Work System Design
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Lecture - 55
Man-Machine System - II

Namaskar friends, welcome to session 55 of the course on work system design and today we are going to conclude our discussion on the important topic of ergonomics. Friends, in the last week we will try to see some applications of the work study or the principles of work study, where we will try to see that what are the principles or what can be guiding lines or what can be the guiding principles for developing or designing a good work system.

So, we may take an example of a chair which each one of us are using. How the chair can be designed to ensure the comfort of the worker. There can be a person who is operating a train or a person who is driving or who is a pilot for the aircraft. What can be the guiding principles, guiding theory behind the development of the work system or the place where he or she is working? So, we can see that at each and every work sphere or work area.

Or there is always a scope for improvement. For example, if we see that constraint of space especially in case of an airplane or aircraft. The cabin crew when they are serving the customers or when they provide maybe the refreshments and food you can see that the trolley that they are carrying. The trolley has to ensure that it moves in the aisle only. The plates are kept in a specific way only.

The other things, other food or beverages that they have to place in the tray are placed in a very, very methodological and systematic manner. So, there also, there is a worker who is a cabin crew member and there is the system that is the trolley that they are operating and then how the operator or the cabin crew member takes out a tray, places the other additional things, may be a water bottle and hands it over to the passenger, that is also work being done.

So we will try in the last week of our course to try to see certain applications, certain case studies in which the work system have been improved or some guidelines of what we have already

studies have been used to actually put them into practice. But, today we are just going to carry our discussion forward in the topic of man-machine system. So, man-machine system, if you remember in the previous session we have understood that what is a man-machine system.

What are the different types of man-machine system, how a person or a man or an operator can be used as a productive element and what are the advantages? Similarly, we have also tried to understand if a machine is being used as a productive element what are the advantages. Finally, we have see a man-machine system that there is a information processing, information decision making based on the information and then this information is useful for the operator to make certain decisions.

Now, what is the information? The information can be in the form of certain displace. A person is working in an organization and suppose the temperature has to be maintained at 24 degree centigrade and he sees the temperature is already at 29 degree centigrade. So, how, which button he must press or how he must actuate the system in such a way that temperature comes down from 29 to well within the prescribed limit of 24 degree centigrade.

So, that is basically the use of the information. Now, how the person is able to see or feel that it is 29 degree because there is a standard display which may be a digital display through which the person will be or the operator will be able to see that the temperature is higher. So, therefore he will use a control mechanism, he may use a switch through which he can control the temperature and bring it down below the critical value.

So, that is basically is what we are going to study today that is the controls, the displays and then we will try to see that how the environment affects the performance of the man-machine system. Because, if you remember in the previous session we have seen that there is a man, there is a machine or equipment or a physical object, so they interact, there is a interface between the 2 and then the environment also affects that how they interact among each other.

So, there are 2 important things the interface or interaction between the man and the system or man and the machine sorry or the equipment and the additional environment factors that affects

this interaction, that we will try to understand today. So today whatever we are going to discuss much is related to information sharing only. So there is nothing much that I feel that needs lot of explanation.

So, I will read through the slides and wherever necessary, I will try to explain because you will yourself be able to understand or maybe able to appreciate that there is lot of similar information available. So, there is breadth and depth of information available related to this area, there are codes, standards, guidelines which have to be followed by industries in order to ensure the comfortable working conditions for the workers.

So we are not going to get into the nitty-gritties of the acts of the guidelines, but we are going to understand that yes, it is important to provide a good working environment to the worker so that he is able to act productively for our organization. He is able to produce whatever has been told to him or her in order to meet the overall objective of the organization, that is to be productive, efficient, effective as well as profitable.

So, let us quickly start today's presentation because we have a lot many slides today and we will have to rush through and try to understand, try to assimilate whatever possible during the session, and may be later on you can refer to the transparencies or the slides and have a better understanding of each and every aspect. So let us now quickly see that what are the various aspects of a man-machine system? First one is the design of information display.

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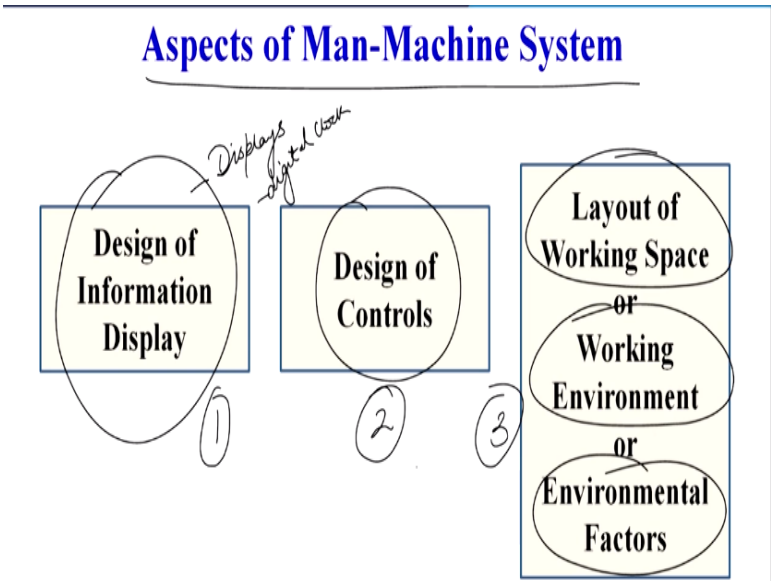

So, there are different types of displays that we will try to understand today. One of the examples is the digital watch that we are using in this studio, so that is 1 example of display, just I will write it for your reference, the digital clock can be 1 example of display. Then design of controls. Now the design of controls can be supposed I have to shift the slide to the next slide there is a button here, if I press this button automatically the slide will be shifted.

So, there is a control available with me, through which I can shift the slide manually. There is a pointer also which is available through which I can shift the slide. So slide changer is available on the screen also there is an option to change the slide that is basically the control that is available with me and the last is the layout of the working space or working environment or environmental factors.

This is the third part of the system. So we have a man, we have a machine and then there is the environmental factors which influence the performance of this man-machine interaction. So, we will go 1 by 1. First, we will see the types of displays, then the controls and then finally the environmental factors.

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Man-Machine System:
Aspect # 1. Design of Information Displays

So, let us see now first the man-machine system, the aspect 1 is design of information displays.

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Display Design

- Displays are **necessary extensions to man's senses** and provide both prime and supplemental **information** needed by operators in making decisions and in effecting control responses.
- Information presented by displays **can be considered dynamic or static.**
- Dynamic **information continuously changes or is subject to change through time**.
- *For example:* Traffic signals, charts or graphs.

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Let us see now, so here we can have an example of a display design that how we must design our displays? So displays are necessary extension to man's senses and provide both prime and supplemental information needed by operators in making decisions and in effecting control responses. One example already I have given today, that is the temperature has gone beyond a particular temperature level or beyond a particular value.

So that is basically will be sensed, it will be senses through a sensor and there will be display. So in the display we will be able to see that, yes the temperature is beyond the critical value. So, that

is the first stage. The second stage is now that we have to rectify, we have to modify, we have to bring back the temperature to the desired value < the critical value, so what we will do? We will exercise the control.

We will press a button or we will change a lever, based on that system will be actuated and the temperature will be brought back below the critical value. So displays are necessary extension to man's senses. Now this can be 1 thing that we can understand. So man may also be feeling that the temperature is more, it is not below the critical value but, he may not be knowing that how much is the change. If the 24 is the critical value, he may feel a little uncomfortable.

He may not be knowing whether it is 26 or it is 27 or it is 25. So, the displays are necessary extensions to man's senses. If he is able to look at the display and find out what is the exact temperature. So, this is the additional we can say information which is available to the worker and this is both will provide as a prime information or a supplemental information needed by operator, so this is first is gathering the information.

Then this information is used in making decisions and in effecting the control responses. Information presented by the displays can be considered dynamic or static. Many times if we see a display outside news company or outside a newspaper publishing company the office of a newspaper publishing company there is a random, there is not a random, but there is a continuous display.

So the news flash is changing maybe after every half an hour or sometimes it may so happen that if there is a breaking news they may stop the normal display of the news and they may only play the breaking news only. So that is also a display that we can make use of just an example of a dynamic display or it can be a static display if it can be a board which is giving us some motivational information or it is just giving a motivational quote that is put inside the shop floor so it is not changing it is static.

So the information presented by the displays can be considered dynamic or static. Dynamic information continuously changes or is subject to change through time. For example, traffic

signals keep on changing. You may have a green signal then it may be changing to orange and then to red or the charts or graphs can be examples of static information or static displays. Now, classification of information: The information can be of different types: First is the display. So, displays can be static or it can be dynamic. Similarly, information can be quantitative or it can be qualitative.

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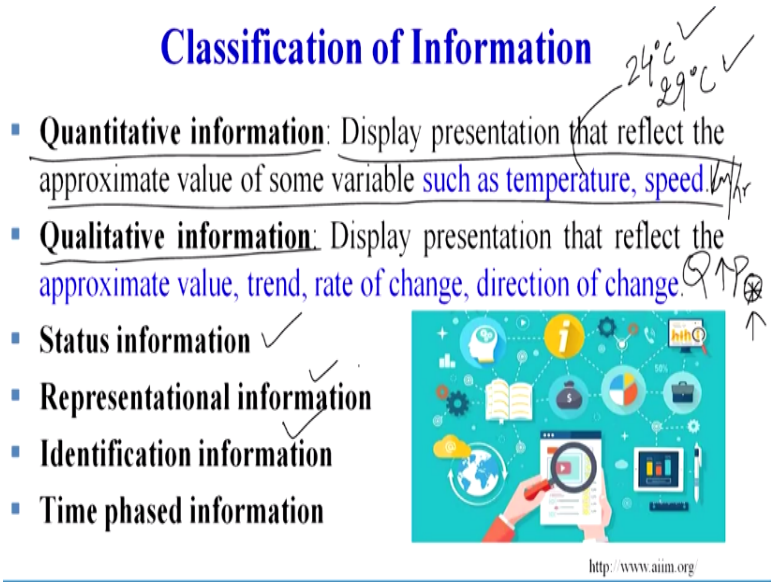

Quantitative information: Display presentation that reflect the approximate value of some variable such as temperature or speed. So, as I have already taken an example so you may have a display of 24 degree centigrade or it can be 29 degree centigrade. So, this is all quantitative information that we are using, then the speed can be given in kilometer per hour, some value can be there so quantitative.

Qualitative information: Display presentation that reflect the approximate value, trend, rate of change or direction of change. So, sometimes qualitative can be some parameter suppose Q it is increasing or it can be some parameter P which is in the red zone. So, here we are not getting the exact value, but we are getting a trend. So, P is a parameter if it is in the red zone it means it is beyond the critical value. So, in qualitative we may not be getting the exact values, but in case of quantitative we will get exact values for the variables.

Then, there can be status information sometimes can be 1 example can be the information for the trains, the status can be given as whether it is on right time or it is late or delayed by how much time. Representational information can be there; identification information can be there. For example, suppose in our passport all our identification information is there, time phased information is there. So, we have different types of information also which can be displayed and in our case our focus will be the information that can be displayed on the shop floor.

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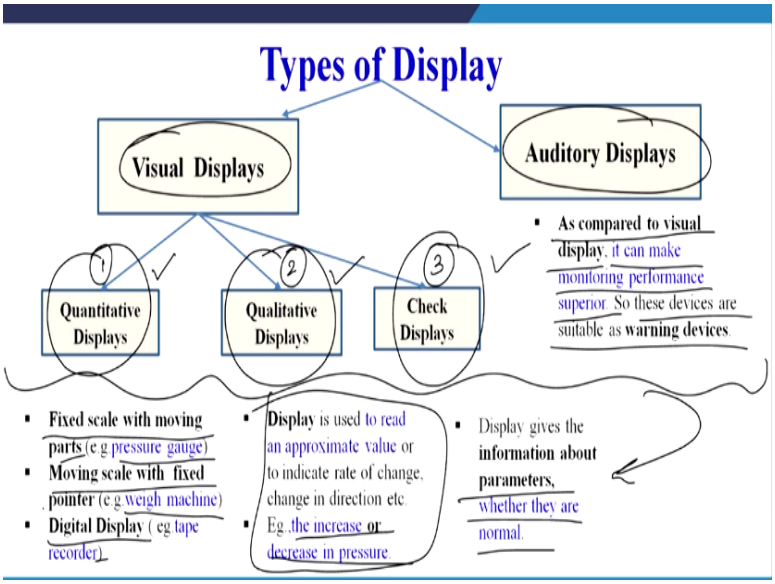

Now we can see different types of displays are there. So what basically, we are trying to understand, we are trying to understand that yes, the displays are important because whatever information is projected on the display we take that information, we process that information, we do some decision making based on that information and then we actuate the control mechanism to bring the things into order if the things are not in order.

But, if the things are in order we will just note down the information and that will be used for our record that for this much period of time there was no problem system was functioning as per desired or system was functioning as per requirement as desired. So, now we were trying to understand what are the different types of displays? Now let us try to see we can have visual displays and we can have auditory displays.

Now within visual displays we can have quantitative, we can have qualitative displays, we can have check displays. So 3 types of displays are there: Quantitative, qualitative, and check displays. Now let us see what are these? Now quantitative displays can be fixed scale with moving parts. For example, pressure gauge will give us a value. Moving scale with fixed pointer for a weigh machine. So the pointer is fixed.

The scale is moving and wherever it stops you get the value. Digital displays for example, in case of a tape recorder. Now displays used to read and approximate value or to indicate rate of change in the direction. For example, the increase or decrease in pressure as I have shown in the previous slide. Display gives the information about the parameters whether they are normal. I have already taken an example that when the value goes beyond a particular value or the particular critical value we need to start our controlling mechanism.

We need to actuate our controller, so that we are able to bring the value which has gone beyond the critical value well within the range which is specified for the operation of that machine or equipment. So we can have. This is giving us examples of different types of displays. We can affix the scale with moving part, moving scale with fixed pointer. Digital display can be there. So display basically why display is required, it is given and already we have covered this thing.

Display is used to read an approximate value or to indicate the rate of change or the change in direction. So let us now see majorly quantitative displays are there, qualitative displays are there and check displays are there. One important thing are the auditory displays. Now what are auditory displays? As compared to visual display it can be make monitoring performance superior sorry it can make monitoring performance superior.

So these devices are suitable as warning devices. So warning signals that are very high amplitude or at a very loud voice or those can be you can say classified as the auditory display. So displays can be quantitative, qualitative, check displays, and the auditory displays and this is the information below this is giving the various you can say characteristics of the displays and given the types the fixed scale with moving parts and the moving scale with fixed pointer. So we will try to see this with a help of a diagram.

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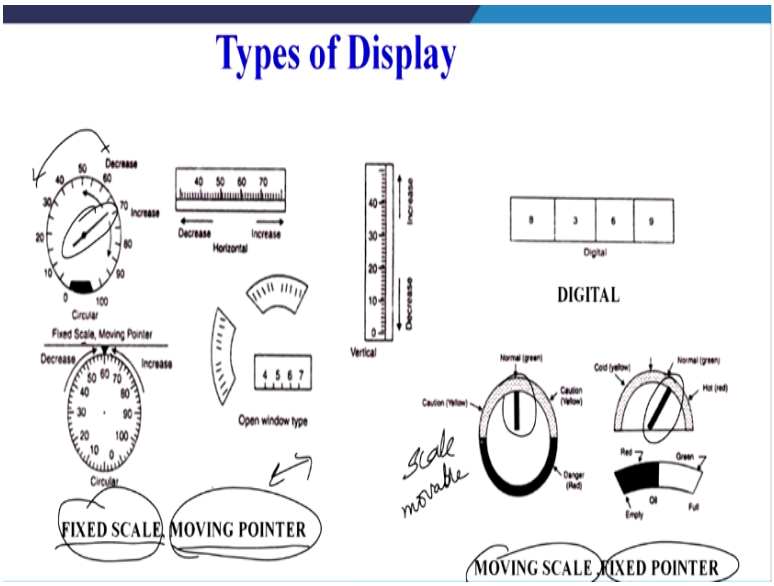

So here we can say fixed scale moving pointer. So the pointer will move in this case. So this is the pointer and this is the scale which is affixed. So the pointer will move as per the value or as per the reading that has to be shown on the pointer. Here also this is fixed scale moving pointer so the scale is fixed, but the pointer will keep on moving and here this is the opposite of that. This is scale is fixed, pointer is moving.

In this case, moving scale, fixed pointer. So your pointer is affixed at 1 point only and the scale will move. So here your scale is movable. So you can have different types of display and if you see you can just try to figure out this type of applications or the examples for these types of displays. No more or less if you go for a weighing scale usually people have kept the weighing scale at their houses also for weighing the weight of a person.

So in that case I think the pointer is fixed at 1 point, that is what I believe and the scale moves. So that is the good example. Pointer is fixed, the scale is moving. The scale will stop where the actual weight is. For example, it is 75 kg for a person so the scale will move from 0 and it will stop at 75, but the pointer remains fixed. Whereas when we are driving a motor bike, your scale is fixed.

In the previous case, I have told the pointer is fixed and the scale is moving, but if you are driving a motor bike, your scale is fixed, but the pointer is moving. You may be driving at 20, then maybe 40, and the scale is at one place, the pointer is moving. So the fixed scale moving pointer and the weighing scale example that I have taken moving scale fixed pointer.

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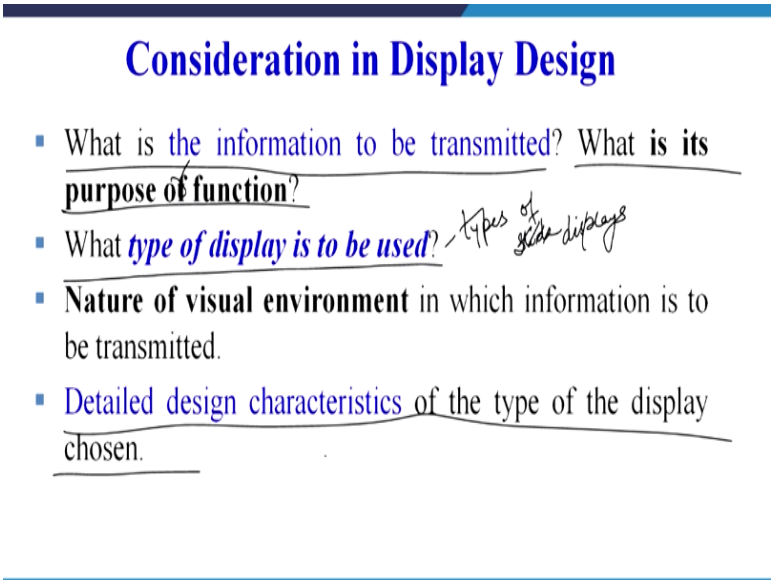

Now what are the consideration? If you have understood the types of information, the types of displays, now let us see the consideration in display design. We need to consider what is the information to be transmitted? What is its purpose of function or we can say purpose or function? What type of displays to be used? We have seen types of displays in the previous slide. So we have to take a decision.

Or consider what type of display types of sorry types of displays that we have already covered, nature of visual environment in which the information is to be transmitted. Detailed design characteristics of the type of display chosen. So if we choose for example that the pointer will be fixed, and the scale will be moving then we need to understand calibrate and calculate all the design related characteristics for this type of display.

So when we are designing a display we have to take into account all these 3 or 4 parameters so that the worker feels comfortable in using the display and is able to derive the desired information looking at the display then he can process this information and use it for decision

making, finally may be leading to the control mechanism if the things go out of control. Now this is the second part that is design of control.

So first part is the display, there is a you can say depending upon the requirement, there will be a display which will give us the information or share the information with us regarding the state of the system. Once we have seen the display, we only need to do some action. We need to change the state of system. We need to perform some (()) (21:35). We need to perform some remedial measures. We need to control actually. So then we need to control we need to have the control or the design of the controls or the controlling mechanism.

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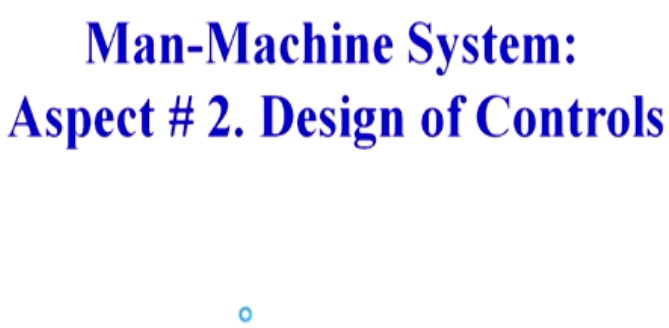

So, now let us see what is related to the controls now.

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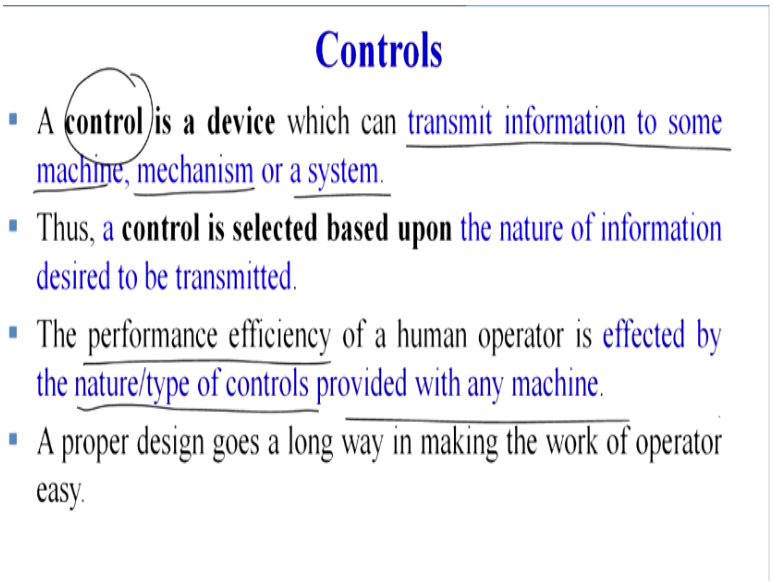

What is the control? A control is a device which can transmit information to some machine, mechanism or a system. So it is able to transmit information to a machine, mechanism, or a system. So basically a control can be we can say a control lever for changing the gear or suppose we are turning a jaw or a asymmetric jaw or a circular cross sectional jaw on a lathe machine. Now we see that the tool has transverse the desired length we will like to withdraw the tool.

So in that case, we have seen the display. We have seen. We have observed what has happened. Now we need to act. So what we will do. We will stop the machine that is 1 control mechanism and then we will try to withdraw or retract the tool or the cross slide so that the tool comes back and then we will try to move it back to the place from where to the position from where the turning operation has to start all over again by giving additional depth of cut.

So this is what we are doing we are using the different levers. We are controlling, manipulating the state of our machine. So the control basically is a device which can transmit information to some machine mechanism or a system. Thus a control is selected based upon the nature of information desired to be transmitted. The performance efficiency of a human operator is affected by the nature and type of controls provided with any machine very, very important, the performance efficiency.

Now suppose it is very, very difficult to control or the control lever is difficult to handle or difficult to reach so that it means that we have not devised a good control mechanism for the operator who has to actuate a particular machine or a particular equipment with the help of a control lever. So if it is not designed properly the efficiency will certainly be poor. Therefore, the performance efficiency of a human operator is affected by the nature and type of controls provided with any machine.

So if the machine is easy to control the worker face comfortable. You can yourself imagine that if we are driving a car now the operator or the driver is a person who is operating a machine. The machine is a car. So if the controls are easily accessible he need not reach to the controls and other thing can be he is able to manipulate the controls while driving comfortably. He will feel less tired. He will be able to drive for more distance.

He will be able to maybe enjoy the ride because there is no mental strain on him that he has to change the song, so he has to look forward look ahead also that somebody is coming or not, look in the rare view mirror also then he has to change the control. So maybe he has to lean towards the control for the audio system. If he need not do that he can control it directly from the steering only he will feel much more comfortable while doing that.

So basically the controls have to be designed in such a way that the operator feels comfortable and it will definitely add to his performance efficiency. So proper design goes a long way in making the work of the operator easy which already I have told the driver's work will become much easy if all the controls are designed properly or in other words we can say ergonomically. Now selection of our control device quickly we can see.

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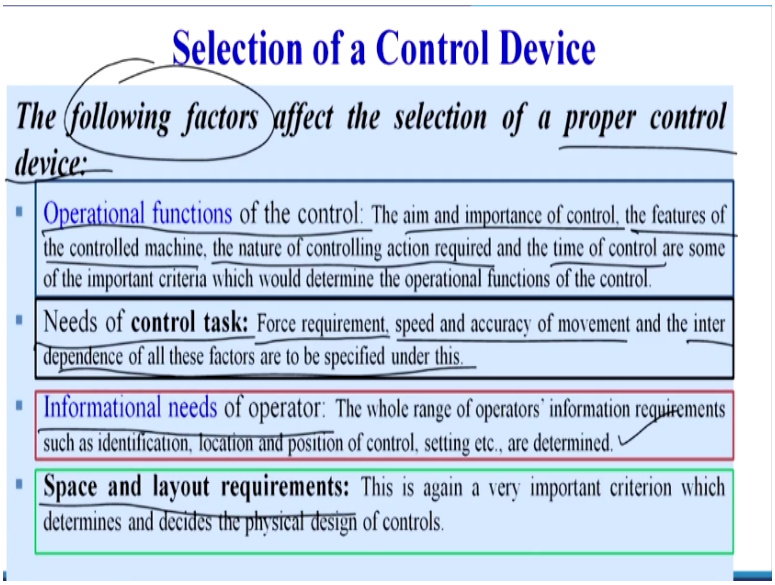

The following factors affect the selection of a proper control device. Already you know why control is necessary. What type of control we must exert? So first are the operational functions of the control needs of control task, information needs of the operator, and space and layout requirement. So, quickly I will read that, what are the important factors that need to be taken into account, when we are choosing or selecting a proper control device.

The aim and importance of control the features of the controlled machine, the nature of controlling action required and the time of control are some of the important criteria which will determine the operational functions of control. So time of control, the nature of controlling action required, the features of the controlled machine, and aim and importance of control are very, very important.

Force requirement if it is very difficult to change the lever you may not enjoy using that lever. Speed and accuracy of movement and the inter-dependence of all these factors are to be specified under the needs of the control task. Informational needs of the operator. The whole range of operator's information requirements such as identification, location and position of control, setting etc are determined in the information needs of the operator.

That one he has to operate a particular control lever that must be known to the operator that is one of the information needs of an operator. Space and layout requirement: This is again a very

important criterion which determines and decides the physical design of the control. So basically there are all these 3, 4 things functions mean what is required out of the control systems. Need of control task may be force requirement must be less.

Speed and accuracy must be better. Information is the worker must know that if he is going to do this control or if he is going to pull this lever what is going to happen. The whole range of operator's information requirements such as identification, location, and position of control settings etc have to be determined. So, finally the space requirement will also affect the performance of the controlling device.

So this is very, very important. In the beginning only I told that we are not going to cover the breadth and depth of this topic, but we will try to introduce that such type of information is available which can be referred to when you are designing the display or we are designing the control, lever or a control device for a particular machine. Now these are the different types of controls we will be able to appreciate. This is one switch one and off.

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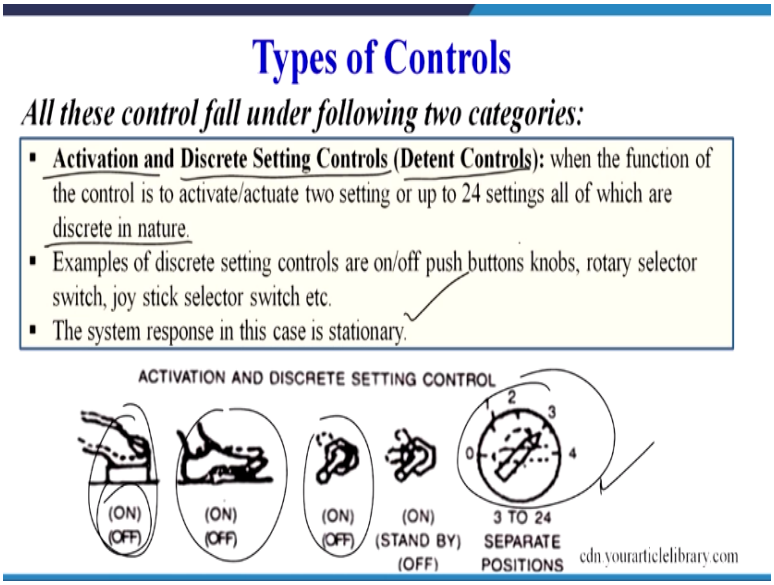

Foot operated, hand operated, on/off switch here again shown here and this is a setting of a controlling device so we can see all these controls fall under following 2 categories. Activation and discrete setting controls, discrete setting controls, detent controls. When the function of the control is to activate/actuate 2 setting or up to 24 settings.

All of which are discrete in nature, very, very important discrete in nature. So here you can see on and off discrete in nature. Examples of these discrete setting controls are on/off push button knobs, rotary selector switch, joy stick selector switch etc. System response in this case is stationary.

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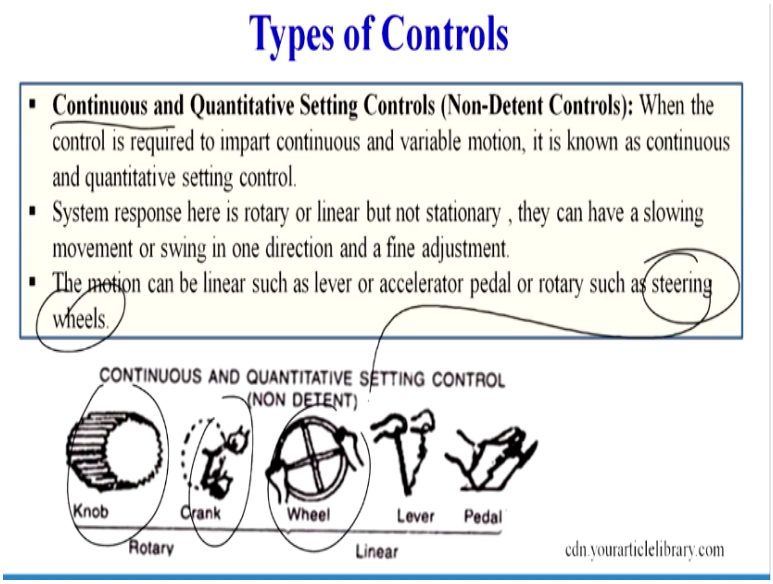

Continuous and quantitative setting controls, this is continuous. So we can see the knob it is continuously you can rotate it, crank, wheel continuously you can change. So there can be levers also then pedal continuously you are pressing the pedal. So in the previous case if you go back it is on/off type, but here it is continuous control. So continuous and quantitative setting controls when the control is required to impart continuous and variable motion.

It is known as a continuous and quantitative setting control. System response here is rotary or linear, but not stationary, they can have a slowing movement or a swing in 1 direction and a fine adjustment. So here the response is not stationary. It is represented by a movement. The motion can be linear such as lever or accelerator pedal or rotary such as a steering wheel. This is a steering wheel example is shown here.

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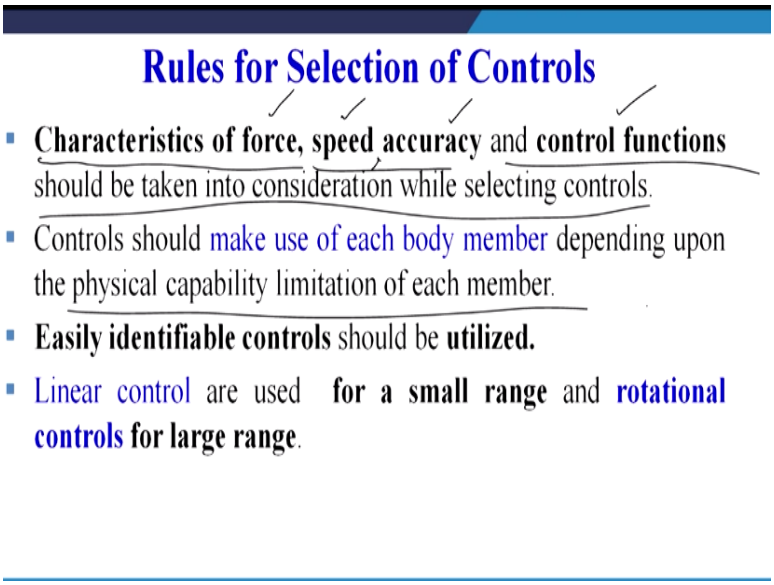

Now rules for selection of controls we must know the characteristics of force, speed, accuracy, and control functions should be taken into consideration when selecting the control very, very important force speed, accuracy, control functions. Control should make use of each body member depending upon the physical capability limitation of each member. So we must try to make use of the different members or limbs of our body even we are trying to design the control system.

The simple example can be when we are driving a motor bike. So we have controls in different limbs of our body. In one hand, we can control the accelerator, other hand we can control the brake in the feet we can control we can have a brake there also and we can have a gear shift lever there in the feet.

So we have to control should make use of each body member depending upon the physical capability, physical capability limitation of each member. Easily identifiable control should be utilized. Near control are used for small range and rotational controls are used for large range. So when the linear controls are there we can have a small range only, but if the circular or the rotational controls we can have large range of values also.

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Man-Machine System:
Aspect # 3. Layout of Working Space or Working Environment or Environmental Factors

Now the last part that we want to cover today is the layout of the working space or working environment. So quickly I will read through this thing. So, working environment.

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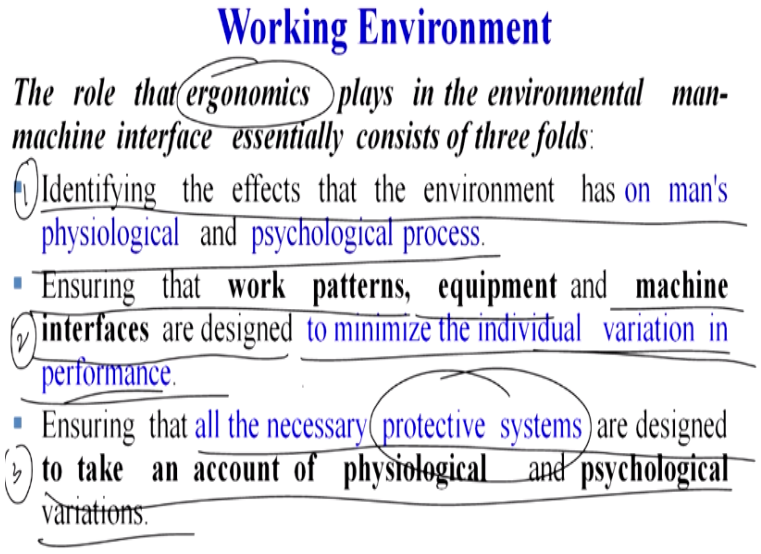

The role that ergonomics so our topic is ergonomics that we are covering. The role that ergonomics plays in the environmental man-machine interface essentially consists of 3 folds. So this is identifying the effects that the environment has on man's physiological and psychological process identification and shearing that the work patterns, equipment and machine interfaces are designed to minimize the individual variation in performance.

This is second and the third is ensuring that all the necessary protective systems are designed to take an account of physiological and psychological variation. So it is related to the protective systems. It is related to the minimizing the individual variations in the performance, and the first one is identifying the effects that the environment has on man's physiological and psychological process. So if we are able to take into account all these factors. The performance and efficiency of the worker is definitely going to increase.

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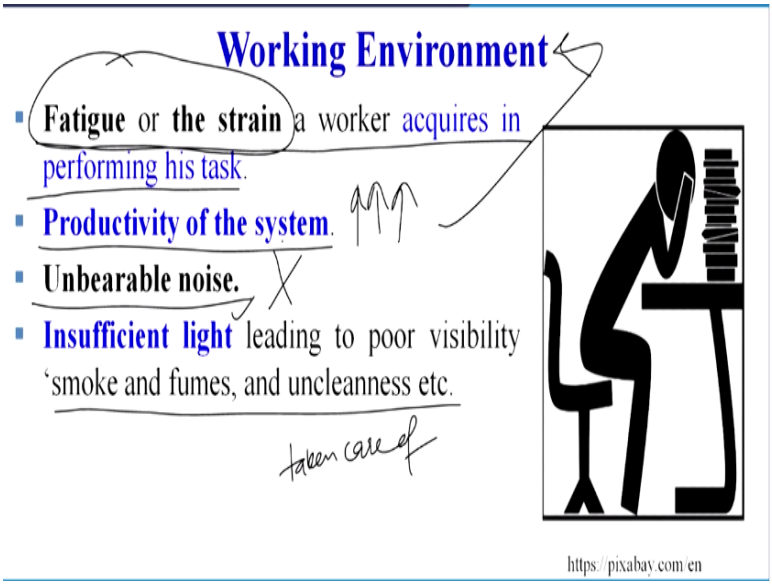

Now working environment very quickly we can see. We must provide a working environment which takes into account the fatigue or the strain a worker acquires in performing a task. So the working environment must mitigate the effect of fatigue or strain that the worker may feel or the worker may encounter during performing his task.

(()) (33:16) productivity of the system must increase by the environment that we are providing, unbearable noise must be avoided, insufficient light leading to poor visibility, smoke, and fumes, and uncleanness also must be taken care of. So we must provide sufficient light, reduce the noise, try to improve the productivity and fatigue or strain must be minimized to the worker.

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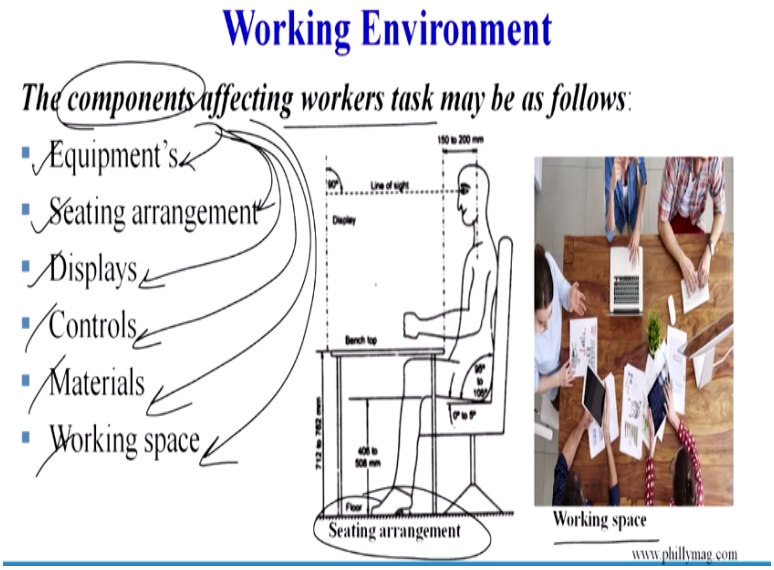

Here we can see this is a worker. This is a seating arrangement for a worker. This is the working space depicted. We can see the working environment, the components affecting workers, task may be as follows. So what are the components which will affect the workers task: The equipment number 1, seating arrangement, displays, controls, materials, working space. Now suppose the environment is such that 3 or 4 people are working in a very small area that is certainly going to affect both the physical as well as the physiological working environment for the worker.

So basically we have to ensure that the equipment that the person is using his seating arrangement, displays, controls, materials, working space must be designed as per the rules and regulations, the guidelines which have been established for all these factors. Then only the worker will be able to deliver the performance which is expected from him. Now this is an important slide maybe the last but 1 slide.

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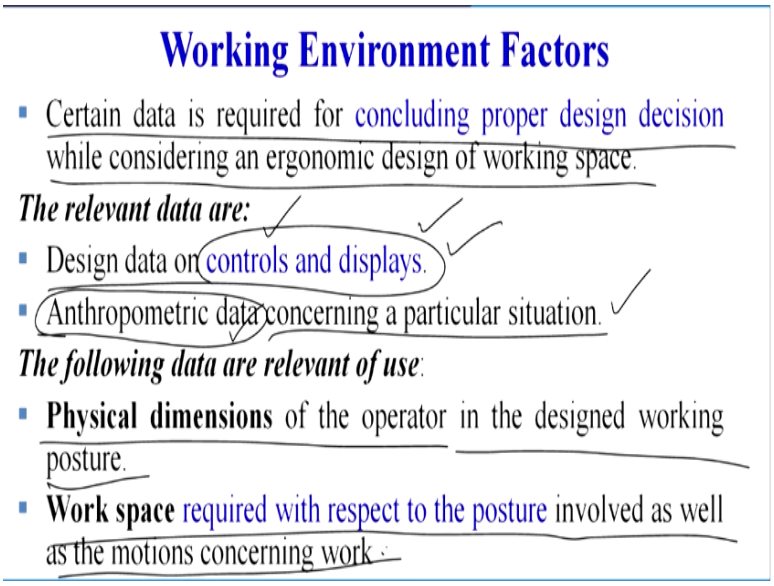

The working environment factors. So certain data is required for concluding proper design while considering an ergonomic design of the working space. The relevant data are design data on controls and displays which I have already told in the previous slide we have seen controls and displays are an important factor that affect the operator's performance. Second is, we have already taken 1 session on anthropometric data that is concerning a particular situation.

So anthropometric data already we have (()) (35:28) types of controls and displays also we have seen characteristics of controls also we have seen. The following data relevant of use physical dimensions of the operator in the designed working posture. The work space required with respect to the posture involved as well as the motions concerning his or her work. So the anthropometric data, the design of controls, design of displays plays an important role in the overall design of the work place for the worker.

Moreover, another thing that is coming in the picture is the posture also so that he must have sufficient space to move around and he must ensure a good or the design must ensure a good posture for the worker. Now this is may be probably the last slide or the second last slide that we are going to cover today.

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Working Environment Factors

The followings are environmental conditions which affect the human capabilities and endurance range:

Working environment factors. The following are environmental conditions which affect the human capabilities and endurance range.

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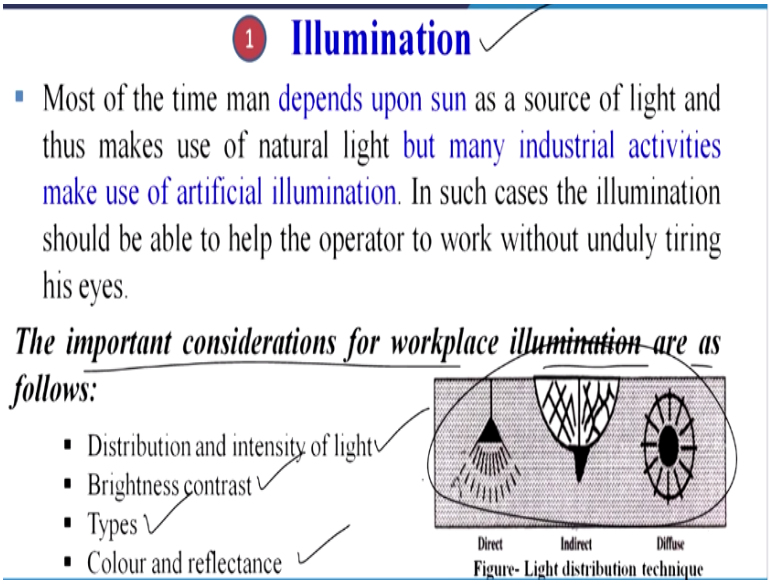

So illumination is very, very important. We have seen different types of illumination techniques are there. So the important considerations for workplace illumination are: Distribution and intensity of light, brightness contrast, types, colour and reflectance. So, even the light plays a very important role.

Now this session is being recorded. We have large array of lighting or illumination sources which are making it good or making it may be comfortable for all of you to view this session being

conducted. So if the light is poor you will also not appreciate the quality of the video. So that is important.

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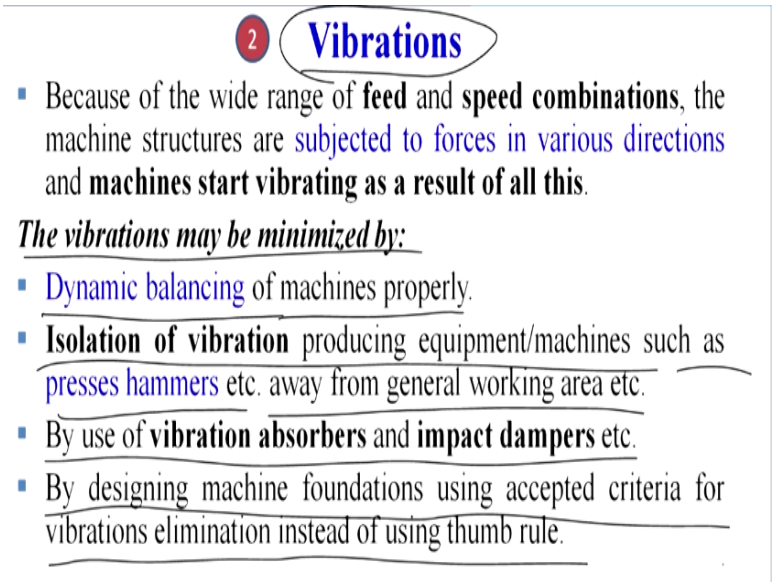

Then the vibrations are equally important. We need to control the vibration. So I may not go into the details, but we need the vibrations may be minimized by the need to minimize these vibrations by dynamic balancing of machines, isolation of vibration producing equipment and machines such as presses hammers away from the general working area. So whatever equipment produces lot of vibration we must isolate it into a different shop.

By use of vibration absorbers and impact dampers etc, by designing machine foundations using accepted criteria for vibrations elimination instead of using thumb rule. So we must follow the accepted criteria for designing the foundations of the machines which we know are going to create a lot of vibrations. So therefore vibrations are an important parameter prior to that illumination is an important parameter and last one is the ventilation is also very, very important parameter.

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3 Ventilation

- Ventilation is the process of displacement of stale air of the building by fresh air to reduce the presence of bad odour, CO_2 concentration, humidity and temperature.
- A good ventilation system provides fresh air.

Most common methods of ventilation are:

- **Windows** and **ventilators** provide natural ventilation.
- **Exhaust fans** extract stale air and creates low pressure area to be filled by fresh air.

So the most common methods of ventilation are windows and ventilators, because they provide natural ventilation and exhaust fans extract stale air and creates low pressure area to be filled by the fresh air. So the ventilation that we are providing for the workers on the shop floor is also equally important. And the last are the thermal conditions.

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4 Thermal Conditions: Temperature, Humidity and Air Flow

- Poor heat and humid condition produce discomfort in the workers which affect their efficiency, concentration and their members of the body.
- Humidity and heat are related to each other, both affect comfort and tolerance of the body to the heat.
- The effect of heat can be minimized by shielding, installation and provision for adequate local ventilation.

That are related to temperature, humidity, and air flow so this I will read for you. Poor heat and humid condition produce discomfort in the workers which affect their efficiency, concentration, and their members of the body. Humidity and heat are related to each other, both affect comfort and tolerance of the body to heat. The effect of heat can be minimized by shielding, installation, and provision for adequate local ventilation.

So, instillation and provision for adequate local ventilation. So we can see that there are 3 things, one is the display, another one is the control and the last one that we have covered is the environmental system that we are providing for the worker who is working on the shop floor. So we need to take care of the ventilation requirements. We need to take care of the temperature and humidity control requirements.

We need to take care of the illumination. So illumination only we can have 2 or 3 lectures depending upon the research which has been conducted by the various researches that what type of light is suitable if you are doing a very, very minute task for example the assembly of the gears of the mechanical type of watch so what type of illumination is required there. So depending upon the type of work, the illumination levels will also change.

The ventilation levels will also change. So the important point to address with this session is that there are lot of parameters that have to be taken into account when we are designing the work system for any organization. So with this we conclude the today's session as well as the discussion for week number 11. In next week, we will try to see the applications of the theory that we have covered over the last 11 weeks in form of examples, case studies where we will see that how these theoretical aspects have been applied or put into practice.