Bab 4. Introduction to: Measurement and Control System

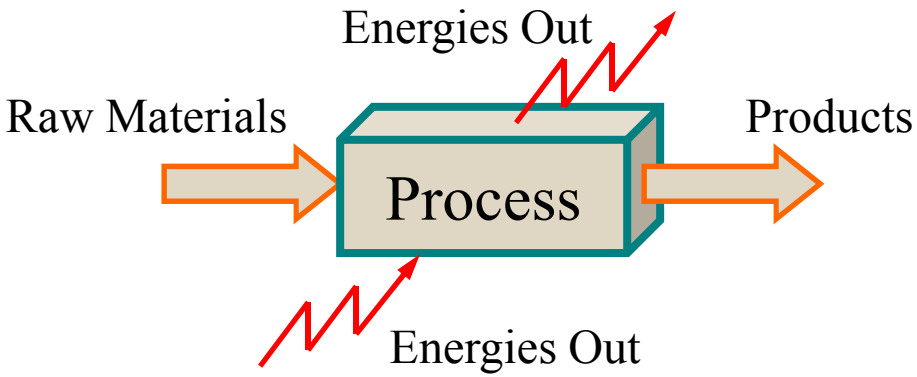


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Definition (1)

Process

- A series of interrelated actions which transform material
  It covers all resources that are involved in the **process** and talks about **process** "inputs" (e.g. resources, raw material) and "outputs" (e.g. finished product)



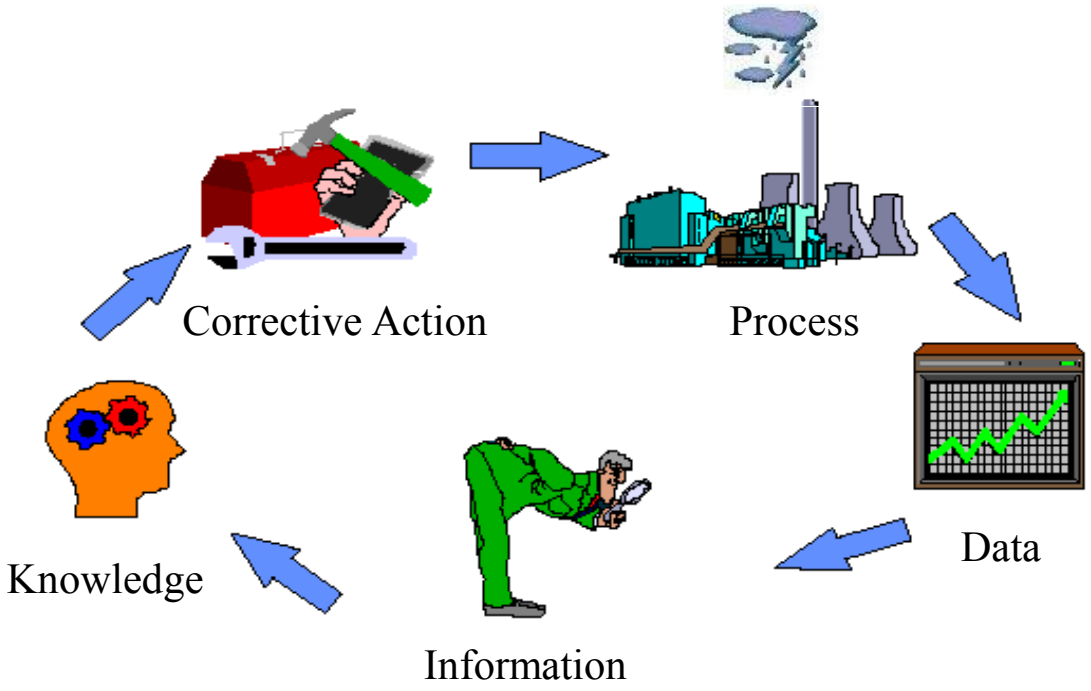
Control

- To maintain desired conditions in a physical system by adjusting selected variables in the system

Definition (2)

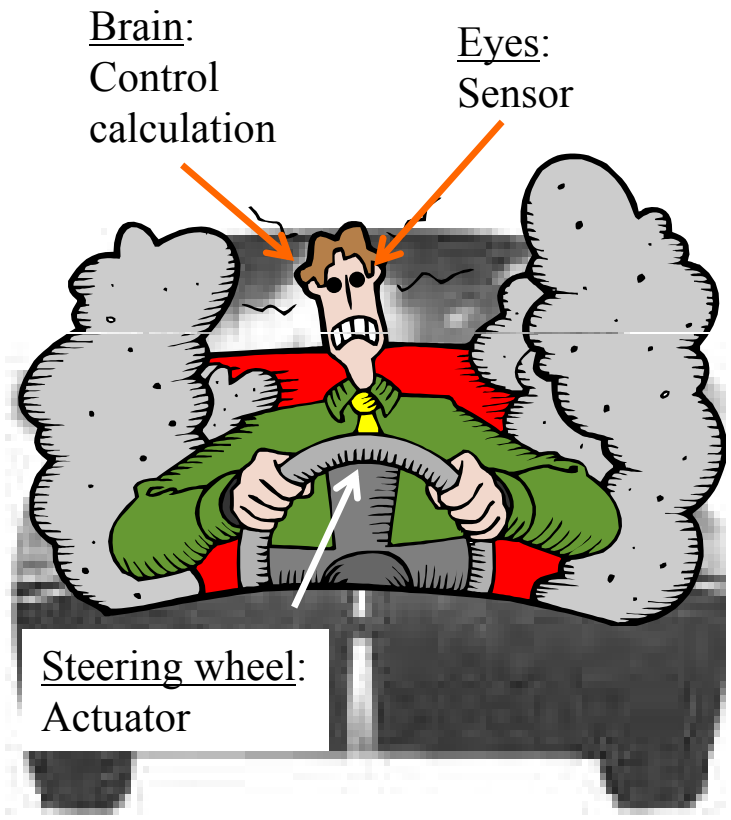
Process Control

- To maintain desired conditions in a physical system by adjusting selected variables in the system in spite of disturbances affecting the system and observation noise



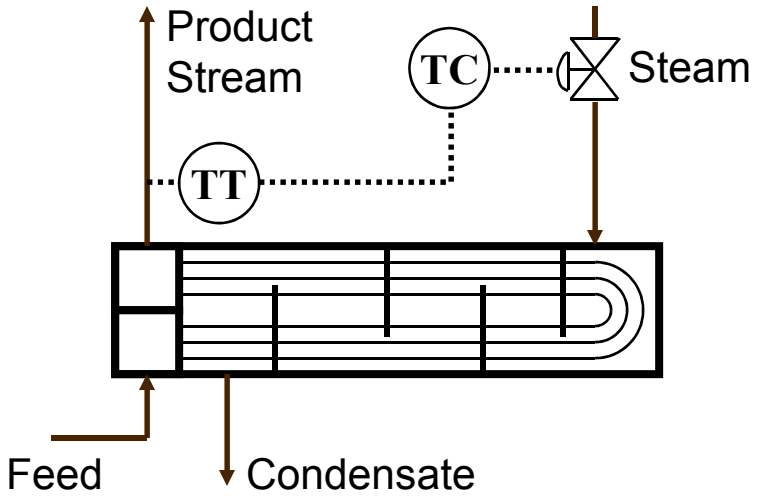
Daylife Example: Driving a Car

- Control Objective (Setpoint):
  - Maintain car in proper lane
- Controlled variable:
  - Location on the road
- Manipulated variable:
  - Orientation of the front wheels
- Actuator:
  - Steering wheel
- Sensor:
  - Driver's eyes
- Controller:
  - Driver
- Disturbance:
  - Curve in road
- Noise:
  - Rain, fog



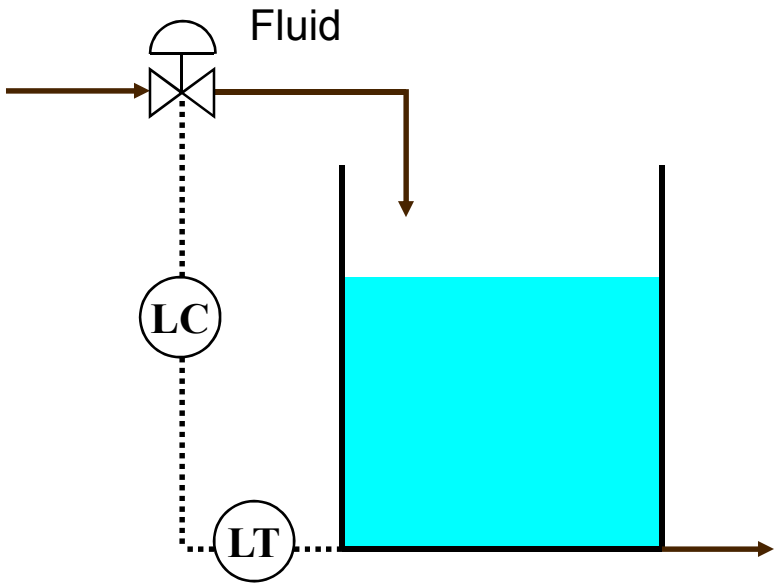
Industrial Example #1: Heat Exchanger

- Control Objective (Setpoint):
  - Maintain temperature
- Controlled variable:
  - Outlet temperature of product stream
- Manipulated variable:
  - Steam flow
- Actuator:
  - Control valve on steam line
- Sensor:
  - Thermocouple on product stream
- Controller:
  - Temperature controller
- Disturbance:
  - Changes in the inlet feed temperature
- Noise:
  - Measurement noise

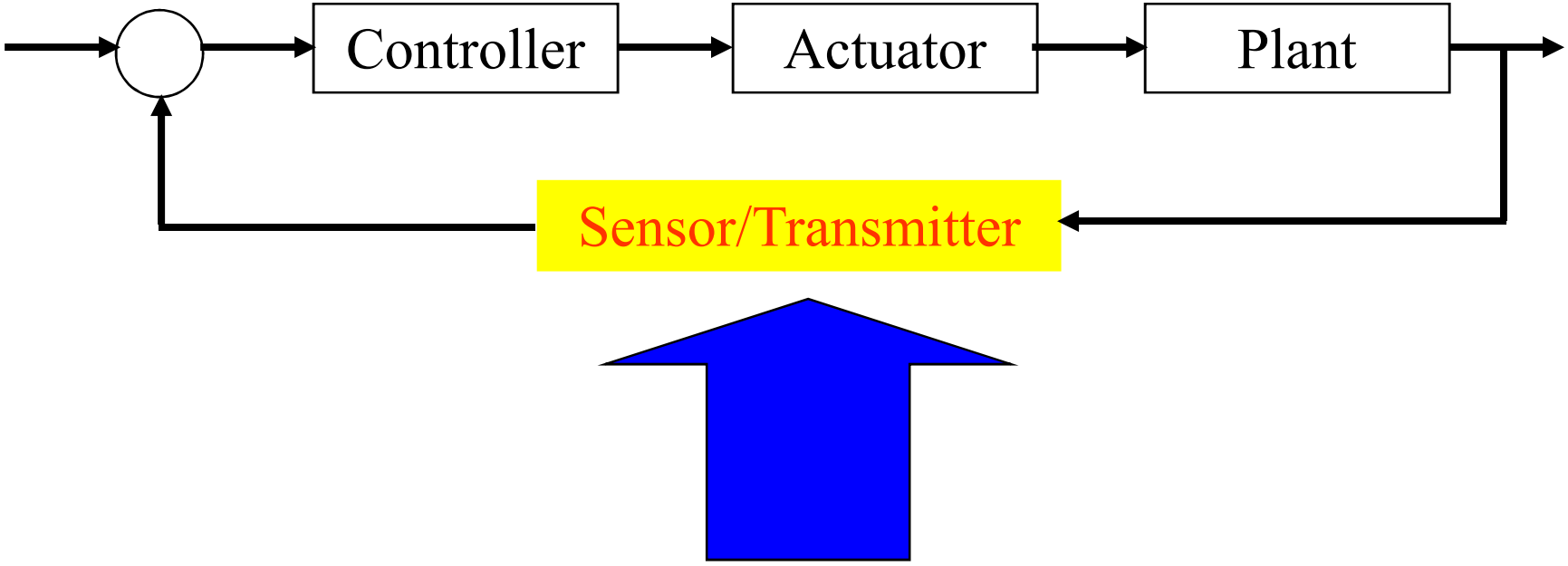


Industrial Example #2: Liquid Level Control

- Control Objective (Setpoint):
  - Maintain level
- Controlled variable:
  - Fluid level in the tank
- Manipulated variable:
  - Fluid flow
- Actuator:
  - Control valve on fluid line
- Sensor:
  - Level transmitter on the tank
- Controller:
  - Level controller
- Disturbance:
  - Changes in the inlet feed flow
- Noise:
  - Measurement noise



Block Diagram of Control System



Transducers:Sensor and Actuator

- **Tranducer:**
  - A device that converts a signal from one physical form to a corresponding signal having a different physical form

    Physical form: mechanical, thermal, magnetic, electric, optical, chemical…
  - Transducers are ENERGY CONVERTERS or MODIFIERS
- **Sensor:**
  - A device that receives and responds to a signal or stimulus
  - This is a broader concept that includes the extension of our perception capabilities to acquire information about physical quantities
- **Transducers:**
  - Sensor: an input transducer (i. e., a microphone)
  - Actuator: an output transducer (i. e., a loudspeaker)

Measurement System & Devices

- A measurement system is any set of interconnected parts that include one or more measurement devices
- Measurement devices perform a complete measuring function, from initial detection to final indication
- Measurement devices such as sensors, or primary elements, measure the variable

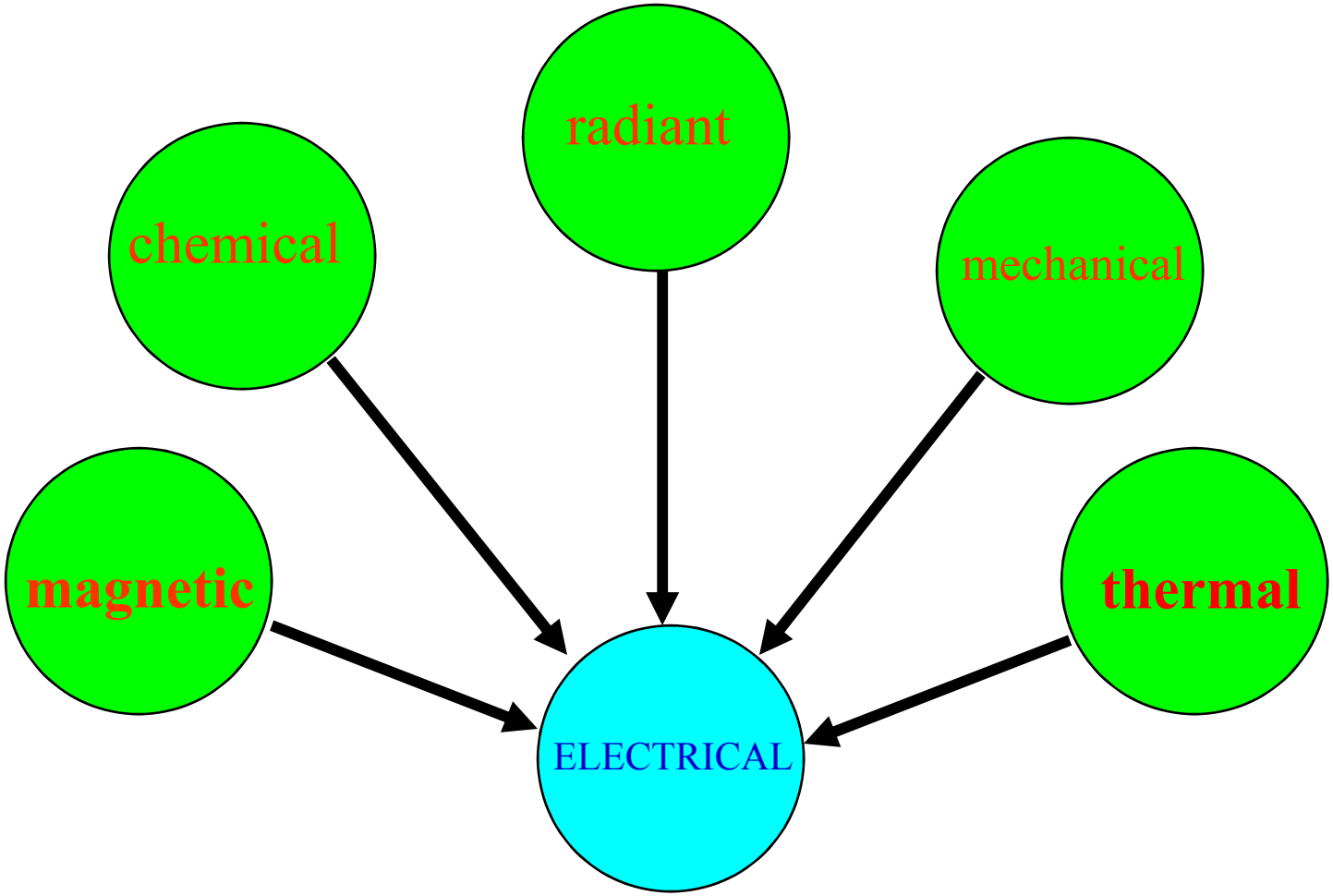
Sensor, Transmitter & Transducer

- Sensor
  - Primary sensing element
  - Converts the physical quantity to signal that can be recognized by other component such as display, transmitter
- Transmitter
  - Generates an industrial standard signal from the sensor output
  - Standard instrumentation signal levels
    - Voltage: 1 – 5 VDC, 0 – 5 VDC, -10 – +10 VDC, etc.
    - Current: 4 – 20 mA
    - Pneumatic: 3 – 15 psig
- Transducer
  - Changes one instrument signal value to another instrument signal value
  - Signal conversion
  - I/P or P/I transducer: current-to-pressure or vice versa
  - P/E or E/P: pressure-to-voltage or vice versa

Sensor electrical output signal

- **Current**
  - Example: some humidity sensors
- **Voltage**
  - Example: sensors based on the seebeck-effect
- **Charge**
  - Example: piezoelectric based sensors

Interrelation of the energy domain



SIGNAL ENERGY DOMAIN

- **Mechanical**
  - length,area, volume, linear velocity, angular velocity,acceleration, mass, flow, force,torque, pressure, accoustic-wave speed, viscosity
- **Thermal**
  - temperature, (specific) heat, heat flow, state of matter
- **Electrical**
  - voltage, current, charge, resistance, inductance, capacitance, dielectric constant, polarization, electric field intensity, dipole moment

SIGNAL ENERGY DOMAIN

- **Magnetic**
  - magnetic field intensity, flux density, permeability
- **Radiant**
  - color, intensity, reflectance, transmittance, refractive index
- **Chemical**
  - composition, concentration, reaction rate, pH,humidity

Sensor Types

- Flow rate
  - Orifice, venturi, ultrasonic, etc
- Pressure
  - Bellows, bourdon tube, diaphragm
- Liquid level
  - Displacement, float, differential pressure
- Temperature
  - Thermocouple, RTD, thermistor
- pH
  - pH electrode