Ergonomics for beginners Industrial design Perspective

Prof. D. Chakrabarti

Department of Design

Indian Institute of Technology Guwahati

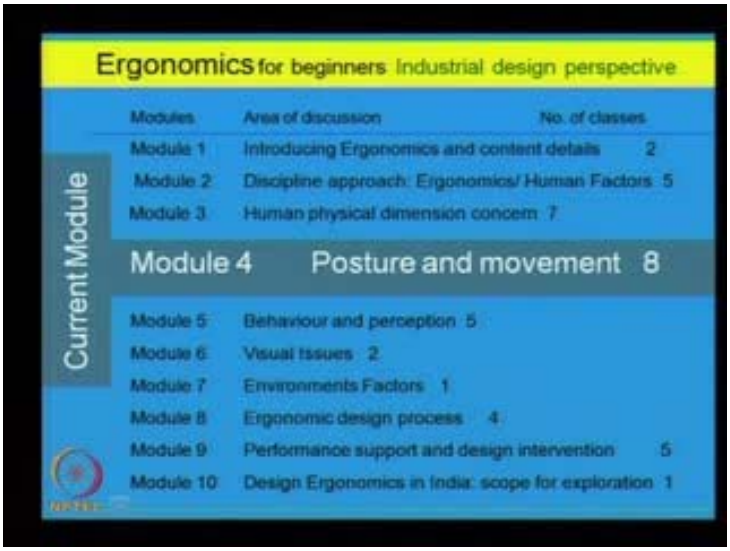
Module No. # 04

Posture and movement

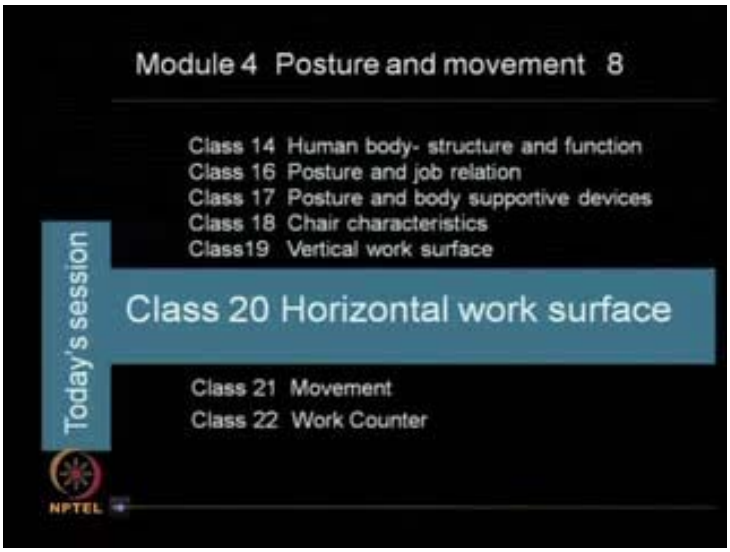
Lecture No. # 20

Horizontal work surface

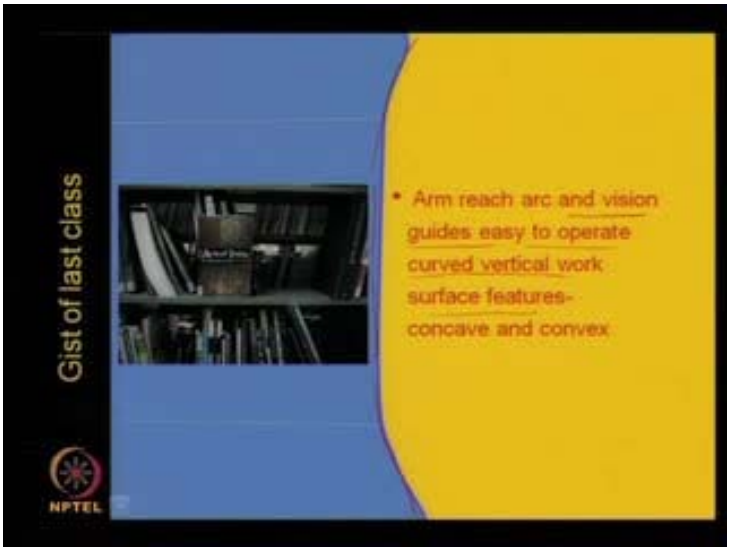
(Refer Slide Time: 00:31)



(Refer Slide Time: 00:40)

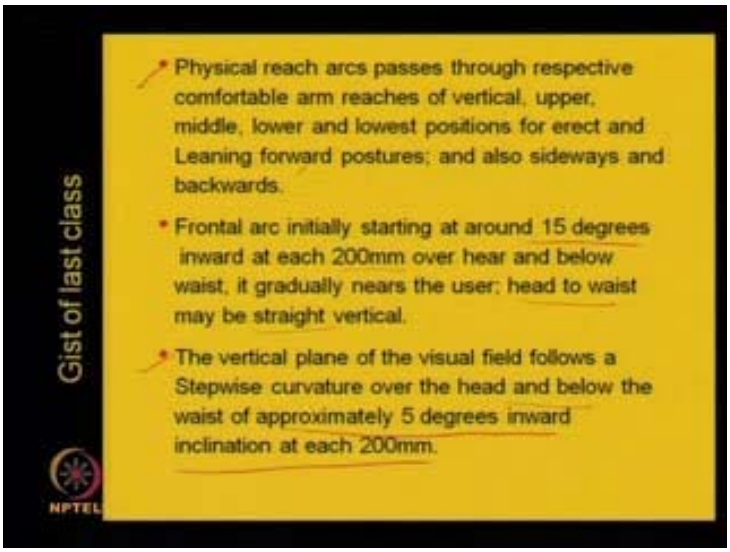


(Refer Slide Time: 00:53)



Welcome to this 20th session of ergonomics for beginners industrial design perspective; current module is module number 4 - posture and movements, out of the total eight classes under this module. So, in today's session that is a class number 20 - horizontal work surface. Now, gist of last class, where we mentioned that the arm reach arc and vision guides easy to operate curved vertical work surfaces features - that is concave and convex. Now, like this, that is from head height to waist height, the curved surface may be; when we are talking about concave surface stayed vertical, and thereafter above head and below waist, it may be inclined like this.

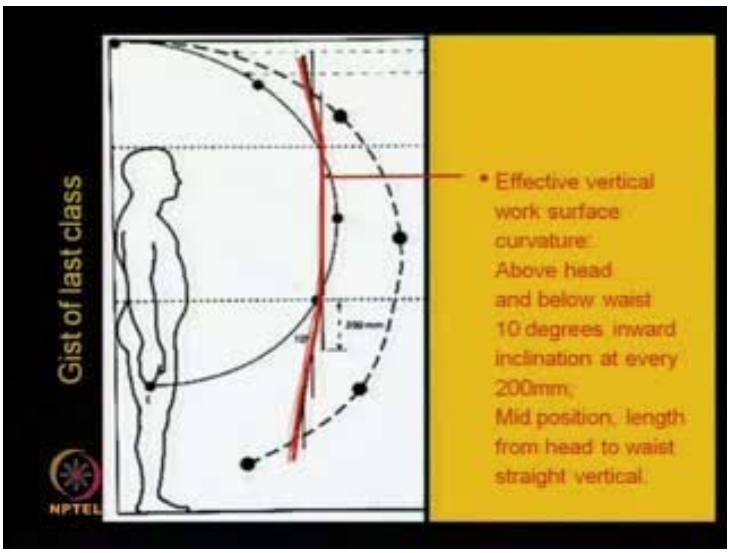
(Refer Slide Time: 01:43)



The physical reach arcs passes through respective comfortable arm reaches of vertical, upper, middle, lower and lowest positions for erect and leaning forward postures; and also sideways and backwards. The frontal arc initially starting at around 15 degrees inward at around 200 millimeter overhead and below waist, it gradually nears the user; head to waist maybe straight vertical.

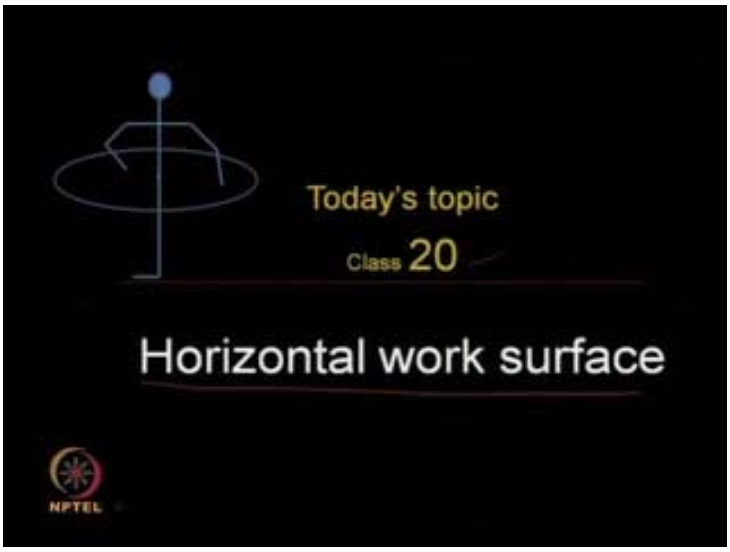
The vertical plane of the visual field follows a stepwise curvature over the head and below the waist of approximately 5 degrees inward inclination at each 200 millimeter.

(Refer Slide Time: 02:52)



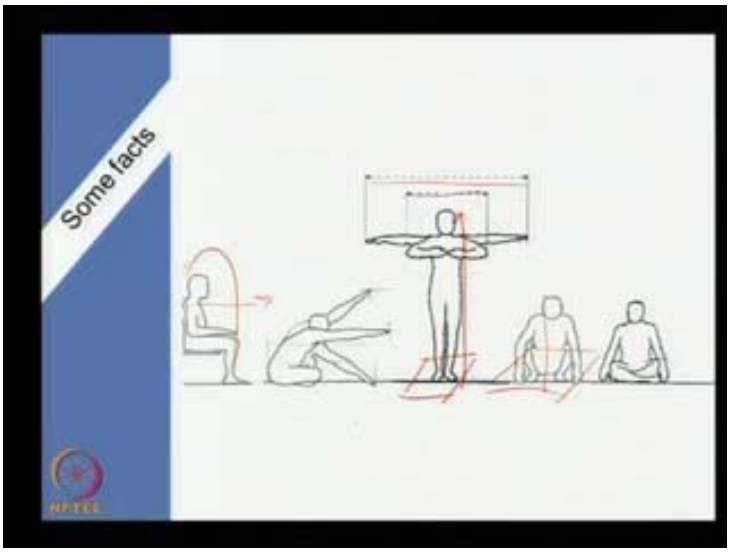
Now, with this figure, we have discussed where with this curved work surface, it can be said - the effective vertical work surface curvature, above the head height and below the waist level 10 degrees inward inclination at every 200 millimeter, if we keep it; and the mid position length from head to the waist straight vertical. So, if we have a curvature of this type of, then we can say that it would be easier to touch and it will be good to see also; and the distance of that work surface would be around 1 to 1.5 meter; so that, either standing erect or leaning forward or with step, it would be easier to operate on that surface.

(Refer Slide Time: 04:12)



So, with this, now, today we are moving the today's topic the class number 20 is that horizontal work surface. Now, if a person stands or sits what is the horizontal work area he can work upon?

(Refer Slide Time: 04:37)



Some facts: some facts that the basic fact of work station design, is that, when a person stand the square area, and the height it is inversely proportional, like when he sits or squats that area it comes in the height like this; also we require to consider the total arm stand and the span akimbo, means, folding arm; at elbow, this distance either in a sitting posture or standing posture, and then forward leaning or sideways and backwards also.

Even in a squatting pose also the forward reach, even in a seated position the forward reach, and how much you can touch? All these things are necessary to concern in this today's discussion. So, the total dimension that this method we have discussed earlier this human body dimension concern; and now we are going to discuss its work station application.

(Refer Slide Time: 06:07)

One example we can say that the godrej's, this furniture method; here it says that - the two the units of work space is made for two persons. Now, somewhere single person work station is also designed, somewhere many people can work together, and that type of workstation is also necessary to concern.

Now, some fact is that why we need to have two persons or single persons or three persons in work unit? If we consider, suppose in a gathering party or something like that, it is observed that most of the groups are made by two persons; means, they are moving in that place, but they are talking to each other; these type of groups are seen maximum for two persons. Now, another person if they join third person, so that, three persons group are relatively less, means, what is happen? If some other persons comes closer to that, there is a chance to break this three persons group, and one person can go to some other area, and can make another group of two or something like that. Four persons group are much lesser, and more than that it is very few. So, considering this aspect if perhaps this design is done for two persons, to make a group.

Now, the concern is that if these two persons are close enough then it is good, otherwise what is happen? There will be privacy problem; so, then, what would be the total privacy feeling? Now, we can see that the arm reach front, and sideways the arm reach value is the physical demarcation of a person's total area he can work upon, but psychological

territorial feeling, it depends on the task, he is doing as well as the feeling he has, for that task, and the other people around him.

For that purpose, in this case, if we can have a modesty panel like this, then it would be good; now, if it is necessary it can be placed, if it is not necessary when we require a larger space, then this can be removed. Now, the concern is that what makes or what activity or what factors decides this dimension of this work surface on a horizontal platform; so, that we could discuss now.

(Refer Slide Time: 09:48)

Now, another example is that like this, is that, stallion of some godrej, it has a single occupancy unit, but three single units are combined together to have a special work unit. So, in this case what is happen? This person gets the privacy as well as all the dimensions here, length, breadth, and the curvature of all these things; it matches the task as well as the person's requirement and psychological requirement as well as physical dimensions.

(Refer Slide Time: 10:33)

Now, though it is seen that in a single work platform people are working, but still all the people they are concentrating on their task independently. So, it keep it rises a query that whether this work unit for single person, two person group or more, whether it would be modular or a single platform, all these questions come and that needs to be answered with specific context.

(Refer Slide Time: 11:25)

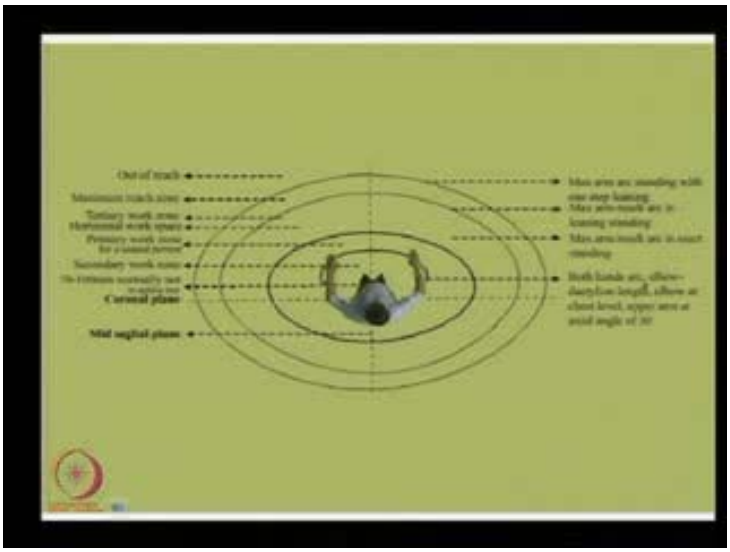
Now, this is another work area, where this person's work area is in such a position that is not comfortable; why he is not comfortable? Because he has to attend something here for

the mouse and keyboard, he is looking at that, and he also needs to concern with all these papers and etcetera; so, what is happen whether what will be the location of these work components on a horizontal surface, we need to concern with body dimensions, movement of ranges body and the arm, and the task requirement, and the placement of work equipment.

(Refer Slide Time: 12:29)

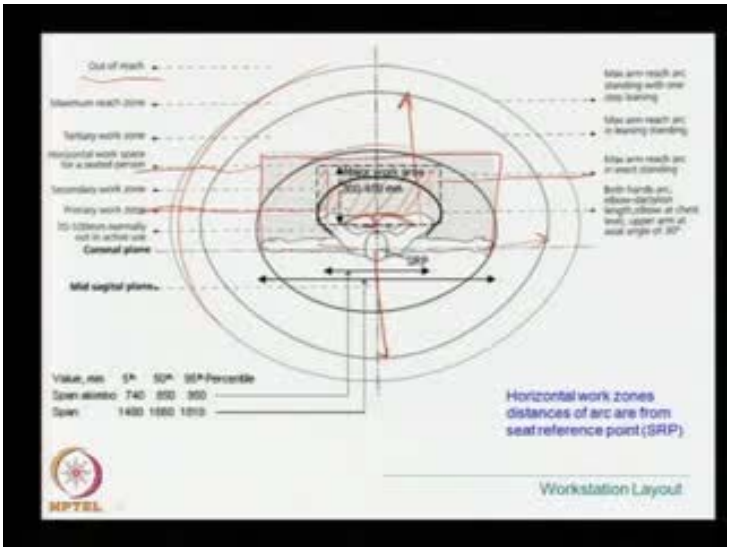
In this is another figure, we are showing here that here the work area that relatively personal work area, and relatively general a common office area where the person, the faculty member, the person can interact with others that is separated.

(Refer Slide Time: 12:56)



So, there are many concerns are there, how it behaves and how we should look? Now, if we see this animation here, that the person moves is in a standing erect, the total arm dimension here, the reach, bending and etcetera, it gives the basic clue for this work space dimension design.

(Refer Slide Time: 13:36)



Now, here with this figure, if we see, it is schematic diagram; then we can say that - the person here he may stand or sit, at normal, at the elbow level or the shoulder to elbow in between when he keeps the arms to this touching the palm over palm; this is that the span

akimbo length, and when he spreads the arm, this is the span length. So, here the concern is if the person can extend his folded arm like this, this is around 300 to 450 millimeter both the sides; and this one, the length wise, this is the span akimbo length. Now, here this data is that the 5th percentile of this span length is 740 millimeter average, 850th percentile it is the 850 millimeter, 90 percentile is 950 millimeter, and the span length also it says that - 5th percentile is that 1480 millimeter, 50th percentile 1660 millimeter, and 95th percentile 1810 millimeter; so, this much space, one can cover with the arm reaches.

Now, so, with the span akimbo length and the total arm length in front, so this much space, this is the major work area is done here, like this one; so, this depth, this area is the primary work zone, where the maximum work is being carried out, is the primary work zone; now, so, this is the primary work zone.

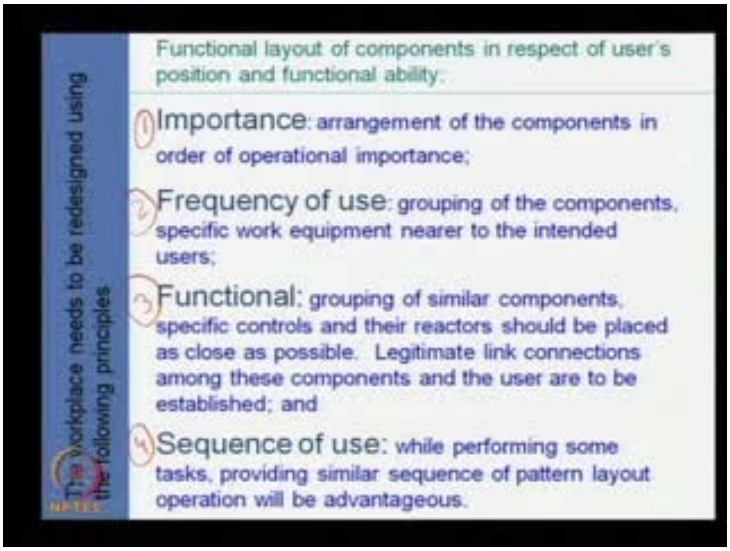
Now, one thing, is that, in that primary work zone when we work something, at least we require some space to rest the palm; so, from body around 7 to 10 centimeter space, we cannot use it, it is specifically required for palm rest; so, this much space here, we need to leave. So, this is the around 70 to 100 millimeter normally not in active use, that much space we need to keep free; so, keeping this much space free, this whole area is the primary work zone. So, most important work where immediate attention is needed to write, read or to do some work that would be placed within this area. And then maximum work area is that if we, when we expand our arm, both the sides this area is that total work area.

So, this is the total horizontal work space for a seated person. Now, if when he bends forward then this is the arm length; when he bends sideways then from the seat reference point, this is the length; and from the back side, this is the length; now, all this arm lengths and etcetera are being centered at the SRP - seat reference point.

What is the seat reference point? If a person stand or if a person sits, then from the center of the head, take the straight axis where the two knees, if you take a line where the two knees are meeting in that axis; so, that point is called seat reference point. So, from this work station design and etcetera, all the dimensions are being concerned with this seat reference point.

Now, if we take one step forward sideways or backward, then the total arm length, this is that maximum arm length, is this one; so, this is that maximum arm reach with a step; so this is that third work zone, and beyond that if we take two steps, then we are losing the central work attention. So, even either erect sitting or standing maximum, we can touch with the arm, then bending, then with one step, still we can come back to the central work attention area; and we can work beyond that if we cross then we will lose this attention of the center point.

(Refer Slide Time: 19:54)



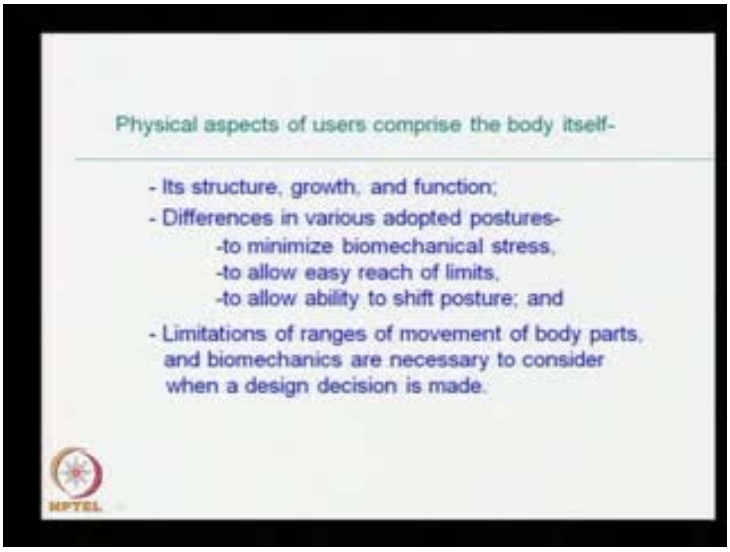
So, this work area, so first work area is that this is called the first work area; so, this is that primary work zone, secondary work zone, this is the tertiary work zone, the maximum reach zone, and beyond that is the out of reach zone. So, within this space, according to our requirement to handle the objects we have to place; now, for placing all the things, there are some principles concerned. So, these principles are the workplace, the workplace needs to be redesigned using these principles.

Now, the functional layout of components in respect of user's position and functional ability; there are four principles, like number 1 principle, is that, importance the principle of importance; now, there are many work components, now arrangement of the components in order to operational importance; means, for, that is the principle of importance wise, we can arrange the work components.

Number 2 is that frequency of use: grouping of the components, specific work equipment nearer to the intended users to be placed is the frequency of use. Number third is that functional, principle of functional: grouping of similar components, specific controls and their reactors should be placed as close as possible. Legitimate link connections among these components and the user are to be established.

And the fourth is that sequence of use principle, to work upon the all the components for a certain purpose; while performing some tasks providing similar sequence of pattern layout operation will be advantageous; so means, if we arrange all the components in a specific way, so that, sequence wise one after another we can operate, and there will be sequence; so that, if we follow this principle then component layout will be like that, but for a specific purpose all the principles work together, to give a specific layout on a work surface, layout of the different components.

(Refer Slide Time: 22:42)

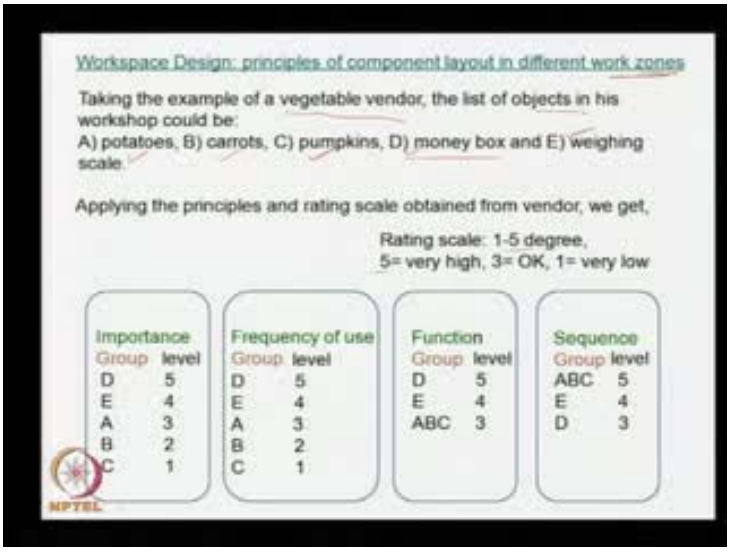


So, now, the physical aspects of users comprise the body itself: human body, structure growth, and function, means, the same work area one cannot use, when body structure changes from young age to old age growth, and function wise when the function deteriorates or if the ability deteriorates; so, modification has to be there.

Differences in various adopted postures, like to minimize biomechanical stress, to allow easy reach of limits, to allow ability to shift posture; and the limitations of ranges of movement of body parts, and biomechanics are necessary to consider when a design

decision is made; so, with this now we will discuss whatever the theory we mentioned right now with an example.

(Refer Slide Time: 23:59)



Now, the example is that we are taking a vegetable vendor's example, vegetable vendor's cart; he is selling some vegetables and he has some other equipment with him, to have this selling business; and on that cart how he can arrange the items? According to these principles, whatever we discussed right now that is principle of importance, principles of frequency of use, principle of function and principle of sequence, now see.

The workplace design principles of component layout in different work zones: primary work zone with this concern, secondary work zone with extended arm, and tertiary work zone with a bent, may be with one step.

Taking the example of a vegetable vendor, the list of objects in his workshop, that is that work cart could be like this. Number A is that he is selling potatoes, number B he is selling carrots; suppose, we are assuming it, then C is the pumpkin larger size, D is carrying money box with him, on that cart in a hidden area, and E is using a weighing scale; so, he has what A, B, C, D, E, five components he is using, for a certain sale purpose.

Now, applying the principles of component layout, the four principles importance frequency of use function, and sequence and rating scale obtained from vendor we get

here, we asked vendors rating scale, means, importance wise when we ask him, that whether you require this potato is the more important for you or weighing scale is more important for you, like that way.

So, with that we are asking that using 1 to 5 degree scale, means, where his response if he says that - it is very high then 5 point, if he says that then 3 point and very low; then 1 point, means, 1 is very low, 2 is low, 3 is, 4 is high, and 5 is very high; so, this is the response, now we are arranging in it.

Now, we asked the vendor and the grouping is that we asked that which one is the importance point of view? Which one is the maximum importance? He said that D, means that, money box for him is the maximum importance; so, he ranked this a 5.

The next is the E, E is the weighing scale, it is next important; then A is the potatoes because mostly people buy potatoes; so, potatoes will get the 3 point. Then B is that carrot, 2 point, and C is that pumpkin, because large size pumpkin and also pumpkin sells suppose a bit less, in that context; so, he gave the number 1 rank.

So, this ranking is that from importance point of view. Then frequency of use point of view, while selling this how frequently he uses all the components, it is almost same to the importance as per his views.

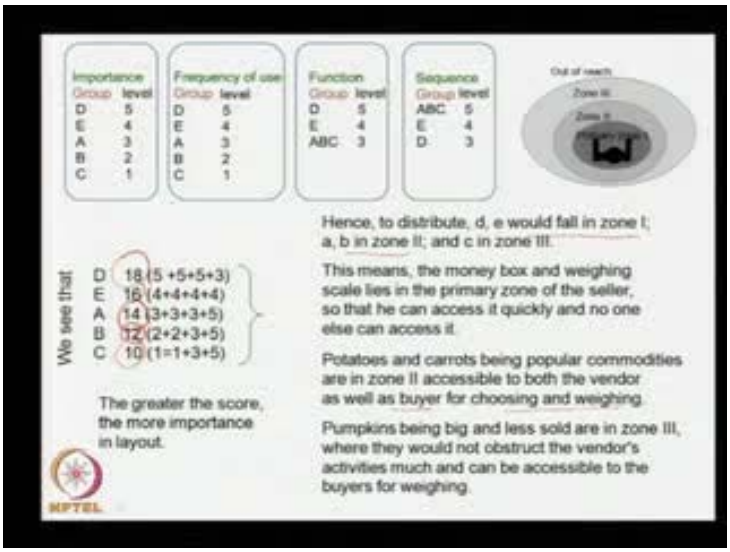
He said that - frequency of use maximum, he uses the money box D is the money, box E next 4 point is for the weighing scale, then A is the potatoes 3, B is the carrot, and 1 is the pumpkin.

Then from function point of view, to perform the selling business, selling function what is that for him? Sale purpose, money box is the very important for the function part, because whatever he does, he may sell potato, he may sell pumpkin, carrot or whatever for the, for each purpose. D - that is the money box, is the maximum importance, and E is the next weighing scale, whatever he sells weighing scale, has to be used; and A, B, C - potato, carrot, and pumpkin for function point of view, they have the almost same value.

Then from sequence point of view, sequence wise for selling purpose, first he has to attend the potato, carrot, and pumpkins, then he takes those things from the customers,

and then he weighs the thing; so, sequence of use. Then number 4 point is for the E, means, weighing scale then he weighs that; and after that at the end he does the money business, that is the money box; so, for sequence of use for selling this is the scale.

(Refer Slide Time: 29:54)



So, this one is different, so for different principles, the components or the group of components, and their rating are different. Now, with this, the same thing is mentioned here, all these things, just is repeated.

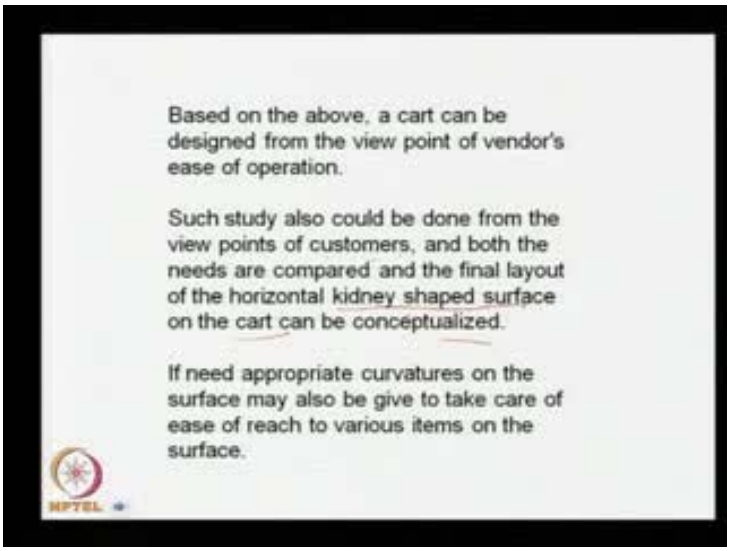
Now, with this we can see that and what we see from here, that if we count then for D, D 5 5 5 and 3, so total 18 points; then for E, E got 4 4 4 4 like this, so it got 16 point; then A 3 3 3 and 5, so it is 14; then for B, B means carrot, 2 2 3 and 5, this is 12 point; then C is the pumpkin that is 10 point, 1 1 3 and 5, so 10 point; from this we can say that which one hence to distribute D, E, D and E would fall in zone one, means, where he is comfortable to work; so means, span akimbo and then this forearm length this area is the primary work zone.

Then A and B, next it may be in the number 2 zone, means, where he can extend arm without bending, that area second zone; and third zone, C we can keep in the third zone. This means, the money box and weighing scale lies in the primary zone of the seller; so that, he can access it quickly, and no one else can access it, his customers does not have easy access, but the seller he has easy access to that. So, this is in combination of importance frequency function and sequence, all four principles of component layout.

Potatoes and carrot being popular commodities are in zone 2 accessible to both the vendor as well as buyers for choosing and weighing. Pumpkins that are C with 10 points, here being big and less sold are in zone number 3, where they would not obstruct the vendor's activities much and can be accessible to the buyers for weighing.

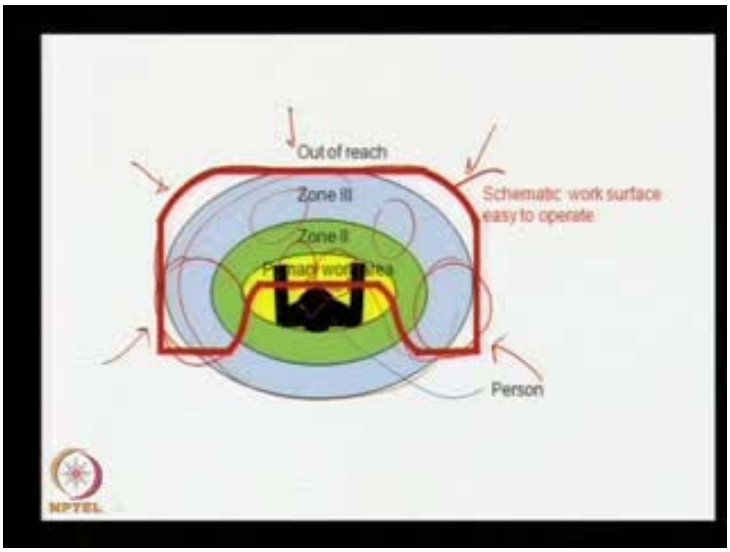
So, by this way, this example, so here the greater the score, the more importance in layout and accordingly the placement will be made; so, this example as we have seen here in a vegetable cart of vendors and buyers convenience point of view, this similar things will be useful for any kind of workstation design in a horizontal place surface or in any work surface that different work component layout and etcetera.

(Refer Slide Time: 33:38)



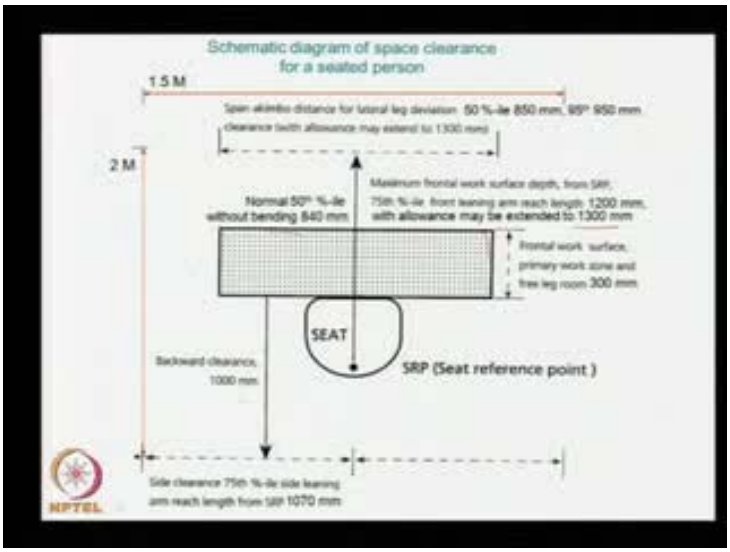
So, based on the above, a cart can be designed from the view point of vendor's ease of operation. Such study also could be done from the viewpoints of customers, even and both the needs are compared - vendor's and customer's, and accordingly and the final layout of the horizontal a kidney shaped surface on the cart can be conceptualized. If need appropriate curvatures on the surface, may also be given to take care of ease of reach to various items on the surface.

(Refer Slide Time: 34:28)



The kidney shaped area is like this, means, this is the person, this is the primary work zone, this is the second work zone, this is the third work zone, and outside the out of the reach; so, combining all means vendor's easiness and customer's easiness, if we can have a cart of this type of size, then with the vendor is here, then from all the sides, these people can approach him, and he can weigh; so, here what is happen, money box weighing scale and etcetera can be kept here, and then potato, carrots and etcetera can be kept like this, and pumpkins as it is sold less, this may be placed in these areas. So, this is the schematic work surface, easy to operate from buyer and seller, both points of view.

(Refer Slide Time: 35:33)

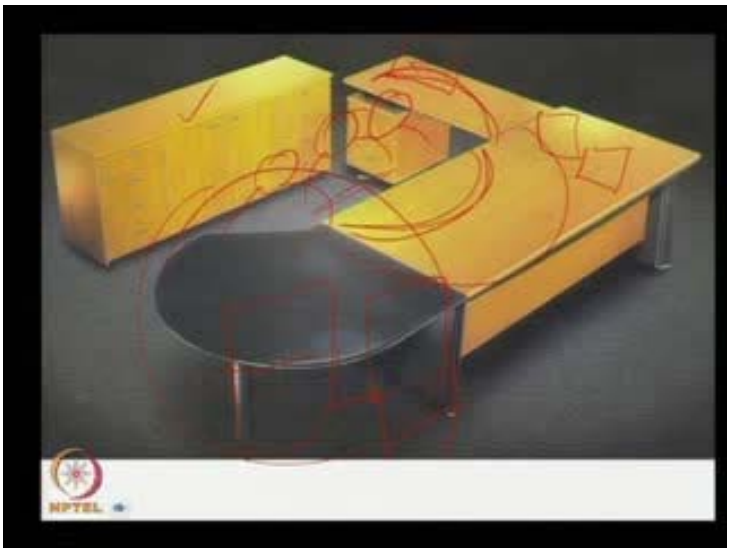


Now, the chair and desk system; this is a seat, this is the work zone; now, if this chair and seat, seat and the desk is joint unit where you cannot separate it, then the maximum distance is still here that is that 75th percentile of front leaning movement on these; this is around 1200 millimeter from the stomach, distance like this, with allowance it maybe till 1300 millimeter; this frontal work area 300 millimeter and then distance total will be 1.5 meter; so that, with extension of arm, they can reach both the sides. And if it is a detachable seat and desk where if you stand, then that seat may go back, at that point; from this table edge around 1 meter gap is necessary, it will facilitate the backward clearance value.

(Refer Slide Time: 36:56)

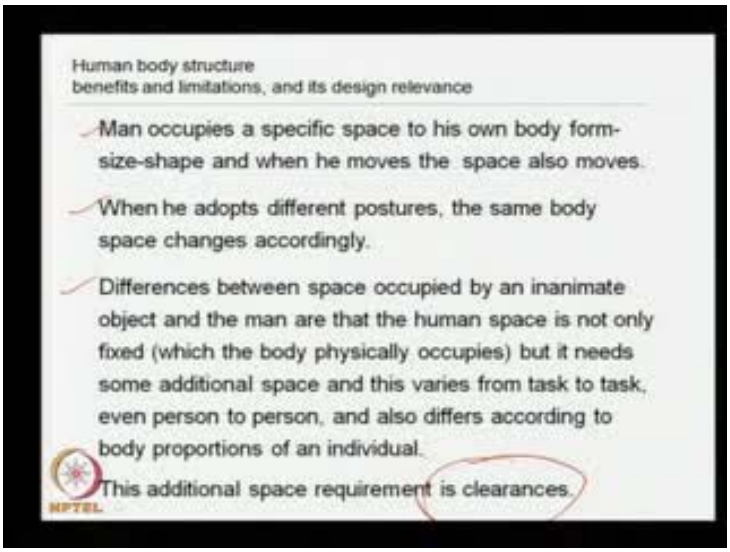
Now, in this case what is happened? The work zones or work areas is totally separated; means, this is the personal work area and this is the meeting work area, but the same chair can be used for both the purposes; this chair with a swiveling wheel and etcetera, it may cross if it is necessary; here, the total work identity is different.

(Refer Slide Time: 37:35)



Now, this is a schematic presentation here, where if a person sits here like this, then this primary work area he can work; this is the secondary work area, and like this, this side if he keeps his computer and etcetera or personal work area, then total maximum work area will be within this primary work zone; if he turns his head, this type, this side he turns his head, the office work, and etcetera, out tray, in tray etcetera, it may be kept here, for that on the tertiary work zone area. Here the furniture's can be placed, so that the visitors can come here and just changing its position; this person can take his side and can make this as a meeting place, and back side if he takes turn this is his personal belongings place etcetera. So, by this way a single user's workstation can be designed.

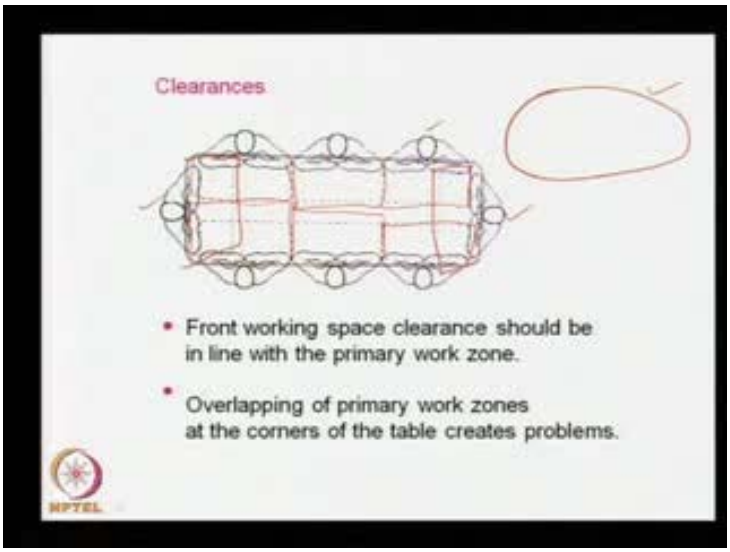
(Refer Slide Time: 39:12)



So, human body structure benefits and limitations, and its design relevance: man occupies a specific space to his own body form, size, and shape and when he moves. The space also moves with him, when he adapts different postures, the same body space changes accordingly.

Differences between space occupied by an inanimate object and the man are that the human space is not only fixed - which the body physically occupies - but it needs some additional space and this varies from task to task, even person to person, and also differs according to body proportions of an individual. This additional space requirement is clearance value.

(Refer Slide Time: 40:31)



Like here, when these persons are sitting, suppose this is a dining table kind of thing, when this person sitting for him, this is the primary work zone area for him, this is for him, this one for this person, this one for this person, this one like this way. So, there is no space for this person to occupy; he requires this much space, so this space is overlapped by this three persons here, so what would be the clearance? For this nowadays dining tables and work spaces and meeting surfaces are more or less oval shape to overcome this problem.

Front working space clearance should be in line with the primary work zone. Overlapping of primary work zones at the corners of the table creates problems; so, these types of solutions one can think of.

(Refer Slide Time: 41:39)

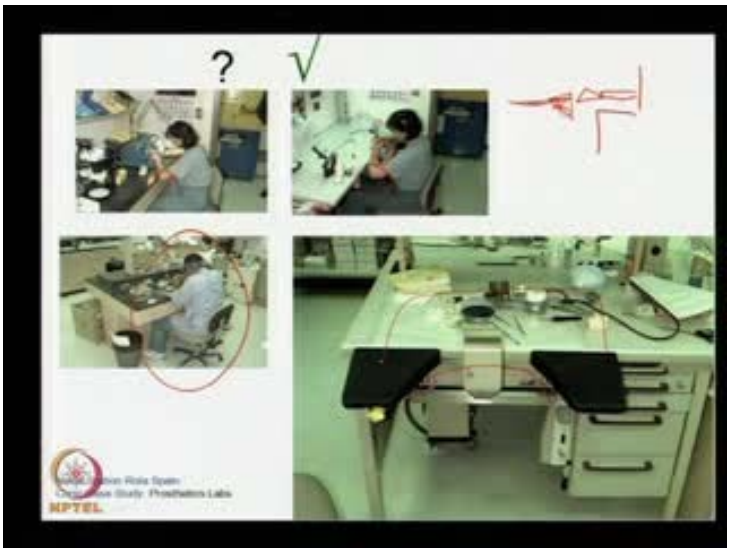
(Refer Slide Time: 42:00)

Based on this type of furniture's are designed developed, and available in markets. So, here all those clearance values and etcetera are taken care of, like this; here the space is clearly mentioned, so that even sometimes with some color differences, it is made, it clear that how to use this work surface; means, two person can sit, this side two person can sit, this side one person, this side one person, this side like that, one one, two persons, here two persons here like that maximum can be used.

(Refer Slide Time: 42:35)

Whatever earlier said this is the thing that if a person sits here then this may be used for meeting place for personal work area, immediate work area, this is the general office or general table; and these are the personal or maybe some storage, where it does not require to attend always, for that some free space is given here for easy access; free space is given here to get free access; so, this is the circulation allowance to be added.

(Refer Slide Time: 43:22)



Here, one thing is that this example has been taken from the naval station Rota Spain clinic, case study the prosthesis labs. In this, it is said that when a person is working, he

is working on the work surface, but her elbows are hanging, see the first elbow rest. Now, if elbow rest is there, then he cannot work close the same case also seen here; so, for that a special development, is that, if we can have an additional arm rest, means, that elbow rest now that elbow rest is can be given, either on the chair arm rest itself or it may be on this work table, on this extended extension.

Now, the question comes that if we have a rest attached to this chair arm, then when we go back then this arm rest also will go back; so, the central attention to the central work area, it cannot maintain; the hand will go back with the body or we have to extend our hand; so, for this it is mentioned that if it is an extension or additional to this work surface like this, then what is happen? He may change his body position, front or back, but this arm rest will remain same.

So, this schematically we can say that is the figure here that then addition is given here; so, it will be used for arm rest and the person can go inside, but with his arm rest, he can work upon this. So, this is the extension of work area, where the we are properly utilizing the primary work zone.

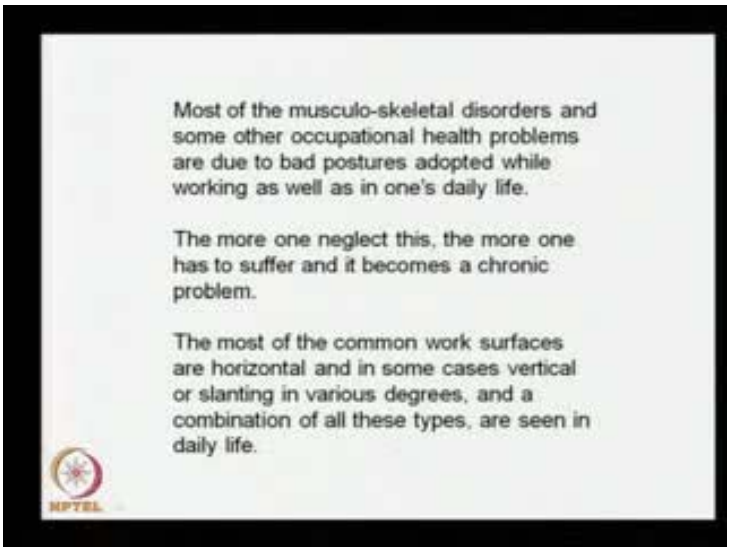
(Refer Slide Time: 45:55)

Now, one query comes in we have discussed this with office work area, we have discussed with different standing and sitting posture; even the same arm reach values and etcetera to be considered, when we work on a squatting posture or sitting with a cross legged position on the floor, that reach values etcetera should be considered the primary

work zone, secondary work zone, tertiary work zone, all may be considered though in all the postures, means, sitting on floor or in a seat desk position or in a standing position.

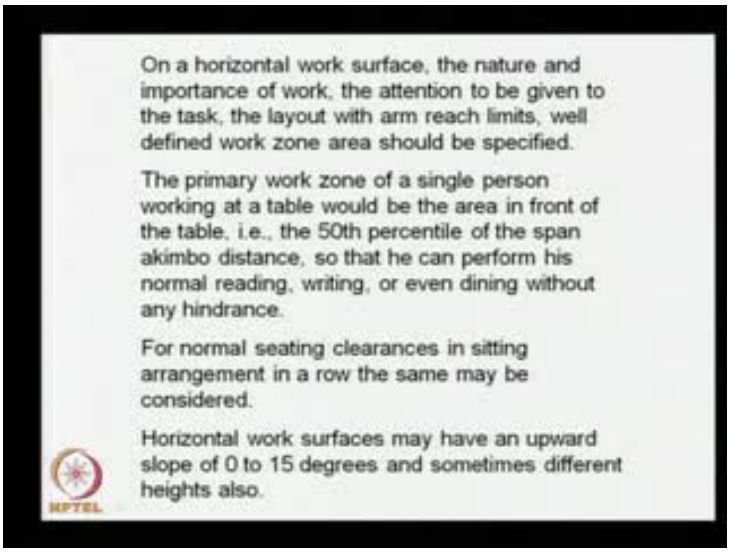
Now, one real life photography shown here; now, we need to consider how all those component layout principles, and other concerns what we discussed, can assist this vendor and these buyers; this vendor is selling, he has to get reach here, buyer though he is sitting, this piece baskets are displayed, at very low height position; so, the person has to bend and select the piece like this. So, now, if we want to develop a specific workstation for this purpose; how it can be developed? How it can be done? So, with that challenge, we are concluding today's session with some thoughts.

(Refer Slide Time: 48:04)



Most of the musculo-skeletal disorders and some other occupational health problems are due to bad postures adopted while working as well as in one's daily life. The more one neglect this, the more one has to suffer and it becomes a chronic problem. The most of the common work surfaces are horizontal and in some cases vertical or slanting in various degrees, and in combination of all these types, are seen in daily life.

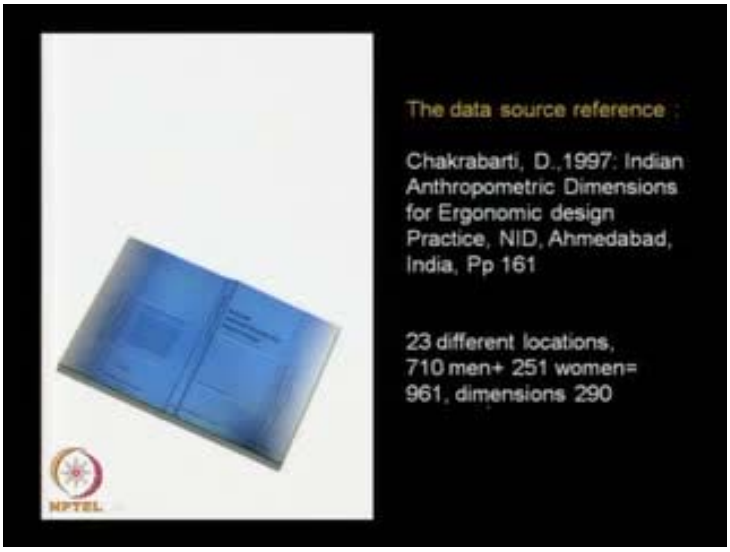
(Refer Slide Time: 48:36)



On horizontal work surfaces, the nature, and importance of work, the attention to be given to the task, the layout with arm reach limits, well defined work zones or areas should be specified. The primary work zone of a single person working at a table should be considered for reading, writing etcetera.

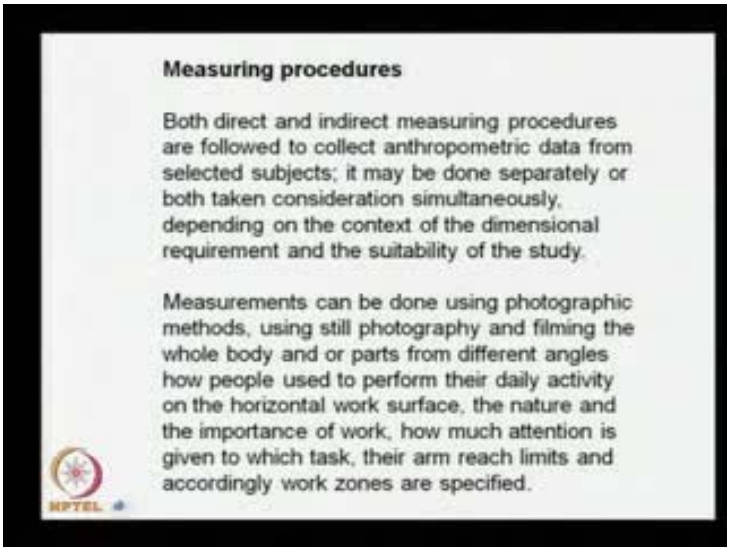
For normal sitting clearances in sitting arrangements in a row the same maybe considered. Horizontal work surface may have an upward slope of 0 to 15 degrees and sometimes different heights also.

(Refer Slide Time: 49:15)



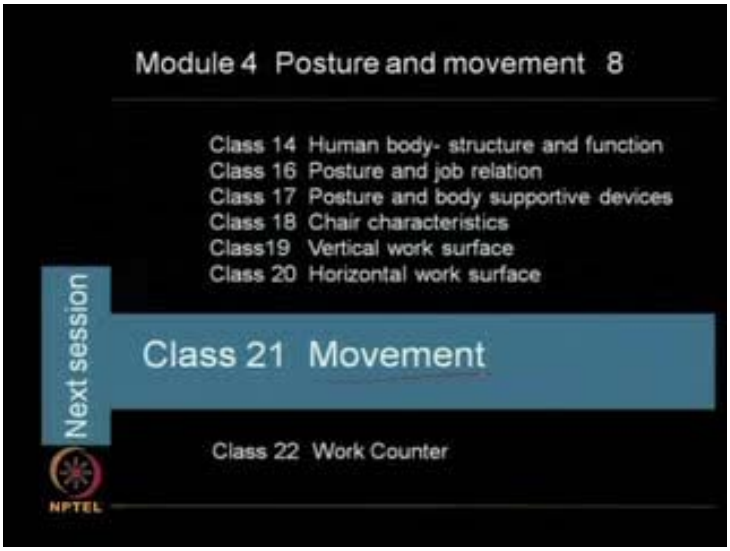
All the data concern, we may measure ourselves or there are some human data also available from this resource, from this source, data can be ready available book.

(Refer Slide Time: 49:35)



The measuring procedure: the person has to sit or we make a mockup stimulation models and then measure directly with anthropometric sets or take the videography photography and analyze all the things.

(Refer Slide Time: 49:51)



So, with this we are concluding today's session that is horizontal work surface and concerns, and next session would be the class 21 that is movement and the posture and

design support requirements for that. So, with this we are concluding the today’s session; so, thank you very much.