Control Systems

EE 447 Fa23 TuTh 12:30—2:20p in OUG 141

Prof Burden

(Sam; he/him/his)

why take this course?

- This course focuses on ***analysis*** and ***design*** of (linear) feedback control systems.

- You will learn to understand and engineer control in robotics, embedded systems, electrical circuits, power systems, and biology.

- We'll build on your background in calculus, signal processing, and linear algebra, providing new analytical and computational tools.

learning outcomes

by the end of this course, you will be able to:

1. ***represent*** a linear system in state space and transfer function form;
2. ***determine*** the effects caused by including feedback in a system;
3. ***linearize*** a nonlinear system around an operating point;
4. ***determine*** if a system is stable;
5. ***understand*** sensitivity and noise/disturbance rejection properties;
6. ***apply*** scientific computing tools to model, design and simulate systems;
7. ***determine*** the performance of a system analytically and from simulation;
8. ***apply*** root locus, frequency response and full-state feedback methods to design a feedback control system to meet performance requirements;
9. ***design*** a full-state observer for a system;
10. ***apply*** observer + controller to estimate and stabilize a system's state.

origins of feedback control

The Origins of Feedback Control

Otto Mayr

THE LIBRARY
UNIVERSITY OF PETROLEUM & MINERALS
DHAHRAN - SAUDI ARABIA

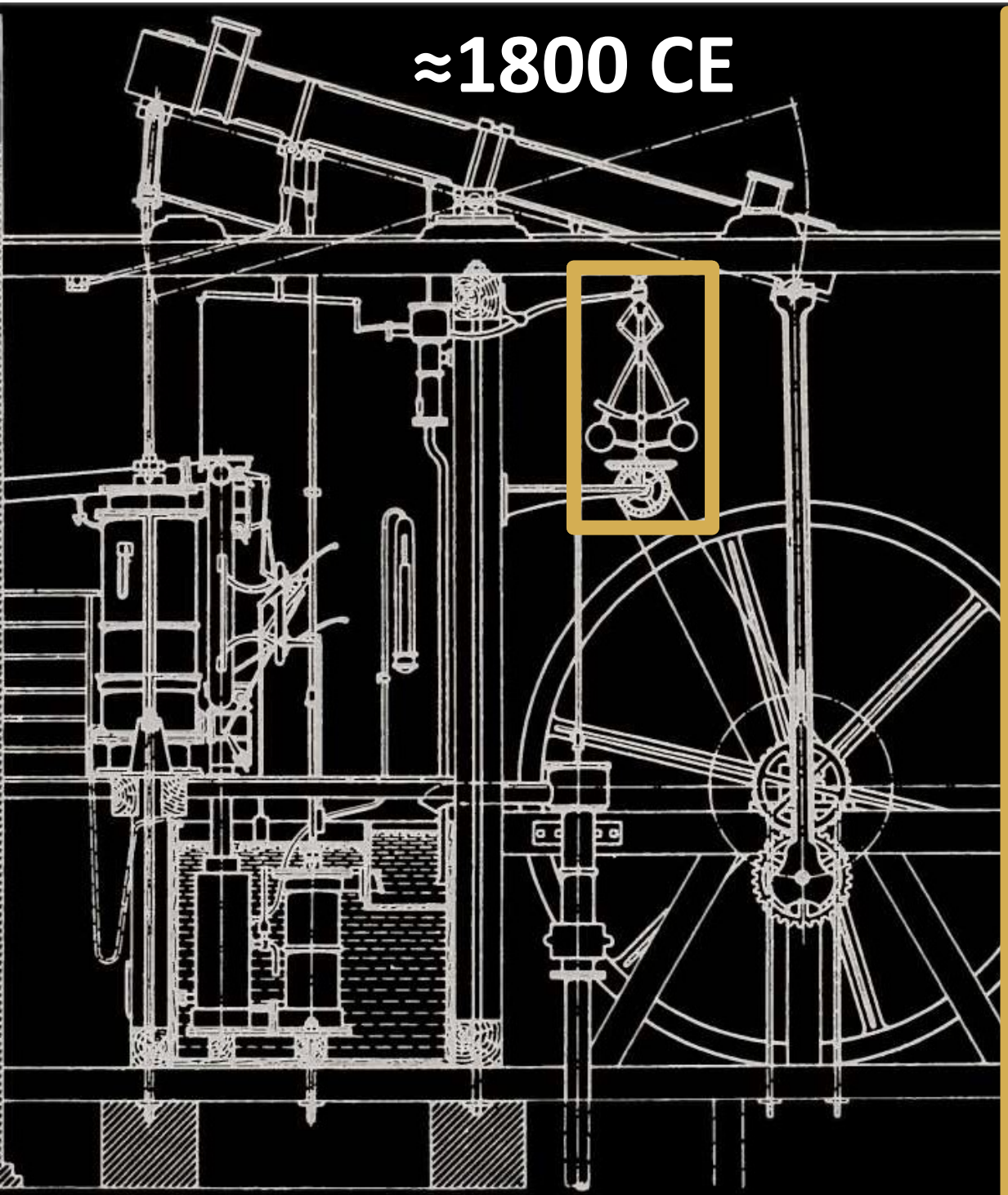
The M.I.T. Press
Cambridge, Massachusetts, and London, England

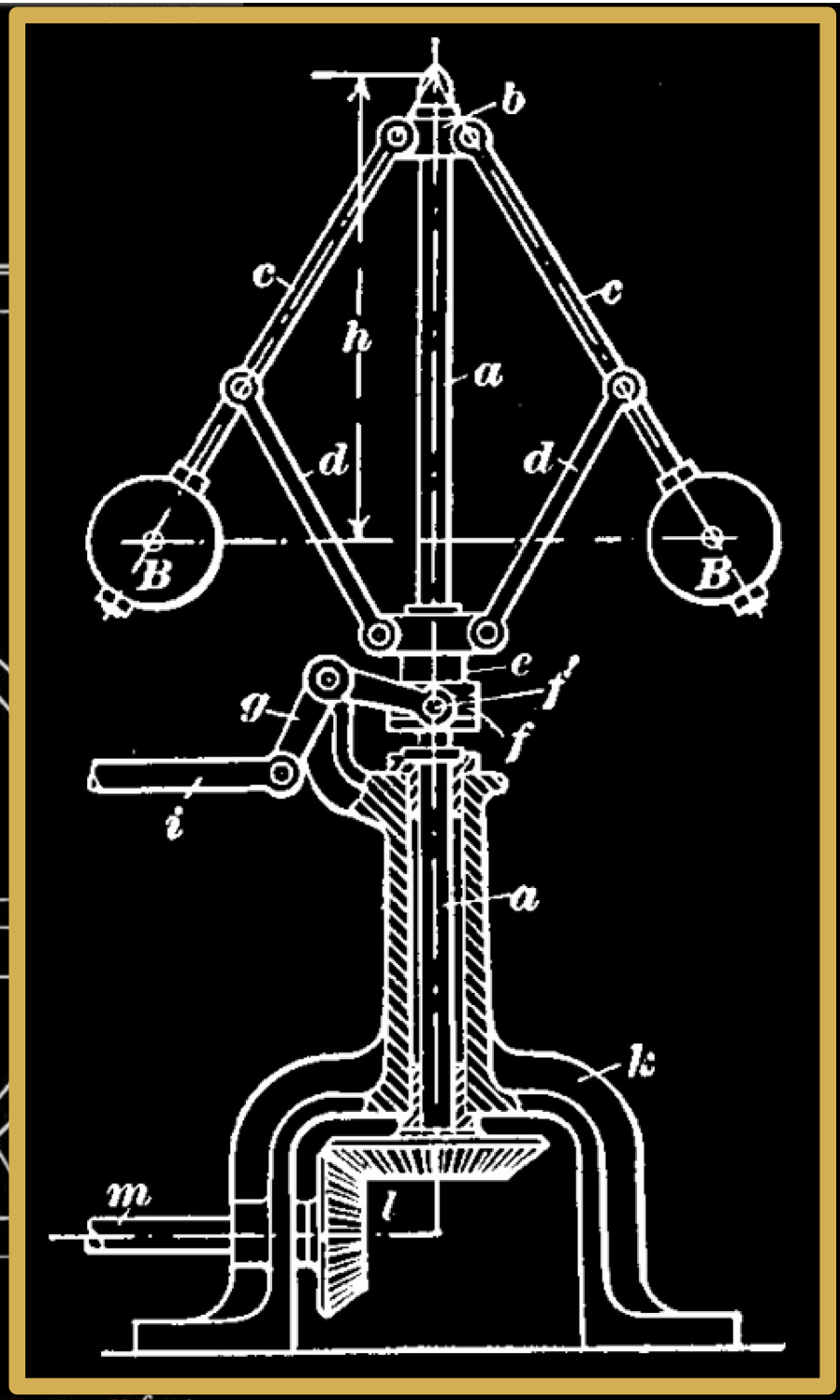
Otto Mayr

"The Origins of Feedback Control"

MIT Press 1970

≈1800 CE

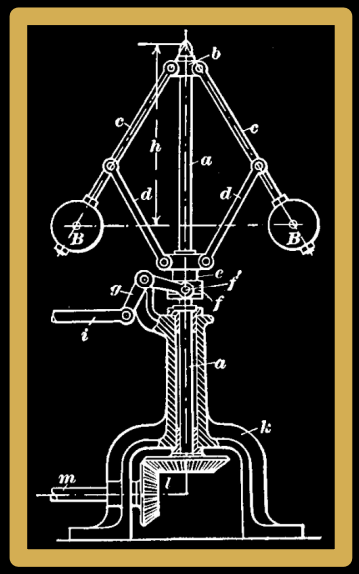




0 1 2 3 4 5 6 7 8 9 10 11 12 feet

0 0.5 1 2 3 4 m

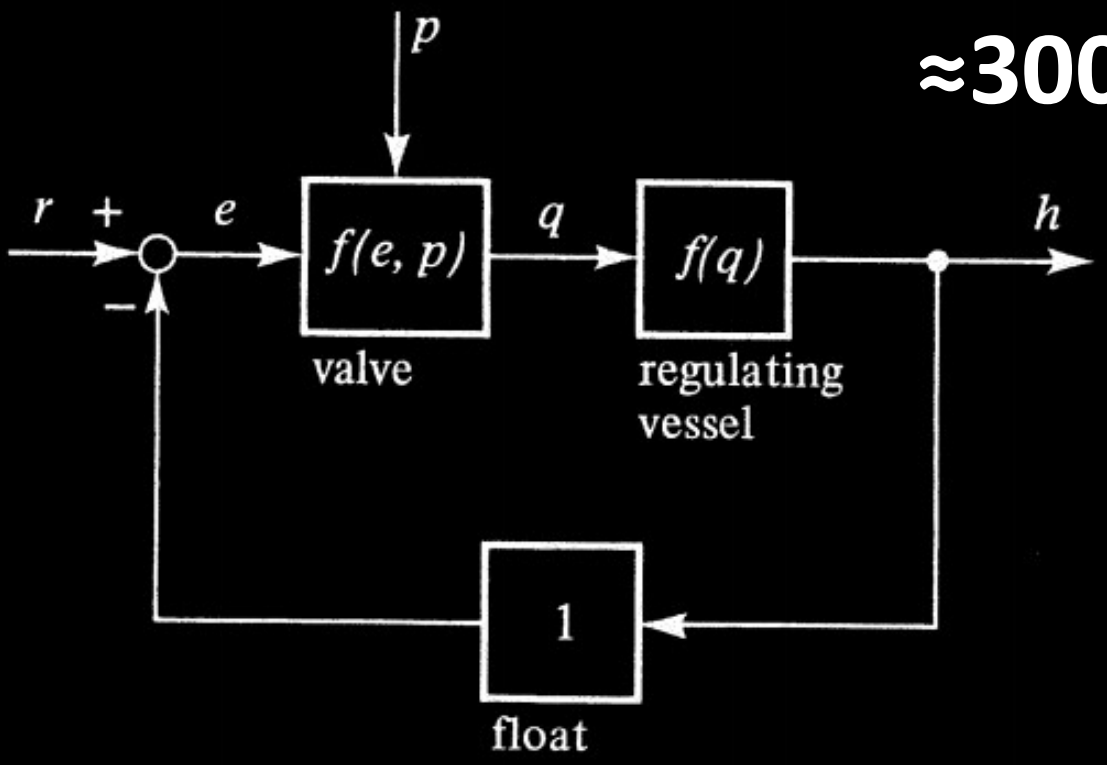
≈1800 CE



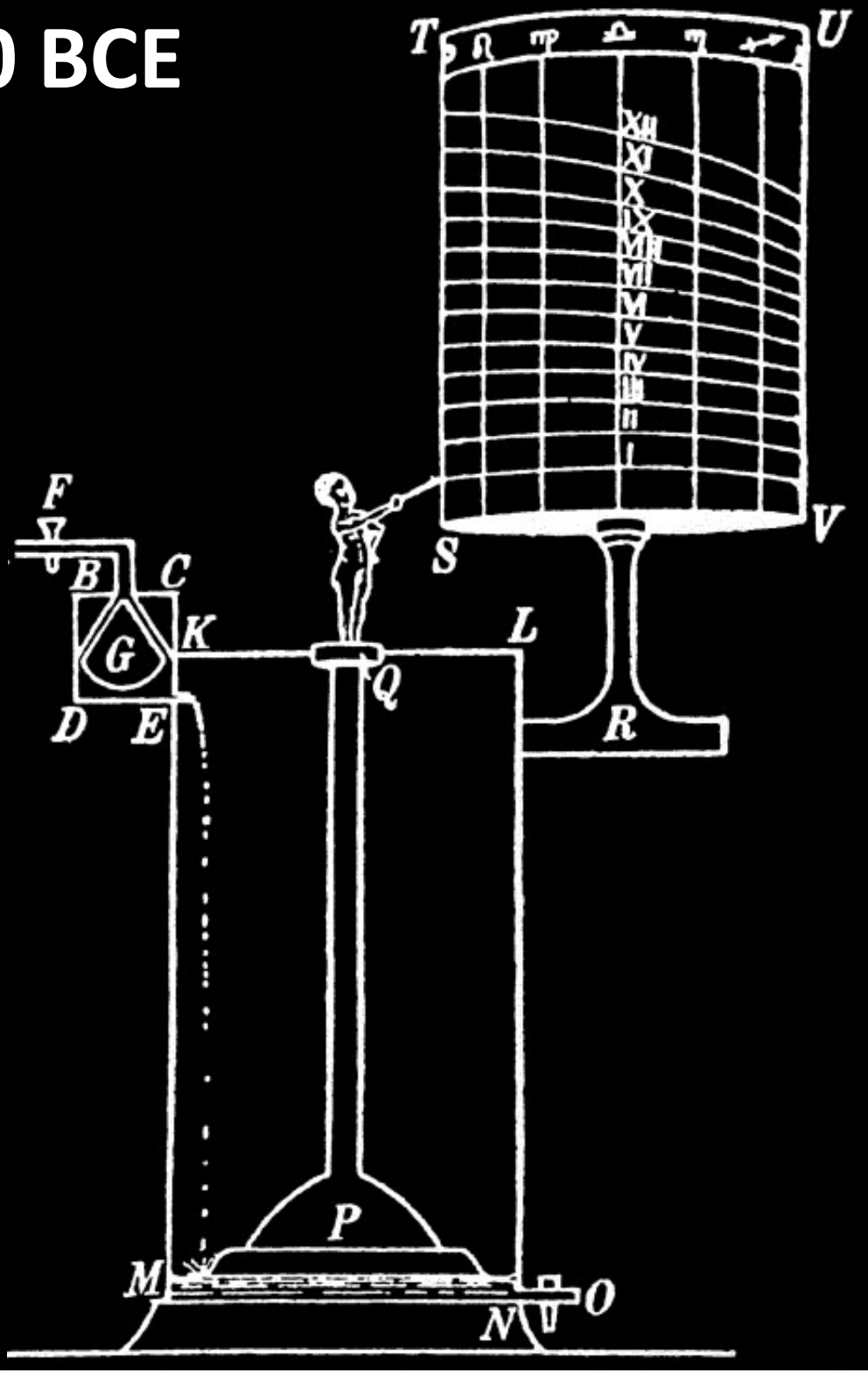
n = desired speed
r = position of vertical valve rod
b = position of the right end of horizontal lever
α = $r - b$
a = angular position of valve lever
p = steam pressure
q = steam flow rate

m_a = driving torque
m_l = load torque
m = $m_a - m_l$
n = actual speed
n_f = speed of governor
s = position of governor sleeve

≈300 BCE

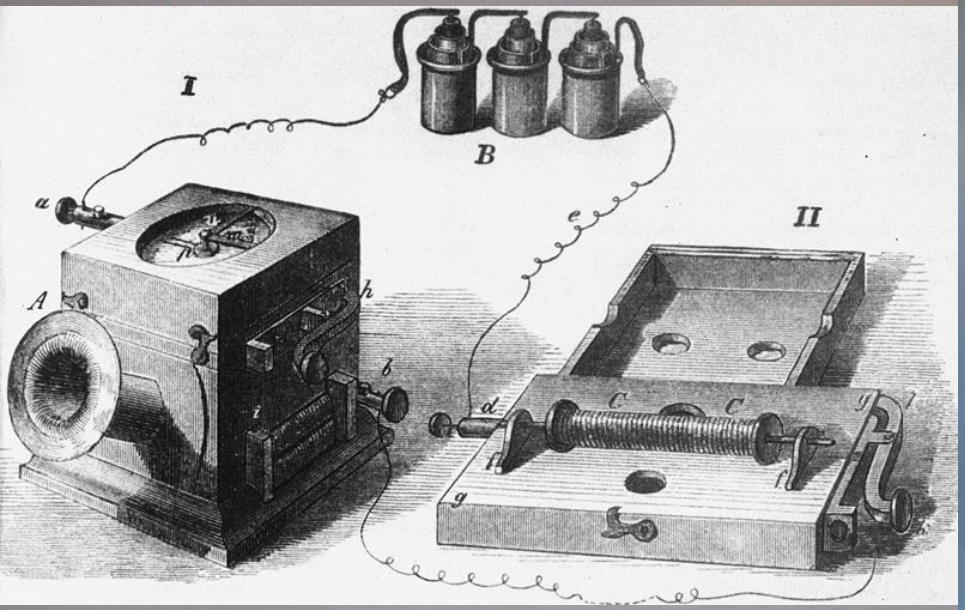


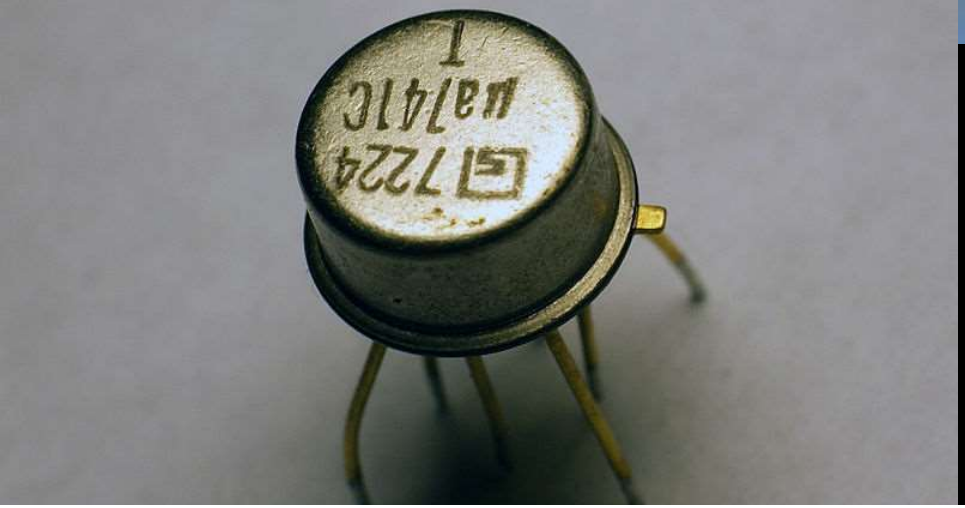
r = desired level (position of float when valve is closed)
h = actual level
e = valve opening
p = water supply pressure
q = flow rate of water entering regulating vessel

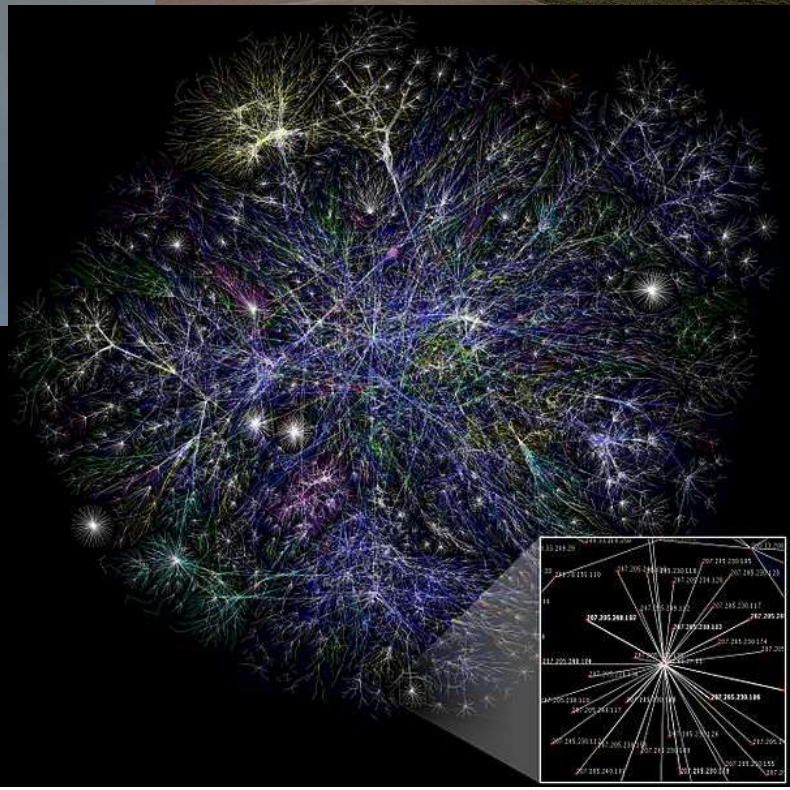


state of the art

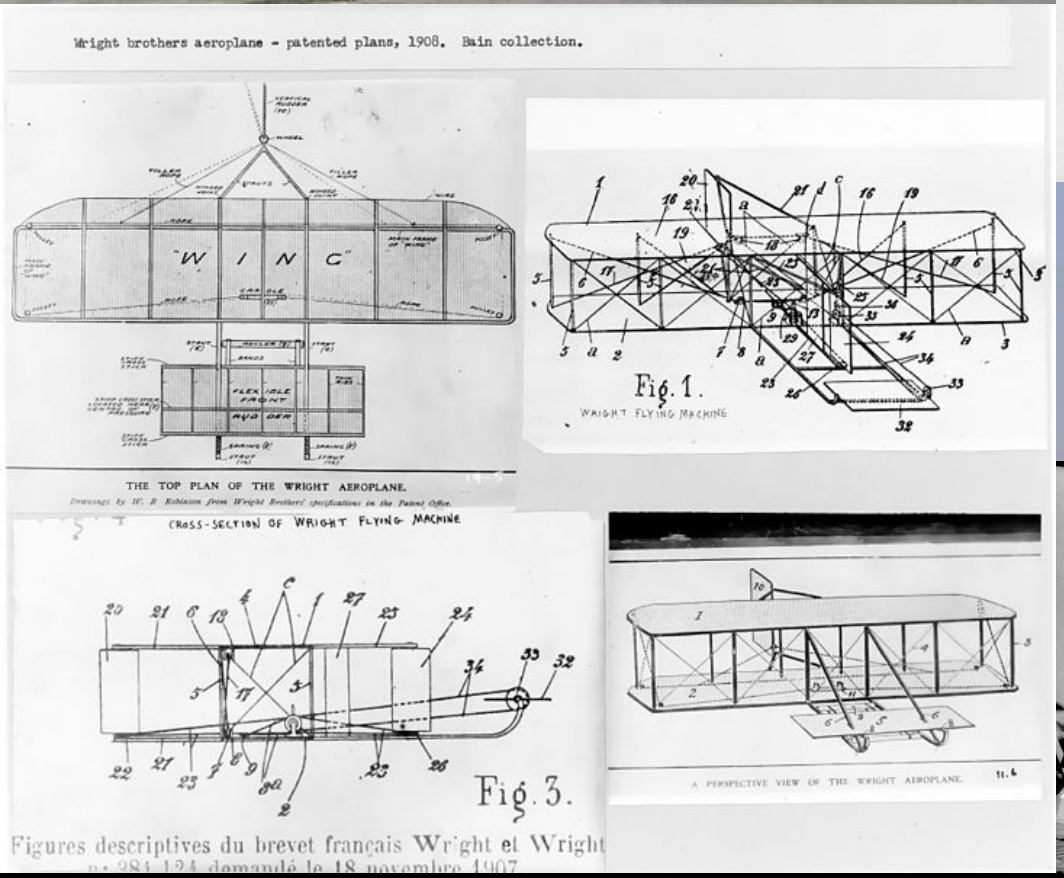
telecommunication

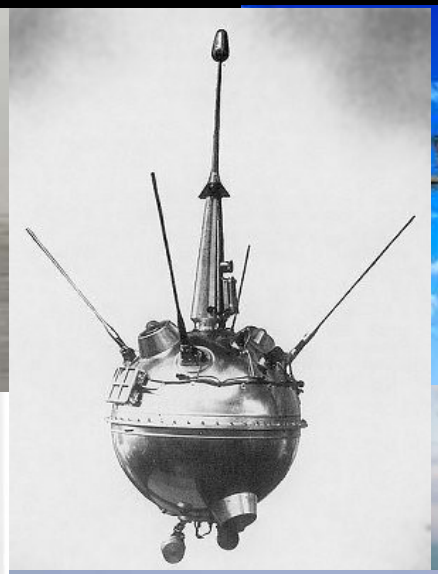


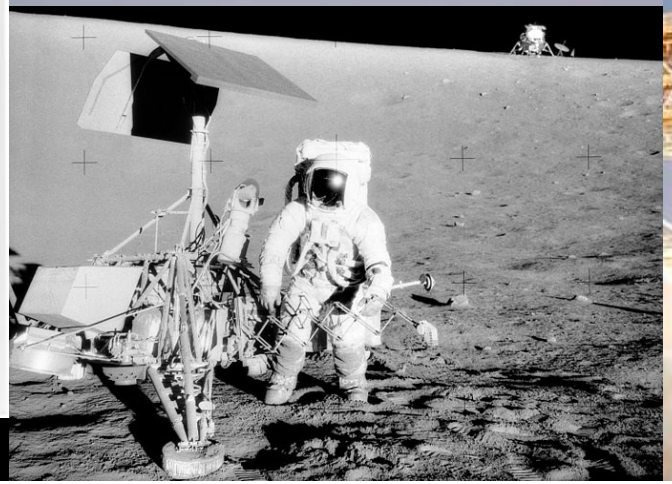




aerospace and transportation







power systems – ECE 458

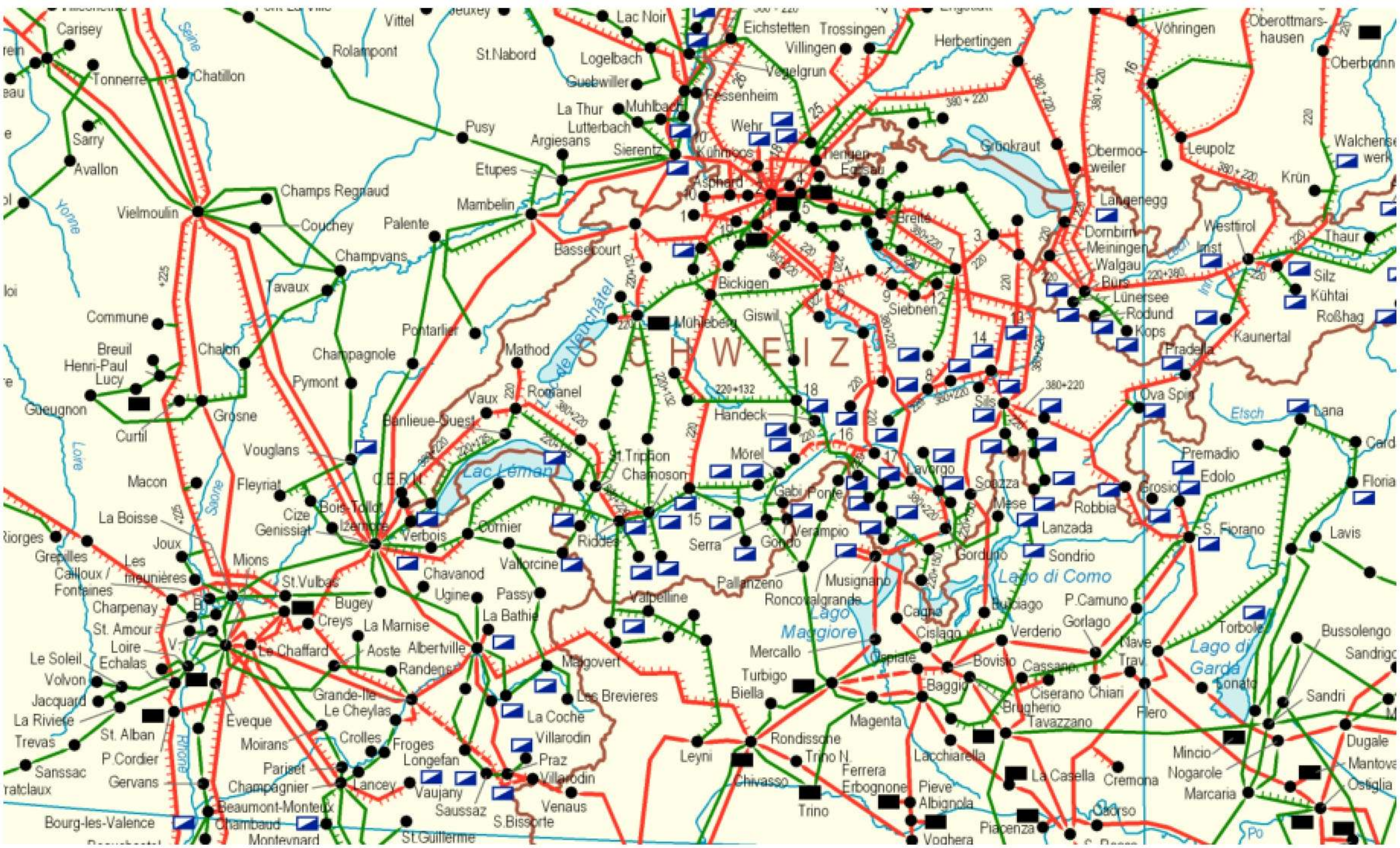
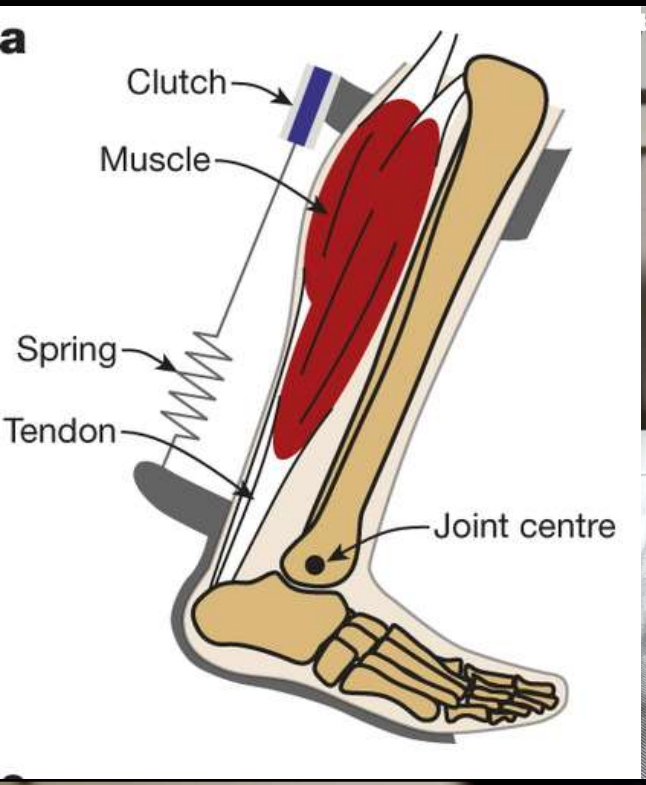
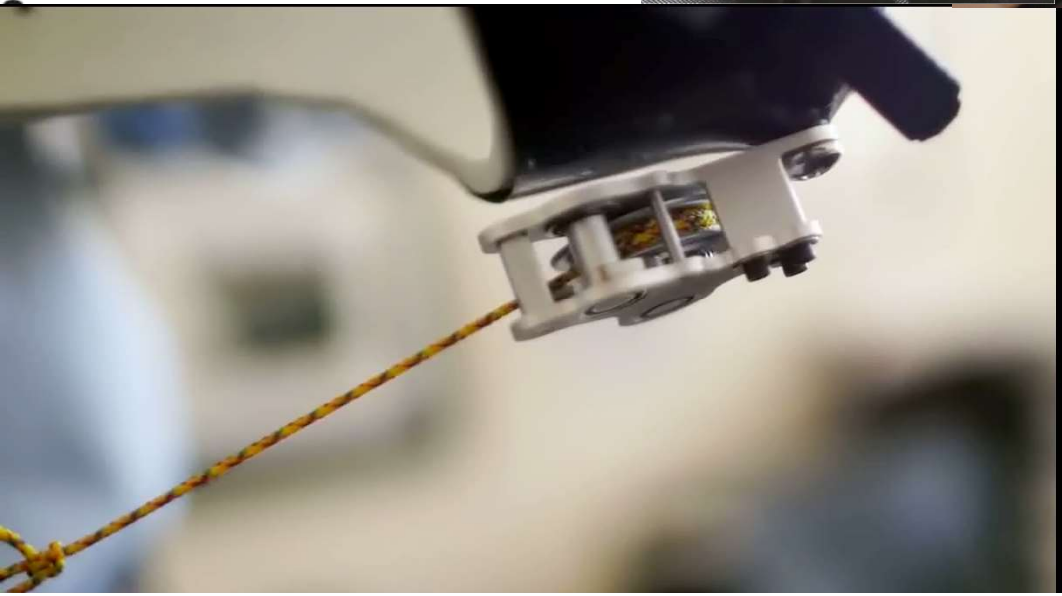


Figure 1.4: A small portion of the European power network. In 2016 European power suppliers operated a single interconnected network covering a region from the Arctic to the Mediterranean and from the Atlantic to the Urals. The installed power was more than 800 GW (8×10^{11} W) serving more than 500 million citizens. (Source: ENTSO-E http://www.entsoe.eu)

robotics and AI – ENGINE capstone

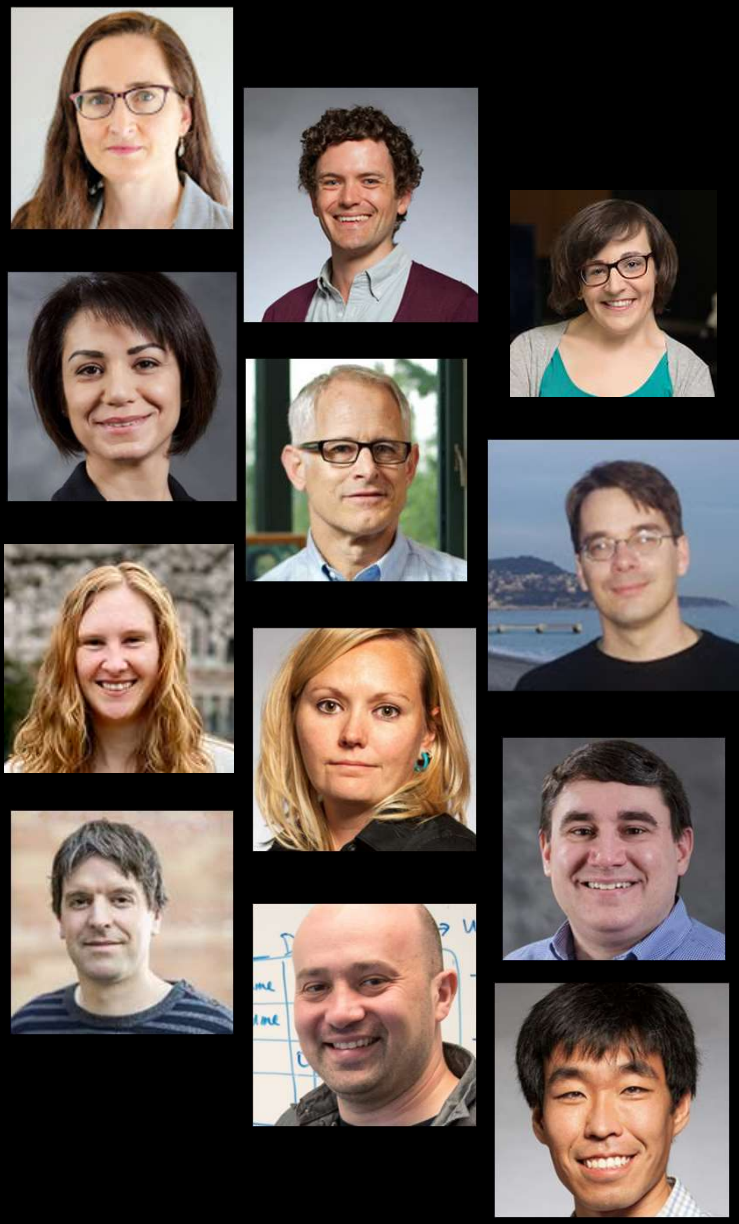
neuroengineering – ECE 466





ECE controls and robotics

Prof. Linda Bushnell	networked control, cyber security
Prof. Sam Burden	sensorimotor control
Prof. Amy Orsborn	brain-computer interface (BCI)
Prof. Maryam Fazel	convex optimization
Prof. Blake Hannaford	medical robotics, telerobotics
Prof. Eric Klavins	systems biology
Prof. Kim Ingraham	wearable robotics and rehabilitation
Prof. Lillian Ratliff	cyber-physical systems (CPS)
Prof. Matt Reynolds	ultra-low power sensing, computation
Prof. Georg Seelig	systems biology
Prof. Eli Shlizerman	data-driven dynamical systems
Prof. Baosen Zhang	cyber-physical systems (CPS)



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life outcomes

by the end of this course, you will be able to:

- translate the physical world into ***equations***
- ***transform*** the equations to do anything you want
- in effect, you will be able to ... ***control*** ... ***systems***

who am I?

Prof Burden (he/him)

currently Associate Professor in UW Seattle ECE

previously Associate Chair for Diversity, Equity, and Inclusion

PhD: UC Berkeley EECS 2014

BS: UW Seattle EE 2008

first-generation college grad!

expertise: control theory, i.e. math of humans & machines

Sam (husband/dad)

born: Forks, WA

raised: Cheney, WA

likes: climbing, biking, gaming

also: I live with a lifelong chronic illness. This means that I become ill sometimes, often with little warning. I will do my best to minimize the impact on this course, but I appreciate your compassion – and I will give you mine.