King Saud University

College of Engineering

IE – 341: “Human Factors Engineering”

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Chapter 1. Introduction

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Lesson Overview

- Human Factors
  - Overview
  - Definitions
  - Characteristics
  - History
  - Profession
- Human-Machine Systems
  - Characteristics
  - Types
- System Reliability
  - Components in Series
  - Components in Parallel

Human Factors: Overview

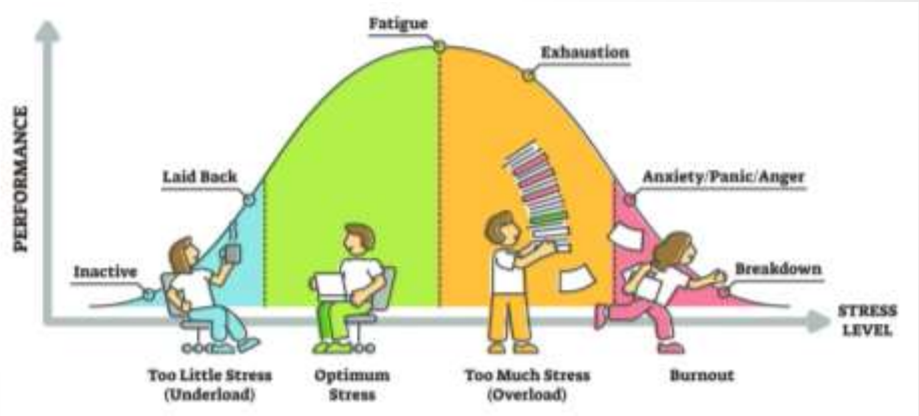
- Successful design entails what man:
  - Needs
  - Wants (desires)
  - Can use

- Human factors investigated by designers:
  - Anthropometry (human physical size, limitations)
  - Physiology: human body,
    - Reactions (hearing, seeing, touching, etc.)
    - Functions
    - Limitations
    - Capabilities
  - Ergonomics (“doing” vs. anthropometry: “being”)
    - dynamic interaction of operator and machine
  - Psychology: influence of mental conditions
  - Others: social, climate, religion, etc.

Cont. Human Factors: Overview

- Objectives of Human Factors (HF):
  - o Increase work efficiency
    - Increase effectiveness of work
    - Increase convenience and ease of use of machines
    - Increase productivity
    - Decrease errors

  - o Study influence of design on people
  - o Change designs to suit human needs, limitations
  - o Increase human values:
    - Increase safety
    - Increase comfort
    - Increase job satisfaction
    - Decrease fatigue and stress
    - Increase quality of life



Human factors, definitions

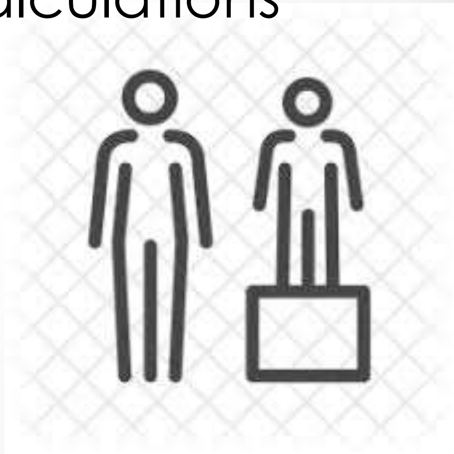
- Definition 1:
  - Systematic application of information about human:
    - Capabilities, limitations, and characteristics
      to the design of:
    - objects and procedures that people use,
    - and the environment in which they use them

- Definition 2:
  - HF discovers and applies information about human:
    - Behavior, abilities, limitations, other characteristics
      to the design of:
    - tools, machines, systems, jobs, tasks, environments for:
    - productive, safe, comfortable, effective human use

Human Factors: Characteristics

- HF involves study of:
  - Human response to environment
  - Response as a basis for design, improvements

- Characteristics of HF:
  - Machines must be built to serve humans (not opp.)
  - Design must take human differences into account
  - Designs influence humans
  - Design process must include data and calculations
  - Human data must be tested scientifically
  - Humans and machines are related
  - NOT just check lists and guidelines
  - NOT: using oneself as model for design
  - NOT just common sense



Human Factors: History (US)

- Early 1900's: Frank and Lillian Gilbreth:
  - Design of workstations for disabled (e.g. surgery)

- After WWII (1945): HF profession was born
- 1949: HF books, publications, conferences, e.g.:
  - *HF in Engineering Design*, 1949
  - *HF Society* (largest HF professional group), 1957
- 1960-80: emphasis moved from military to industry:
  - Pharmaceuticals, computers, cars, etc.
- 1980-90: HF in PC revolution
  - "ergonomically-designed" equipment, software
  - HF in the office
  - Disasters caused due to HF considerations
    - e.g. Chernobyl, Soviet Union, 1986
  - HF in forensics (injury litigations, defective designs)

- >1990's:
  - Medical devices, devices for elderly
  - OSHA ergonomic regulations

Human Factors: Profession

- HF Society members:
  - Psychology: 45.1%
  - Engineering: 19.1%

- People performing HF work (in general)
  - Business (private): 74%
  - Government: 15%
  - Academia: 10%

Human-Machine Systems

- System (Def^n):
  - "Entity that exists to carry out some purpose"
  - Components: humans, machines, other entities
  - Components must integrate to achieve purpose (i.e. not possible by independent components):
    - Find, understand, and analyze purpose
    - Design system parts
    - System must meet purpose
- Machine (Def^n):
  - Physical object, device, equipment, or facility
  - used to perform an activity
- Human-Machine system (Def^n):
  - ≥1 Human + ≥1 physical component
  - Interaction using given input/command
  - Result: desired output
  - e.g. man + nail + hammer to hang picture on wall
  - *See Figure 1-1, pp. 15 (Sanders and McCormick – next page)*

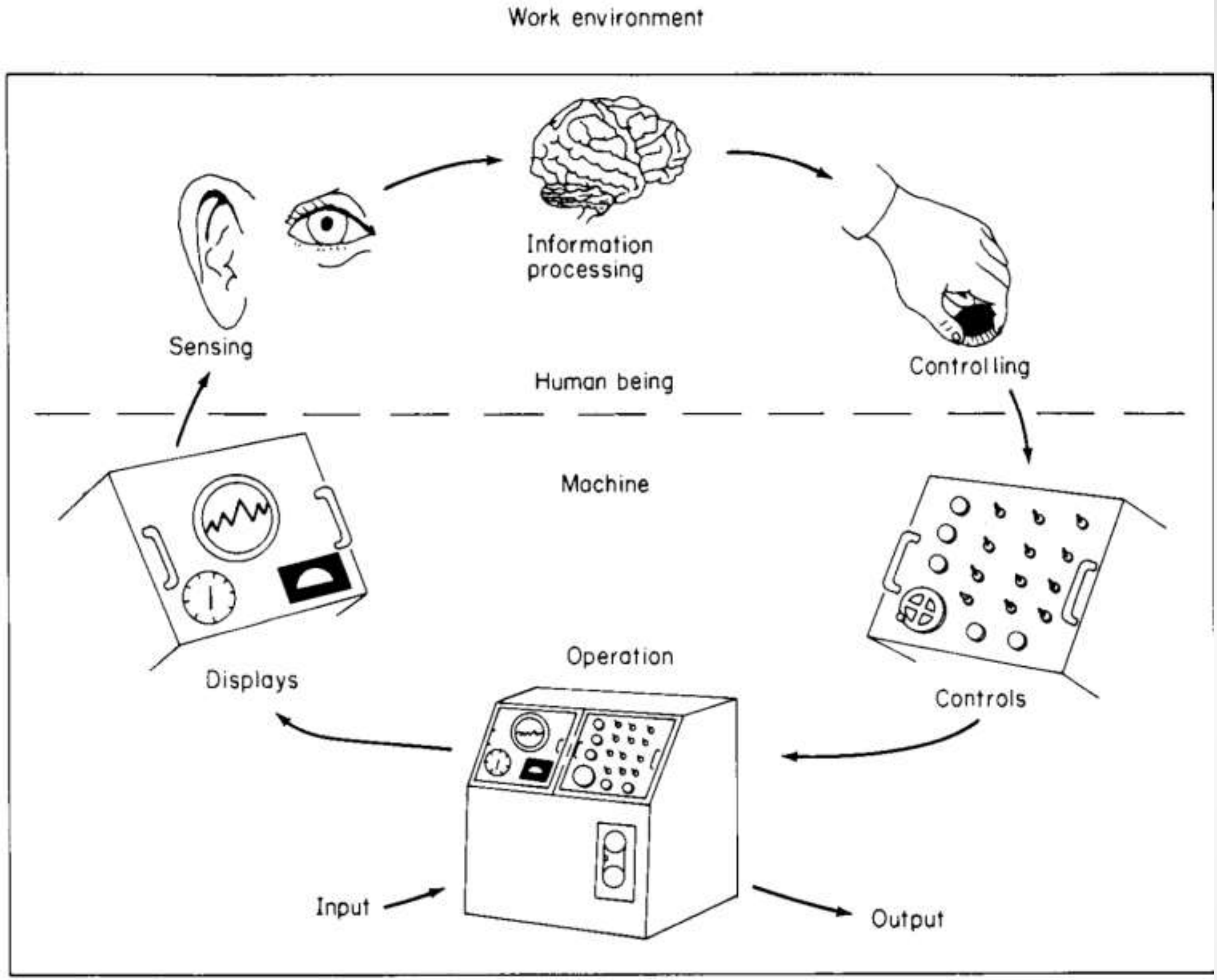


FIGURE 1-1
Schematic representation of a human-machine system. *(Source: Chapanis, 1976, p. 701. Used by permission of Houghton Mifflin Company.)*

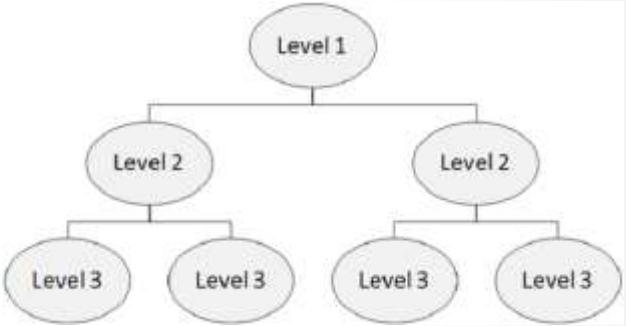
Cont. Human-Machine Systems

- Types of HM systems:
  - **Manual systems**:
    - operator + hand tools + physical energy
  - **Mechanical systems** (AKA semiautomatic systems):
    - operator (control) + integrated physical parts e.g. powered machine tools
  - **Automated systems**:
    - little or no human intervention (e.g. Robot)
    - Human: installs programs, reprograms, maintains, etc.

Consider broomstick vs vacuum vs [Roomba]™

HM System Characteristics

- Systems are purposive
  - o Systems have ≥ 1 objective
- Systems can be hierarchical
  - o Systems may have subsystem levels (1, 2, etc.)
- Systems operate in **environment** (i.e. inside **boundary**)
  - o Immediate (e.g. chair)
  - o Intermediate (e.g. office)
  - o General (e.g. city)



- **Components** serve functions
  - o Sensing (i.e. receiving information; e.g. speedometer)
  - o Information storage (i.e. memory; e.g. disk, CD, flash)
  - o Information processing and decision
  - o Action functions (output)
    - Physical control (i.e. movement, handling)
    - Communication action (e.g. signal, voice)

HM System Characteristics

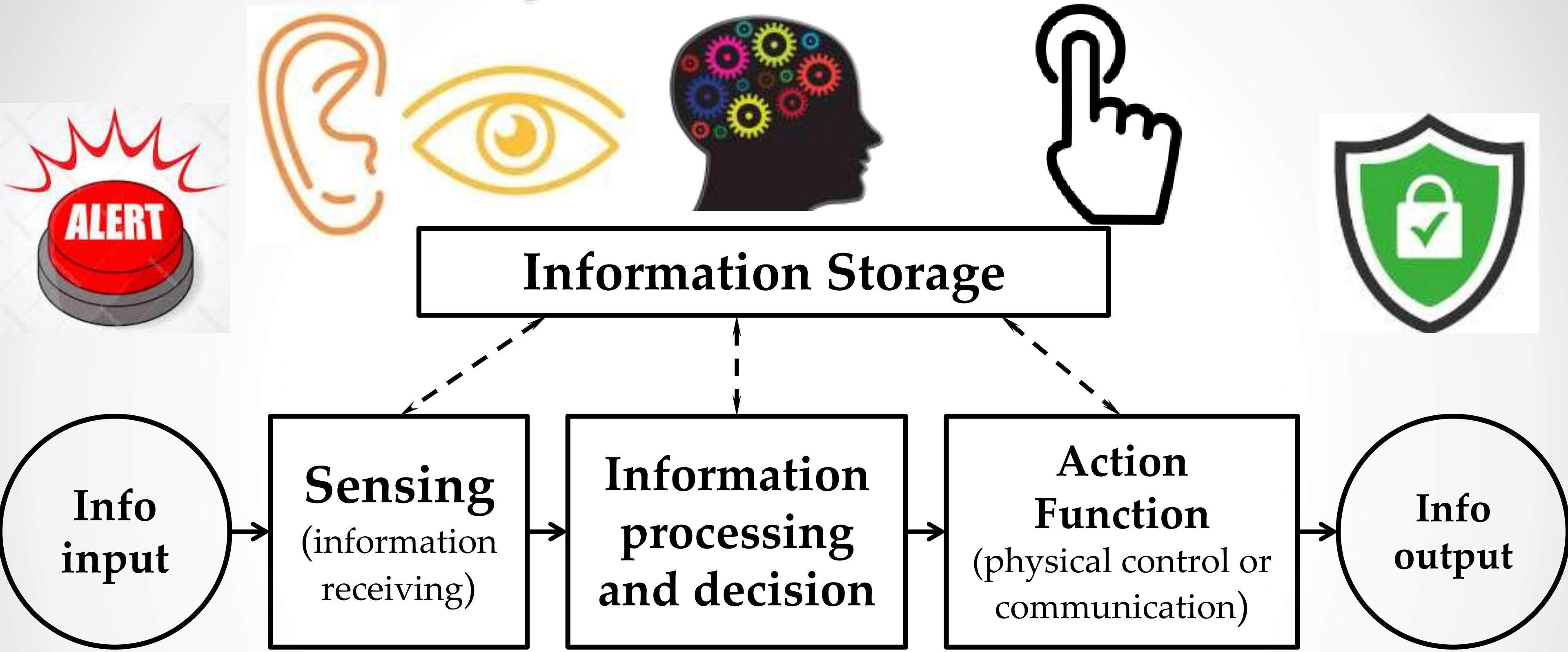


FIGURE 1-2
Types of basic functions performed by human or machine components of human-machine systems.

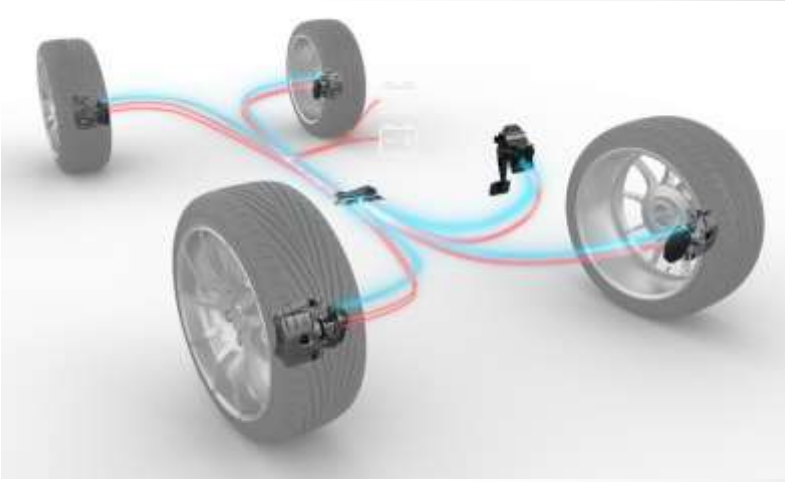
Cont. HM System Characteristics

- Components interact
  - components work together to achieve a goal
  - components are at lowest level of analysis

- Systems, subsystems, components have I/O
  - I: input(s)
  - O: output(s)
  - O's of 1 system: can be I's to <u>another system</u>
  - I's:
    - Physical (materials)
    - Mechanical forces
    - Information

Types of HM Systems

- Closed-loop systems
  - Require continuous control
  - Require continuous feedback (e.g. errors, updates, etc.)
  - e.g. car operation



- Open-loop systems
  - Need no further control (e.g. car cruise-control)
  - Feedback causes improved system operation

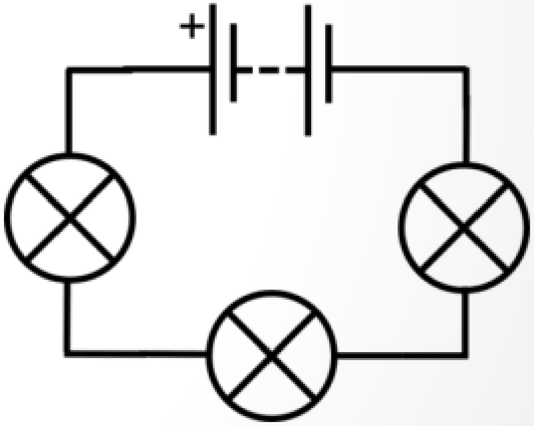
System Reliability

- Def^n: "probability of successful operation"
- Measure #1:
  - **success ratio**
  - e.g. ATM gives correct cash:
    9999 times out of 10,000 ⇒ Rel. = 0.9999
  - Usually expressed to 4 d.p.

- Measure # 2:
  - mean time to failure (**MTF**)
  - i.e. # of times system/human performs successfully (before failure)
  - Used in continuous activity

System Rel.: Components in Series

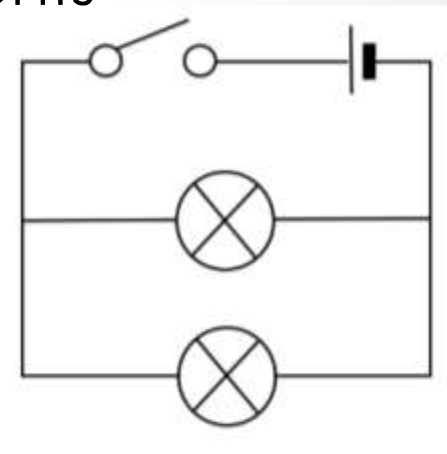
- Successful operation of system ⇒ Successful operation of **ALL** components (i.e. machines, humans, etc.)
- Conditions:
  - Failure of 1 component ⇒ failure of complete system!
  - Failures occur independently of each other
- Rel. of system = Product of Rel. of all components
- e.g. System has 100 components
  - components all connected in series
  - Rel. of each component = 99%
  - ⇒ Rel. of system = 0.366 (why?)
  - i.e. system will only work successfully: 366 out of 1,000 times!
  - Conclusions:
    - more components ⇒ less Rel.
    - **Max.** system Rel. = Rel. of least reliable component
    - least Rel. component is usually human component (weakest link)
    - In reality, system Rel. ≪ least Rel. component



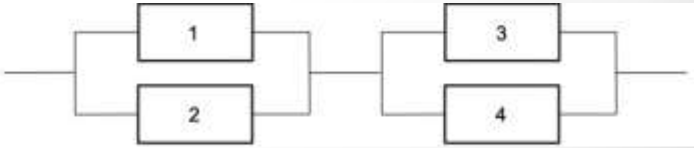
System Rel: Components in Parallel

- ≥ 2 components perform same functions
  - AKA: backup redundancy (in case of failure)

- System failure ⇒ failure of ALL components



- e.g. System has 4 components
  - components connected in //
  - Rel. of each = 0.7
  - ⇒ System Rel. =
    $1 - (1\text{-Rel}_{c1})(1\text{-Rel}_{c2})(1\text{-Rel}_{c3})(1\text{-Rel}_{c4}) = 0.992$
  - Conclusions
    - more components in // ⇒ higher Rel.



  - Note, Rel. ↓ with time (e.g. 10-year old car vs. new)

References

- ***Human Factors in Engineering and Design***. Mark S. Sanders, Ernest J. McCormick. 7th Ed. McGraw: New York, 1993. ISBN: 0-07-112826-3.