AULA 1: Sistemas de Controle

PROMINP

ESCOLA POLITÉCNICA DA UNIVERSIDADE DE SÃO PAULO

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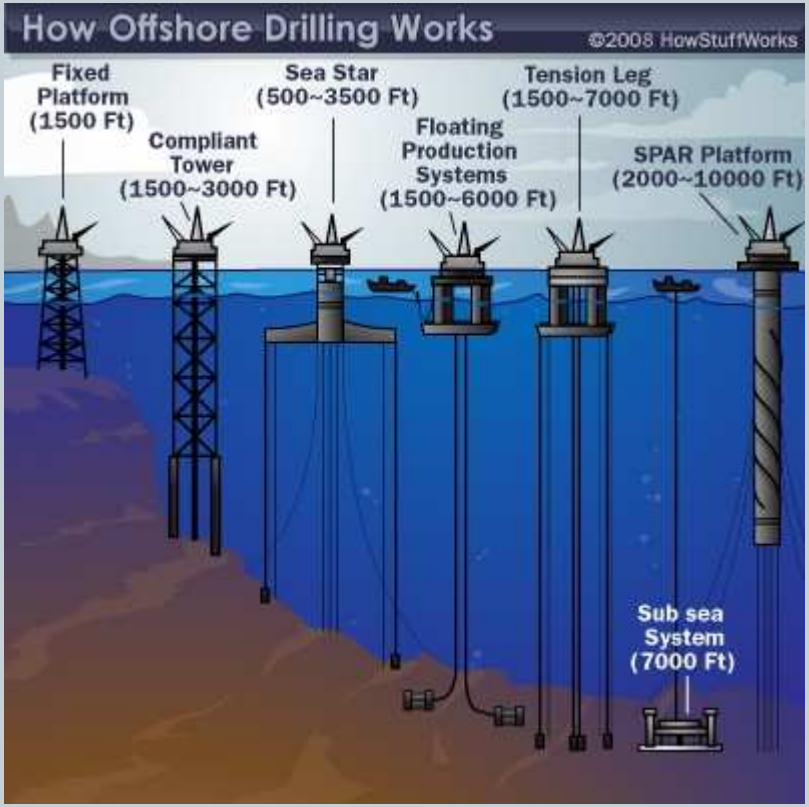
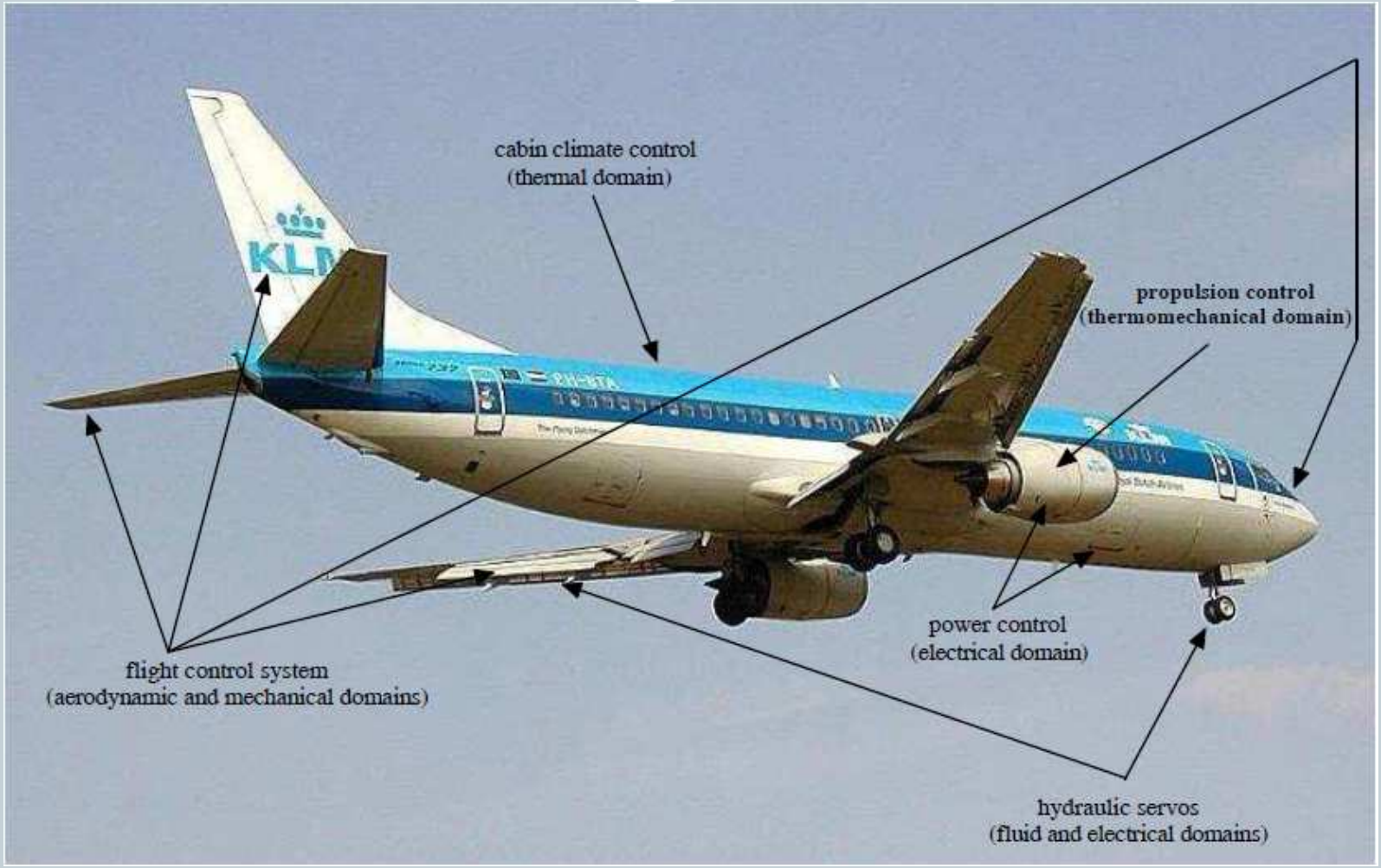
DEPARTAMENTO DE ENGENHARIA MECATRÔNICA E DE SISTEMAS MECÂNICOS

Plataformas Offshore

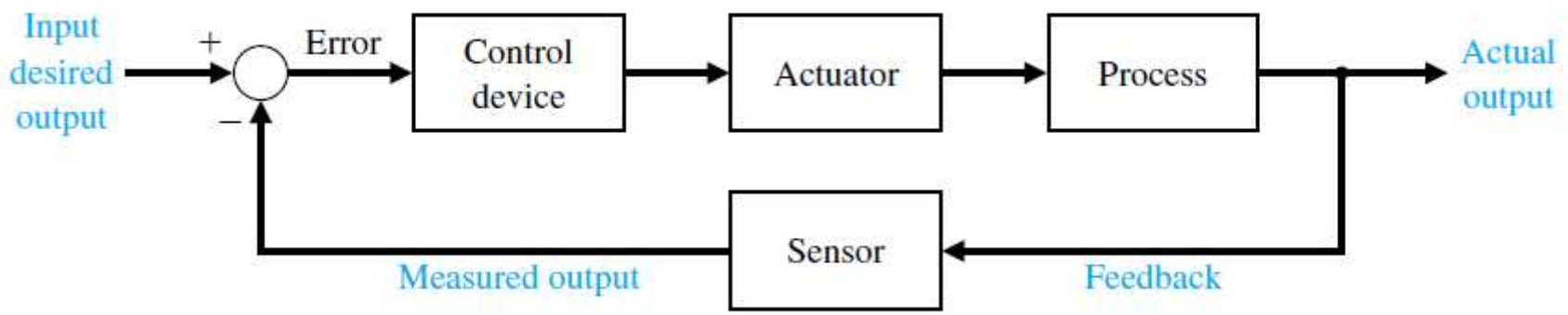


Refinaria

Avião

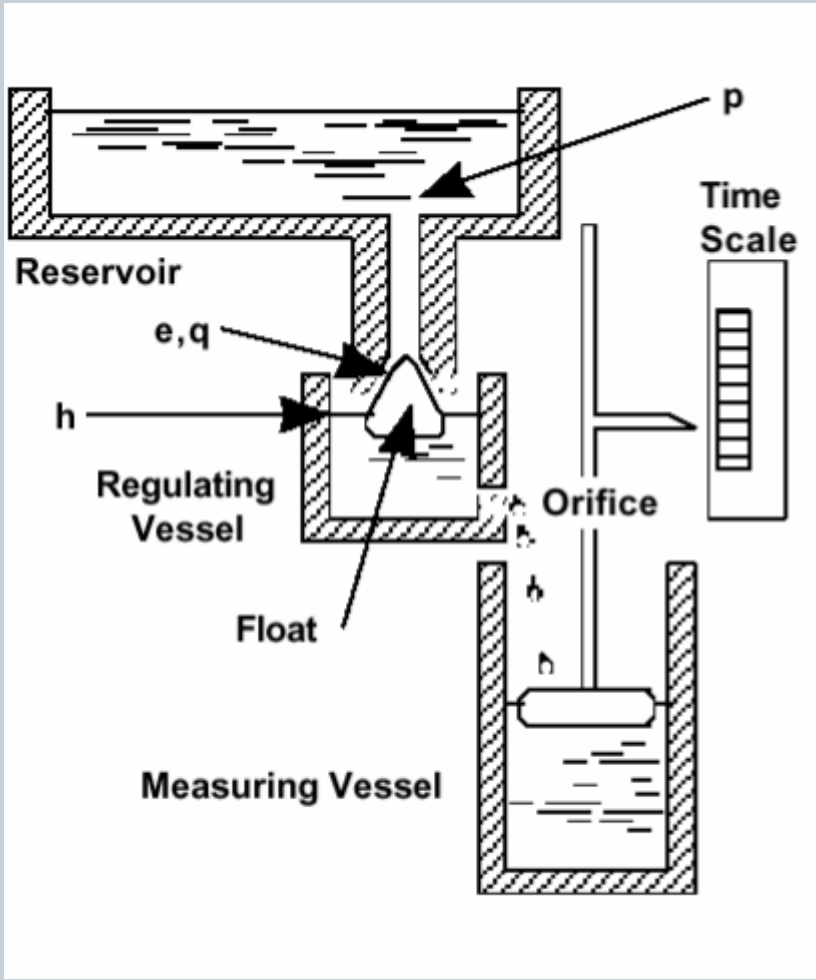

cabin climate control
(thermal domain)
propulsion control
(thermomechanical domain)
power control
(electrical domain)
flight control system
(aerodynamic and mechanical domains)
hydraulic servos
(fluid and electrical domains)

Conceito-chave: realimentação negativa

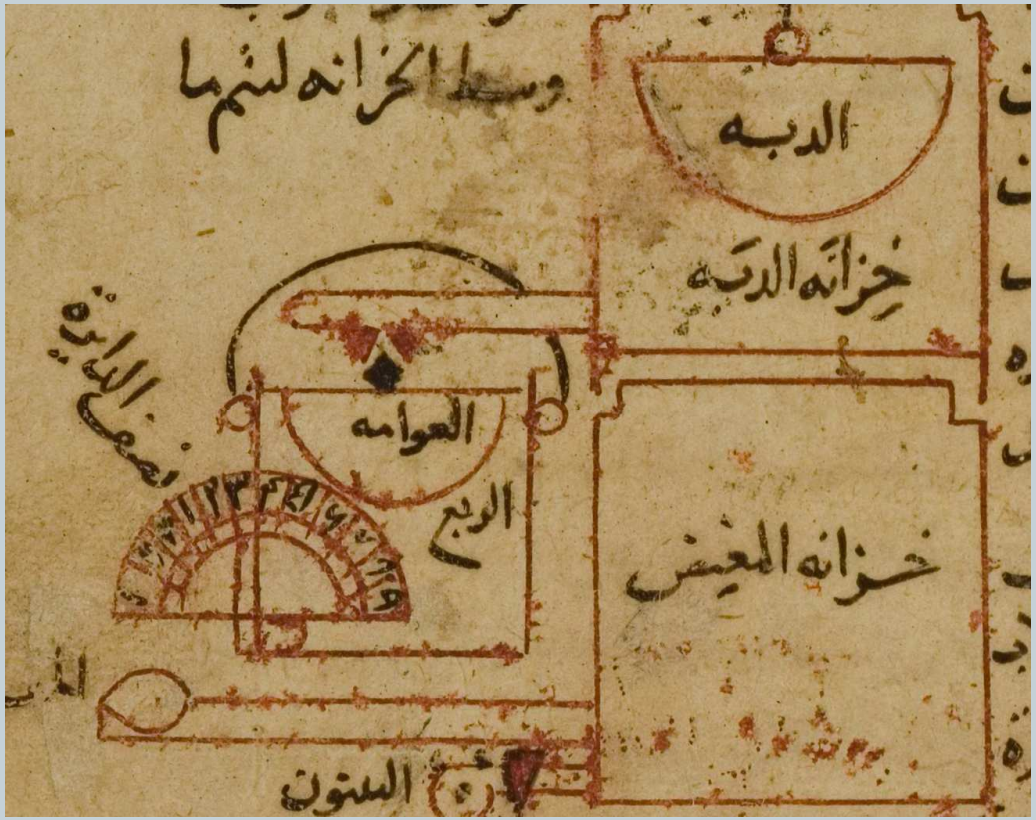


Relógio de Agua

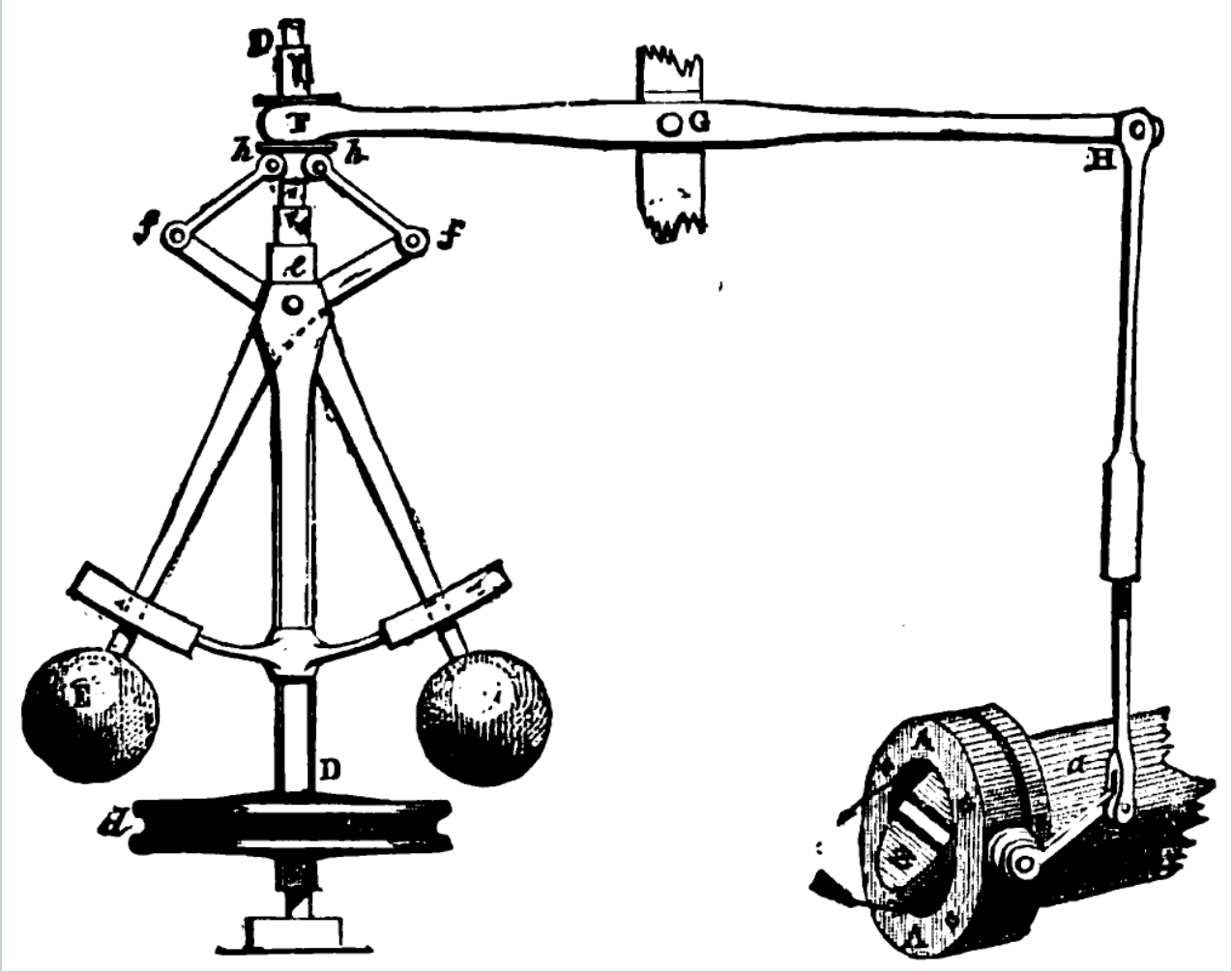
- **Ktesibios**
- Século 3 AC (Egito de Ptolomeu)
- Grego de Alexandria



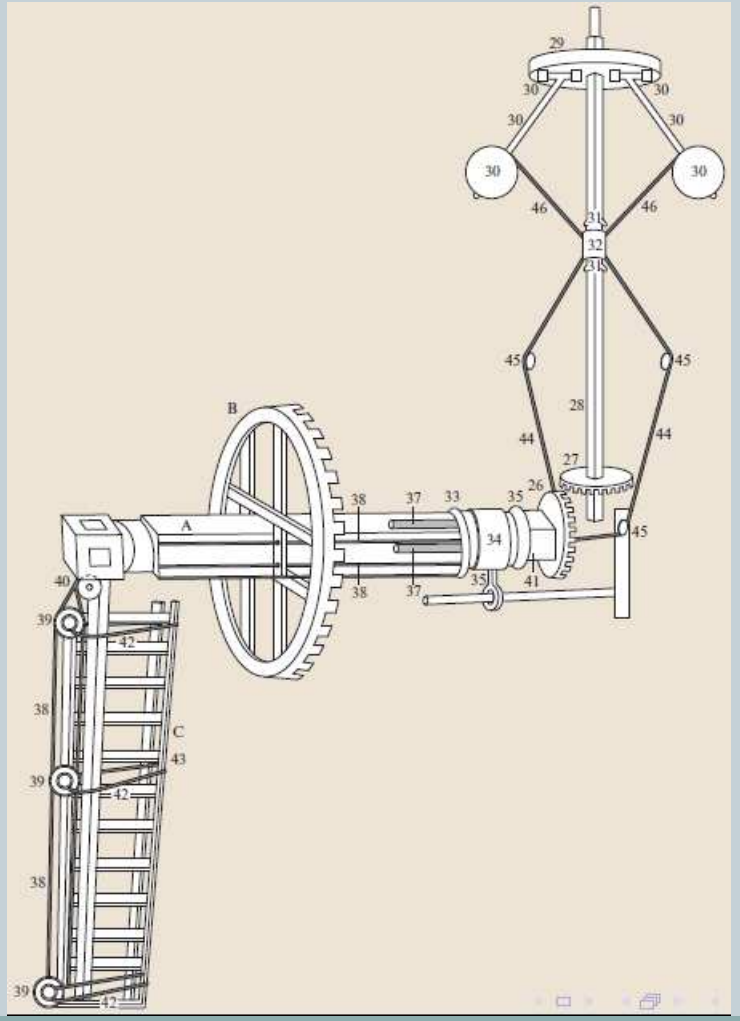
Relógio: detalhe do projeto



Regulador de Watt



Regulador de Watt



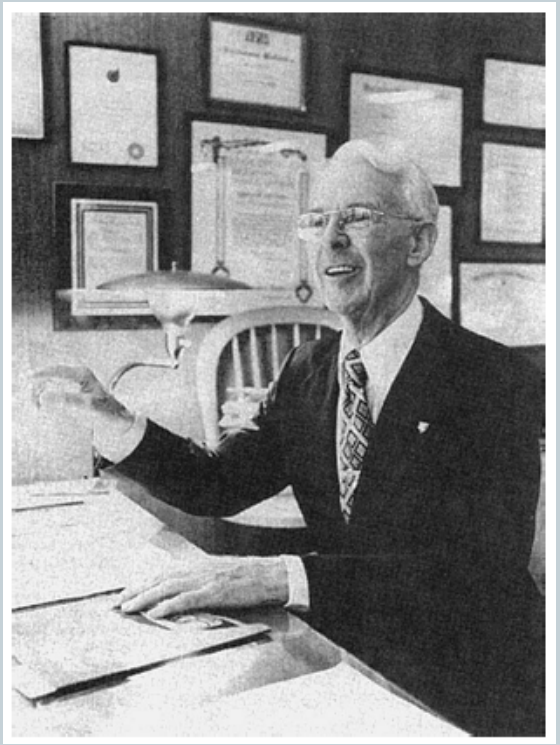
Regulador de Watt

On governors,
Proceedings of the Royal Society,
vol. 16, 1868, pages 270–283,
James Clerk Maxwell
(1831-1879)

Harold Black

Harold L. Black's Classic Paper "Stabilized Feed-Back Amplifiers" appeared five years after he invented the feedback amplifier and four years before the patent was finally issued. Black's paper shows the advantages of negative feedback in reducing harmonic distortion, increasing the bandwidth, and maintaining robust performance using primitive vacuum tubes. It also introduces a nomogram similar to the well-known Nichols Chart. In an effort to gain a better understanding of the unerlying mechanism of feedback, he enlisted the aid of H. Nyquist who responded with his famous paper, "Regeneration Theory."

Keywords—*Feedback, feedback amplifiers, history.*



Amplificador de sinais

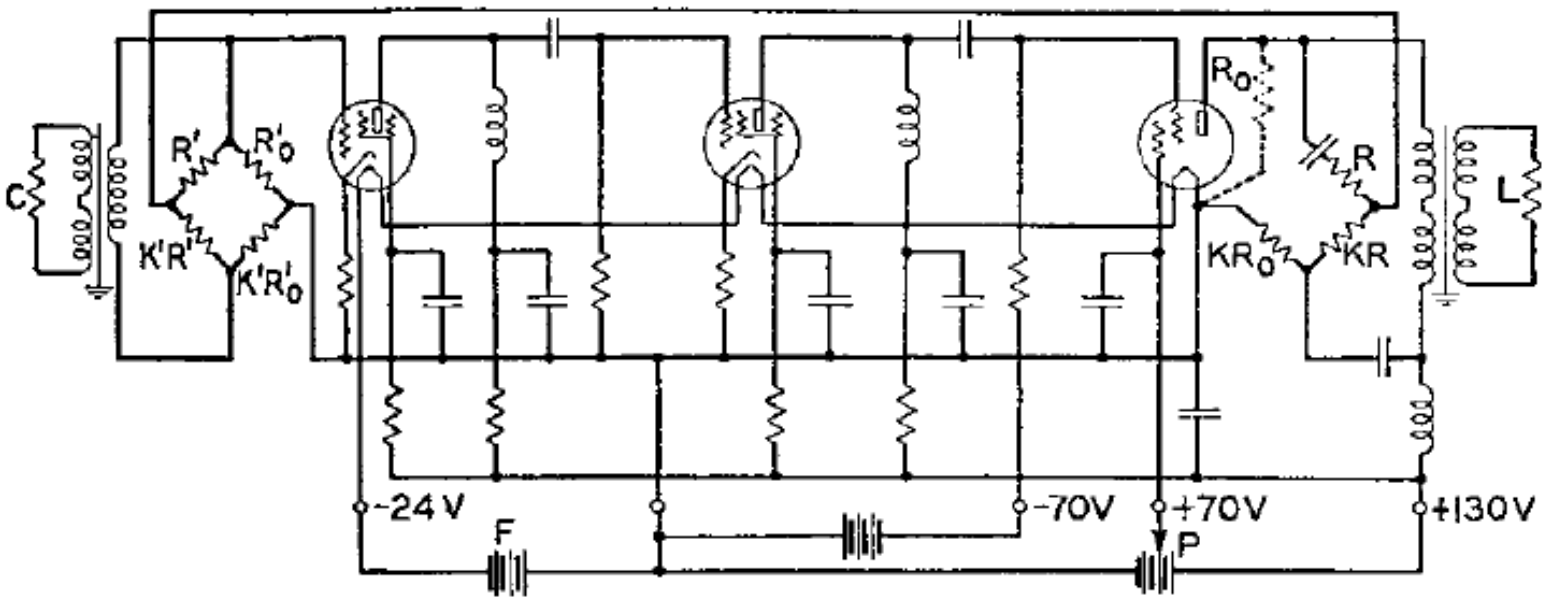
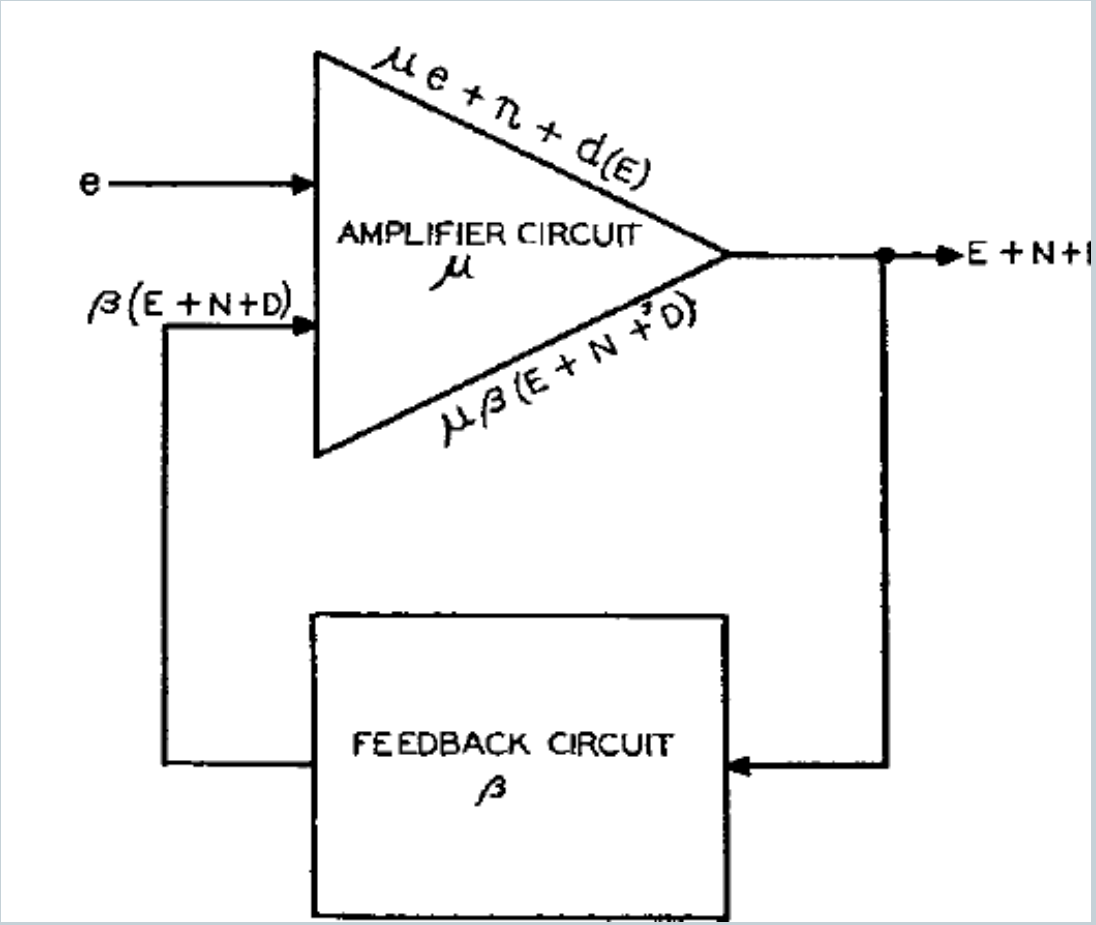


Fig. 2. Circuit of a negative feed-back amplifier.

Amplificador de sinais



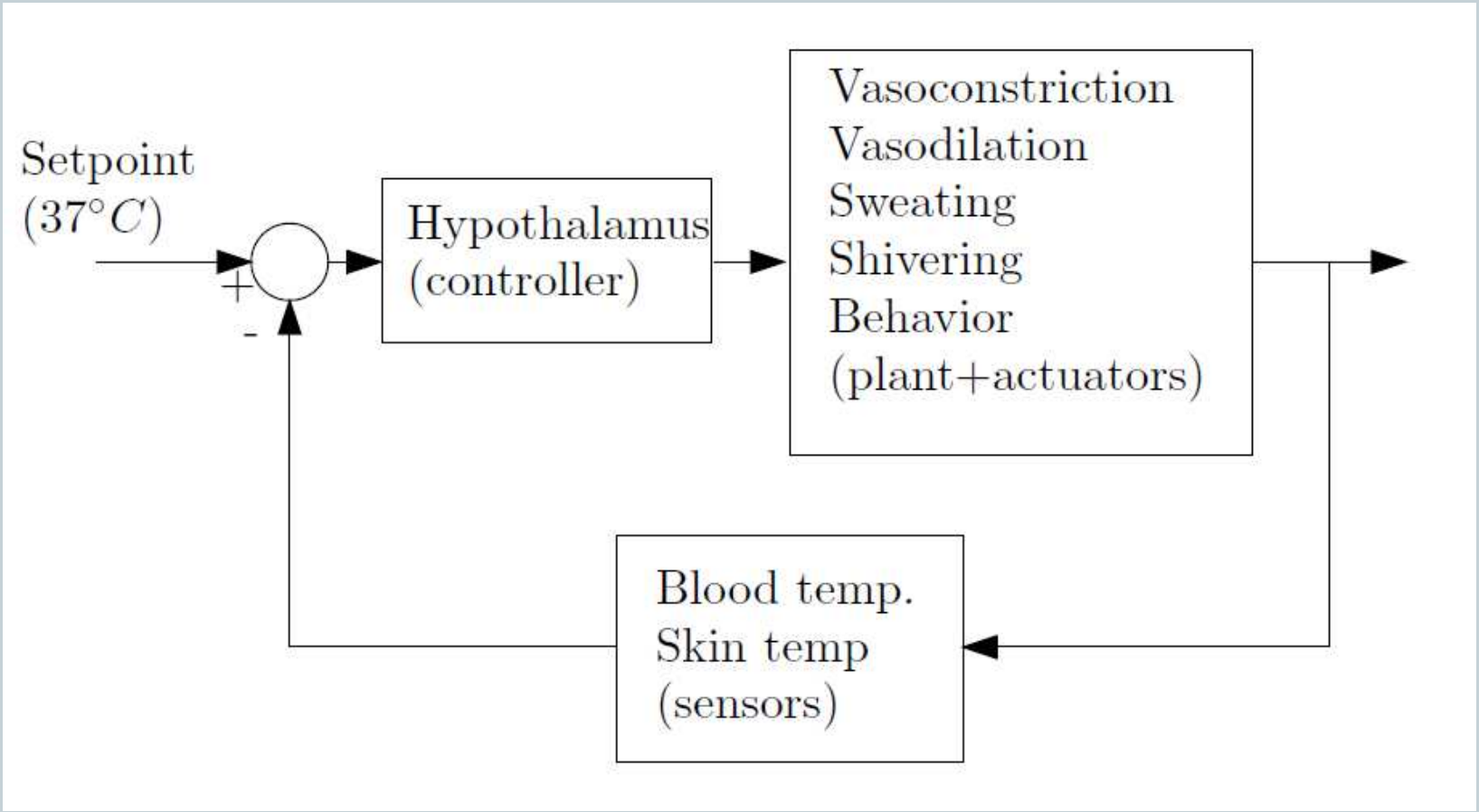
História

Table 1.1	Selected Historical Developments of Control Systems
1769	James Watt's steam engine and governor developed. The Watt steam engine is often used to mark the beginning of the Industrial Revolution in Great Britain. During the Industrial Revolution, great strides were made in the development of mechanization, a technology preceding automation.
1800	Eli Whitney's concept of interchangeable parts manufacturing demonstrated in the production of muskets. Whitney's development is often considered to be the beginning of mass production.
1868	J. C. Maxwell formulates a mathematical model for a governor control of a steam engine.
1913	Henry Ford's mechanized assembly machine introduced for automobile production.
1927	H. W. Bode analyzes feedback amplifiers.
1932	H. Nyquist develops a method for analyzing the stability of systems.
1952	Numerical control (NC) developed at Massachusetts Institute of Technology for control of machine-tool axes.

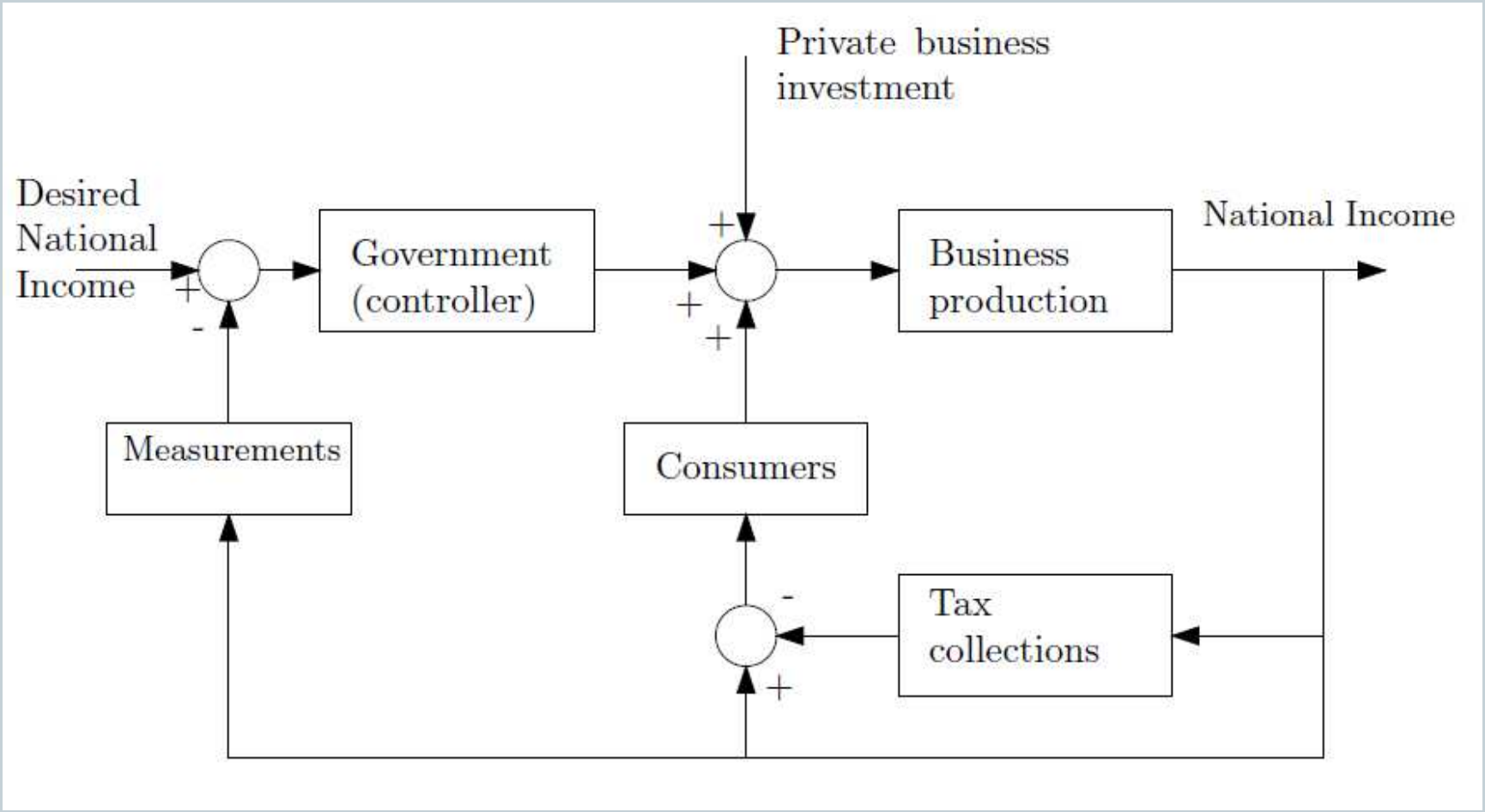
História

1954	George Devol develops "programmed article transfer," considered to be the first industrial robot design.
1960	First Unimate robot introduced, based on Devol's designs. Unimate installed in 1961 for tending die-casting machines.
1970	State-variable models and optimal control developed.
1980	Robust control system design widely studied.
1990	Export-oriented manufacturing companies emphasize automation.
1994	Feedback control widely used in automobiles. Reliable, robust systems demanded in manufacturing.
1997	First ever autonomous rover vehicle, known as Sojourner, explores the Martian surface.
1998–2003	Advances in micro- and nanotechnology. First intelligent micromachines are developed and functioning nanomachines are created.

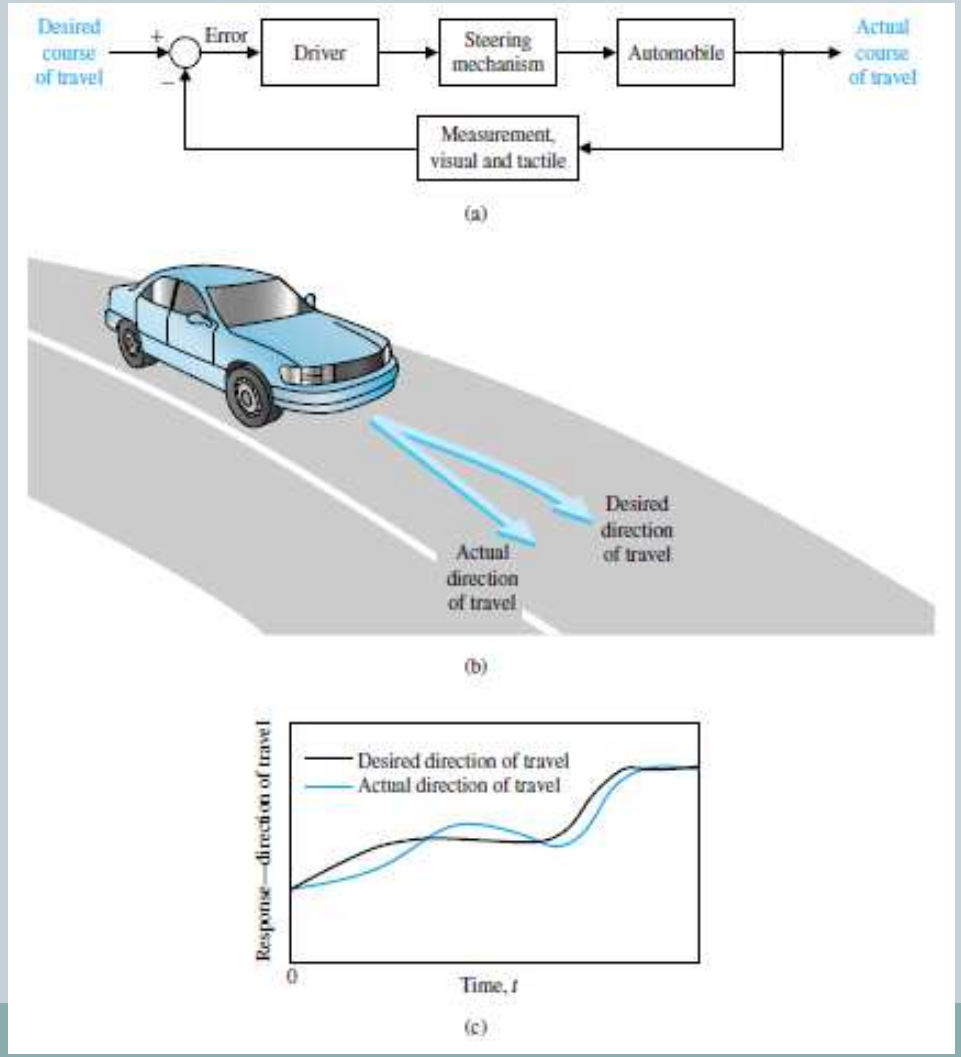
Homeostase térmica



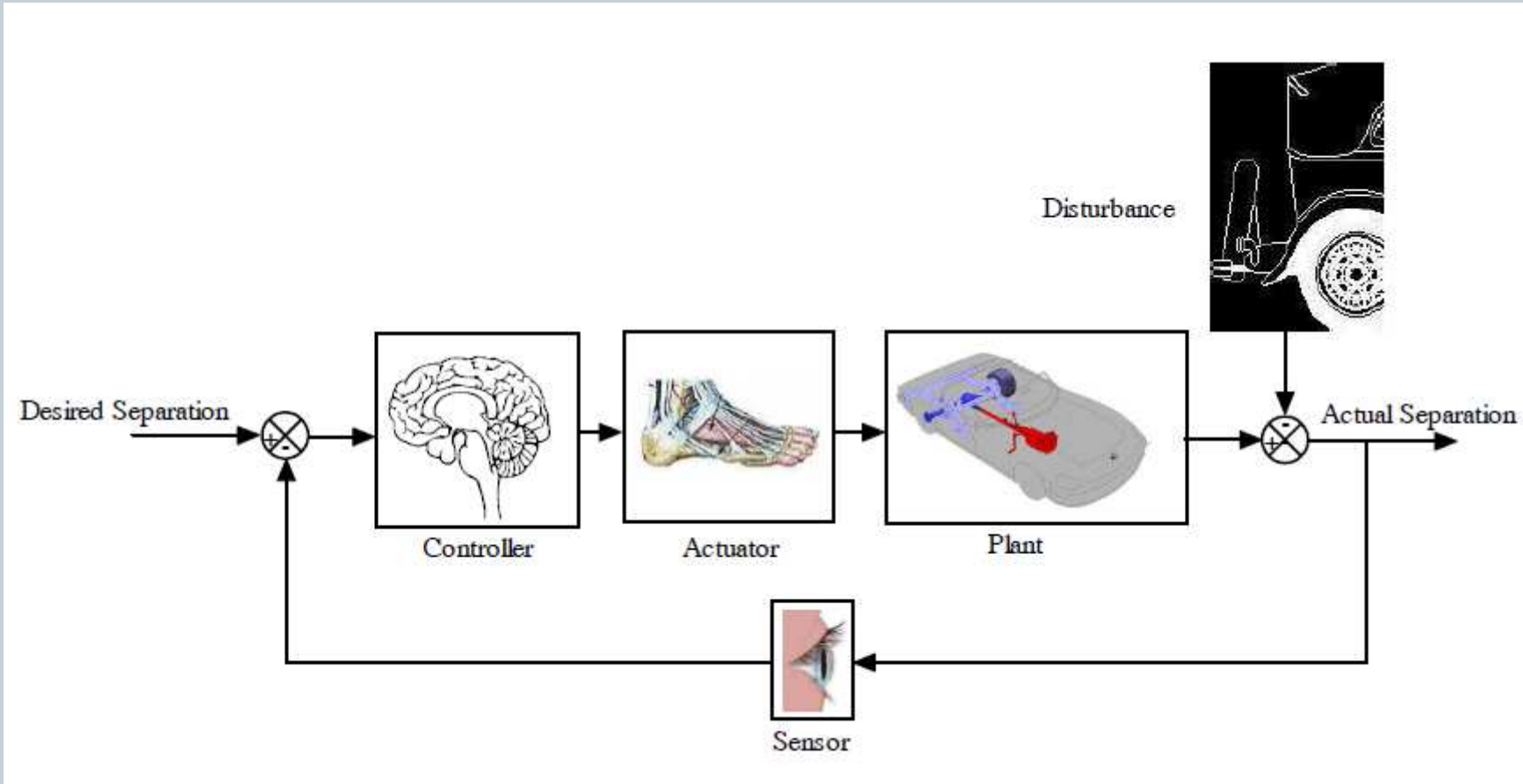
Economia


Private business investment
Desired National Income
+
-
Government (controller)
+
+
+
Business production
National Income
Measurements
Consumers
-
+
Tax collections

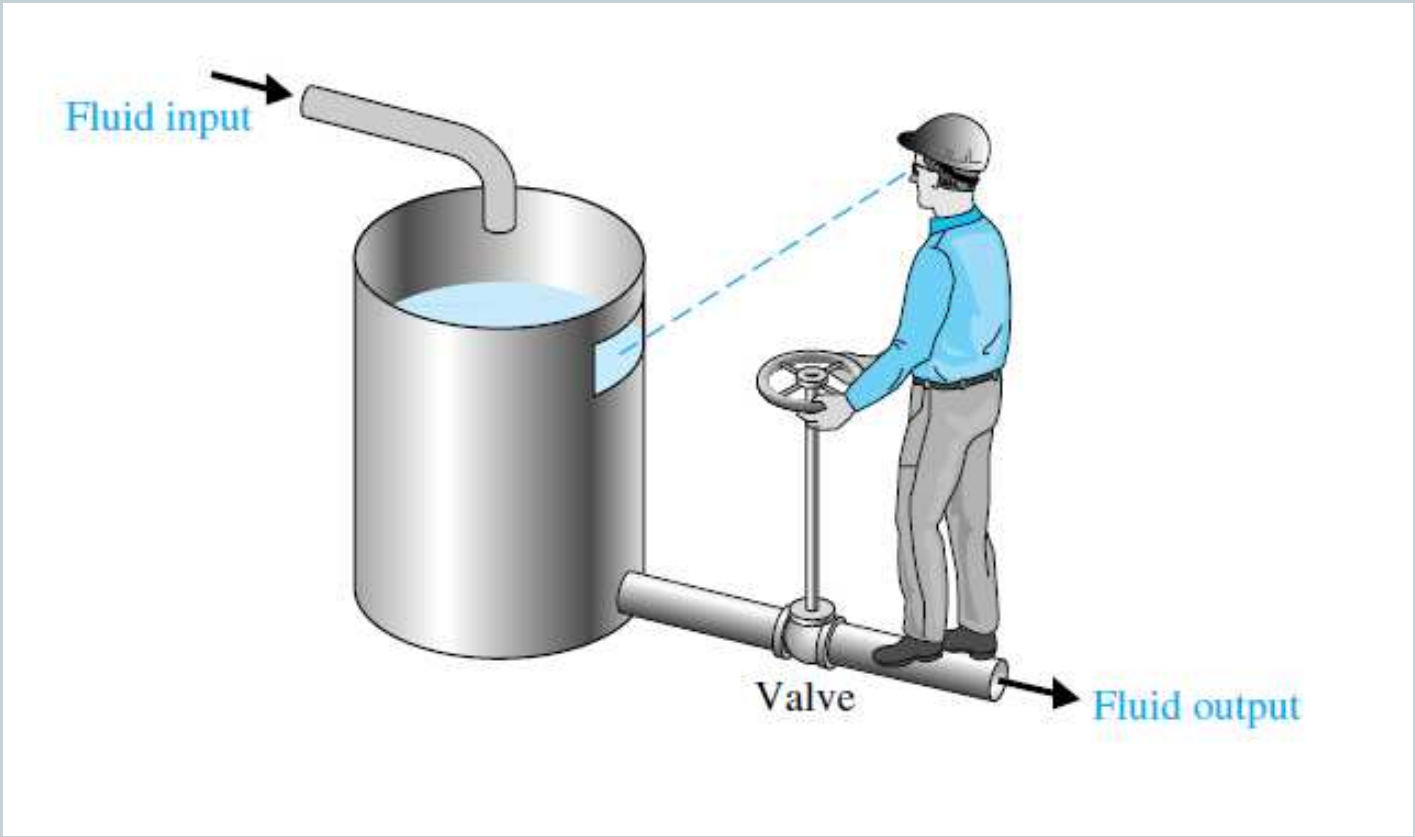
Direção de carro



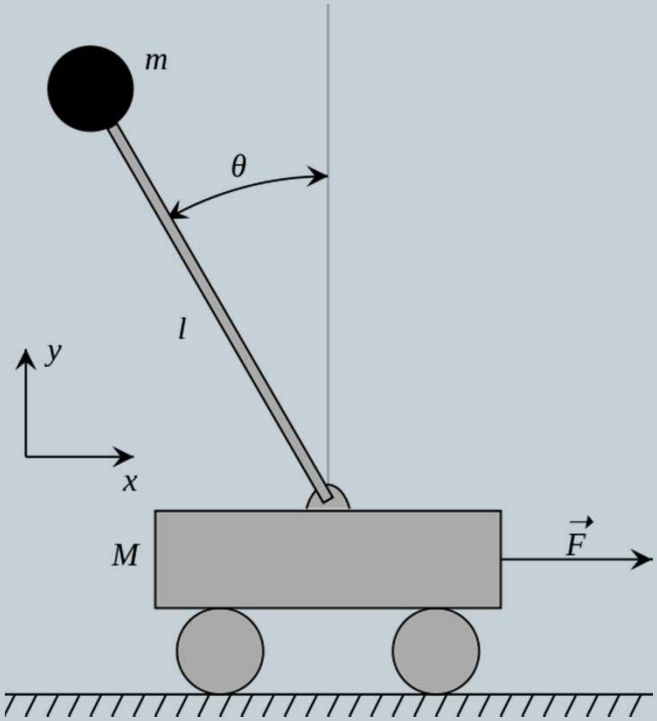
Direção de carro

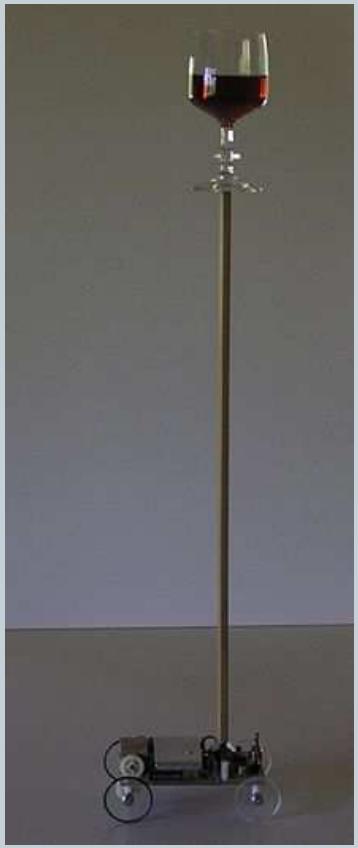


Controle de nível



Pêndulo invertido





Robôs industriais

Drone: Reaper

Big Dog, Boston Dynamics

DARPA Grand Challenge 2005

Erros de Projeto, Falhas

- Erros de projeto e falhas do sistema de controle podem acarretar sérias consequências
- Sistemas críticos

Foguete Ariane 5, 1996

- Primeira missão
- Custo de desenvolvimento durante 10 anos US$7.0 Bilhões
- Carga: 4 satélites da Agência Espacial Européia (US$ 370 Milhões)

Ariane 5

- Sistema de controle de atitude reaproveitado do Ariane 4,
- Intervalo de acelerações maiores no Ariane 5,
- Conversão de tipo de ponto flutuante (64 bits) para inteiro (16 bits),
- Falha na verificação do software.

Gripen JAS39, 1989

Figure 1. *Gripen JAS39 prototype accident on 2 February 1989. The pilot received only minor injuries.*

Chernobyl, 1986

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Figure 2. *Chernobyl nuclear power plant shortly after the accident on 26 April 1986.*