

King Saud University

College of Engineering

IE – 341: “Human Factors Engineering”

Spring – 2024 (2nd Sem. 1445H)

Chapter 1. Introduction

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Lesson Overview

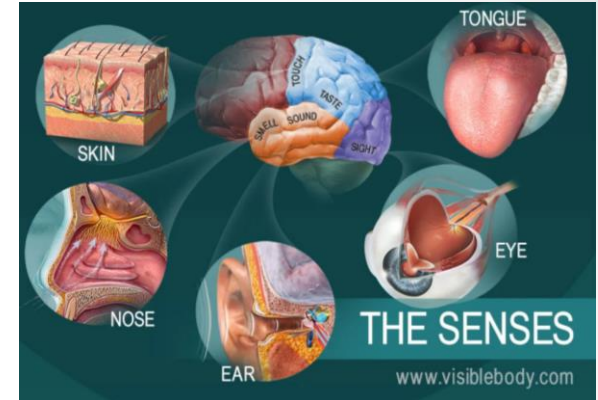
- Human Factors
 - Overview
 - Definitions
 - Characteristics
 - History
 - Profession
- Human-Machine Systems
 - Characteristics
 - Types
- System Reliability
 - Components in Series
 - Components in Parallel



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.

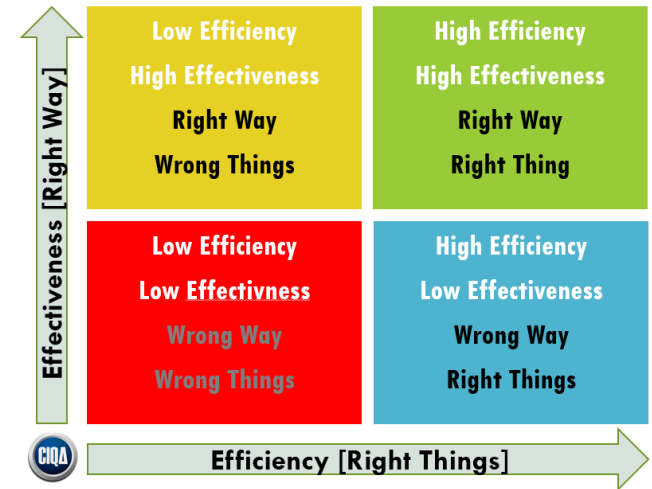


Cont. Human Factors: Overview

- Objectives of Human Factors (HF):

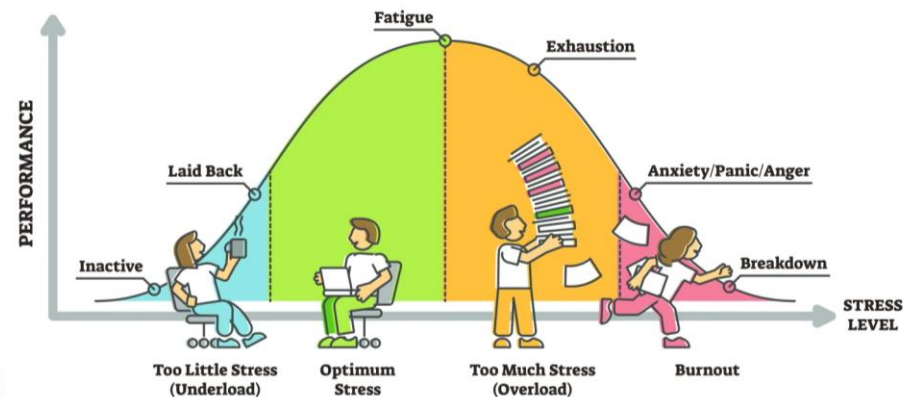
- Increase work efficiency
 - Increase effectiveness of work
 - Increase convenience and ease of use of machines
 - Increase productivity
 - Decrease errors

EFFECTIVENESS VERSUS EFFICIENCY CHART



- Study influence of design on people
- Change designs to suit human needs, limitations
- 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 (Defⁿ):
 - “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 (Defⁿ):
 - Physical object, device, equipment, or facility
 - used to perform an activity
- Human-Machine system (Defⁿ):
 - ≥ 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)

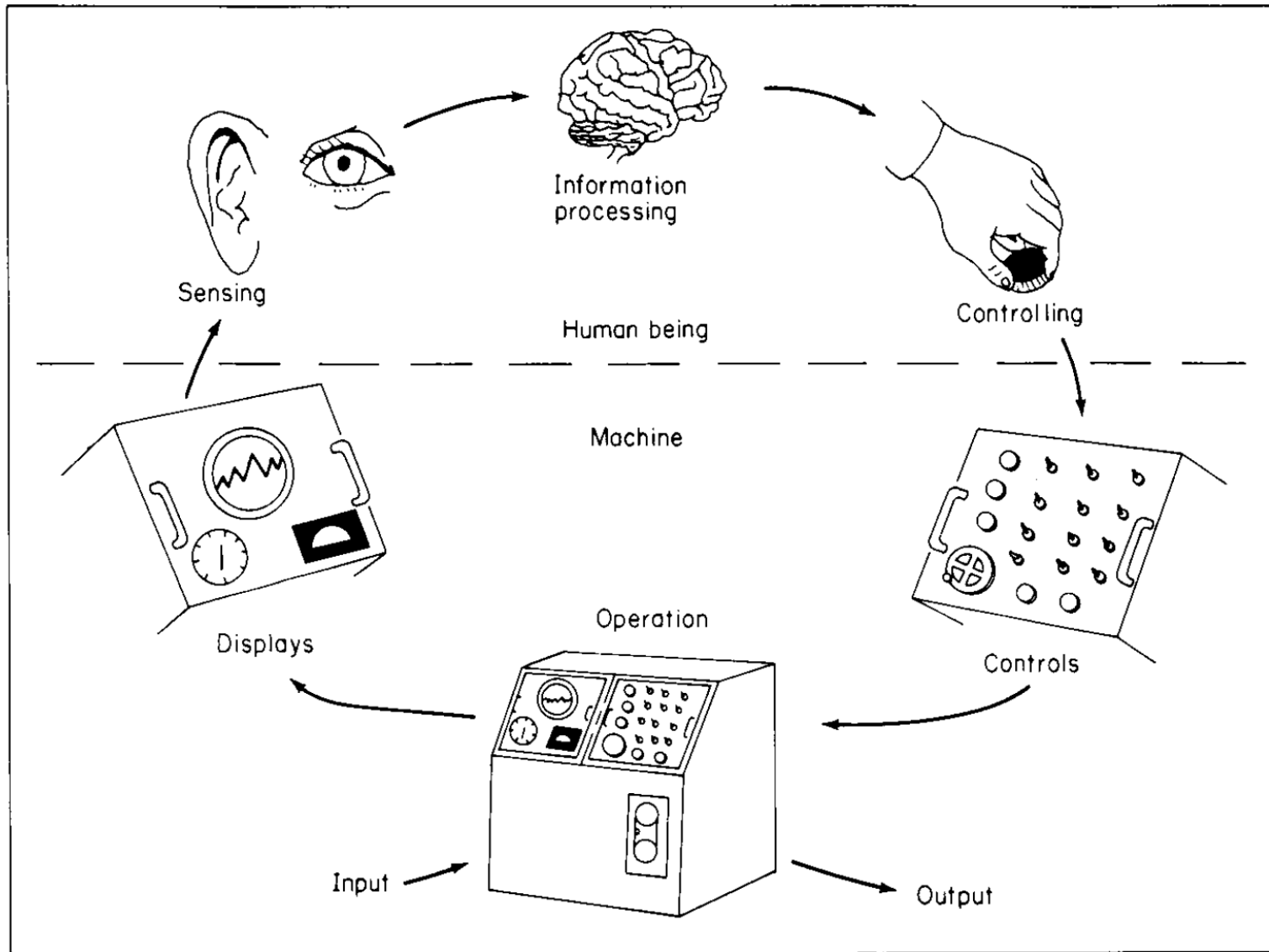


FIGURE 1-1

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

Cont. Human-Machine Systems

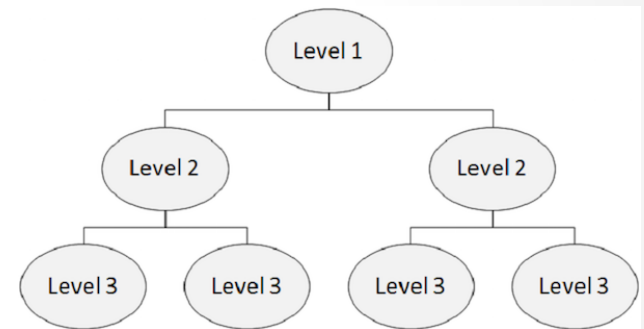
- Types of HM systems:
 - **Manual systems:**
 - operator + hand tools + physical energy
 - **Mechanical systems** (AKA semiautomatic systems):
 - operator (control) + integrated physical parts
e.g. powered machine tools
 - **Automated systems:**
 - little or no human intervention (e.g. Robot)
 - Human: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

Consider broomstick vs vacuum vs [Roomba™](#)



HM System Characteristics

- Systems are purposive
 - Systems have ≥ 1 objective
- Systems can be hierarchical
 - Systems may have subsystem levels (1, 2, etc.)
- Systems operate in **environment** (i.e. inside **boundary**)
 - Immediate (e.g. chair)
 - Intermediate (e.g. office)
 - General (e.g. city)
- **Components** serve functions
 - Sensing (i.e. receiving information; e.g. speedometer)
 - Information storage (i.e. memory; e.g. disk, CD, flash)
 - Information processing and decision
 - Action functions (output)
 - [Physical control](#) (i.e. movement, handling)
 - Communication action (e.g. signal, voice)



HM System Characteristics

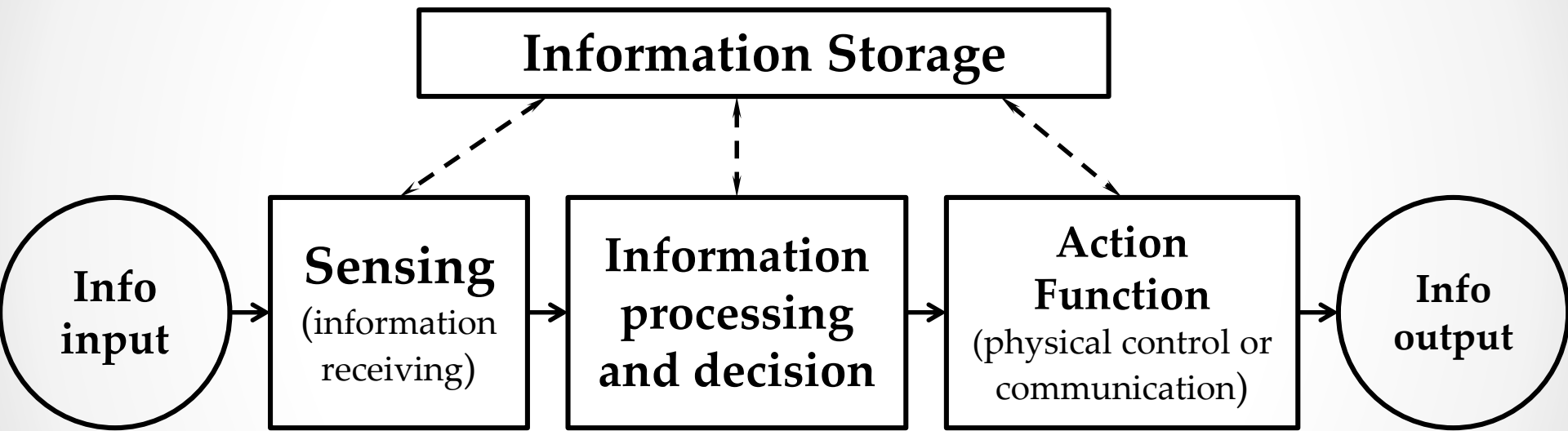


FIGURE 1-2

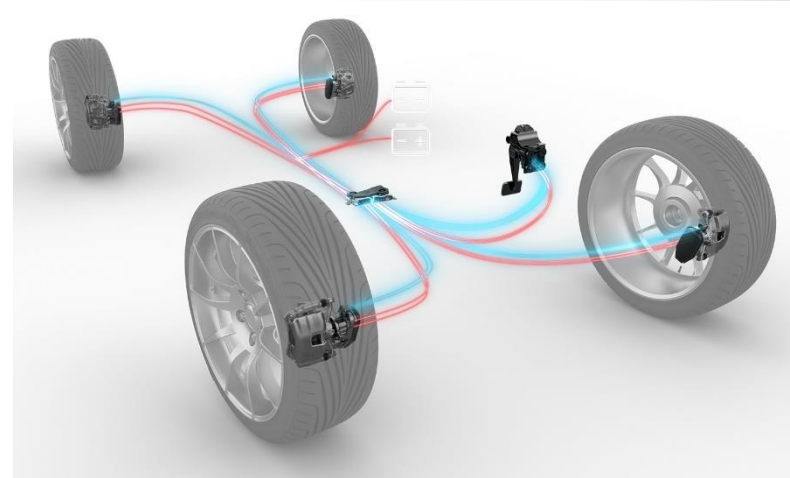
Types of basic functions performed by human or machine components of human-machine systems.

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 [another system](#)
 - 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



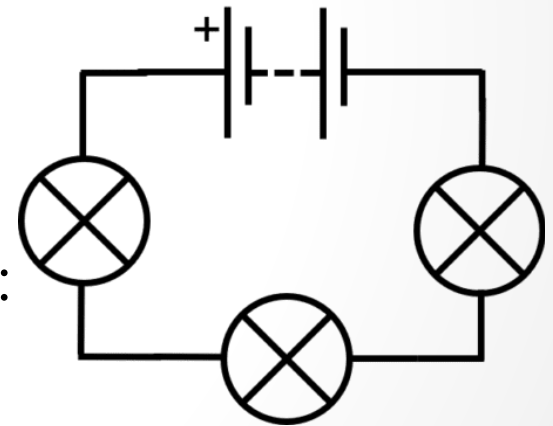
System Reliability

- Defⁿ: “probability of successful operation”
- Measure #1:
 - **success ratio**
 - e.g. ATM gives correct cash:
9999 times out of 10,000 \Rightarrow 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

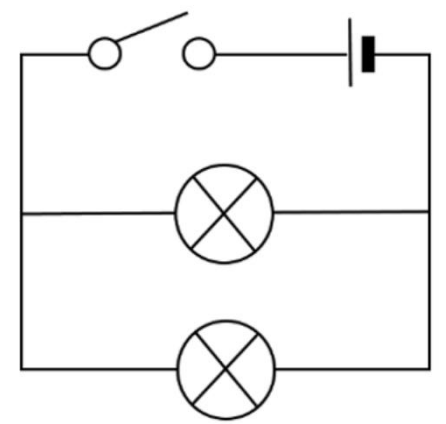
- Successful operation of system \Rightarrow Successful operation of **ALL** components (i.e. machines, humans, etc.)
- Conditions:
 - Failure of 1 component \Rightarrow failure of complete system!
 - Failures occur independently of each other
- Rel. of system = Product of Rel. of all components
- e.g. System has 100 components
 - components all connected in series
 - Rel. of each component = 99%
 - \Rightarrow Rel. of system = 0.365 (why?)
 - i.e. system will only work successfully: 365 out of 1,000 times!
 - Conclusions:
 - more components \Rightarrow less Rel.
 - **Max.** system Rel. = Rel. of least reliable component
 - least Rel. component is usually human component (weakest link)
- In reality, system Rel. \ll least Rel. component



System Rel: Components in Parallel

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

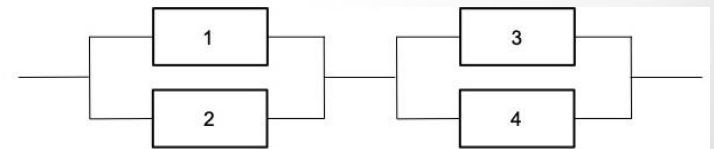
- e.g. System has 4 components
 - components connected in //
 - Rel. of each = 0.7
 - \Rightarrow System Rel. =



$$1 - (1 - \text{Rel}_{c1})(1 - \text{Rel}_{c2})(1 - \text{Rel}_{c3})(1 - \text{Rel}_{c4}) = 0.992$$

- Conclusions

- more components in // \Rightarrow higher Rel.



- Note, Rel. \downarrow 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.