# Ergonomics and Human Factors

*Work Systems and the Methods, Measurement, and Management of Work*
by Mikell P. Groover, ISBN 0-13-140650-7.

# Introduction to Ergonomics and Human Factors

Sections:

1. Overview of Ergonomics
2. Human-Machine Systems
3. Topic Areas in Ergonomics

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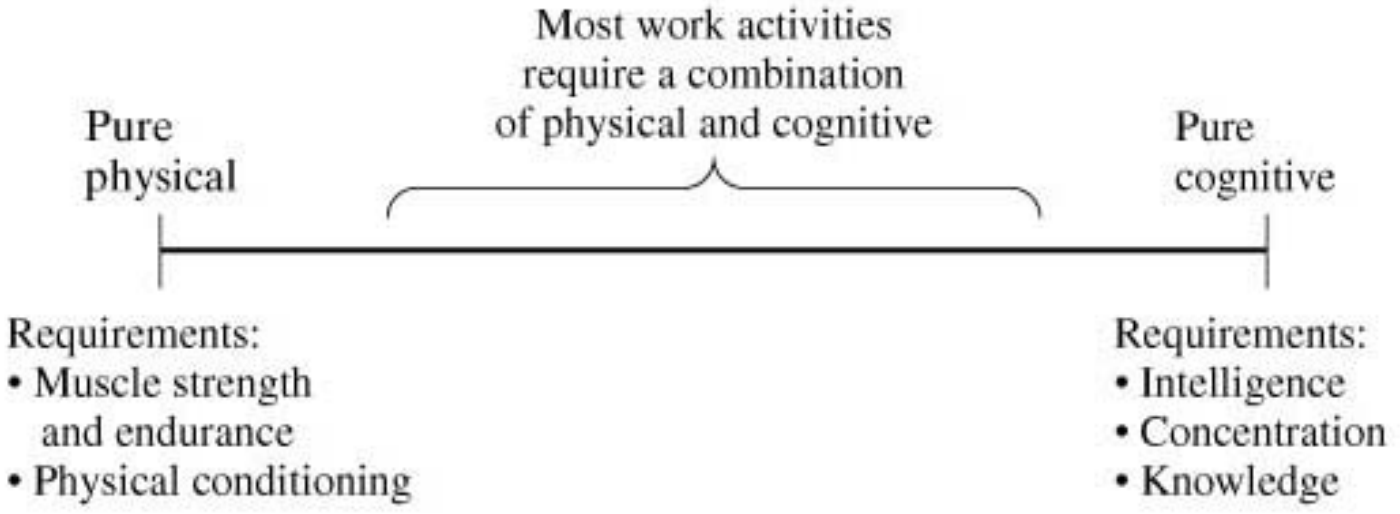
# Physical and Cognitive Demands

Most work activities require a combination of physical and cognitive exertions




Shoveling

Translation

# Ergonomics

- An applied scientific discipline concerned with how humans interact with the tools and equipment they use while performing tasks and other activities
- Derived from the Greek words ergon, meaning work, and nomos, meaning laws
- The word ergonomics was coined by British scientist K. F. H. Murrell and entered the English language in 1949
- Earlier applications in “fitting man to the job” (1900’s)
  - Choose from the pool of job applicants who were best suited to the requirements (psychological tests)
- Hawthorne experiments (1920’s)
  - Importance of social factors in work

# Human Factors

- **Human factors** is synonymous with **ergonomics**
- **Ergonomics** emphasizes work physiology and anthropometry (individual at work)
  - Europe – industrial work systems
- **Human factors** emphasizes experimental psychology and systems engineering (the human element in a system)
  - U.S. – military work systems

# History of Ergonomics

- Taylor – scientific management movement
  - Critics against Taylorism
- Frank and Lillian Gilbert- human factors
- Early 1900s: “fitting the man to the job”
- Late 1920s: The Hawthorne experiments – social factors in the workplace- “human relations” research
- 1900-1945: growth of use of machinery and mechanization
- End of WW II: Increased complexity of equipment – human-machine systems
- K.F.H. Murrel: the term ergonomics – emphasis on industrial work systems
- 1950: Ergonomics Research Society (UK)
- 1957: The Human Factors Society (US)
- 1960: consumer products and working class impact politically
- 1980 - current:
  - Advances in computer and automation technologies
  - Disasters: critical importance of human in the operation of human-machine systems

# From www.ergonomics.org.uk

- **1949**
- July - "Ten scientists of differing background, but all interested in the study of human work, decided to form a group to enable research workers in different disciplines to meet and exchange ideas. They called themselves the "Human Research Society"" (K.F.H. Murrell, BPS Bulletin, No.22, January 1954).
- Summer - "Ergonomics" defined by Murrell after consultation with Greek and Latin Scholars as "the study of the relationship between man and his working environment".
- Autumn - meeting held in Oxford which decided to turn the group into a Society
- 27th September - Ergonomics Research Society formed - Queen Anne's, Admiralty, London.

# Objectives in Ergonomics

- **Main objective:** to improve the performance of systems consisting of people and equipment.

- Human-machine systems
  - Machine: a variety of objects – aircraft, appliances, automobiles, chairs, computers, hand tools, sports equipment

- "using knowledge of human abilities and limitations to design and build for comfort, efficiency, productivity and safety" – The Ergonomics Society

# Objectives in Ergonomics

- Greater ease of interaction between user and machine
- Avoid errors and mistakes
- Greater comfort and satisfaction in use of the equipment
- Reduce stress and fatigue
- Greater efficiency and productivity
- Safer operation
- Avoid accidents and injuries

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# Methods Engineering vs. Ergonomics

- Closely related and their general objectives are the same:

1. To improve the performance of existing systems

2. To design new systems for optimum performance

# Methods Engineering vs. Ergonomics

| Emphasis in Methods Engineering | Emphasis in Ergonomics and Human Factors |
|---|---|
| Efficiency | Safety |
| Cost reduction | Comfort |
| Labor reduction | Interaction between human and equipment |
| Workplace layout | Workplace environment |
| "One best way" | Fitting the work to the individual |
| Facility layout | Reduction of human errors |
| Elimination of waste | Accident avoidance |

# Ergonomics Application Areas

- Work system design: interaction between worker and the equipment used in the workplace
  - Objectives: safety, accident avoidance, improved functional performance
  - Also includes environment such as lighting

- Product design
  - Objectives: safety, comfort, user-friendly, mistake proof

- Our focus: work systems (which in fact overlap with the product design)

# Ergonomists – What They Do

- Research on human capabilities and limitations
  - Discover the characteristics of human performance, e.g., how much can an average worker lift?

- Design and engineering applications
  - Use the research findings to design better tools and work methods

# Fitting the Person to the Job (FPJ)

- Common philosophy prior to ergonomics
- Considers worker's physical and mental aptitudes (skills) in employment decisions
  - Psychometric testing (e.g., tests for intelligence and personality characteristics)
  - For example, using worker size and strength as criteria for physical work
- FPJ is still important
  - For example, educational requirements for technical positions

# Fitting the Job to the Person (FJP)

- It is the approach that ergonomics follow and opposite of FPJ
- **Philosophy:** design the job so that any member of the work force can perform it
- Why the FJP philosophy has evolved:
  - Changes in worker skill requirements
    - Today, companies do not need to be much selective, since workers are much more educated. In stead of investing time in selection procedure, companies spend time to train the new workforce
  - Demographic changes (e.g. more women in the workforce, recruiting fewer people of young age)
  - Social and political changes (e.g., equal opportunity laws, trade unions, collective bargaining)
    - Hiring handicapped workers is encouraged by the laws.

# Changes: 1930 and 2000

| | 1930 | 2000 |
|---|---|---|
| Total U.S. Population | 123 million | 281 million |
| Life expectancy | 60 years | 77 years |
| Median age | 27 years | 35 years |
| Number of people age 65 and over | 7 million | 35 million |
| Proportion of women in the labor force | 24% | 61% |

[a] Source: U.S. Census Bureau

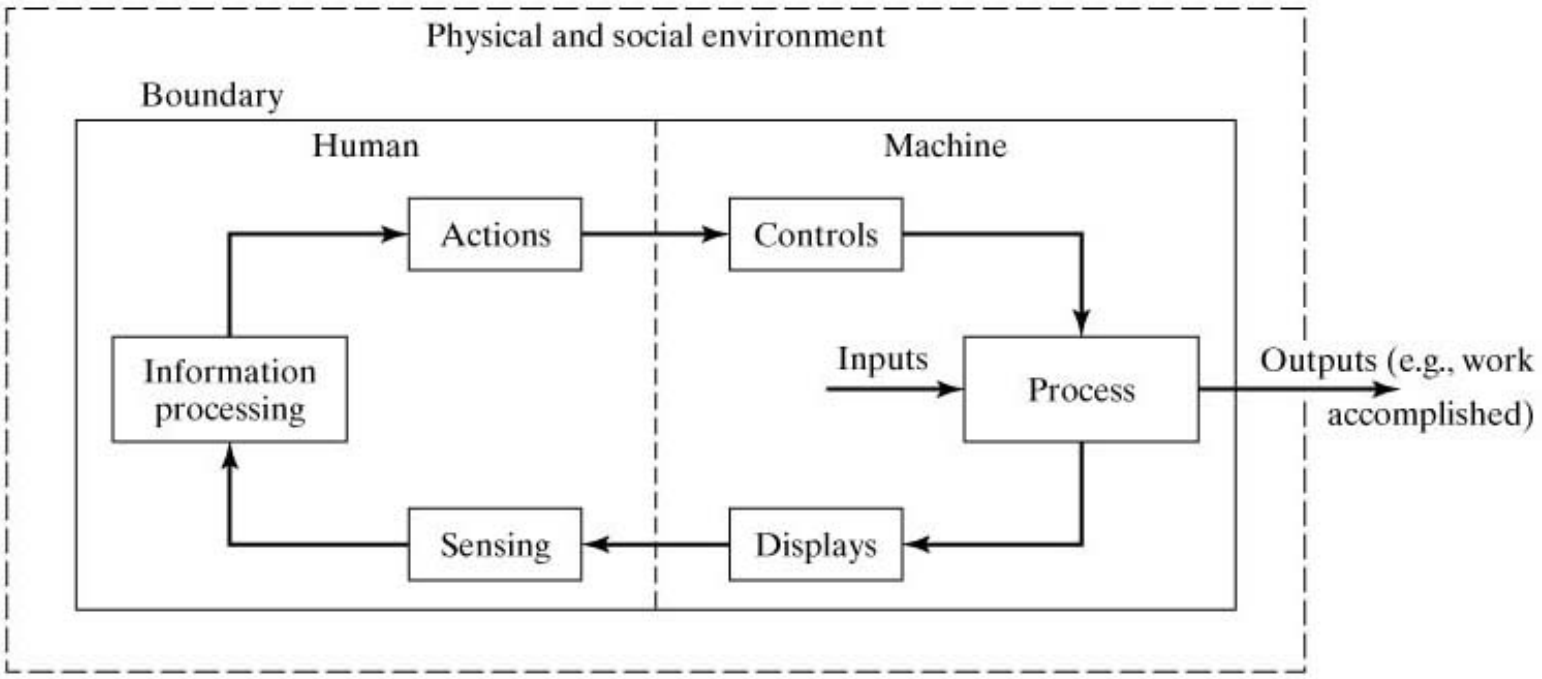
# Human-Machine Systems

- Basic model in ergonomics

- Defined as a combination of humans and equipment interacting to achieve some desired result – ref. Chp. 2 (e.g. external vs. internal work elements, levels of operator attention)

- Types of human-machine systems:
  1. Manual systems: a person using some (nonpowered) tool
  2. Mechanical systems: one or more humans using powered equipment
  3. Automated systems: automated system requiring occasional human attention

# Human-Machine Interactions




- A human-machine system has boundaries, that define what components are included within the scope of the system.
- A worker-machine production cell is one component in the larger production department.
- The ergonomist must decide where to draw the boundaries of the human-machine system of interest.

# System Components

- Setting the boundary matters because
  - it identifies controllable / uncontrollable
  - it reflects what the human -machine system operation is assumed to be

- The human
- The equipment
- The environment (both physical and social)
  - Poor lighting may effect worker's ability to perform an inspection task
  - An unfriendly supervisor may reduce a worker's motivation to work.

# Human Components

- **Functions:** (1) sensing the operation, (2) information processing, (3) actions
  - Human senses - to sense the operation
    - Five basic human sense (vision, hearing, touch, taste, and smell)
    - Related with sensory (+ nerveous) system of the body
  - Human brain - for information processing by the stimuli received from the senses
    - Thinking, planning, calculating, making decisions, solving problems
    - Related with the brain
  - Human effectors - to take action by the impulses from the nervous system
    - Fingers, hands, feet, and voice
    - Related with the musculoskeletal system (+ nerveous) system of the body.

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# Machine Components

- The machine in a human machine-system can range from a simple hand tool to a complex and sophisticated system of equipment.
- The process – function or operation performed by human-machine system
- Displays - to observe the process
  - Direct observation for simple processes
  - Artificial displays for complex processes (speedometer in a car)
- Controls - to actuate and regulate the process
  - Steering wheel, computer keyboard
- A worker using a shovel to dig a hole in the ground.
  - Process: digging, Displays: direct observation (no need for displays), Controls: handle of the shovel
- A worker monitoring the operation of an automated process. The worker should make sure that the process is within defined tolerances
  - Process: process itself, Displays: a digital monitor, Controls: buttons, levers

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# Environmental Components

- Physical environment
  - Location and surrounding lighting, noise, temperature, and humidity
- Social environment
  - Co-workers and colleagues at work
  - Immediate supervisors
  - Organizational culture
  - Pace of work