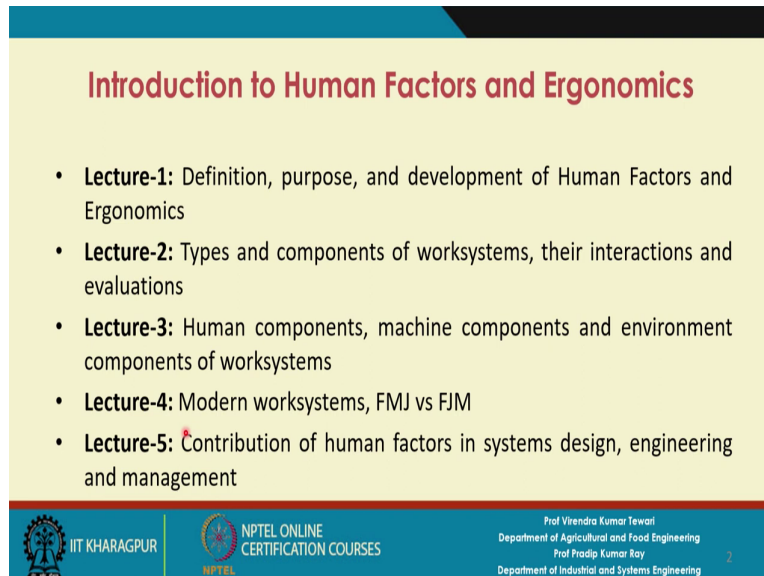


Human Factors Engineering
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Lecture - 01
Definition, purpose, and development of Human Factors and Ergonomics

Dear participants, this is the 1st week, 1st lecture session and we will be discussing some introductory issues related to the course called Human Factor Engineering. When we refer to such introductory lecture sessions on human factors engineering we refer to certain topics.

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Introduction to Human Factors and Ergonomics

- **Lecture-1:** Definition, purpose, and development of Human Factors and Ergonomics
- **Lecture-2:** Types and components of worksystems, their interactions and evaluations
- **Lecture-3:** Human components, machine components and environment components of worksystems
- **Lecture-4:** Modern worksystems, FMJ vs FJM
- **Lecture-5:** Contribution of human factors in systems design, engineering and management

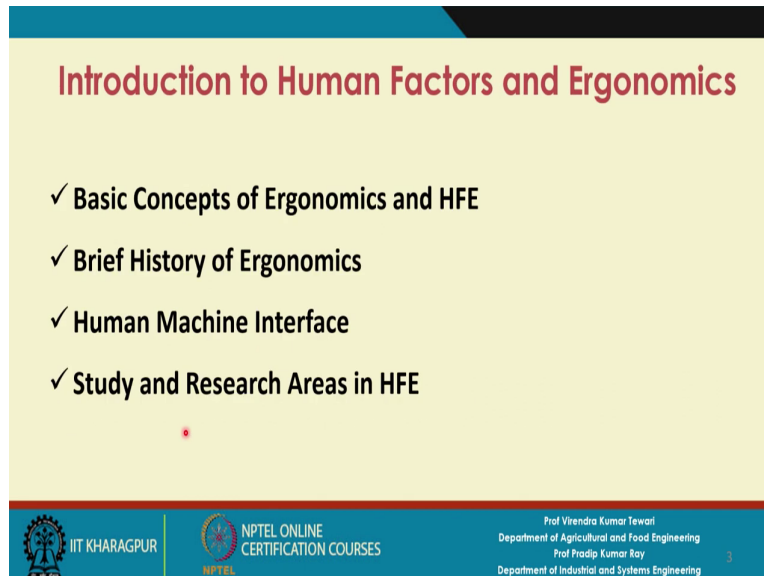
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In the 1st lecture we will be defining different terms and terminologies related to human factors engineering, the purpose of this particular course or this particular discipline and we will also refer to the development of human factors in ergonomics aspects.

In the 2nd lecture we will define and explain the different issues related to types and components of the work systems, their interactions and evaluations. In subsequent three lectures we will be discussing in detail the human components, machine components and environmental components of different types of work systems. In next lecture, we will be referring to the modern work systems and the concept of fit man to job versus fit job to man.

And in the last session we will be discussing the contribution of human factors in systems design, engineering and management.

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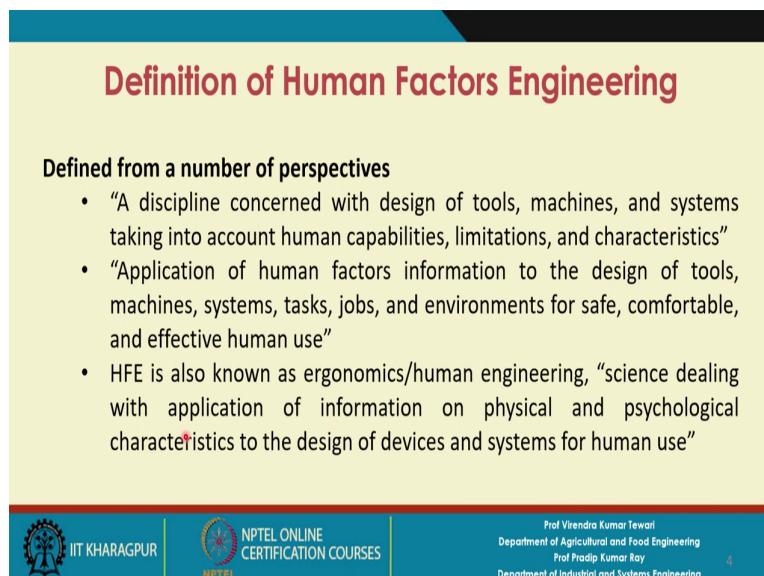
Introduction to Human Factors and Ergonomics

- ✓ **Basic Concepts of Ergonomics and HFE**
- ✓ **Brief History of Ergonomics**
- ✓ **Human Machine Interface**
- ✓ **Study and Research Areas in HFE**

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Now, the next half an hour or so, I will be discussing the certain important issues like, basic concepts of ergonomics and human factor engineering, brief history of ergonomics, human machine interface and the study and research areas in human factor engineering.

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Definition of Human Factors Engineering

Defined from a number of perspectives

- “A discipline concerned with design of tools, machines, and systems taking into account human capabilities, limitations, and characteristics”
- “Application of human factors information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use”
- HFE is also known as ergonomics/human engineering, “science dealing with application of information on physical and psychological characteristics to the design of devices and systems for human use”

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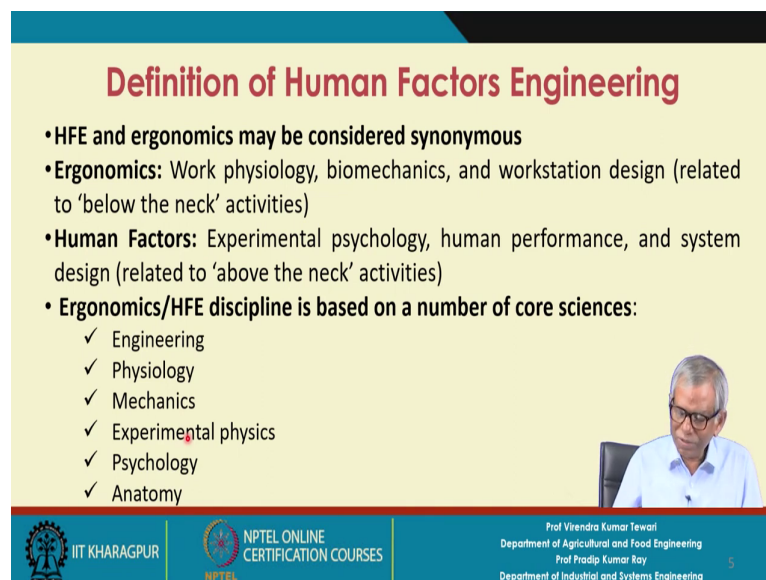
As you may be aware, that human factor engineering is a well-established discipline and this discipline has been defined from a number of perspectives. Whenever we use human factors engineering there are certain other synonyms also we use like, ergonomics, human factors, etc. and in certain cases even we use the term ‘human engineering’; these terms and terminologies are all synonymous. Human factors engineering we try to define as “A discipline concerned with the design of tools, machines and systems taking into account human capabilities, limitations and characteristics”.

A large number of researchers, a large number of practitioners, they have define human factors engineering from several perspectives.

Human factors is nothing but application of human factors related information to the design of tools, machine, system, tasks, jobs, environments for safe, comfortable and effective human use. The basic purpose of ergonomics or basic purpose of human factors is design.

Human factor engineering is also known as ergonomics human engineering in certain context. And it is basically a science dealing with application of information on physical and psychological characteristics to the design of devices and the products or the systems for human use. So, the most simple definition of human factors or ergonomics is, the design for human use.

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Definition of Human Factors Engineering

- **HFE and ergonomics may be considered synonymous**
- **Ergonomics:** Work physiology, biomechanics, and workstation design (related to 'below the neck' activities)
- **Human Factors:** Experimental psychology, human performance, and system design (related to 'above the neck' activities)
- **Ergonomics/HFE discipline is based on a number of core sciences:**
 - ✓ Engineering
 - ✓ Physiology
 - ✓ Mechanics
 - ✓ Experimental physics
 - ✓ Psychology
 - ✓ Anatomy

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Our focus is the human beings and when we define human beings, we say what is their capabilities, their potential and their limitations. Essentially, this is a challenging assignment; you need to create a work systems for everyone. Otherwise, whenever we talk about work system, the work system is designed based on the tasks.

But, today the work system is to be designed based on the capabilities and limitations of the humans. HFE or human factors engineering and ergonomics may be considered synonyms and when we talk about ergonomics we say it is originated in European countries.

This is referred to as the European ergonomics. The focus is work physiology, biomechanics and work system design or work station design related to 'below the neck' activities; the kinds of activities you do as a human being at any workplace. What you will find, that certain physical activities you carry out are essentially 'below the neck' activities. You carry out many other activities, which are referred to as 'above the neck' activities. So, when we talk about 'above the neck' activities, we say that it should be the human factors related issues.

Human factors as a discipline which is originated actually in US and the human factors when we talk about, we refer to experimental psychology, human performance and the system design. Initially the society for ergonomics was established in European countries and Europe, and human factor society was established in US. But, today what has happened is that, these two societies have merged together and we have just one society called ergonomics and human factors.

Whenever we refer to the ergonomics or human factors engineering discipline, we refer to the several core sciences like, engineering, physiology, mechanics like, biomechanical modelling, biomechanical evaluation, experimental physics, psychology, anatomy of human being, etc.

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Purposes of HFE

- An ergonomist should first identify and assess the problem(s), and suggest improvement alternatives for a worksystem
- Interaction/interface design is most crucial
- Designing for human use
- Design improvement is the main objective of HFE
- An interdisciplinary approach needs to be used for analysis and design
- Whatever may be 'design level' of a product/process/system of all types, there is always a scope of improvement
- Example: 1. Pin(1834) to stapler pin (1954): 120 years
2. Original paper clip (1814) to present paper clip (1934): 120 years

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Now, we have already explained to you the basic purpose of this course. If you have knowledge on human factors engineering, then what is the advantage you will have? An ergonomist should first identify and assess the problems. Ergonomics or human factors engineering is applicable for the human beings at the workplace.

The workplace is to be defined, work system is to be defined in details. And then I should specify or I should design the interaction between humans and other components of the work system.

So, the basic focus is interaction and interface design, in today's context, even if the machine component is fantastic or the person concerned is also having excellent performance; but when you put the person on the job, when you put the person on the system you never know. How and what will be the interaction?

The interaction in design is very complex subject, there are many issues involved and all those important issues related to different types of interactions we will be discussing. What kinds of tools and techniques you should use, what sort of the methodologies you should use, so that you can explain the human performance with respect to the factors related to the interaction.

Design improvement is the main objective of HFE. There are many examples, you may be aware of the concept called 'design level' and you also must be aware, that in a given

condition the design has become fully matured. And when you say the design is fully matured, whether it is to be supported by the human beings or not.

So, whatever may be the design level of a product process system, there is always a scope for improvement. One example; way back in 1834 the pin was designed. And the stapler pin was designed in 1954, that means it took 120 years. Even today you cannot say that the stapler pin, the design is available from the interaction point of view, whether it is fully matured or not.

That is the basic assumptions, that we will try to apply ergonomic principles and the existing design from the ergonomics point of view; we must be able to assess existing design and always there should be a scope for improvement. There is another example: the original paper clip was introduced in 1814 and the present paper clip was introduced in 1934.

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History of Ergonomics and Human Factors

- **Stone age:** Design and use of hand tools
- Ramazzini in 1717 wrote a book '**The Disease of Workers**'
 - ✓ Occupational hazards, type of work, RMI, CTD, Body posture, mental stress
- **La Mettrie in 1748:** Comparison between human and machine capability
- **Industrial Revolution:** references to 'human-centred design'
 - ✓ 'Interesting' tasks for operator and 'repetitive' tasks to machines
- **Taylor, Frank and Lillian* Gilbreth:** Time and motion study

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The ergonomics term was used for the first time by a police gentleman who comes from Poland and his name is Wojciech Jastrzebowski, way back exactly 175 years ago, in 1857. He used this term called 'ergonomics'. Later on in some certain cases one school of thought tried to link it with economics also.

'Ergo' means there is a work and 'nomos' means loss. The application of ergonomics and human factors, you find even in the Stone Age knowingly or unknowingly. Like whenever you talk about the design and use of hand tools, we refer to the Stone Age.

When you assess the design, certain ergonomic principles the designer used to follow. Later on in 1770 once when you refer to the recorded history, we find a person named Ramazzini, in 1717 wrote a book 'The Disease of Workers'.

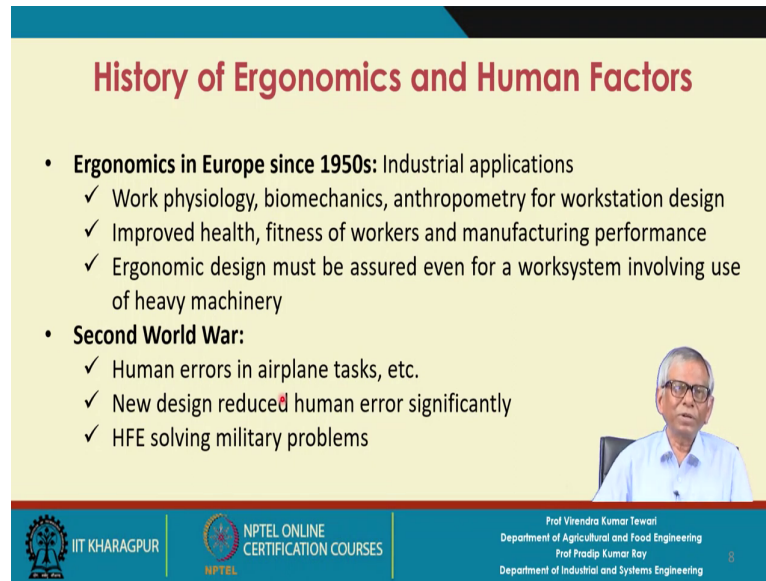
Where he refers to the occupational hazards, the type of work or the type of jobs, we will discuss certain aspects of RMI, that is repetitive motion injuries and the CTD-cumulative trauma disorders. Then the body postures and the mental stress.

Later on, La Mettrie in 1748 compared between the human and the machine capability. In today's context you may be knowing about the contribution of the Drake Taylor, he is referred to as the father of scientific management. In the past, the human has been the first and today the system has become the first.

That means, we will focus on definitely human beings while designing a system, but the first thing we must care is the quality of the system. The industrial revolution has impact on the quality of the work systems. To what extent, you can propose an 'human-centred design'; Whether you can make the task very interesting for the operators and the interesting task will be given to the operators and the repetitive task will be given to the machines. Later on, when we refer to the time and motion study not directly, but indirectly, we are trying to measure the job in terms of time units.

There is a lot of limitations. When we try to measure the job from the ergonomics or the human factors principles, we say that here is the job given to you, what is the physiological cost of the job? The physiological cost of the job you have to measure.

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History of Ergonomics and Human Factors

- **Ergonomics in Europe since 1950s:** Industrial applications
 - ✓ Work physiology, biomechanics, anthropometry for workstation design
 - ✓ Improved health, fitness of workers and manufacturing performance
 - ✓ Ergonomic design must be assured even for a worksystem involving use of heavy machinery
- **Second World War:**
 - ✓ Human errors in airplane tasks, etc.
 - ✓ New design reduced human error significantly
 - ✓ HFE solving military problems

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That is one important aspect and then we will be referring to the history of ergonomics and human factors, when we refer to the ergonomics in Europe since 1950s. What are kinds of industrial applications? We refer to the work physiology, biomechanical modelling, anthropometry for work station design.

To what extent the manufacturing performance is related to improved health or deteriorating health or the fitness of workers or the work capacity of the workers. Ergonomics design must be assured.

Even for a work system involving use of heavy machinery or underground mining ergonomics cannot be applied. Whatever may be the quality of work systems or the systems or the manufacturing system or the service systems, the ergonomic principles can be used and have to be used.

During Second World War there are lots of applications of the ergonomics or the human factors like, human errors in airplane task, etc. During the Korean War, 95% of the airplane accidents happened during the training session, not in the actual combat. The main reason is the cockpit in the aircraft cockpit design was not perfect from the ergonomics point of view.

In that sense the kinds of interfaces they used to have in the cockpit, it's not acceptable. Ultimately, this system is forcing you to make errors, which is called human errors. So,

whenever we talk about ergonomics one of the important objective is, to what extent you can control the human error.

The human error is to be controlled significantly. One of the objectives and human factors engineering is solving military problems.

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History of Ergonomics and Human Factors

- **Introduction of computers at workplaces, since 1980s:** High-tech workplaces, specific problems are solved using HFE
 - ✓ What are the main problems you face while you work at a computer workstation?
- **Civilian applications of HFE in US:**
 - ✓ FHA, NASA, Traffic safety administration, closed space (underground mining), NIOSH, Nuclear power plants
 - ✓ In manufacturing sector, since 1960s, companies like Eastman-Kodak, IBM, etc.
 - ✓ Worked on consumer product design, computers and software systems

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If you apply human factors principles or you propose a human factors based design, even in the extreme cases the health of the human beings or the fitness of the human beings or the capacity of the human beings are assured. Now, in almost of all workplaces the computers have been introduced.

Specific problems are solved using HFE, that means, you propose a new technology and the old problems vanished, but the new problems may come. And what we find that if you apply the human factors based design, many times it will be a flexible design and always you are on the path of continuous improvement and design. So, one important question we may raise is- what are the main problems you face while you work in a computer workstations?

Now there are many civilian applications of HFE particularly in US. First one is the Federal Highway Administration, the NASA, the traffic safety administration, the closed space underground mining, the faced drilling operations in underground mine, the NIOSH(National Institute of Occupational Safety and Health), and nuclear power plants.

In manufacturing sector, 1960s companies like Eastman-Kodak IBM; In all such case studies you should refer to and there are many persons that worked on consumer product design, computers and software systems.

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History of Ergonomics and Human Factors

- **Human Factors Society in USA changed to Human Factors and Ergonomics Society**
 - ✓ Both body and mind must 'fit' with a job as designed
- **Due to industrialization at a very fast rate in recent times, many kinds of ergonomic problems are identified, being the sole cause of MSDs, industrial injuries, poor health status, severe work stress**
 - ✓ Many such problems remain hidden
- **Ergonomic design and development of work systems address these problems**
 - ✓ Solution leads to '**Best Possible Interface**' between human and machines/systems/products

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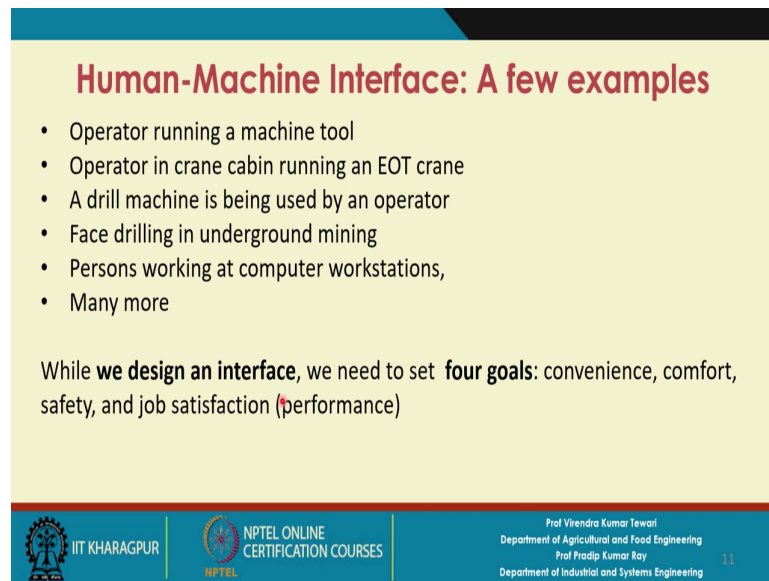
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Initially the society human factor society was created in US. So, both body and mind must 'fit' with a job as designed. Previously because of historical reasons, nobody used to bother about the mind part. But, today, without bothering about the mind part, how can you say that this is a good design? We make sure that you stand in front of the machine or you are using a product within a system, with the work systems, now we have to make sure that your body is with the job and your mind also with the job. The main advantage is that you become intrinsically motivated and the job satisfaction will be at the highest level.

If the job satisfaction is at very high level, the workplace, the organization becomes sustainable. Due to industrialization at a very fast rate, in recent times, many kinds of ergonomic problems are identified being the sole cause of MSDs (Musculoskeletal Disorders). Industrial injuries become very common, poor health status and severe work stress.

That means while we refer to ergonomics and human factors engineering, all kinds of jobs being carried out by people at all strata of the society you have to look into. The ergonomic design and development of work systems leads to best possible interface.

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Human-Machine Interface: A few examples

- Operator running a machine tool
- Operator in crane cabin running an EOT crane
- A drill machine is being used by an operator
- Face drilling in underground mining
- Persons working at computer workstations,
- Many more

While **we design an interface**, we need to set **four goals**: convenience, comfort, safety, and job satisfaction (performance)

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Certain examples like, operator running a machine tool, everywhere is visible. Many types of machines have different kinds of operators. Operator in crane cabin running an EOT crane, a drill machine is being used by an operator, face drilling in underground mining, , persons working at computer workstations.

While we design an interface we need to set four goals-first one is working method should be convenient. And also the product which you use or the system or the particular machine you are handling must be convenient to use.

Then second one is- you must have the comfort and a safe working place and the last one is the job satisfaction.

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Study and Research Areas in HFE: Important Ones

- Human-computer interface
- Physical work environment
- Control room design of process plants
- Interface design of FMS and other high-technology based system
- Human errors and reliability
- Development of appropriate technology
- Work organization design (e.g. shift schedule)
- Musculoskeletal disorders/RMIs
- Job/task design and occupational health
- Ergonomic Performance System

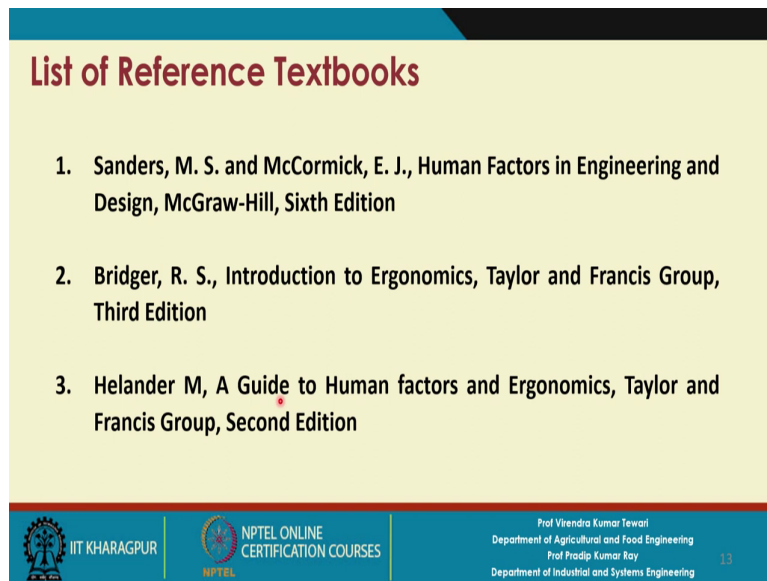
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These are the research areas, human-computer interface, Physical work environment, control room design of process plants, interface design of FMS flexible manufacturing system and other high-tech based systems, human errors and reliability, development of appropriate technology, work organization design like the shift schedule, the musculoskeletal disorders and repetitive motion injuries, job or test design and occupational health and operational performance and financial performance.

Now today we are referring to ergonomic performance systems, we will also discuss the ergonomic performance systems in detail.

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List of Reference Textbooks

1. Sanders, M. S. and McCormick, E. J., Human Factors in Engineering and Design, McGraw-Hill, Sixth Edition
2. Bridger, R. S., Introduction to Ergonomics, Taylor and Francis Group, Third Edition
3. Helander M, A Guide to Human factors and Ergonomics, Taylor and Francis Group, Second Edition

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In the next lecture session, we will be referring to the details about the work systems.