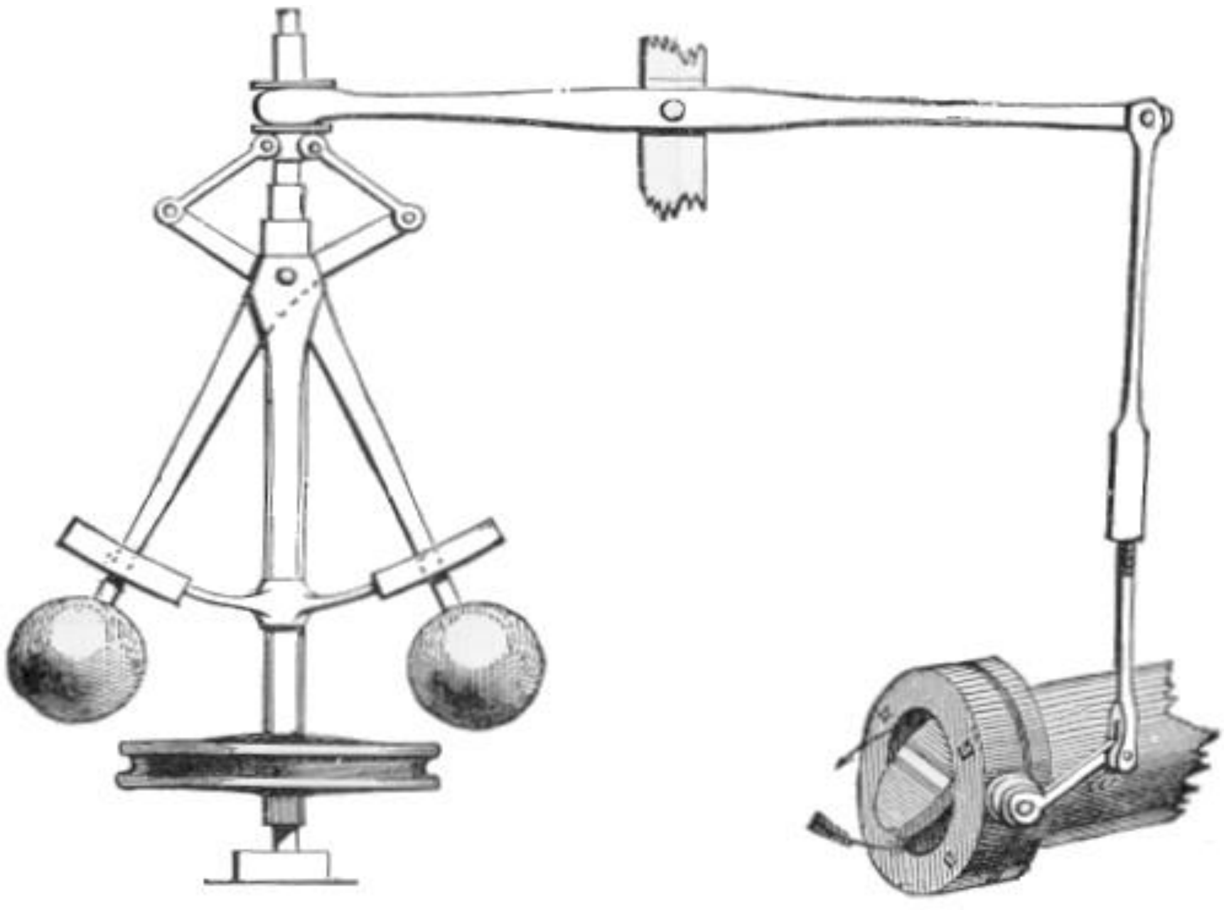


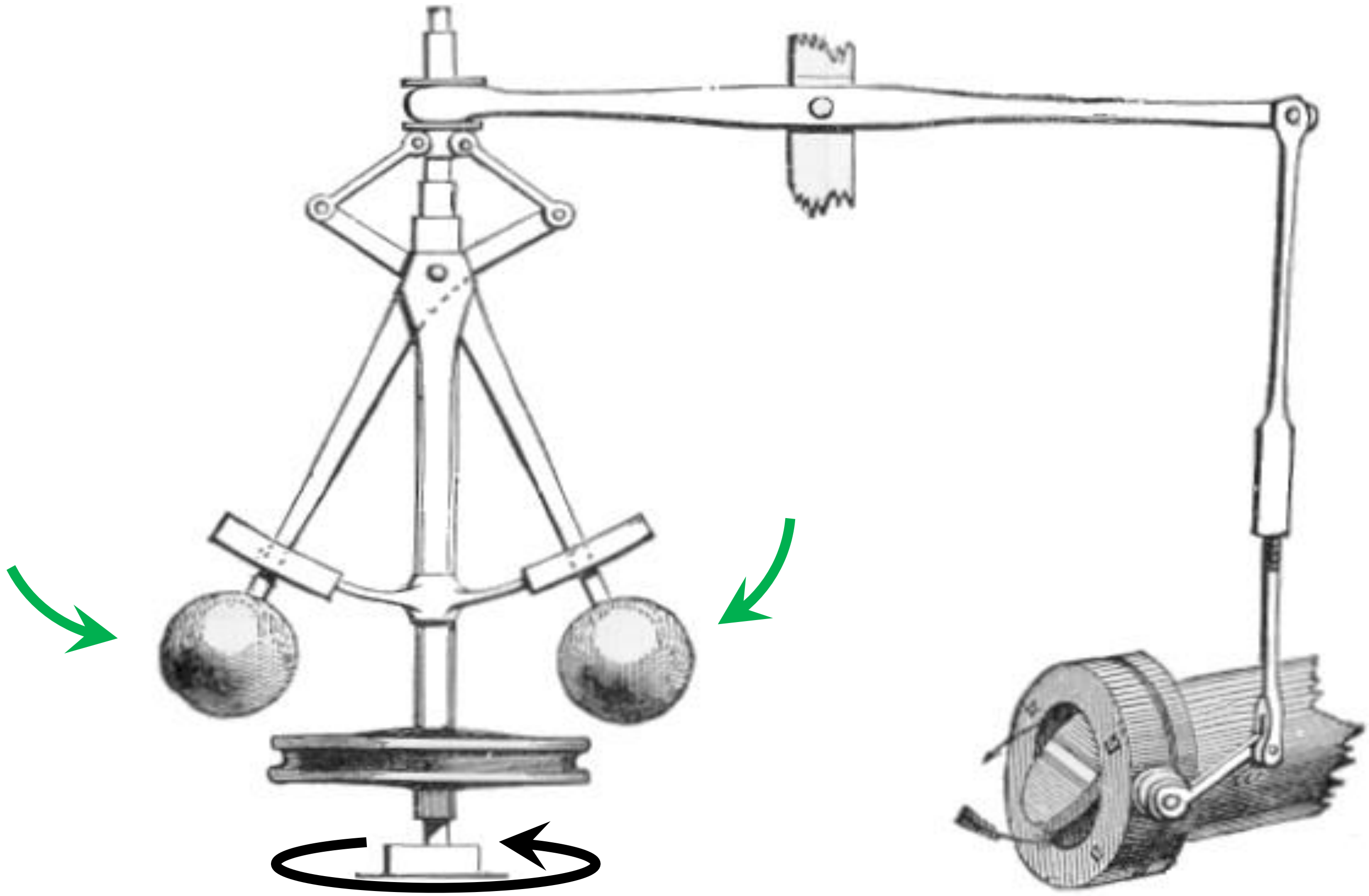
Examples – Flyball Governor



James Watt

Examples – Flyball Governor

If shaft speed is dropping …



Examples – Flyball Governor

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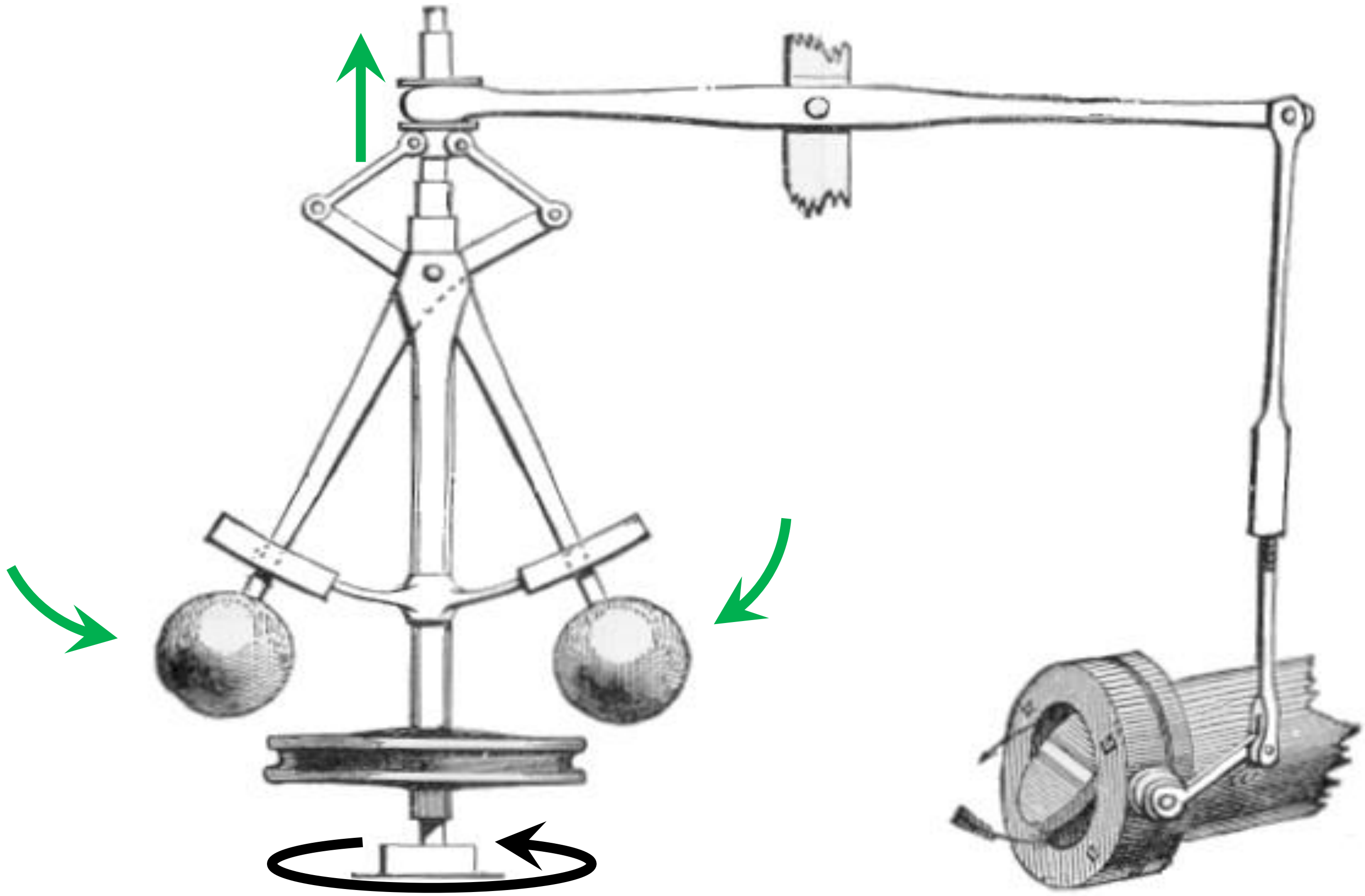
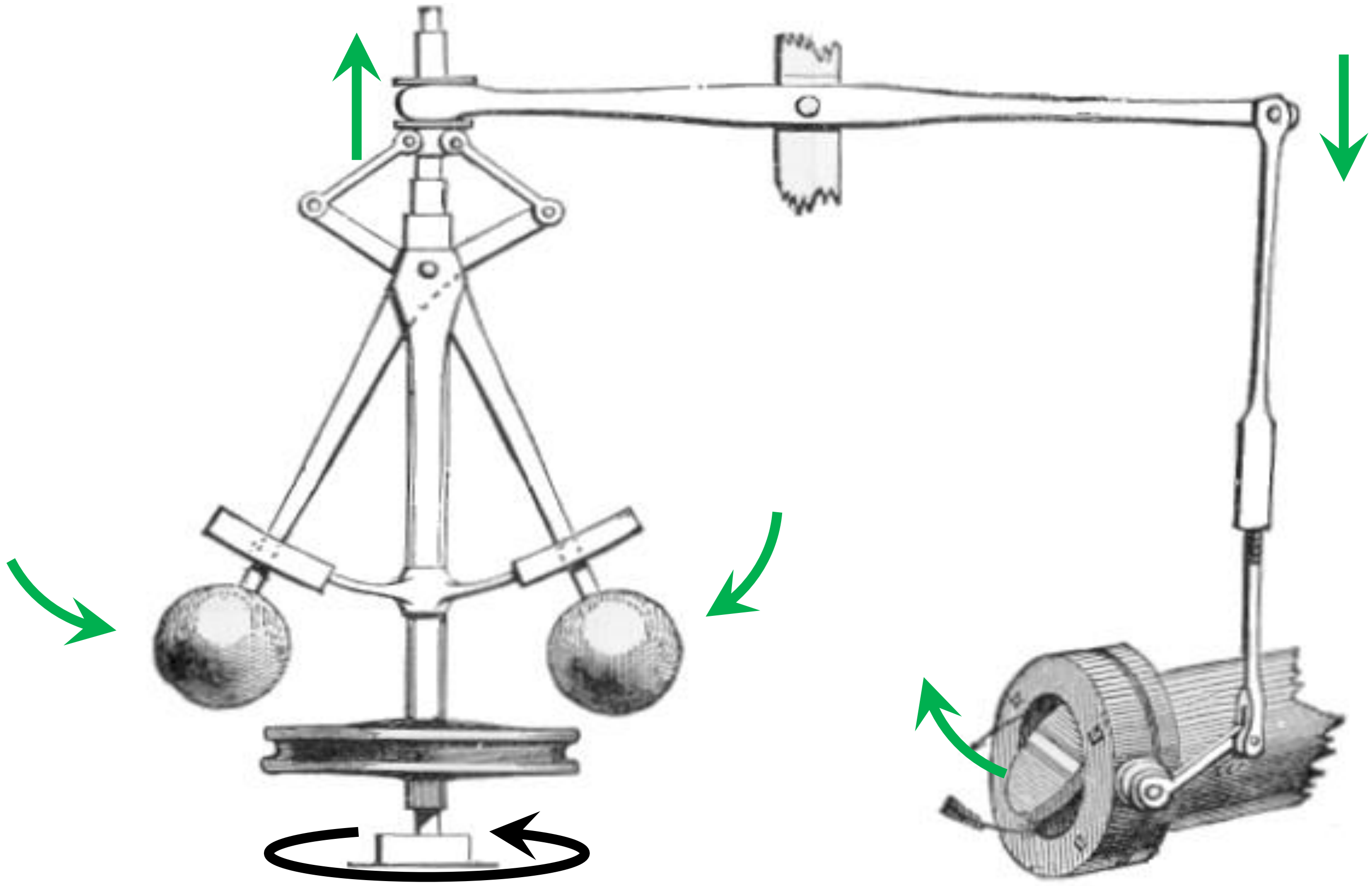


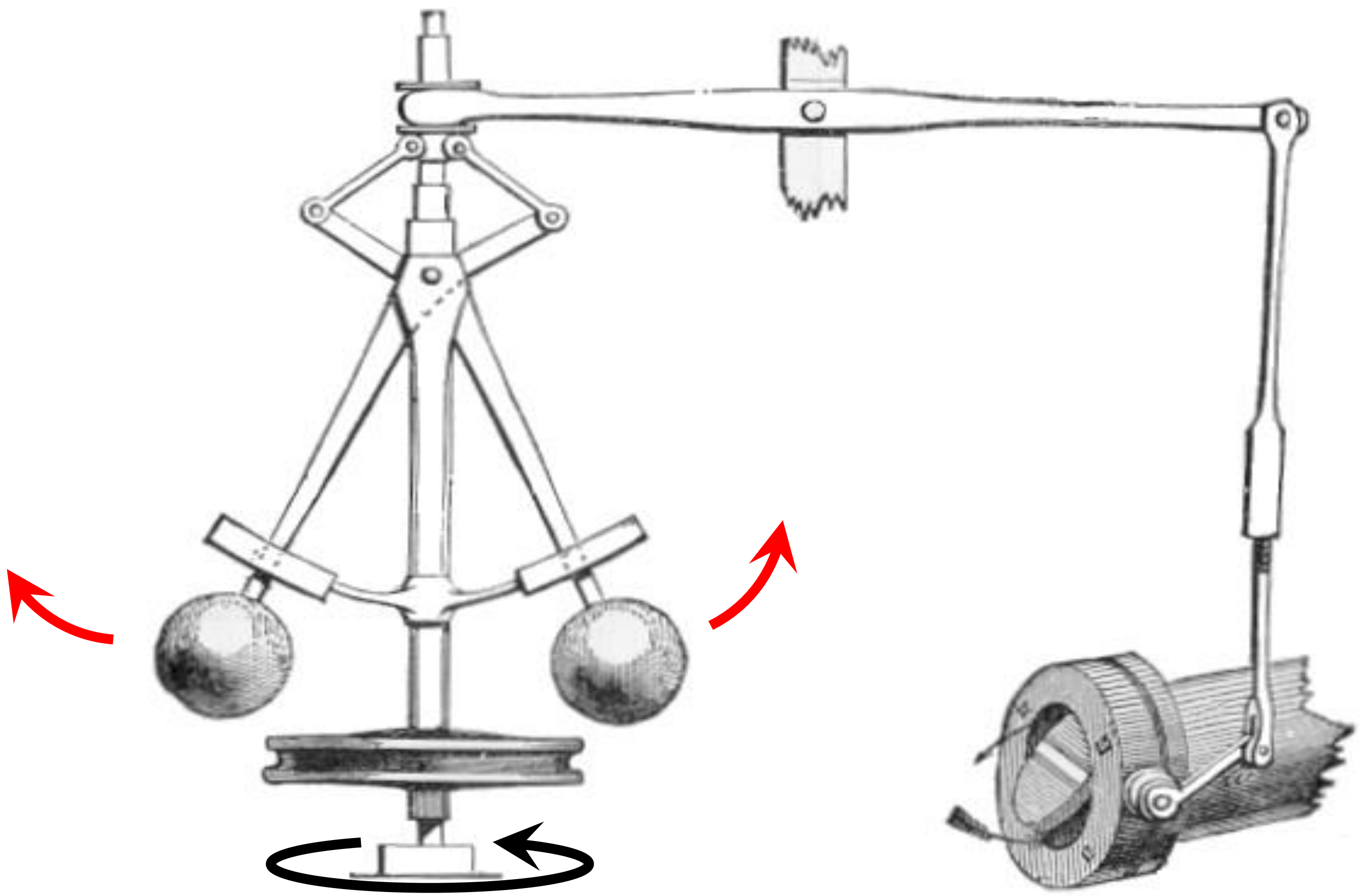
Examples – Flyball Governor

If shaft speed is dropping … valve opens proportionally!



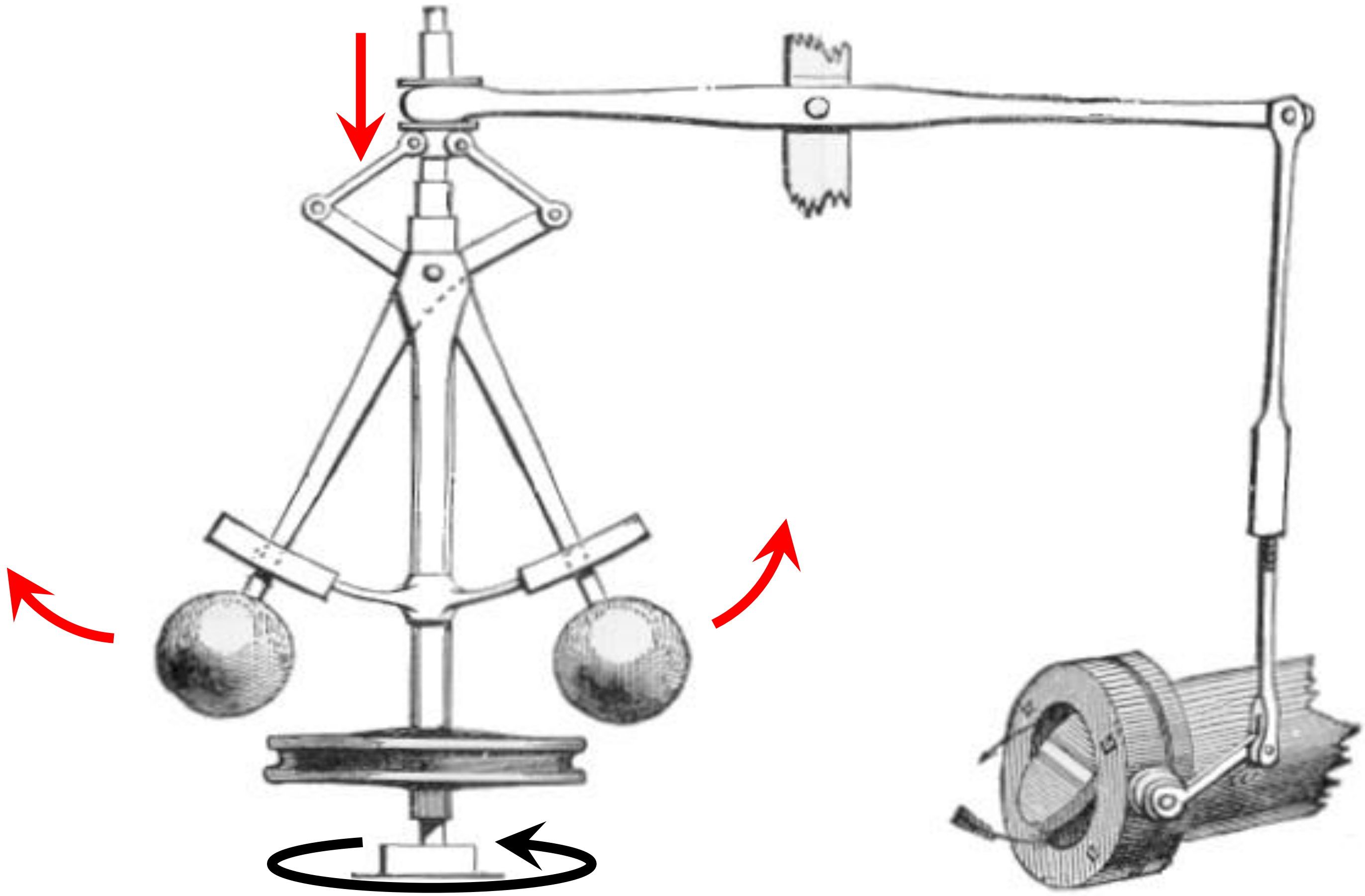
Examples – Flyball Governor

If shaft speed is rising …



Examples – Flyball Governor

If shaft speed is rising …



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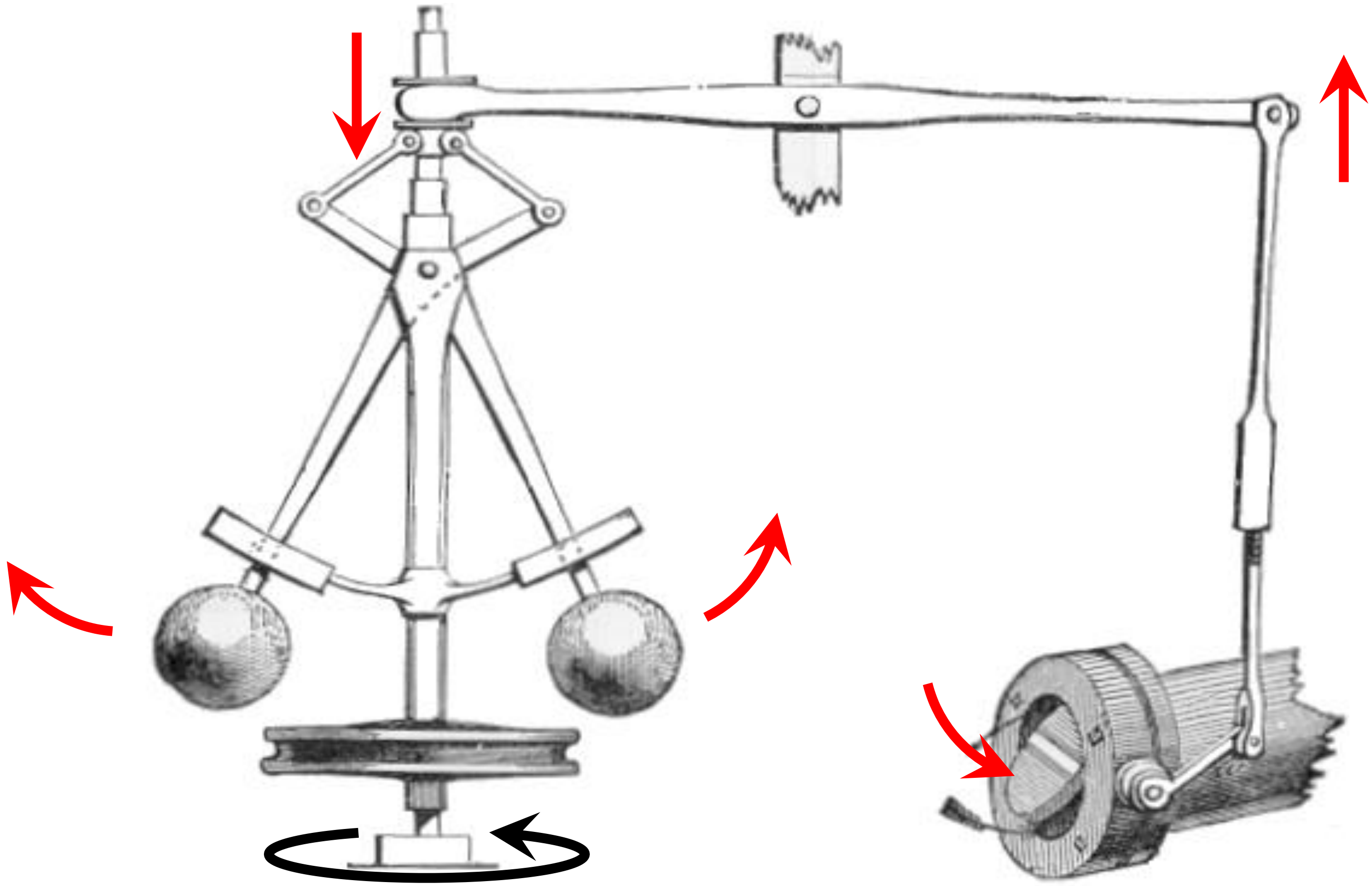

Everyday Examples

	Manual control	**Automatic control (Inherent)**
Open-loop	• Cutting paper without visual feedback • Gas stove temperature control	• Cooling fan • Drilling machine
Closed-loop	• Cutting paper with visual feedback • Task scheduling & supervision	• Potato peeler • Water level controller • Thermostat • Flyball governor

What is Control Engineering?

- Body of knowledge focusing on designing an appropriate controller for a system such that the closed-loop response complies with set criteria or specifications.
- Example: Shock absorbers for cars are designed to damp out bouncing.

History of Control

- Primitive Control Methods (1868-1900)
  - First rigorous mathematical analysis of a feedback control system by J.C. Maxwell in 1868
  - Ad hoc analysis of individual problems with no general methodology

- Classical Control Methods (1900-1960)
  - Performed in the frequency domain and the *s*-plane
  - Limited to linear time-invariant systems with some extensions to non-linear systems
  - Methods: PID, Lead, Lag and Lead-Lag control

History of Control

- Modern Control Methods (1960-present)
  - Fundamentally time-domain techniques
  - Applies to non-linear and time-varying systems
  - Methods:

State variable control	Optimal control
Model reference control	Adaptive control
Sliding mode control	Non-linear control
Intelligent control	H_2 & H_∞ control

Brief History of Classical Control

- Drebble (1624) – Incubator
- Watt (1728/1769) – Flyball governor
- Maxwell (1868) – Flyball stability analysis
- Routh (1877/1905) – LTI system stability
- Lyapunov (1890/1893) – Nonlinear stabilty
- Nyquist (1932) – Frequency domain stability
- Bode (1938) – Frequency response methods
- Evans (1948) – Root locus method

Course Roadmap

- System Modelling
- Prototype 2nd Order System Analysis
- Block Diagram Algebra
- PID Control
- Routh-Hurwitz Stability Criterion
- Root Locus Method
- Frequency Domain Classical Control Design
- Steady-State Error Analysis

Course Roadmap

- Zero-Error Systems
- ITAE Criterion Criterion and Control Design
- Z-Transform
- Discrete-Time Systems
- Digital Controller Design

Thank you!

Any Questions?