LINEAR CONTROL SYSTEMS

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Lecture 1

An Introduction to Linear Control Systems

Topics to be covered include:

- Introduction
- A brief history of control.
- Introducing of some advanced control system.
- Important parts of a control system.

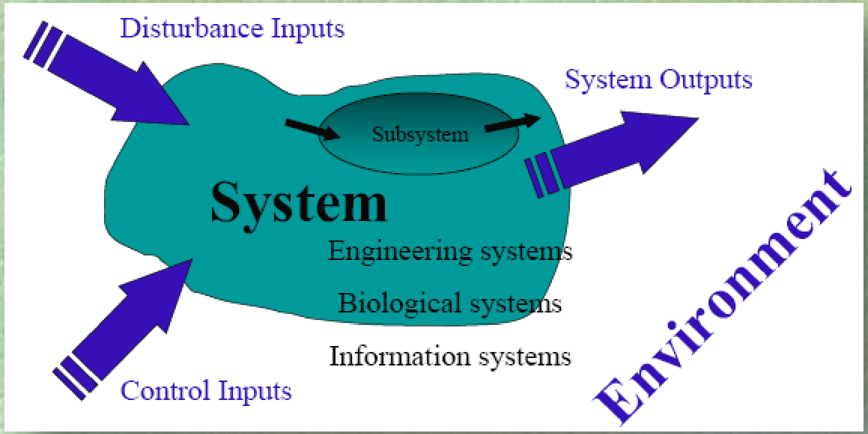
Introduction

System An interconnection of elements and devices for a desired purpose.

Control is the process of causing a system variable such as tempreture to conform to some desired value.

Control System An interconnection of components forming a system configuration that will provide a desired response.

Process The device, plant, or system under control. The input and output relationship represents the cause-and-effect relationship of the process.



History of Control Engineering

18th Century James Watt’s centrifugal governor for the speed control of a steam engine.

1920s Minorsky worked on automatic controllers for steering ships.

1930s Nyquist developed a method for analyzing the stability of controlled systems

1940s Frequency response methods made it possibl
control systems

1950s Root-locus method due to Evans was fully de

1960s State space methods, optimal control, adaptiv

1980s Learning controls are begun to investigated .

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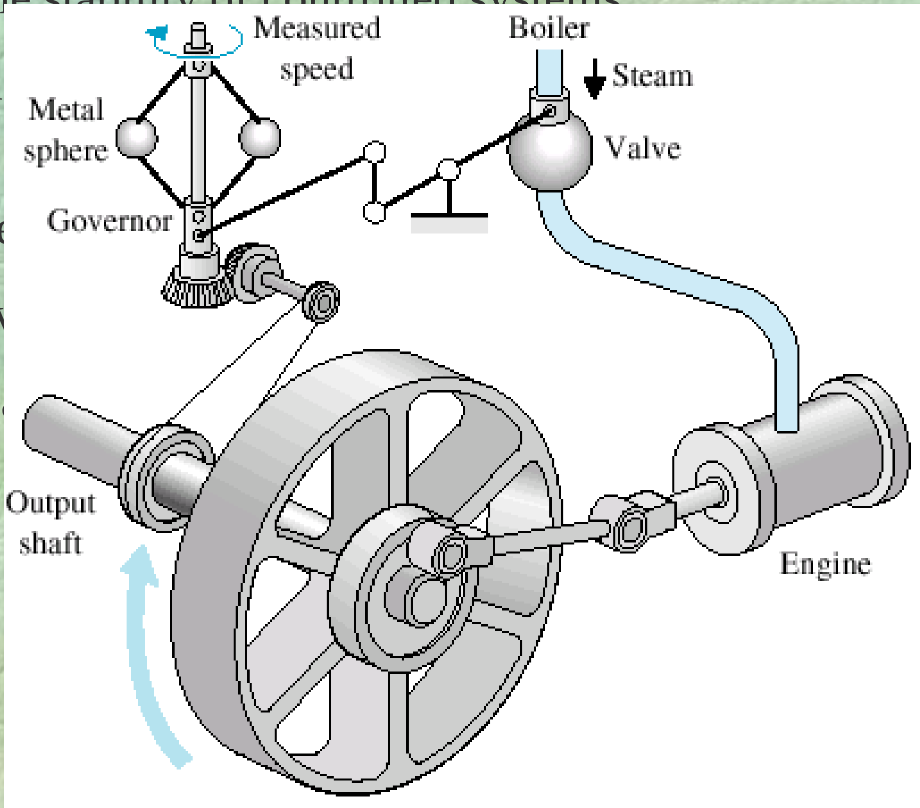
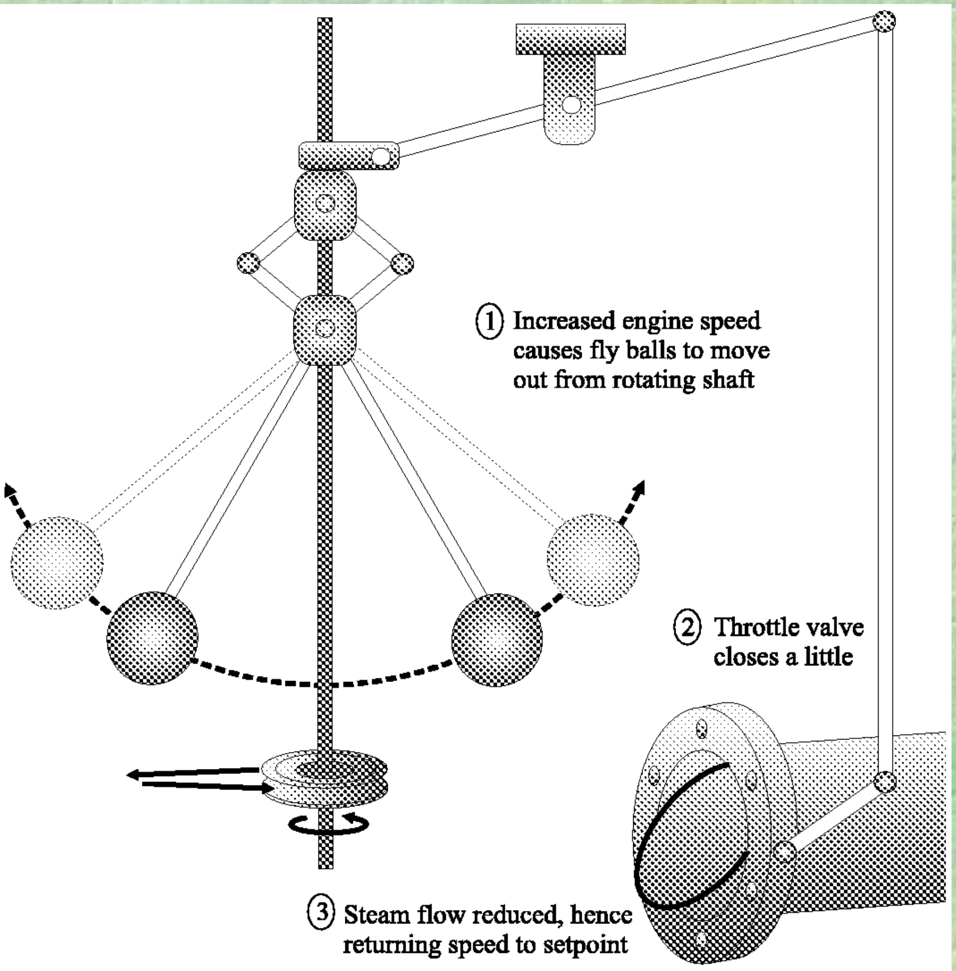
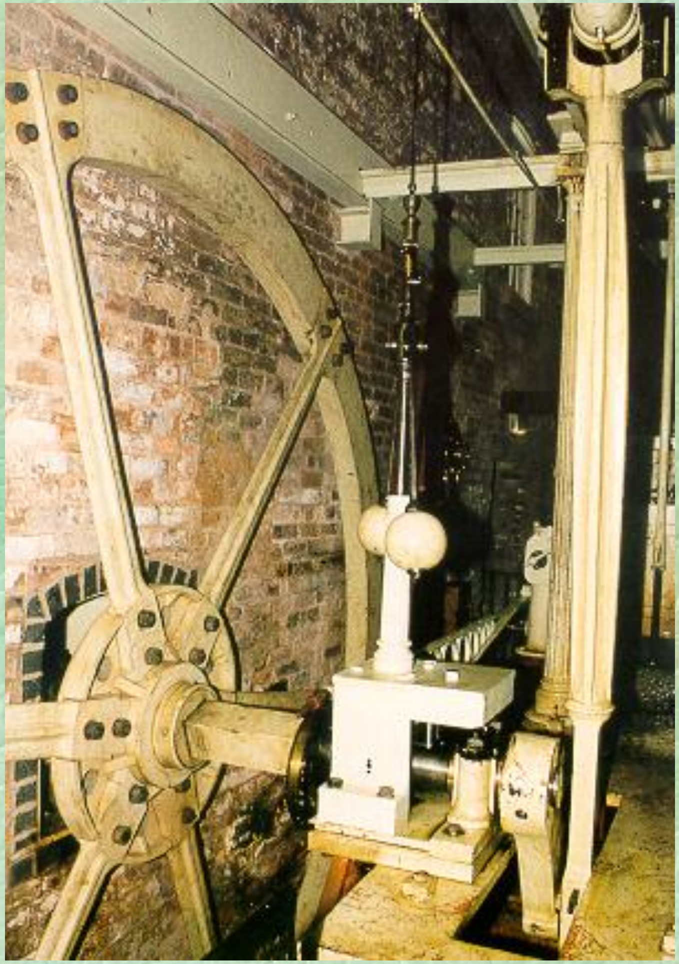


History of Control Engineering



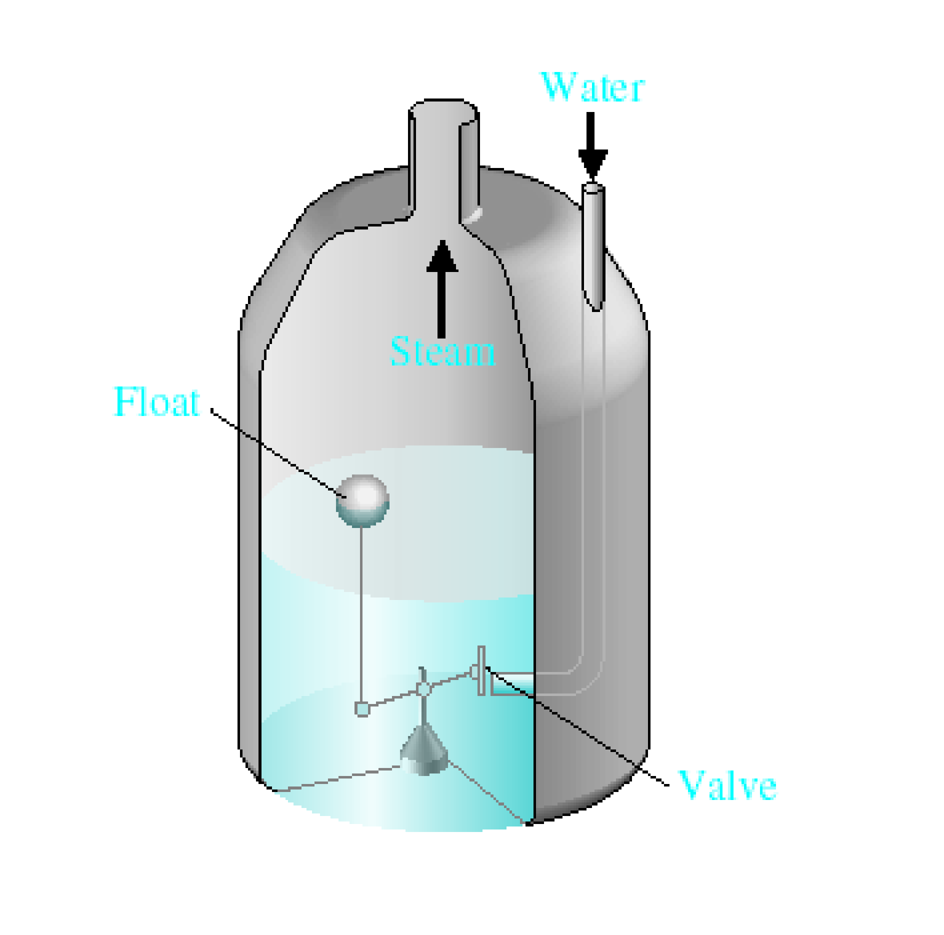
History of Control Engineering



This photograph shows a flyball governor used on a steam engine in a cotton factory near Manchester in the United Kingdom. Actually, this cotton factory is still running today.

Earlier Control Systems?

Water-level float regulator (before BC)



Earlier Control Systems?

Human System

i. Pancreas
   - Regulates blood glucose level

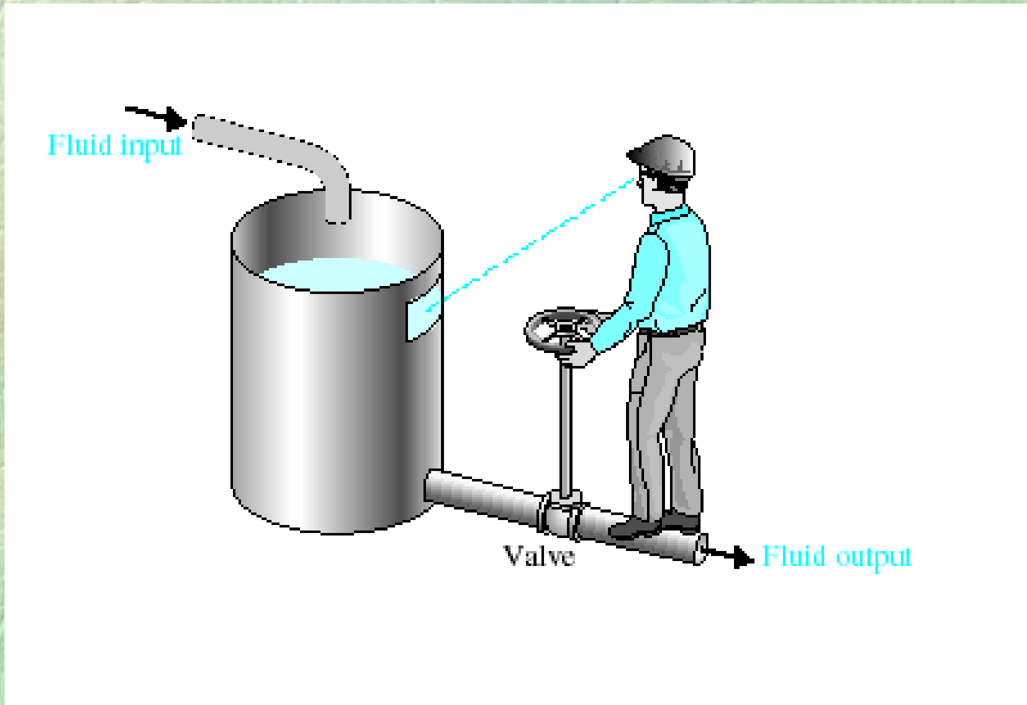
ii. Adrenaline
   - Automatically generated to increase the heart rate and oxygen in times of flight

iii. Eye
   - Follow moving object

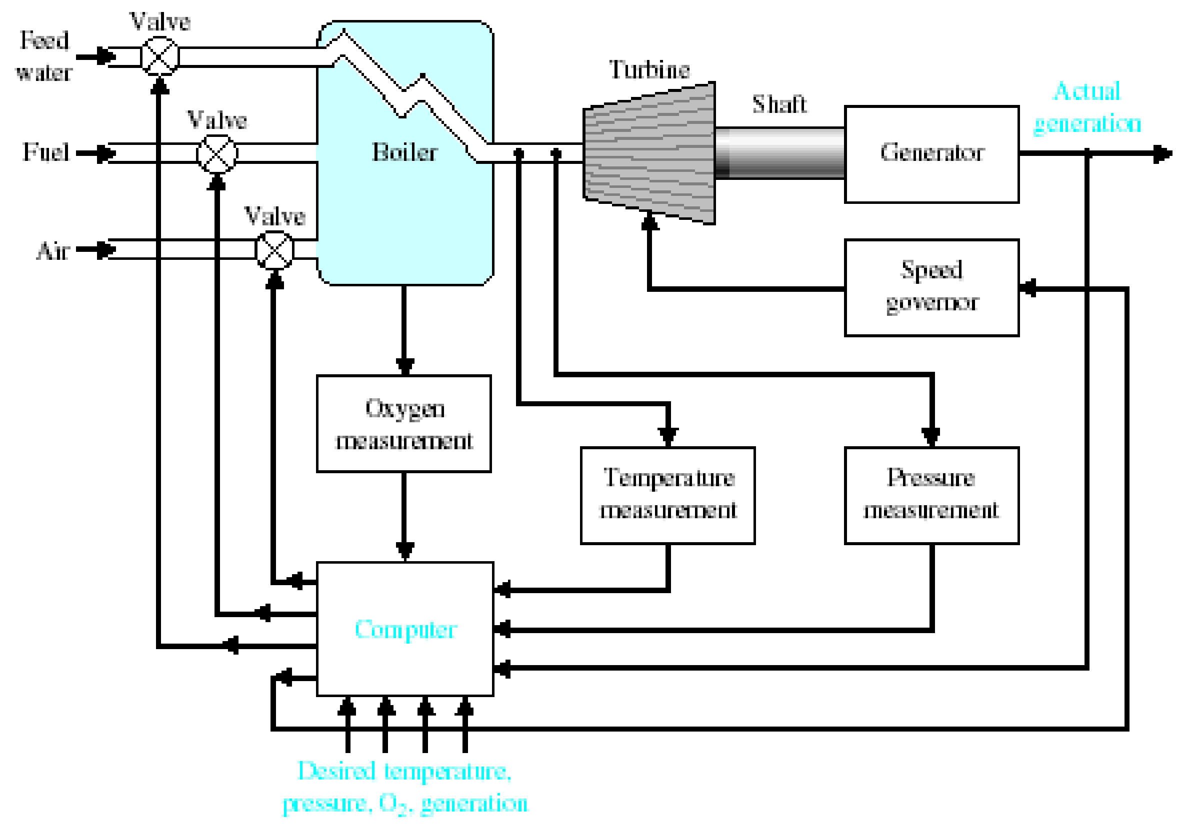
iv. Hand
   - Pick up an object and place it at a predetermined location

v. Temperature
   - Regulated temperature of 36°C to 37°C

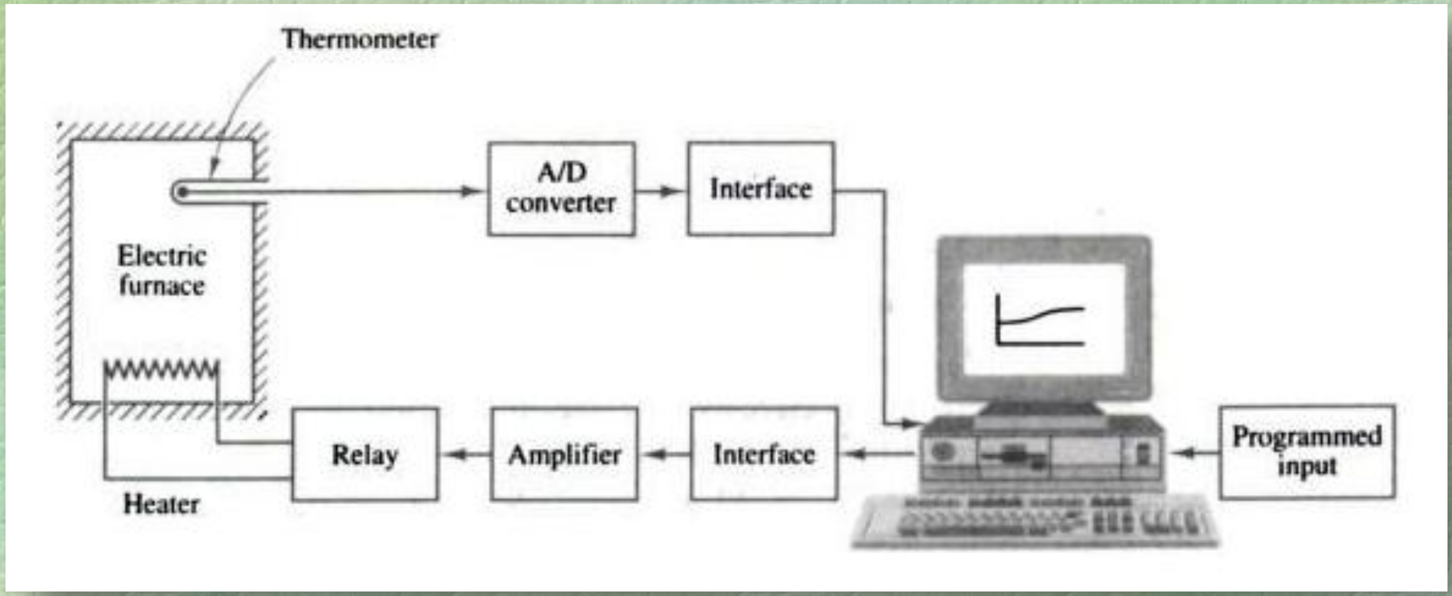
A manual level control system



Control system for a boiler of a thermal plant



Schematic diagram of temperature control of an electric furnace



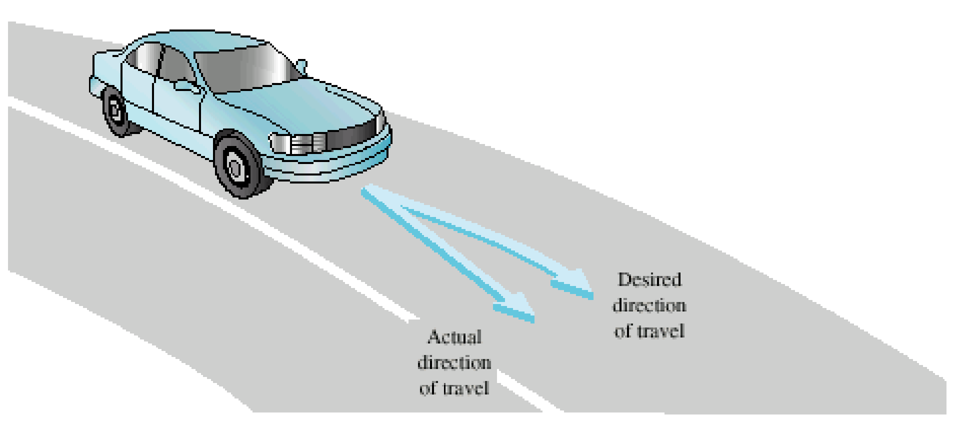
A modern high voltage tranformator

A wind farm

A modern industrial plant: Asalooye south of Iran

Transportation

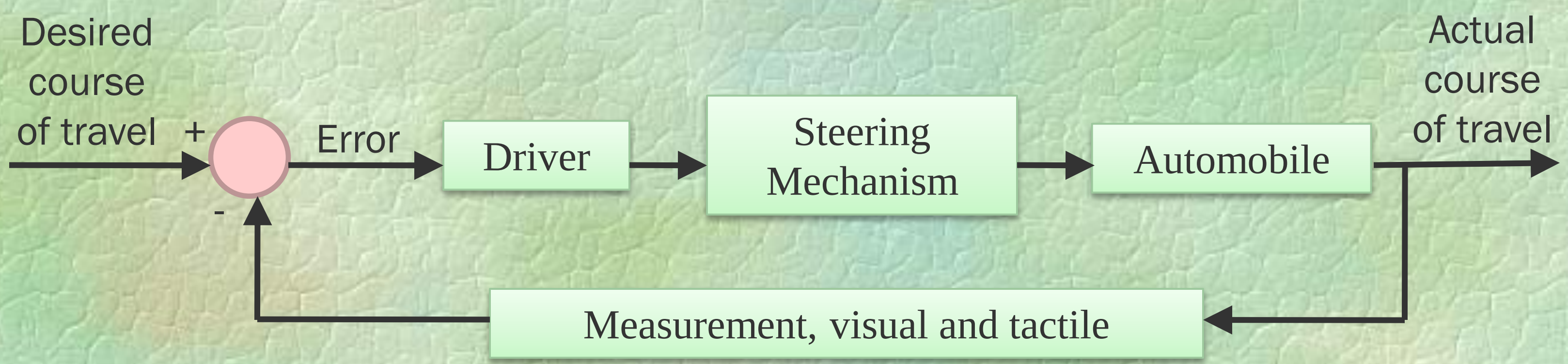
Car and Driver



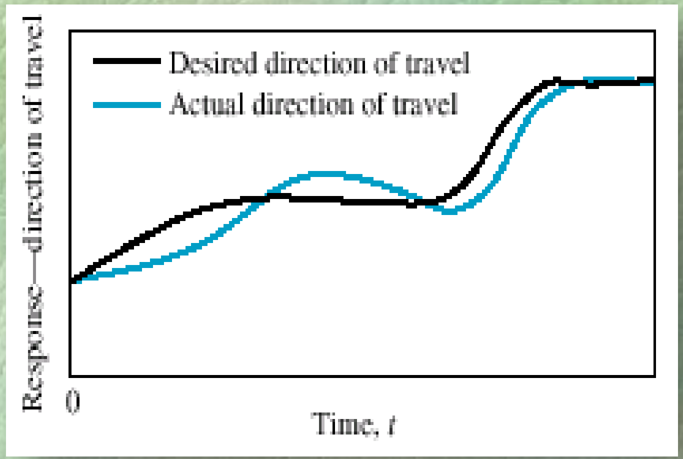
- Objective: To control direction and speed of car
- Outputs: Actual direction and speed of car
- Control inputs: Road markings and speed signs
- Disturbances: Road surface and grade, wind, obstacles
- Possible subsystems: The car alone, power steering system, breaking system

Transportation

Functional block diagram:



Time response:



Control benefits

Improved control is a key enabling technology to:

- enhanced product quality
- waste minimization
- environmental protection
- greater throughput for a given installed capacity
- greater yield, and
- higher safety margins

Successful Control

Success in control engineering depends on some of the issues:

- plant, i.e. the process to be controlled
- objectives
- sensors
- actuators
- computing
- accounting for disturbances and uncertainty

Plant

The physical layout of a plant is an intrinsic part of control problems.

Thus a control engineer needs to be familiar with the "physics" of the process under study.

This includes a knowledge of the basic energy balance, mass balance and material flows in the system.

As an example consider position control of an aeroplane, or temperature control of a room.

Objectives

Before designing sensors, actuators or control architectures, it is important to know the goal, that is, to formulate the control objectives. This includes

- what does one want to achieve (energy reduction, yield increase,...)
- what variables need to be controlled to achieve these objectives
- what level of performance is necessary (accuracy, speed,...)

Sensors

Sensors are the *eyes* of control enabling one to *see* what is going on. Indeed, one statement that is sometimes made about control is:

If you can measure it, you can control it.

As an example consider the altitude sensor in an aeroplane or the temperature in a room.

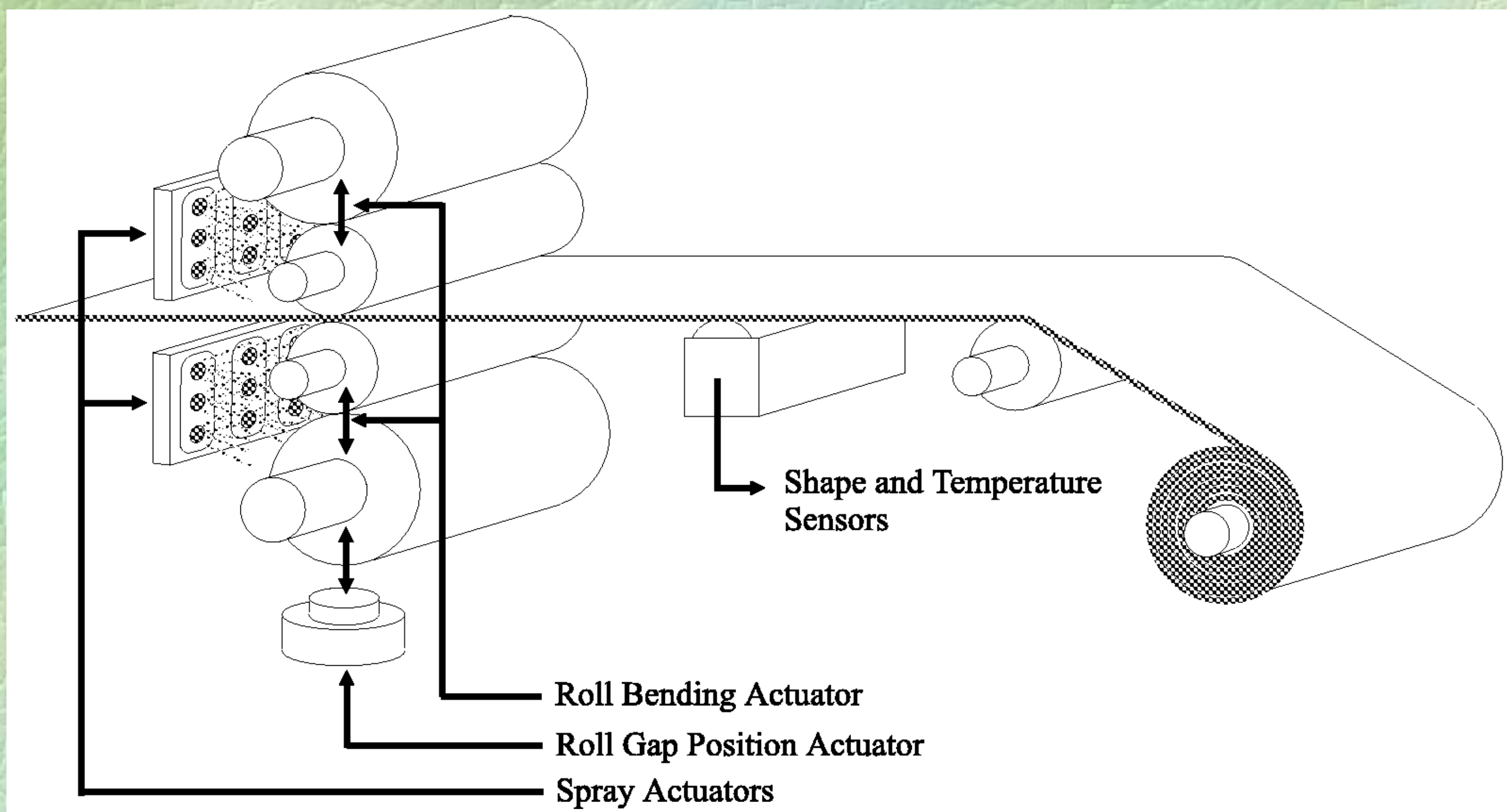
Actuators

Once sensors are in place to report on the *state* of a process, then the next issue is the ability to affect, or actuate, the system in order to move the process from the current state to a desired state.

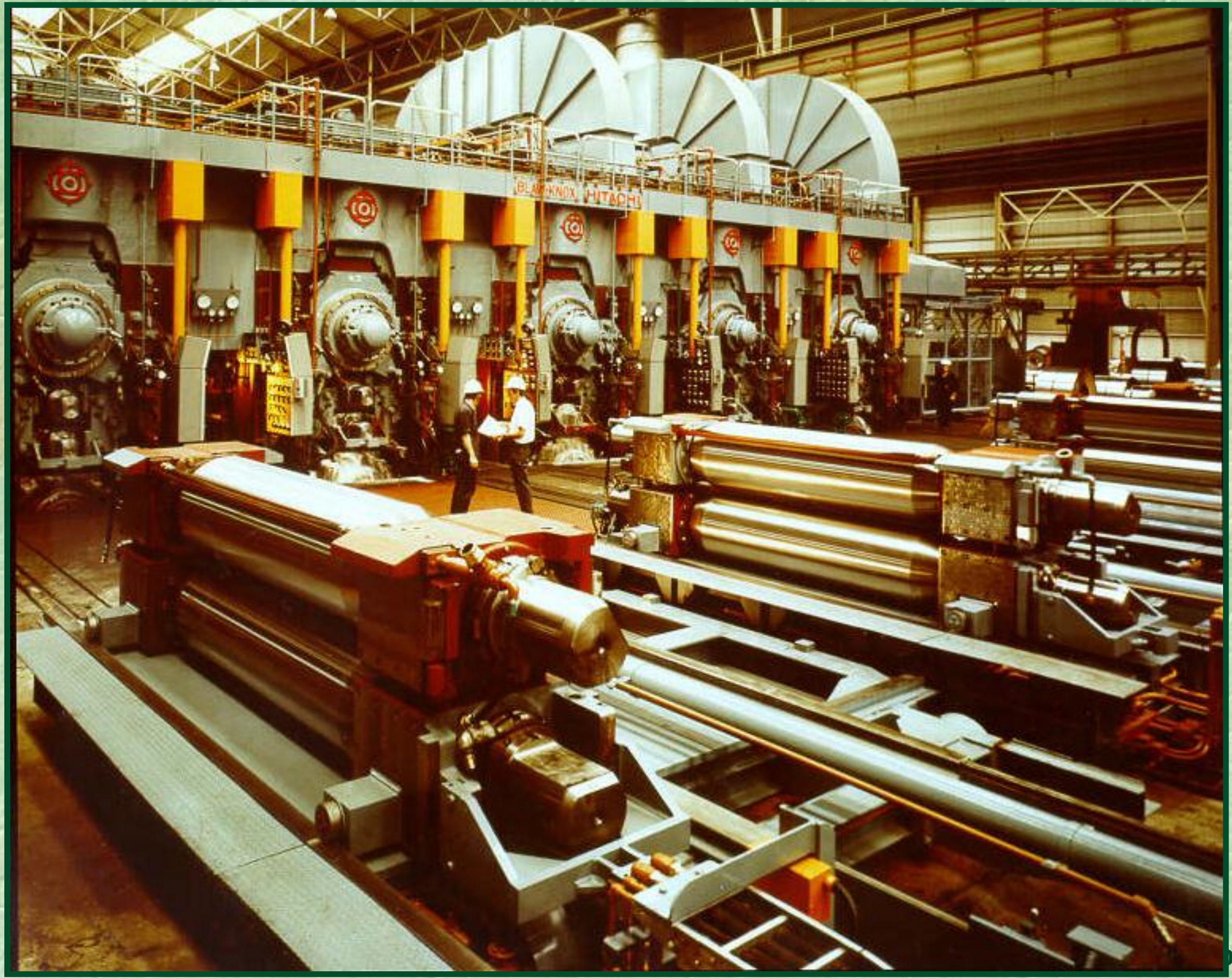
As an example consider the ballet in an aeroplane or the fan in a room.

Typical flatness control set-up for rolling mill

A typical industrial control problem will usually involve many different actuators - see below:



A modern rolling mill



Computing

In modern control systems, the connection between sensors and actuators is invariably made via a computer of some sort.

Thus, computer issues are necessarily part of the overall design.

Current control systems use a variety of computational devices Including PLC's (Programmable Logic Controllers), PC's (Personal Computers), microcontrollers, etc.

In Summary

In summary:

Sensors provide the eyes and actuators the muscle but control science provides the finesse.

In Summary

- **Better Sensors**

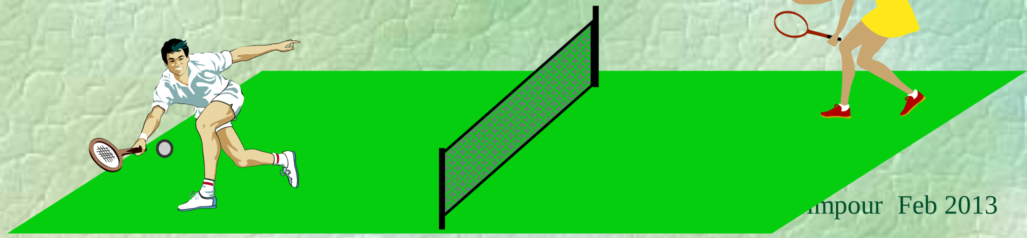
  Provide better *Vision*

- **Better Actuators**

  Provide more *Muscle*

- **Better Control(Computing)**

  Provides more finesse by combining *sensors* and *actuators* in more intelligent ways



Disturbances and Uncertainty

One of the things that makes control science interesting is that all real life systems are acted on by noise and external disturbances. These factors can have a significant impact on the performance of the system.

As a simple example, aircrafts are subject to disturbances in the form of wind-gusts, and cruise controllers in cars have to cope with different road gradients and different car loadings.

Control System Design process

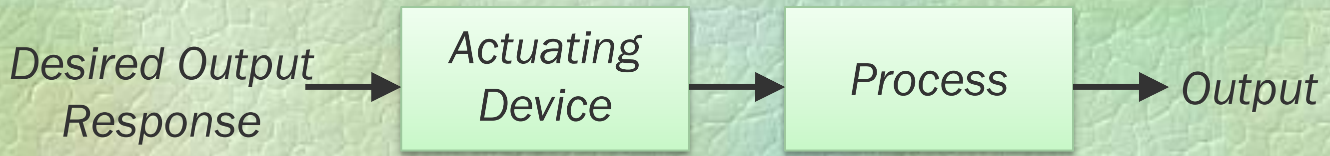
1. Establish control goals
2. Identify the variables to control
3. Write the specifications for the variables
4. Establish the system configuration and identify the actuator
5. Obtain a model of the process, the actuator and the sensor
6. Describe a controller and select key parameters to be adjusted
7. Optimize the parameters and analyze the performance

If the performance does not meet specifications, then iterate the configuration and actuator

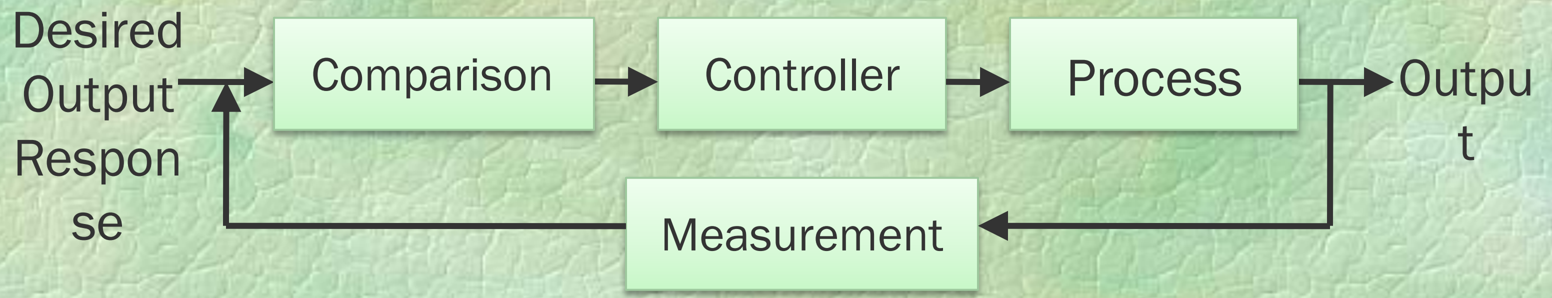
If the performance meet the specifications, then finalize design

Control System Classification

- An open-loop control system utilizes an actuating device to control the process directly without using feedback.

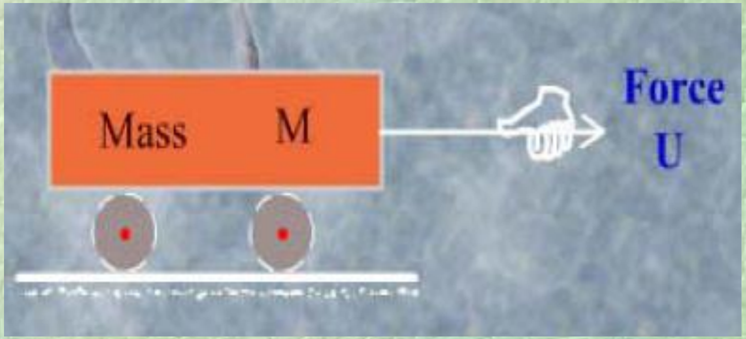


- A closed-loop feedback control system uses a measurement of the output and feedback of the output signal to compare it with the desired output or reference.



Exercises

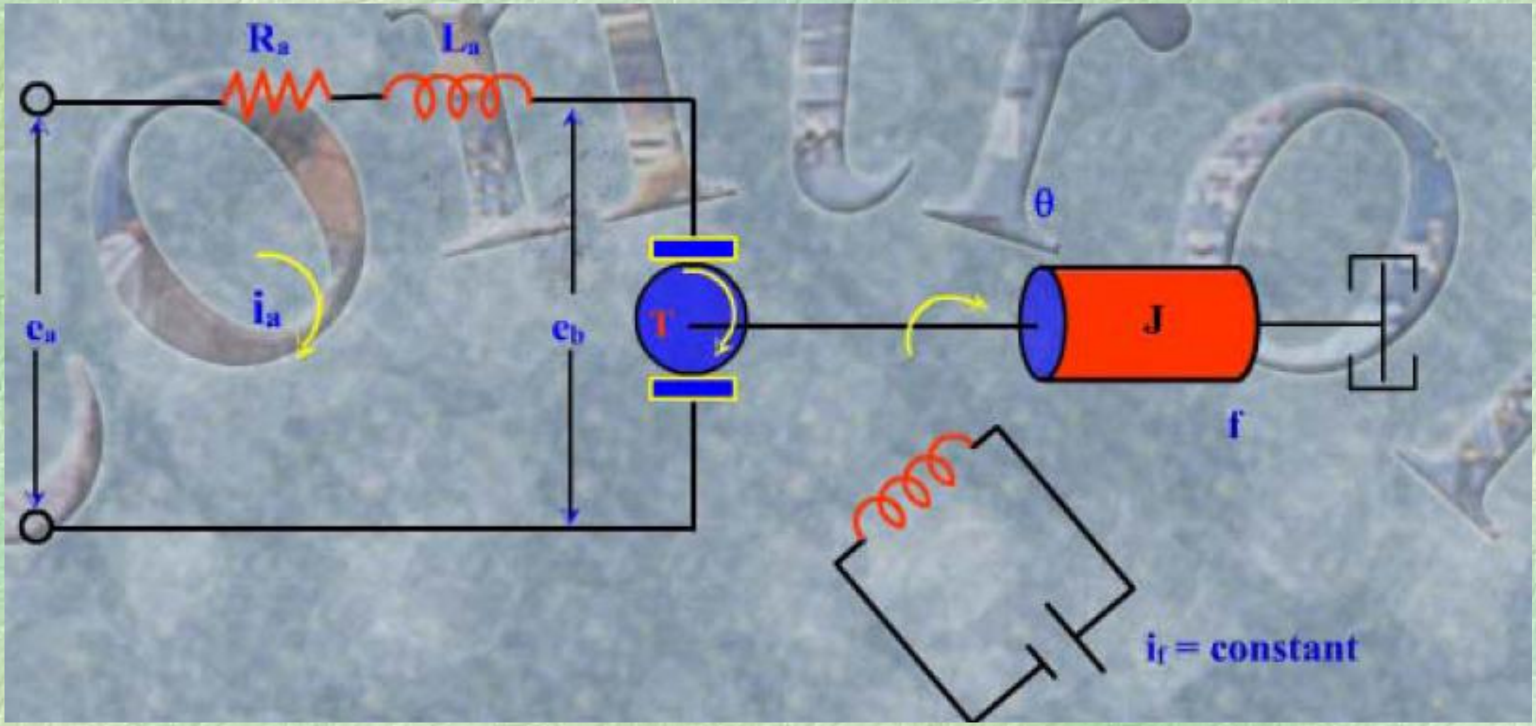
1-1 Specify the actuator in following system.



1-2 Specify the disturbance in the system of exercise 1-1.

Exercises (Continue)

1-3 Specify the actuator (input) and sensor in following system.



1-4 Specify the disturbance in the system of exercise 1-3.