ANTHROPOMETRY

The design of all equipment must be considered in relation to both the size of the individuals who are going to use it and the movements with they can make without difficulty or strain. Individuals vary greatly in their size from dwarfs to giants (though luckily these extremes occur very rarely indeed); on the other hand the limits imposed on movement by the joints and tendons show much less variability. For our purpose it is necessary to have some information about the body measurements of the population which is likely to use the equipment, and the systematic measurement of body dimensions, using specialized instruments, is known as anthropometry (the measurement of man).Broadly speaking anthropometric data may be used for two purposes. First, to determine the size and shape of the equipment which a man is to use, and second, to determine the space in which a man is to work. The dimensions which are required for these two purposes will not always be the same. Data on the limits of body movement and on the forces which can be exerted by a man will come from studies in functional anatomy or, as it is sometimes called, biomechanics. In the practical situation the body dimensions and the functioning of the limbs must be considered at the same time.

ANTHROPOMETRY

Anthropometry deals with the measurement of the dimensions and certain other physical characteristics of the body; such measurements are, of course, relevant to the design of the things people use. There are two primary types: structural (static) and functional (dynamic) measurement. What is sometimes called engineering anthropometry is concerned with the application of both types of data to the design of the things people use.

Static dimensions are measurements taken when the body is in a fixed (static) position. They consist of skeletal dimensions (between the centers of joints, such as between the elbow and the wrist) or of contour dimensions (skin-surface dimensions such as height or seat breadth).

Dynamic dimensions are taken under conditions in which the body is engaged in some physical activity. In most physical activities (whether one is operating a steering wheel, assembling a mousetrap, or reaching across the table for the salt) the individual body members function in concert. The practical limit, of arm - reach, for example, is not the sole consequence of arm length; the limit is also affected by shoulder movement, partial trunk rotation, possible bending of the back, and the function to be performed by the hand.

In the use of anthropometric data for designing something, the data should be reasonably representative at the population that would use the item. In many instances the population of Interest consists of "people at large’ implying that the design features must accommodate a broad spectrum of people.

<u>Principles in the Application of Anthropometric Data</u>

There are three principles for applying anthropometric data to specific design problems; each applies to a different type of situation.

1- Design for Extreme Individuals: In some circumstances a specific design dimension or feature is a limiting factor that might restrict the use of the facility for some people; that limiting factor can dictate either a maximum or minimum value of the population variable or characteristic in question.

Designing for the maximum population Value is the appropriate strategy when <u>high</u> value of some design feature should accommodate all (or virtually all) people. In turn, designing for the minimum population value is the appropriate strategy if a given minimum <u>low</u> value of some design feature has to accommodate all (or virtually all) people.

Sometimes there may be reasons for accommodating most, but not 100 percent of the population (e.g. it is not reasonable to have all doorways 9 ft (2.7 m) high to accommodate circus giants). Thus, it frequently is the practice to use the 95th and 5th percentiles of the distributions of relevant population characteristics as the maximum and minimum design parameters.

2- Designing for Adjustable Range: Certain features of 'equipment or facilities can be designed so they can be adjusted to the individuals who use them. Some examples are automobile seats, office chairs, etc... In The design of such equipment, it frequently is the practice to provide for adjustments to cover the range from the 5th to the 95th percentile of the relevant population characteristic (sitting height, arm reach, etc.).

3- Designing for—the Average: - The human factors literature is strewn with pronouncements that there are very few (or not) individuals who are "average." Indeed, there are few, if any, individuals who are average on each of many anthropometric characteristics. The use of average values in the design of certain types of equipment or facilities, is appropriate specifically when, for legitimate reasons, it is not appropriate to pitch the design at an extreme value (minimum or maximum) or feasible to provide for an adjustable range. As an example, the checkout counter of a supermarket built tor the average customer probably would discommode customers less in general than one built either for the circus midget or for Goliath. This is not to say that it would be optimum for all people, but that, collectively, it would cause less inconvenience and difficulty than one might be lower or higher.

<u>Design Principles</u>: In the application anthropometric data to specific design problems: there can be no nicely honed set of procedures to follow, because of the variations in the circumstances in questions and in the types of Individuals for whom the facilities would be designed. As a general approach, however the following suggestions are offered [Sanders and McCormick]

1. Determine the body dimensions important in the design (e.g., sitting height as a basic factor in seat-to-roof dimensions in automobiles).

2. Define the population to use the equipment or facilities. This establishes the dimensional range that needs to be considered (e.g., children, women, different age groups, etc.)

3. Determine what principle should be applied (e.g., design for extreme Individuals, for an adjustable range, or for the average)

4. When relevant, select the percentage of the population to be accommodated (for example, 90 percent, 95 percent) or whatever is relevant to the problem.

5. Locate anthropometric tables appropriate for the population, and extract relevant values.

6. If special clothing is to be worn, add appropriate allowances (some of which are available in the anthropometric literature).

Factors to be considered in the design of seating

It is the requirement of good seating that the person sitting in a seat should be able to maintain a good posture which will not cause any strain of any particular group of muscles. It has already been" explained that continual- strain on one particular group of muscles can cause fatigue and therefore it would seem that a good seat should enable the user to change posture at intervals so that different muscle groups may be called into play. At the same time the use of a well designed and positioned back-rest may relieve the back muscles of a good deal of a postural work. Any seat which maintains the body in a rigid, position is likely to be unsatisfactory, especially if it causes bad postural habits which may result in the development of the postural abnormalities. Some writers have suggested that a satisfactory posture is achieved only when there is a lumbar concavity but this may well be too rigid an interpretation.

A second important factor is that the seat should not press unduly on the tissue of the thigh which is not designed to withstand pressure as is the tissue of the buttocks. Thus if the thighs are pressed into the front edge of a hard seat of the type so often found in many factories, they may be compressed by a quarter or even a third of their full thickness before the weight is taken by the femur. This pressure will restrict the blood flow and may cause pressure on the nerve trunk which runs on the under -side of the thigh and will cause discomfort and may cause the limb to “go to sleep” [Murrell]. The parts of the body which are intended to be sat upon are two bony protuberances of the pelvis known as the ischial tuberosities and the tissue in the vicinity is adapted to withstand pressure without restriction if the blood supply, in fact after the feet and the hands it is

probably the part of the body best adapted to the bearing of weight.
A well designed seat should therefore bear the weight of the body in a good posture on the buttocks and not on the thighs, and when achieving this objective there are anatomical, physiological and anthropometric principles which have to be taken into consideration and these may impose a few restriction on the design of seats for specific purposes. The elements of good seating will depend on the length, width and shape of the seat; to a limited extent on the material of which the seat is made; on the shape and height of the back-rest and the height of the seat above the floor.

Percentile-Standard Deviation Relationships:

Percentile	Equation used in Calculation	Percentile
1'st	**$\mu \pm 2.326\ \sigma$**	**99'th**
2'nd	**$\mu \pm 2.054\ \sigma$**	**98'th**
5'th	**$\mu \pm 1.645\ \sigma$**	**95'th**
10'th	**$\mu \pm 1.282\ \sigma$**	**90'th**
15'th	**$\mu \pm 1.036\ \sigma$**	**85'th**
25'th	**$\mu \pm 0.674\ \sigma$**	**75'th**
30'th	**$\mu \pm 0.524\ \sigma$**	**70'th**
35'th	**$\mu \pm 0.385\ \sigma$**	**65'th**
40'th	**$\mu \pm 0.253\ \sigma$**	**60'th**
50'th	**μ**	

Note: **μ : The Average or Mean.**

σ : The Standard Deviation.

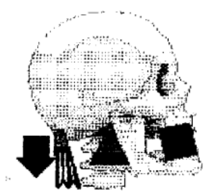
BIOMECHANİCS

The muscular forces in response to a work load depend on 1)- Muscles used, 2)- The posture, 3)- Amount of force required to meet task.

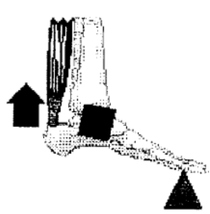
An Overview of Levers:

The connections between joints, called "synovial joints," are fulcrums, the bones they connect are levers, and the muscles attached to them apply force (or resistance).

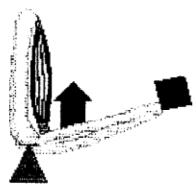
An example of a first-class lever is the joint between the Skull and the Atlas Vertebrae of the Spine; the spine is the fulcrum across which muscles lift the head.



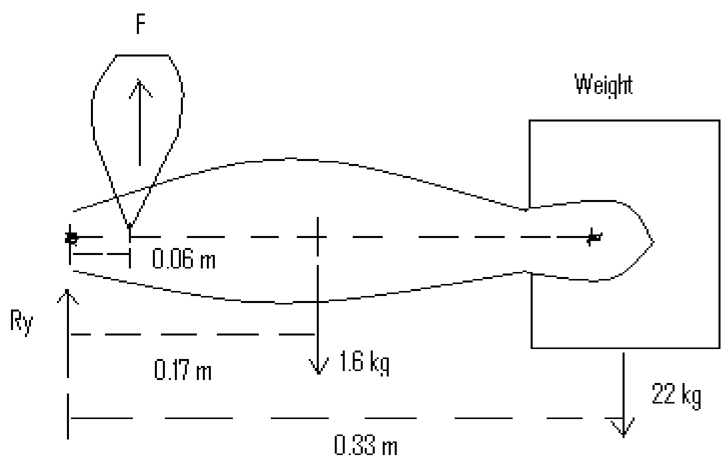
An example of a second-class lever is the Achilles tendon, pushing or pulling across the heel of the foot.



A third class lever might be the Elbow join; when lifting a book, the elbow joint is the fulcrum across which the biceps muscle performs the work.



<u>Example</u>: A person is holding a box with both hands. The box weighs 22 kg and is carried equally with both arms. The box is maintained in front of the body with elbows bent at right angles (90°). Compute the muscular forces required?



Elbow moment = 22x0.33 + 1.6x0.17 = 7.53 kg-m

We can refine our analysis slightly by considering the work of individual muscles. In this case we will assume that biceps will provide the resisting moment.

1- **Sum of all horizontal forces are zero,**
2- **Sum of all vertical forces are zero,**
3- **Sum of all moments at a given point are zero.**
   Therefore: -0.06 x F + 1.6 x 0.17 + 22 x 0.33 = 0

   F = 125 N

   From 1 and 2 we get Ry = 104.4 N