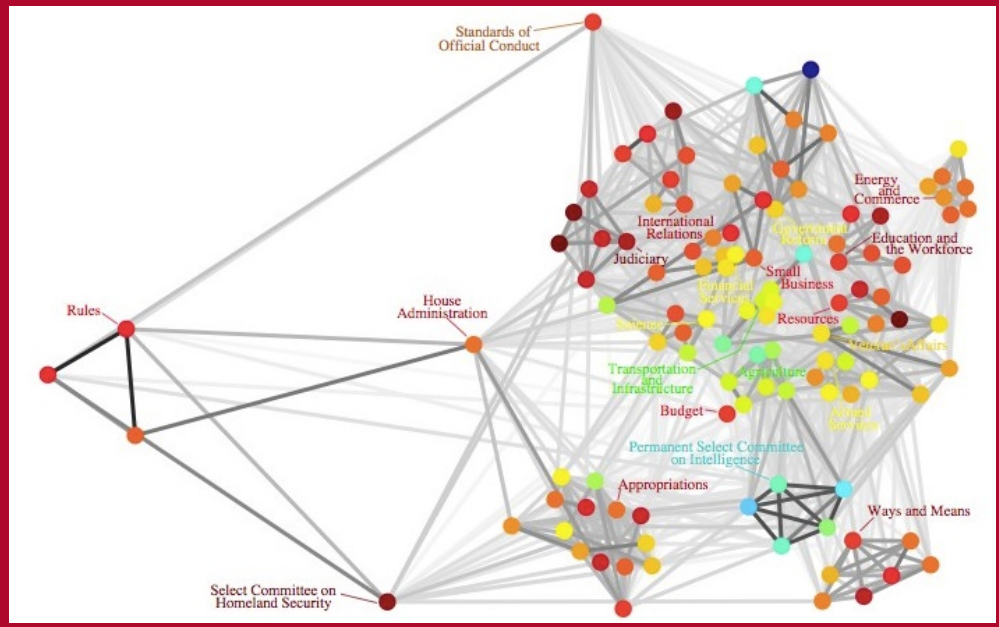
Automatic Control Theory

Chapter 1



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Who is the lecturer?

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  - Mobile phone: 15736167898

Property, Objective and Requirement

课程性质：专业发展课/必修课

适用专业：自动化

开课学期：4学期

课程学时：117学时（理论 90，实验 27）

课程学分：6学分

先修课程或需要的基本知识：高数、大学物理、电子技术、线性代数、电路、复变函数与积分变换、自动化概论

课程目的：掌握控制理论的基本原理和基本概念，能够运用控制理论的基本方法对控制系统进行定性分析与定量计算，并提高学生的系统分析与设计能力

Reference Books

1. Richard C. Dorf, 现代控制系统（第九版），科学出版社
2. Gene F. Franklin,J. Da Powell,Abbas Emami-Naeini，Feedback Control of Dynamic Systems (7th Edition), Prentice Hall
3. 程鹏　自动控制原理(第二版),高等教育出版社
4. 吴麒　自动控制原理，清华大学出版社
5. Benjamin C. Kuo, Automatic control systems, John Wiley & Sons, Inc.
6. 胡寿松 自动控制原理(第四版)，科学出版社
7. 胡寿松主编.自动控制原理（第四版）.北京:科学出版社.2001.02.

Assessment, Scores Evaluation

考核方式及成绩评定

1. 考核方式：考试

2. 总成绩评定：

本课程考核采用考试方式，课程最终成绩由**平时成绩（20%）**、**实验成绩（20%）**和**理论考查成绩（60%）**构成。

3. 平时成绩评定：

（1）课堂表现（40%）：学生主动参与课堂练习、讨论，创造性地提出问题的能力 ；

（2）作业完成情况（30%）：学生平时作业提交次数及完成质量；

（3）考勤（30%）。

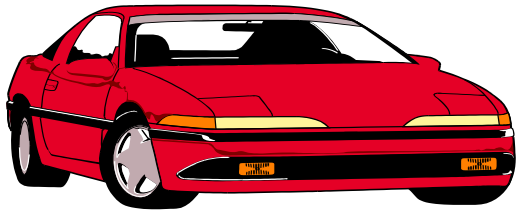
4. 期末考试：闭卷

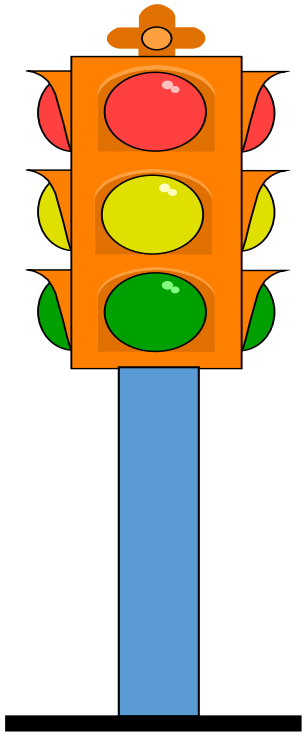
Chapter 1: Introduction to Automatic Control

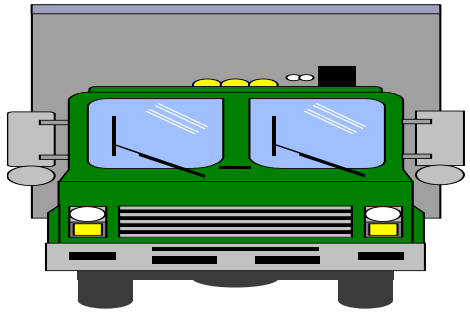
- What is a control system?
- Why are control systems important?
- What is an automatic control system?
- Basic components and types of control system.
- How to evaluate a control system?
- The development of control theory.

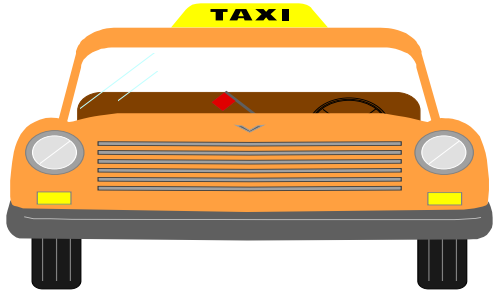
What is a control system?

Examples









Control of Traffic Lights

Definition of a control system

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

(由相互关联的部件按一定的结构构成的系统，能够提供预期的系统响应)

Why are control systems important?

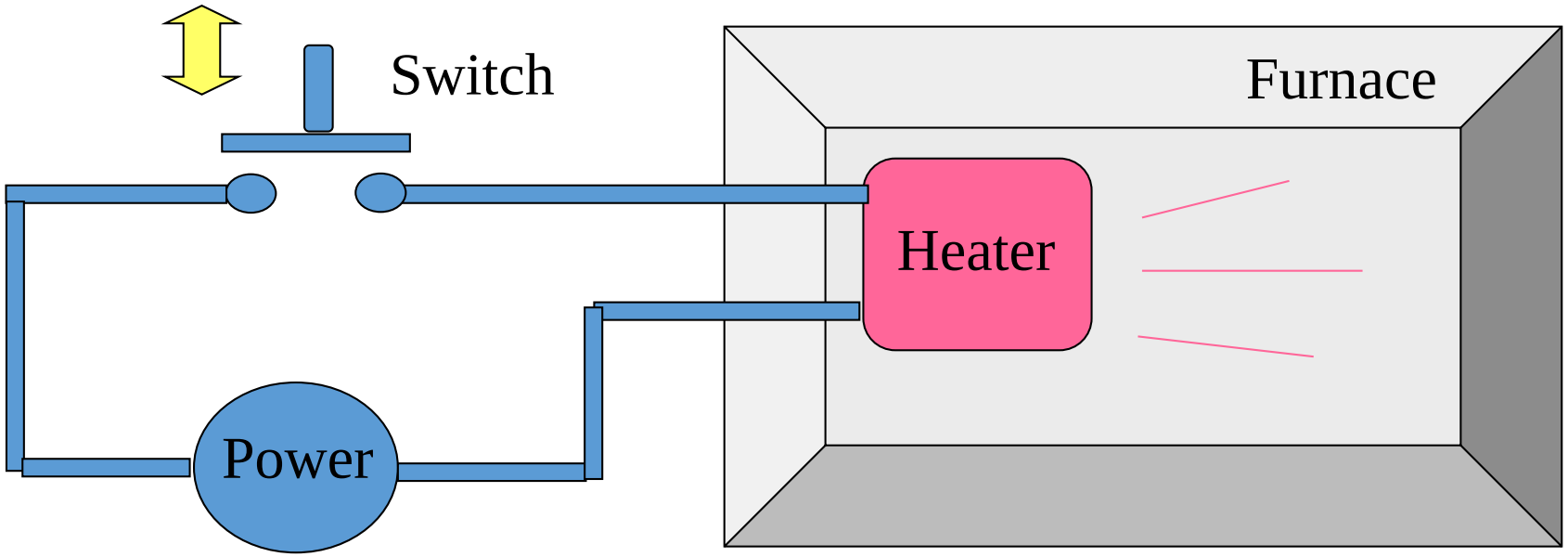
(1) 控制系统无处不在.

(2) 提高产量，降低成本.

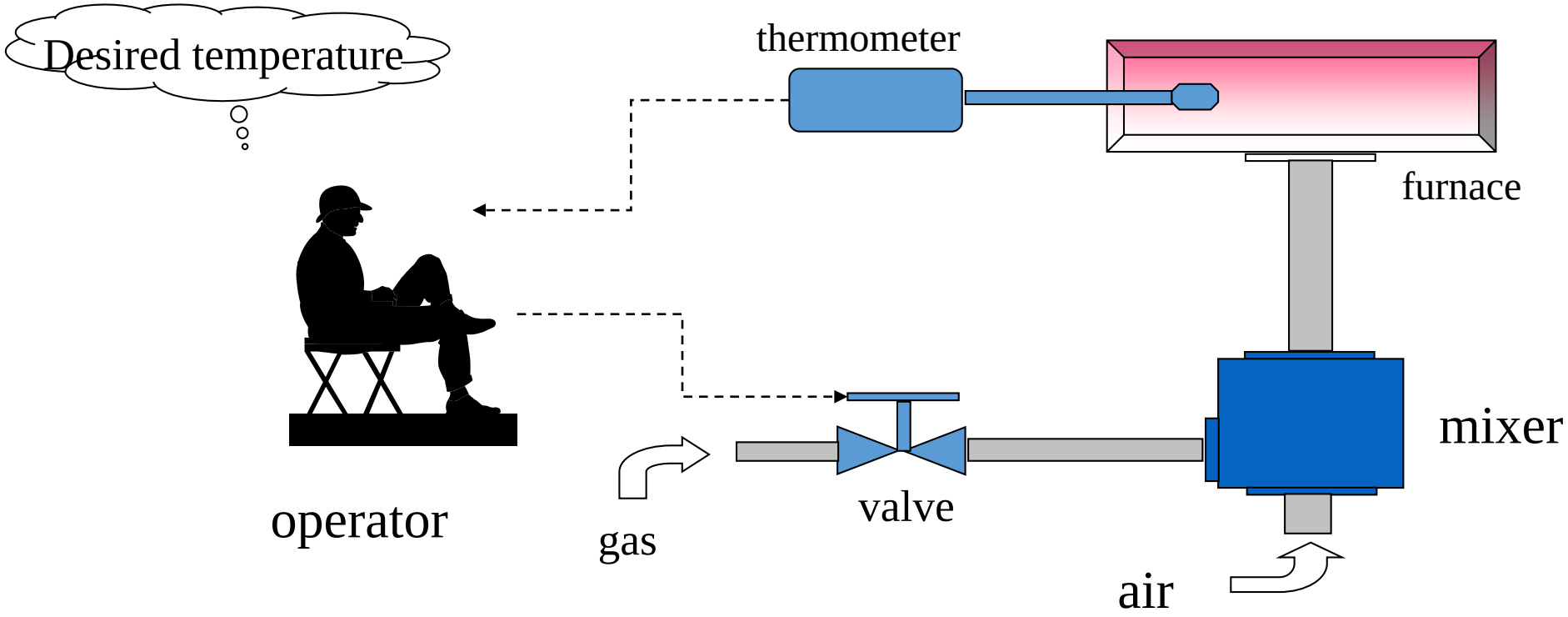
(3) 提高精度、可靠性.

(4) 能够在许多人不到达的场所发挥作用.

Furnace temperature control system



Temperature control system



Definition of automatic control system

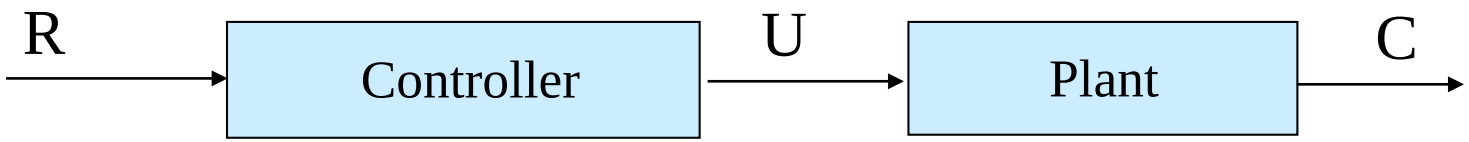
A control system **without** people involved is called **automatic** control system.

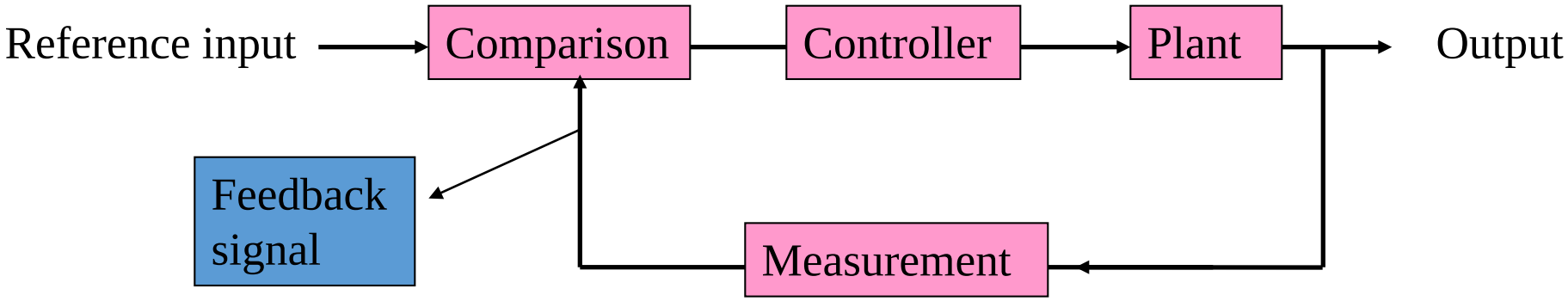
Basic components of control systems

- **被控对象（plant, process）** 区分被控对象和被控量 热机/空气

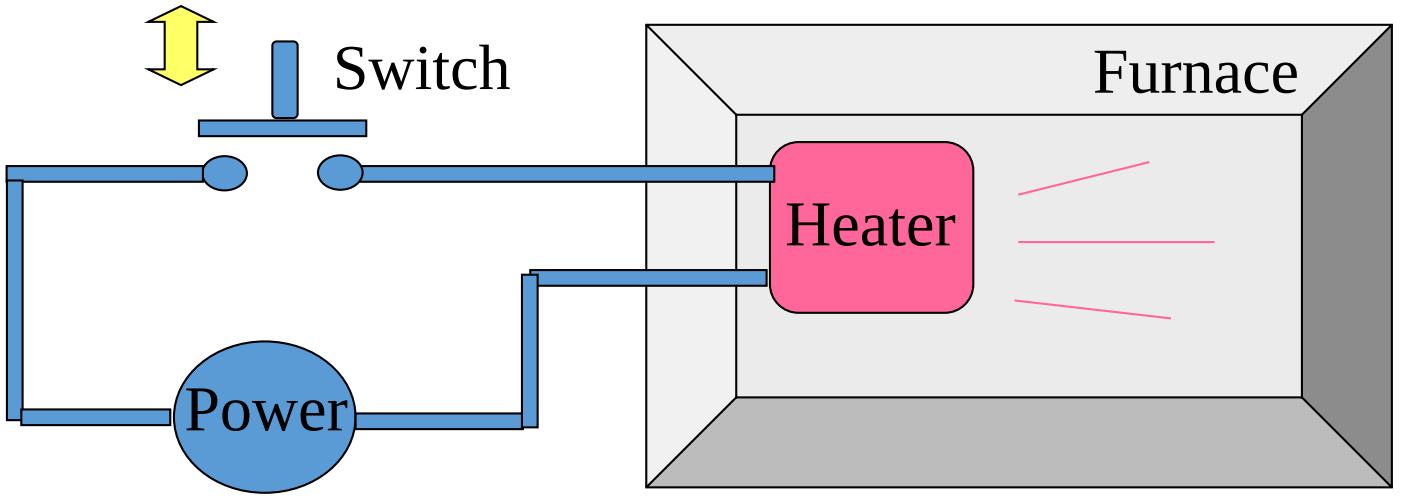
- **测量元件（sensor）** 传感器
  - 可以对被控量进行测量，并转换成能与输入信号进行比较的量纲和数值，也称为反馈元件；
- 比较环节（comparison） 自动控制中 用其他代替人
  - 实现误差检测；
- **执行机构（actuator）**
  - 实现对受控对象的操控，起到功率放大的作用。
- **控制律或控制算法（algorithm):**
  - 控制器的核心。

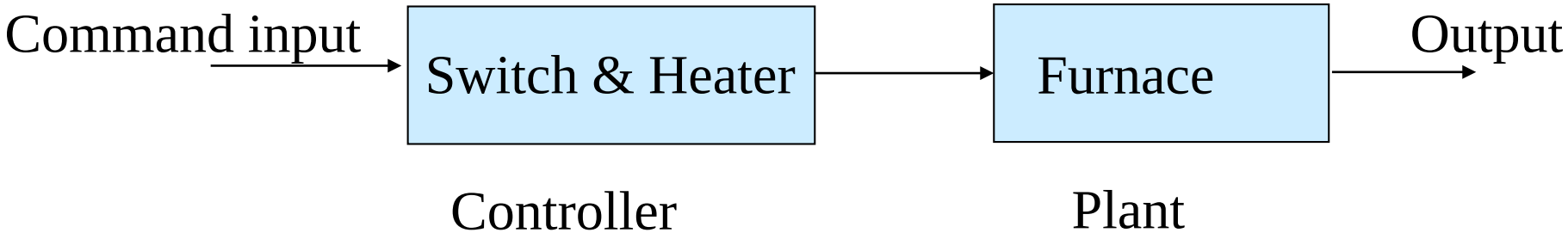
Block diagram of control systems





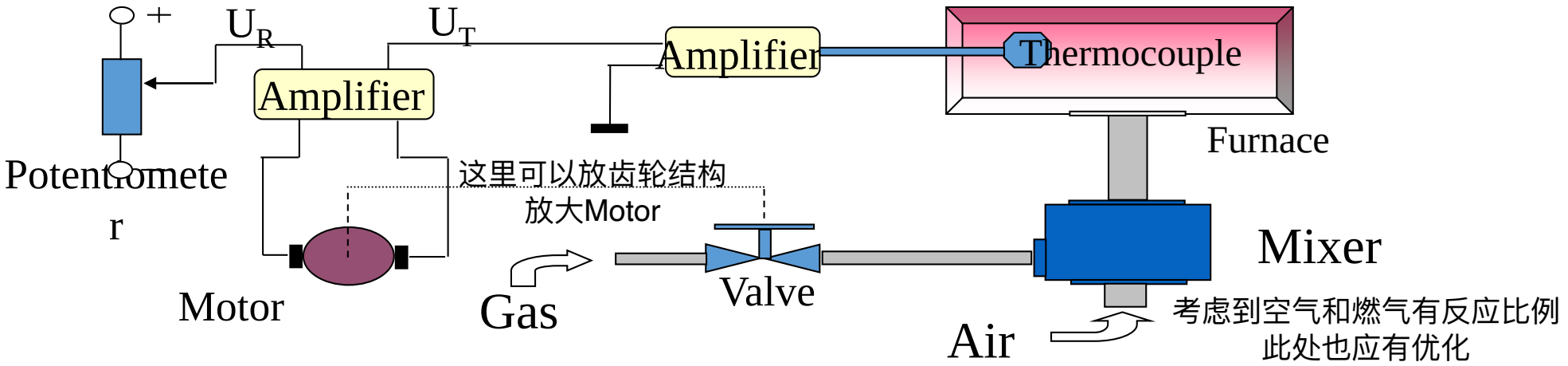
Furnace temperature control system

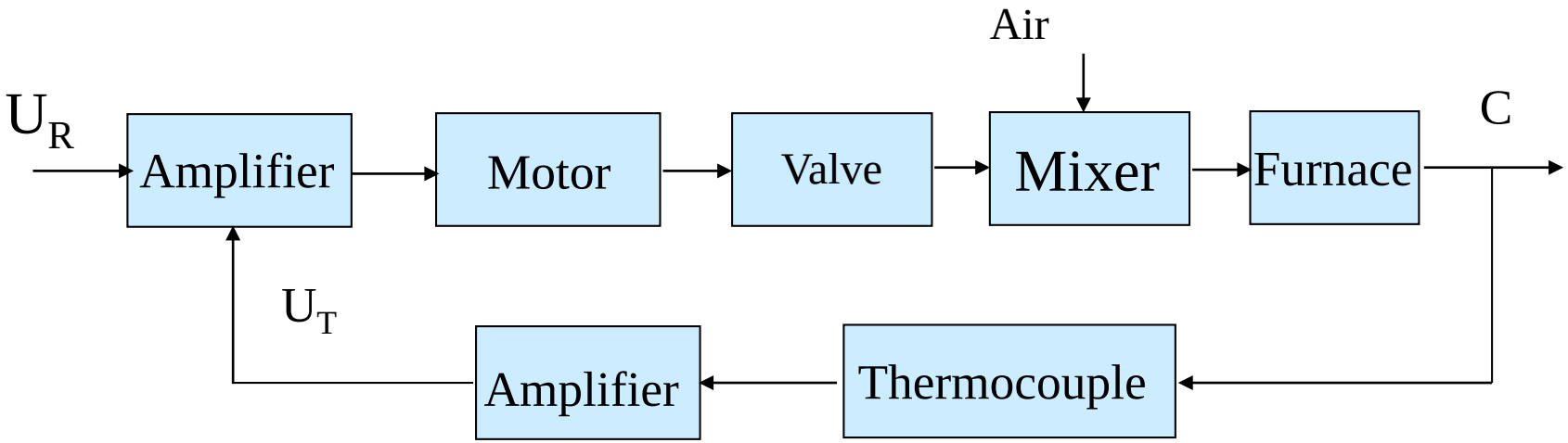




Temperature control system

假设UT<UR
Motor正向转动
阀门变大
假设UT>UR
Motor反向转动
阀门变小



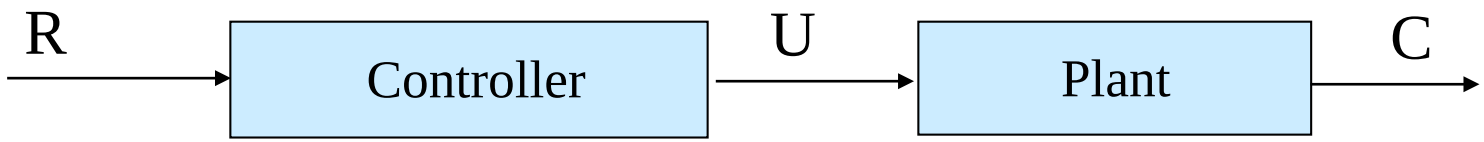


Open loop control

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

- 开环控制(Open-loop Control)——系统的输出端与输入端之间不存在反馈回路，输出量对系统的控制作用没有影响。

Open-loop Control System



The output of the open-loop system has **no effect** upon the input signal.

There is the need to know an accurate model of individual components.

建立精确模型 适合使用

Features of open-loop control

- **优点**：

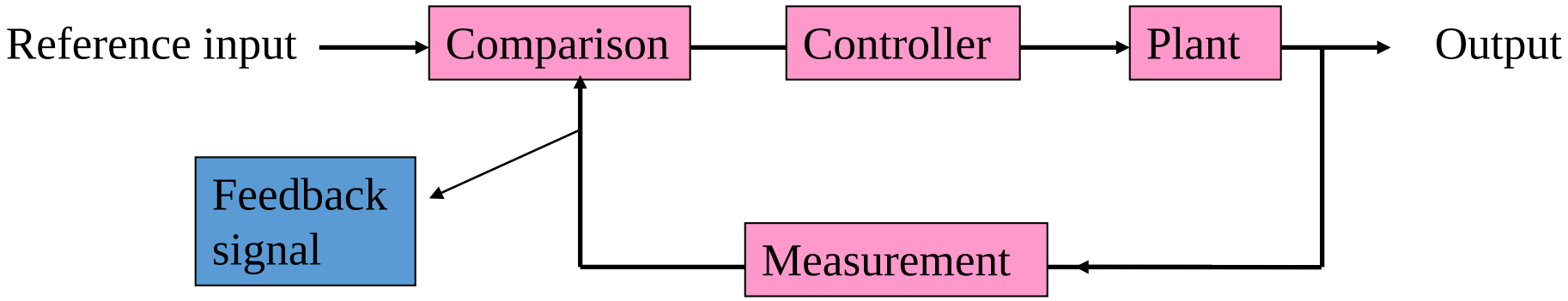
  简单，相对来说成本低

- **缺点**：

  对可能出现的被控量偏离给定值的偏差**没有任何修正能力**，抗干扰能力差，控制精度不高。

Closed-loop control systems

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



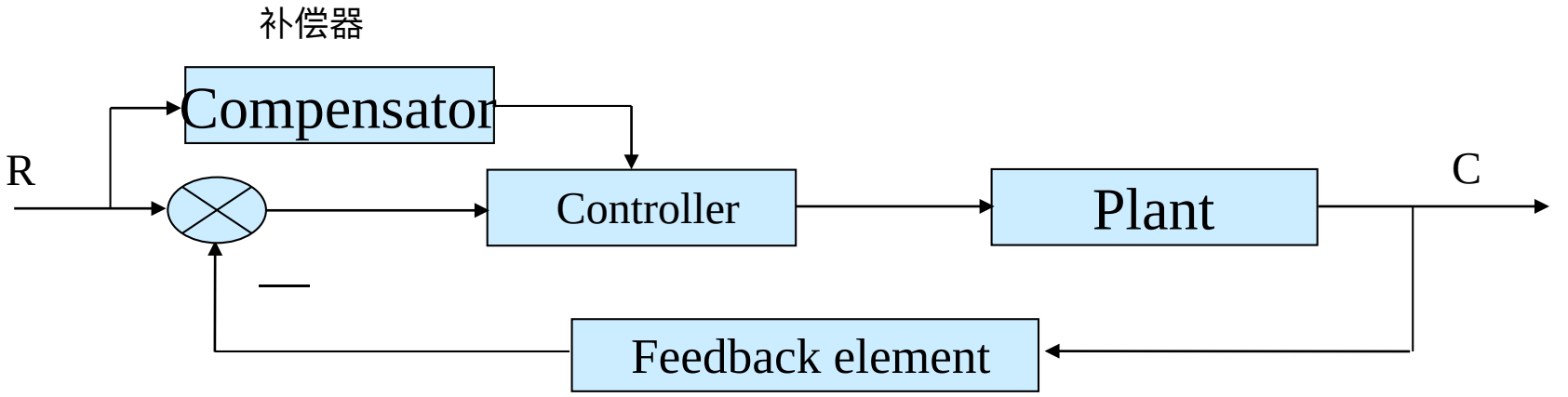
Features of feedback control systems

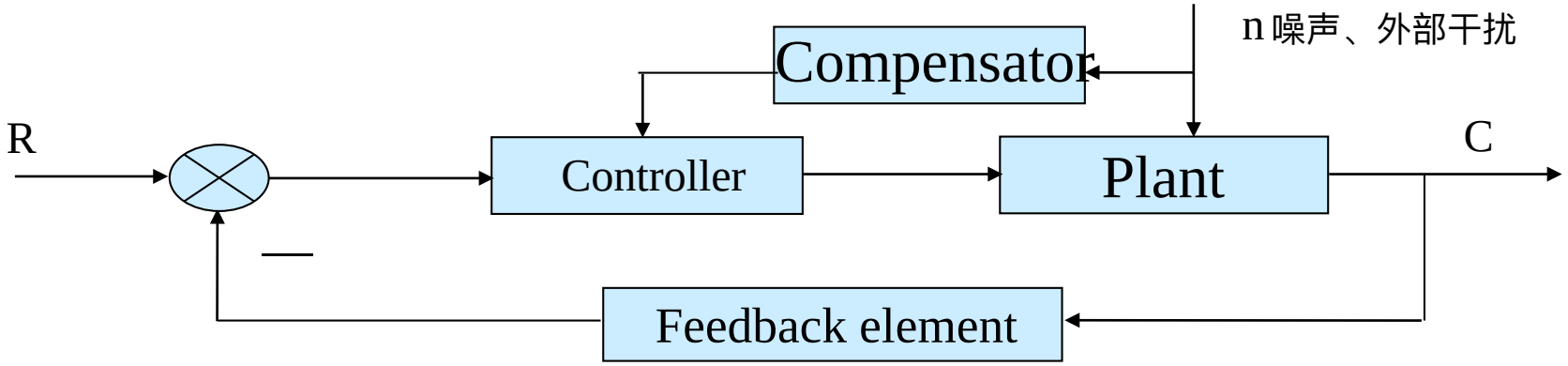
- **优点：**
- 抗干扰能力强，控制精度高

- **缺点：**
- 复杂，有时会产生不稳定。

Compound Control systems

Combination of open-loop and closed-loop





Objectives of control

目标/参考输入

The objectives of the control system is to control the outputs in some prescribed manner by the inputs through the elements of control systems.

In general, the objectives can be identified with inputs.

通常目标规定为系统的输入。

Analysis of automatic control system

Step1 确定系统任务；

Step2 明确：被控对象、被控量、给定值、测量元件、执行机构和比较元件；

还原论：把整体分到部分最小单元到整体
（相反的）系统论：例 人工智能深度学习

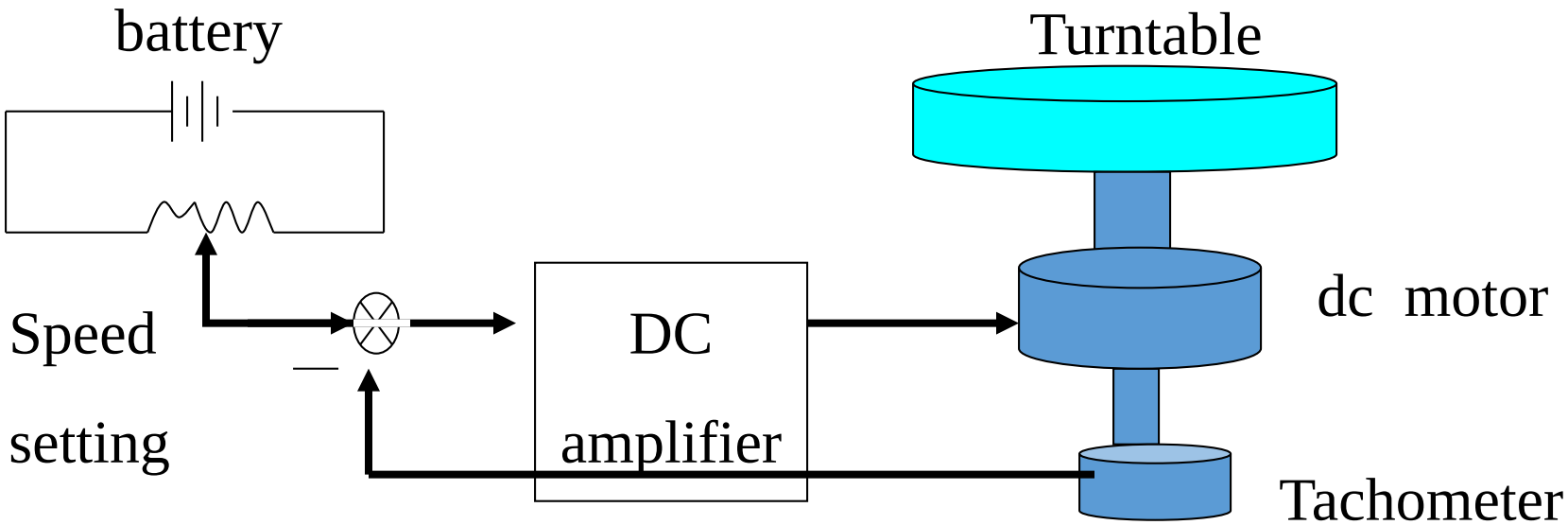
Step3 叙述系统工作原理；

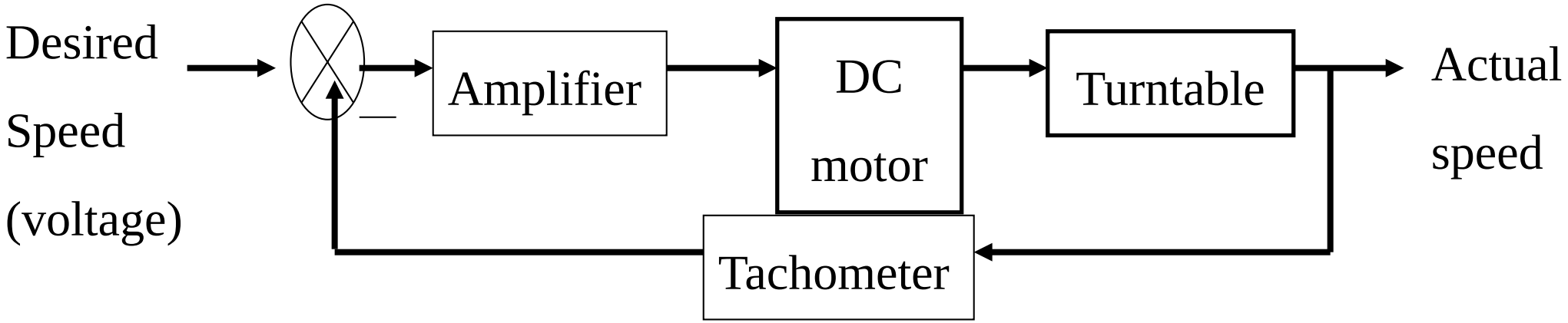
Step4 系统原理方框图。

Terms

1. 被控对象（plant）
   指被控制的设备或过程
2. 控制器（控制装置controller）
   除了被控制对象之外的各部分的组合
3. 控制系统(control system)
   受控对象与控制装置构成控制系统
4. 给定值（期望值、输入量reference/input）
   被控制量要求的变化规律
5. 被控量(controlled variable)
   被控制的物理量
6. 输出（Output）
   The response obtained from a system （通常与被控量一致。）
7. 干扰(disturbance)
   所有使被控量偏离期望值的因素
8. 反馈（Feedback）
   The output of a system that is returned to modify the input

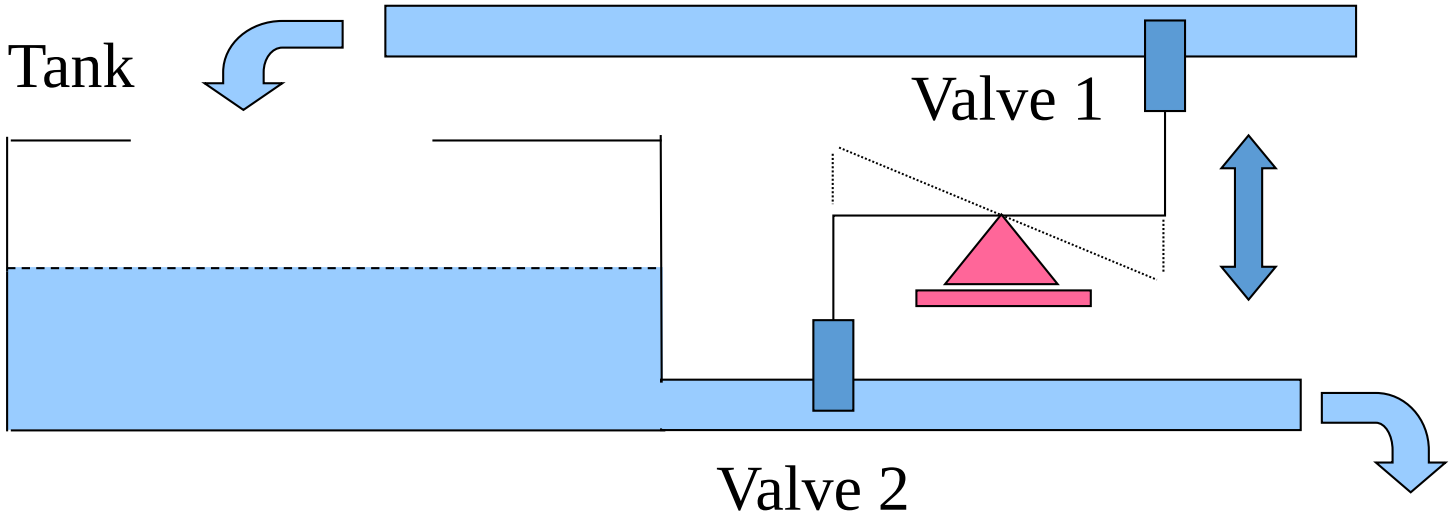
Turntable speed control

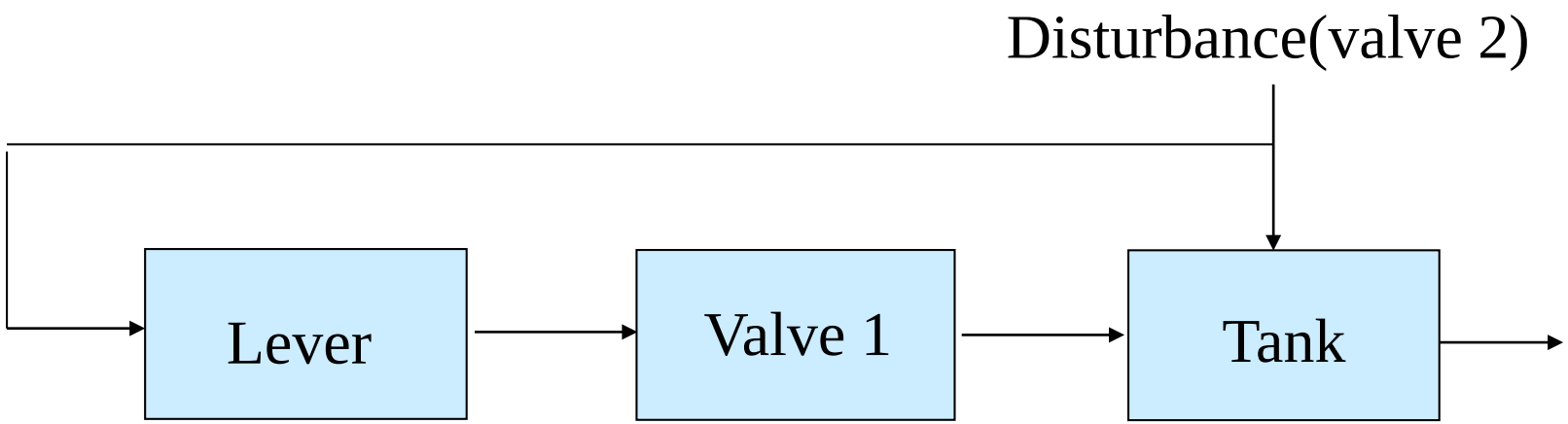




Water Level control system

该例子就不是闭环控制





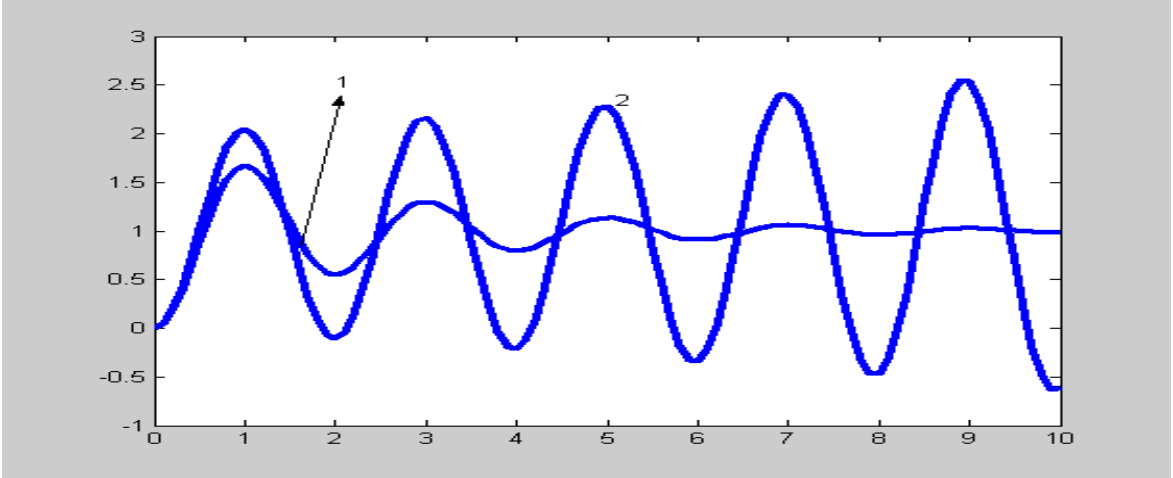
How to evaluate a control system?

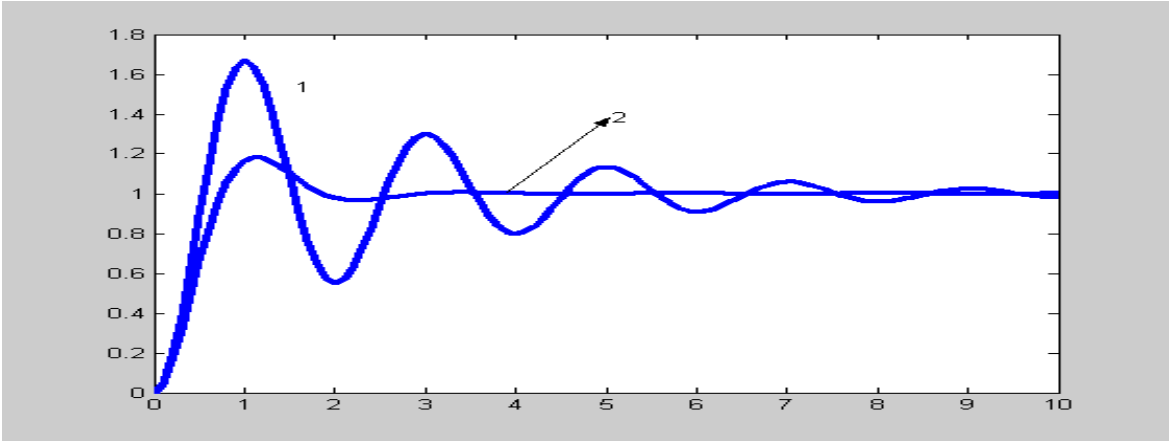
Specifications

(1) **Stability:** stability ,smooth and steady

(2) **Swiftness** :peak time, settling time

(3) **Accuracy:** steady-sate error





History of Automatic Control

1769: James Watt’ s steam engine and flyball governor.

1868: J.C.Maxwell formulates a mathematical model for a governor control of steam engine.

1932: H.Nyquist develops a method for analyzing the stability of systems.

1952: Numerical control developed at MIT for control of machine-tool axes.

1970: State-variable models and optimal control developed. (Liapunov, Minorsky,Pontryagin and Bellman)

1980: Robust control system design widely studied.

1994: Feedback control widely used in automobiles. Reliable , robust systems demanded in manufacturing.

Chapter 1: Introduction to Automatic Control

核心

- 控制系统的基本组成
- 基本的控制方式及反馈控制系统的特点
- 控制系统的性能要求

续

CH2 Mathematical Models of Systems

Automatic Control Theory

Thanks!