HUMAN FACTORS

IENG 301

FUNDAMENTALS OF WORK STUDY AND ERGONOMICS

Human Factors

- Human factors is a system concerned with the relationship between human beings, machines, and the work environment.

- The diverse and complex nature of probles encountered by the human factors group in many organizations calls for an interdisciplinaty approach and may require skills from a variety of professions, such as psychology, sociology, biology, phsiology, and engineering.

Definitions

- The central focus relates to the consideration of human beings in the design of the man-made objects, facilities and environments that people “use” in the various aspects of their lives.

- The objectives of human factors in the design of these man-made objects are:
  1. To enhance the functional effectiveness with which people can use them
  2. To maintain or enhance certain desirable human values in the process (e.g. Health, safety and satisfaction)

Definitions

- The central approach of human factors is the systematic application of relevant informatiın about human characteristics and behavior to the design of the man-made objects, facilitates and environments that people use.

- The worker-machine relationship is the central core of human factors. The worker and the machine may performs similar functions. Both have certain capabilities and limitations. The worker-machine system, like any system, has an objective and consists of inputs and outputs.

A person ordinarily does three things in performing a task

- Receives information – through the sense organs: eyes, ears, touch, etc…
- Make decisions – acts on the information obtained and on the basis of his or her own knowledge
- Takes action – action resulting from the decision that has been made. The action may be purely physical, such as operating a machine or it may involve communication such as giving oral or written instructions.

Men and machines both have sensors

- The machine senses by mechanical, chemical or electrical means.
- Decision making or information processing by machines occurs through the use of computers, electrical circuits or mechanical means.
- The action function is the accomplishment or the output resulting from the decisions made.
- Both men and machines may store information and there is usually feedback.
- The division of work between mena nad machines is generally determined by economic consideration although many other factors enter the picture.

- The number of people working in the human factors field grew rapidly during World War II.
- A most important contribution of this group was the solving of complex man-machine problems, such as assisting in the design of aircraft cocpits, fire-control systems, and ship and submarine control systems.
- In some cases, military equipments had not been designed for effective human use – failures occured, human errors were made, and planes and ships were lost because people operating the equipment were unable to perform their functions – the designer had not taken into consideration human capabilities.
- Human factors groups continue to be used in military and space systems design but increasingly these groups play an important part in business and industry.

Noise

- Noise is very physical and noticeable to most employees.
- Workers usually point out noise as the most important probem.
- Compared with many other ergonomic problems, noise is very obvious and concrete.

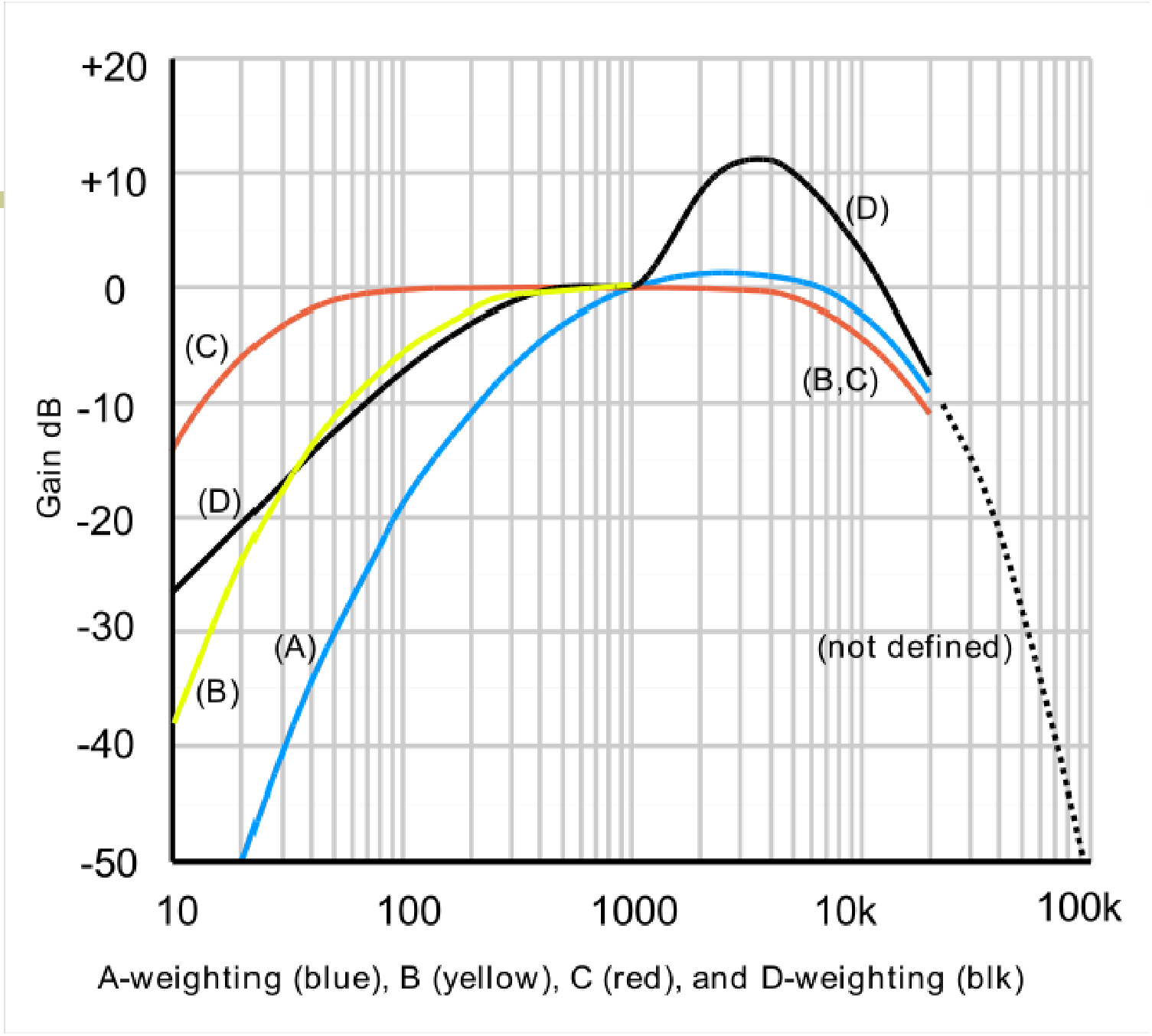
Noise

- In humans the audible range of frequencies is usually said to be 20 Hz (cycles per second) to 20 kHz (20,000 Hz), although there is considerable variation between individuals, especially at the high frequency end, where a gradual decline with age is considered normal.

- Dogs: 40 Hz to 60,000 Hz
- Bats: 20 Hz and 120,000 Hz
- Mice: 1 kHz to 90 kHz

Noise

- Sound level meters are ued to measure noise.
- They consist of a microphone, an amplifier and a meter that gives a visible reading in decibels (dB) on a scale.
- Most meters incorporate three different types of weighting of the sound. These are known as A, B and C scales.
- The dBA scale has achieved widespread use in most industries.


+20
+10
0
-10
-20
-30
-40
-50
Gain dB
10
100
1000
10k
100k
(C)
(D)
(A)
(B)
(D)
(B,C)
(not defined)
A-weighting (blue), B (yellow), C (red), and D-weighting (blk)

Noise

- The dBA scale is referenced to a sound pressure level of 0.0002 N/m^2, which corresponds to the threshold of hearing.

- The formula to calculate the sound pressure level (L in decibels) is given by:

$$L = 20 \log_{10}(P/P_0)$$

Range of frequency audible to human ear is so wide that, logarithmic scale is used

P: the root mean square (r.m.s.) sound pressure

P_0: the reference sound pressure (0.00002 N/m^2)

Noise

- From the formula, it can be derived that doubling the sound pressure would lead to an increase of 6dB.

- Inmost countries, there are laws that regulate how much noise employees can be exposed to.

Permissible noise exposures according to OSHA

Sound level dBA		Permissible time h
80		32
85		16
90		8
95		4
100		2
105		1
110		0.5
115		0.25
120	*	0.125
125	*	0.063
130	*	0.031

* Exposures above 115 dBA are not permitted regardless of duration, but should they exist, they are to be included in computations of the noise dose.

Noise

- Noise exposure of different intensity can be added according to the following formula:

$$D = \sum \left(\frac{C_i}{T_i} \right)$$

D: allowable noise dose (D≤1)

C: number of hours of exposure to a loise level i

T: permissible number of hours pf exposure to noise level i

Example

- A machine subjects its operator to 85 dBA when it is idle and to 90 dBA when it is used at full power.
- Assume 7 hours use per day, with 2.1 hours at 85 dBA and 4.9 hours at 90 dBA.
- The total noise dose:

$$D = 2.1/16 + 4.9/8 = 0.74375$$

- Since the noise dose is less than 1.0, this work exposes its operator to a noise level which is permissible

Noise

- There are four different aspects that can make noise unacceptable in the working environment:

1. Noise can cause hearing loss
2. Noise can affect performance on productivity
3. Noise can be annoying
4. Noise can interfere with spoken communication

Climate

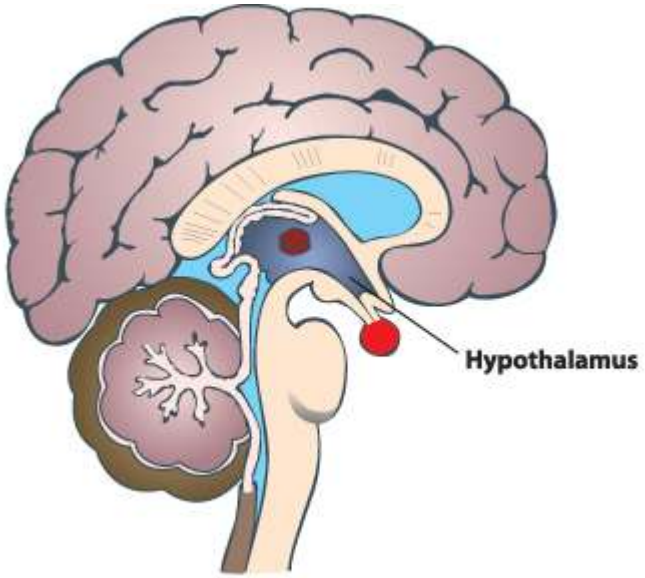
- Heat Stress is often a serious problem in industrially developing countries where work is conducted outdoors or manufacturing facilities lack insulation and/or cooling.
- It is also a problem in southern Europe and the USA.
- In no other field of ergonomics are there as many detailed regulations.

Thermoregulation

- There are several physiological mechanisms for regulating body temperature.

- These are under involuntary control by nerve cells in the hypothalamus (structure in the lower brain), and they maintain the body temperature within a narrow range (about 37 ± 0.5^0C).

- This process is known as thermoregulation



Climate

- There are two major ways of adapting to a hot environment:

1. Through acclimation
2. Through acclimatization

Acclimation & Acclimatization

- ***Acclimation*** refers to physiological changes, such as sweatimg in response to temperature.

- ***Acclimatization*** refers to more enduring changes in physiological mechanisms that enable an individual to work in extremely hot environments.
  - Repeated exposure to hot environments leads to an improved tolerance to the heat load.
  - During acclimatization, there are progressive increases in bıdy temperature, working heart rate and sweat rate.
  - These processes can be completed in 1-10 days of exposure to a hot environment.

Acclimatization

- If thebody gains an excessive amount of heat, there could be excessive sweating, dehydration, heat stroke and finally death may occur.
- The time required for acclimatization is reduced when people actually perform physical work in the heat.
- However, acclimatization to a hot environment can be lost over a period as short as weekend.
- People who work outdoors and spend the weekend in an air-conditioned environment will have to acclimatize again.
- Recoveryto the prior level will take about a day.
- Acclimatization is usually completely lost after 3-4 weeks in a cool environment.

Measurement of Heat Exposure

$$M - W = C + R + E + S$$

Where;

- M: metabolic power,
- W: effective mechanical power,
- C: heat exchange by convection,
- R: heat flow by radiation at the skin surface,
- E: heat flow by evaporation at the skin surface,
- S: heat storage.

- The heat storage (S) should in essence balnce at around zero.
- If S becomes large, tehre is a risk of heat stroke.
- There are many ways to reduce S – stopping working is one way.

Wet Bulb Globe Temperature

- One common method of evaluating heat stress is to record the wet bulb globe temperature (WBGT).

- This index takes into account four basic parameters:
  1. Air temperature,
  2. Mean radiant temperature,
  3. Air speed, and
  4. Absolute humidity

Wet Bulb Globe Temperature

- There are two different formulations for WBGT:

1. Inside buildings and outside buildings where there is no sunshine

$$WBGT = 0.7(T_{NW}) + 0.3(T_G)$$

2. Outside buildings with solar load

$$WBGT = 0.7(T_{NW}) + 0.2(T_G) + 0.1(T_A)$$

T_{NW}: natural wet bulb temperature,
T_G: globe temperature,
T_A: dry bulb temperature.

A Wet Dry Hygrometer featuring a wet bulb thermometer

Wet Bulb Globe Temperature

- In hot areas, some US military installations display a flag to indicate the heat category based on the WBGT. The military publishes guidelines for water intake and physical activity level for acclimated and unacclimated individuals in different uniforms based on the heat category.

Category	WGBT °C	Flag color
1	<=26.6	No flag
2	26.7-29.3	Green
3	29.4-31.0	Yellow
4	31.1-32.1	Red
5	=>32.2	Black

Heat Stress Management

- Reduce the relative humidity by using dehumidifiers,
- Increase air movement by using fans or air conditioner,remove heavy clothing, permit loose-fitting wide clothing,
- Provide for lower energy expenditure levels,
- Schedule frequent rest pauses, rotate personnel,
- Schedule outside work so as to avoid high temperature periods,

Heat Stress Management

- Select personnel who can tolerate extreme heat,
- Permit gradual acclimatization to outdoor heat (2 weeks),
- Supply cool, refrigerated vests (containing cooling elements),
- Install local cold spots, e.g. Refrigerated rooms for rest breaks,
- Maintain hydration by drinking water and taking salt tables.