Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation

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Lecture – 01
Introduction to Ergonomics

Welcome to the course Digital Human Modeling and Simulation for Virtual Ergonomics Evaluation.

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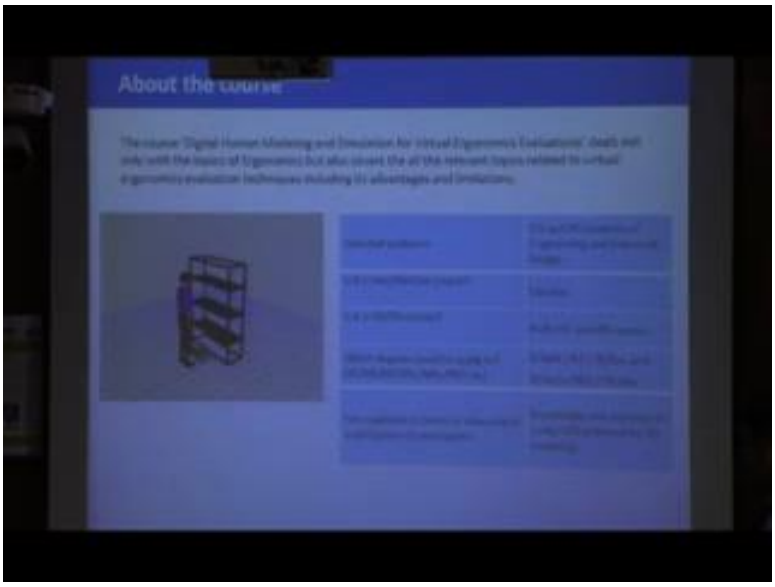

So, in this course, the course digital human modeling and simulation for virtual ergonomics evaluation, deals not only with the basic ergonomics, but also covers all the relevant topics, related to virtual ergonomics evaluation techniques, including its advantages and disadvantages. So now, intended audience, for whom this course has been designed. This course is for undergraduate and post graduate students, of engineering, the industrial design disciplines.

It is expected that engineering students of undergraduate and postgraduate departments, from various background like mechanical engineering, production engineering, then civil engineering, who are also studying biomedical engineering, all of them will be mostly benefited from this course. Not only engineering students, but also students who are studying industrial design, as well as architecture or various course related to occupation

health and safety. They will also find this course very interesting, and also beneficial for their curriculum.

Now, this course is mainly elective course, and as I opt for, already mentioned both undergraduate students and post graduate students can opt for this course, but one there is some prerequisites, for digital human modeling and simulation for virtual ergonomics evaluation. If you want to learn this course, you want to know about this course, and then what are the prerequisites? Prerequisite is the, you must have basic knowledge of 3D modeling CAD software, that may be unigraphics, that may be CATIA, that may be (Refer Time: 02:33), but at least one of the 3D CAD modeling software you must know. If not very proficient no problem, but basic knowledge of any 3D CAD modeling software is essential for this course.

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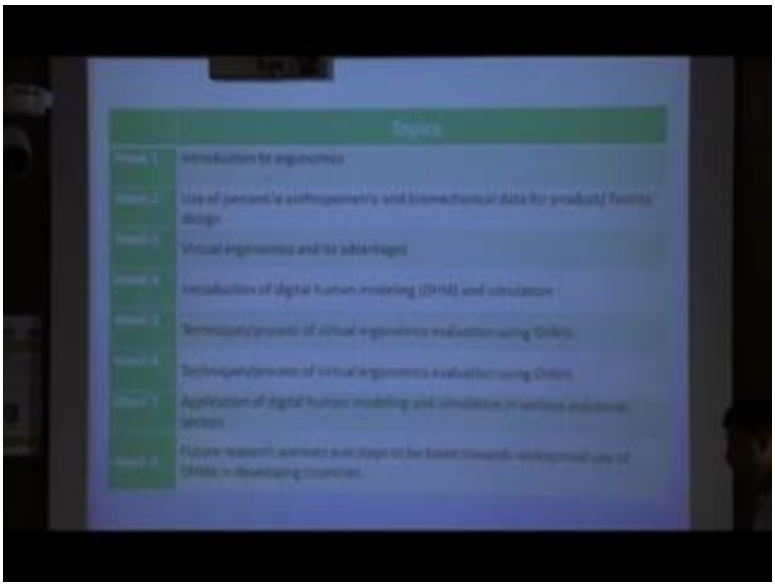

Now, the course will have made like this way in particular, this course will run for 8 weeks, and in different weeks, we will discuss different topics. So, if you start from introduction to ergonomics in the first week, and then gradually well move towards digital human modeling so that in the second week use of percentile anthropometric and biomechanical data for designing various facilities or work station or products we will discuss, then in the third week, we will discuss about virtual ergonomics and its advantages. In the fourth week, introduction to digital human modeling, and simulation,

then in week 5, techniques or methods of virtual ergonomics evaluation, using digital human modeling software.

The same will continue in week 6. And in week 7, we will discuss how this digital human modeling software is used for virtual ergonomics evaluation, across diverse industrial sectors or occupational sectors. And in the last week, that is 18th week, we will discuss about the future research flow in this direction, and what states or what initiative is needed to be taken, to popularize this subject, and popularize this domain of knowledge in developing countries like India. Now, moving to the course, we are starting today the first module; module one, and this module is related to introduction to ergonomics.

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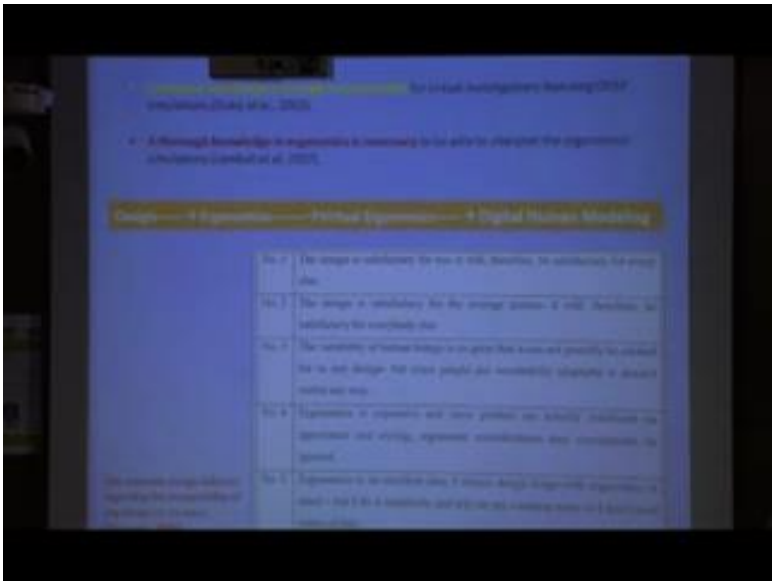

Before moving to the actual topic, that is digital human modeling and simulation for virtual ergonomics evaluation, we should discuss something related to design, then gradually well move to ergonomics, then virtual ergonomics and digital human modeling. Because, as we are studying virtual ergonomics. For studying virtual ergonomics knowledge of ergonomics is required, first you know by contextual knowledge of ergonomics, second is the design. You must know that how we use ergonomics in designing the years products or work place or different types of facilities. If you see this statement by duplicator to 2002, we mentioned contextual knowledge is

strongly recommended for virtual ergonomics evaluation or virtual investigation, using CAD and Digital Unit Software.

So, this is very important for contextual knowledge in which context we are evaluating the product of facility, using our software CAD modeling, CAD software that is very important. And the second important thing is that knowledge of ergonomics is very important for that purpose. So, while someone is going to learn digital human modeling software or want to use digital human modeling for virtual ergonomics evaluation, he or she must have the knowledge of ergonomics, otherwise interpretation will go in wrong direction.

Now, in this course we are starting from design. Now, very interestingly is in 1986, we mentioned that there are common five philosophies regarding the design, that how we should design. Some people think if we design, the design is satisfactory for me, it will therefore, satisfy everyone, but it is not possible in the real scenario. People also believe that if design is satisfactory for the average person, (Refer Time: 06:59) average person? The person with average body dimension, average capacity of working, and is all other average performance capability, then the product will satisfy everybody, that is also not true. Similarly, the (Refer Time: 07:17) that in the third understanding or belief is that, in human population there is huge variation. So, it that possible to design any facility or any product, which will satisfy everybody, but since people are wonderfully adaptable it does not matter, what you are designing. So, it means some of the people are adaptable.

The fourth design analysis is ergonomics is expensive, and since products are actually purchased based on its appearance or visual aesthetics. So, it does not matter whether ergonomics principle has been incorporated in the product or not. The fifth (Refer Time: 08:06) analysis is that ergonomics is the excellent idea, but I always design things with ergonomics in mind what I do, it intuitively and rely on myself understanding, I do not need table of data. It means many people thinks ergonomics is the common sense. So, whatever we can do, we apply our common sense; that is the ergonomics for that purpose more database or standard is required, but that is also wrong. So, these are the five common designs, halas is which are believed by the people it has been mentioned by design 1986.

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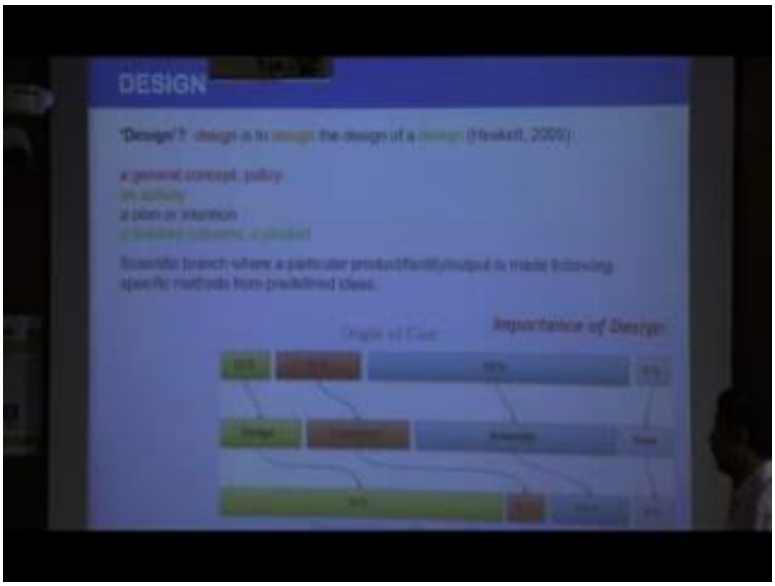

Now, if we will ask you what is design, in (Refer Time: 09:01) defining design is very difficult, because sometimes people will say it is a noun, it is a verb, it is an adjective, but what actually design is, if I say for example, if we say that design of this I have a design in my mind for this pen, or I want to design a pen and I have some concept in my mind. So, design sometimes it is the concept, sometimes I want to design a chair what does it mean. It means I want to make some chair; that is the process I want to follow some processes. Sometimes design may be I like the design of the chair what does it mean, design mean the product. So, sometime design is the product, sometimes design is the process, sometimes design is the concept or idea. So, actually defining the word design is very difficult.

So, for that reason Heskett 2005, he nicely mentioned what is design. Design is to design, the design of a design. Now you notice the color coding, what is design. Design is an inner concept or policy, it is an activity, design is a pair or intention or concept and the last this web design, the theories product or outcome. So, in general how we can define design. So, we can define design, as design is an design is a scientific branch, hire a particular product or facility or output is developed, made following, some methods, how to define ideas, means design is a process parallerly making something, following some specific process from the concept ideas. Now, why design is important, because here this is the course for virtual ergonomics in this course, why we are discussing about

design, because design is very important in our daily life, if you see this diagram then what you understand.

So, here you originate importance of design origin of cost, and here potential to influence the cost in the typical design development process, which is starting from design then fabrication, then assembly and remaining that the first phase; that is the design. For designing any product or any facility what is required, only 12 percent origin cost, is there origin cost. Only 12 percent means out of hundred only 12 is required for this purpose, but the design is such an important phase in the design development process, that it has the potential to increase the cost by 75 percent. So, although in the design phase first requirement is very less, but if your design is not proper or correct then what will happen. It will influence the cost by 75 percent. So, design is a very important phase in the product or process development cycle.

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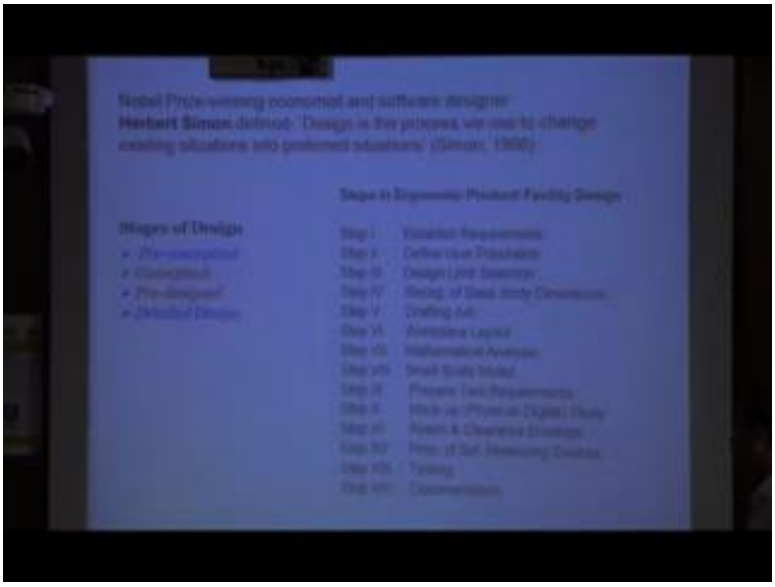

Now, Nobel Prize winning economist Herbert Simon he defined design, how will I define design. Design is the process we use to change whatever existing; you will have to make it better. So, that is why he mentioned design is a process we use to change the existing scenario, existing situation to the preferred situation. Now in design process there are various phases, pre conceptual phases, then conceptual, then pre designed, and finally, detailed design. So, these are the four stages in the design process. So, what we do pre conceptual stage, then conceptual.

In conceptual stage which is very clear from this second one conceptual stage. So, we have conceptualization or we are going for some ideas for that product, or the facility or the process then we are going for designing pre designing stage, but what is pre conceptual, means before the conceptualization what we are going to make for that concept before. We need some information to conceptualize the product for the process. So, this will be much clearer if you go to the next slide.

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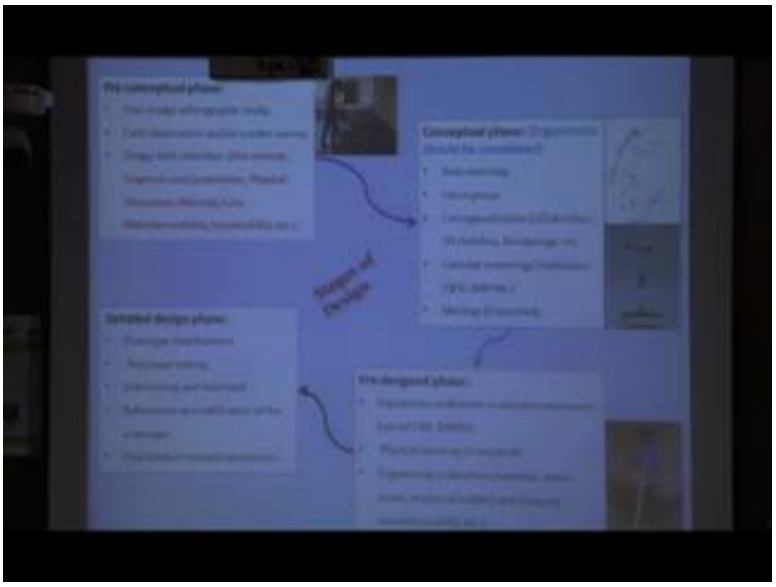

So, in pre conceptual say for example, we are going to design something for that purpose what we need, in the pre conceptual stage. we need to go for user study or (Refer Time: 14:15) study, means who are the actual user or intended user, but either who they are presently using that type of product, or you are developing some new product which intended user will use next field observation for market survey, then design limit station. This is very important, because before conceptualization of that product you need this information, means what is the used context, what the targeted user physical dimension of that product or facilitate material cost manufacturability, sustainability.

All these information you must have with you, then only you can move for the conceptual phase. Then in the conceptual phase, ergonomics should be considered from this phase onwards, not like that in the detailed design phase. So, role of ergonomics is actually starting from this conceptualization phase. So, first we should go for brainstorming, then focus (Refer Time: 15:22) study, conceptualization, then 2 d

sketches, 3 d sketches, then red CAD modeling, rendering, conceptualizing of finalization, using various techniques like quality function deployment analytic hierarchy process.

So, many other techniques are there. So, with those techniques, we can stream those concepts, and we can go for mock up development if it is required so. So, starting from pre conceptual phase, gradually move towards conceptual phase. After conceptual phase, where to hide your concept is ready, and following that concept streaming, you are entering a pre designed phase. In pre designed phase what you are doing. We are doing ergonomic evaluation in virtual environment, if we have already developed the 2D, 3D CAD model and inner CAD model. So, we can go for virtual ergonomics evaluation, using CAD and (Refer Time: 16:30) software. Then we can go for physical mock up development, it is required, then various types of engineering evaluation like material properties, (Refer Time: 16:41) structures, stability, integrity manufacturability.

All these issues we can study here. Along this pre designed phase there we can. So, ultimately here only we are gathering the information what are required for a conceptualization. Then in the conceptual phase we are making the concept making the following concept spinning, we are finalizing the concept in pre designed stage, mainly we are developing either CAD model or physical mock up. After that we are going for prototype development, very important thing in pre designed stage, what we discussed about, either physical mock up or virtual mock up or CAD model, in this case these are. So, as we measure this is mock up, but here it is prototype. So, what is the difference between mock up and prototype? In mock up generally what we do. We make the product in its miniature form, or scale down model and the material may not be the original one.

Its functionality may not be like the actual product, actual intended product, but in case of prototype it is material, is also the same like the actual product. It is usable, its function is similar to the original product for intended product, and the same thing generally prototype is made in one to. Once scale made with the, at the actual size, but in case of mock up we can make any scale down model for our visualization for understanding. Now, in the detailed, now we are again coming to detailed design phase. in detailed design phase from this mock up, while we are developing the prototype or allowing CAD model, we are developing the prototype, then prototype is tested user

feedback, is taken and ultimately, we move towards final product development or production process. So, here we have given one example in this example. So, this is called mopper for floor cleaning, when you are cleaning the floor, for that purpose we use this type of mopper.

Now, first we need the information who are using, then what is the dimension, what is the size, what is the affordability of the people who are using this type of mopper; that is important in this phase, then gradually why do we are moving to conceptualization phase. Then we are going for 2 d sketches, with paper pencil, and argumently developing the CAD model, while CAD model is ready. Then we are meeting at physical mock up CAD model, following CAD model ergonomic evaluation or engineering evaluation are ultimately were coming with this type of mock up development, when mock up is ready, then after testing of that mock up, we can go for final production, we can go for prototype, even in this prototype development phase also we can go for prototype one (Refer Time: 19:43), then prototype two, then prototype three, and ultimately we go for production

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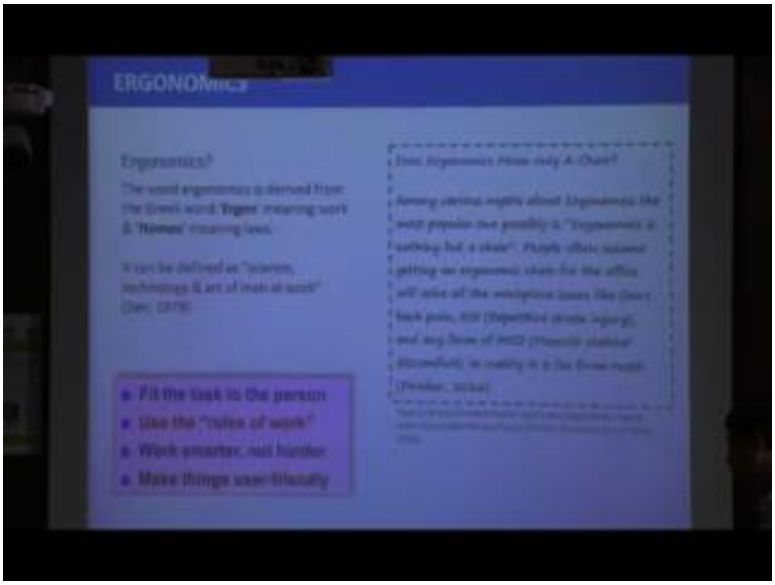

So, just going back, we started from this slide if we look at this slide. So, we started from design, then as we mentioned gradually will move towards ergonomics. So, first slide we have covered design. What is design, what are the stage in design, why design is important. Now we are moving to ergonomics. The word ergonomics is derived from

Greek word ergo, meaning one and nomics meaning law. So, in general we can say; what is ergonomics. Ergonomics is the law of one or principle of one. There are various definitions of ergonomics. Ergonomics is hitting the task to the person, use the rule of work, works smarter not harder, then makes things user friendly, more useable, more comfortable. Here I want to mention one interesting thing. This is from linking post made by Doctor Hira Poddar in 2016. This is very interesting. I will suggest all of you to go through this one, already link is given. So, she mentioned, does ergonomics means only a chair, because among various needs about the ergonomics, the most popular one is, possibly ergonomics is nothing, but a chair still now in developing countries, as well as in few developed countries ergonomics as a subject is not that much popular, and people are aware about this subject.

So, whenever we ask someone what is ergonomics, they reply something like, this is something related to comfort, user friendly, and generally how we can make chair table all these. So, that is why, see rightly pointed out that most popular myth regarding ergonomics, is ergonomics is nothing, but a chair people often assume getting an ergonomic chair at the office will solve all the problems, related to that work place, like back pain, repetitive sting injury or any form of muscular skeletal disorder, but in reality it is far from there, because ergonomics is not only that comfort or sitting or designing of that chair for that work place ergonomics gives us, so many other factors.

So, such just example, even this case only, is not only office chair, while at talking about the office ergonomics, it is related to hierarchical structure of that office, then physical environment, hire that of a person is walking in that office, is cognitive work load, how much information he is receiving, and how much physical activity or mental activity he has to do. So, many other aspects are associated with this, but peoples only understanding as what is ergonomics. Ergonomics is only comfortable sitting posture or chair table design.

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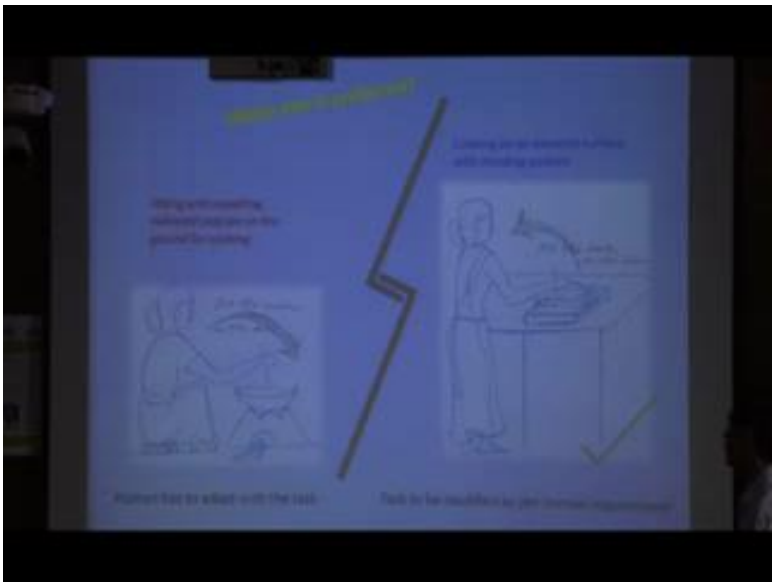

Now, as we have discussed the definition of ergonomics that if we ask him. We have two scenarios, this is scenario one on the left side, and on the right side scenario two.

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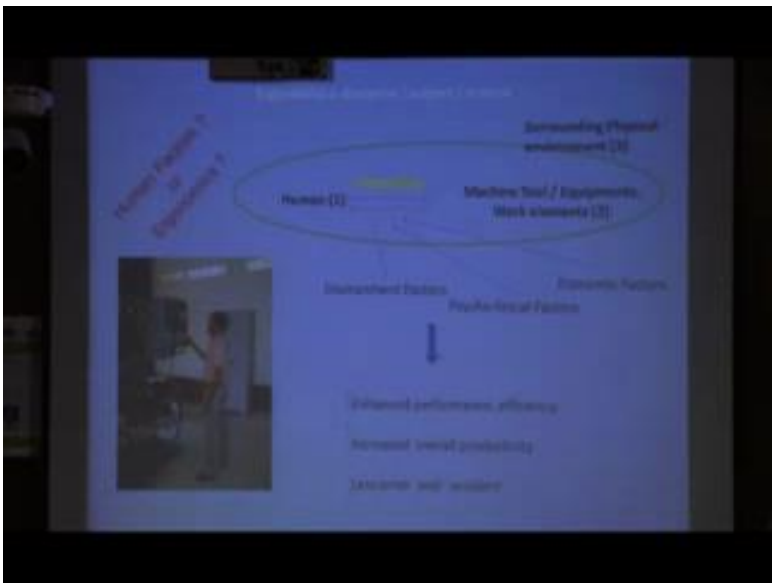

So, which one is preferred? In the first scenario, one lady she is in squatting posture, sitting on the ground and cooking on chula or stove. On the other hand in the right hand side, lady is standing and cooking on elevated surface. Now if we look at these two pictures. What happened in this case? This is the task, and we force that human that fit the man to the task. So, human is bound to be fitted with the task, even he is bound to be

fitted, with the task means fit the man to the task this scenario. And on right side as per human requirement, human comfortable posture, the task has been modified; fit the task as per the requirement of human. So; obviously, between these two well prefer for this one. This is the right one, means as we discussed about the ergonomics. Ergonomics is fitting the task, will have to fit the task to the man, but never, we compel the man or women to be fitted with the task.

Now, if we elaborate the definition of ergonomics, more elaborately what we can say about ergonomics. Ergonomics in a single word, what is ergonomics - Ergonomics is an interaction of what, ergonomics is an interaction between human, and his or her machine tools two equipments, ultimately we can mention work elements. So, this is ergonomics is an interaction, between human and his or her work elements. Now more elaborately we can mention, ergonomics is a discipline or subject or science, as we discussed interaction between human, and work element. And this is a two way interaction, and this interaction is been influenced by surrounding physical environment. Not only physical environment there are so many other factors also. This interaction is influenced by environmental factors various environmental factors like (Refer Time: 26:23) chart humidity illumination. Similarly, psycho social factors, various types of economic factors.

So, many factors are there which are affecting the interaction. Then, how we can mention the definition of ergonomics, ergonomics is a discipline or a subject or a science, as we discuss about the interaction between human, and these all are work elements, and all other factors, which all other factors which are those factors which affect this interaction. Why we study this subject. To improve, enhance the performance and efficiency of what, performance and efficiency of the system. Now the thing what is system. It is human; I will just put number one, work elements that is two, and surrounding physical environment three. Man machine and surrounding environment. These three components are collectively forming overall system.

So, man machine and environment these collective systems, that system performance efficiency, is enhanced, if we follow ergonomics principle. So, we discussed this subject which added this subject, so that the performance and efficiency of overall system can be improved. We can increase the productivity at the same time we can reduce the (Refer Time: 27:47) and accident. Now, again we are coming to the definition of ergonomics.

So, what is ergonomics or human factors? Ergonomics is discipline or subject or science, as we discuss about the interaction between human and work elements, and all other factors, which affecting this interaction, to improve systems performance, productivity, efficiency and at the same time reduction of (Refer Time: 28:20) and accident. So, this is the overall definition of ergonomics by human factors.

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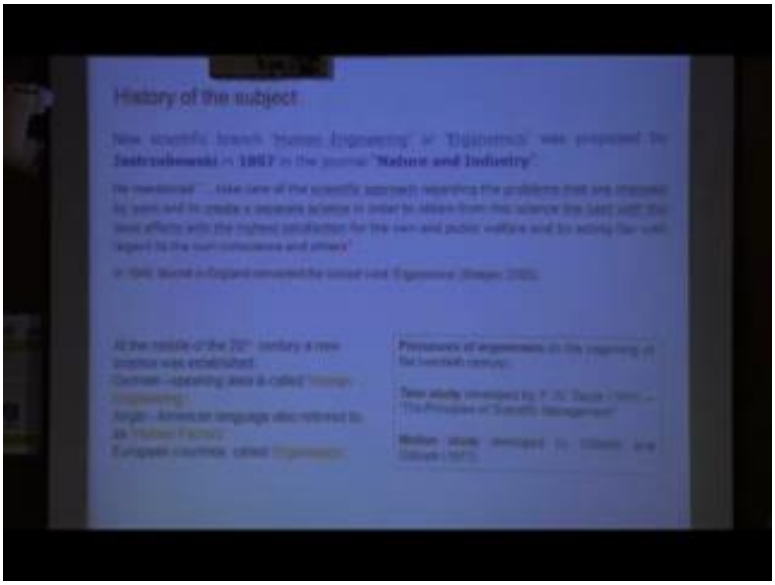

Now, if we move towards the history or origin of the subject, that how this subject ergonomics, or human factors developed. So, first the word ergonomics was used in 1857 by Justrzebowski in the journal nature and industry. He mentioned that one scientific approach, regarding the problems that are imposed by work is needed, and he suggested that there is requirement to create a separate science, which we deal with these issues, like in order to obtain from the science the best with the least effort with the high satisfaction, for the own and public welfare and by acting fair, with regard to own conscience and others. So, long back 1857 the word ergonomics was coined. Now, in 1949 Mural in England reinvented the coined on ergonomics.

So, that is in 1949, after that in 20th century middle of the 20th century, then not only ergonomics other words also came like human Indian in journal speaking areas. Anglo American language they mention this science for this subject as human factors, and in European countries they call the ergonomics. So, the human engineering ergonomics, which was first coined in 1857 gradually in different countries or different parts of the

world, took different names; like human engineering human factors ergonomics. Not only these names there are. So, many other precursors of ergonomics; like time study, motion study, there are also other precursors which has been used by various authors.

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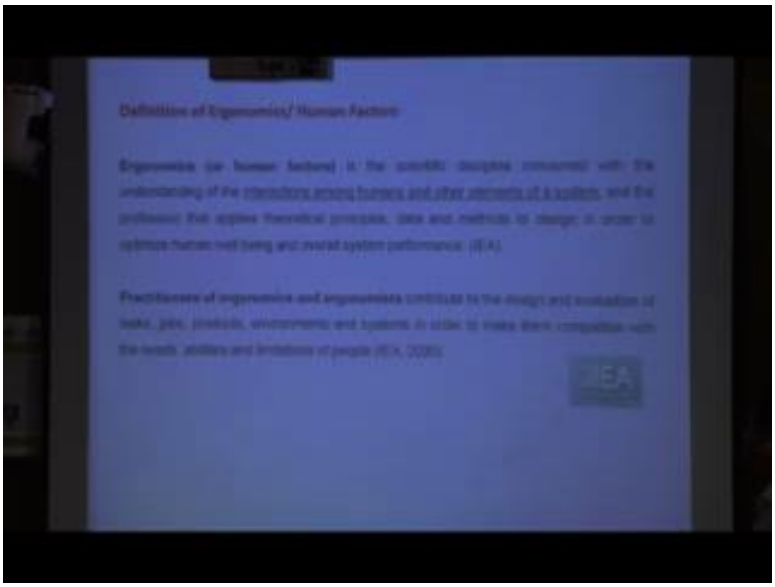

Now, most widely used or widely accepted definition of ergonomics is given by international IEA international ergonomic association. International ergonomic association, as per their definition what is ergonomics. They define ergonomics is a scientific discipline, concerned with the understanding of the interactions among humans and other relevance of a system, and the profession. So, this is the ergonomics as a subject, and here ergonomics as the profession, and the profession that applies theoretical principles data, methods to design in order to design, in order to optimize human wellbeing and overall system performance. So, earlier defined ergonomics as a subject, as well as, as a profession, now who are ergonomics as further definition of IEA, practitioners of ergonomics and ergonomics contribute to the design, and evaluation of tasks jobs products environments consistency, in order to make them comfortable with the needs, abilities and limitation of the (Refer Time: 32:13).

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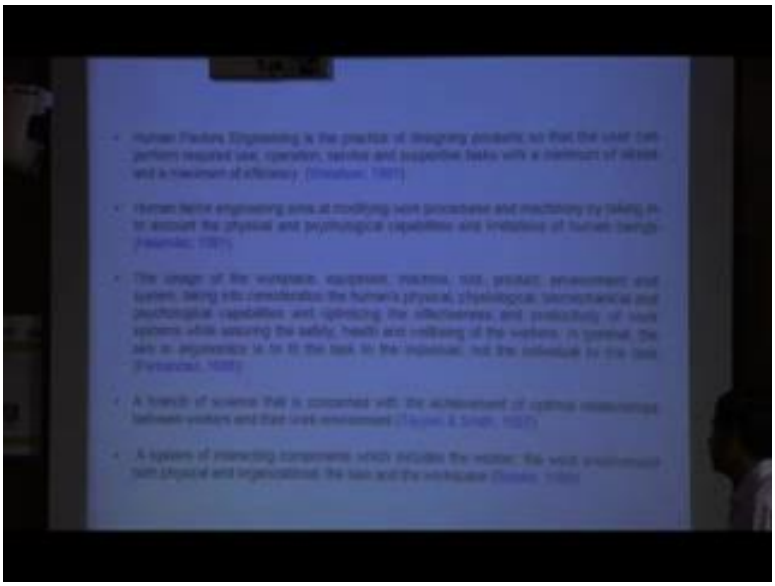

So, I m define both what is ergonomics, as well as what ergonomist. Then down the line, years after years in various research papers, various researchers, and research papers for books, they have mentioned ergonomics; define ergonomics as per the understanding. If you see this definition by (Refer Time: 32:47) 1995 the design of the workplace, equipment, machine, tool, product environment and system taking into consideration that human physical physiological, biomechanical and psychological capabilities, and optimizing the effectiveness and productivity of the work system, while assuring the safety health welding of the waters. In general the aim in ergonomics is to fit the task to the man, not individual to the task, as you have already mentioned. So, in this way, if you go through all these definition, so various authors in the research paper, they define differently

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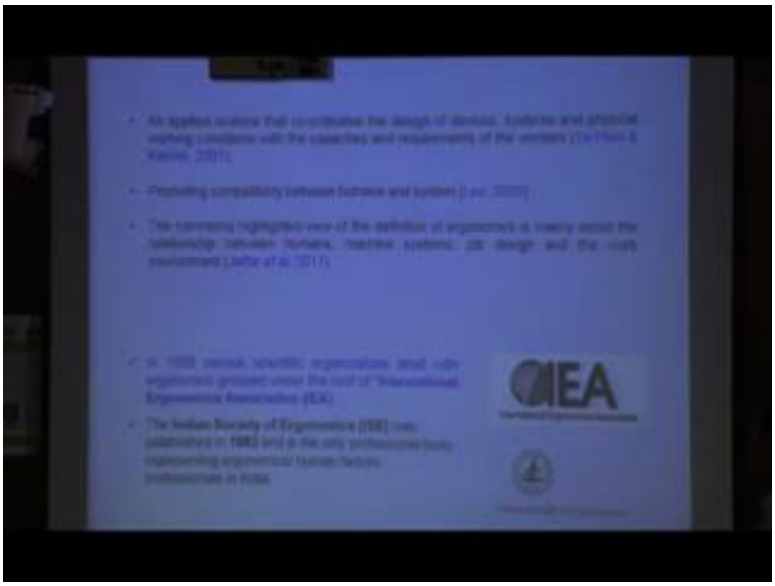

Now, in the research paper Jaffer Et Al 2011 they mentioned the commonly highlighted view of the definition of ergonomics, is mainly about the relationship between human machine systems, job design and the work environment. Now in 1959, we are discussing about the history. So, after history we have discussed few definitions of ergonomics, and then if we look at this one in 1959 various scientific organizations dealt with ergonomics, put under the group of international ergonomics association. So, in 1959 ergonomics, international ergonomics association was originated, then in India we are talking about Indian annum, Indian society of ergonomics, because this we are from India, Indian Institute of Technology Guwahati.

So, in this curriculum, in this course we emphasize the (Refer Time: 04), about the ergonomics scenario living here. So, for that purpose, here I have mentioned the Indian society of ergonomics. The Indian society of ergonomics was established in 1983, and it is the only professional body in India, which determines ergonomics and human factor professionals in India.

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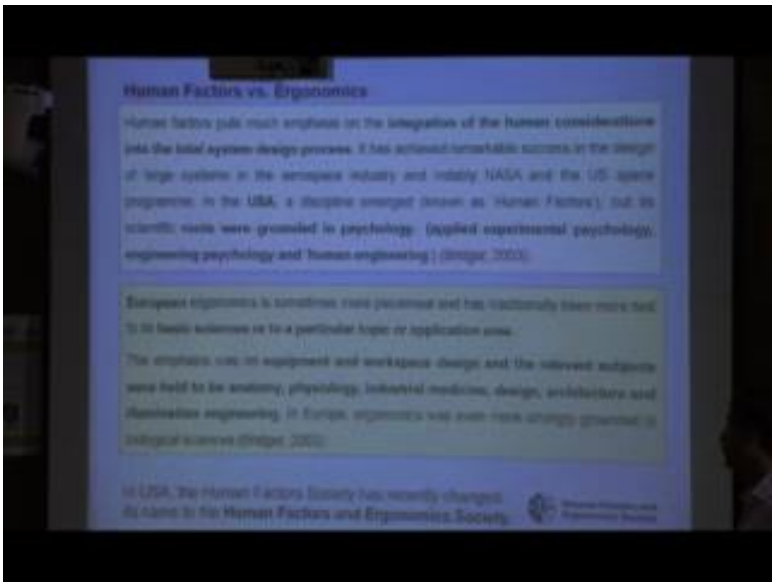

Now, so far during discussion of definition of ergonomics and human factors, we have many times used that word; sometimes you are giving ergonomics, sometimes you are mentioning as human factors, but now the question is coming, are these two words human factors and ergonomics are they synonymous, or these two completely defined for, or what is the relation between ergonomic human factors and ergonomics. So, if we look at the development of both these subject area, then well find the (Refer Time: 36:14) the subject area in human factors, actually developed in United States Of America U S A, and its roots subject are, roots are grounded in psychology, applied experimental psychology, engineering psychology and human engineering. So, the subject human factor, human factors or human factor engineering, actually developed from some other discipline like psychology, and it was mainly popular in U S A.

On the other hand, if we look at the ergonomics, ergonomics is popular in European countries, and the subjects from which this subject evolved, or flourished. Those subjects are actually anatomy, physiology in industrial medicine design architecture. So, from all these subjects, that ergonomics to input and gradually established as a new branch; that is ergonomics. As such there is no difference between human factors and ergonomics. These two words human factors and ergonomics, now I guess have been used synonymously, in the names are same. Only difference is the from which subject it is originated, at the same time where it is much more popular which countries, only there is the difference, but in other words these two human factors and ergonomics, these two

words are synonymous. For that reason if you look at this portion, in U S A human which was earlier known as human factors society, has recently changed its name to human factors and ergonomics society. To emphasize that human factors and ergonomics are not different, this is synonymous only.

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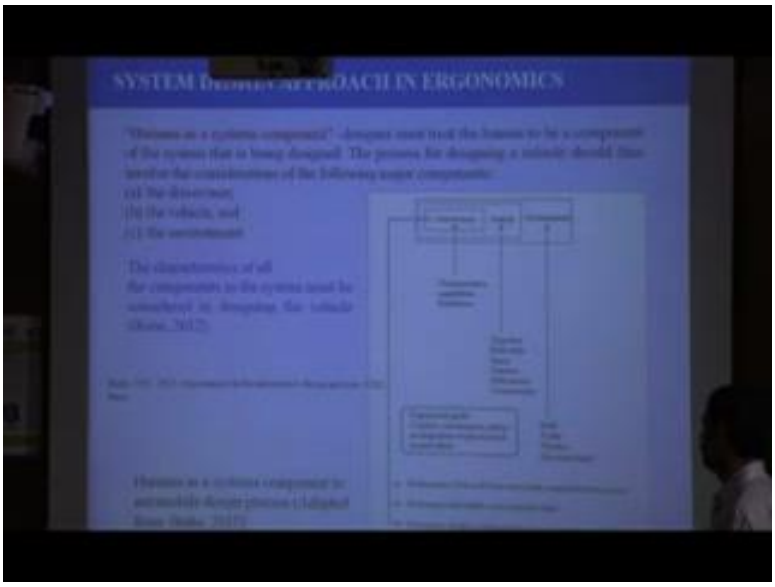

Now, while we are discussing about ergonomics, then we are moving towards system design approach in ergonomics. So, all may be during discussion of definition of ergonomics to mention, that human, work element and surrounding physical environment, these three components operates in a system. So, in this example, we say in 2012 in his book he mentioned that human assistant component, designers must treat that human to the component or integral component of the system that has been designed the process for designing the vehicle, should does involve the consideration of the following major components; one is; obviously, driver then vehicle and environment, because this is defining the system approach of ergonomics in the field of automotive ergonomics. In automotive ergonomics while there is interaction between driver and vehicle, in that interaction there is surrounding environment in driver vehicle interaction.

With this driver vehicle interaction, he has described various system components. Now, if you look at the driver, and user. Driver and user, we are discussing about driver and user. You must know about the characteristics capabilities and limitation of driver. Similarly for vehicle we need to study time, size, body shape, subsystem components, all

these. Similarly while you are talking about environment, then road condition, traffic, weather, dust, illumination level, or it is day or night. So, all these factors are related to environmental valuables. Now by this overall system driver is interactive with the vehicle, where there is this environmental factor. In this interaction, why the study of this interaction is important? Because we need to discuss about performance, how will, how much trust competition time here. So, you need to discuss about the performance. We need to discuss about the preference; like, dislike.

Similarly perception, quality, workmanship, harmony, in driver vehicle interaction also, that system driver vehicle interaction, in that case the system is comprising of these three factors, and this interaction is going on, and there is major role of ergonomics, because that vehicle; its operation, its design, everything is actually performed by human being only. So, key learning from this slide is that, if any system, while you are designing that vehicle, we should not feel that, driver is out of that system, the whole vehicle design process, we include both driver or human or passenger, and at the same time it we should also consider the surrounding environment.

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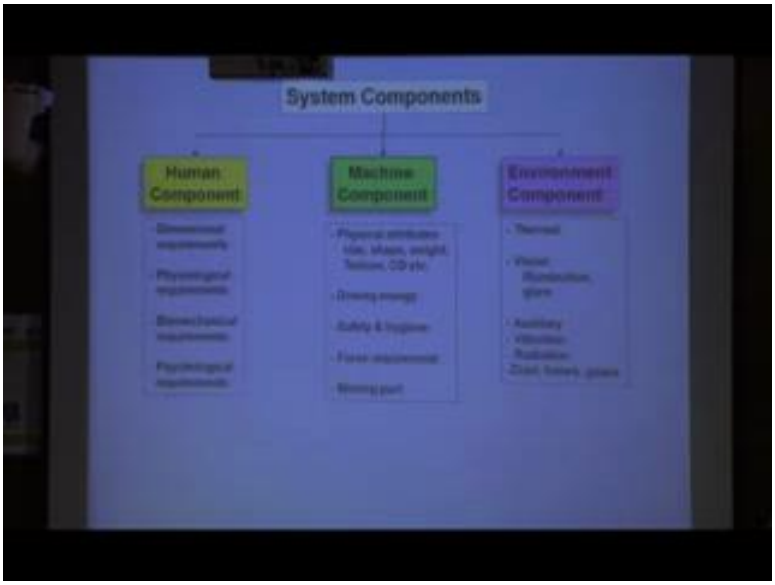

Now, in this slide we have categorized those three components; what we are discussing so far, that in this system, man machine environment system, there are three component. One is human component, second is machine component, and the third one is environmental components.

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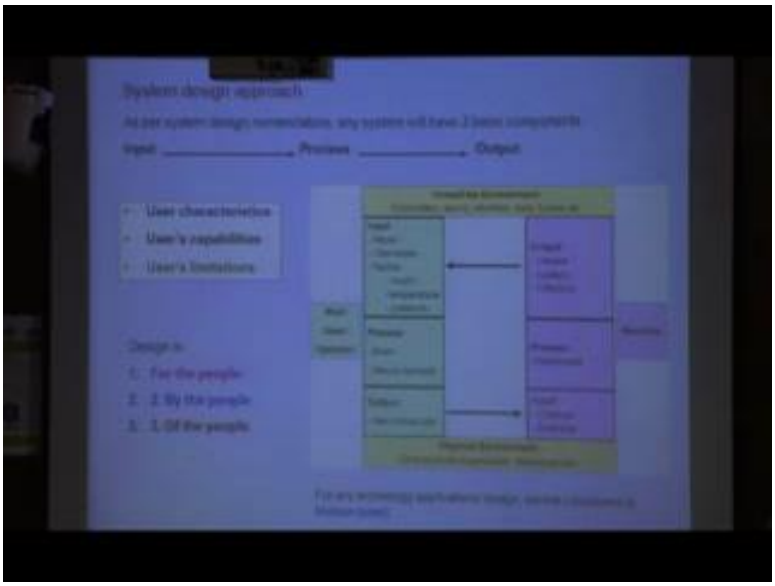

So, under human component what we are discussing. We are discussing about dimensional requirement, physiological requirement, biometrical requirement, and psychological requirement. So, these are discussed under human component. Similarly under machine component what we discussed. We discussed about physical attributes of the machine, or facility, or the product, then energy to run that machine, then safety and hygiene, force requirement, moving parts all these are actually coming under machine component. Similarly under environmental component what we are discussing; the thermal condition, visual, illumination glare, then auditory vibration variation task. So, all these chapters are discussed under environmental component.

Now, for any system there are three elements, three basic components; one is the input process and output. In man machine system also, these three factors will be available; one is the input, second is process, third one is output. Now if you look at this diagram in this side man in human or user operator. Human user operator for that there are three; first input, process, output. Similarly this side is the machine part, machine part for machine also there is, output, process, input.

Now if I give the example it will be much easier to understand. If we give the example; say I am human being. So, we should know about the characteristics of the human, user characteristics, user capabilities, user limitations. Now if we take the example of my interaction (Refer Time: 44:22) then what is happening. as a human being, I am typing

on the first input. First we are giving the (Refer Time: 44:38) the input. We are receiving the input from the computer screen, I am looking at the computer screen, input is coming through my visual sensory system, and that information is going to my brain. First information, I am pursuing that information through my visual sense, special sense, then it is going to my next, it is going to my brain, it is being processing.

So, first input is received by various sensory channels. In this particularly, in this case I am receiving information through my eyes, and then it is going to my brain. In the brain it is being processed. after that, some output is there. What is that output? After processing in the brain then I am pressing the key. So, that is actually neomuscular action. So, first I am receiving the information from the computer. I am processing that information in my mind in my brain, and then I am doing some muscular activity, you know muscular activity; that is the output whatever is the output from my side; that is actually going as the input for the computer. So, my output that is typing of that key is going as a input for the computer and laptop.

While I am basically suite that is actually input for the machine, then machine processing that one, that laptop is processing that one, mechanical; either mechanical process is there, or electronic process is there. Then machine is giving some output, the screen is now changed. So, this step after pressing the speed, that input is going it is processed electronically in that laptop, and ultimately it is giving some output it is moving towards the next thing.

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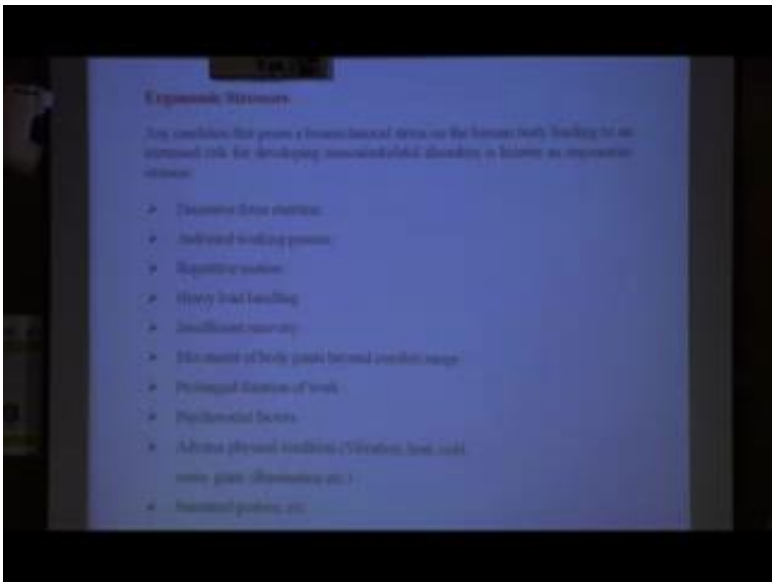

Then whatever is that output is provided by the machine in this example, laptop. So, whatever output is provided by the laptop, that again going as the input for human being. So, while I am pressing, it is going to the next screen, and now I am looking at the next screen. So, this is the input for me. and this interaction man and machine, this interaction is going on, and this interaction is also influenced by surrounding immediate environment as well as the overall so many other factors; like organizational factor (Refer Time: 46:58) factor, sound factors also affect this influence interaction. So, regarding the system design approach, it is very important. in the earlier side also we mentioned, in this slide that human is the prime system component, because whatever you are designing, whatever you are developing that is for human, for the people, that is developed by the people, and of the people, as the design process considering these three factors, three things so this is very important.

Now, while you are discussing about ergonomics, there are. You will find one what are ergonomics testers. What are ergonomics testers? any condition that possess biomechanical stress or human body leading to an (Refer Time: 48:00) of developing muscular (Refer Time: 48:01) problem; that is known as ergonomics stresses there are varieties of ergonomics stresses; like excessive force exertion, upward body posture, repetitive motion, heavy load handling, in a (Refer Time: 48:17) insufficient recovery time, movement of body (Refer Time: 48:20) beyond the comfort range, prolonged duration of work, psychosocial factors, adverse physical condition; like vibration, heat,

cold, noise illumination. They sustain posture, means we are unable to fill the questionnaire undergoing a constant posture. So, all these factors these are only a few of the stresses. There is a very lengthy list; all these factors actually affect the human body, human performance and argumently productivity.

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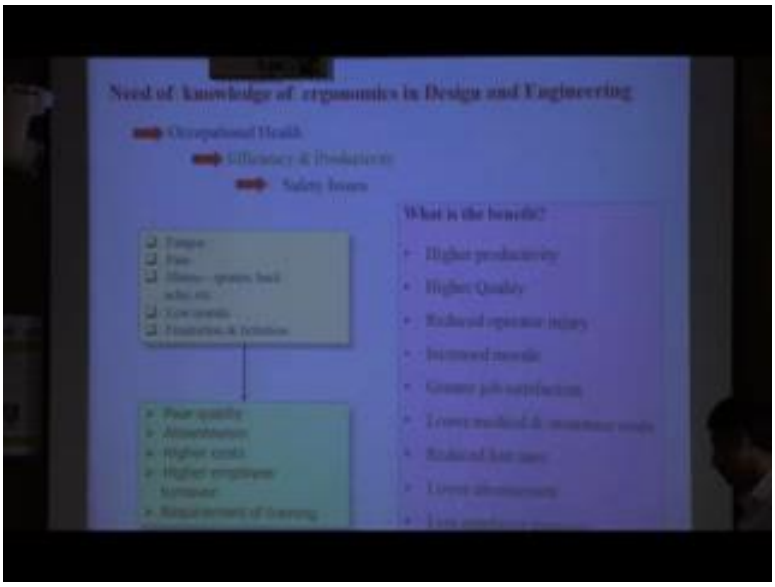

Now, after discussing the definition of ergonomics, various system approaching ergonomics, where few are moving towards importance of ergonomics, why knowledge of ergonomics is important, or designing any product or facility because ergonomics is such a subject. It actually deals with occupational head, it deals with efficiency, productivity of the system, and also it is the various safety issues. If any product facility or process designs, if we follow ergonomic principle, then what will? If you do not follow them what will happen. Then there will be fatigue, pain, illness, low morale, frustration, irritation, all these things will happen. And ultimately in the long run, it will lead to poor quality, absenteeism, higher cost, higher employee, turnover requirement of training; this will be in the output.

On the other hand if we can use ergonomic principle in our day to day life, or you are developing some product facility, then we will get so many benefits, what are those benefits. There will be higher productivity, higher quality, reduced operator injury, increased morale, greater job satisfaction, lower medical and insurance costs, and reduced time and so on. So, from this it is very clear ergonomics is a subject, who is

dealing with these types of important areas; like occupational health, safety, productivity, efficiency. And if we follow ergonomics then we will have so many benefits. So, knowledge of ergonomics is very much important, while we are designing or developing some product, facility or process.

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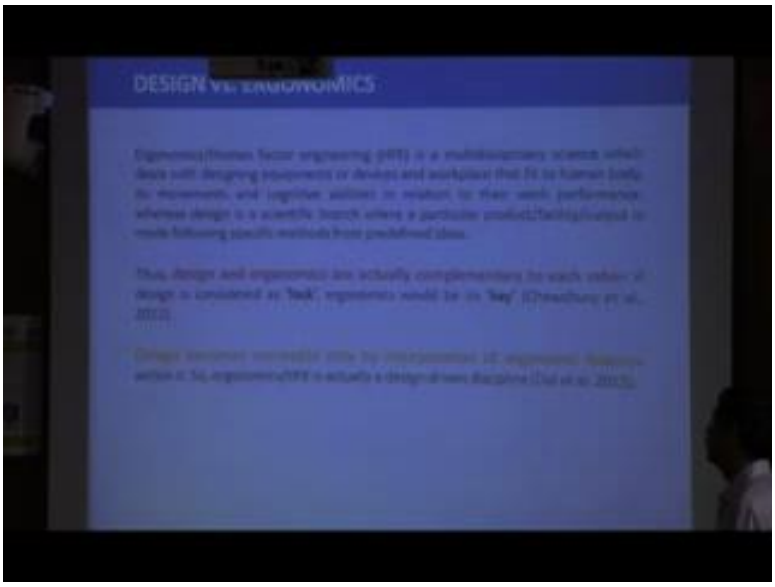

So, if we recall that slide which is mentioned that we start from design first. We have some basic idea about the design, then will discuss about basics of ergonomics, its definition. So, now, the point is that, what is the relation between these ergonomics and design, if you see this statement Chowdhury Et Al 2012 they rightly pointed out that design and ergonomics are actually complimentary to each other, like a lock and key model, without key, lock is useless. On the other hand, without lock, key is narrowness. So, relationship between this design and ergonomics, actually they are complimentary to each other, ergonomics or human factors engineering is a multidisciplinary science, which deals with designing equipments or devices, and work places that fit to human body, its movement and cognitive abilities in relation to their work performance. Whereas, design is a scientific branch at a particular product or facility or output, is made following specific methods from predefined ideas.

So, ergonomics is actually used in the design process. Again we can recall that slide. In the slide you mention that in the design development phases, we have to consider, we have to provide ergonomic inputs from the very beginning .Very beginning means from

conceptual phase, then; obviously, design phase, and detailed design phase also. Dul Et Al 2012 mentioned the design becomes successful, only by incorporation of ergonomics features within you, ergonomics or human factors engineers. Engineering is actually a design driven discipline. So, what is ergonomics? So, he clearly pointed out that ergonomics or human factors engineering is actually a design driven discipline, where we have to put knowledge of ergonomics, so that you can make our design better.

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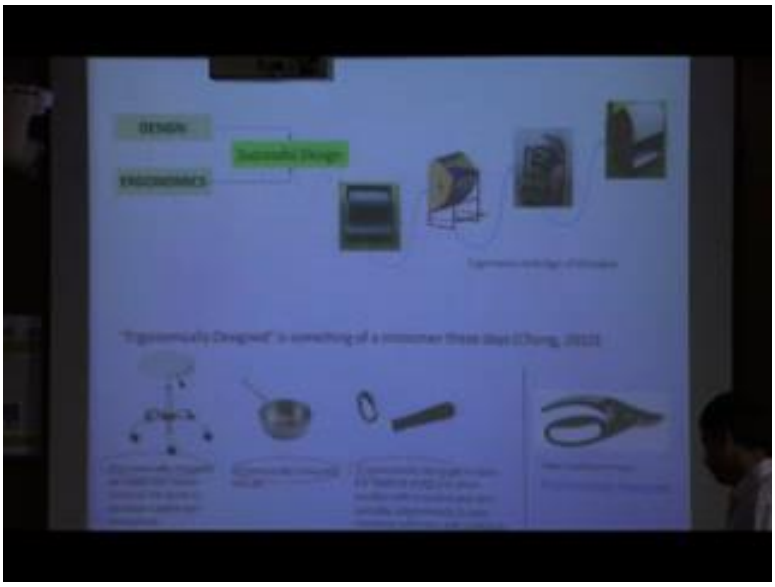

As we have already mentioned design becomes successful, only when we are incorporating ergonomic knowledge in the design process. So, what is successful design, what is good design? The successful design or good design is that, where in the design we have considered ergonomic principle, or we have provided ergonomic consideration into that product, whatever product we are developing or whatever facet we are developing, we have to reach, that is human compatibility of that product. Now, here it is one example. In this example, this is an existing session; session is from equipment that is generally used for facing various types of, so that session if we want to redesign, how we proceed. We in various steps will follow, will provide various ergonomic input and gradually to develop this type of redesign product and to made some CAD model of that product, again go for the actual prototype and then refinement of that prototype.

Now, ergonomically designed is some time, is used (Refer Time: 55:33) largest. This is very true, because many places or many advertisements will find, it is written

ergonomically designed, there may be for furniture, there may be for utensils, there may be for. So, many point, range of product people are mentioning widely that ergonomically designed, but what is ergonomically designed, if you look at those advertisements we find nothing is there. Those products in many cases, those products are really not ergonomically designed and there are so many design loop holes are possible. For example, this type of advisement you will find that this tool is ergonomically designed, but truly speaking this is not. If you study this one, then you will understand that is the ergonomically designed, that is not good for seating also.

Similarly, ergonomically designed handle; here you can clearly understand that there is no coating, no cover. So, whenever you will hold this, serving this pan is hot; obviously, you can a hold the handle. Similarly this type of spoon that manufacturer or the seller claim that this is an ergonomically designed, but if you check the usability, sorry. So, if you check the usability that is actually not good for use, but it does not mean that ,all the products in the market are not ergonomically designed or a good design; obviously, there are so many products in the market which are really good, and various ergonomics are human factor aspect has been considered in their design. So, one example is this one, finger loop bypass product. So, this is really ergonomically designed. We have considered human hand dimension (Refer Time: 57:30) and so many other issues.

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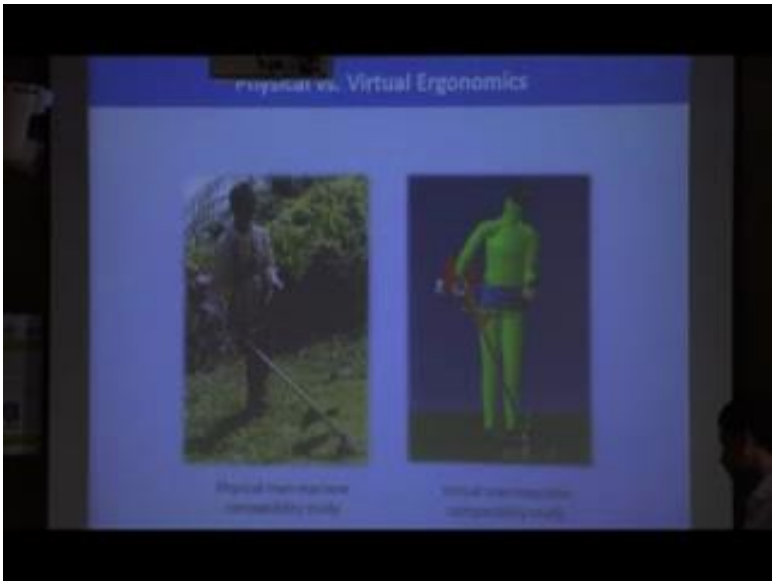

So, far what we discussed. We discussed about design then gradually moved to ergonomics, next we discussed; what is the relation between ergonomics and design then we are coming to physical ergonomics versus virtual ergonomics. Now what is physical ergonomics and what is virtual ergonomics. In physical ergonomics if you look at these two images. So, in this cases, real human being is operating this cutter machine, and this is the CAD generated human model operating, the CAD model of the mesh cutter machine. In both the cases, so what is happening human machine interaction is going on, but this interaction is going on in real scenario, means in physical environment, that human being is real, product is also real and interaction is going on, and that interaction is going on in real life. So, while we are studying this human machine compatibility in physical mode that is called physical ergonomics.

On the other hand while we CAD generated the environment, as human modeling is CAD generated, product modeling is also CAD generated, while we are studying the compatibility between products and human, that is coming under virtual ergonomics. So, virtual can categorize ergonomics, in these two careers; one is physical ergonomics, another is virtual ergonomics. In digital human modeling software, we go for this virtual man machine interface and virtual ergonomics evaluation.

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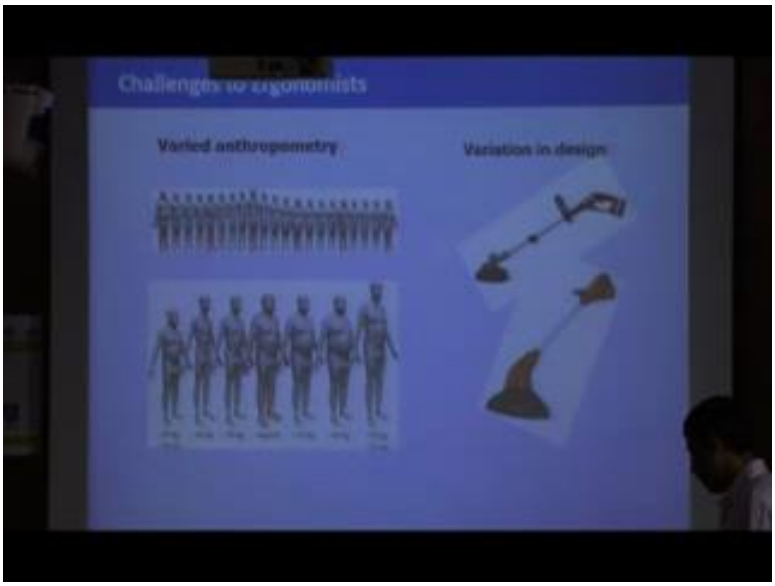

Now, what are the challenges to ergonomics, why ergonomics is important, and how we can use this type of CAD software generated human model, and use that human model

for various ergonomic evaluation or providing ergonomic input in the design. So, here you can see, there are huge variations in human body, shape and sizes in population. Similarly in the market also, there may be different types of product in the market; otherwise in your mind there are thousands of concepts of the new product. Now how will you understand, that which product will be optimally fitted with the human requirement. Human requirement in terms their body dimension their capability, all those points' capabilities, limitations and all these.

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Next the same thing we can evaluate, which product is good or the population of wide range of operation. So, for that purpose you can go for this type of physical ergonomic evaluation, where the product model, or the product we can acquire and we can go for real human (Refer Time: 61:09) we can ask different types of real human. Who are real human in different types in terms of say; age variation, sex variation, somatotype variation? So, you can (Refer Time: 61:22) fat person thin person, children, adult, different types of people we can call, we can ask them to use the product and get the feedback

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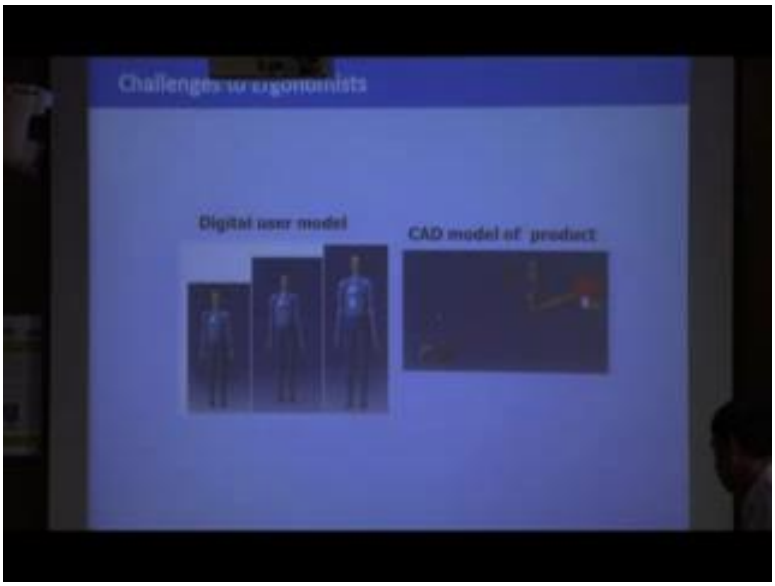

On the other hand what we can do, if we go for this type of process, then this is time consuming. Then if we find any problem in the design, again we have to go for redesign and modification that will be costly, because already you have made that product. So, redesign modification will be time consuming, costly, then there will be wastage of material so many problems are there, but the same evaluation, if we do in virtual environment like this way, if you generate CAD model of the, CAD model for human and we can hire, we can make male model, female model, or you can prepare the human model as per somatotype variation, age variation.

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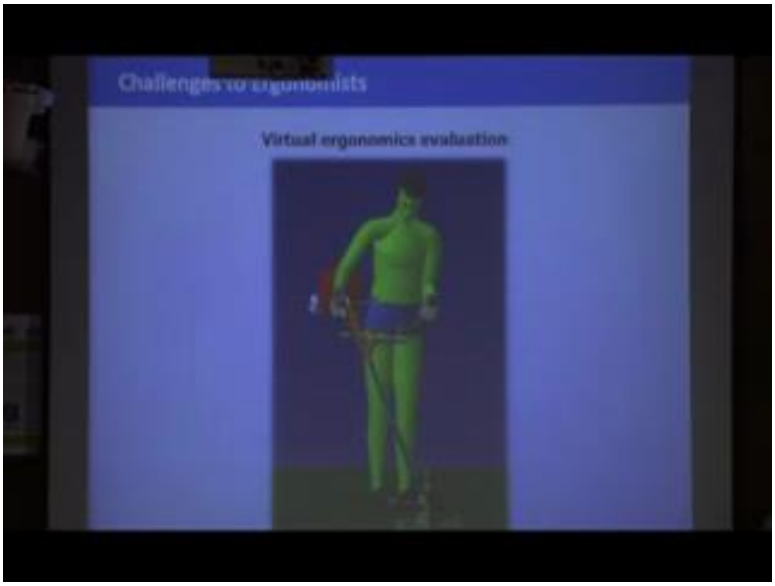

Similarly we can make the CAD model of the product. After developing CAD model of human and CAD model of the product what we can do, we can go for in surfacing these two, with the appropriate working posture. we can simulate various activities, and that time we can check, various that whether this is compatible with the human body dimension, dimensional requirement or atomic; that is atomic requirement, or biomechanical requirement, and whether that human can operate this equipment or machine comfortably unknown, in this way, using virtual environment. In virtual environment that CAD generated environment, using digital human model, using CAD product model we can evaluate, we can go for various types of ergonomic evaluation.

Fine, so far we have discussed about design, it should be in ergonomics, relationship between ergonomics and design then what is virtual ergonomics, what is physical ergonomics? And what is virtual ergonomics. Now as I mentioned I am assistant professor from Indian Institute of Technology. So, for Indian students, we want to give some information about how ergonomics originated and developed in India.

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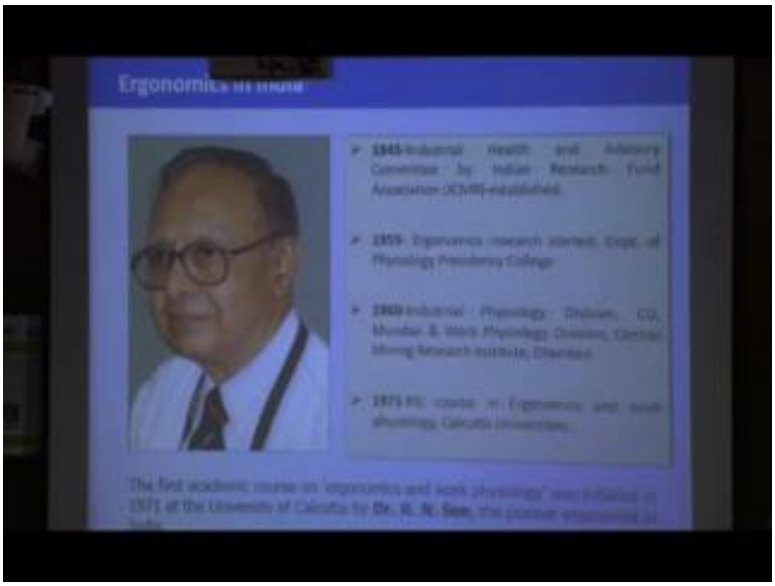

So, for that purpose in the next few slides we will discuss about ergonomics in India. In this developing country India, ergonomics actually started long back in 1945, industrial health center and advisory committee by Indian research and research fund association I C M R was established. Then, in 1955 ergonomics research started in department of physiology, presidency college Calcutta in 1960 industrial physiology division, Central

Labour Institute Mumbai and work physiology division, central mining research institute and they started research in the field of occupational health and ergonomics. Here most important thing, these are only related to research, but in 1971, first postgraduate course in ergonomics and work physiology was introduced in Calcutta University by this person. He is professor R.N.Sen, the first academic course of ergonomics and work physiology was initiated in 1971 at University of Calcutta by this pioneer ergonomist professor R N Sen.

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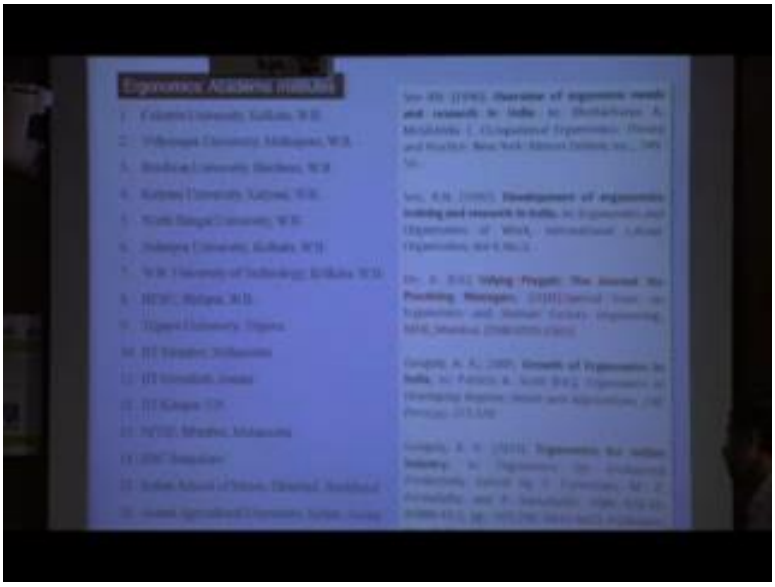

Then years after years, in so many colleges, universities they introduced course, fully fledged course on ergonomics or as a part of that curriculum they started. Presently in India there are various academic institutions, where ergonomics is been taught. So, this is a list of those colleges or universities for example, Calcutta University, Vidyasagar University, Burdwan University, Kalyani University. So, there is a many of the IITs also, then IISC Bangalore NITs. So, in many institutions of India right now these academic institutions are learning course related to ergonomics. And on the right side panel, we will find various research papers, where say overview of ergonomics, ergonomics needs a research in India.

So, that has been published in this journal. So, you can go through this thing, then, will get more ideas or more knowledge about the development of ergonomics in India. Growth of ergonomics in India by K K Ganguly in 2009, he has published. Similarly he

has another publication in 2013 ergonomics for Indian industry. So, if we go through these literatures, then will get a fair idea about history and development of ergonomics in Indian scenario, then there are many other academic institutions, where these course ergonomics or human factors related course are been taught.

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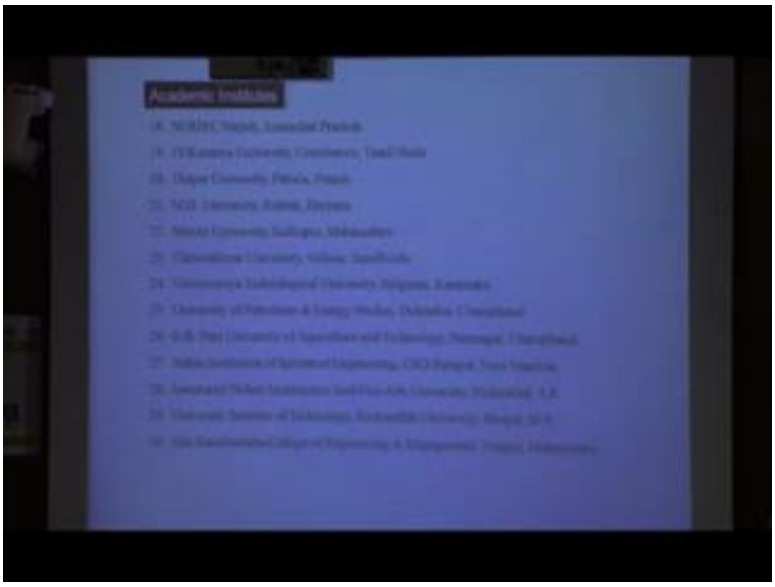

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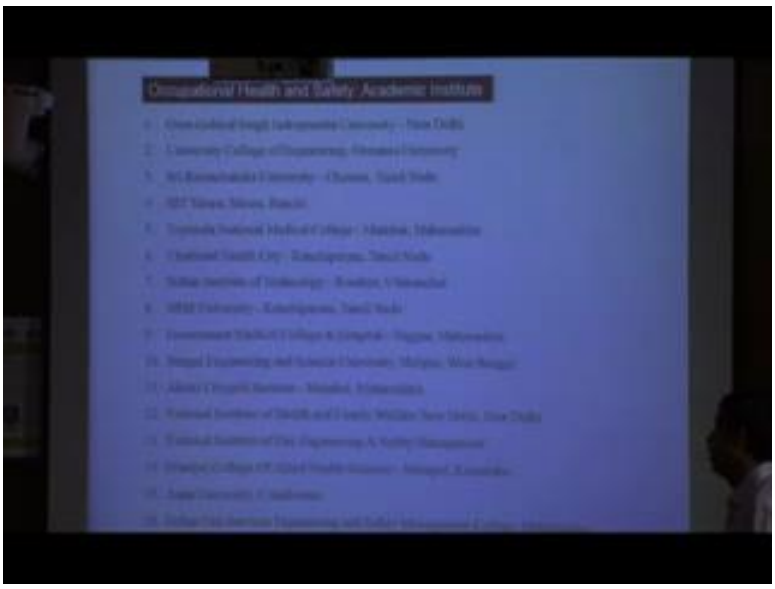

So, here I have listed almost 30 institutions, similarly in many other institutions, why they are not teaching that course with the name of ergonomics or human factors. In their curriculum they are mentioned, the similar topics under occupational health and safety.

So, these are the institutions where occupational health and safety related forces are being taught in India. So, here is also a lengthy list, you can go through one after another. So, here I have listed almost 24 institutions.

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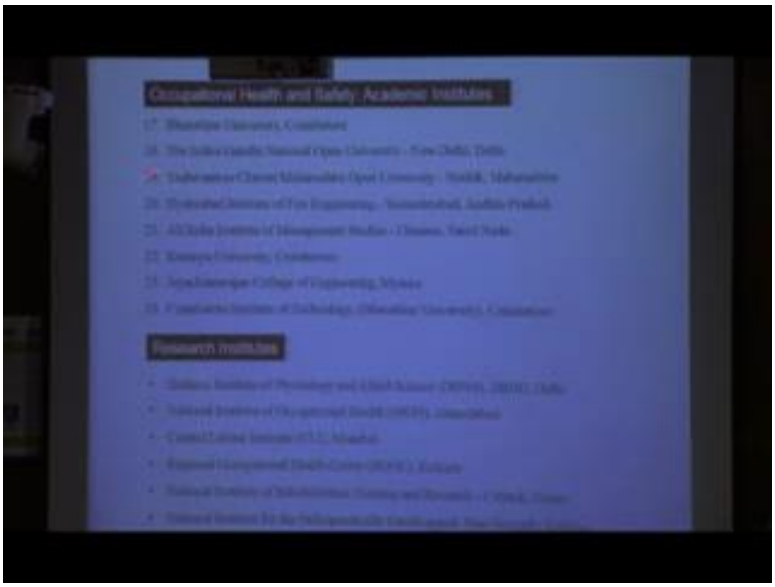

Then there are many research institutions which are dealing with research R & D. Other R & D labs on ergonomics, as well as occupational health, out of those research institutions, these are the popular one; Defence Institute of Physiology and Allied Sciences D R D O Delhi, National Institute of Occupational Health N I O H Ahmadabad, Central Labour Institute Mumbai, Regional Occupational Health Center Kolkata, then National Institute of Rehabilitation Training and Research Orissa, National Institute of Orthopedically Handicapped, it is also in Calcutta.

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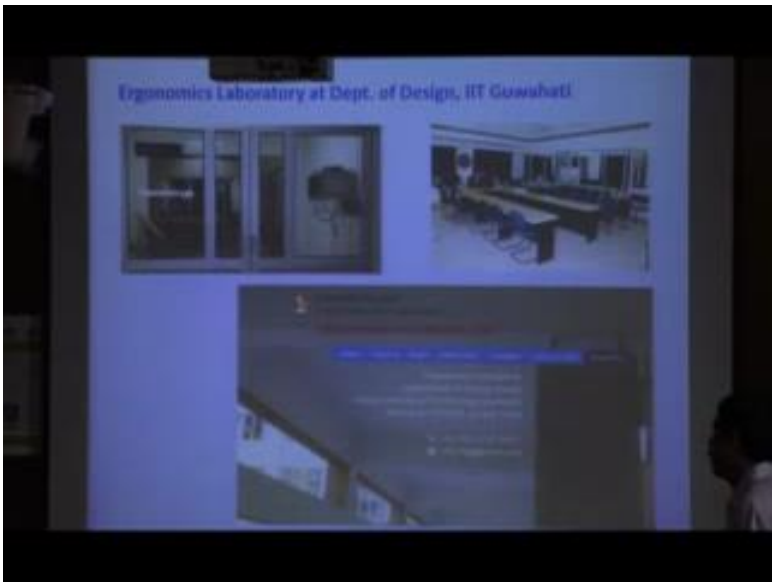

So, now there is some information related to my lab, where I am associated. This is ergonomics laboratory and department of design IIT Guwahati. So, in our lab we have the state of art facility for different types of ergonomic evaluation. So, I suggest all the students to explore this website, then, you will get much more idea about various types of facilities, and our publications, and also what types of research is going on in Indian scenario in the field of ergonomics.

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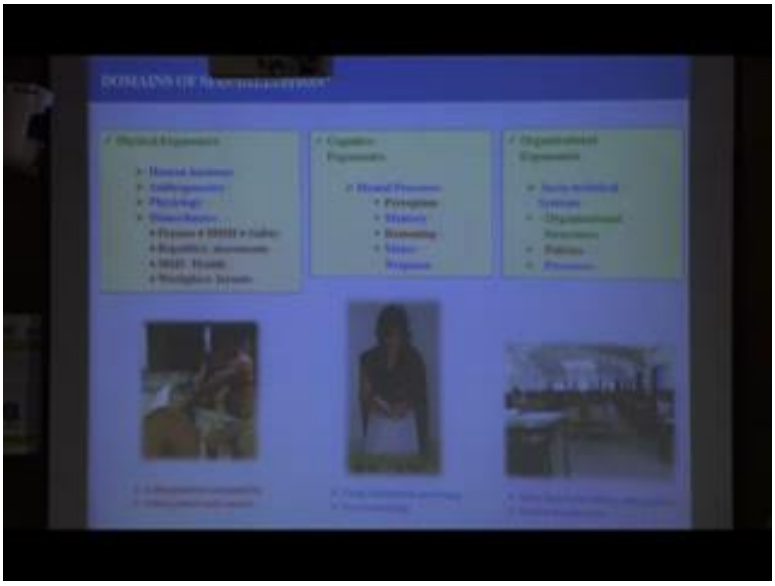

Now, domain of specialization, already we have mentioned that ergonomics, we can categorize physical ergonomics and virtual ergonomics, in terms of whether that ergonomic evaluation is going on, in physical environment or in virtual environment, but as a subject, ergonomics which is been categorize the three different domains. What are those domains; one is physical ergonomics, another is cognitive ergonomics, another is organizational ergonomics. So, these three are the domains or specialization under ergonomics. In physical ergonomics, we study these areas; human anatomy, anthropometry, physiology, biomechanics.

In cognitive mental processors, perception reasoning, motor response. Similarly in organizational ergonomics we discuss about organizational structure, policies processes. Now, here are three examples of different types of different domains. So, one is this one physical ergonomics. So, what is in this, what it is shown? It is shown whether human body dimension is compatible with the dimension of the physical dimension of the product. So, that type of compatibility study, in physical environment where we are discussing about the (Refer Time: 71:43) compatibility or posture or comfort; that it is coming under physical ergonomics.

Similarly under cognitive ergonomics, say for example, this is decision making in front of you, there are so many products, and you have to select one particular product, you have to make decision that which product you like. So, that visual information processing, or auditory information processes or decision making. So, all these are areas actually coming under cognitive ergonomics. Similarly if you look at this, this is an example of a class room in this class room example, it is coming under organizational ergonomics, mean the organization that is colleges or university, college and university administration they have decided, that how should be the size of the classroom, what should be the student teacher ratio, how should be the space layout. all these things actually decided by the organization. So, this is coming under organizational ergonomics. Now, if you go through these three domains. So, physical ergonomics, it is concerned with human anatomical anthropometric physiological and biomechanical characteristics.

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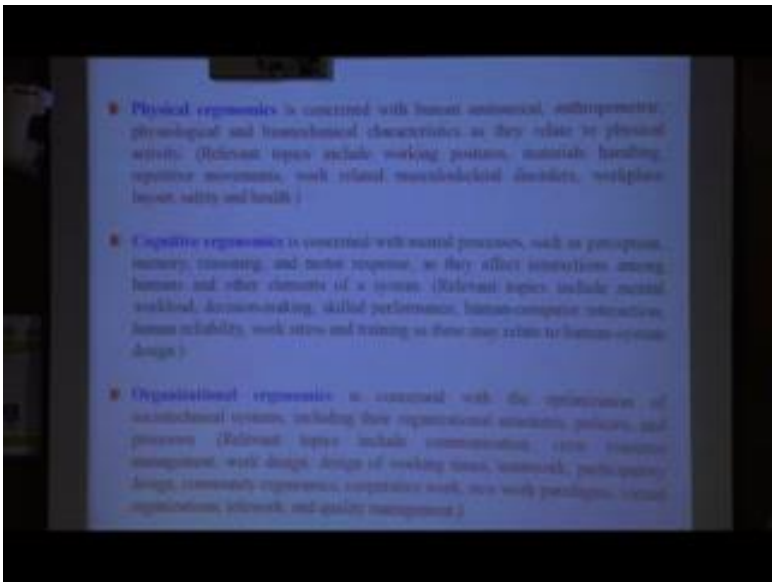

As they relate to the physical activity. Relevant topics include working postures, material handling, repetitive movement, musculoskeletal disorders, workplace, and so on. Similarly in cognitive ergonomics, is concerned with mental a process; that is perception memory, reasoning, and motor response, as they affect interaction among humans and other elements of a system. Relevant topics include mental workload decision making as we have already mentioned in the earlier slide. Like this one physical. In the next one; this is physical ergonomics, then cognitive ergonomics, the next one is organizational ergonomics.

In organizational ergonomics it is concerned with optimization of the sociotechnical system, including their organizational structure, policies, and processes. Relevant topics include communication, new response management, work design, design of working times, teamwork, participatory design, community ergonomics, and cooperative work. So, these areas are coming under organizational ergonomics. So, now, these three domains will be much more clear. So, we are giving in a. So, earlier slide we have discussed with a different example. One example is, physical one for cognitive and another for organizational.

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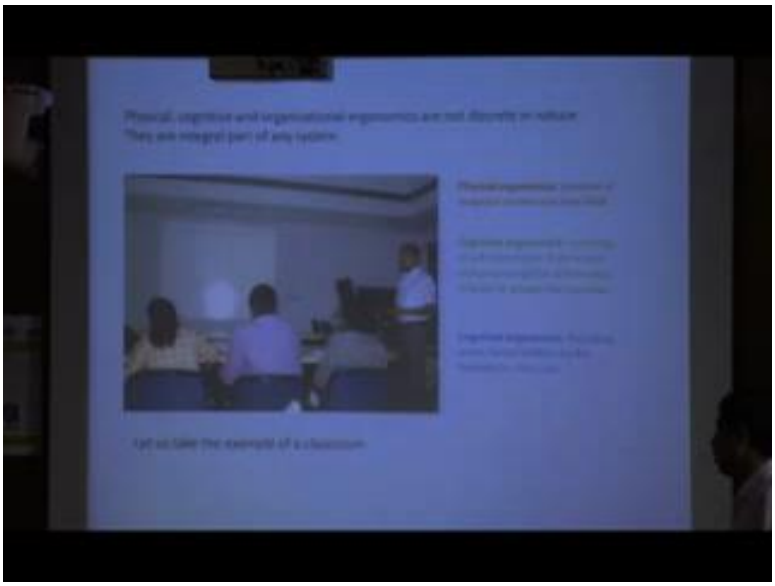

But if we combine these three domains in a single example, and how it is coming we are giving. Let us take the example this class room. In this class room, in the same actually these three domains are not separate; these are integral part of any system. These are the integral part of any discussion, while we are discussing about physical ergonomics; obviously, there is cognitive ergonomics and organizational ergonomics. See if we take this example class room. So, while teacher is interactive with the students or students, and teachers interacting with the overall workplace, then different domain of ergonomics is involved, physical ergonomics. So, where this projector screens is places, so that all the students as well as the faculty members can see it clearly.

So, positioning of the screen is very important, that positioning of that screen, projector screen, is coming under physical ergonomics, so that the students as well as teacher can visualize it very clearly without much effort, and without much neck movement. Similarly, cognitive ergonomics teacher is telling something, students are listening. Then on the projection there is some visual information, students perceive in those information. So, they are sensory moralities, particularly through vision sense, and then they are replying to teacher. So, this is coming under cognitive ergonomics. Similarly the third part is, sorry this should sufficient (Refer Time: 76:31) this should be organizational ergonomics. In organizational ergonomics what is there, in organizational ergonomics.

So, providing audio visual facilities by the institute, in this classroom whatever audio visual facilities has been provided, or whatever is the arrangement of the classroom space layout, all these actually provided by the institute. So, institute as an organization, decide that what which type of audio visual facility to be provided, or what type of the classroom layout is required, or what type of furniture we purchased for the classroom. So, all these actually decided by the organization as a whole. So, in every system, all these three domains of ergonomics can be discussed. So, we have discussed this one with the example of this classroom, in the same classroom, example we can discuss about physical ergonomics, cognitive ergonomics, as well as organizational ergonomics.

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Next moving to human factors to be considered for designer technology application, various human factors or ergonomics issues, which we need to discuss in human machine interaction. Now here if you look at this chart on y axis it is user or operator characteristics. So, these are the user or operators characteristics. On x axis it is machine or product characteristics, so human characteristics and this product or facility characteristics. Now how these two characteristics are interacting with each other. Static physical requirement from user side; users' physical requirement at the same time static physical dimension of the product or facility that is discussed under anthropometry; so what is anthropometry. So, here you can look at this color coding, these are characteristics of the user, these are the characteristics of the product, and if you look at the color coding. So, what it indicates. It indicates that anthropometry is a subject, where

we discussed about static physical requirement by the user or human and static physical dimension of the product.

While human is interacting with a product, humans physical dimension whether human physical dimension, is compatible with the products physical dimensions; that is coming under anthropometry. Similarly under biomechanics what we are discussing. We are discussing dynamic physical requirement of the human body, with dynamic physical dimension; that is coming under biomechanics. For example, one example we can give the reachability, how human can move their different body parts, mainly particularly hand or leg, or reaching or holding some object. And physical dynamic physical dimension, say if someone opening a door or closing a door. So, for that purpose how much human hand can move, at the same time what that further facility for door movement, what allowances has been provided.

Similarly, if we look at this top one; aesthetic evaluation. Under aesthetic evaluation what we do affective needs of human, at the same time ours or visual aesthetics of the product. So, that is actually coming under aesthetic evaluation. Similarly, cognitive ability of human being, and operatibility of the product and machine, it is coming under information processing. So, under information processing we discuss about what is the operational requirement of the machine or instrument, at the same time whether that is compatible with the human cognitive ability, we will discuss about that. So, with this schematic diagram, it is very clearly understood that various subject or discipline, under the field of ergonomics, is actually interaction between various characteristics of the operator, and various characteristics of the machine or product.

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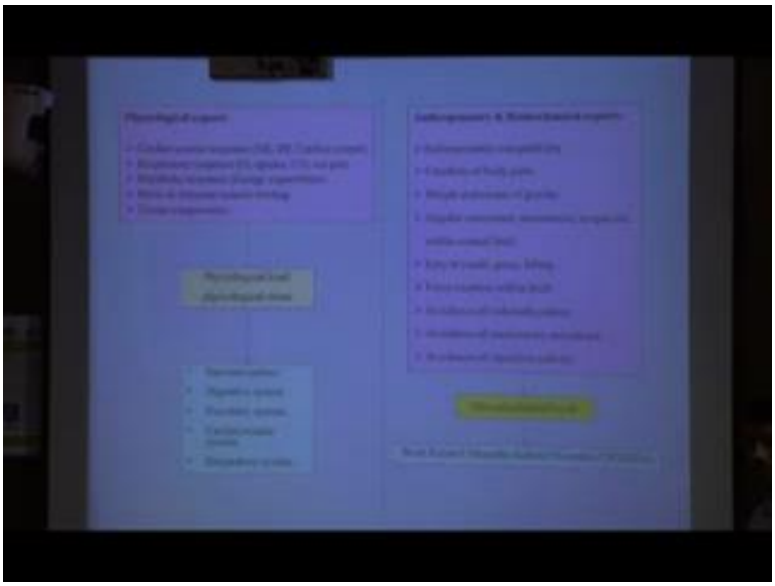

Now, in this subject ergonomics or human factors, we discussed various aspects of human or environment. Physiological aspect, under physiological aspect we discuss cardiovascular risk process, respiratory response, metabolic response, and ultimately all these response leads to, if the product or facility, is not ergonomically designed. So, what it will do. It will lead to physiological load or physiological stress, and when there is physiological load or physiological stress, it ultimately affects human body systems. There are various systems; nervous system, digestive system. So, all these systems actually will be affected by physiological stress, and human will become thin, or he or she feels discomfort.

Similarly, under anthropometry and biomechanical aspect, various issues like anthropometric compatibility comfort of body joint parts, then weight and center gravity. So, these factors we will study, and while there is anthropometric or biomechanical incompatibility, then what will happen. It will leads to musculoskeletal load. There will be enhanced musculoskeletal load. While there is musculoskeletal, enhanced musculoskeletal load, in the long run it will develop different types of musculoskeletal (Refer Time: 83:39).

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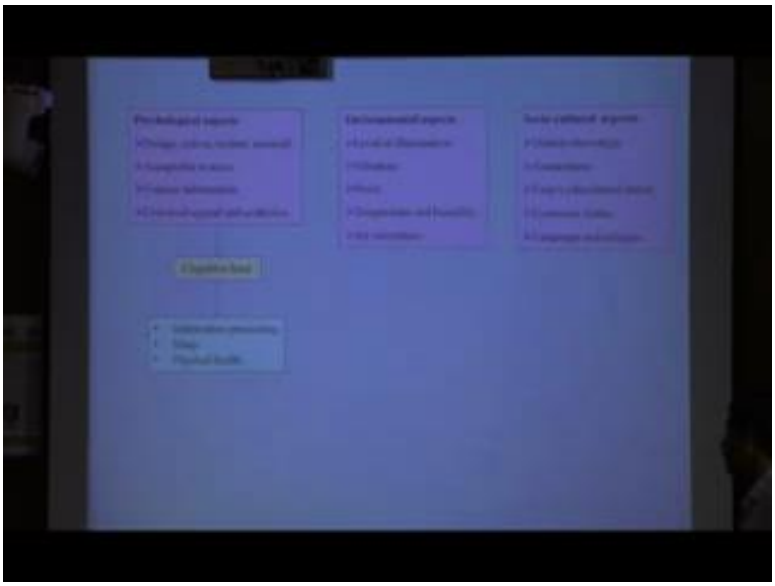

Now, various psychological aspects, in various psychological aspects we discuss about design, color, texture, material of the product, concise information, universal appeal and aesthetics. So, this psychological aspect ultimately relate to cognitive load. So, whatever information, is been provided, by the instrument or human being is perceiving from that instrument or product, that ultimately increasing the cognitive work load of the human. If cognitive work load is high, what is cognitive work load? Cognitive work load is the human perception about the work being performed. If he feels that work is difficult, if he feels that work is taking much mental effort or physical effort, then his cognitive work load is more.

If cognitive work load is high, then it will affect information processing, it will tell there will (Refer Time: 84:51) either other, there will be, it will also affect physical health. Then under ergonomics, we also discussed about various environmental aspects. We mentioned already that level of illumination noise, vibration, radiation, and all these factors we studied. Similarly there are also other aspects like sociocultural aspects. Under sociacultural aspect, we discussed about motion stereo type and they (Refer Time: 85:23) left hand wave, right hand wave, uses, educational status, economic status, language engineers. So, many other issues actually discussed under the field of ergonomics.

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Now, moving towards the application, we already discussed why ergonomics is important in the field of design. Now if we talk about application why ergonomics is been applied. Answer is ergonomics is applied everywhere, where there is human there is application of ergonomics, and we have already defined that ergonomics is interaction between human, and these are all work limit. So, while human is interacting with any short of product, or process or article or artifact, everywhere there is requirement of ergonomics. If any industrial or occupational sector, starting from aerospace engineering, agricultural sector, fashion technology, health care, everywhere there is application of ergonomics. Even if we say that we want to design something for our pet dog or cat. In that case also we have to think, we are designing what they say one (Refer Time: 86:52) for that cat or dog. We are not designing for them only; we are designing for human convenience. So, ultimately whatever you are designing that always have to keep in mind the human need, human requirement.

Now, this is always very small list, in any field there is application of ergonomics. So, here are some examples are given; say for example, virtual environment, we are using we are going for ergonomic evaluation, in all the places references are provided. If aerospace and aviation sector, there is also use of ergonomics, how we can design this navigation (Refer Time: 87:36) then this type of helmet, then in various industrial sector how we can use the knowledge of ergonomics, for betterment of the occupational health

for providing their better infrastructure facility. So, that should, can work easily comfortably.

Similarly, not only this type of industrial sector or aviation sector even garment industry, ergonomics is important, because we have to think that how that garment should be designed. Not only it should be fitted with the human body at the same time you have to think that material of the garment, or fabric type of the fabric or material. It should be such that after wearing that garment; one should feel comfortable he or she should not sweat. Or it should not feel feeling of too hot or it is too tight at the same time when someone is wearing some cloth, he or she must have the normal range of motion of body parts. It should not restrict at the leg movement or body parts movement. So, that much allowance should be given in the design. Similarly ergonomics is used in different types of industrial product design, then automobile industry, automobile sector vehicle design, we use, we consider ergonomics, so that design can be improved.

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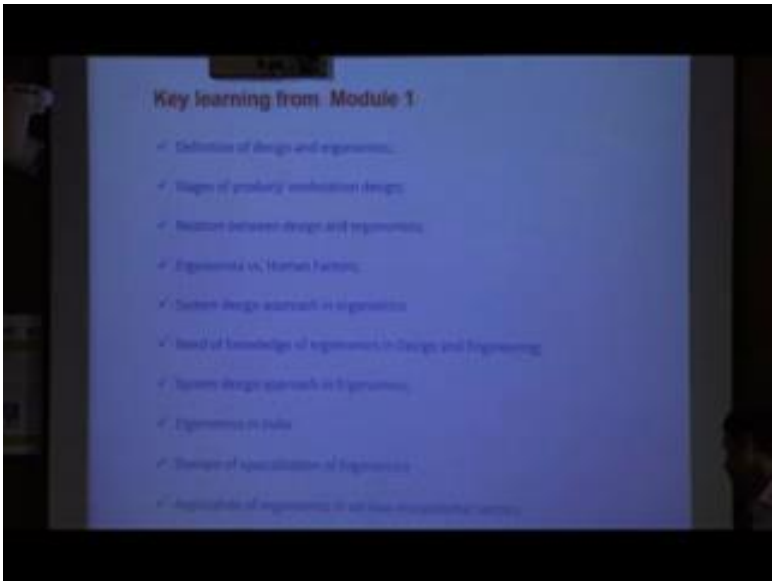

So, now key learning from module one, so far what we have learnt. So, first we discussed about definition of design and ergonomics. What is design, what is ergonomics, then stage of product, workstation design. So, what are the key defined have we mentioned, that three conceptual phase, conceptual phase, pre designed stage, detailed designed stage. So, various stages in the design process then relationship between design and ergonomics, then whether ergonomics are human factors, these two

words are different or they are same means synonymous. Then system design approach in ergonomics, we have discussed about that, you know when knowledge of ergonomics is required in field of industrial design or engineering. System design approach in ergonomics already we have mentioned, then another is ergonomics in India, how the subject ergonomics has been introduced in India, and how it is developing, or it is flourishing that is also discussed.

We discussed about various academic institutions, research institutions, where this type of ergonomics or occupational health and safety related courses have been taught. Then we discussed about domain or specialization of ergonomics. You talked about physical ergonomics, cognitive ergonomics, and organizational ergonomics. Then at the end we discussed application of ergonomics in various occupational or industrial sectors. and in this slide we mentioned, particularly that ergonomics is such a subject, its requirement is in everywhere, any facility product or any process, which is used by human, which is for the human or by the human or of the human. There is obviously, requirement of ergonomics.

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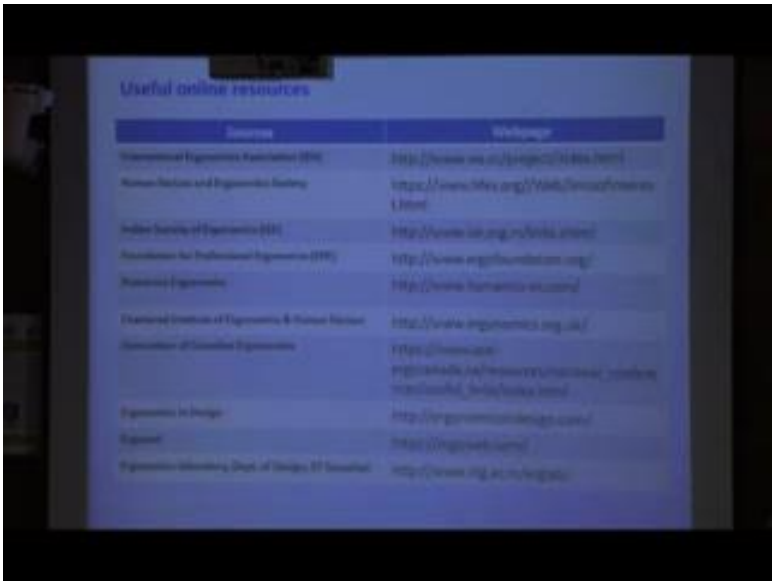

Now, you can note down these. All these information that there are various useful online resources, you can go through all these resources to get so many, other information which has not been covered within these slides. So, all these resources are very important. I suggest all of you to explore those links.

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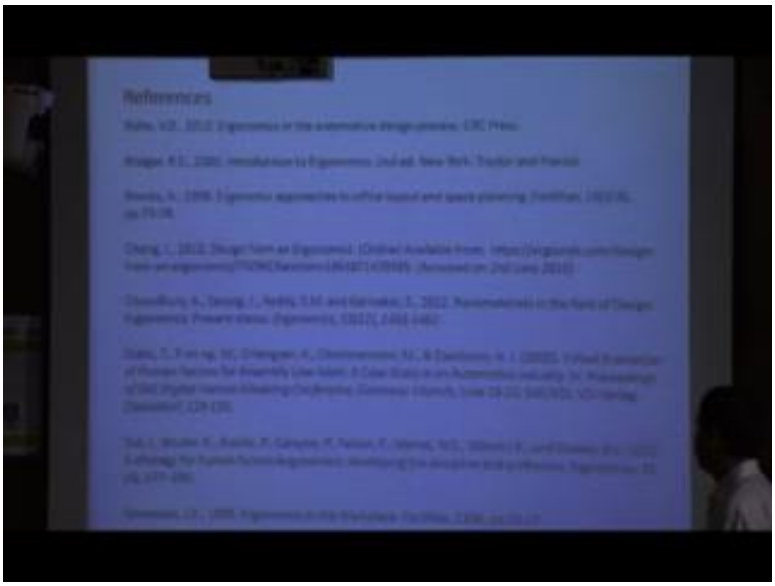

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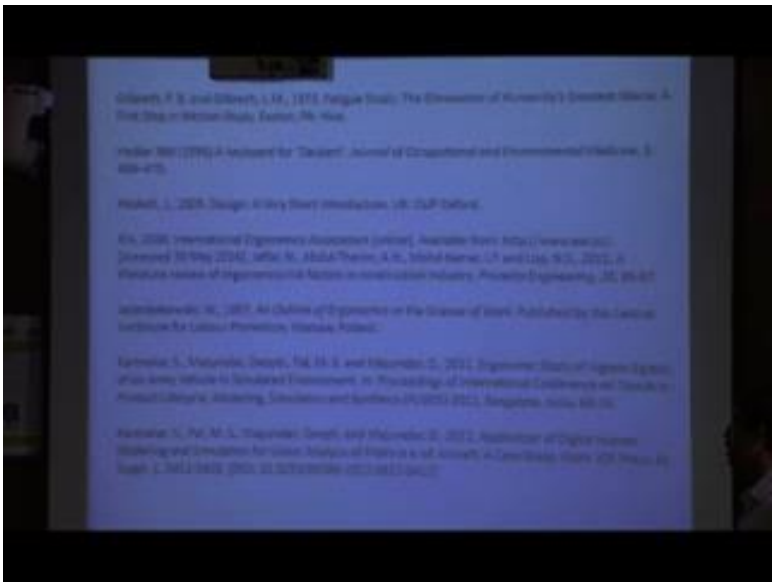

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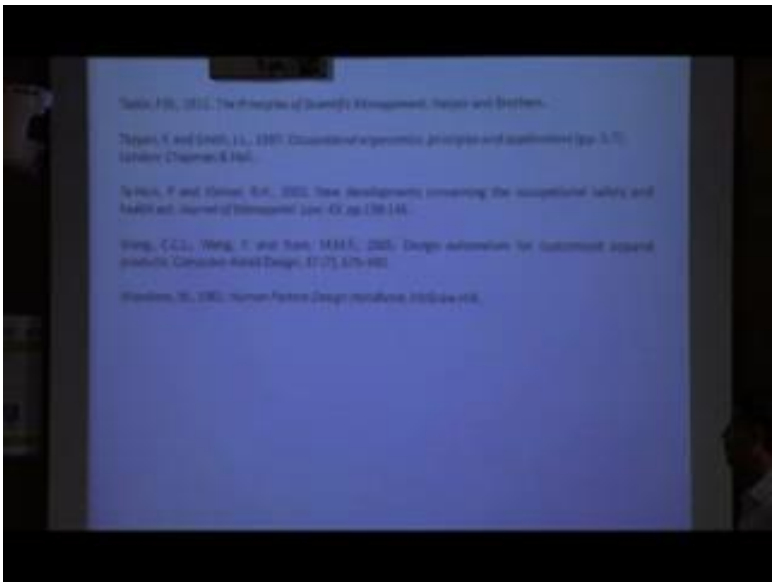

And these are the references, which I have used in various slides, or preparing the slides.

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And at the end thank you all and this is a beautiful campus of our institute; that is Indian Institute of Technology, Guwahati. I welcome you all to this beautiful campus.

Thank you.