

ME 8043114 Automatic Control

Lecture 12: Control History & Summary

Dr. Shadi M. Munshi

E-mail: smmunshi@uqu.edu.sa

Dr. Badr AlOufi

E-mail: baawfey@uqu.edu.sa



Lecture Outline

- History of Control
- Course Summary



History of Automatic Control

James Watt (1736-1819)

Scottish engineer

Steam engine with flyball governor

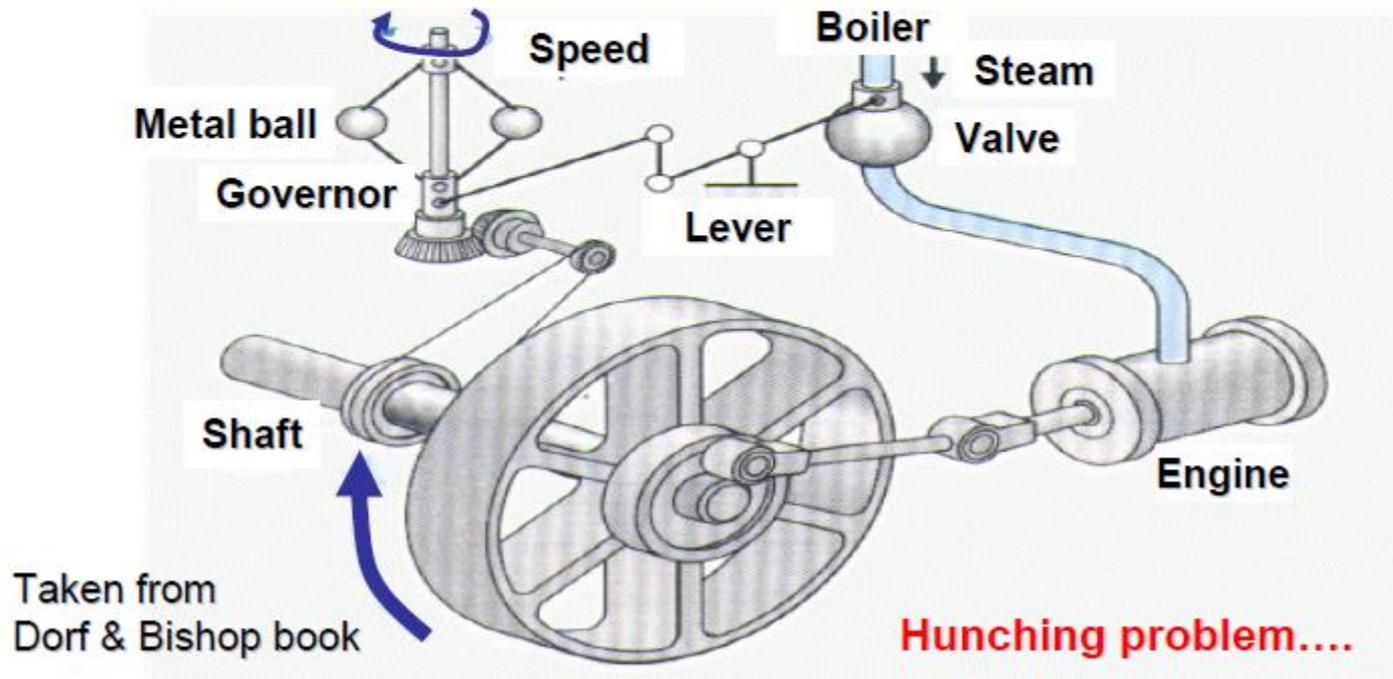
Year: 1788

- The key innovation to Industrial Revolution
 - Steam locomotive
 - Steam boat
- Birth of **Feedback Control** and **Control Engineering**



Steam engine with flyball governor

Flyball governor forces the engine to operate at a constant speed.



History of Automatic Control

James Maxwell (1831-1879)

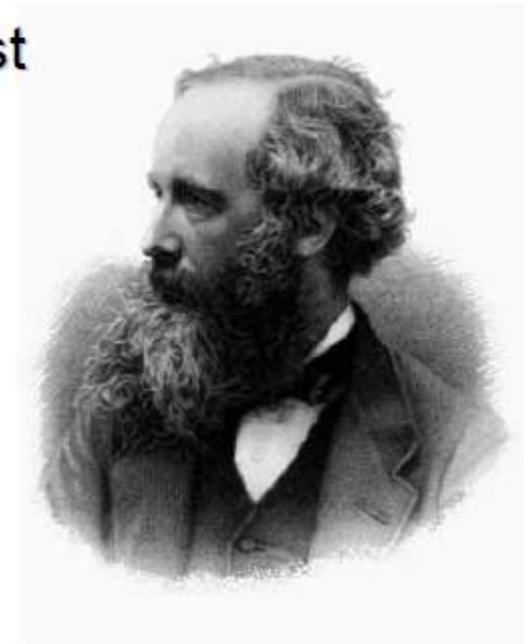
Scottish mathematician & physicist

University of Cambridge

A famous paper "*On governors*"

Year: 1868

- Analysis of stability for a 3rd-order differential equation
- Birth of **Control Theory**
- Special case of Routh-Hurwitz stability criterion



History of Automatic Control

Edward Routh (1831-1907)

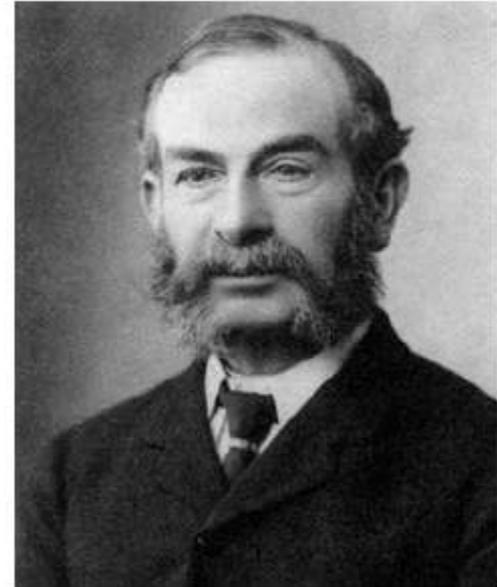
English mathematician (born in Quebec)

University of Cambridge

Routh stability criterion

Year: 1877

- Analysis of stability for ordinary differential equations
- Equivalent to Hurwitz criterion
(What you learned is Routh's criterion.)



History of Automatic Control

Adolf Hurwitz (1859-1919)

German mathematician

ETH Zurich

Hurwitz stability criterion

Year: 1895

- Analysis of stability for ordinary differential equations
- Equivalent to Routh criterion, but presented in a different form



History of Automatic Control

Aleksandr Lyapunov (1857-1918)

Russian mathematician

University of Saint Petersburg

Stability analysis

Year: 1892

- Lyapunov method
- Applicable to nonlinear, time-varying systems, too.

(Normally taught in

Nonlinear Control Course.)



History of Automatic Control

Harold S. Black (1898-1983)

American electrical engineer

Bell Telephone Laboratories

Negative feedback amplifier

Year: 1927

- Long-distance telephone service by eliminating
 - Distortions (**disturbance rejection**)
 - Noises (**noise rejection**)
- It can be unstable.... (Nyquist!)



History of Automatic Control

Harry Nyquist (1889-1976)

American research engineer

Bell Telephone Laboratories

Nyquist stability criterion

Year: 1932

- Stability of feedback amplifiers
- Frequency domain (Earlier stability analyses are in time domain.)
- Cauchy's theorem in complex function theory



History of Automatic Control

Hendrik W. Bode (1905-1982)

American research engineer

Bell Telephone Laboratories

Bode plot (1938)

Feedback amplifiers (1945)

- Sensitivity
- Bode integral formula
- Frequency domain feedback design and analysis



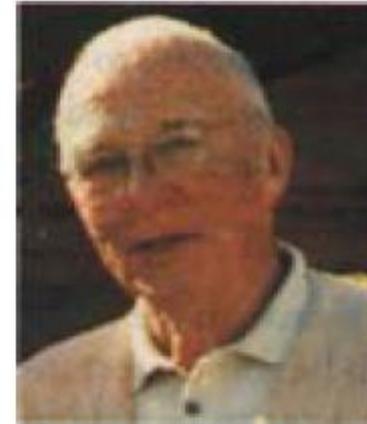
History of Automatic Control

John Ziegler (1909-1997)

American process control engineer

Taylor Instruments

Ziegler-Nichols tuning rule (1942)



Nathaniel Nichols (1914-1997)

Mathematician

Taylor Instruments, MIT

Ziegler-Nichols tuning rule (1942)

Nichols chart (1947)



History of Automatic Control

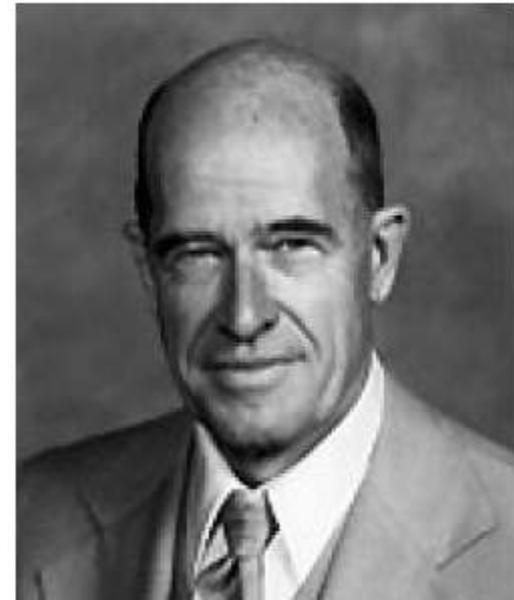
Walter R. Evans (1920-1999)

American engineer

North American Aviation

Root locus (1948)

- Unstable plants in aerospace control problems
- Difficult to apply frequency response techniques
- Back to characteristic equation and closed-loop poles



Categories of Automatic Control

- Classical control (contents in this course)
 - Transfer function
 - Frequency domain
- Modern control (1960-)
 - State-space model
 - Time domain
 - Optimality
- Post-modern control (1980-)
 - Robust control
 - Hybrid control, etc.



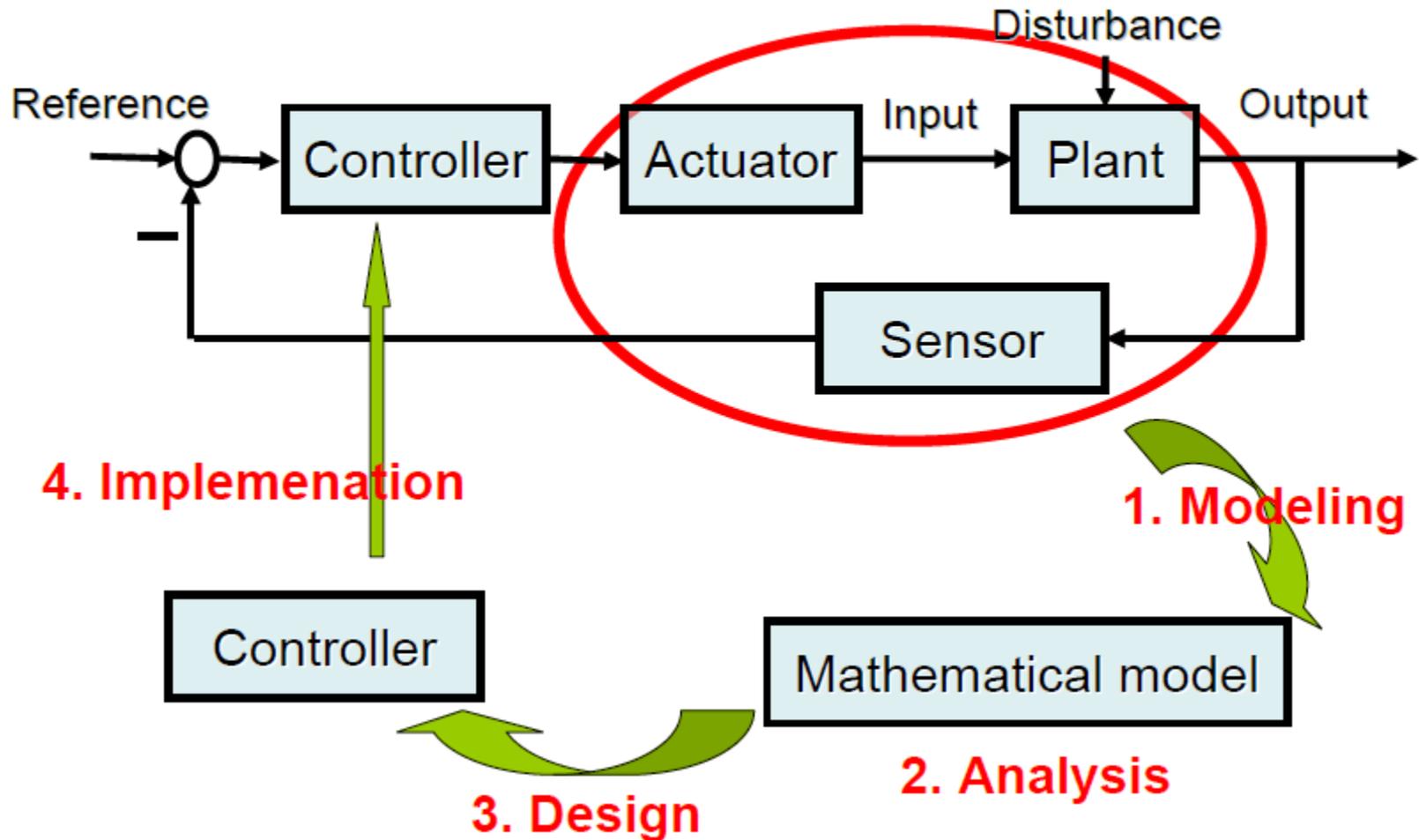
Weak points of classical control

- Single-input single-output (SISO)
(Multivariable (MIMO) control theory)
- Linear time-invariant
(State-space, nonlinear control theory)
- No optimality in design
(Optimal control theory)
- No robustness, except GM and PM
(Robust control theory)

*Much more control theory has been,
and is being, developed!*



Systematic controller design process



Goals of this course

To learn basics of feedback control systems

- **Modeling** as a transfer function and a block diagram
 - Laplace transform (Mathematics!)
 - Mechanical, electrical, electromechanical systems
- **Analysis**
 - Time response, frequency response
 - Stability: Routh-Hurwitz criterion, Nyquist criterion
- **Design**
 - Root locus technique, frequency response technique, PID control, lead/lag compensator
- **Theory, simulation with Matlab, practice in laboratories**



Course roadmap

Modeling

- ✓ Laplace transform
- ✓ Transfer function
- ✓ Models for systems
 - ✓ electrical
 - ✓ mechanical
 - ✓ electromechanical
- ✓ Linearization, delay

Analysis

- ✓ Time response
 - ✓ Transient
 - ✓ Steady state
- ✓ Frequency response
 - ✓ Bode plot
- ✓ Stability
 - ✓ Routh-Hurwitz
 - ✓ Nyquist

Design

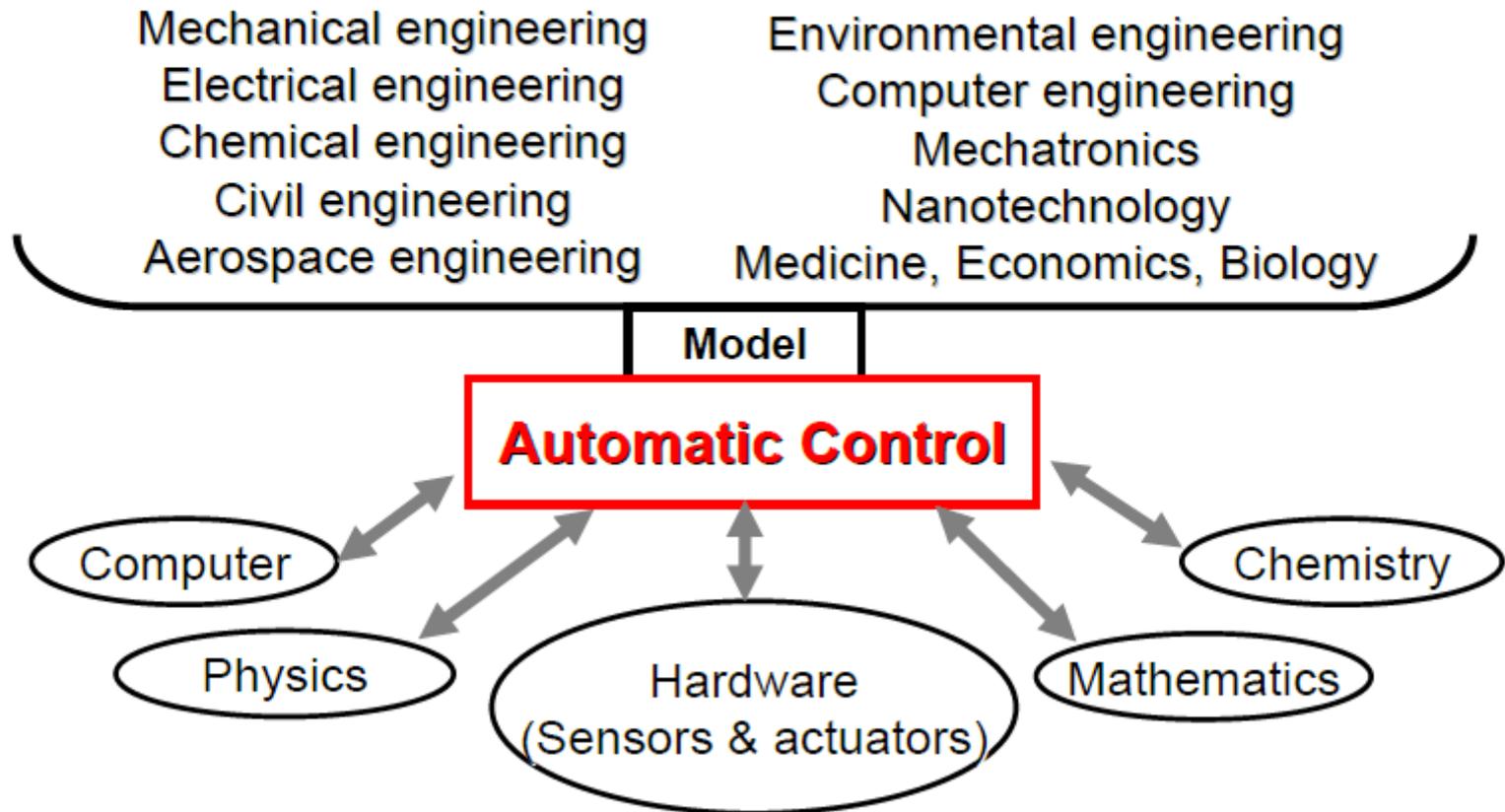
- ✓ Design specs
- ✓ Root locus
- ✓ Frequency domain
- ✓ PID & Lead-lag
- ✓ Design examples

✓ *Matlab simulations & laboratories*



Summary

Automatic control supports various disciplines!



**GOOD LUCK
ON YOUR
FINAL EXAM**

