Human Factors Defined

A Few Terms
- Human Factors
- Ergonomics
- Human Engineering
- Engineering Psychology
Focus of HF

- Focus is on **HUMAN** beings and their interactions with products, equipment, facilities, procedures, and environments.
- Emphasis is on the **HUMAN**
- HF seeks to change the things people use/their environment to better match the capabilities, limitations, and needs of people.

Objectives of HF

1. To enhance the effectiveness and efficiency:
   - Increased convenience of use
   - Reduced errors
   - Increased productivity
2. To enhance certain desirable human values:
   - Improved safety
   - Reduced fatigue/stress
   - Increased comfort
   - Greater user acceptance
   - Increased job satisfaction
   - Improved quality of life

Approach of HF

- Is to utilize known information about human capability to design things for human use
Best Definition of HF

- Human factors discovers and applies information about human behavior, machines, systems, tasks, jobs, and other characteristics for productive, safe, comfortable, and effective human use.

A Brief History of HF

Early History

- Ergonomics was said to have started in ancient history.
- The Egyptian chief architect, physician, and high priest of Heliopolis, Imhotep (2667 - 2648 BC), was credited the first report of documenting the treatment of back pain resulting from the Egyptians' work habits during the building process of the Third Dynasty, King Djoser's (2687-2668 BC), step pyramid at Saqqara.
Bernardino Ramazinni

- The next known publication came thousands of years later, when Bernardino Ramazinni (1633-1714), a physician, wrote about the work-related complaints that he saw during his medical practice in 1713.
- His publication was called the “De Morbis Artificum,” or “The Diseases of Workers.”
- However, up to that point, this science had no known or recognizable term.

The Term “Ergonomics”

- It wasn’t until 1857, that Wojciech Jastrzebowski, coined the term “Ergonomics.”
- Jastrzebowski, was a polish scholar and professor of natural sciences at the Agronomical Institute in Warsaw-Marymount.

The Industrial Revolution

- While the industrial revolution was taking first stage in all manufacturing fields, many tasks were still performed by hand.
- In the early 1900's, a number of accommodations were developed to improve worker productivity and efficiency.
- At the time, Ergonomics took a turn towards management, and was dubbed “Scientific Management.”
Turn of the Century History:

- Early 1900’s: (Coach Stage Syndrome) from driving horse-pulled coach carts
- 40’s and 50’s: (Telegraph Syndrome)

Frederick Winslow Taylor

- In 1911, Frederick Winslow Taylor, a management consultant developed the “One Best Way” method to enhance worker production.
- Taylor was ranked at the top, along with Darwin and Freud, as one of the daring and forward thinkers of modern times.

Lillian Moller Gilbreth

- Frank and Lillian Moller Gilbreth pioneered the science of time-motion studies, and were able through job evaluations and analysis to reduce time, and effort by which a task is being conducted.
- After her Husband’s death, Lillian continued her work in the science of Scientific Management and was dubbed “The Mother of Management.”
- The Gilbreth’s efforts reduced the number of motions in bricklaying from 18 down to 4.5, and hence, enhancing productivity from 120 to 350 bricks/hr.
World War II & Human Factors

- World War II (1939-1945) marked greater leaps in sophisticated military equipment, subsequently, non-military applications.

After WW-II

- An Engineering Psychology lab was developed by the U.S. Army Air Corps (currently, the U.S. Air Force)
- 1st Civilian consulting company to do Engineering Psychology was founded

Cockpit Design

- As a result, human-machine interaction captured greater interest, especially, in airplane and cockpit design.
This paved the way for such human factors designs to occupy center stage during the race for outer space supremacy during the late 60's and early 70's.

In Britain

As the interest in Ergonomics and Human Factors Engineering grew, supporting societies and organizations started to sprout around the world.

The Ergonomics Research Society was first formed in Great Britain in 1949, currently called the “Ergonomics Society”.

This society started the “Ergonomics Journal” in 1957.

In the USA

The Human Factors Society was founded in 1957, and has now grown to 22 technical groups and numerous local and student chapters, and now publishes the Human Factors Journal (The Human Factors Society).

Membership grew from 500 in 1960, to 3,000 in 1980, to around 13,000 members today.
Further International Growth

- In 1961, the first International Ergonomics Association meeting was held in Stockholm, Sweden.
- This organization has members from the USA, UK, Europe, Japan, Australia, Scandinavia, and other countries interested in that type of research.
- In 1990, the Board of Certified Professional Ergonomists (BCPE) was established to certify Human Factors and Ergonomics practitioners, researchers, and engineers in the USA.

Modern History (1979):

Three-mile-island: (Nuclear Reactor meltdown)

Systems

A System is an entity that exists to carry out some purpose.
Human Machine Systems

- Def: These are systems that involve Man and Machine to carry out a purpose (given some input, it will produce some output)

Types of Human-Machine Systems

- Manual Systems:
  - Human provides power and control
- Mechanical Systems:
  - Machine provides power, Human provides control
- Automated Systems:
  - Machine provides power, and control. Human has very little input
Characteristics of Systems

- Systems are Purposive
- Systems can be Hierarchical
- Systems operate in an environment
- **Components serve a function**
- Components Interact
- Systems have inputs and outputs

Components Serve Functions

1. Sensing (Information receiving)
2. Information Storage
3. Information Processing and Decision making
4. Action Functions

Categories of Systems

- Closed-loop systems:
  - One that requires continuous control
- Open-loop systems:
  - One that requires NO control once activated
System Reliability

- Reliability is expressed in:
  - Probability of successful performance (man vs. machine)
  - Mean Time-to-Failure (MTF)

System Reliability

Components in Series

Reliability of this system is:
90% X 80% X 75% X 95% = 0.513 or 51.3%

- Max possible reliability is equal to the reliability of the least reliable component (typically, the human in any system)
Components in Parallel (Backup or Redundancy)

Reliability of this system is:

\[1 - \frac{1}{(1 - 90\%)} \times \frac{1}{(1 - 80\%)} \times \frac{1}{(1 - 75\%)} \times \frac{1}{(1 - 95\%)}\] = 0.996 or 99.6%

Reliability of overall system increases by adding more components.

Metrics that Affect Human Accuracy + Response

- Heart Rate
- VO\textsubscript{2}
- Respiration Rate
- EKG
- EMG

Physiological
**Human Factors Engineering**

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### Physical Factors

- Motion tracking
- Eye tracking
- Voice
- Video
- Kinematics (Fitts' law)*
- Hick's Law**
- Force
- Torque
- Keystrokes
- Anthropometry

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### Fitts' Law

\[ T = k \log_2(D/S + 0.5) \]

Where:
- \( k \approx 100 \text{ msec} \)
- \( T \) = time to move the hand to a target
- \( D \) = distance between hand and target
- \( S \) = size of target

**Example:**
- To model the time it takes to use a mouse and other input devices to click on objects on a screen.
- Can be applied by designers to suggest moving target buttons closer and making them larger for extremely commonly used buttons.
- Used for exact design of time-critical applications.

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### Hick's Law

1. \[ H = \log_2(n + 1) \]
2. \[ H = \sum p_i \log_2(1/p_i + 1) \]

\[ T = kH, \text{ where } k \approx 150 \text{ msec.} \]

Where:
- \( H \) = the information-theoretic entropy of a decision.
- \( n \) = the number of equally probable alternatives.
- \( p_i \) = the probability of alternative \( i \) for \( n \) alternatives of unequal probability.
- \( T \) = the time it takes to make a decision (roughly proportional to \( H \))

This can be used to make a time estimate for how long people will take to make a decision in using a user interface, such as choosing a menu item, choosing a tool, or selecting an item on a navigation bar.

Cognitive modeling approaches such as GOMS apply this to making predictions of human performance.
### Environmental
- Lighting
- Suited
- Climate
- Temperature
- Noise / Acoustics
- Speed

### Performance
- Accuracy
- Time to completion
- Reaction Time
- Control Reversals

### Behavioral
- Training level
- Previous Experience
- Competency