Control and Instrumentation

Unite code : 308EAC

Dr. Mohammad Alakhras

Text Book

W. Bolton.

'Control Engineering', 2nd Edition

Available in the library

Recommended Books

1. W. Bolton., 'Mechatronics', 2nd Edition, (Longman)
2. Curtis D. Johnson, 'Process Control Instrumentation Technology', 6th Edition, (Prentice Hall)
3. System dynamics, Ogata
4. Modern control technology : components and system, Delmar
5. Modern control engineering , Ogata
6. Advanced control engineering , Roland
7. Feedback and control system, Schaum’s series, Joseph J. Distefano

Grading

- 70% : Course work
- 30% : Final Exam
- ----------

  100%

Passing mark = 40%
provided that both CW
and EX grades are 35%
or above with overall 40%

I: 70%-100%
II-I: 60%-70%
II-II:50%-60%
III: 40%-50%

Method of Assessment

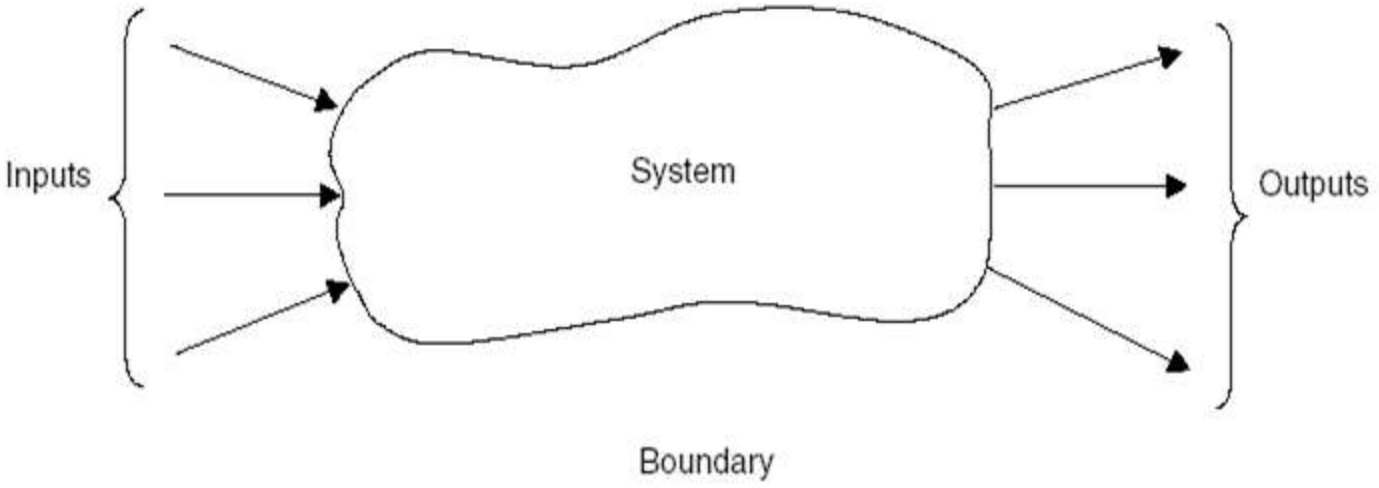
- **CW – 70%**
  - **Lab Experiments (20%)**
  - **Assignment (30%)**
  - **Quiz (20%)**
- **Final Exam (30%)**

Lecture 1

Control systems

System

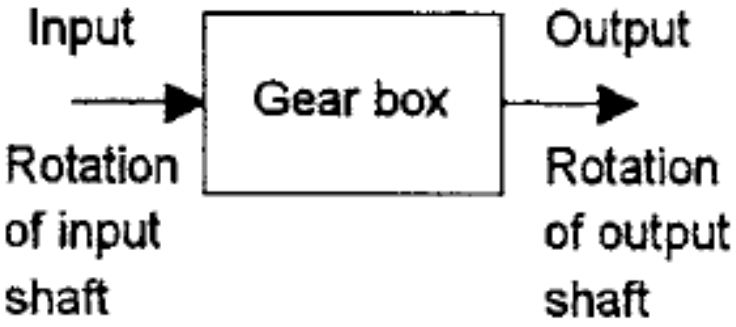
- A system is an arrangement of parts within some boundary which work together to provide some form of output from a specified input or inputs

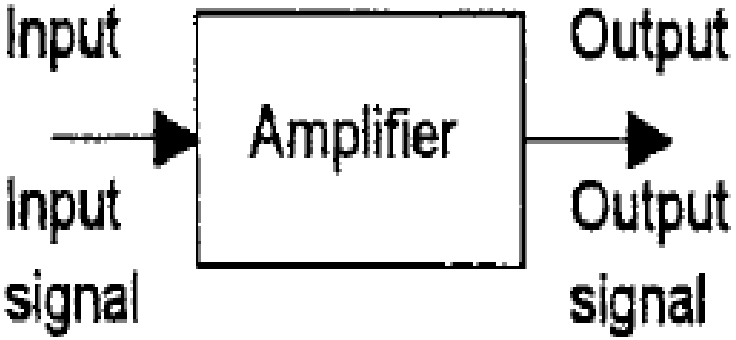


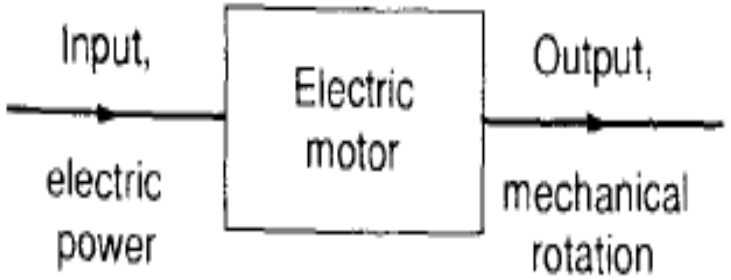
System types

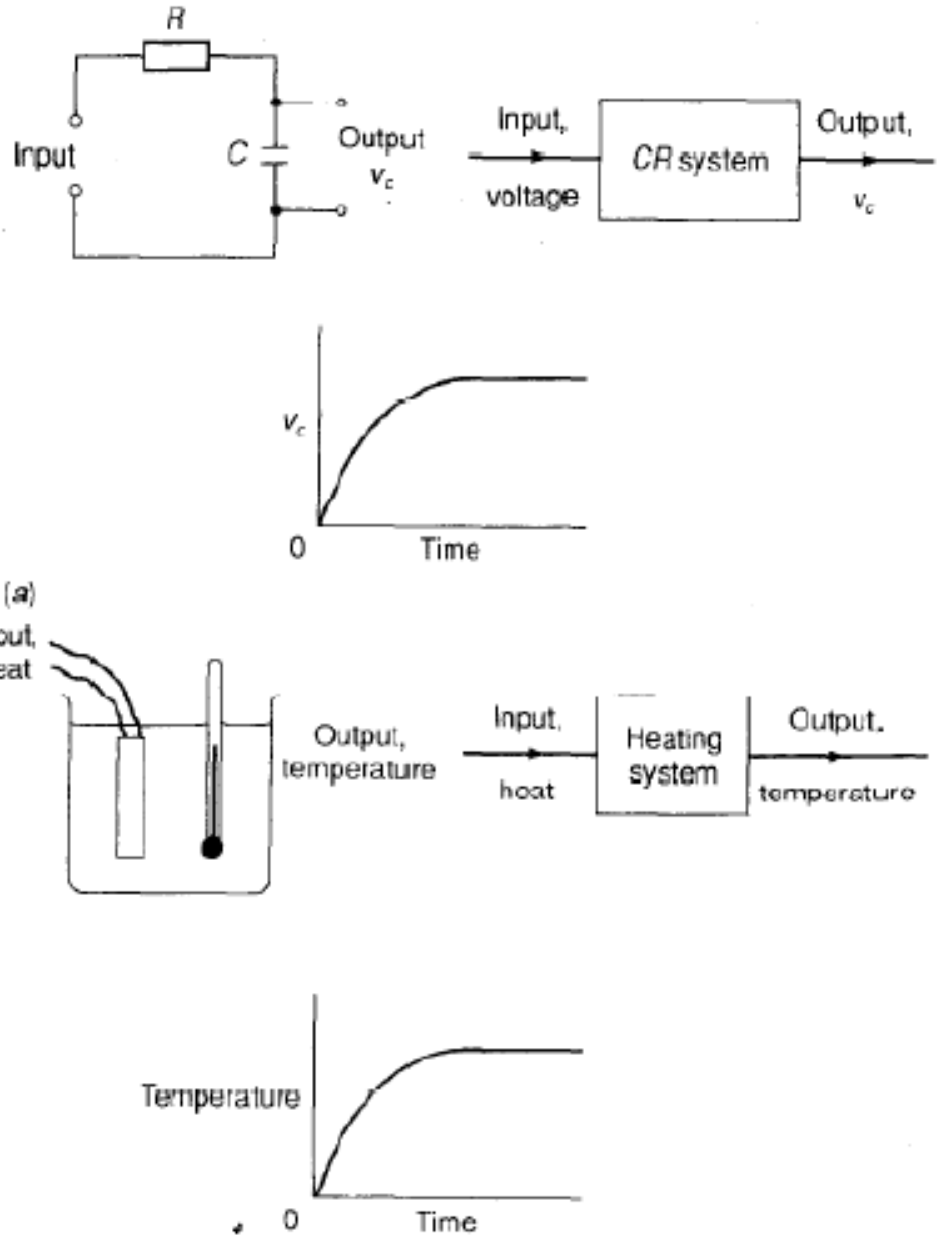
- Electrical
- Mechanical
- Thermal
- Hydraulic
- Pneumatic
- etc

Examples of Systems



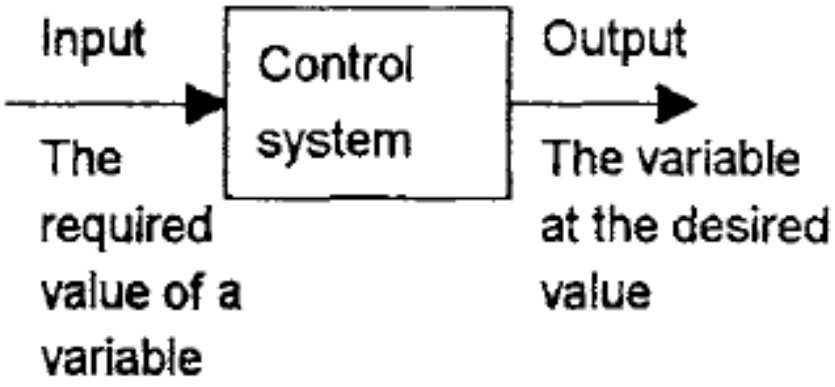




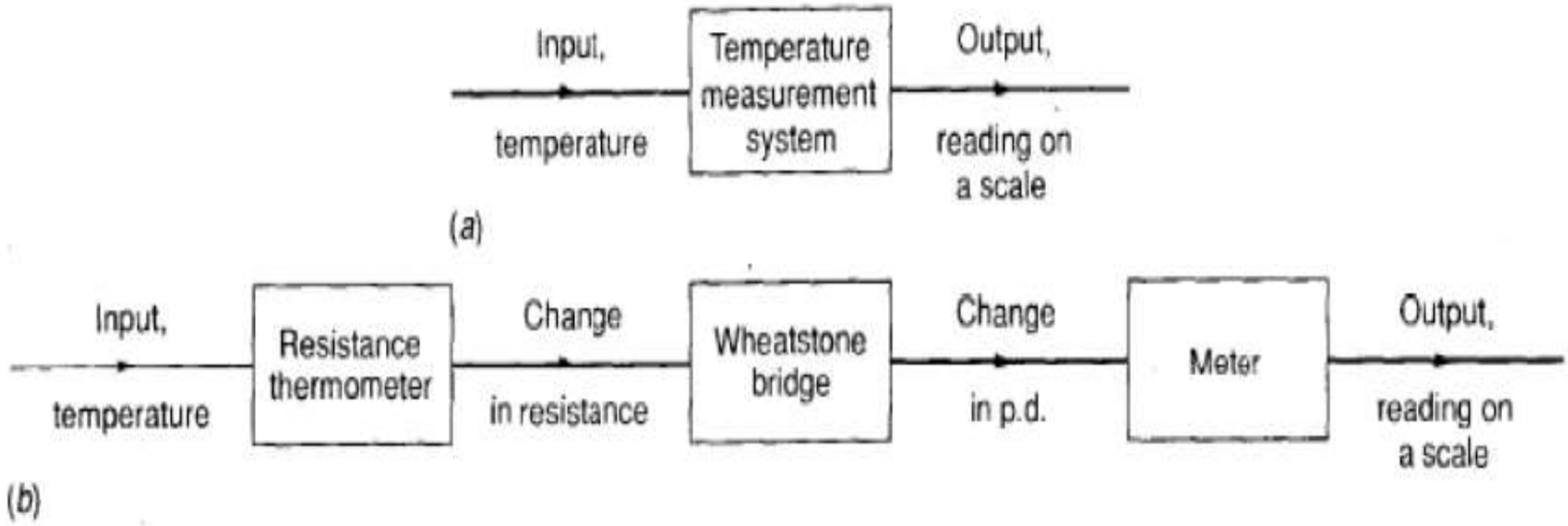

R
Input
C
Output
v_c
Input,
voltage
CR system
Output,
v_c
v_c
0
Time
(a)
Input,
heat
Output,
temperature
Input,
heat
Heating
system
Output,
temperature
Temperature
0
Time
(b)

Control system

- Control systems are systems that are used to maintain a desired result or value.
- It has an input of the required value of some variable and an output of the variable at the desired value



Examples of control systems
Temperature measurement system

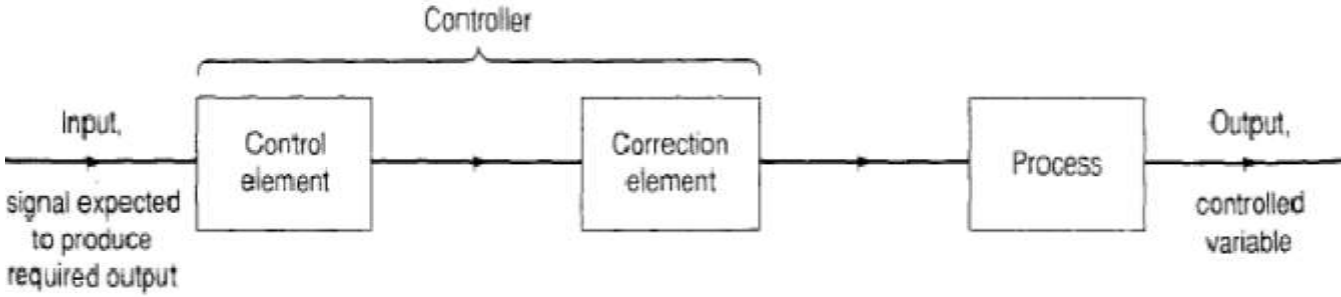


Classification of control systems

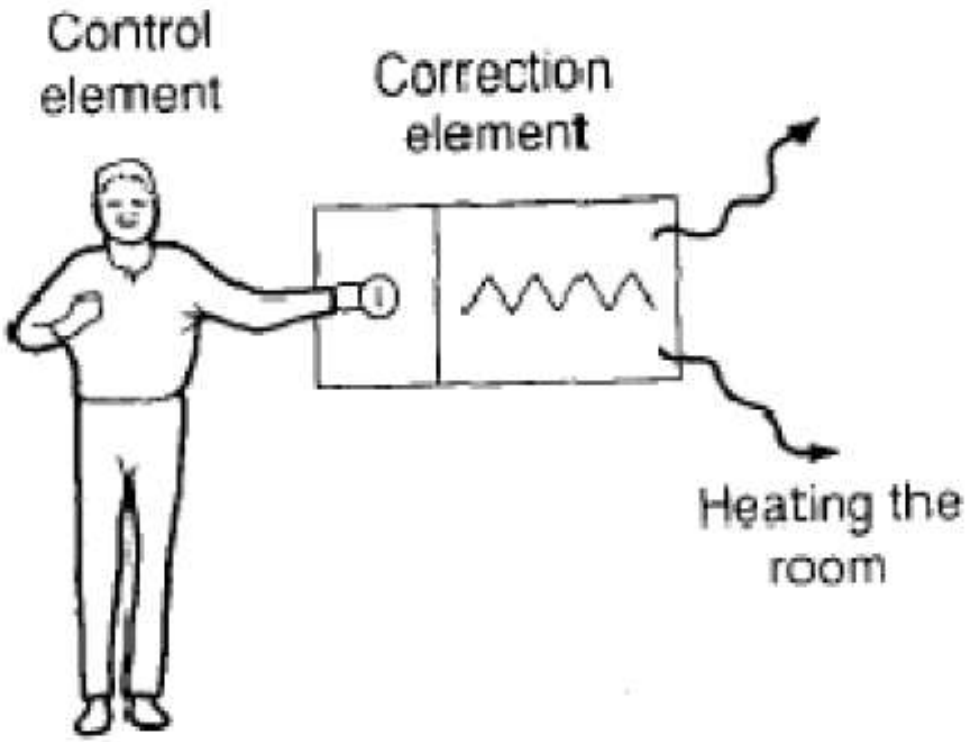
- Open loop control system
- Closed loop control system

Open loop control system

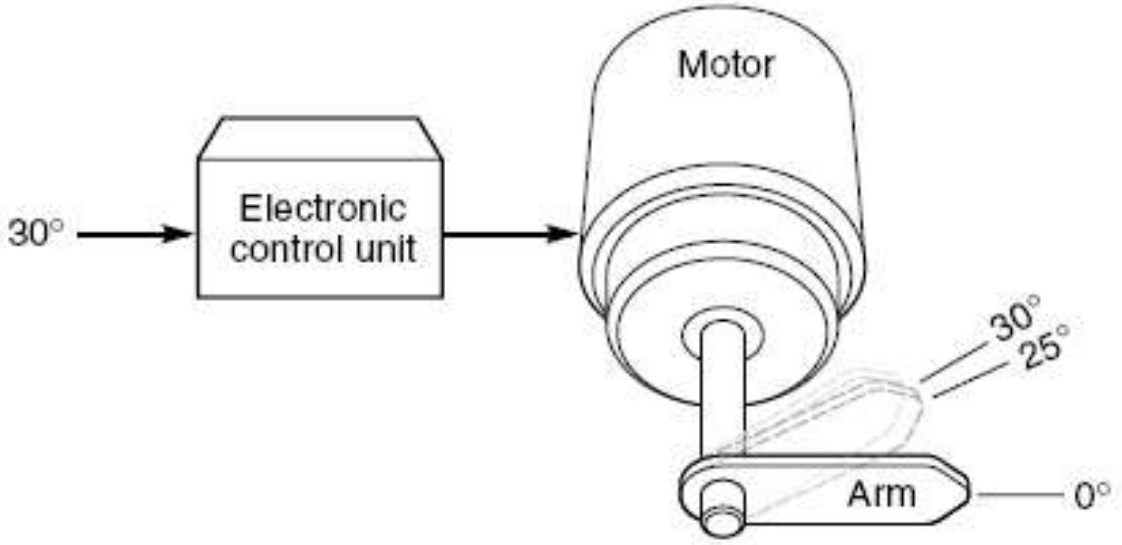
- The output variables can not change the control mechanism.
- The output variables are sensitive to any change in the disturbance input.
- Basic elements:
  - Control element
  - Correction element
  - Process

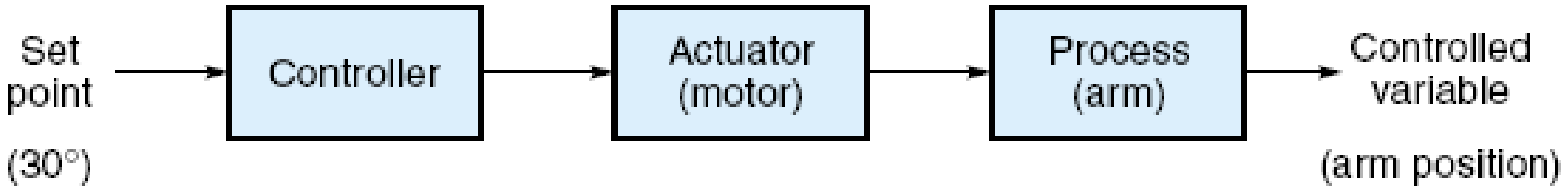


Room-temperature open loop control system



Position control system

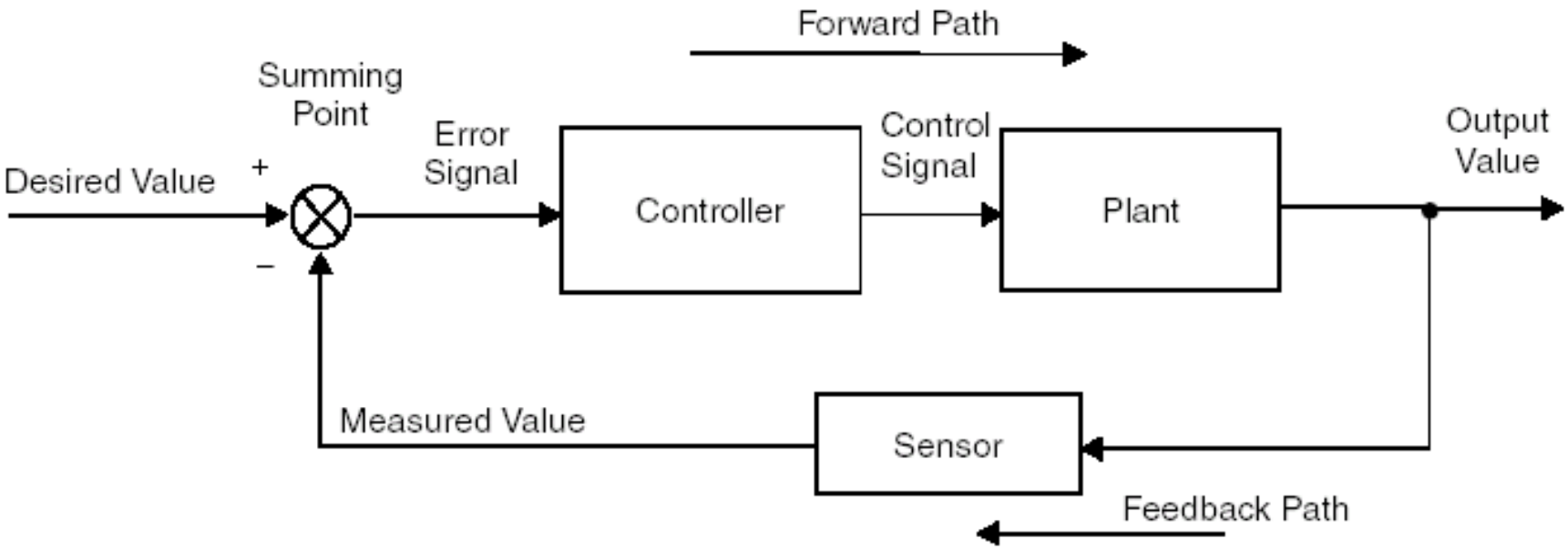




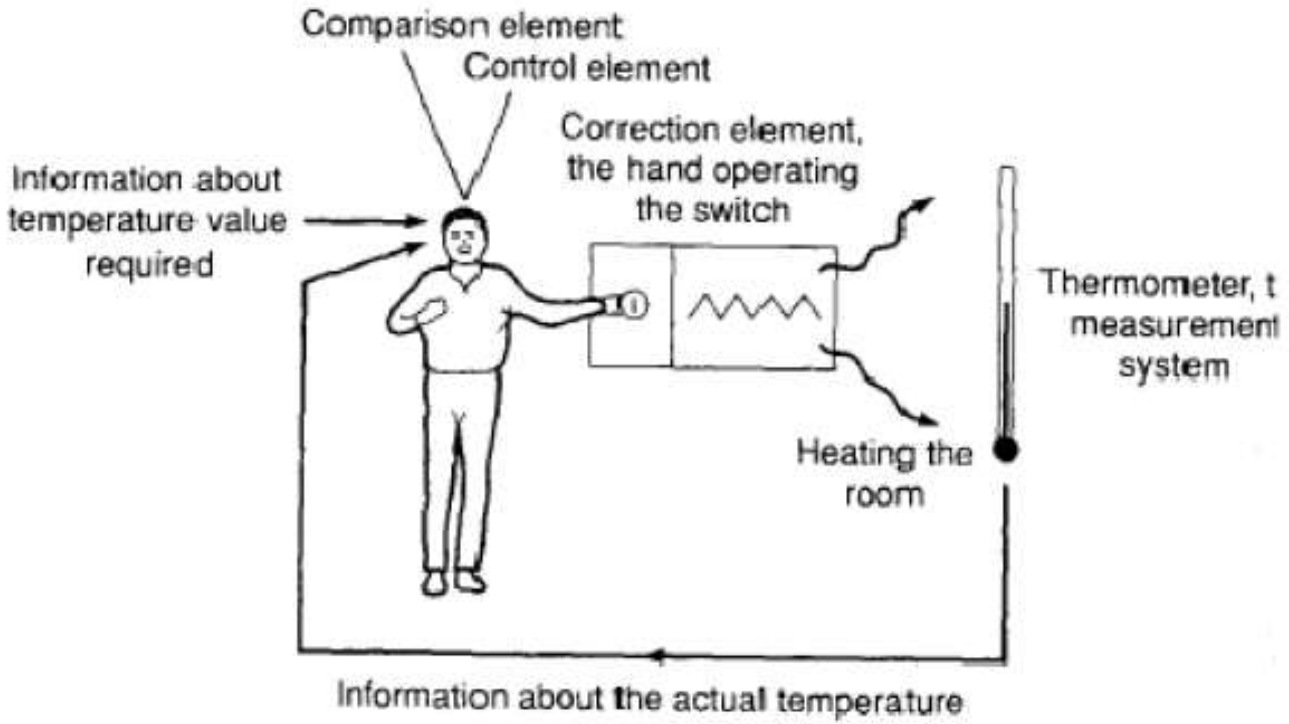
Closed loop control system

- The output variables changes the control mechanism.
- The output variables are picked up using sensors and used as inputs to the controller.
- The controller make a necessary adjustments to keep the output as desired ➔

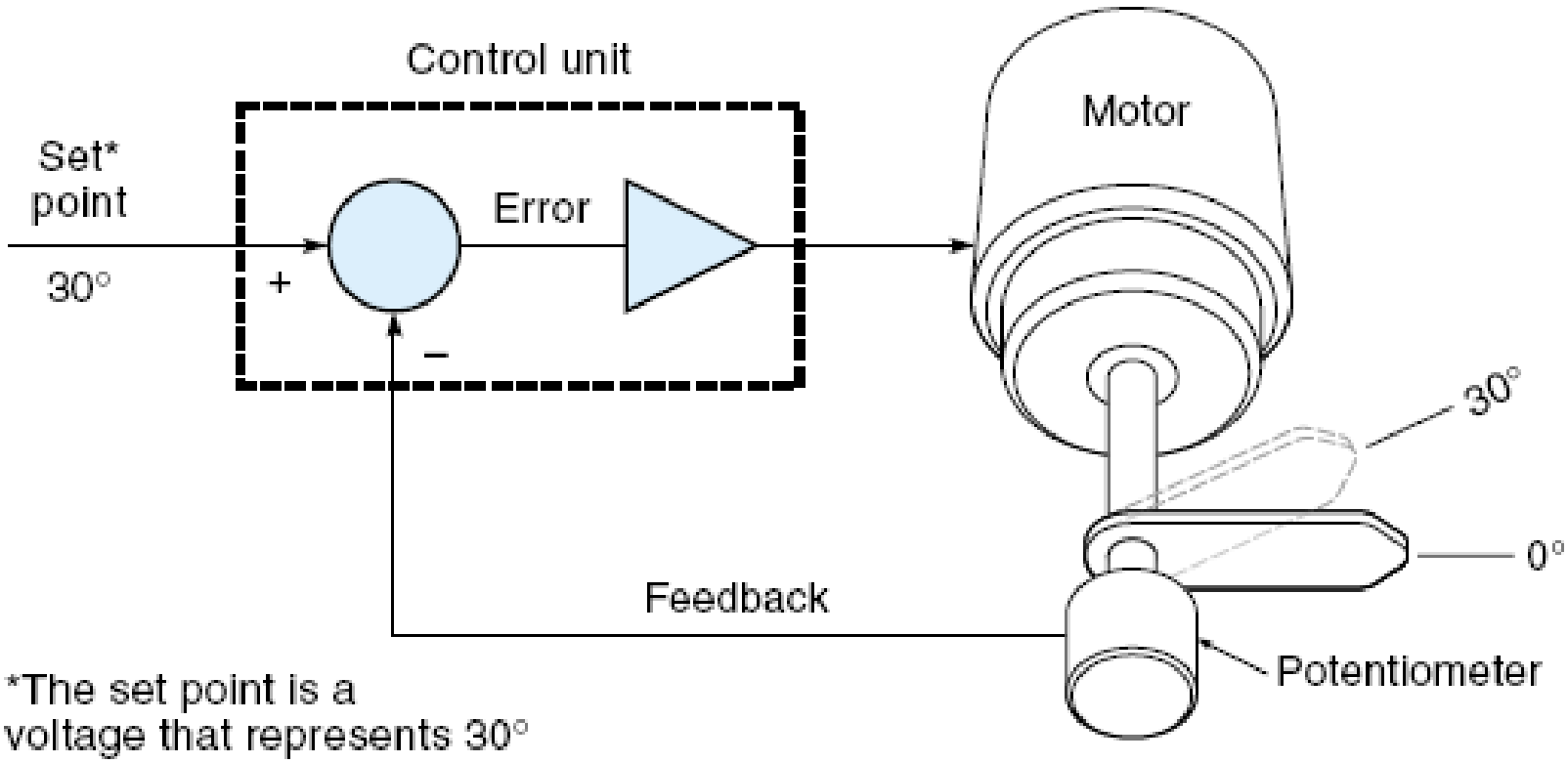
Closed loop system



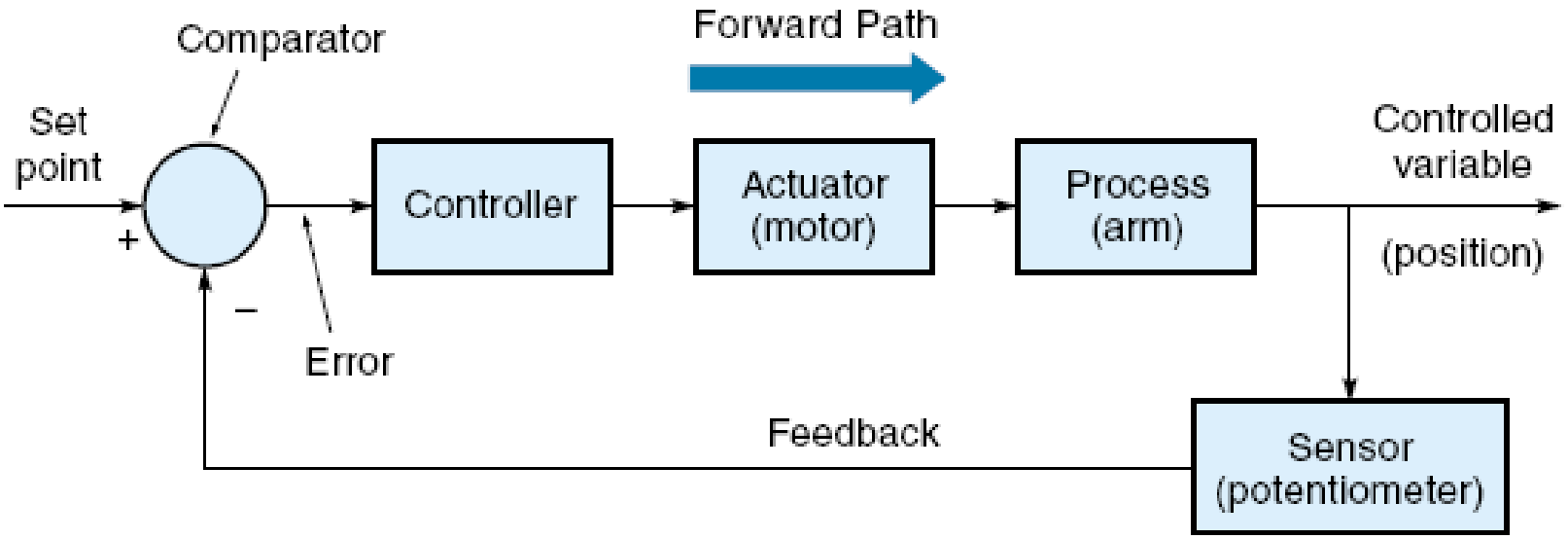
Room-temperature closed loop control system



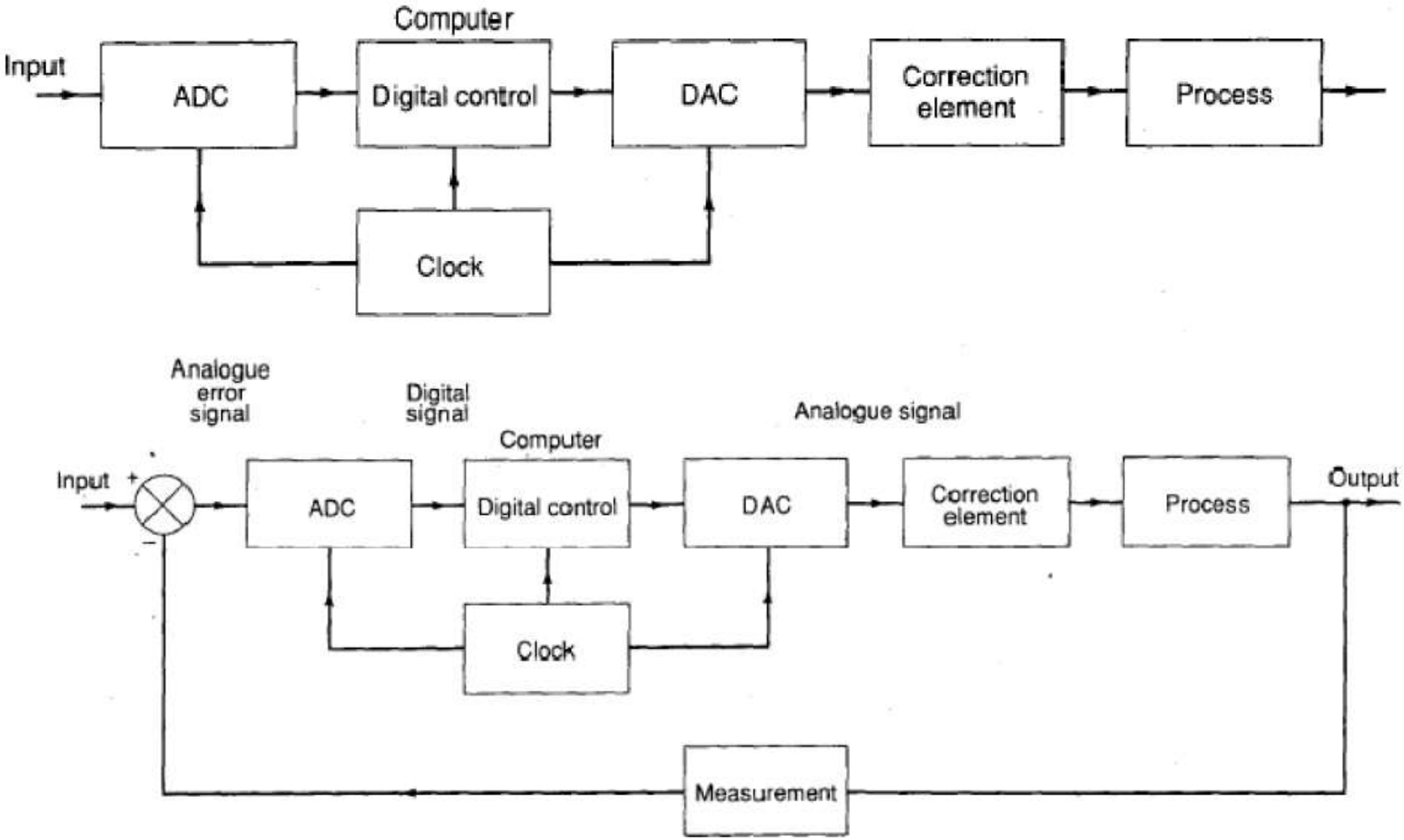
Position control system



Position control system



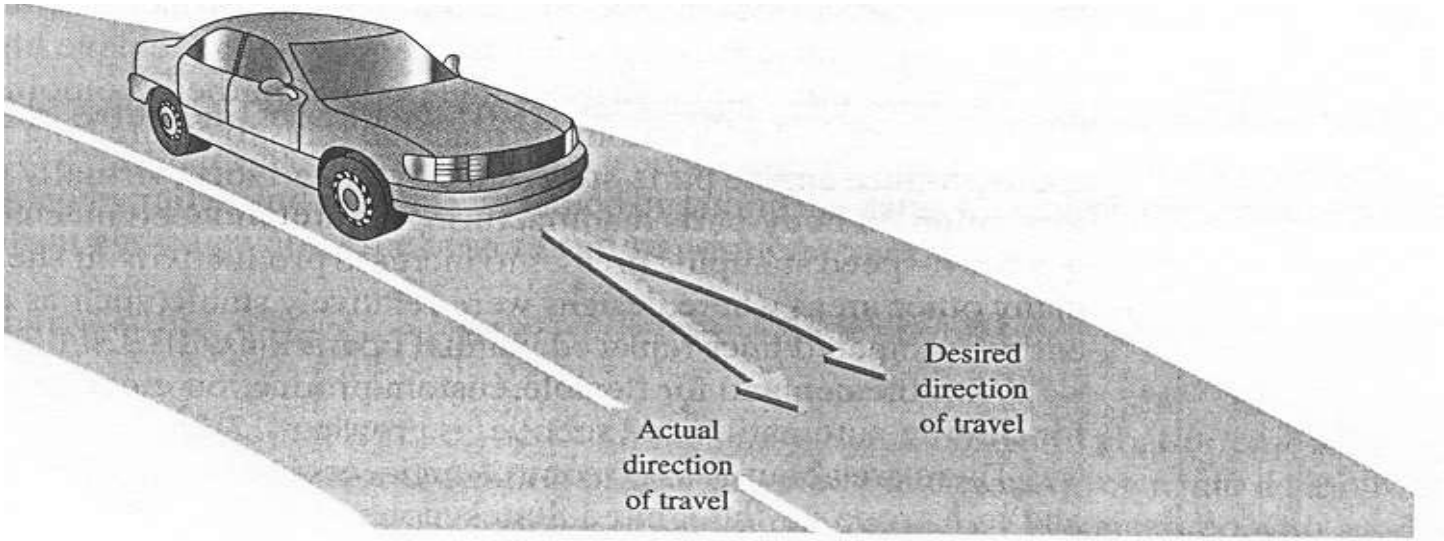
Continuous time digital control system



In class activity

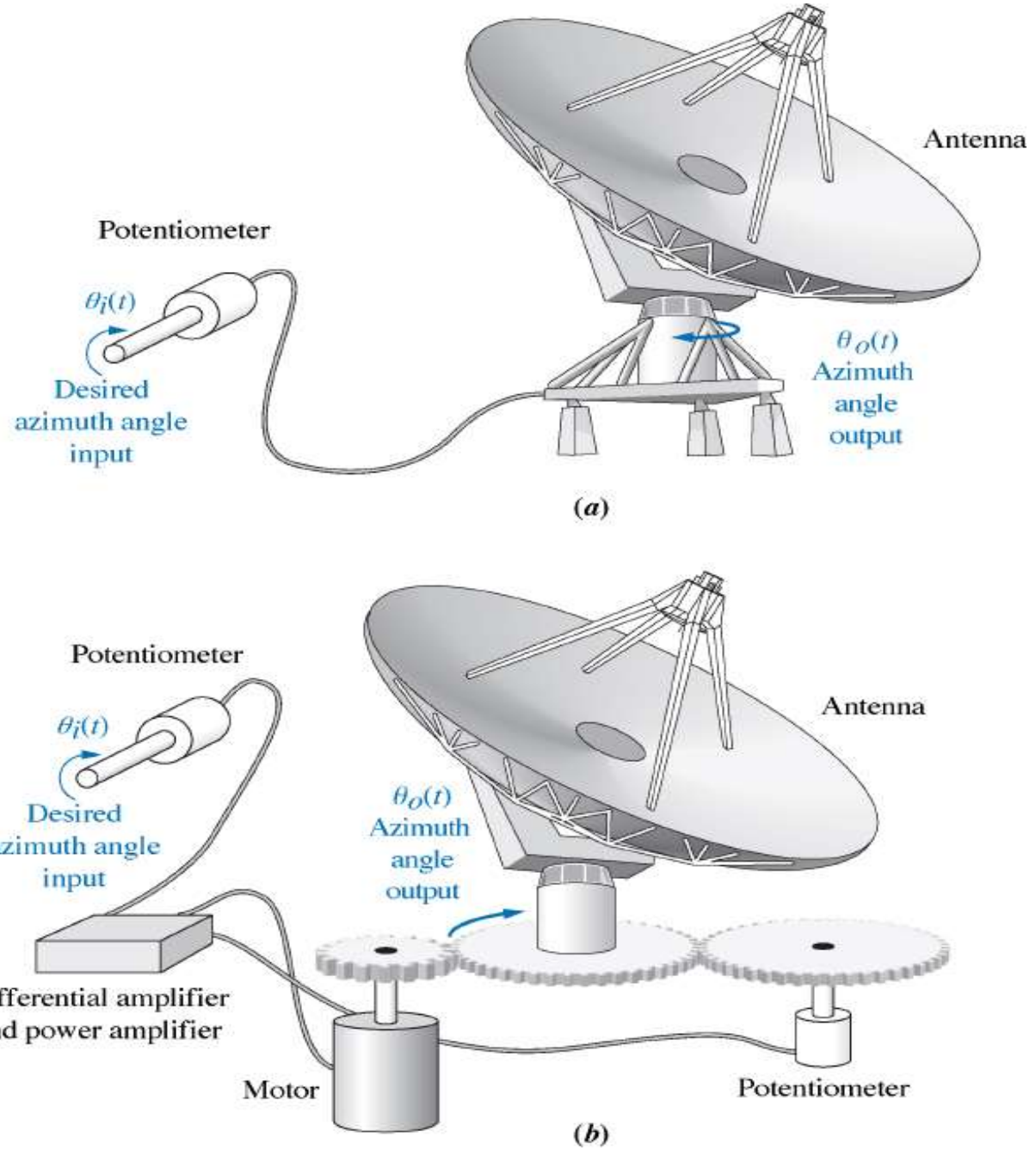
- List 3 other control systems and draw their block diagrams?

Automatic steering control system

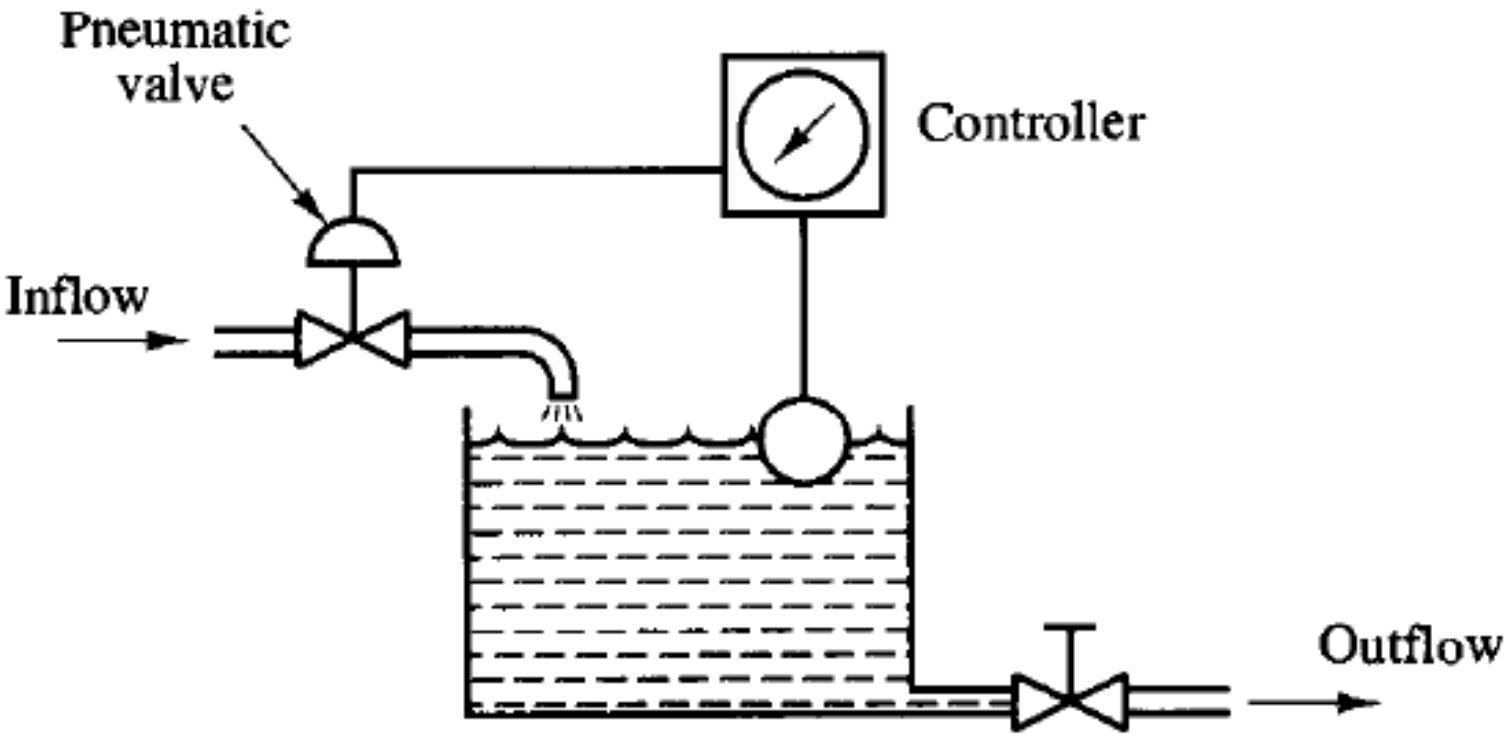


(b)

Antenna position control system



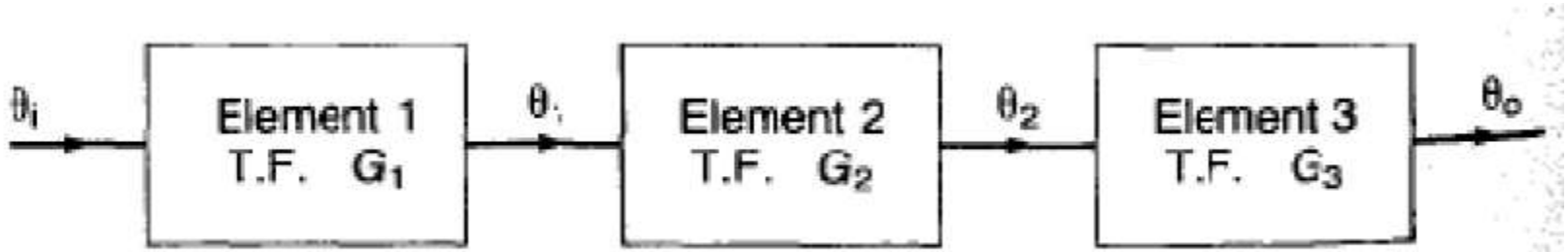
Water level in a tank



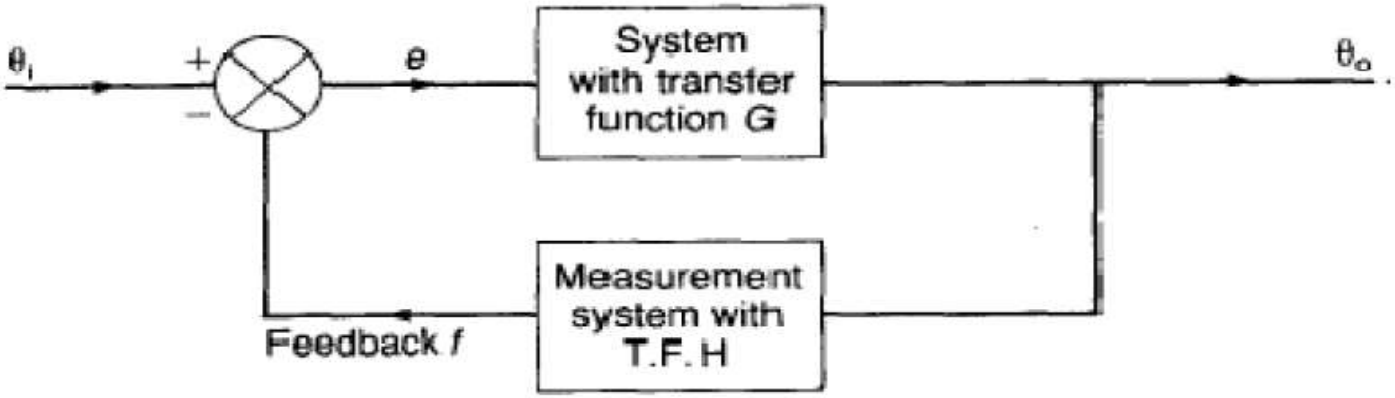
Mathematical models for systems

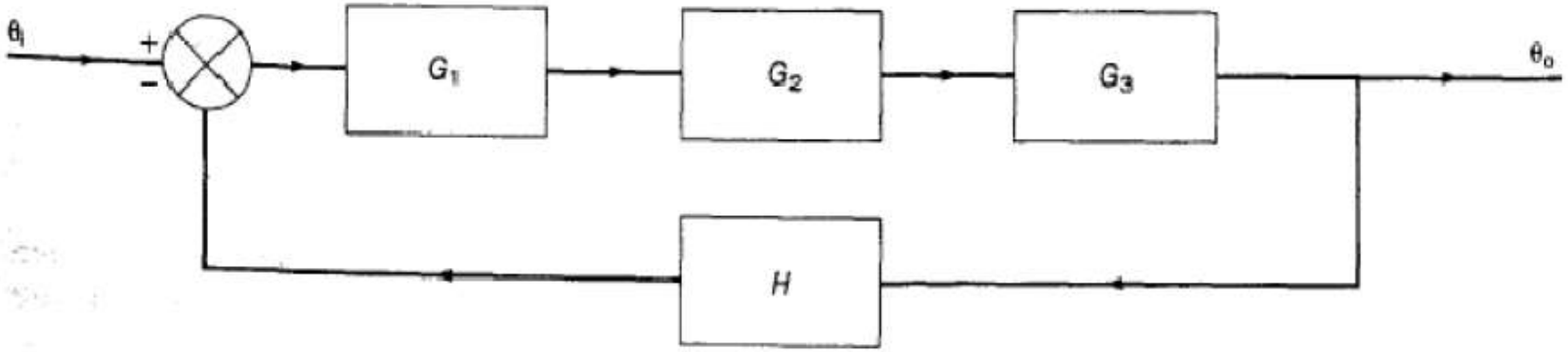
- Motor as a system
- Relationship between voltage and motor speed
- Mathematical model
- Steady state value
- TF or G
- Examples :
  - Amplifier
  - Room temperature

Open loop TF



Closed loop TF





Steady state error

- Open loop steady state error
- Closed loop steady state error

Effect of disturbance open loop

$$\theta_o = G_1 G_2 \theta_i + \theta_d$$

$$\theta_o = (G_1 \theta_i + \theta_d) G_2 = G_1 G_2 \theta_i + G_2 \theta_d$$

Effect of disturbance closed loop

$$\theta_o = \theta_i\left(\frac{G_1G_2}{1 + G_1G_2H}\right) + \theta_d\left(\frac{1}{1 + G_1G_2H}\right)$$

$$\theta_o = \theta_i\left(\frac{G_2G_1}{1 + G_1G_2H}\right) + \theta_d\left(\frac{G_2}{1 + G_1G_2H}\right)$$

Example 12/ P29

Sensitivity to component

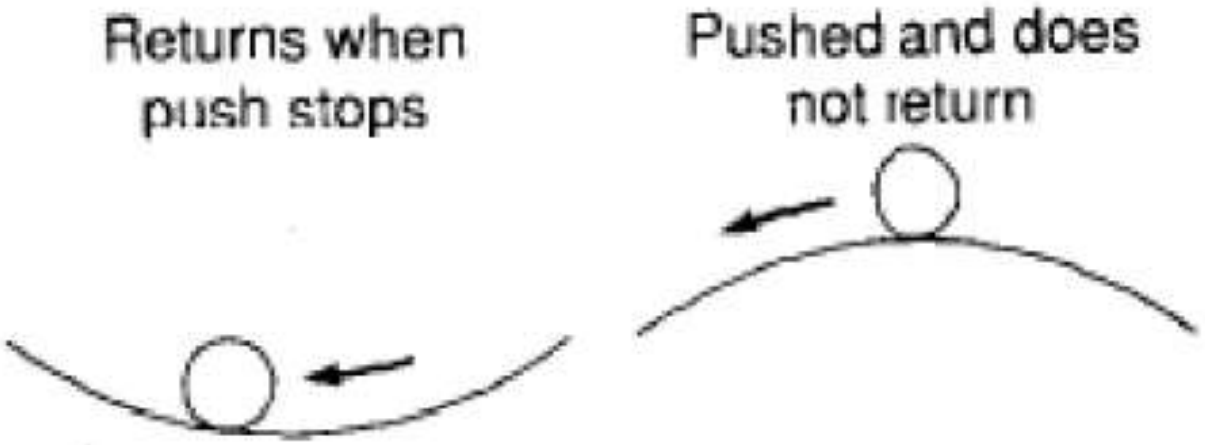
- Open loop

$$\text{Transfer function} = G_1 \times G_2 \times G_3$$

- Closed loop

$$\text{Transfer function} = \frac{G_1 G_2 G_3}{1 + G_1 G_2 G_3 H}$$

Stability of Control System



Closed path versus open path

The advantages of having a feedback path and hence a closed-loop system rather than an open-loop system can be summarized as:

1 More accurate in matching actual to required values for the variable.
2 Less sensitive to disturbances.
3 Less sensitive to changes in component characteristics.
4 Increased speed of response and hence bandwidth, i.e. range of frequencies over which the system will respond.

Closed path versus open path

But there are the disadvantages:

1. There is a loss in gain in that the transfer function of an open-loop system is reduced from G to $G/(1 + GH)$ by a feedback loop with a transfer function H.
2. There is a greater chance of instability.
3. The system is more complex and so, not only more expensive, but more prone to breakdown.

Problems

1 Explain the difference between open-loop and closed-loop control systems.

2 State which of the following are open-loop and which closed-loop control systems and give reasons for your statements:
   (*a*) An electric kettle which switches off when the water boils.
   (*b*) A refrigerator.
   (*c*) An electric hotplate with no thermostat.

3 Traffic lights at a road crossing can be open-loop or closed-loop control systems. Explain how the systems would differ.

4 Draw box diagrams showing the subsystems in the following closed-loop systems:
   (*a*) An automatic (exposure) camera.
   (*b*) A thermostatically controlled oven.
   (*c*) An automatic light which comes on when it gets dark and goes off when it becomes light.

End