College of Engineering
GE106:Introduction to Engineering Design

Human Factors in Engineering Design

By

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Outline

- What is Human Factors Integration in Design?
- Some Definitions of Human Factors Engineering
- Importance of Human Factors in Design
- Difficulties of Human Factors
- Forms of Human Factors Integration in Design
  - Anthropometric Factors
  - Ergonomic Factors
  - Physiological Factors
  - Psychological Factors
- Concluding Statements

What is Human Factors Integration in Design?

- Considering information about human behavior, abilities, characteristics and physical limits.
- Ensuring that the final product can be effectively utilized by the end user, without exceeding their capabilities.
- 'Fitting the Job to the Man' rather than 'Fitting the Man to the Job'.
- Optimizing Efficiency, Health, Safety and Comfort of people through better designs focused on the end-user.

Human factors must be considered during the design phase:

"You can use an eraser on the drafting table or a sledge-hammer on the construction site."

Frank Lloyd Wright (Architect)

Some Definitions

Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design to optimize human well-being and overall system performance. (*Wikipedia*)

Designing tasks, equipment and work stations to suit the user can reduce human error, accidents and ill-health. ... The application of human factors to the design and development of systems and services is often called Human Factors Engineering or Human Factors Integration. (*HSE, UK.Gov*)

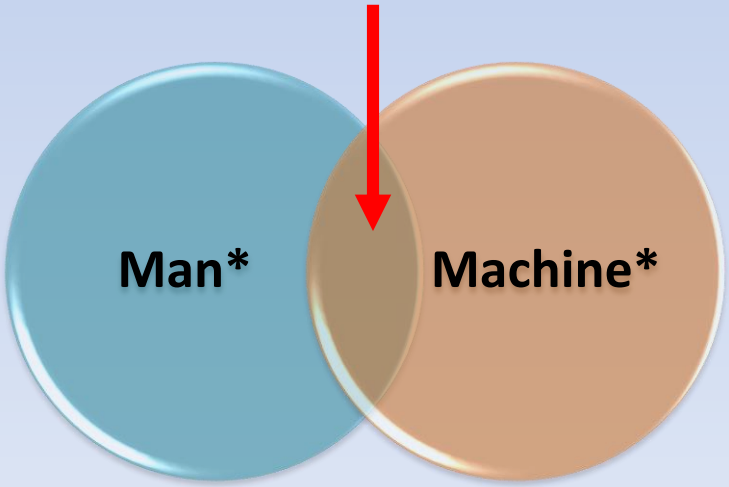
Human factors in design refers to ergonomic and aesthetic factors that influence the design of products, systems and environments. These factors are supported by the use of anthropometric, psychological and sensory data gathering and analysis techniques.

Importance of Human Factors in Design

- Improve productivity
- Improve safety
- Improve comfort
- Improve satisfaction
- Decrease errors
- Reduce fatigue
- Reduce the learning curve
- Meet user's needs and wants
- Positive perception of product

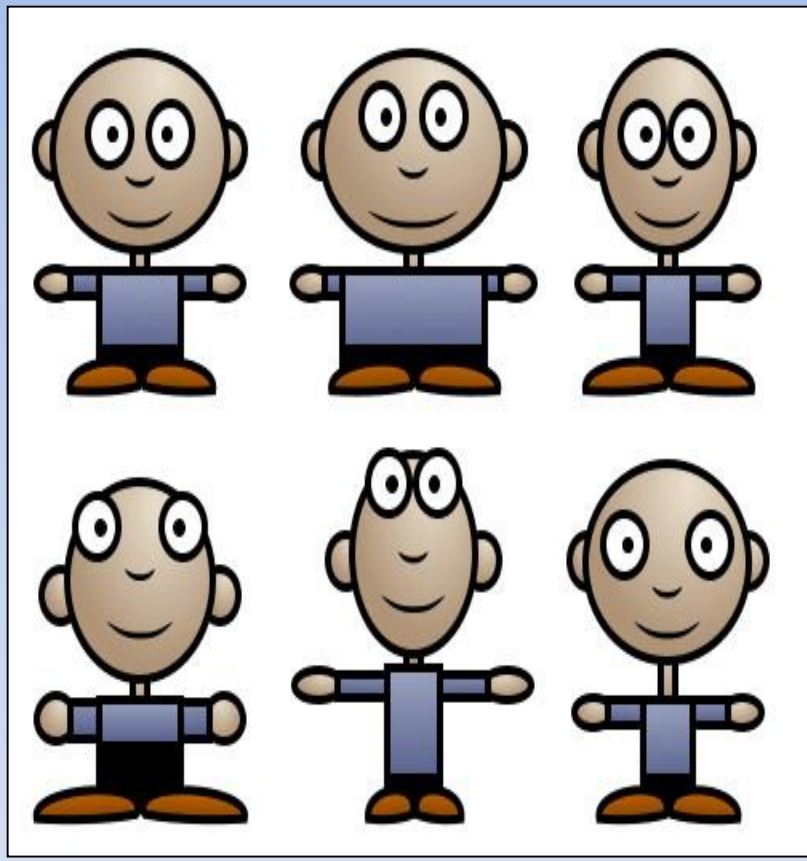
Ease and Efficiency

Human factors



Difficulties of Human Factors

- Humans are flexible and adaptable
- Large individual differences
  - Obvious differences: Physical size and strength
  - Non-obvious differences: culture*, style, and skill



Forms of Human Factors

1. **Anthropometric**

   (Human interaction in static sense; dimensions of human body)

2. **Ergonomics**

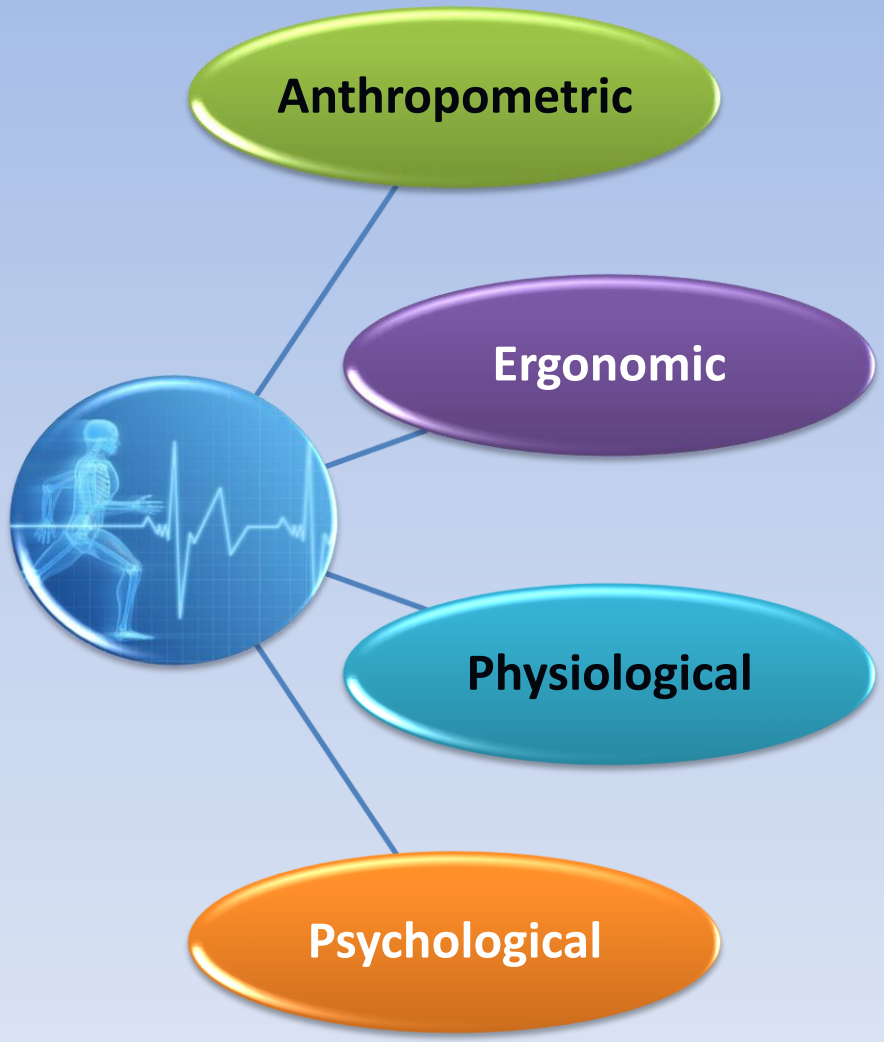
   (Human interaction in dynamic sense; repeated tasks)

3. **Physiological**

   (Human interaction with body characteristics)

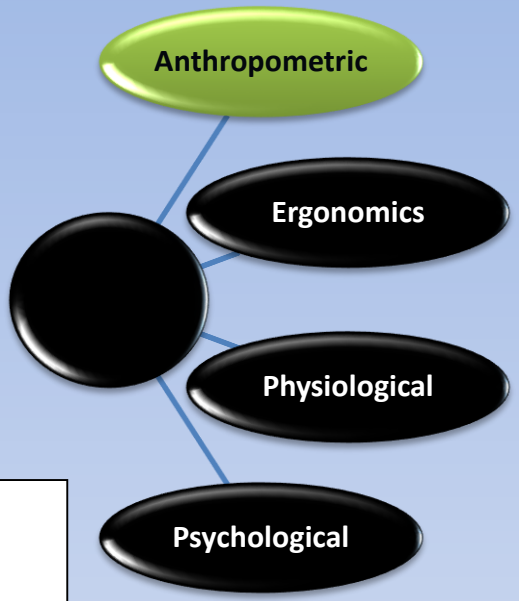
4. **Psychological**

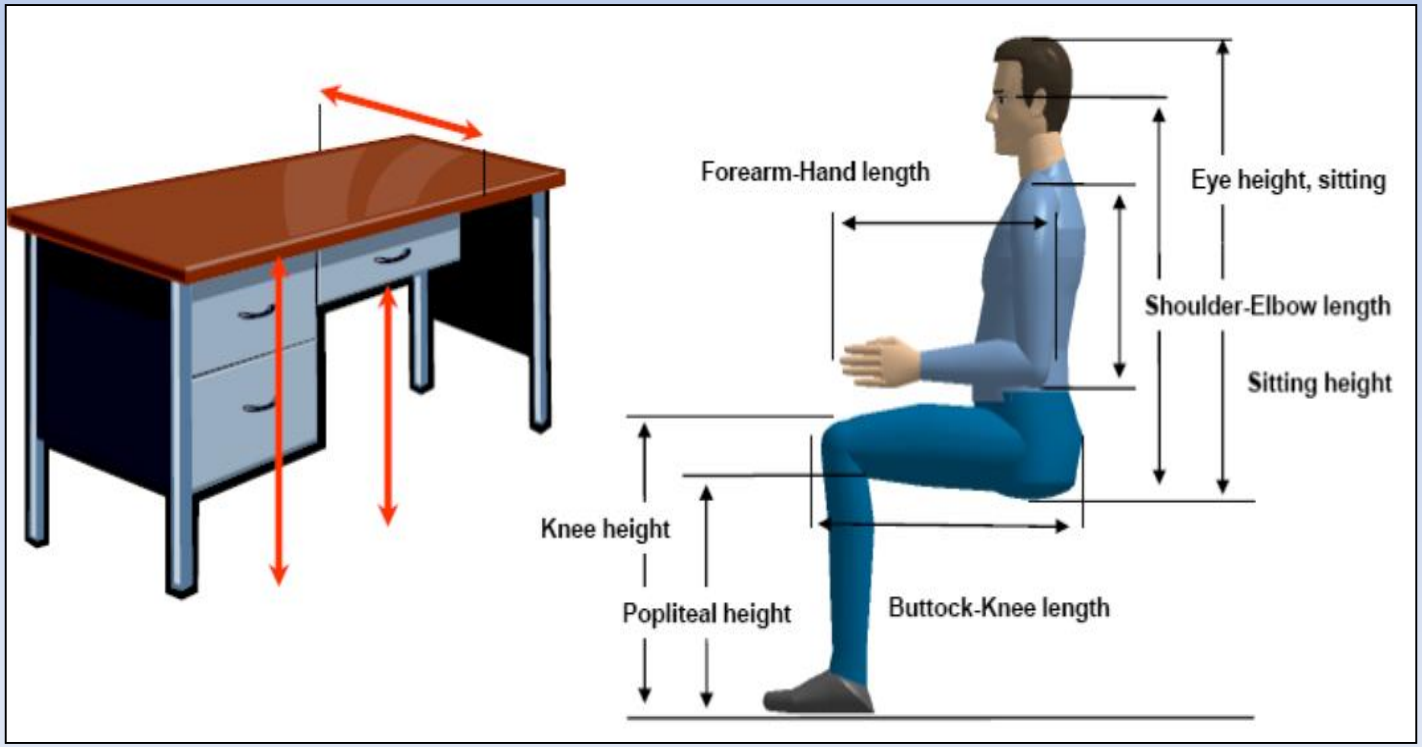
   (Human interaction with mental activities)



1. Anthropometric Factors

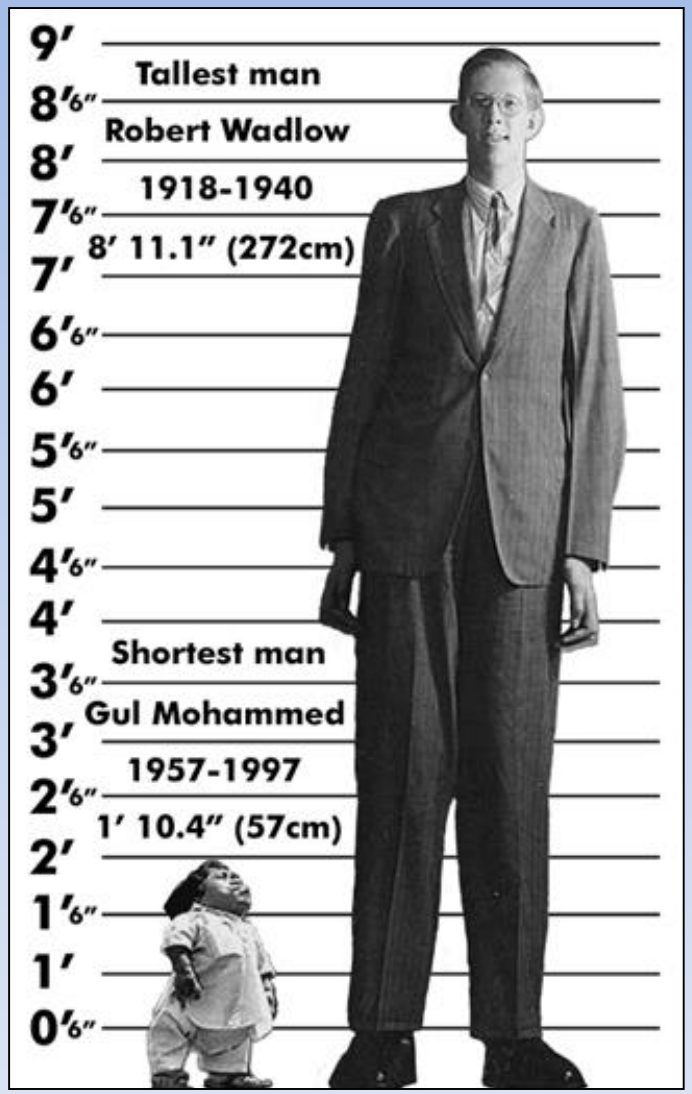
Anthropometric human factors are related to the physical size of humans; it is man-machine interaction in the static sense.





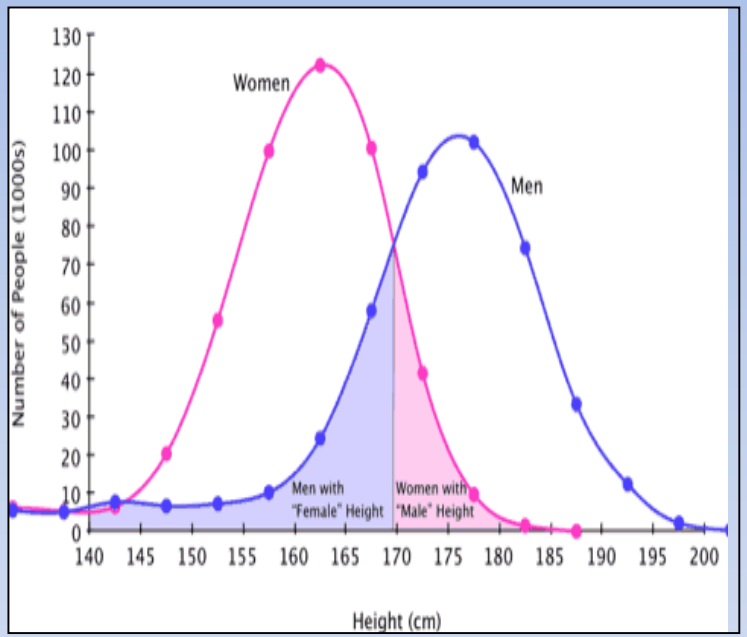
Anthropometric Factors (Cont'd)

Adequate attention to the nature of the **physical dimensions of humans.**

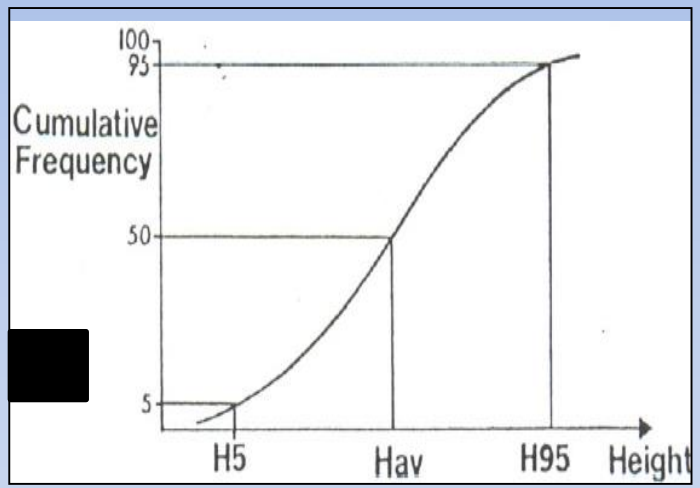


Anthropometric Factors (Cont'd)

Statistical distribution (relative frequency) diagram for the height of people



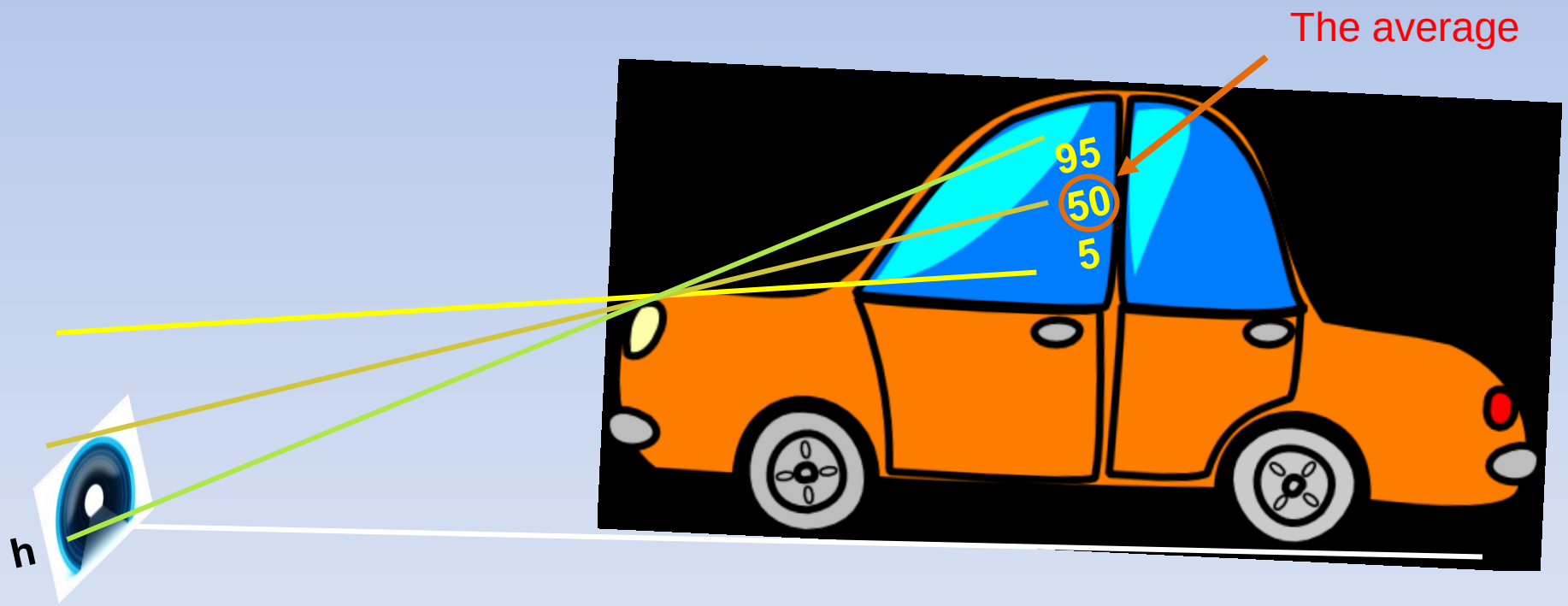
Cumulative distribution diagram is an alternative method to present the same information



- The peak in the relative frequency diagram is often close to the **average value**
- By designing for the average person we often **exclude 50% of the population**

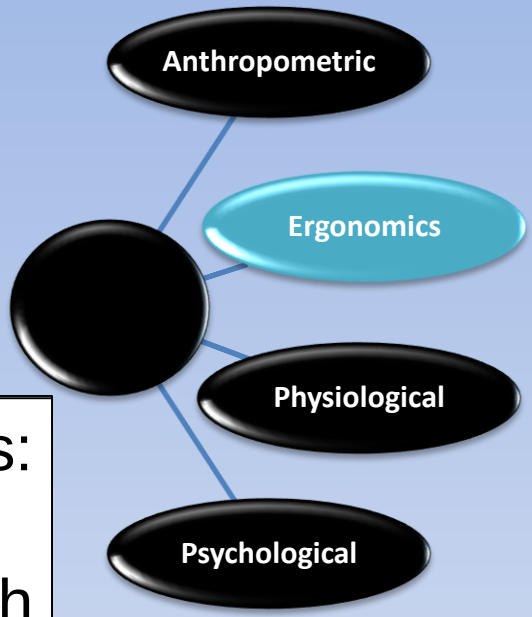
Anthropometric Factors Example

Being able to <u>see</u> an obstacle of <u>height *h*</u> at a <u>minimum distance *L*</u> from the front of the car*

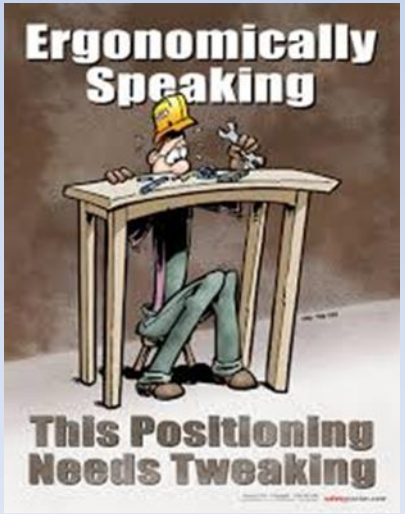


2. Ergonomic Factors

Greek Words: Ergon = work, Nomos = law
Ergonomics= Study of Work Laws



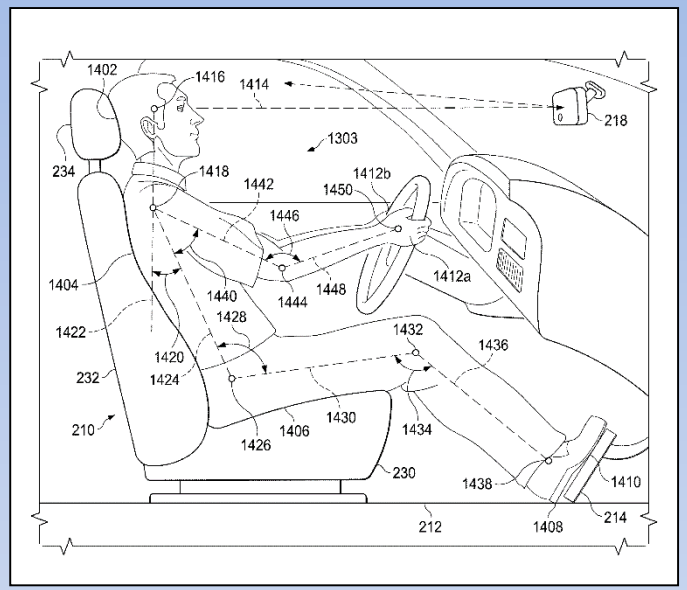
- The three aspects of ergonomic factors: **Safety, comfort and efficiency.**
- Important when the human is involved with the machine or product in a dynamic sense.
- A human is required to exert a force or perhaps supply work to the machine.
- The effective operation of a machine over long periods of time will depend upon the matching of requirements to human capability.

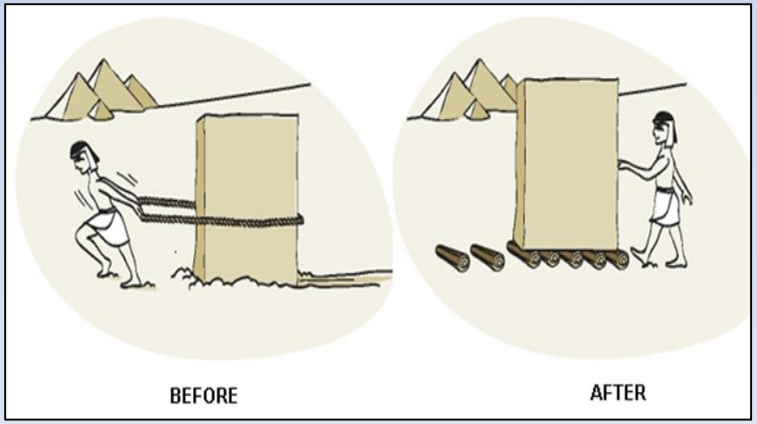


Ergonomic Factors (Cont'd)

The capability for performing many tasks depends on:

- The physical ability of the operator
- The range of movement required
- The speed of movement
- The duration of the activity
- The position of the operator
- The environmental condition





Ergonomic Factors (Aircraft Instrument Panel Example)

- **First, determine functions inter-relationships and their relative values**
- **A useful measure of the relative value of a relationship is the product of the importance of the particular event by the frequency of occurrence**

If these can be established, the designer has a logical perspective available to assist in planning the display.

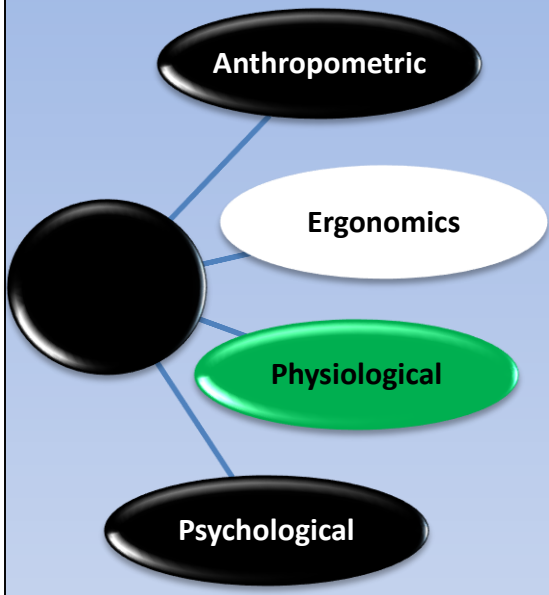
Aircraft Instrument Panel (Importance and Frequency)

Instrument	Duration of observation (sec)	No. of observations per min.	Relative value
Cross pointer	0	0	0
Air speed	0.67	22	14.7**
Directional Gyro	0.51	24	12.2*
Gyro. Horizon	0.59	26	15.3***
Engine Instruments	1. 13	5	5.6
Altimeter	0.47	10	4.7
Turn and Bank	0.39	5	2.0
Vertical Speed	0.17	12	5.6

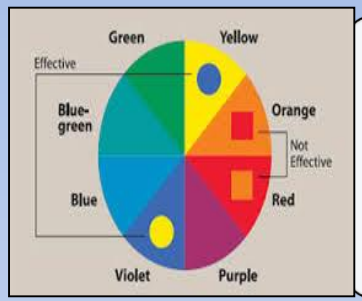
Air speed, Directional Gyro, and Gyro. Horizon are the most important and must be very visible and close to each other

3. Physiological Factors

- **Physiological factors are of concern when the physicochemical characteristics of the body are significant, these** deal with human **sensations.**
- **They involve the neurological, muscular, respiratory, vascular and sensory systems.**
- **They can be grouped according to the response to various inputs such as:**
  - **Visual**
  - **Auditory**
  - **Tactile** (the sense of touch)
  - **Kinesthetic** (detecting body position)
  - **Taste senses* (also smell: olfactory)**
  - **Environment**



Physiological Factors (examples)



- Color
- Light

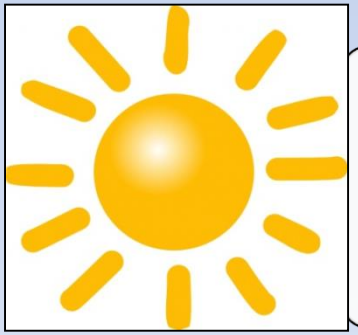
- Noise
- Speech

Vision

Hearing

Weather

Touch



- Temp.
- Humidity

- Braille
- Comfort

Physiological Factors

- Human operators receive a great deal of information visually.
- The visual processes enable us to perceive form, color, brightness and motion and so read printed instructions and instruments, observe moving objects and react emotionally to combinations of shape and color.
- In order to achieve the discrimination necessary for correct interpretation it is necessary to achieve satisfactory intensity and color discrimination and resolution.

Physiological Factors

- Color discrimination is impaired when illumination levels are low, and this can lead to unexpected difficulties in comprehension.

- An associated problem of illumination which has a critical effect on contrast is that of glare and shadow formation. These can be controlled by careful design of lighting systems and selection of materials and colors.

Physiological Factors

- Another source of information is that which is transmitted audibly (capable of being heard). This will range from spoken information to the noise which machinery makes when operating.

- Spoken communication is, of course, very obvious, but the unusual sound that is made by malfunctioning equipment are often recognized as such and lead to the taking of remedial action.

Physiological Factors

- An excessive level of **noise pollution** is, in fact, undesirable for a number of reasons:
  - Leads to degradation of speech intelligibility (clearness)
  - Will lead to physical damage to the human auditory system.
  - Hinders mental activity due to distracting influences.
  - Can lead to psychological and mental disorders if sustained.

Physiological Factors

- The speech interference level (SIL) is a measure of the destructiveness of noise.
- It is determined by the level of noise in certain frequency bands.
- High levels of sound intensity cause pain and even physical damage.
- The usually accepted threshold of pain is at about 0.5 *W/m2 (sound intensity watt/m2)*

Physiological Factors

The following steps are available for the **acoustic (sound) treatment** of working environments:

- Control the noise at its source by changing the dynamic behaviors of the machine, modifying fluid jet flow, … etc.
- Create barriers between the source and the listener.
- Provide personal protective devices.
- Modify operating procedures so that the exposure of personnel to noise is reduced.

Physiological Factors

- Acoustic design can also take on a positive aspect when we are concerned with the quality of sound. This is important in the design of concert halls, recording studios, amplification equipment, to name a few areas.

- In these cases it is necessary to consider the frequency analysis of the sounds and the reflection and absorptive characteristics of surfaces over the appropriate frequency range.

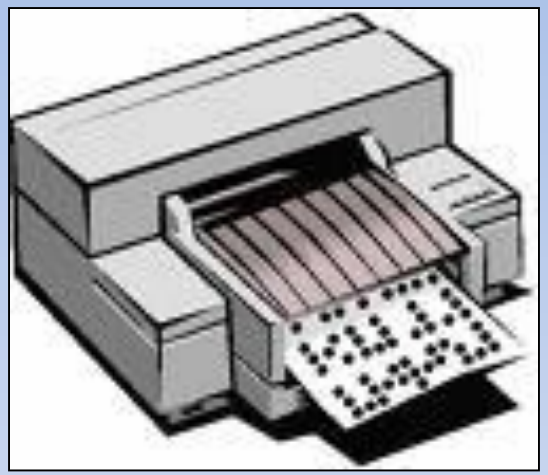
- The geometric design is also of considerable importance since this determines the reflection of sound waves and the possible interferences.

Physiological Factors

- There are many sensory inputs to which the body responds and which must be taken into account, or made use of in the man-machine relationship.

- The sense of touch is one which is of great value in various recognition situations.

- **Braille printing** of coded impressions is an example of the recognition process by the sense of touch.



Physiological Factors

- Humidity has little effect on heat exchange for normal temperatures.

- **At high temperatures, however, humidity has an important effect on heat transfer, comfort and physiological tolerance.**

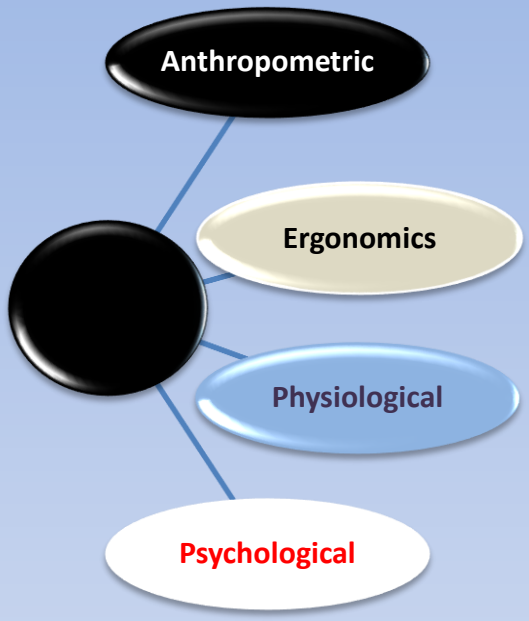
- There is a relationship between temperatures and humidity which leads to similar degrees of comfort.

Physiological Factors (Summary)

- It is necessary to achieve satisfactory intensity and color discrimination and resolution.
- Need careful design of lighting systems and selection of materials and colors.
- Consider the frequency analysis of the sounds.
- Control the noise at its source.
- The sense of touch is of great value in various recognition situations (e.g., Braille printing).
- The atmospheric environment in which the human performs his tasks may considerably affect his working efficiency and accuracy.

4. Psychological Factors

Psychological considerations in human factors analysis are concerned with the mental activity relationship between man and the product.



This involves:

- Interpretation of information
- Motivation and fatigue
- Decision making
- Aesthetics (philosophy of art)

Psychological Factors (Cont'd.)

- Here we are concerned with the manner of presentation which will lead to minimum error of interpretation.

- The design of **visual displays** such as control panels, instrument panels and other informative displays is a typical example of psychological factors at work.

- There are a number of principles which have been developed. Some of these include:

1. Retain the usual method of operation (e.g., a power switch is ON when the operating lever is DOWN

Psychological Factors (Cont'd.)

2. Use digital indicators for precise numerical values with no need for interpretation. That is satisfactory only when values are constant or not changing rapidly.

3. For time variable readings not requiring high accuracy use moving pointers over a fixed linear or circular scale.

Psychological Factors (Cont'd.)

4. Arrange control movement to coincide with required direction of instrument pointer movement.

5. Color coding on dials are useful in helping to recognize conditions quickly e.g., green-normal, yellow-caution, red-danger.

Psychological Factors (Cont'd.)

- If the operator feels he can easily assert control, and that the system will respond, then he has less fear of the operation resulting in reduced fatigue and improves motivation.

- This means that the mechanism of the control device should be designed so that:
  - (i) Movements are easy.
  - (ii) Slackness is eliminated.
  - (iii) The operator is aware of a feedback response.
  - (iv) The system response is rapid.

Psychological Factors (Cont'd.)

- If this cannot be achieved the controller should incorporate some restriction so that over reaction and instability does not develop.
- Decision making is sometimes a difficult task for people to carry out.
- It is important that the incoming information be presented in a readily assimilated manner.
- However, it is also necessary that this information be supplied in ample time for the operator to be able to decide on his course of control action.

Psychological Factors (Summary)

- Use presentations which will lead to minimum error of interpretation*
- Retain the usual method of operation (e.g., a power switch is ON when the operating lever is DOWN)
- Use digital indicators for precise numerical values.
- Use color coding on dials for fast recognition: green-normal, yellow-caution, red-danger.
- Arrange control movement in a logical manner

Concluding Statements

- Human factors must be considered in Engineering design.
- A well designed product must adequately incorporate the necessary components of Human factors engineering.
- Product should be designed for adjustability and inclusivity, this will ensure wider acceptability amongst the population. Do not just design strictly for the average user.
- Your project design for this course must integrate necessary human factors engineering considerations and you should demonstrate how these were integrated in your project design.

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