GE105: Introduction to Engineering Design

Human Factors

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Outline

- Human Factors in Engineering Design
- Man-Machine Interface (1)
  - Anthropometric Factors (2)
  - Ergonomic Factors (3)
  - Physiological Factors (4)
  - Psychological Factors (5)

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(1) Border
(2) The study of human body measurements
(3) Maximizing productivity by minimizing operator fatigue and discomfort
(4) Body characteristics
(5) Mental

Human Factors in Engineering Design

- Engineering Design is concerned with the satisfaction of human needs.
- In many applications, **human factors** must be taken into account in the design process.
- **M**an-**M**achine **I**nterface (**MMI**) is very important to be considered in the design process

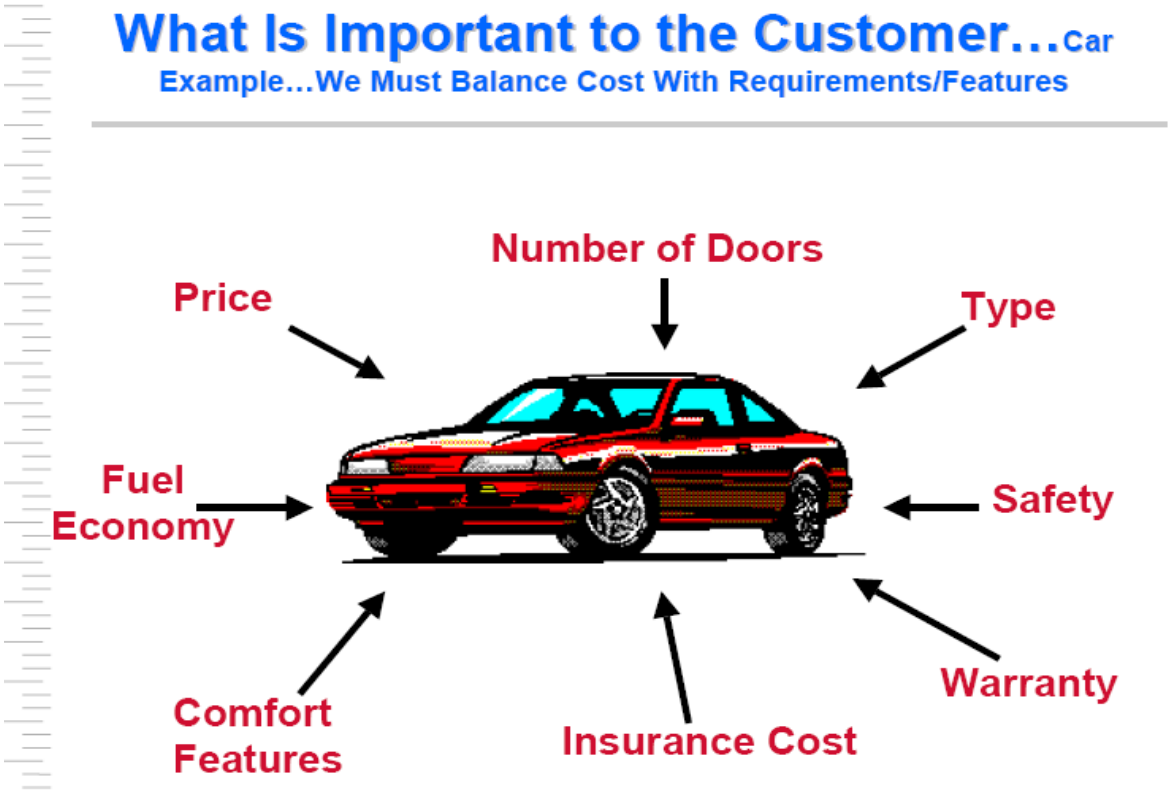
Man-Machine Interface

Human factors in **man-machine** relationship have the following forms:

- **Anthropometric**
  (Human interaction in static sense: dimensions of body)
- **Ergonomic**
  (Human interaction in dynamic sense: repeated tasks)
- **Physiological**
  (Human interaction with body characteristics)
- **Psychological**
  (Human interaction with mental activities)

Man-Machine Interface

The **Design Engineer** can determine the relative importance of human factors in his design

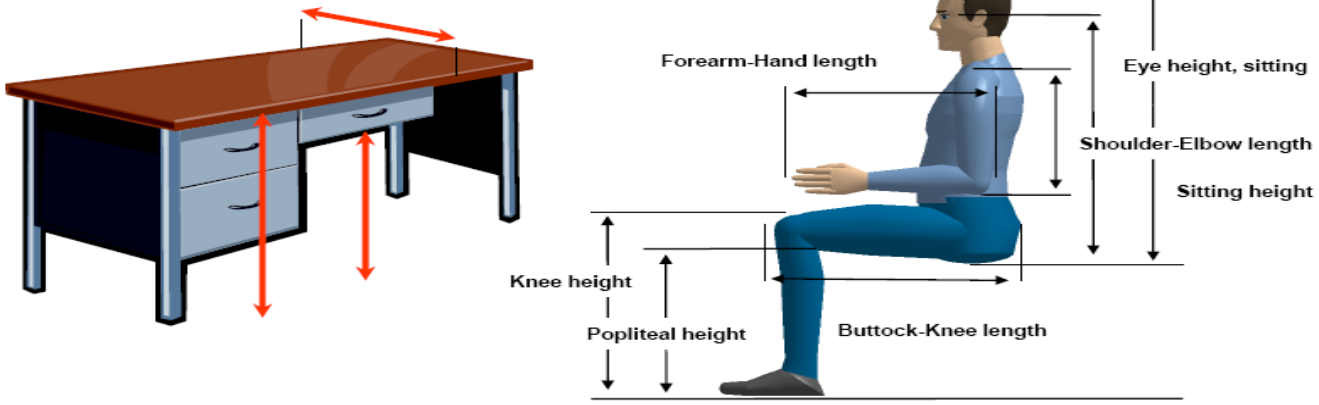


Anthropometric Factors

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

Critical variables

- Human dimensions that define the design solution



Anthropometric Factors

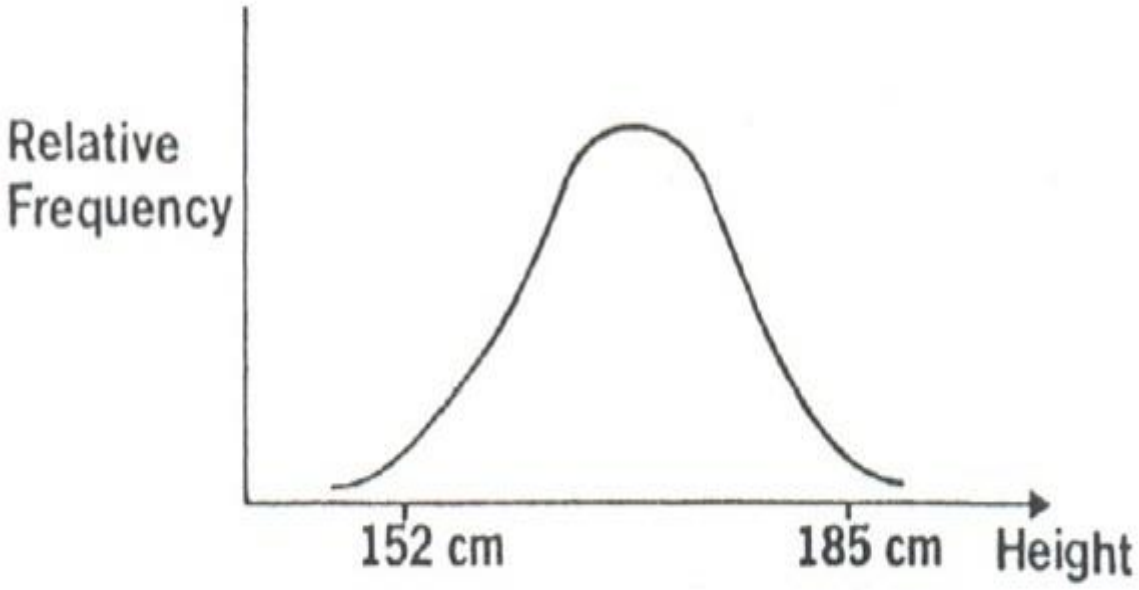
- One of the most common problems is that of driver accommodation in automobiles.

- Some may have experienced difficulties in either getting in or out, reaching the controls or adequate visibility.

- These may have been due to inadequate attention to the nature of the **physical dimensions of humans**.

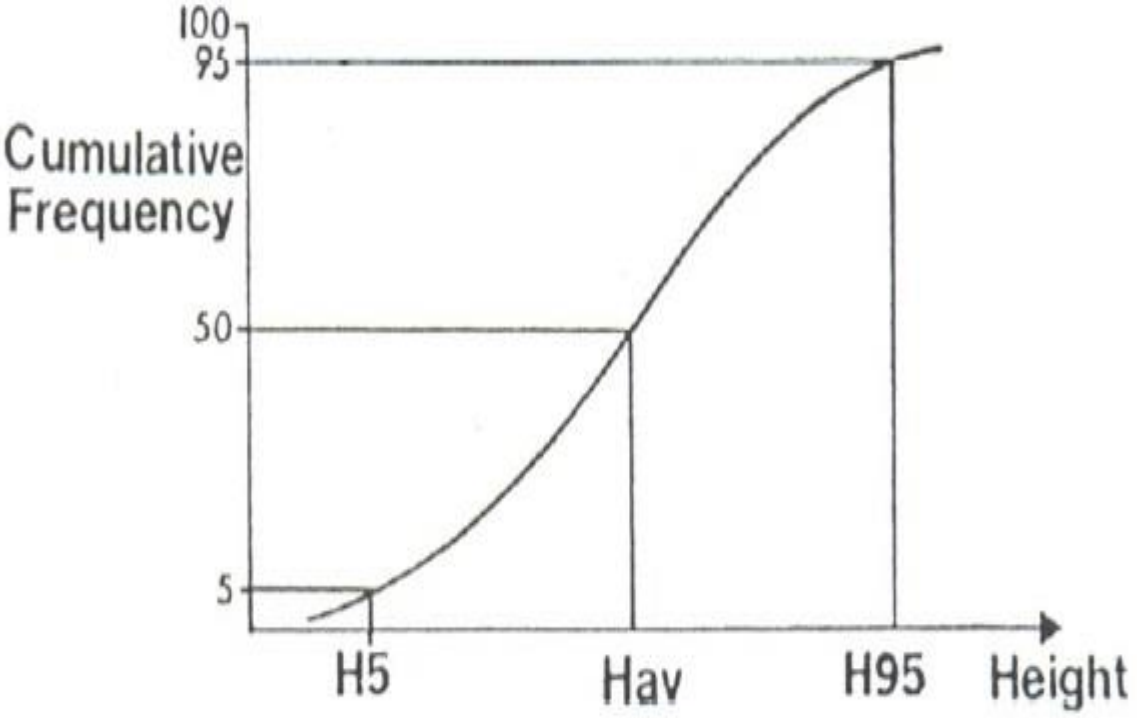
Anthropometric Factors

Statistical distribution (relative frequency) diagram for selected population-persons over 18 year's old living in Saudi Arabia.



Anthropometric Factors

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



Anthropometric Factors

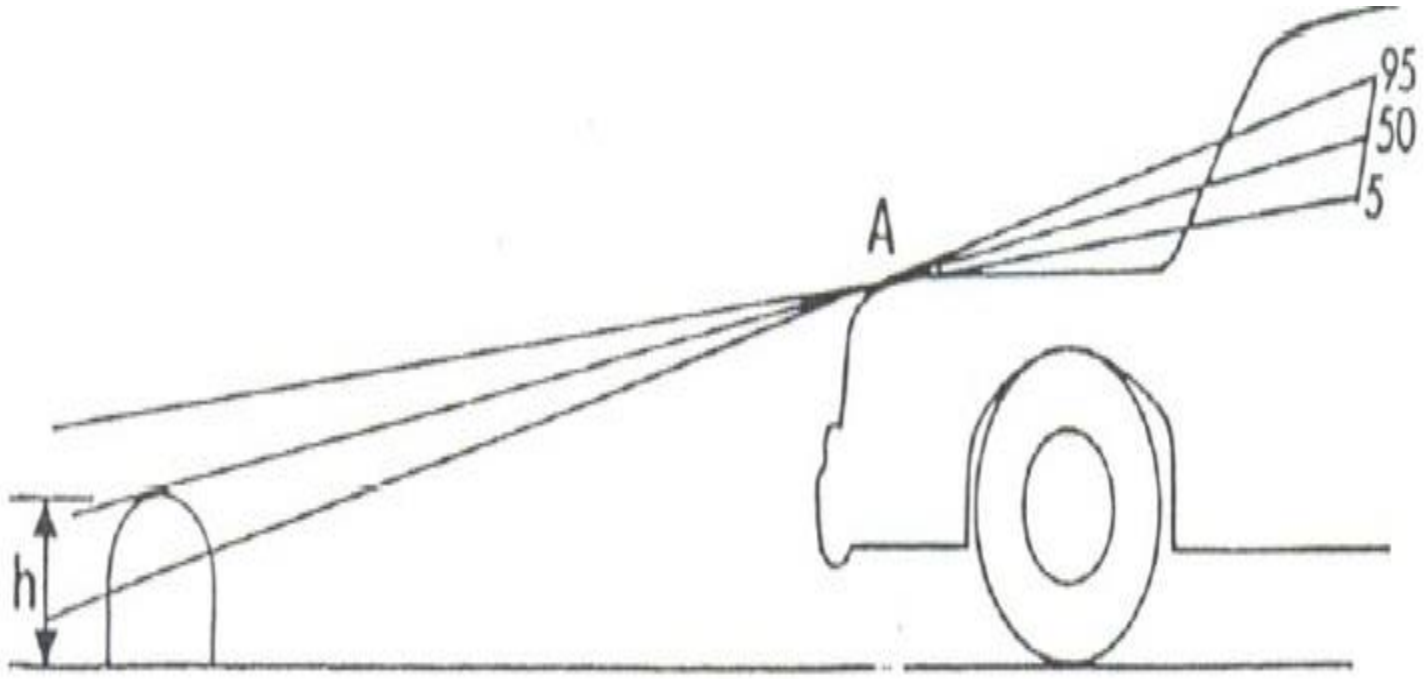
- The peak in the relative frequency diagram is often close to the **average value**.

- By designing for the average person we often **preclude (exclude) 50% of the population**.

- An example which illustrates this concept is that of the forward **visibility of a car driver**.

Anthropometric Factors

For a car driver to be able to see an obstacle of height h up to a minimum distance L from the front of the car.



Ergonomic Factors

The concept of Ergonomics:

The three main optimizational goals of ergonomics:

1. Safety
2. Comfort
3. Efficiency

Ergonomic Factors

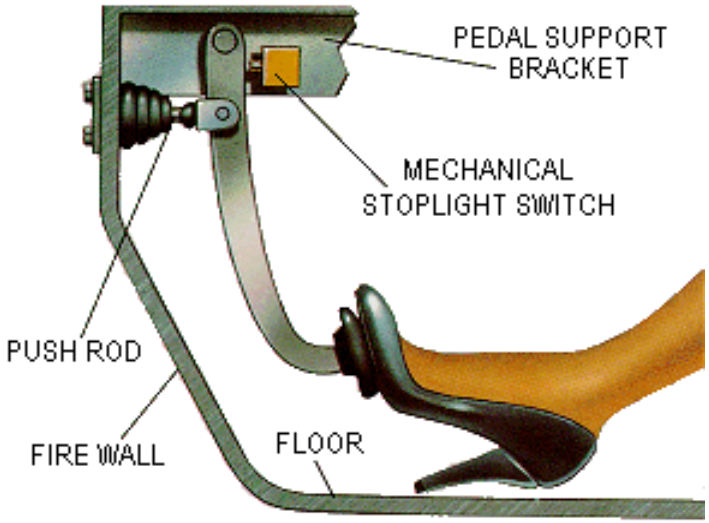
- Importance when the human operator is involved with the machine in a dynamic sense.

- A human is required to exert a force or perhaps supply work to the machine.

- It should be obvious that the effective operation of a machine over long periods of time will depend upon the matching of requirements to human capability.

Ergonomic Factors

One simple example is that when the brake operating force is higher than can be normally tolerated. The driver will cope with the situation at first, but if the brake operation is frequent, muscle fatigue will eventually occur and a dangerous situation will develop.



Ergonomic Factors

The capability for performing mechanical tasks of this type depends upon:

- 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

- The speed of movement consideration is important for assembly operations and also in control solutions.

- It may be necessary to execute rapid movements to operate a control device such as a stop button.

- Ergonomic principles are also known as motion and time study.

- There are two features of movement which are independent:
  1. The acceleration and deceleration stage.
  2. The constant velocity stage.

Ergonomic Factors

- The designer of the system from an ergonomic point of view must commence (start) with **the establishment of the system representation showing the interrelationships and their relative value**.
- 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 logic available to assist in the planning of the layout.

Ergonomic Factors

- An aircraft instrument panel can be considered as an example of this analysis.

- The pilot devoted varying lengths of time to looking at a variety of instruments and at different frequencies of observation. This data is as indicated in the following table.

Ergonomic Factors

Instrument	Duration of observation (sec)	No. of observation 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 Indicator	0.39	5	2.0
Vertical Speed	0.47	12	5.6

Ergonomic Factors

- we assume that all instruments are equally well designed so that the difficulty of reading is the same for each, then the duration of observation may be regarded as a measure of its importance.

- The relative value is then the product of duration and frequency and is listed in the third column.

- This indicates that the instruments of greatest importance are airspeed, directional gyro, gyro horizon.

Ergonomic Factors

- These must be placed in the prime position of the instrument panel for ease of viewing.

- The next are altimeter, vertical speed and turn and bank indicator.

- Ergonomic considerations are important in the design of control buttons, handles, levers, etc.

- There is an infinite variety of combinations of size, shape, surface texture, material and color which can be chosen for control knobs as an example.

Physiological Factors

- Physiological factors are of concern when the physicochemical characteristics of the body are significant.
- As far as body functions are concerned these involve the
  - Neurological
  - Muscular
  - Respiratory
  - Vascular
  - Sensory systems.
- The exterior appearance can be grouped according to the response to various inputs such as:
  - Visual
  - Auditory
  - Tactile, kinesthetic and taste senses
  - Environment.

Tactile: The sense of touch

Kinesthetic: The sense that detect body position

Physiological Factors

- Human operators receive a great deal of information visually.
- The visual processes enable us to perceive (understand) 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.

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discrimination: recognition

Physiological Factors

- Color discrimination is reduced when illumination (lighting) 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 (prevent) 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/m^2 *(sound intensity watt/m^2)*

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.

- 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.

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

- The atmospheric environment in which the human performs his tasks may considerably affect his working officially and accuracy.

- When the temperature is below 10 ^{o}C, physical stiffness of the extremities begins.

- Above 25°C physical fatigue begins and above 30°C the mental processes begin to slow down.

- A temperature of 50°C is tolerable (acceptable) for a short time but mental or physical effort is almost impossible.

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.

Psychological Factors

Psychological considerations in human factors analysis are concerned with the mental activity relationship between man and the machine. This involves:

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

Psychological Factors

➢ 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

* Retain : Keep in mind

Psychological Factors

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

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

➢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

- 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 (realize) 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.