Chapter 1.

Introduction

Key Concepts

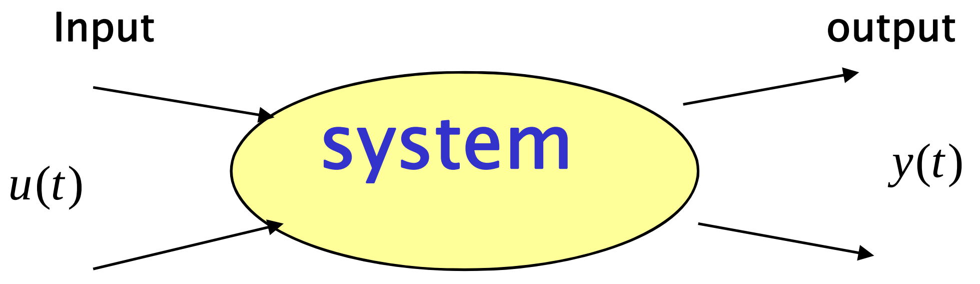
- System : A combination of components acting together to perform a specific objective.
- A component : Single functioning unit of a system

A system is not limited to physical component.

It includes abstract dynamic phenomena such as economics, transportation, populating, biology, politics etc.

- Static System vs. Dynamic system
- Linear System vs. Nonlinear System
- Block Diagram
- Transfer Function
- Analysis vs. Synthesis

System, Input and Output



Output depends on inputs !

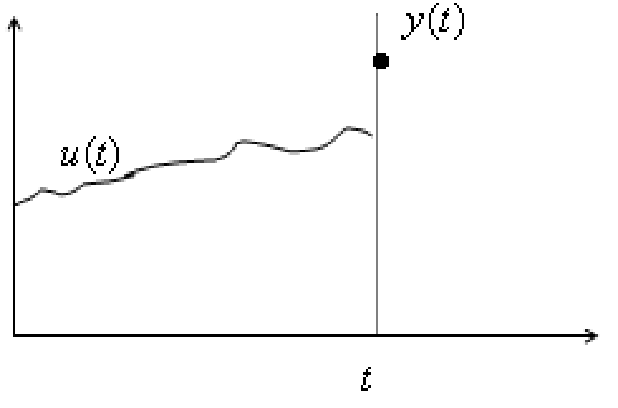
Dynamic Systems, System Dynamics

- Dynamic systems

$$y(t) \text{ depends on } \{u(\tau) \mid \tau \le t\} \quad \text{(depends on past input)}$$

- Static systems

$$y(t) \text{ depends on } u(t)$$



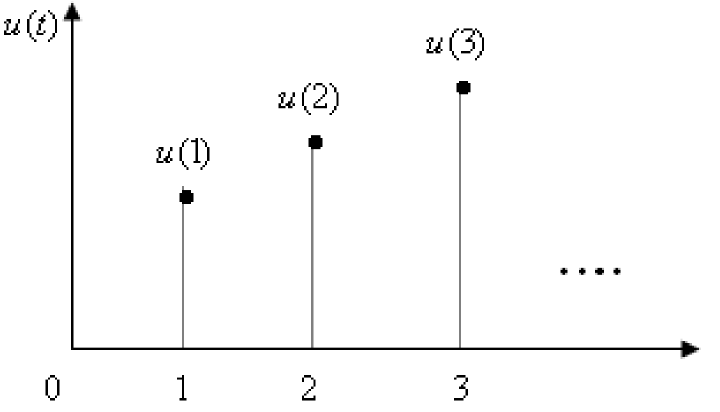
Static System vs. Dynamic System

Ex) Interest and Balance of a saving account

1% monthly interest

$u(t)$: monthly payment

$y(t)$: balance

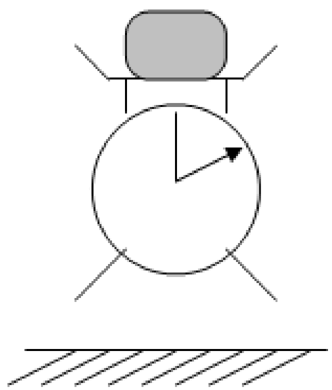


$$y(1) = u(1)$$
$$y(2) = u(1)\times 1.01 + u(2)$$
$$y(3) = y(2)\times 1.01 + u(3) = \{u(1)\times 1.01 + u(2)\}\times 1.01 + u(3)$$
$$\vdots$$
$$y(k) = y(k-1)\times 1.01 + u(k)$$

=> Dynamic System

Static System vs. Dynamic System

Ex) Balance



=> Static System

Static System vs. Dynamic System

- Static systems : algebraic equations

$$y(t) = f(u(t))$$

- Dynamic systems : differential equations or difference equations

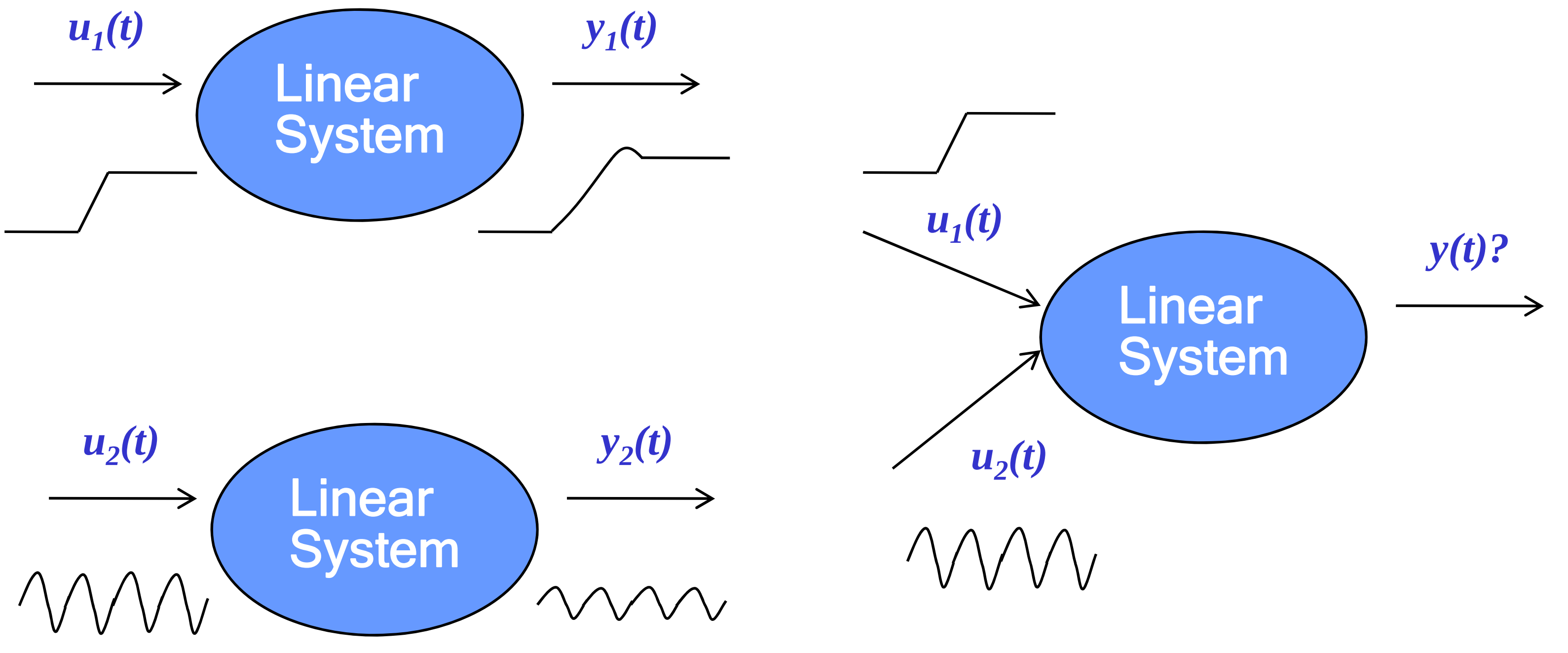
$$y(k) = f(y(k-1), u(k-1), k)$$

$$\frac{dy}{dt} = f(y, u, t)$$

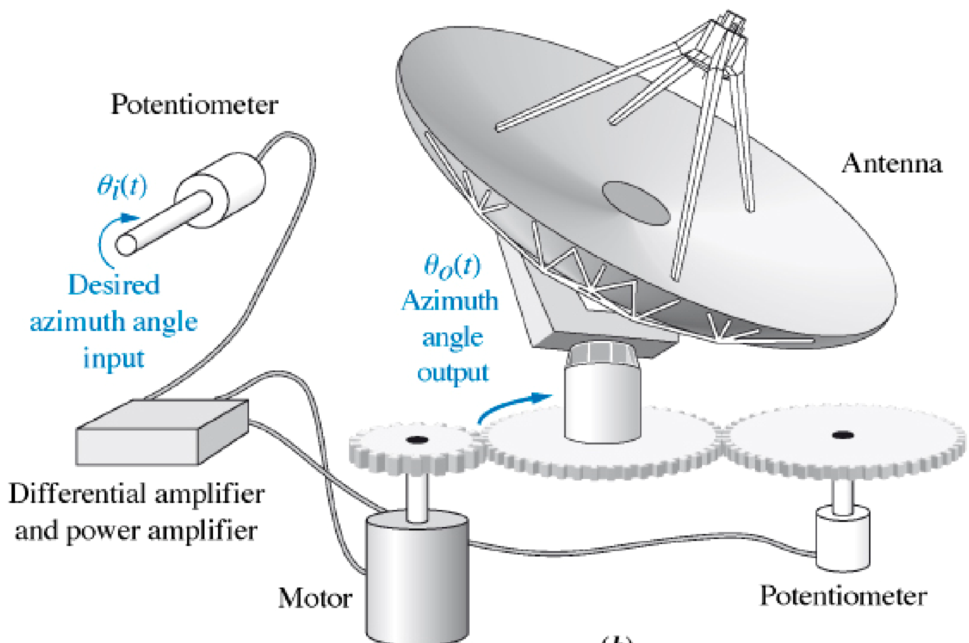
Linear vs. Nonlinear

Linear systems : linear superposition principle

$$u(t) = \alpha_1 u_1(t) + \alpha_2 u_2(t) \longrightarrow y(t) = \alpha_1 y_1(t) + \alpha_2 y_2(t)$$

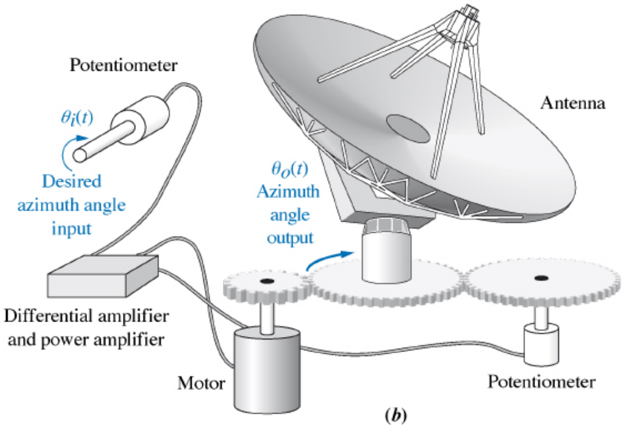


Antenna azimuth position control system



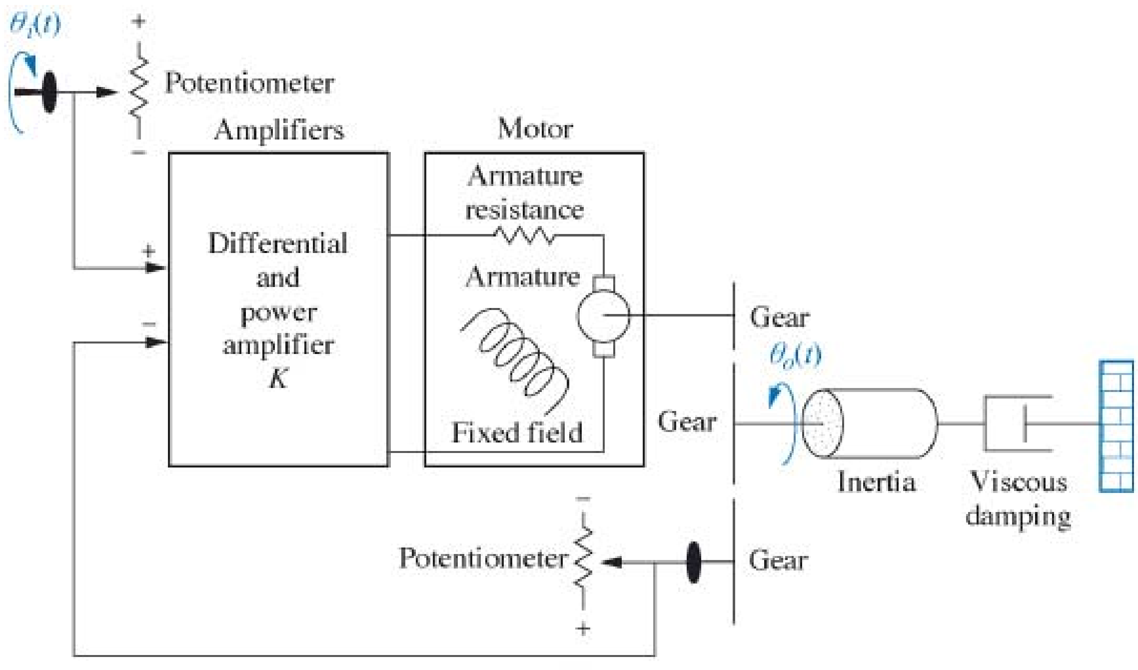
(b)

Schematic



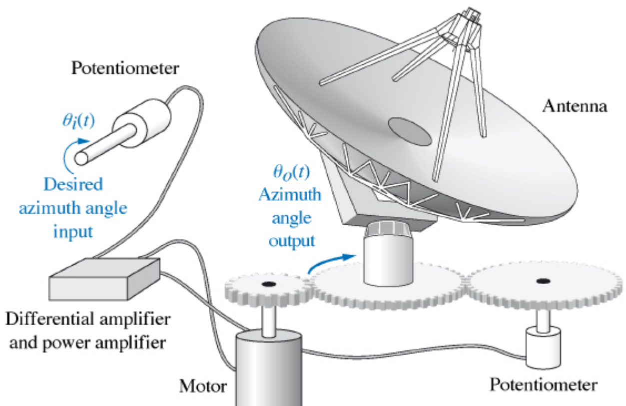
Potentiometer
$\theta_i(t)$
Desired azimuth angle input
$\theta_o(t)$
Azimuth angle output
Antenna
Differential amplifier and power amplifier
Motor
Potentiometer

(b)

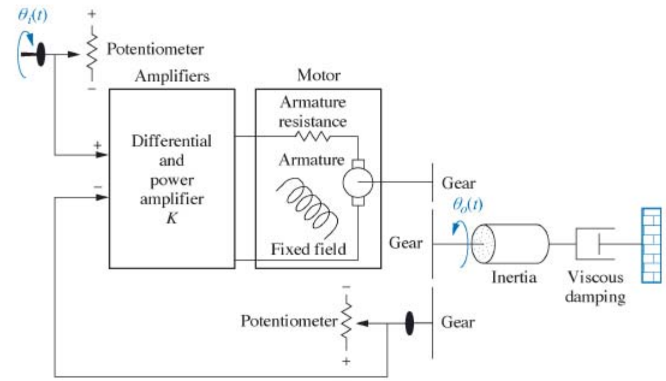


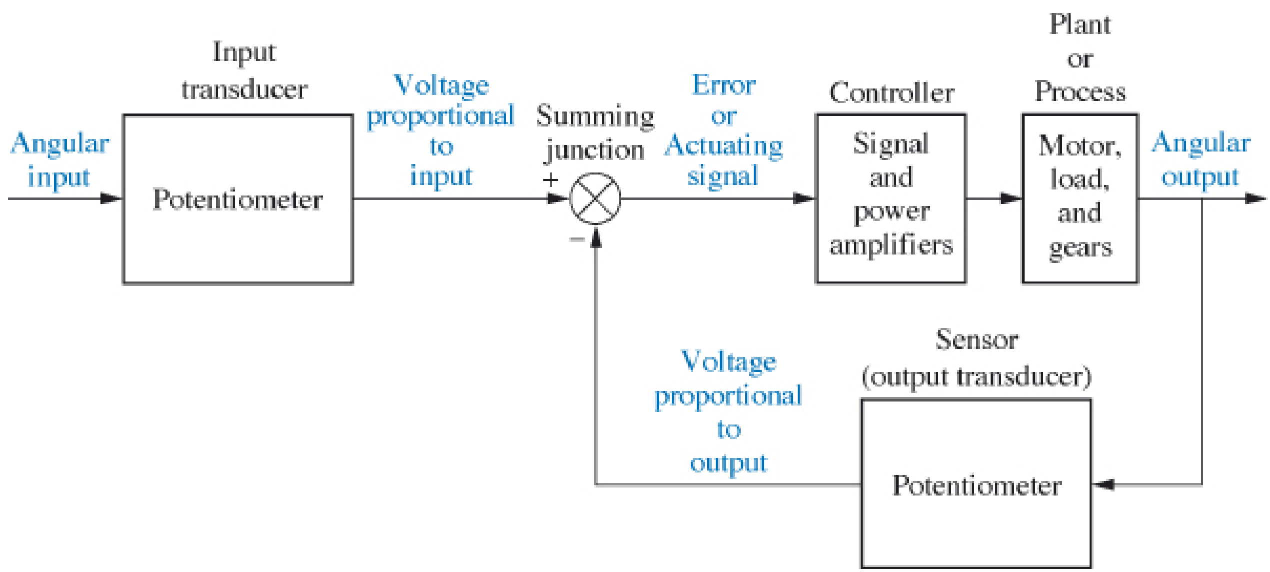
$\theta_i(t)$
+
Potentiometer
–
Amplifiers
Motor
Armature resistance
Differential and power amplifier K
Armature
Fixed field
+
–
Gear
$\theta_o(t)$
Gear
Inertia
Viscous damping
–
Potentiometer
Gear
+

Block Diagram

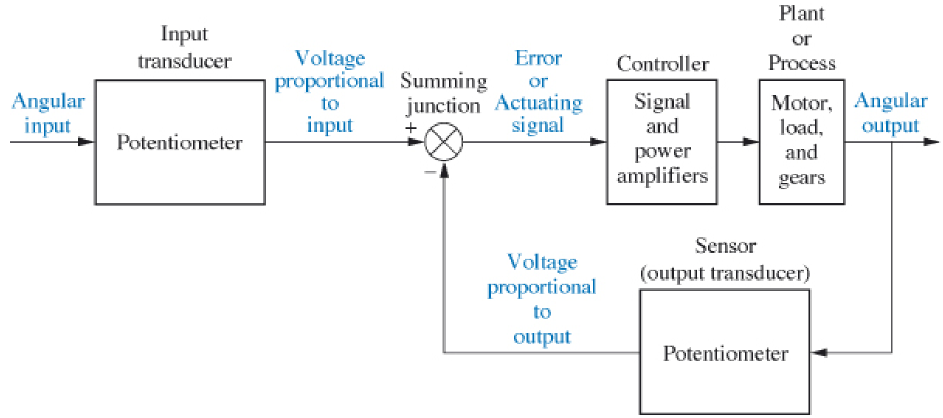


(*b*)





Transfer Functions



Mathematical Modeling

- Mathematical model (of Dynamic systems)

  -Differential equations obtained by applying natural laws to the systems.

  -Differential equations that describe the dynamic behavior of the system.

- Modeling methods ;

  1. Analytic: physical laws $\Rightarrow$ mathematical models

  2. Experimental: Experimental results.

     $\Rightarrow$ Input-output relationships. (mathematical models)

- Compromise in modeling process;

  "Simplicity versus Accuracy"

Mathematical Modeling Procedure

1. Draw a schematic diagram of the system and define variables.

2. (Physical laws) Write dynamic equations to obtain a mathematical model

3. (validation) Compare the solution of the equations of the model with experimental result.

4. Modification of the model to obtain a satisfactory agreement between prediction and experimental results.

· Linear Dynamic Systems $\Rightarrow$ linear D.E

· Nonlinear Dynamic Systems $\Rightarrow$ Nonlinear D.E

Analysis and Design

- Analysis : the investigation of the performance of a system whose mathematical model is known.

  1. Derive mathematical model.

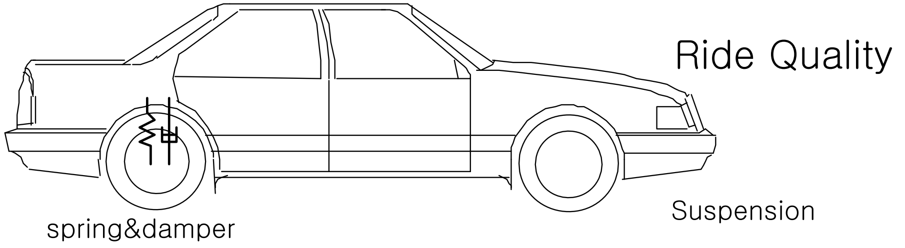
  2. Parameter variations – a number of solutions.

  3. Interprets and applies the result to the basic task.

- Design : (system design)

  -the process of finding a system that accomplishes a given task.

Ex)



Synthesis

(we mean) The use of *an explicit procedure* to find a system

that will perform in a specific way

1) system characteristics

2) use various mathematical techniques

– completely *mathematical* from the start to the end of the design procedure

Design of dynamic systems

- Theoretically, synthesis of linear system is possible
  - Can systematically determine the components necessary to realize the system's objective
- Practically, no synthesis methods are applicable
  - Constraints
  - Nonlinearities
  - Uncertainties

Design procedures

1. Trial-and-error procedures

2. Model-based (analysis and design) procedure

Model-based design procedure