JECRC Foundation

JAIPUR ENGINEERING COLLEGE AND RESEARCH CENTRE

Jaipur Engineering College and Research Centre

Department of Computer Science and Engineering

Year & Sem – 4th Year & VII Semester

Subject –Human Engineering and Safety (7AG6-60.1)

Unit – 3 (Anthropometry)

Presented by – Dr. Sanjay Gour, Professor & Head

Dr. Vijeta Kumawat, Associate Professor, Dy. HoD

Ms. Anima Sharma, Assistant Professor

Ms. Sweety Singhal, Assistant Professor

VISSION AND MISSION OF INSTITUTE

Vision of the Institution:

To become a renowned centre of outcome based learning and work toward academic, professional, cultural and social enrichment of the lives of individuals and communities.

Mission of the Institution:

M1:Focus on evaluation of learning outcomes and motivate students to inculcate research aptitude by project based learning.

M2:Identify, based on informed perception of Indian, regional and global needs,theareas of focus and provide platform to gain knowledge and solutions.

M3:Offer opportunities for interaction between academia and industry.

M4: Develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VISSION AND MISSION OF DEPARTMENT

Vision of the Department:

To become renowned centre of excellence in Computer Science and Engineering and make competent engineers & professionals with high ethical values prepared for lifelong learning.

Mission of the Department :

M1: To impart outcome based education for emerging technologies in the field of Computer Science and Engineering.

M2: To provide opportunities for interaction between academia and industry.

M3: To provide platform for lifelong learning by accepting the change in technologies.

M4: To develop aptitude of fulfilling social responsibilities.

RAJASTHAN TECHNICAL UNIVERSITY, KOTA

Open Electives Syllabus

B. Tech.: IV Year- VII & VIII Semester

7AG6-60.1 : Human Engineering and Safety

Credit: 3 **Max. Marks: 150(IA:30, ETE:120)**

3L+0T+0P **End Term Exam: 3 Hours**

SN	Contents	Hours
1	Introduction: Objective, scope and outcome of the course. (This compulsory for all course)	01
2	*Human factors in system development* – concept of systems; basic processes in system development, performance reliability, human performance. Information input process, visual displays, major types and use of displays, auditory and factual displays.	09
3	Measurement of energy, direct and indirect methods. Energy cost of different activities and Acceptable work load. Noise and vibration, its measurement and control.	10
4	*Anthropometry:* arrangement and utilization of work space, atmospheric conditions, heat exchange process and performance.	10
5	Dangerous machine (Regulation) act, Rehabilitation and compensation to accident victims, Safety gadgets for spraying, threshing, Chaff cutting and tractor & trailer operation etc.	10
	Total	**40**

Course Description & Objectives:

To impart the fundamental knowledge to the student on the importance of human engineering and safety in the field of agriculture machinery

Course Outcome

At the completion of the course the student will be able to:

1. understand the importance of human factors and their application in system development and know the effect of visual, auditory and factual displays in human performance.
2. Exposure to human factors for engineering design, measurement of energy cost of different activities.
3. be able to ideally design the work space in accordance to anthropometry
4. have the general understanding safety features and regulation acts in farm machinery.

List of reference books:

1. Ernest and Mc Cormick, E.L. (1970). Human factors in engineering and design. Mc Graw Hill Co., New York.

2. Sanders M S., Human Factors In Engineering And Design 7th Edition, Tata Macgraw Hill

INTRODUCTION

- Anthropometry is the branch of the human science that deals with the data described by the size of human body measurements including body dimensions and the other physical characteristics and mechanical aspects of or the human body motions.
- Anthropometry is the technology of measuring various human traits as size, mobility and strength, whereas engineering anthropometry is the effort of the operator since human machine interface decides the ultimate performance of the equipment/work system.
- There is a large variation among body dimensions it is not economical or sometimes practically feasible to design the equipment/work places so as to suit 100% of the users. Therefore, generally the design is made in such a way so as to satisfy 90% of the users.
- They will be able to use the equipment but may be with less efficiency and comfort.
- Anthropometric measurements are a critical element in equipment and workspace design.
- With the familiar with anthropometric data and its applications the work system, equipment's, tools and jobs for proper fit to the human, to achieve safe and efficient operation.
- For example a tractor seat is designed, so the backrest, hand rest, seat cushion, seat width should be based on anthropometric data of farm workers.

BASIC ERGONOMICS DESIGN PRINCIPLES

a) Design for the average: The design of average is not fit for anyone. Because no one is average in all dimensions. These designs are utilized for design public facilities like public transport buses seats, roadside benches, these facilities are used by a large variety of peoples.

b) Design for the extremes: The extremes value may be large or very small for examples a tractor seat is designed for accommodate a range of persons, if the person is for heavy or the largest person or the smallest, so it may be not suitable for extremes.

c) Design for a range: it is the most common design philosophy and commonly used by the ergonomic to design arrange of population. A typical range of 5^{th} and 95^{th} percentile of population is used such a design would be expected to accommodate 90% of population.

MEASUREMENT OF ANTHROPOMETRIC DATA

- There are very few studies available on anthropometric data on agricultural workers, again which are mainly case studies and involving only male workers.
- Therefore, a comprehensive data base involving 79 body dimensions and 16 strength parameters of at least 1000 agricultural workers (male : female :: 70% : 30%) as formulated by the ICAR is a major step towards future machinery design and development and also for modification in design of the existing machinery.

EQUIPMENT'S USED FOR MEASUREMENT OF ANTHROPOMETRIC DIMENSIONS

a) Anthropometric equipment type A : It consists of a fixed pipe structure rigidly attached to a pentagonal base. Several lateral pipes are attached to the main pipe. All the steel pipes bear a linear metric scale so that measurement can be easily taken. The pipes can also rotate about their axis and locked in any position with the help of wing nuts.

b) Anthropometric equipment type B : It consists of several square section tubes which bear linear scale in centimeters. The tubular sections can be prolonged by sliding and inserting one end into the other. A veneer provision helps taking down various kinds of and difficult measurements. A span of 210 mm can be measured with this equipment. However, minimum distance measurable being only 0.6 cm (Fig.10.1).

c) Anthropometric seat/ chair : It consist of a number of angled iron which are arranged together to form a seat. The seat surface and the back one are made of plywood. The seat height is of 600 cm while the back being 100.0 cm & the width and length being 50.0 and 70.0 cm respectively. In accordance with the data requirement, the seat surface slides along the slots in the four legs of the seat for a distance of 24.0 cm vertically while horizontally it is 14 cm.

EQUIPMENT'S USED FOR MEASUREMENT OF ANTHROPOMETRIC DIMENSIONS

The equipments consisted of the following:
i) Anthropometer in canvass bag for measurement of length 0-960 mm on one side and 0-2100 mm on opposite side.
ii) Base plate for anthropometer.
iii) Re-curved measuring branches for anthropometer.
iv) Martin type sliding caliper used for measuring length up to 200 mm and depth up to 50 mm.
v) Spreading caliper with rounded ends having a measuring range of 0-600 mm.
vi) Skin fold caliper for measuring skin fold dimensions.
vii) Plastic tape of length of 2000 mm.

EQUIPMENT'S USED FOR MEASUREMENT OF ANTHROPOMETRIC DIMENSIONS

Grip cone
A truncated cone having a height of 27.8 cm was fabricated for measuring grip diameter (inside as well as outside). Its diameter range varied between 35-95 mm. Another cone of height 18.8 cm was fabricated for measuring middle figure–palm grip diameter. This cone has a measuring range of 10-40 mm.

Weighing balance
A spring type weighing balance having a least count of 0.5 kg and a range of 0-130 kg was used for measuring body weight of the subjects.

PROCEDURE FOR MEASURING ANTHROPOMETRIC DIMENSIONS

1) Isolate the equipments and prepare the subject.
2) Let the subject stand on the pentagonal platform of anthropometric equipment type A.
3) Measure the height, while standing, and while sitting in accordance with the instruments depictet.
4) Note the dimensions where the equipment type A and then introduce equipment type B.Vice-versa is also possible
5) Record each reading according to specifications
6) Put the subject into the anthropometric seat and take the dimensions as per the diagram.
7) Repeat similarly to different number of subjects

ARRANGEMENT AND UTILIZATION OF WORK SPACE, ATMOSPHERE CONDITION

- Human workspace can consist of many different physical situations including that of the plumber working under a stoped up sink, the astronaut in his capsule, the assembler at his position on the assembly line, the flagpole painter and the minister in his pulpit.
- There are millions of peoples whose work activities are carried out while seated in a fixed location.
- The space with in which such an individual works is sometimes referred to as the ‘work-space envelop’.
- This envelop should be designed on a situational basis, considering the particular activities to be performed and the types of people who are to use the space.

WORKPLACE AND WORKSPACE

- Most workers spend a major portion of their time in a small work area, called the work space or 'work envelop'.
- A work space is a three dimensional region surrounding the worker, define by the outmost points touched by various parts of the body and by the controls, tools or other equipment used by the worker.
- The term workplace is more comprehensive and can be as varied as assembly stations, offices, warehouses, vehicle cabs or any other area where work is performed.

ARRANGEMENT AND UTILIZATION OF WORK SPACE

- The area for potential regulations affecting operator work space designs which is Minimum dimensions based on normal operational requirements.
- If the driver is to safely operate his vehicle he must first be able to fit into the cab without being forced into awkward postures. He must then be able to reach and operate all controls without undue hindrance.
- In essence this means that the cab needs to be designed around the operator. While we are primarily talking about minimum dimensions, it is important to note that male and female maximum dimensions must also be considered when designing for the smaller drivers.
- The design dimensions of the cab interior workspace can have an impact on driver comfort and safety.
- If the driver has to assume cramped or awkward postures due to inadequate space, he may tend to fatigue more quickly.
- If there is insufficient room to operate steering wheel, foot pedals and other controls, the driver may not perform at his best.
- Regulations for the cab's interior should require designs which ensure a minimum safety, health, and comfort level and which reduce the severity of the deterioration in the driver's performance capability over time. A reduction in the driver's allotted space in the cab is certainly a trend in the wrong direction to achieve these objectives.

FACTORS CONSIDERED IN OPERATOR WORKPLACE DESIGN

Multiple factors are to be considered in operator workplace design (OWPD) on which review of literature is citied and has been presented under following heads:

1. Ergonomics in agricultural operations
2. Anthropometry in agricultural machines
3. Optimization of operator workplace
4. OWPD in relation to seat
5. OWPD in relation to steering wheel
6. Driver's response
7. Operating posture
8. Control locations

WORKPLACE LAYOUT

Proper workplace lay out requires that consideration be given to various workplace dimensions. The control and the operation being controlled must be located with due regard to :

1. The operator size
2. His position and the direction in which he can most easily look
3. The spaces in which he can best manipulate controls
4. Special influences such as protective clothing.

DETERMINING THE OPERATION WHICH THE OPERATOR IS CONTROLLING

- Before beginning to design the workplace it is necessary to obtain preliminary information about the man-machine system.
- According to the nature and extent of the project a decision will have to be made on the degree of formality that is required at this stage.

Human Factors in System Development - Concepts of System

Ergonomics or Man-Machine-Environment System deals with the machine or job, its operator and working environment as a complete system affecting the intended work performance

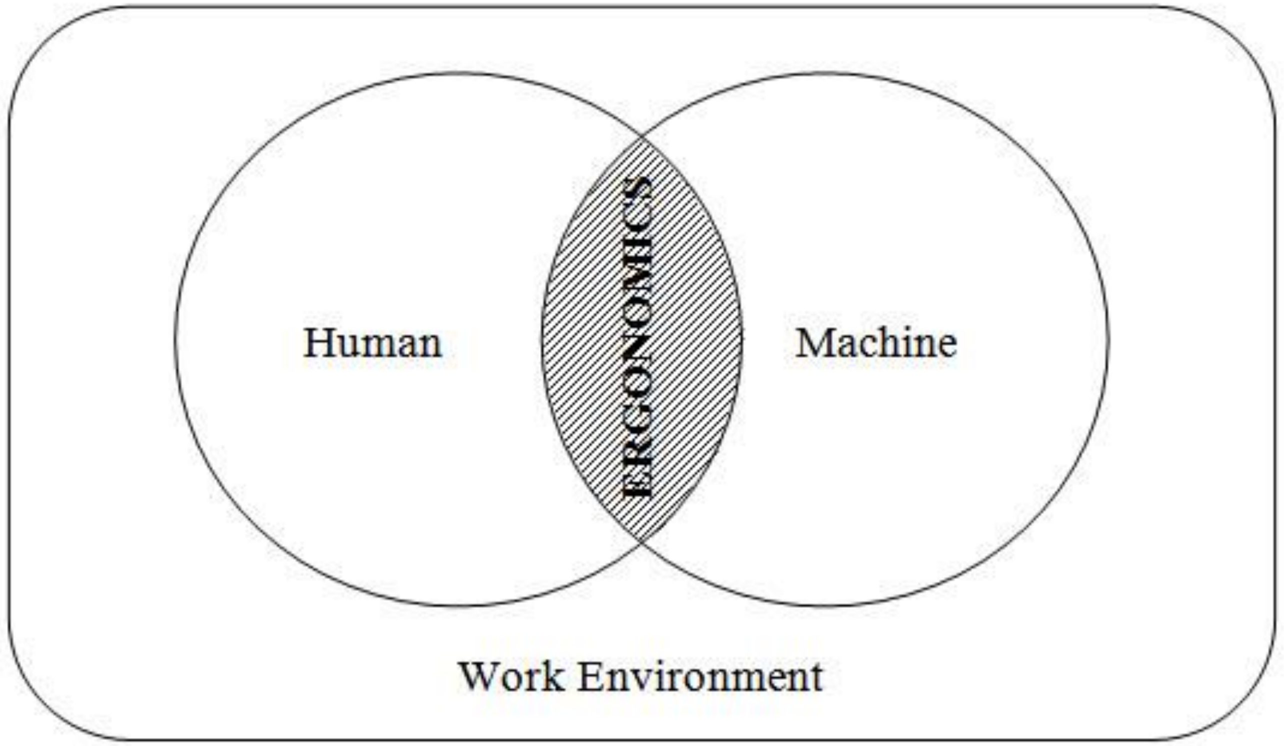


Fig.1.1 Ergonomics as Man-Machine-Environment interaction.

Source: Tayyari and Smith (1997).

HUMAN FACTORS IN SYSTEM DEVELOPMENT - CONCEPTS OF SYSTEM

The working environment may involve workspace, controls, ambient environment, noise, dust, vibrations, smoke and gases, light, safety concerns, etc. Ergonomics is an application of Medical and Engineering Sciences principles related to human factors in the task concerned

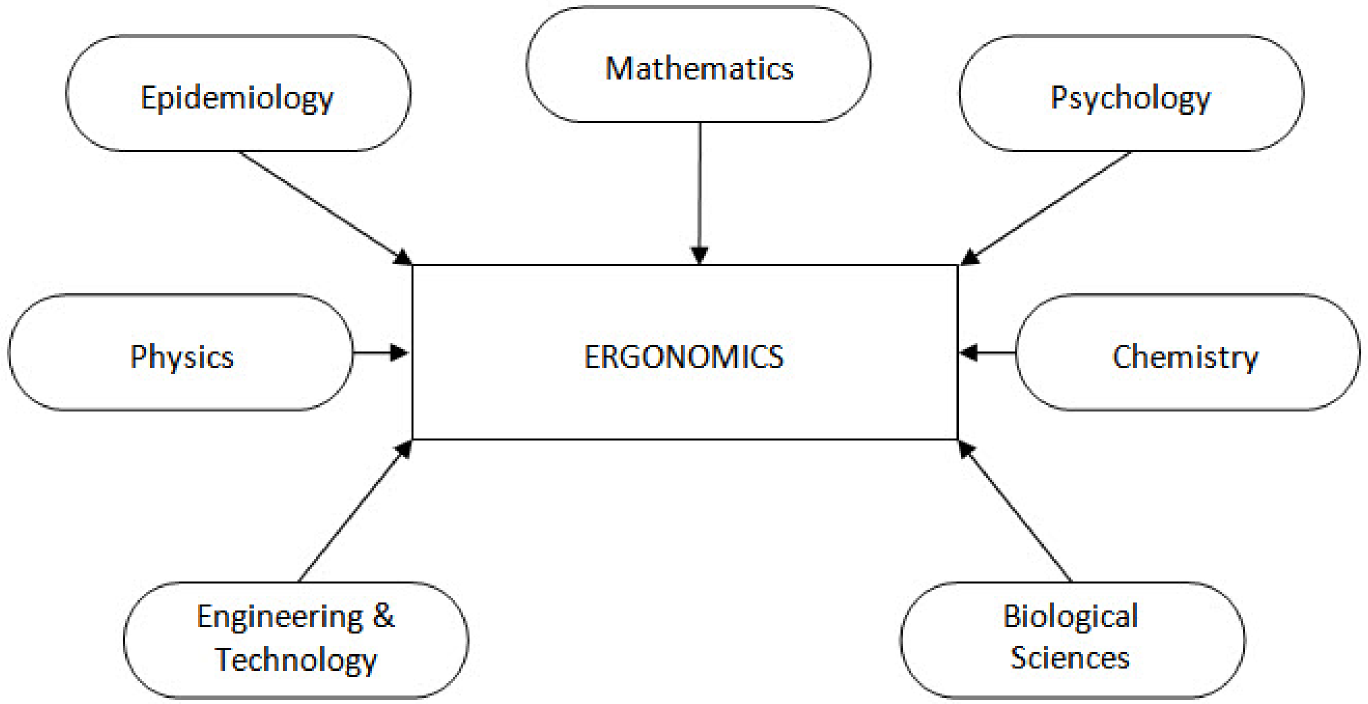


Fig.1.2 Major disciplines contributing to ergonomics.

Source: Tayyari and Smith (1997).

THE OPERATOR-MACHINE-ENVIRONMENT SYSTEM APPROACH

- The human has a limiting capability as a power of source in comparison to the engine/ machine. However, it has a distinct advantage in terms of its intelligence and decision making as per need.
- The operator acts as a core of the system. Operator uses his sensory system to perceive the environment, takes decision based upon information available, and finally takes appropriate action for desired output.
- If the task is new and not well known to operator then the decision making process is very slow.
- For routine and well known task, decisions are very quick and accurate.
- Stress is one of the variables that affect operator perception, decision making, and response selection.
- Many factors including operator's age, training, motivation, etc. affect the success of task performance.

THE OPERATOR-MACHINE-ENVIRONMENT SYSTEM APPROACH

- The machine characteristics that are involved in the system are its features, controls, displays, power availability, speed of operation, seat, vibrations, noise, exhaust, visibility, safety features, etc.
- Workspace, controls layout and display arrangement affects the operator capability to a large extent.
- For example, a tractor seat is designed for comfort of operator and easy accessibility of controls like brake, steering, gears, clutch, etc.
- Noise, vibrations, dust, smoke, field conditions, are some of the other major environmental factors that come into play, thereby affecting task performance.

RELATIVE ADVANTAGES OF MAN AND MACHINE

Characteristic	Machine	Man
Speed	Much faster	Quickest reaction approx. 0.05 second
Power	Consistent at any level, large, constant standard forces.	2.0 hp for about 10 seconds 0.5 hp for few minutes 0.2 hp for continuous work over a day
Consistency	Ideal for: routine; repetition; precision.	Not reliable: should be monitored by machine.
Complex activities	Multi-channel	Single-channel.
Memory	Best for literal reproduction and short term storage	Large store, multiple access. Better for principles and strategies.
Reasoning	Good deductive	Good inductive.
Computation	Fast, accurate, poor at error correction	Slow subject to error. Good at error correction.
Input sensitivity	Some outside human senses, e.g., radioactivity Can be designed to be insensitive to extraneous stimuli.	Wide energy range (10^{12}) and variety of stimuli dealt with by one unit: e.g. eve deals with relative location, movement and colour. Good at pattern detection. Can detect signals against high levels of background noise. Affected by heat, cold, noise and vibration (exceeding known limits)
Overload reliability	Sudden breakdown.	Gradual degradation.
Intelligence	None.	Can deal with unpredicted and unpredictable: can anticipate.
Manipulative abilities	Specific.	Great versatility.

BASIC PROCESS IN SYSTEM DEVELOPMENT

In Ergonomics, each of the human machine and environment has an effect on the complete system. The basic components of each are:

- Human Components
- Machine components
- Local environment

BASIC PROCESS IN SYSTEM DEVELOPMENT

Human Components:

- Sensors/ senses: Through which a human is made aware of its surroundings. Human being has five senses namely right, hearing, touch, taste and smell.
- Information processor: This includes joints, muscles and memory to provide information and feedback and brain to act as information processing system.
- Effectors: The three primary effectors are the hands, feet and voice. However, the whole body more can be regarded as effecter because no physical activity can be carried out without its supporting role.

BASIC PROCESS IN SYSTEM DEVELOPMENT

Machine Components:

- Displays: These include gauges dials, meters, indicators, etc. and provide information about status and working of machine to the operator.
- Controls: These include components of machine like steering wheel, accelerator, clutch, brake lever etc. through which a human changes and control action of machine.
- Controlled process: This is the basic operation of machine in its local environment as controlled by the human.

BASIC PROCESS IN SYSTEM DEVELOPMENT

Local environment: It is the place and circumstances in which work carried out. It consists of:

- Workspace: It is the three dimensional space in which work is being carried out. It is decided by dimensions of the machine, anthropometry of human and space required for activities of human and machine.
- Physical environment: It means the local environment factors having a bearing on the complete system. It includes noise, vibrations, lights, exhaust, climate etc.
- Work organization: It refers to the organizational structure in which work activity is embedded. It includes role of human and machine in system, organization and other persons of the team upon which the performance depends.

OBJECTIVE OF ERGONOMICS

While planning of the human factors in ergonomics, the objectives and end goal required is to be taken into considerations. These objectives may be one or a combination out of the following:

Basic objective:

- To improve system performance
- To reduce errors
- To increase safety

OBJECTIVE OF ERGONOMICS

Objectives concerning users and operators:

- To increase ease of use
- To reduce fatigue and physical stress
- To improve the working environment
- To increase user acceptance
- To improve aesthetic appearance.

Objectives concerning reliability and logistic support:

- To improve reliability
- To reduce maintenance
- To reduce labour requirement
- To reduce training requirement

Other objectives:

- To improve system efficiency
- To reduce cost of production

HUMAN TECHNOLOGY INTERACTION

Ergonomics and technology have a specific role to play with each other.

The technology can be defined as entire system of people and organizations, knowledge, process and devices that go into creating and operating technological artifacts. Technology is a product and process involving both science and engineering.

Engineering represents ‘design under constraints’ of cost, reliability, safety, environmental impact, ease of use, available human and material resources, manufacturability, government regulations, laws and politics.

Ergonomics discovers and applies information about human behavior, abilities, limitations and other characters to the design of tools, machines, systems, tasks jobs and environments for productive, sofa, comfortable and effective human use.

HUMAN TECHNOLOGY INTERACTION

The basic issues and processes covered under Ergonomics for design and development are:

A. Human Characteristics

1. Psychological aspects
2. Physiological and anatomical aspects
3. Group factors
4. Individual differences
5. Psycho physiological state variables
6. Task-related factors

HUMAN TECHNOLOGY INTERACTION

B. Information Presentation and Communication

1. Visual communication
2. Auditory and other communication modalities
3. Choice of communication media
4. Person–machine dialogue mode
5. System feedback
6. Error prevention and recovery
7. Design of documents and procedures
8. User control features
9. Language design
10. Database organization and data retrieval
11. Programming, debugging, editing, and programming aids
12. Software performance and evaluation
13. Software design, maintenance, and reliability

HUMAN TECHNOLOGY INTERACTION

C. Display and Control Design

1. Input devices and controls
2. Visual displays
3. Auditory displays
4. Other modality displays
5. Display and control characteristics

D. Workplace and Equipment Design

1. General workplace design and buildings
2. Workstation design
3. Equipment design

E. Environment

1. Illumination
2. Noise
3. Vibration
4. Whole body movement
5. Climate
6. Altitude, depth, and space
7. Other environmental issues

F. System Characteristics

1. General system features

HUMAN TECHNOLOGY INTERACTION

G. Work Design and Organization

1.Total system design and evaluation

2.Hours of work

3.Job attitudes and job satisfaction

4.Job design

5.Payment systems

6.Selection and screening

7.Training

8.Supervision

9.Use of support

10.Technological and ergonomic change

H. Health and Safety

1.General health and safety

2.Etiology

3.Injuries and illnesses

4.Prevention

HUMAN TECHNOLOGY INTERACTION

I. Social and Economic Impact of the System

1.Trade unions

2.Employment, job security, and job sharing

3.Productivity

4.Women and work

5.Organizational design

6.Education

7.Law

8.Privacy

9.Family and home life

10. Quality of working life

11. Political comment and ethical considerations

J. Methods and Techniques

1.Approaches and methods

2.Techniques

3.Measures

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

Some of the important factors considered in design, testing and evaluation of man-machine-environment system are as listed by Dul and Weerdmeester (1993).

A. Anthropometric, biomechanical, and physiological factors:

1.Are the differences in human body size accounted for by the design?

2.Have the right anthropometric tables been used for specific populations?

3.Are the body joints close to neutral positions?

4.Is the manual work performed close to the body?

5.Are any forward-bending or twisted trunk postures involved?

6.Are sudden movements and force exertion present?

7.Is there a variation in worker postures and movements?

8.Is the duration of any continuous muscular effort limited?

9.Are the breaks of sufficient length and spread over the duration of the task?

10.Is the energy consumption for each manual task limited?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

B. Factors related to posture (sitting and standing):

1.Is sitting/standing alternated with standing/sitting and walking?

2.Is the work height dependent on the task?

3.Is the height of the worktable adjustable?

4.Are the height of the seat and backrest of the chair adjustable?

5.Is the number of chair adjustment possibilities limited?

6.Have good seating instructions been provided?

7.Is a footrest used where the work height is fixed?

8.Has work above the shoulder or with hands behind the body been avoided?

9.Are excessive reaches avoided?

10.Is there enough room for the legs and feet?

11.Is there a sloping work surface for reading tasks?

12.Have combined sit–stand workplaces been introduced?

13.Are handles of tools bent to allow for working with the straight wrists?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

C. Factors related to manual materials handling (lifting, carrying, pushing and pulling loads)

1.Have tasks involving manual displacement of loads been limited?

2.Have optimum lifting conditions been achieved?

3.Is anybody required to lift more than 23 kg?

4.Have lifting tasks been assessed using the NIOSH method?

5.Are handgrips fitted to the loads to be lifted?

6.Is more than one person involved in lifting or carrying tasks?

7.Are there mechanical aids for lifting or carrying available and used?

8.Is the weight of the load carried limited according to recognized guidelines?

9.Is the load held as close to the body as possible?

10.Are pulling and pushing forces limited?

11.Are trolleys fitted with appropriate handles and handgrips?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

D. Factors related to the design of tasks and jobs

1.Does the job consist of more than one task?

2.Has a decision been made about allocating tasks between people and machines?

3.Do workers performing the tasks contribute to problem solving?

4.Are difficult and easy tasks performed interchangeably?

5.Can workers decide independently on how the tasks are carried out?

6.Are there sufficient possibilities for communication between workers?

7.Is sufficient information provided to control the tasks assigned?

8.Can the group take part in management decisions?

9.Are shift workers given enough opportunities to recover?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

E. Factors Related to Information and Control Tasks

(i) Information

1.Has an appropriate method of displaying information been selected?

2.Is the information presentation as simple as possible?

3.Has the potential confusion between characters been avoided?

4.Has the correct character/letter size been chosen?

5.Have texts with capital letters only been avoided?

6.Have familiar typefaces been chosen?

7.Is the text/background contrast good?

8.Are the diagrams easy to understand?

9.Have the pictograms been used properly?

10.Are sound signals reserved for warning purposes?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

E. Factors Related to Information and Control Tasks

(ii) Control

1. Is the sense of touch used for feedback from controls?

2.Are differences between controls distinguishable by touch?

3.Is the location of controls consistent, and is sufficient spacing provided?

4.Have the requirements for control–display compatibility been considered?

5. Is the type of cursor control suitable for the intended task?

6.Is the direction of control movements consistent with human expectations?

7.Are the controls objectives clear from the position of the controls?

8.Are controls within easy reach of female workers?

9.Are labels or symbols identifying controls used properly?

10.Is the use of color in controls design limited?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

E. Factors Related to Information and Control Tasks

(iii) Human–computer interaction

1. Is the human–computer dialogue suitable for the intended task?
2. Is the dialogue self-descriptive and easy to control by the user?
3. Does the dialogue conform to the expectations on the part of the user?
4. Is the dialogue error-tolerant and suitable for user learning?
5. Has command language been restricted to experienced users?
6. Have detailed menus been used for users with little knowledge and experience?
7. Is the type of help menu fitted to the level of the user's ability?
8. Has the QWERTY layout been selected for the keyboard?
9. Has a logical layout been chosen for the numerical keypad?
10. Is the number of function keys limited?
11. Have the limitations of speech in human–computer dialogue been considered?
12. Are touch screens used to facilitate operation by inexperienced users?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

F. Environmental Factors

(i) Noise and vibration

1.Is the noise level at work below 85 dBA?

2.Is there an adequate separation between workers and source of noise?

3.Is the ceiling used for noise absorption?

4.Are acoustic screens used?

5.Are hearing conservation measures fitted to the user?

6.Is personal monitoring to noise/vibration used?

7.Are the sources of uncomfortable and damaging body vibration recognized?

8.Is the vibration problem being solved at the source?

9.Are machines regularly maintained?

10.Is the transmission of vibration prevented?

FACTORS CONSIDERED IN SYSTEM DEVELOPMENT

F. Environmental Factors

(ii) Illumination

1.Is the light intensity for normal activities in the range 200 to 800 lux?

2.Are large brightness differences in the visual field avoided?

3.Are the brightness differences between task area, close surroundings, and wider surroundings limited?

4.Is the information easily legible?

5.Is ambient lighting combined with localized lighting?

(iii) Climate

1.Are workers able to control the climate themselves?

2.Is the air temperature suited to the physical demands of the task?

3.Is the air prevented from becoming either too dry to too humid?

4.Are drafts prevented?

5.Are the materials/surfaces that have to be touched neither too cold nor too hot?

6.Are the physical demands of the task adjusted to the external climate?

7.Are undesirable hot and cold radiation prevented?

HUMAN PERFORMANCE

- The ergonomic aspects during application in agricultural machinery are of great importance as the operator has to operate the machine in field.
- The physiological as well as psychological fatigue affects performance of the operator and hence, man-machine-environment system.
- There are many factors acting as stress on the operator during the work. These stresses may be due to workload, immobilization for longer duration work, ambient temperature, relative humidity, vibrations, noise, dust, smoke, exhaust gases, etc.
- A feeling of chance of accident during work, space confinement, overload of information to be handled, etc. results in psychological fatigue.
- During the ergonomic studies, these stresses can be measured in terms of strain on the operator.
- The most important among physiological strains are related to heart activity, respiration, discomfort, muscular fatigue, etc.
- During ergonomical studies, stress on eyes, hearing loss, errors, speed of work, work performance are some of the commonly used parameters for measurement of psychological/ mental strain.

HUMAN PERFORMANCE

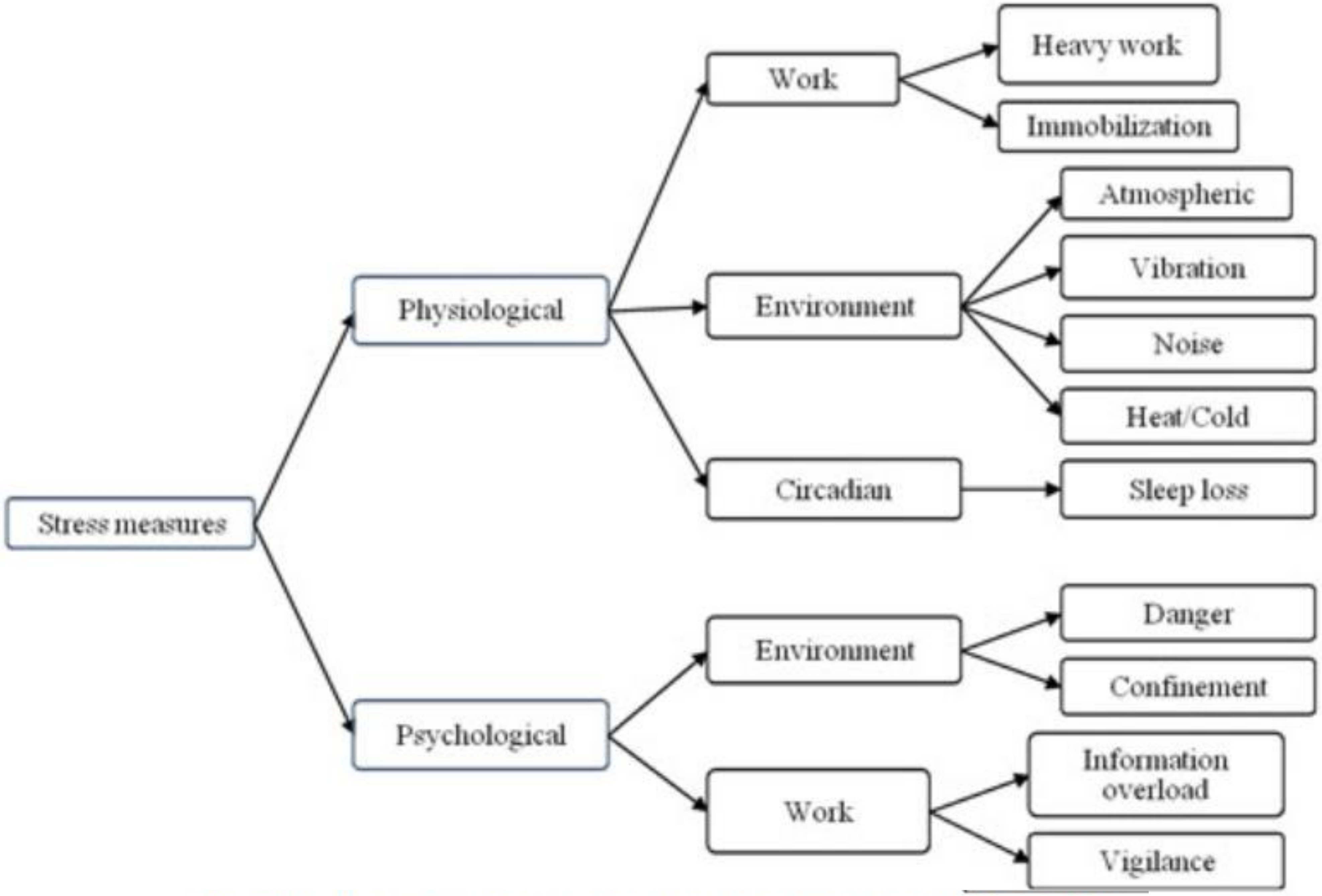


Fig.3.1. Human stresses and strains in ergonomic studies

HUMAN PERFORMANCE

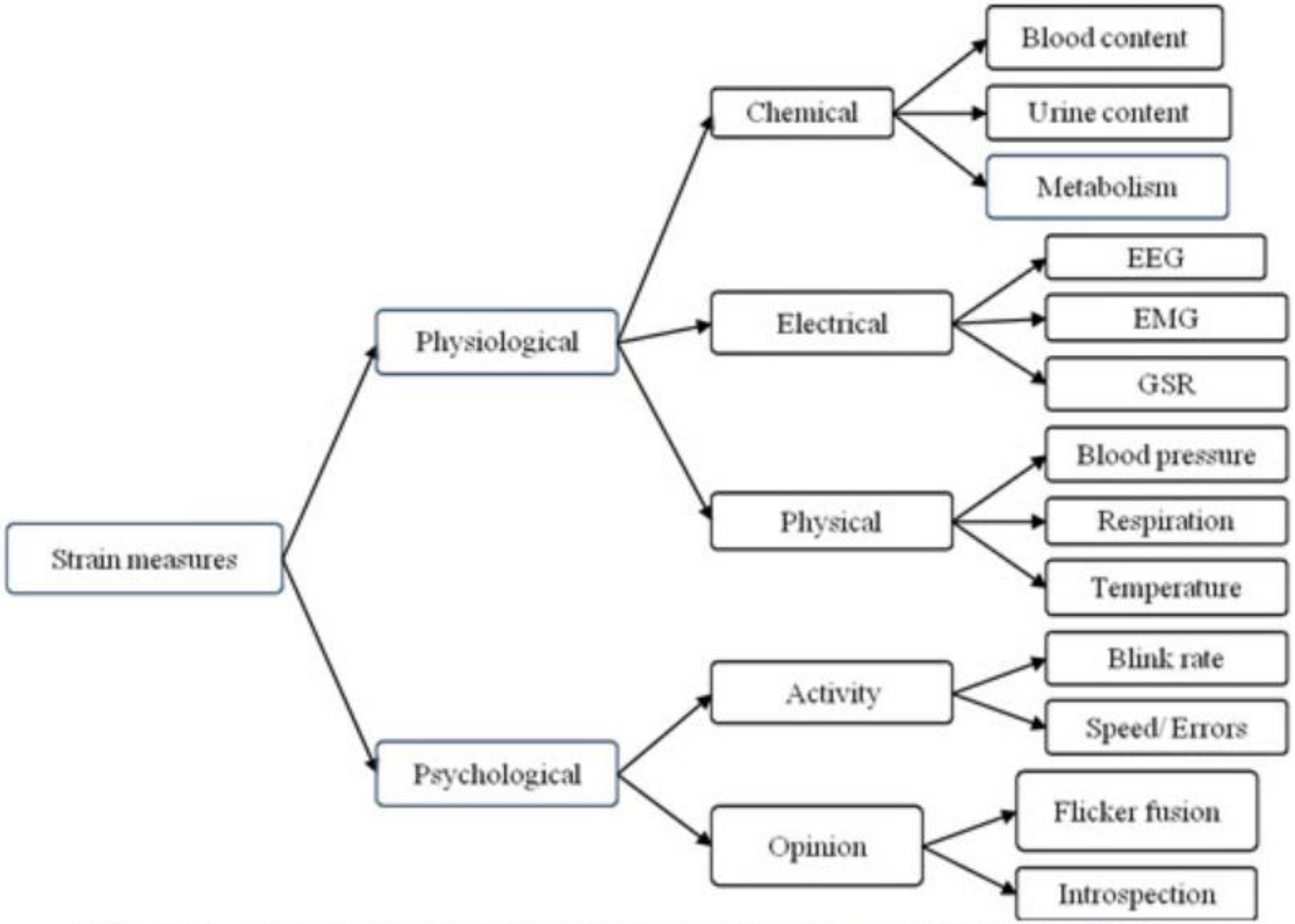


Fig.3.1. Human stresses and strains in ergonomic studies

PHYSIOLOGICAL FACTORS FOR MEASUREMENTS

Physical activities stimulate certain physiological responses in human beings. These responses provide basis for human energy expenditure and fatigue. The physiological measurements are made generally in terms of heart and respiration activities.

1. Heart rate

- Heart rate (HR) is the most reliable dependent parameter in ergonomic studies.
- This is because the heart rate has a direct and linear relationship with the human workload and stress.
- A starting period of 2-3 minutes is sufficient for heart/pulse rate to stabilize depending upon nature of exercise. Also, care has to be taken so that the operator is not subjected to workload leading to heart rate more than HR_{max} i.e. the upper limit of heart rate allowed during an activity. Here,

$$HR_{max} \text{ (beats/min)} = 220 - \text{Age (years)} \qquad \text{------ (1)}$$

PHYSIOLOGICAL FACTORS FOR MEASUREMENTS

2. Respiration rate

- It is measured in terms of rate of volume of air inhaled or air exhaled or oxygen intake (VO_2) or respiration rate.
- The greater the demands made on the muscle by the physical activities, the more air or oxygen is inhaled.
- The human energy expenditure (kilo Joule, kJ) is computed by multiplying the oxygen consumption (litres, l) with the calorific value of oxygen (20.88 kJ/l).
- The human workload has been categorized between light work and extremely heavy work depending upon heart rate or oxygen consumption.
- Another criterion for measurement of human performance is Relative Load (RL) which is expressed as percentage of maximum aerobic power (VO_{2max}); where, VO_{2max} is volume of oxygen intake corresponding to HR_{max} calculated from established relation between VO_2 and HR of an individual through subject calibration on treadmill or bicycle ergometer.
- Daily (8 hours) physical activity involving 35% of VO_{2max} might be considered as an acceptable workload (AWL) for Indian workers.

PHYSIOLOGICAL FACTORS FOR MEASUREMENTS

Table 1. Limits of physiological responses and work category.

S. No.	Work category	Physiological response	
		Oxygen consumption (l/min)	Heart rate (beats/min)
1	Light work	< 0.5	Up to 90
2	Moderate work	0.5 - 1.0	90-110
3	Heavy work	1.0-1.5	110-130
4	Very Heavy work	1.5-2.0	130-150
5	Extremely heavy work	> 2.0	150-170

PHYSIOLOGICAL FACTORS FOR MEASUREMENTS

3. Discomfort rating

Body posture is one of the major factor which causes muscular fatigue and discomfort in the body. Uncomfortable body posture in different activities reduces work efficiency, capacity and safety of operator. The effect due to working posture can be measured in terms of overall discomfort rate and body part discomfort rate techniques.

Table 2. Pain intensity score as a measure of overall discomfort rating (ODR).

Subjective feeling	ODR Score	Subjective feeling	ODR Score
Comfortable	0	Moderately painful	4
Uncomfortable	1	Highly painful	5-6
Pain starts	2	Very highly painful	7-9
Slightly painful	3	Extremely painful	10

PERFORMANCE RELIABILITY

Performance reliability refers to quantitative values that characterize the dependability of system or components performance. The reliability of system can be defined in many ways:

- Reliability is probability of a system performing its intended function over a given period of time under the operating condition encountered.
- Reliability is the probability that a system will operate without failure for a given period of time under given operating conditions.
- Reliability is mean operating time between two successive failures.
- Reliability is integral of distribution of probabilities of failure free operation.

PERFORMANCE RELIABILITY

Components in series

System consists of number of components connected in series i.e. system operates if all are OK and system fails if any one of components fails. So weakest link i.e. component having lowest possibility of survival is the most critical one

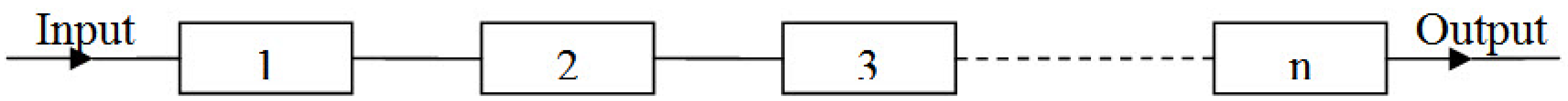


Fig.3.2 Components in series.

Here, reliability of system (R_s) is product of reliability of each and every individual component connected in series.

Thus; $R_s = R_1 \times R_2 \times R_3 \times \ldots\ldots\ldots R_n$

PERFORMANCE RELIABILITY

Components in parallel

Parallel system involves more cost, but is more reliable because if any of the components in parallel is functioning, that means system is in working order. The system fails only if each and every component connected in parallel fails simultaneously. Reliability of system (R_s) is determined after calculating probability of failure of the system (Q_s)

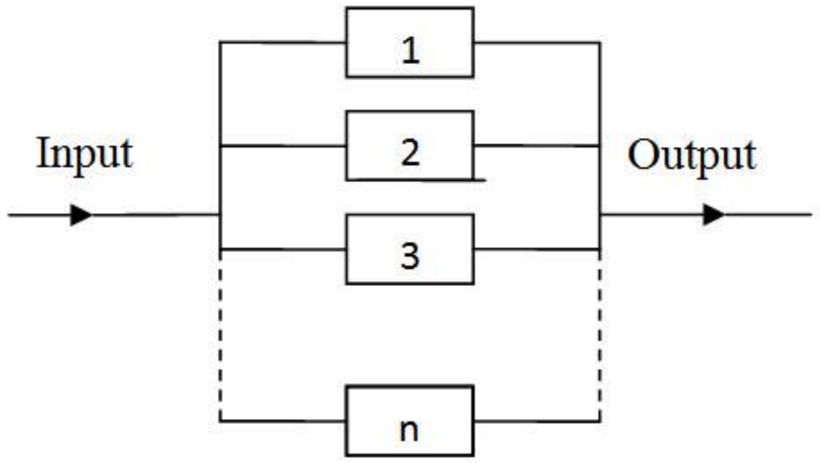


Fig 3.3 Components in parallel.

Thus; $R_s = 1 - Q_s$ ------ (3)

Where, $Q_s = Q_1 \times Q_2 \times Q_3 \times \ldots\ldots\ldots Q_n$ ------ (4)

Here, Q_i is failure probability of i^{th} component.

INFORMATION INPUT PROCESS

- "Information" is the transfer of energy that has meaningful implications in any given situation; e.g. a driver communicating with his tractor through displays and controls.
- The input to the operator is the information received through the sense organs.
- Our sensory mechanisms are sensitive to certain stimuli, which convey meaning to us.
- The stimuli are various forms of energy, such as light, sound, heat, and mechanical pressure.
- Information from the original source may be direct (e.g. a visual signal of undulated field), or indirect (e.g. quantity of fuel in tractor tank through fuel meter on display board, change in sound of tractor engine).
- The humans are continually bombarded with stimuli from our immediate environment, these stimuli consisting of various forms of energy to which our senses organs are sensitive.

INFORMATION INPUT PROCESS

Table 1 Human sensors and associated input signals

Human sensors	**Associated input**
Eyes	Visual input
Ears	Acoustic signals
Skin	Touch/ Warm
Nose	Smell
Tongue	Taste

It is noticed that usually multiple senses operate at the same time. For example, driver of a tractor uses eyes, ears and skin or all of them at same time.

INFORMATION PROCESSING SYSTEM

- How humans perceive and process information must be taken into account in order to design interfaces that can be learned and used efficiently.
- In all human-system interactions, the user must perceive information, process information, and make decisions based on that information, leading to responses and actions.
- For example, the human eye receives visual information and codes information into electric-neural activity which is fed back to the brain where it is stored and decoded. This information can be used by other parts of the brain relating to mental activities such as memory, perception and attention.

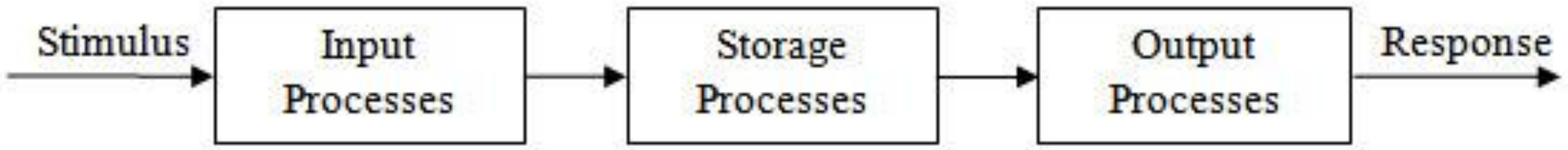


Fig 4.1 Information processing system

INFORMATION PROCESSING SYSTEM

Information processing system consists of a series of stages, which represent stages of processing. Arrows indicate the flow of information from one stage to the next.

Input processes are concerned with the analysis of the stimuli.

Storage processes cover everything that happens to stimuli internally in the brain and can include coding and manipulation of the stimuli. Information stored can be a short term or a long term memory.

Output processes are responsible for preparing an appropriate response to a stimulus.

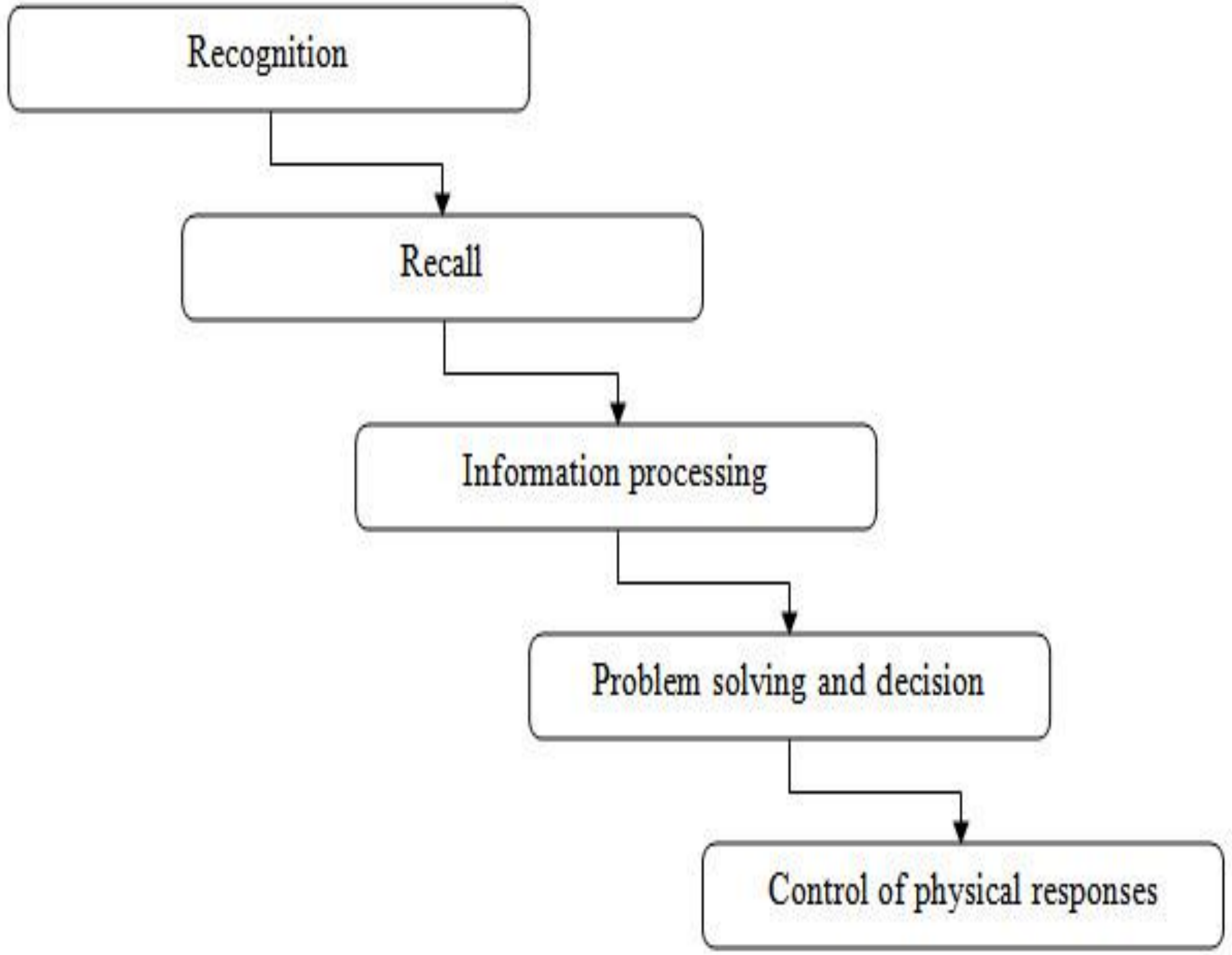


Fig. 4.2. Information retrieval and processing

MEASUREMENT OF INFORMATION

- Information is measured in bits (binary unit). A bit is defined as the amount of information obtained from one of two equally likely alternatives specified. When various alternatives are equally probable, the amount of information is given by formula:

$$H = \log_2 n \qquad \text{-------- (1)}$$

Where, H is amount of information in bits, and n is number of equally probable alternatives.

- If n is 2 then H is logarithm of 2 to the base 2, which is 1.
- For example, if there are four lights on a panel and only one of them may be on at a time, then we have two bits of information. Equation 1 can be written in terms of probability of each alternative, where probability is the reciprocal of n. Therefore:

$$H = \log_2 1/p \qquad \text{-------- (2)}$$

STIMULUS CHARACTERISTICS

- The stimulus inputs that human receive via any sensory modality (vision, audition etc.) differ in terms of their characteristics.
- For example, visual characteristics include shape, configuration, size, position, color, etc.
- The auditory characteristics include sound pressure level, frequency, duration, continuous/intermittent signal, etc.

DISPLAYS FOR INFORMATION INPUT

- Displays can be either dynamic or static.
- Dynamic displays are continually changing or are subject to change with time, e.g. temperature or pressure gauge, fuel gauge, ampere meter, RPM meter, speedometer, monitors and displays, TV and radio signal, etc.
- Static displays remain fixed over time, e.g. signs, charts, graphs, labels etc.
- There is a need of presenting information to people by use of displays in such a manner so that usefulness of information under given conditions is enhanced affectively.

INFORMATION PRESENTED BY DISPLAYS

Major types of information presented by displays are described below.

1.Quantitative information: Such displays present quantitative value of some variable like temperature, pressure, speed, etc.

2.Qualitative information: Such displays provide approximate value, trend, rate or direction of change. E.g. ampere meter of chargeable battery, RPM meter showing approximate value, etc.

3.Status information: Such displays present condition or status of a system. E.g. ON-OFF indicators, stop-caution-go lights, indicator for reverse gear, warning indicators, battery status indicator, etc.

4.Warning and signal information: Such displays indicate emergency or unsafe conditions or absence of some object/ conditions. E.g. aircraft or lighthouse bacons, reverse light indicators, turning indicators, brake light indicators, signal for low/high beam light, seat belt signal, door open signal, fuel refill indicator, etc.

5.Representational information: Such displays provide pictorial or graphic representation of objects areas or other configurations. E.g. movies, photographs, maps, charts, diagrams, graphs, door open signal, seat belt indicator, heart beat shown on heart rate monitor, etc.

6.Identification information: Such displays are used to identify a particular condition, situation or object. E.g. sign boards on the roads, traffic lights, color coded signals, etc.

SELECTION OF SENSORY MODALITY

Table 1. When to use the auditory or visual form of presentation

Use auditory presentation, if:	**Use visual presentation, if:**
The message is simple	The message is complex
The message is short	The message is long
The message is not be referred to later	The message will be referred to later
The message deals with events in time	The message deals with location in space
The message calls for immediate action	The message does not call for immediate action
The visual system of the person is overburdened	The auditory system of the person is overburdened
The receiving location is too bright or dark-adaption integrity is necessary	The receiving location is too noisy
The person's job requires him to move about continually.	The person's job allow him to remain in one position

MAJOR TYPES AND USES OF DISPLAYS

Classification of displays

Displays provide useful and required information in a conveniently presentable form.

Displays can be broadly classified under three categories:

- Visual displays
- Auditory displays
- Tactual displays

MAJOR TYPES AND USES OF DISPLAYS

Visual displays

They are the most common in use and involve visual capabilities and skills of users. The commonly used types of visual displays are discussed here.

1. Quantitative visual displays

These displays provide information about quantitative value and some variable, which may be a dynamic variable such as temperature or speed, or a static variable such as measurement of length with a ruler. Such displays have units written along with quantity of variable. There are three basic types of dynamic quantitative visual displays

1. Fixed scales with moving pointers
2. Moving scales with fixed pointers
3. Digital displays or counters

Fixed scale with moving pointer type displays are mostly preferred; however, for long scales displays having circular or tape type moving scales are preferred. Digital displays used if values remain long enough to read.

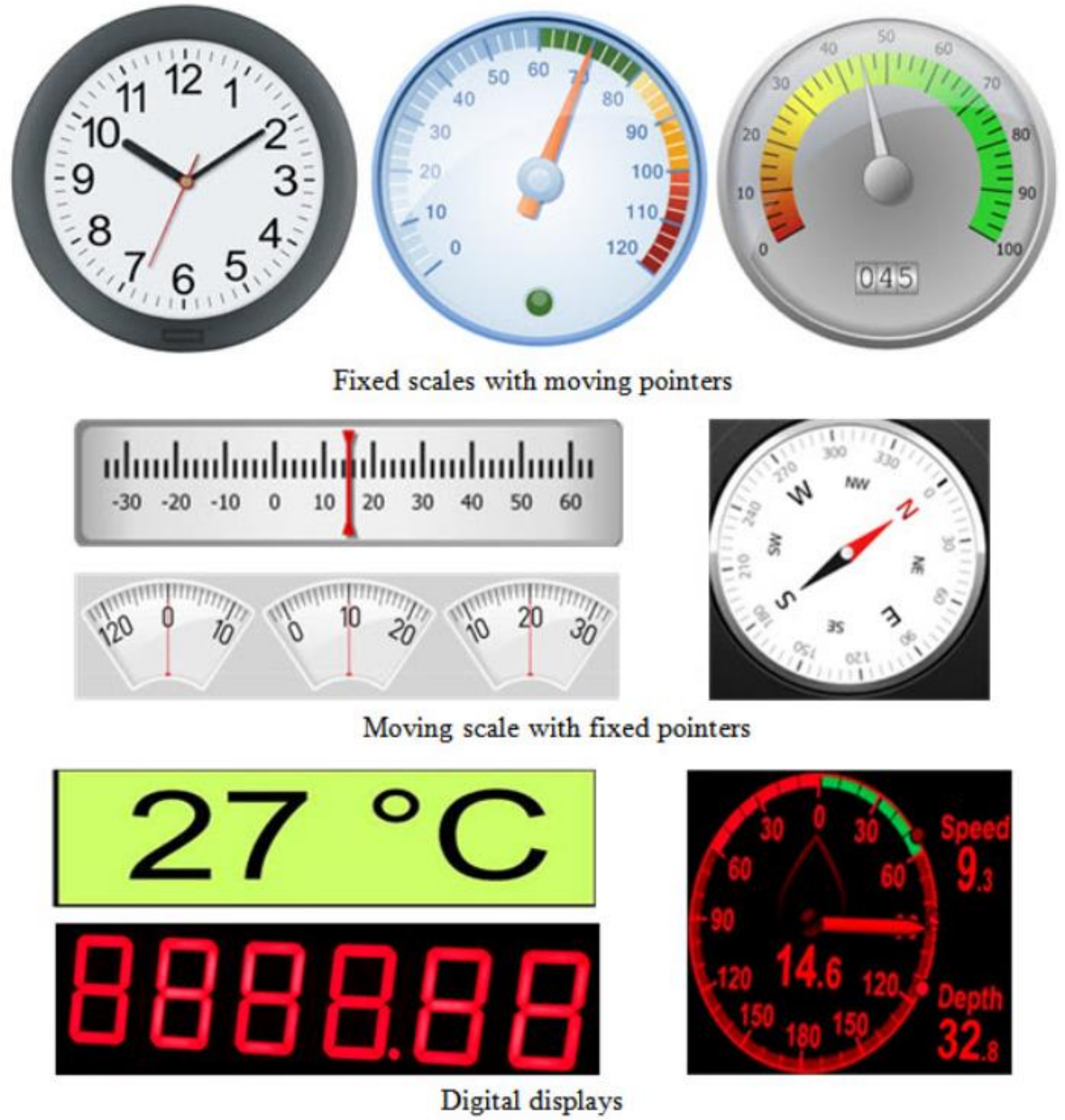


Fig.5.1 Quantitative visual displays

MAJOR TYPES AND USES OF DISPLAYS

2. Qualitative visual displays

Such displays provide approximate value, trend, rate or direction of change. Quantitative data is used as a basis for qualitative reading in at least three different ways:

- To convey information about status or condition of variable falling within limited number of predetermined ranges. E.g. temperature gauge to determine if engine whether engine is cold/ normal/hot.
- To maintain roughly a desirable range of values. E.g. speedometer showing range of speed between 0-50 mph for safer control.
- To observe trends, rate of change, etc. E.g. engine RPM meter.

Fig.5.2 Qualitative visual displays

MAJOR TYPES AND USES OF DISPLAYS

3. Status indicators

They provide approximate information as an indication of status of a system or component. E.g. temperatures gauge to dip it if the engine is cold/normal/hot. Other examples include ON/OFF indicator, traffic light on roads etc (Fig.5.3). If a quantitative instrument is to be used only for check-reading purpose, status indicator should be preferred.

4. Signal and warning lights

Flashing and steady state lights are used for various purposes viz. indications of lower/upper beams of lights, warning lights for low-battery, low-fuel, seat-belt not used, door-open, engine-oil level low, low brake-oil, hand-brake ON, reverse gear engaged, beacons, etc (Fig.5.4). Detection of signals and warning lights may depend upon size, luminance, color, background, exposure time, and flash rate.

5. Representational display

Representational displays may be pictorial i.e. intended to reproduce an object/scene or may be symbolic/illustrative. The purpose of such display is to convey a visual impression that requires little interpretation. For example: aircraft position display, GPS for road map, charts and graphs, etc (Fig. 5.5).

MAJOR TYPES AND USES OF DISPLAYS

6. Alphanumeric and related displays

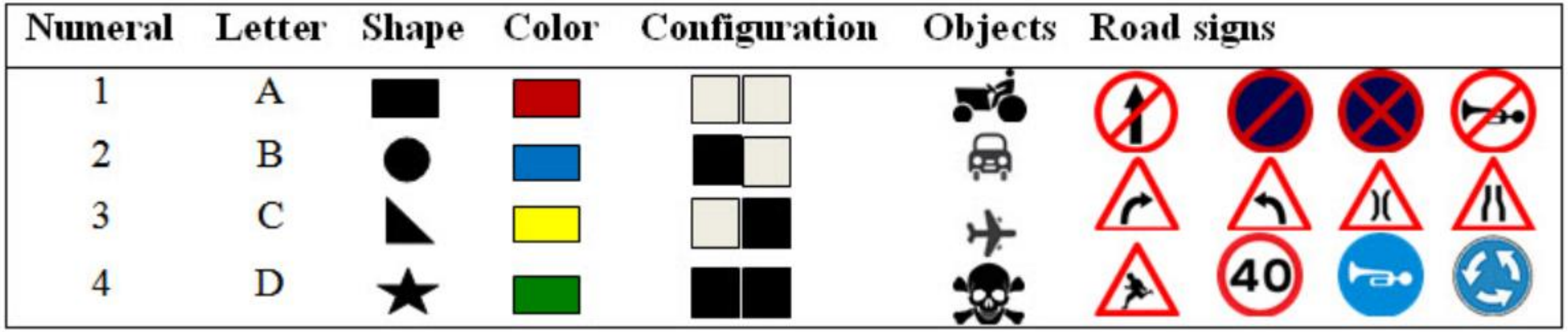
The effectiveness of such displays depends upon various factors like typography, content, selection of words, color, background, contrast, illumination, and writing styles. The typography of alphanumeric information includes stroke width, aspect ratio, font type, font size, spacing of characters, spacing between lines, margins, color, etc. The communication of message by such displays depends upon visibility, legibility, and readability (Fig. 5.6).

7. Visual codes symbol and signs

In our daily life we use a variety of visual codes symbols and signs which convey their intended meaning. They includes numerals, letters, geometrical shapes, colors, configurations, symbolic shapes representing various objects and messages.

MAJOR TYPES AND USES OF DISPLAYS

Table 5.1. Some examples of visual symbols and signs



Numeral	Letter	Shape	Color	Configuration	Objects	Road signs
1	A					
2	B					
3	C					
4	D					40

AUDITORY DISPLAY

- The auditory displays involve sound as a signal.
- In a human-machine interface, the frequency and intensity/amplitude are two primary attributes of sound.
- In general, the human ear is sensitive to sound waves having frequency range between 20-20,000 Hertz (Hz).
- Intensity of sound or sound pressure level is generally measured in *decibel* (dB).
- A *decibel* is one-tenth of a *bel* (named after Alexander Graham Bell) and is expressed as a ratio on logarithmic scale. The Sound pressure level (SPL), measured in *decibels*, can be written as:

$$SPL = 20 \log P_o/P_r \qquad \text{------ (1)}$$

Where, P_o is root mean square (rms) acoustic pressure at point of consideration, and P_r is reference pressure (20 µPa).

AUDITORY DISPLAY

- Circumstances under which auditory displays are preferred:
  a) When the origin of a signal itself is a sound.
  b) When the message is simple and short.
  c) When the message doesn't need to be referred afterwards.
  d) When the message deals with events in time.
  e) When the message calls for immediate action.
  f) When the visual display system is overloaded.
  g) When illumination limits use of vision.
  h) When the operator moves away from visual display.
- The commonly used auditory displays are radio signals (dot-dash system) or warning and alarm signals. The commonly used devices for warning and alarm signals are horn, whistle, siren, bell, buzzer, chimes, etc.

TACTUAL DISPLAY

- Tactual displays use cutaneous (skin or somesthetic) senses.
- Such displays utilize a qualitative or comparative sensation of thermal or mechanical or chemical or electrical stimulus.
- Thus its use is only to a very limited extent or under special conditions.
- Braille is particularly important for people who are visually impaired.
- The Braille display and textual maps are good examples of tactual displays.
- Another use of tactual senses control knobs.
- The coding of such devices for tactual identification includes their shape, texture and size.
- Vibrator of a cell phone that uses a mechanical stimulus is another example of our daily life.

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Thank you!