Ergonomics for Beginners Industrial Design Perspective

Prof. D. Chakrabarti

Department of Design

Indian Institute of Technology, Guwahati

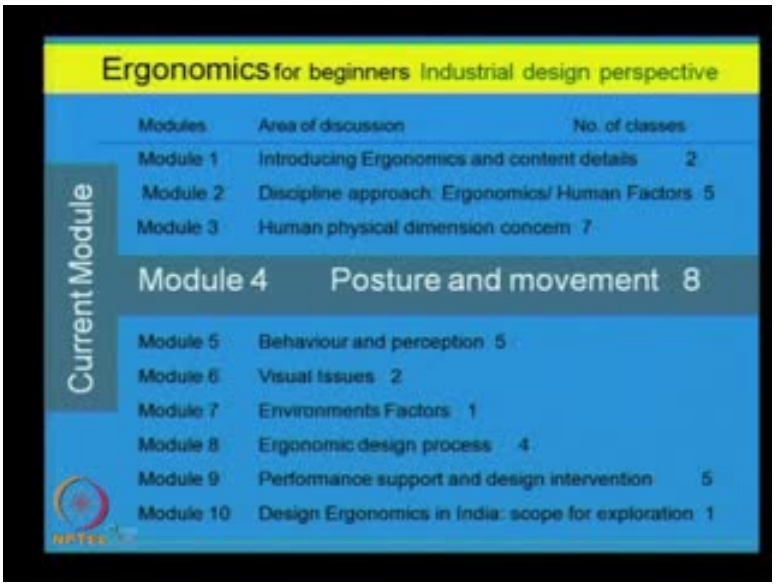
Module No. # 04

Posture and movement

Lecture No. # 15

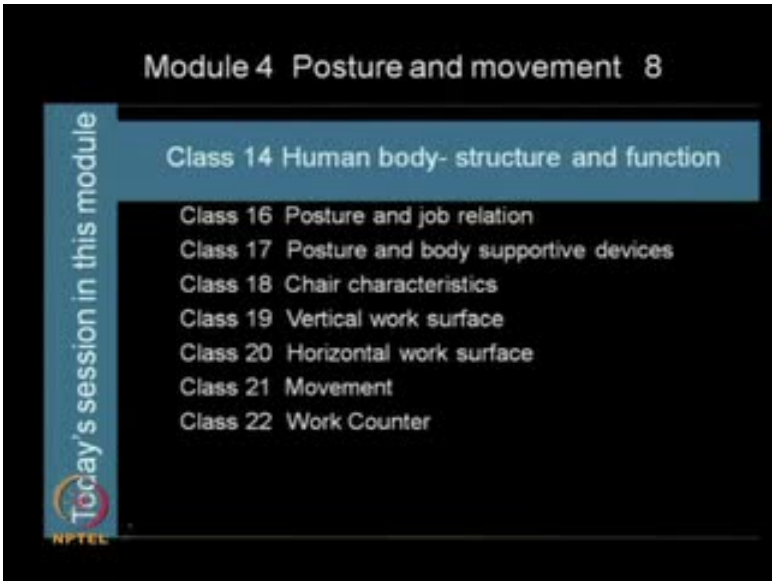
Human Body-structure and Function

(Refer Slide Time: 00:27)



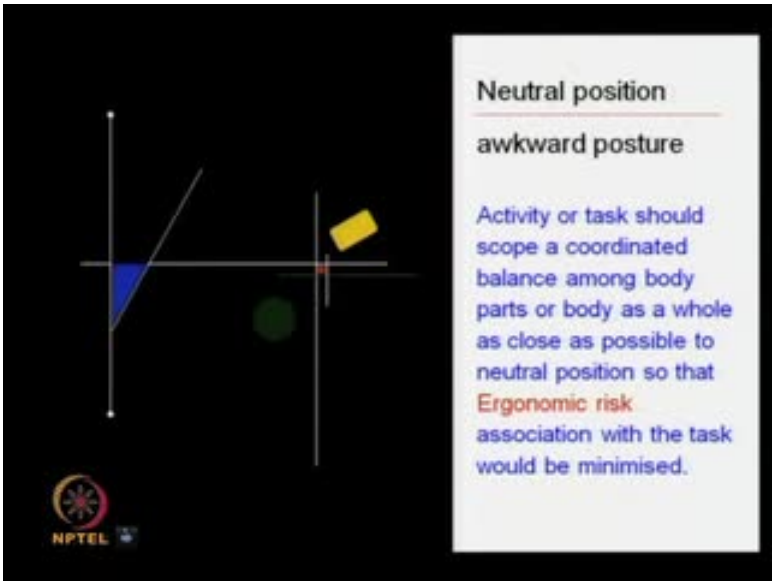
Welcome to this fifteenth session of ergonomics for beginners industrial design perspective. Today, we are going to start module number 4 - that is, posture and movement; under this module there are totally 8 sessions.

(Refer Slide Time: 00:42)



Eight sessions are: class number 14 - human body-structure and function; class number 16 would be posture and job relation; next, class number 17 - posture and body supportive devices; class 18 would be chair characteristics; class 19 - vertical work surface; class 20 - that is horizontal work surfaces; class 21 - we will concentrate on human movement and their design deliverance; and class 22 would be work counter.

(Refer Slide Time: 01:36)



So, today, if we consider the neutral position and awkward posture, the activity or task should scope a coordinated balance among body parts or body as a whole as close as

possible to the neutral position. So, that ergonomic risk association with the task would be minimized.

Now, what is the neutral position? Neutral position, we can say that if a man stands or sits, his total body weight will be distributed evenly and there will be no stress or pain feeling on the body. So, that we can say the neutral position, but for any kind of activity even during leisure time also we adopt various postures, and some of the postures, it effects negatively on our health and performance; that we call an awkward posture.

(Refer Slide Time: 03:18)

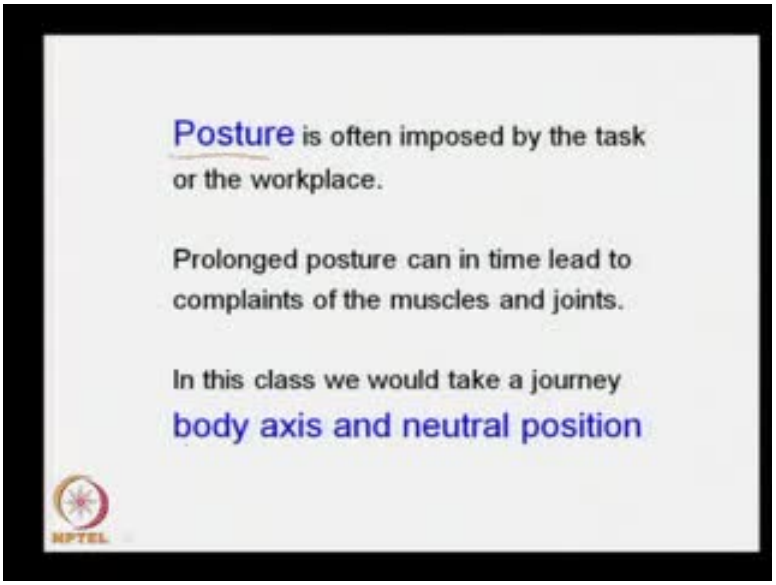
Now, if we understand the factors behind this, then we can work upon accordingly and we can design. Now, what is the ergonomic risk factor? Now, everyone wants a safe and healthy product and workplace to work with, but we do not achieve this and vary a great deal; means, what we do to achieve this vary a great deal?

Now, if you consider these ergonomics risk factors and dynamics risk, we can compare it with the fire triangle. This fire triangle, we can say it has three arms: heat, fuel and oxygen.

If we can reduce the intensity of anyone or the intensity in combination, it will reduce the effect. It means if we reduce the heat or the fuel supply or the oxygen availability, it reduces the fire hazards. In a similar way, the ergonomics risk at any work or at leisure period, it can be postural adaptation. What type of posture he adopts?

Then force with that posture, what type of force he applies, how long he applies, and the frequency of that posture adoption, and the duration of that posture, and the force application frequency - these three work together and give this triangle of ergonomic risk factors. If anyone is eased out, it would minimize the risk.

(Refer Slide Time: 05:45)



Now, in today's discussion we are concentrating on the posture. Handling this posture, how we can reduce the ergonomics risk factor? Now, what is the posture? The posture is often imposed by the task or the workplace nature.

The prolonged posture, can in time, lead to complaints of the muscles and joints. In this class, today, we would take a journey on body axis specifically and the neutral position.

(Refer Slide Time: 06:56)

Now, what are the normal body axis we have and how we work, how we apply force and what are the normal axis of body movement? If we follow, it will exert the desired force and effect. Now, if we see this figure, we can see the person is working in a lock manufacturing factory, where he has to give a pressure; it means he has to operate this control, as well as he has to work here and to operate this. Now, all the people we can see that this posture is not by seeing it appears it is not a good posture, but this type of posture it demands the work. So, what can be done? Can we do something on this design of the machine, the workplace and the method of work, so the person can work according to his normal body axis movement.

Now, here he is sitting; they are looking at this side and this side and operating. Here at the same time with the sideways, he is operating this. So, sideways operation of exposal lateral position of the leg is not the natural position. So, what can be done in this case? This is a matter of study field.

(Refer Slide Time: 08:31)

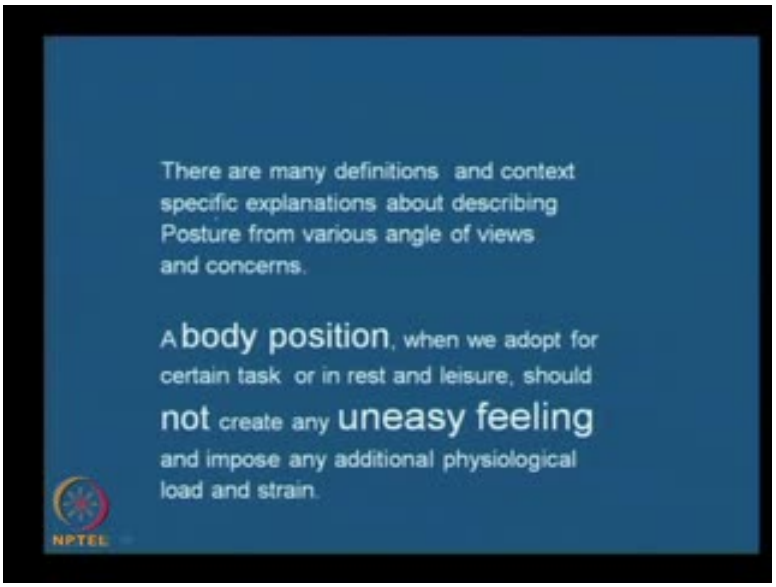
Now, in another figure, we can see here that while working, see the person - how he is operating. So many things he has to operate with the body.

(Refer Slide Time: 08:49)

Here also the handle is provided here for ease of operation, but the position he is sitting here, whether it scopes for good study, whether we can increase the height of this work table or we can modify this design of the machine, so that the person can sit properly and exert all the force requirement or the area, he needs to work with skill. Skillful

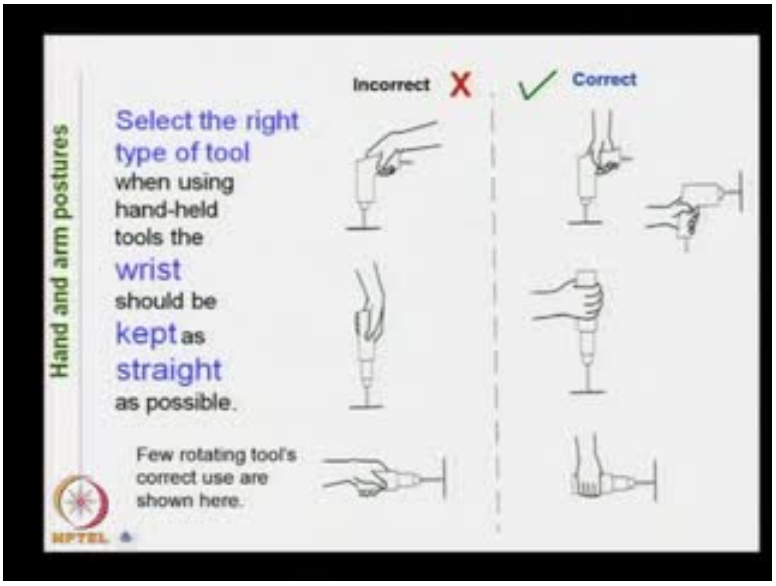
movement can be performed through the body axis movement and that would be close to the neutral posture.

(Refer Slide Time: 09:46)



Now, what is the posture definition? Now, there are many definitions and context specific explanations about describing posture from various angles of views and concerns. It can be said that a body position, when we adopt for certain task or in rest and leisure, should not create any uneasy feeling and impose any additional physiological load and strain; that would be a good posture.

(Refer Slide Time: 10:36)



Now, if we see these hand and arm postures, the posture maybe as a whole body posture. How we adopt for certain task or in a specific part of body to do a certain task, how it behaves naturally and what would be the work tool to support that or go along with that posture?

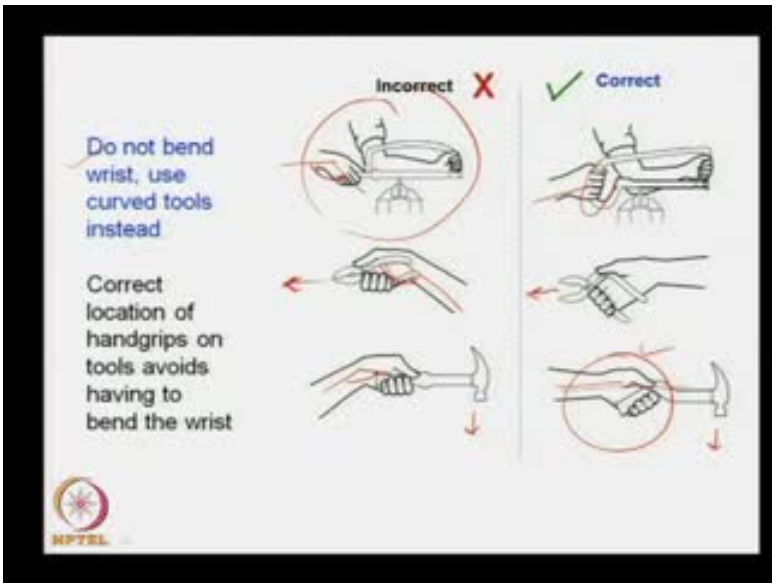
Now, here we are showing some of the work item like this way - while holding this drill machine, the arm position is in a different angle; so, this is not the natural holding. So, if we want to hold something, this is the normal holding position and with this holding position, it can be said that from this angle and this straight angle it is around 13 to 19 or around 20 degree angle in between.

So, if we want to hold something in a horizontal way, so the wrist has to be bent, but if we try to make the equipment like this way, then either we can hold it like this way or we can hold like this way. So these are the some methods of that. In this case, this holding is not correct because here the angle of bending is there, but in this case if we hold, it may hold.

Now, holding in this area also has some bent, but here this hold is only. So, here what happens without changing the equipment, the holding pattern if we use correctly then, we can get a good result.

Now, select the right type of tool; when using hand-held tools, the wrist should be kept as straight as possible. Now, these are the some of the examples shown here.

(Refer Slide Time: 12:58)

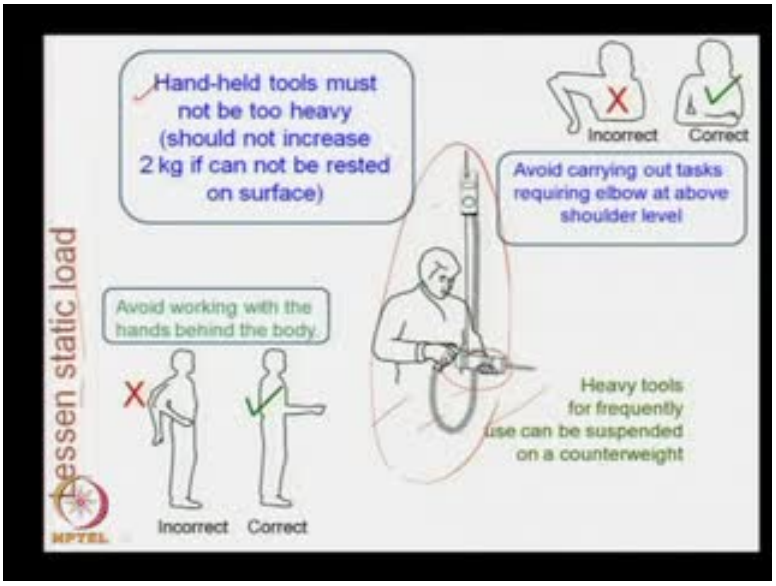


Accordingly, suppose that we can say - do not bend the wrist, use curved tools instead. It means if we see this figure while operating it, one arm is holding here; the another arm is holding here and with bent under angle. So, instead, if we can have a handle turn like this way, then it is the normal holding. So, it will be better to work with.

Now, another thing is that for normal players if we have to exert the resultant work here, the holding of hand is like this and here what happens, the angle takes place.

Now, on a holding area if we can bend then holding will be easier, but resultant effect will be at the same level. In this small hammer - in the straight handle this is the angle and if we bend this, then it will be straight; so only holding easiness here, but resultant effect for the both remains same. So, correct location of handgrips on tools avoids having to bend the wrist. So, here we considered normal axis of holding matter.

(Refer Slide Time: 15:00)



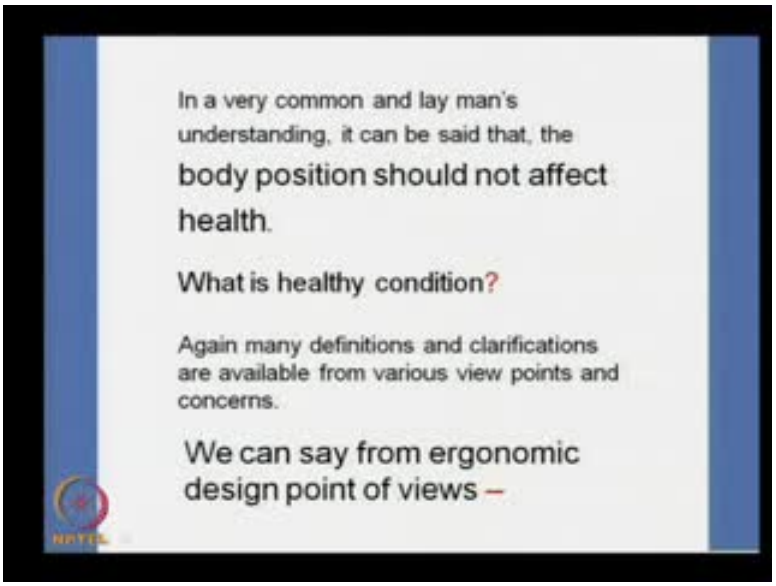
Now, another topic we can say that lessen the static load. Now, here three sets of examples are provided. Now, see the top right corner example. If we want to operate something at the back of the body, then it is difficult; but our body structure is in such a way, that it is better to operate the front and then side; but in this case also it is said that if we keep any operable handle or switch at the center of the body, and if we expect that we can operate like this, it is difficult because our normal body this distance, and if we extend our arm from the center it takes around 15 to 30 degree angle. So, at that area position the handle switch is kept and it will easier to operate than the straight one.

So, here it can be said that - avoid carrying out tasks requiring elbow at above shoulder level. Also, above shoulder level, some work should not be done because to maintain this position over shoulder, we have to spend some energy here; it also provides static load on this arm. Normally, arm natural position is the hanging down, so it will be better to position certain activity area below the shoulder level.

Another example at the left hand bottom corner - avoid working with hands behind the body. Another example - we can say the center is that while operating or holding some heavy equipment - in these category drill machine kind of thing, if we have to operate then hand-held tools must not be too heavy, should not increase 2 kg it cannot be rested on surface.

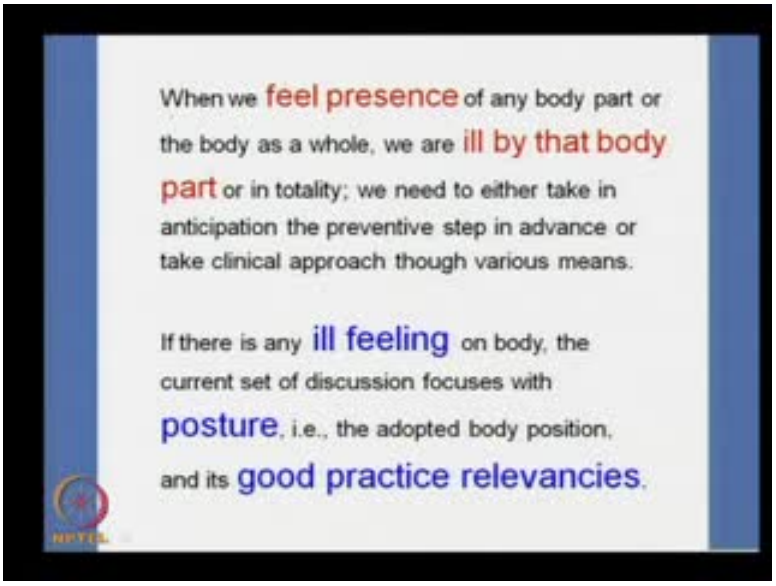
We cannot hold more than this weight for longer time. In this case, if he is operating and assembly belt is here; in the assembly belt some items are passing and he has to operate on it. Then, when he is operating this object, it can be hanged with a spring kind of thing, so that when he needs to operate, he can hold it and operate, and in between the gap when he is waiting for next one to come, here is the front, he can release this; it can be remain hanged on these, so he can get relief. So, it can be said that heavy tools for frequent use can be suspended on a counter weight.

(Refer Slide Time: 18:46)



Now, in a very common and lay man's understanding what we can say? Earlier, we said that the working postures would be such that it should not affect negatively on the health, but then what is the health? It can be said that the body position should not affect health. What is healthy condition then?

(Refer Slide Time: 19:36)

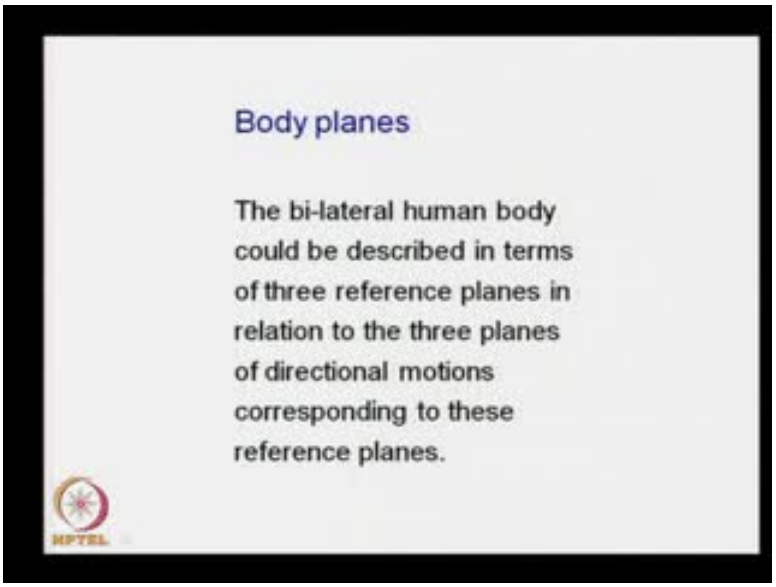


Again, many definitions and clarifications are available from various view points and concerns. We can say from ergonomic design point of views that when we feel presence of any body part or the body as a whole, we are ill by that body part or in totality; we need to either take in anticipation of preventive step in advance or take clinical approach through various means. We can say that - if there is any ill feeling on body, the current set of discussion focuses with the posture that is the adopted body position, and its good practice relevancies. How we can understand this feel presence, ill by ill that body part etcetera? Suppose, when we are sitting, we are not feeling the presence of our head or palm finger or anything. Now, if I or I do not feel any problem of back at this moment, but if I sit for quite longer time here, then I may feel pain at back. It means I am feeling presence of my back means I am ill by that part. So, then look into the facts or factors why it pains? Then we can find out the design dimension of the chair matter it matters and then accordingly, design something.

Something like that while writing at the beginning, I am not feeling any problem, but after few minutes I may feel pain in these fingertips because while writing with anxiety I gradually go on increasing the pressure on this pen with these fingers, then its starts paining. Then I am ill by this this part, why it happens means, holding may not be good. If I can change my holding pattern position, then the muscles responsible for holding it may get relaxed after sharing the load to other group of muscle etcetera like that way. So,

then accordingly, design the pen for that; it gives a chance to change the positions. So, by this the good practice relevancies can be designed.

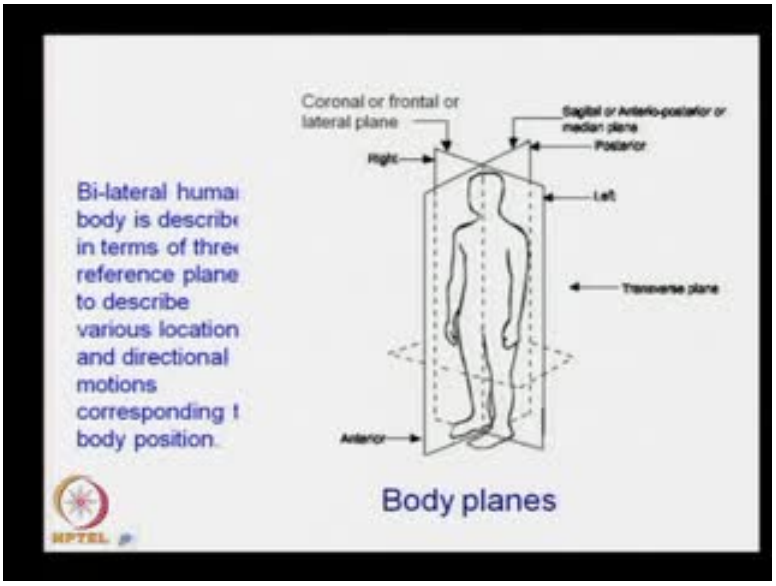
(Refer Slide Time: 22:53)



Now, with this there are some items it can be said that - like body planes. Now, while mentioning that making a workplace or something, we can say that - which area of my body- this is the central body axis through head to the heel point straight though, which left, right, front side, backside, up, down, bottom part, middle part how to express the positions or that the body planes are there these descriptions.

The bi-lateral human body could be described in terms of three reference planes in relation to the three planes of directional motions corresponding to these reference planes.

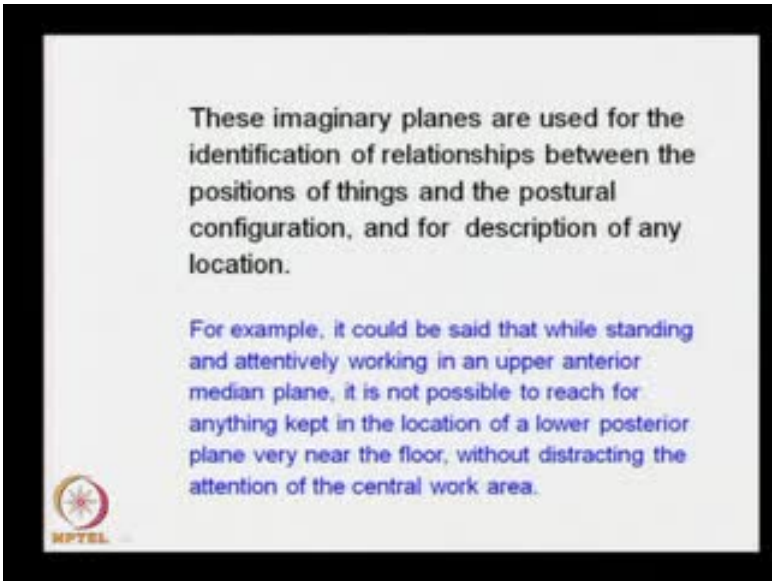
(Refer Slide Time: 23:58)



Now, here the body - we can say that the first one division is like this, we can break and we can cut it. So, it makes a front side and backside, so this plane is called coronal or frontal or lateral plane.

If we make a body part right side and left side and in between if we break it that is like this plane, it is sagittal or anterior, posterior or median plane, it is named- anterior means front, posterior is backside and another is that - if we cut in the transverse way the top and bottom part, this is the transverse plane. Accordingly, we can say that, which position, either this position or this position we can name it. It means the bi-lateral human body is described in terms of three reference plane to describe various location and dimensional motion corresponding to body position.

(Refer Slide Time: 25:19)



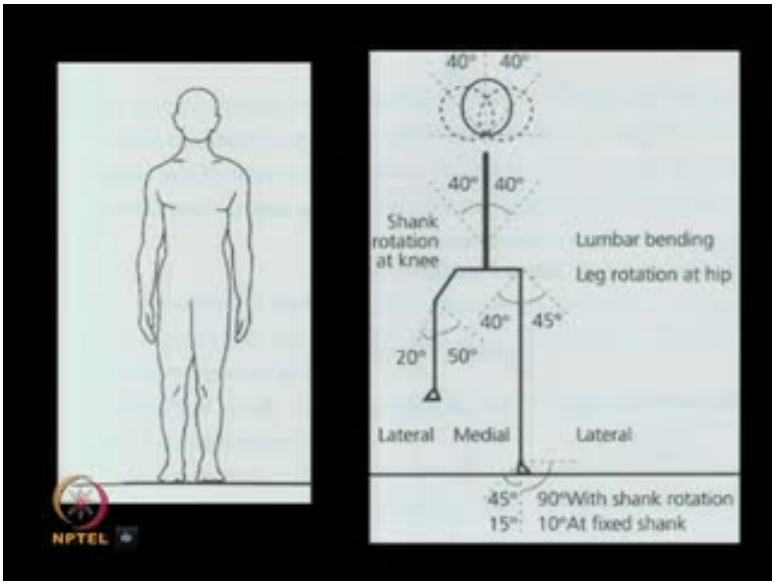
These imaginary planes are used to for the identification of relationship between the positions of things and the postural configuration, and for description of any location. For example, it could be said that - while standing and attentively working in an upper anterior front side middle plane, it is not possible to reach for anything kept in the location of the lower posterior plane very near to the floor, without distracting the attention of the central work area, like that way it may normally described.

(Refer Slide Time: 26:18)

(Refer Slide Time: 26:36)

Now, a human natural movement axis - now, we are going to discuss, normal movement ranges at joints for a normal ranges. If any movement or force to be applied either using a part or the whole article, the direction for force application should go with the configuration of the human body; that is it should synchronize with the human natural movement axis, so that maximum mechanical advantage could be achieved.

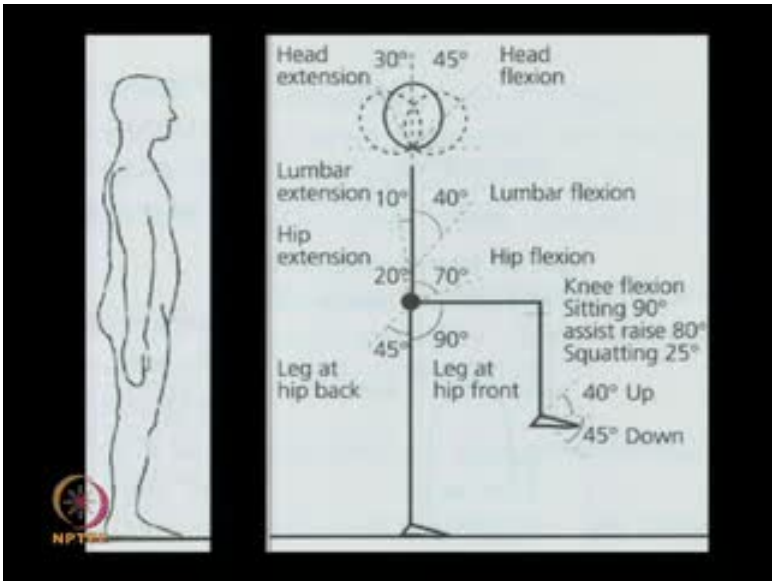
(Refer Slide Time: 27:09)



Now, if a man stands like this way- head till forty 40 degree angle it can rotate - like that 40 degree and 40 degree like this. Body, the whole upper trunk at the middle point at that

lumbar point it can bend 40 degree and 40 degree, so totally 80 degree it can bent. Leg at hip can bend 40 degree inner side medial side and outer side lateral side around 45 degree the leg can extend. Knee can bend inner side 50 degree and lateral middle side 50 degree and lateral side 20 degree. The foot here from heel point, heel joint inner side 45 degree and outer side 90 degree. So, it means 90 degree with shank rotation; shank is lower leg, 10 degree at fixed shank. Here also 45 degree with shank rotation and 15 degree at fixed shank. It means, if lower leg is fixed, then it can go maximum or with like this it can bend it.

(Refer Slide Time: 28:44)



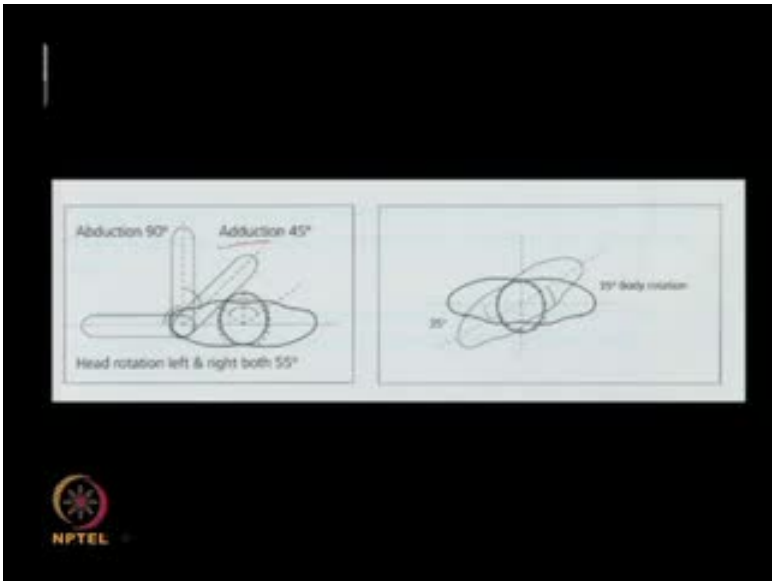
Now, from the side profile, head can bend front and back 30 degree, front 45 degree head flexion. At the lumbar area front, it can bent, lumbar flexion 40 degree and lumbar extension 10 degree backside. At hip extension- back side 20 degree, hip medial side frontal side 70 degree and leg at hip back, leg can go maximum backside 45 degree and front normally, at around 90 degree, each one can extend like this way.

Knee flexion at a sitting position 90 degree and to assist raise this leg little back; so it becomes around 80 degree and squatting it is 25 degree, here up 40 degree and down 45 degree. So, these are the normal body movement ranges normal ranges.

So, for designing for mass use, when you do not know who will be intended users, these ranges would be considered. Now, another thing is that - the arm movement is like this way and then if we do the arm movement, the inward movement is called adduction and

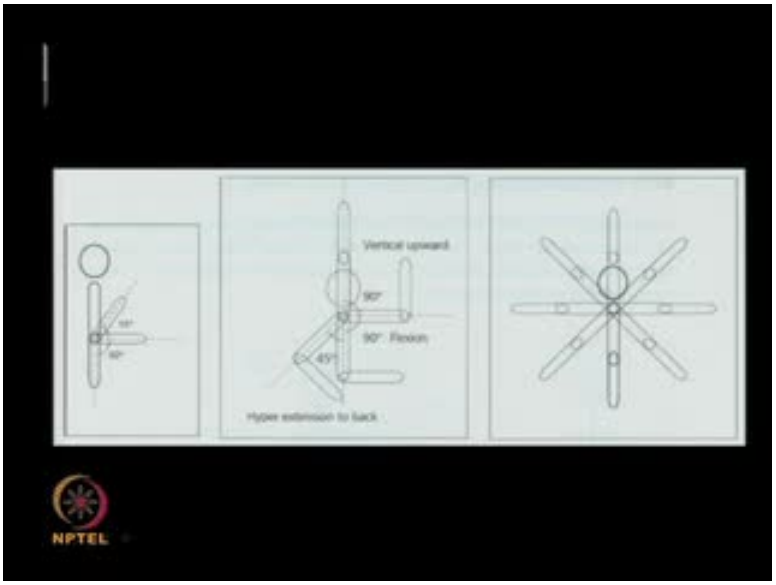
outward movement the lateral side is the abduction. So, adduction with the fixed point, it can come till 45 degree. Normally, with the arm hanging down vertically like this a 45 degree because it gets a stuck here and outer side it may go maximum 90 degree like that but beyond that it cannot go.

(Refer Slide Time: 30:58)



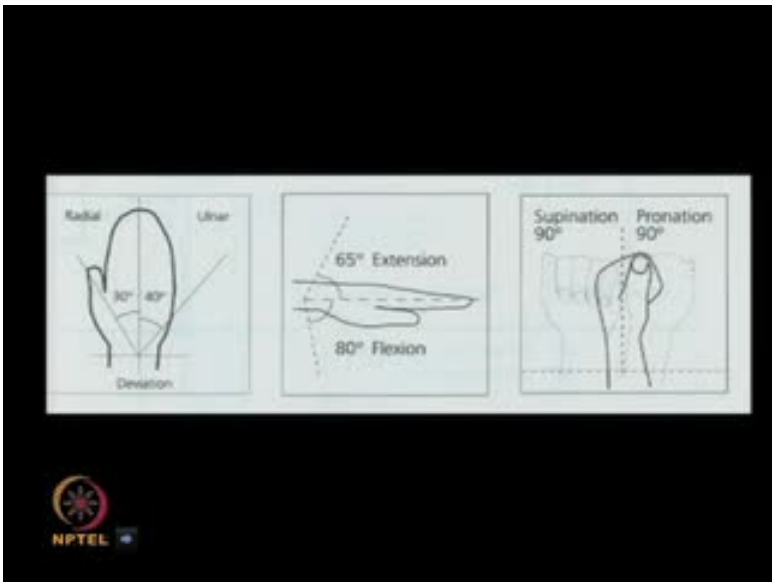
Now, head rotation means, like this a head rotation is possible around both the left side and right side at the 45 degree.

(Refer Slide Time: 31:27)



Now, the shoulder rotation, shoulder rotation, will be around 35 degree from the horizontal position. Then arm at elbow point 55 degree and below till 90 degree, here hyper extension at back. The arm if it goes back in 45 degree, 90 degree, 90 degree and vertically it can go till 180 degree .Now, here what happens, the whole arm movement over the head it is around 360 degree, if one can move out the arm.

(Refer Slide Time: 32:05)



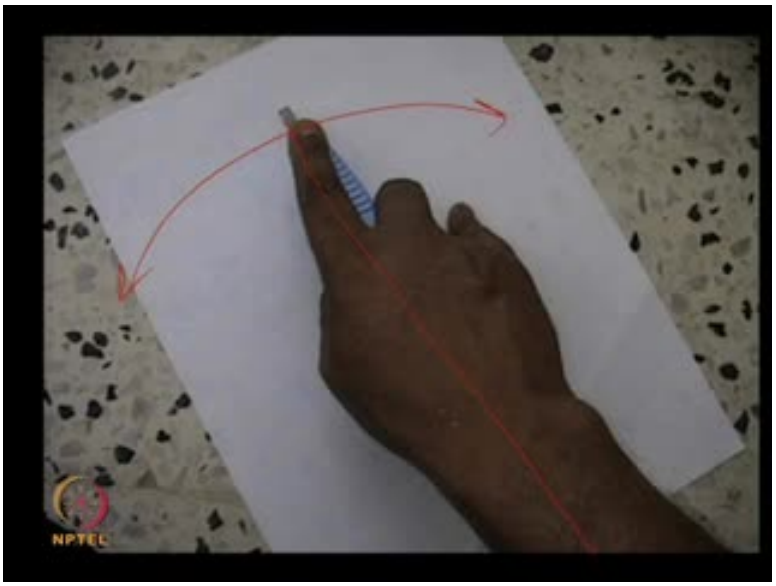
Now, the palm rotation, deviation, etcetera. Palm, outer side 40 degree that is ulnar side and medial side radial side inner side that is 30 degree, we can bend.

Now, palm extension upward 65 degree, lower 80 degree flexion. The fist pronation and supination like that here around 90 degree one kind of means arm can go like this way and can go like this way from this position 90 degree, 90 degree.

(Refer Slide Time: 33:12)

So, if I have to hold something, design but if I want to work this distance, then it should be within this range it cannot go beyond. These are the normal body axis movement and the ranges of joint movement. Now, if we see some of the figures here again; that it gives reaches and the frontal work area.

(Refer Slide Time: 33:19)



When we are holding a paper cutter, it has to be hold like this and if it remains straight and it we can exhaust skillful moment, but if I want to cut something in this region like this way with the sweeping moment, it may not give that clear or that skillful activity

because the equipment the blade is concern, it does not allow to work this it allows to work like this.

(Refer Slide Time: 33:55)

Now, again, something see the handle position, this area is inner side is the bathroom and outer side is the main room. So, that door itself here the handles put in a little diagonal way not in a horizontal or vertical because it will be easier to hold we cannot hold like this, we cannot hold like this; it is better to have a 45 degree angle at this position, so it gives that flexibility.

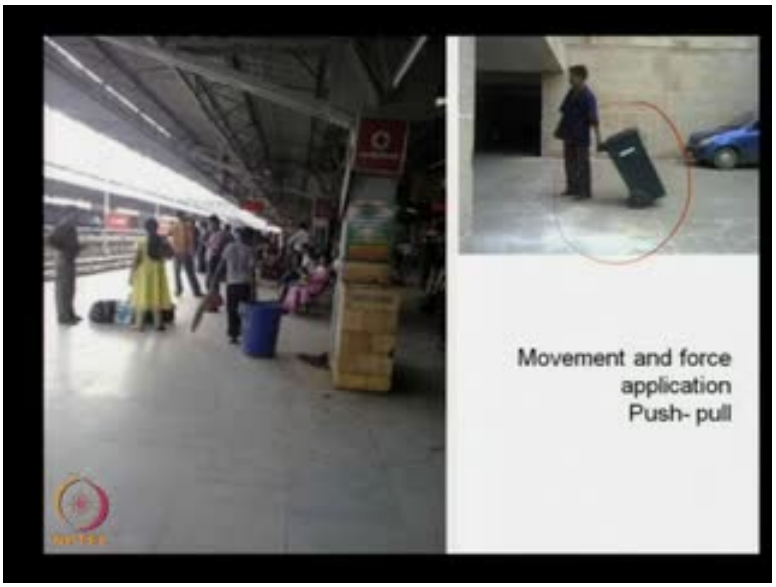
(Refer Slide Time: 34:32)

In this case, the handle here and the person moves frontal move movement. So, this also works accordingly if the person frontal movement here, but if this handle is in the sideways then that movement would have been difficult.

(Refer Slide Time: 35:02)

So, the design should go along with the normal body access movement. Now, movement and force application push - pull this type of products either needs to be pulled or pushed; this type of product it requires mostly the pushing force with the mechanical and electrical assistances.

(Refer Slide Time: 35:33)



(Refer Slide Time: 35:52)

In this case, pure manual pulling- pushing would be little difficult because if you pull the normal physics rules it helps pushing would be difficult. This type of trolley, it may be pushed and pulled this type of chair push - pull and total rotation.

Now, what is the the policy? The main matter here is that suppose, a trolley it has four wheels. Now, if we want to have a clear direction then either front wheels or the rare wheel should have the swivel movement if all the four legs have swivel wheels, then there may not be proper direction.

So, normally trolleys are used. Mostly the front wheels are swiveling or rare wheels are fixed, it follows that but in case of chair, we require five legs swiveling because it needs all different movements. Everywhere it does not require a specific direction, so that smooth rotation it is there; so all these things we need to consider while designing.

(Refer Slide Time: 37:21)

Now, another thing we can say that suppose, in this there are some activity areas. In this activity areas we can say that now, the work here is being done with a normal sweeping hand movement, so it is as per and then movement is in front.

(Refer Slide Time: 38:02)

Now, if we see the another work area of these type of activities - the frontal movement is like now, see the hip he uses to work sideways till it will be difficult for him. So, the frontal work area - so this is the normal body axis movement; one can beat like this way frontal, so it goes along with the normal body axis movement.

(Refer Slide Time: 38:43)

Now, the holding and operation both hands. Now, see all the work activities shown here it follows a normal movement the way it is operating, the group is also operating in this.

(Refer Slide Time: 39:06)

Now, if we see another thing is that here a grass cutting or dividing equipment. He is holding like this way and then he is holding, but he is and movement he is moving front or side and the equipment is carrying like that is like this, but in this case, what happens, though he is moving, but while holding it gives a static load on the both arms

So, to assist it there is a belt to hang from the back. Now, if we see this is the total movement. Now, here the person is moving, he is moving, but his arms are in a fixed position, it gives a static load. So, whether it is as per his normal body access movement while holding that, we need to study it.

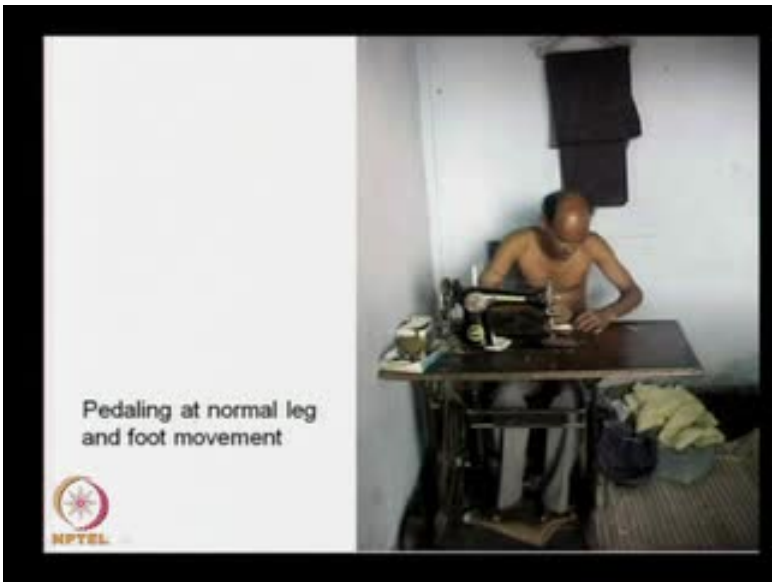
(Refer Slide Time: 40:47)

Now, in this case, the force application and hands movement pattern, and position. Now, we can see that the beating of this bell is as per normal movement like this way it is been fixed.

(Refer Slide Time: 41:07)

Now, handle holding position to be noticed here. In this case, how he is operating, how he is going and the leg pedal position that is a break and etcetera position. Here now, how it is seeing it is not that the center, it is little away. So, even for the pedal operation also it needs from the center of the body it has to be around 15 to 30 degree away from that center line. So, that are normal the drilling operation can be done.

(Refer Slide Time: 41:38)



Now, here the same thing that pedaling at normal leg and foot movement these ranges of this movement, as we said earlier, the total movement of the foot should be within the normal movement range.

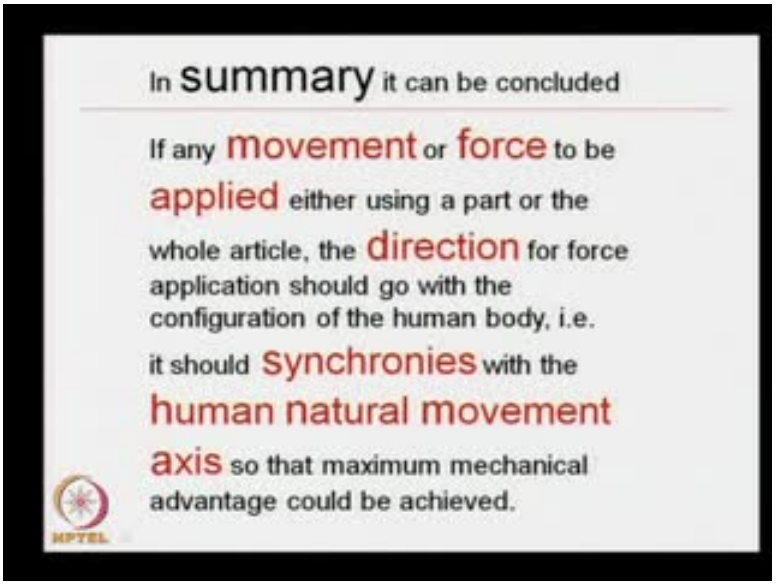
(Refer Slide Time: 42:02)

(Refer Slide Time: 42:18)

Now the well the car making, the different car holding positions are shown here and it says that whether to operate this various operations, whether it is within the range like this while getting up or going inside like that, what is the normal movement, whether it is within their normal range of body angle movements etcetera, like this the these values and now while holding etcetera like that way.

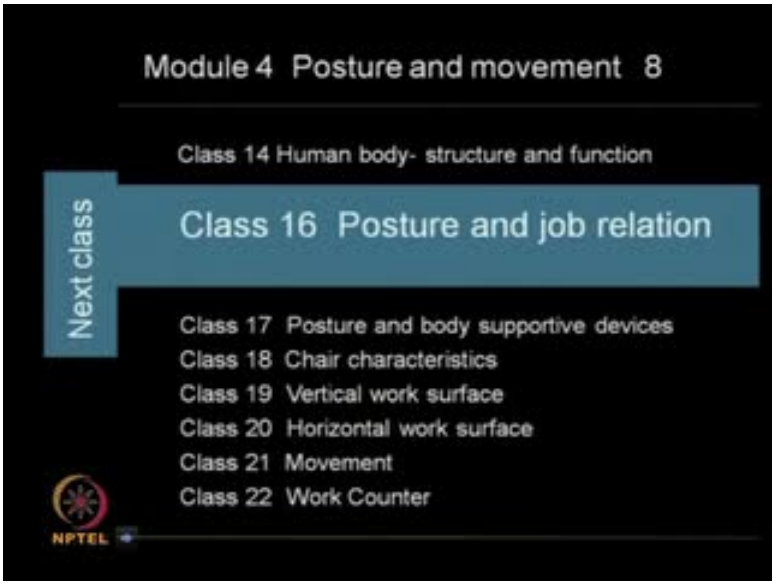
(Refer Slide Time: 42:39)

(Refer Slide Time: 42:59)



This is type of studies are being carried out with an example, just I am showing here to get acquaint with the theory portions. Now, in summary it can be concluded, what we discussed today is - at the beginning we said it also, now we are repeating it - if any movement or force to be applied either using a part or the whole article, the direction for force application should go with the configuration of the human body; that is it should synchronies with the human natural movement axis, so that maximum mechanical advantage could be achieved.

(Refer Slide Time: 43:52)



Now, with this we are concluding today's session and next class that is the class number 16 - we would concentrate on posture and job relation. So, till then thank you very much. We will see you in the next class.

Thank you.