Engineering Psychology

Prof. Naveen Kashyap

Department of Humanities and Social Sciences

Indian Institute of Technology, Guwahati

Week-01

Lecture-01

Introduction - 1

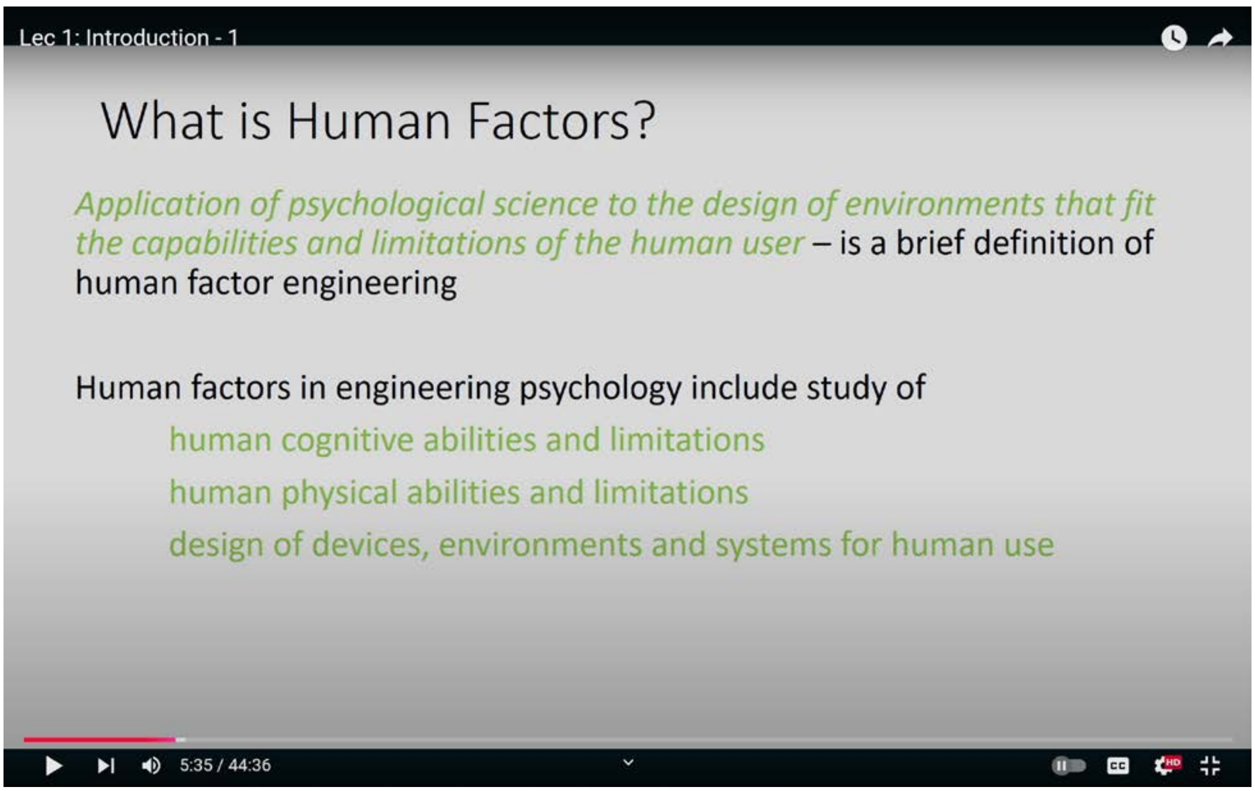
Namaskar, viewers. Welcome to this first lecture of the course on Engineering Psychology. In this introductory lecture, I will guide you through the fundamentals of engineering psychology. As we move forward in subsequent lectures, we will explore various facets of this field. However, the focus of today's lecture is to introduce the concept of applying psychology within the realm of engineering.

(Refer Slide Time: 00:36)

The term "engineering psychology" can often be misunderstood. Contrary to popular belief, engineering psychology is not directly related to traditional engineering disciplines. Instead, it involves applying psychological principles to address challenges in engineering and the natural sciences. This field helps in designing systems that enhance and complement human users.

To begin, let me illustrate this with an example. Last year, there was a tragic train accident in Orissa. Two trains collided, one was stationary, while the other approached at a significant speed. The accident occurred at night, and one of the trains was carrying passengers. This collision resulted in the unfortunate loss of lives, including the train pilot and several passengers. Although an official inquiry was initiated, the reports have yet to be made public. It appears, however, that the accident was caused by a misinterpretation on the part of the train engineer.

(Refer Slide Time: 05:35)

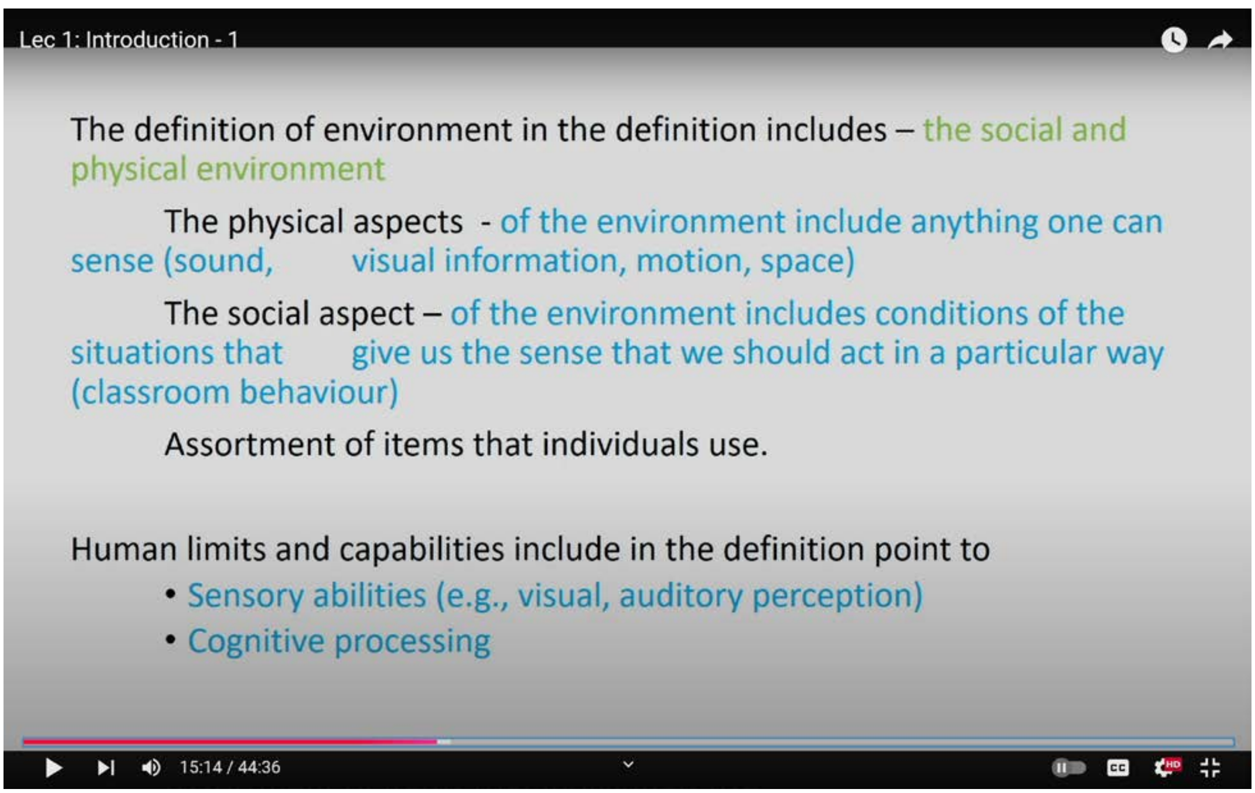


In this case, the train pilot misread a visual display or signal, causing the passenger train to accelerate. Additionally, a failure on the part of the station manager resulted in both trains being directed onto the same track. This accident could have been easily prevented by applying principles of human engineering.

Let us consider another example. You may have encountered automatic doors in various locations. Recently, while visiting a well-known mall, I came across automatic glass doors operated by sensors. Children, in particular, enjoy playing with such doors in malls. One of these doors had sensors that detected movement to open and close accordingly. However, in this instance, a child ran toward the door without realizing that it operated automatically. Unfortunately, the sensor failed to detect the child's movement, and the door remained closed, causing the child to collide with it. The child was injured and required hospital treatment. Once again, this issue could have been avoided by incorporating appropriate visual or auditory warning signals based on human engineering principles.

These two examples clearly demonstrate how psychological principles can be integrated into engineering to improve human-machine interactions and make them more effective. Now, let us begin by defining what we mean by human engineering or human factors.

(Refer Slide Time: 15:14)



So, by definition, human factors involve the application of psychological science to the design of environments that accommodate the capabilities and limitations of human users. Although this is a brief and narrow description of human factors engineering, it captures the essential aim of engineering psychology. It asserts that engineering psychology draws on principles from experimental and cognitive psychology, examining the capabilities and limitations of both users and systems to help design interactions between them. The goal is to ensure that these interactions are both efficient and productive.

Returning to the example of the glass door I mentioned earlier: if visual signs, either written or illustrated, had been placed on the door to indicate that it was automatic, or to caution individuals to wait for the sensor to open the door, the accident involving the child could have been prevented. This kind of knowledge can be used to design safer environments for human-machine interaction.

Now, what does the study of human factors engineering include? I have mentioned three key aspects. The study of engineering psychology encompasses the investigation of human cognitive abilities and limitations, human physical activities, abilities and limitations, and the design of devices, environments, and systems for human use. Let’s take each of these in turn.

Human Cognitive Abilities and Limitations:

This includes all cognitive functions such as perception, attention, problem-solving, decision-making, and thinking, among others. An illustrative example is the design of casinos. What can we learn from the psychology of decision-making in such environments? One insight is that many humans are impulsive and tend to prefer smaller immediate rewards over larger, delayed rewards. Additionally, there is a correlation between personality types and risk-taking behavior. Another simple example could relate to attention and memory span. Most users have a limited memory span, so designing systems or websites that present limited information at any given time can enhance user interaction with the system.

Human Physical Abilities and Limitations:

As engineering psychologists, it is important to recognize that humans have finite physical capabilities. Certain actions are within the physical range of what humans can do, while others exceed those limits. For instance, turning 180 degrees in one direction or moving both hands in opposite directions simultaneously is physically impossible for most individuals. Controls that require such movements are likely to fail. Consider a typical car, which has three controls, yet humans only have two legs. This is a prime example because the operator has to manage three controls with only two legs, which can lead to accidents. At best, two legs can operate two controls or perform two actions simultaneously.

Design of Devices, Environments, and Systems for Human Use:

Devices are created to assist humans, and their design, whether related to the interface or control mechanisms, should be intuitive, allowing operators to easily understand various states of the device. For example, consider a printer: the power switch should clearly indicate the device's state, with a non-lit state signaling "off" and a lit state signaling "on." This makes it easier for users to interact with machines. Similarly, environments can be designed to assist users in interacting with them more effectively. For instance, environmental supports can be incorporated to help users perform tasks more efficiently. Systems, too, should be designed in ways that benefit the user and facilitate positive interactions.

Thus, human factors engineering or engineering psychology encompasses the study of these three primary factors or variables. Now, if we were to redefine the concept of human factors, especially in the context of psychology, the definition might be phrased as follows: Human factors refer to an area of applied psychology where knowledge of psychological principles is used to design environments that accommodate the limitations and capabilities of human users. While this definition is quite similar to the one I initially provided, you might wonder why we need this rephrased version. The reason is that human factors engineering is an extensive field of study that integrates knowledge from a wide array of disciplines, including computer science, biology, psychology, mathematics, data science, and engineering. Many disciplines, including psychology, contribute to the field of human factors and ergonomics.

This course is dedicated to the study of engineering psychology, which examines human factor problems from a psychological perspective. Hence, the definition I provided earlier was necessary. As psychologists, our focus is on understanding how human factor problems or man-machine issues are studied and resolved through the principles of psychology. In this context, we will explore the physiological, cognitive, and physical capacities of humans, as well as the design of human-machine environments.

The definition I previously discussed mentions environments and the design of those environments. So, what exactly is an environment? Let us try to understand the concept. In this definition, the term "environment" includes both the social and physical environments. Therefore, when designing environments, we need to consider these two aspects.

What is the physical environment, or the physical aspect of an environment?

The physical aspects of the environment are the elements that people or operators can sense. For example, these include sounds, visual information, motion, and spatial arrangements. All these factors should be taken into account when designing environments in which humans and machines interact. Let's consider sound as an example. In engineering psychology, there are generally two types of sounds: signals and noise. A signal is the sound that the operator seeks in the environment, as it triggers further action. Noise, on the other hand, is any sound that interferes with the detection of the signal. Understanding how to control noise or how to help users detect signals more efficiently in noisy environments can lead to the creation of better-designed environments where signals are more easily recognized by the user. This is one way to understand the physical aspects of an environment.

What about the social aspect of an environment?

The social aspect refers to the conditions and situations that influence how individuals feel they should behave. While the physical part of the environment is more overt and directly sensed, the social part can be more covert, indirectly shaping how users interact within the environment. For example, consider a classroom setting. The schema of a classroom consists of certain objects, roles, and actions. Typically, there will be a teacher, students, and an interaction between them. The environment allows for certain actions, such as delivering lectures, asking questions, taking notes, and engaging in academic discussions. Anyone entering this environment would likely anticipate such actions, and this illustrates the social aspect of an environment.

Thus, the definition of the environment includes both physical and social aspects. However, there are other components as well. These may include the way an individual interacts with the environment or how their behavior is influenced by specific design features. These additional factors also contribute to the overall environment.

When discussing engineering psychology, it is essential to consider not only the design of environments but also the limitations and capabilities of the human user. Humans possess specific sensory abilities, and it is important to account for these when designing systems.

For example, let’s examine the human visual system.

The human visual system has both capabilities and limitations. A key example is that humans can see clearly up to a distance of around 25 meters, beyond which lines converge and the concept of a horizon becomes apparent. Additionally, the design of the visual system affects how we perceive things in our peripheral and central vision. Objects in the periphery must be larger for humans to detect them because the peripheral region of the eye is lined with rod cells, which are more responsive to larger objects but less sensitive to rapid changes. In contrast, the central area of the eye, known as the fovea, is capable of detecting smaller objects, bright colors, and rapid changes in stimuli.

These considerations should be kept in mind while designing displays or cautionary signs. In upcoming lectures, we will examine the structure of the visual and auditory systems and explore their capabilities and limitations. Additionally, the cognitive processing of information by the operator must be a key focus in the study of engineering psychology. What do I mean by this? Let’s assume we install a road sign, and the best way to do so is by using a symbol.

As engineering psychologists, we must recognize that symbols can have multiple meanings. Therefore, before implementing any symbols, research should be conducted to understand how these symbols are processed and interpreted, and how this understanding translates into actions. The way a symbol is perceived and evaluated will ultimately determine the type of action humans will take. A good example here is traffic lights. We commonly see red and green lights: red signals "stop" and green signals "go." In some intersections, there is also an orange or yellow light. Understanding what this orange light means and how different users interpret it requires surveys or experiments. Based on this understanding, the placement of orange lights at intersections can be optimized. While the orange light is generally believed to signal "slow down," is that what it actually means to all users? Additionally, there are signs that indicate a U-turn or a crossed-out U-turn. What do these signs mean, and how do users interpret them? If you have taken a driving test, you might have a clearer idea of what I am suggesting here.

Thus, it is not just about how human sensory systems process displays, symbols, or signs from the environment; the study of engineering psychology should also include how humans cognitively process this information, as this determines the future actions they will take. Moreover, engineering psychology is now classified as an applied field because the research conducted in this area is not only used to understand how accidents occur, consider the cover story mentioned at the beginning of this lecture, but also to find ways to prevent accidents by examining the precursors and understanding the limitations and capabilities of both the user and the system. By doing so, efficient methods can be designed to prevent accidents.

One possible solution to the Orissa train accident, mentioned at the start of this lecture, could have been the implementation of an auditory warning system or a tactile warning system, both of which could have been activated well in advance of the accident. These tactile and auditory warnings should supplement visual warnings, allowing the driver to process the information and take necessary actions to prevent accidents. Understanding accidents and developing methods to prevent them is another fundamental goal of human engineering.

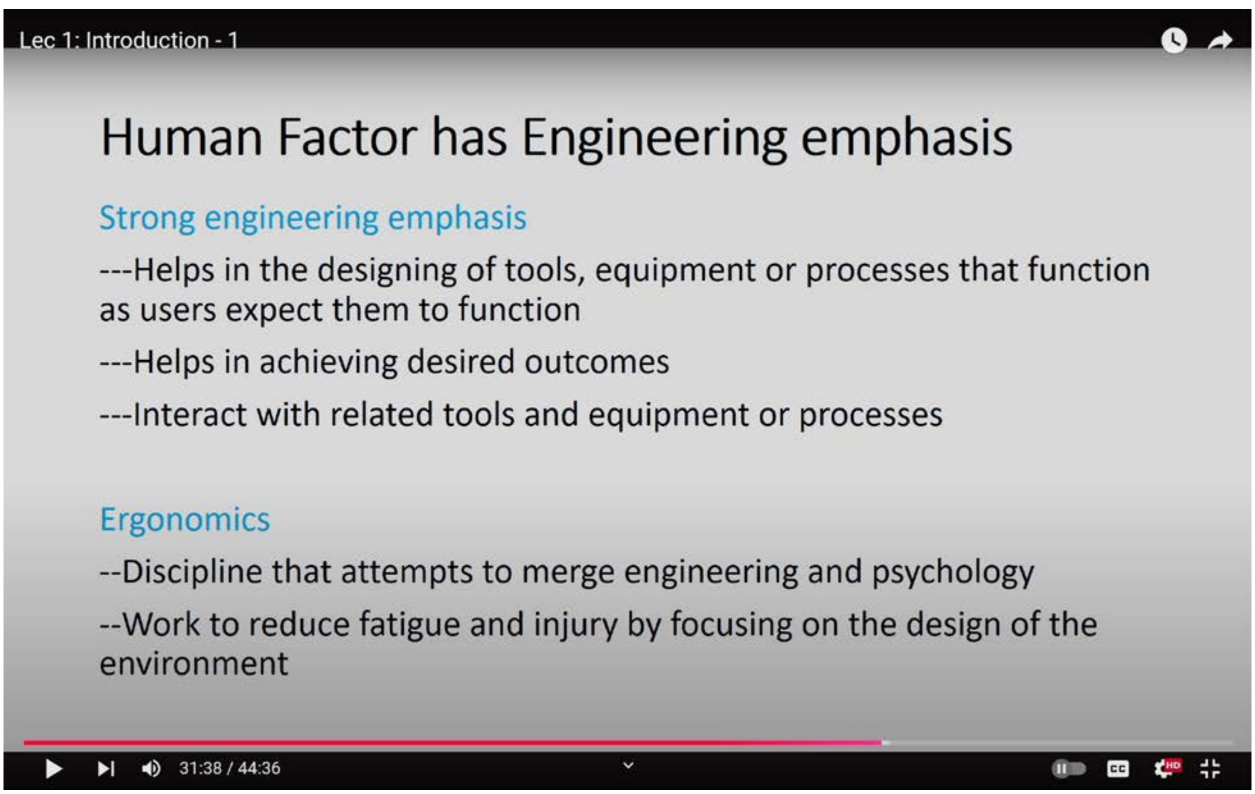
What is the emphasis of this field?

Human factor engineering focuses on designing tools, equipment, or processes that operate as users expect them to. Objects have affordances, which is a principle from perceptual psychology. This concept suggests that objects provide subtle cues to users about how to interact with them. Consider a door handle, for example. It is designed so that you naturally grasp it and pull it toward you to close the door. However, if the handle were designed in such a way that you couldn't grasp and pull it, and if the door only permitted inward movement, how would you close it? The shape of the handle provides an affordance that suggests pulling it toward you. Similarly, if the same door were meant for exiting a room, it should have a different design or a different handle that affords pushing it open. Thus, designing tools, equipment, or processes with affordances becomes a central requirement in human engineering.

By incorporating psychological principles into the design of tools and environments, operators of machines or users of systems can achieve their desired outcomes more efficiently. For instance, if a machine is designed in a highly intuitive and efficient manner, it becomes significantly easier to operate than if it were designed poorly. Think of early-generation cameras, where you had to manually turn a wheel to advance the film. You had to keep turning it until all 36 frames were exposed, and even then, there was no clear instruction on how to rewind the film. If you reached the 36th frame, and the wheel wouldn't turn further, opening the back of the camera could ruin the entire roll of film. However, newer motorized systems were developed that automatically rewound the film at the end, preventing users from accidentally exposing the film and rendering such problems obsolete.

Redesigning the wheel mechanism in such a way that it automatically rewinds or prevents the door encasing the film from opening at the end of the film can solve many issues. The only function allowed at that point should be reversing the wheel. By implementing this small change, users would naturally reverse the wheel, safely wind up the entire film, remove it, and proceed to have it processed. Thus, the desired objective of successfully capturing photographs can be achieved by making minor adjustments to this mechanism. Furthermore, human engineering principles can be applied to understand how secondary-level machines or equipment should be managed.

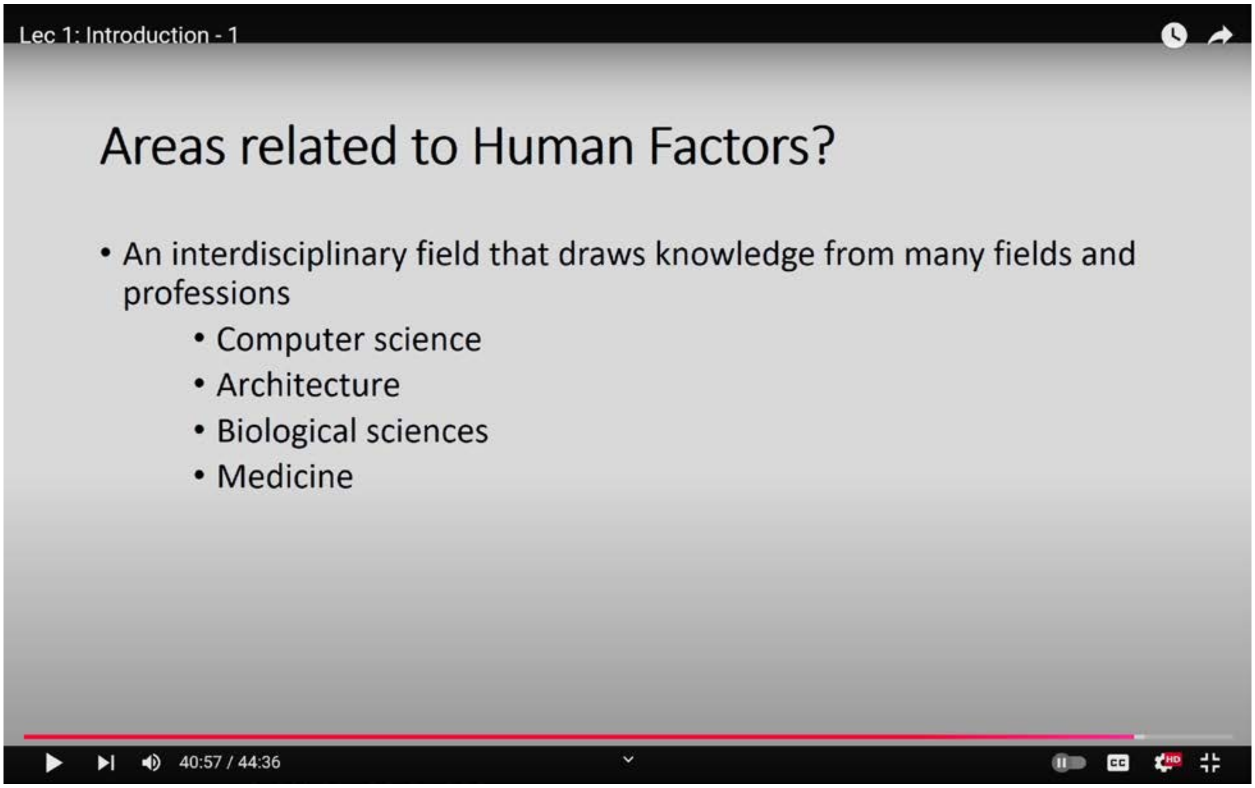
(Refer Slide Time: 31:38)



For example, consider how a pen drive is plugged into a computer. The design of the computer or system, the main machine we interact with, should ensure that the pen drive can only be inserted in the correct orientation. You are likely familiar with this, as inserting the pen drive incorrectly will prevent it from fitting. Thus, the design of both primary systems and secondary systems can be optimized using human engineering principles.

Human factor engineering emphasizes the discipline of ergonomics. But what is ergonomics? It is the discipline that integrates engineering sciences and psychology. By merging these fields, ergonomics utilizes psychological principles concerning the limits and capabilities of the human operator, as well as the system's capabilities, and combines them to improve human-machine interaction. But why is it essential to combine knowledge from psychology and engineering?

(Refer Slide Time: 40:57)



By merging these fields, ergonomics aims to design environments that reduce fatigue and injury for human operators working with systems, creating a more efficient work environment with fewer accidents and errors. Human errors, whether consciously or unconsciously made, are significant causes of reduced industrial profitability. By identifying the types of errors that can occur within human-machine systems, steps can be taken to mitigate these errors and thus improve system efficiency.

There are several related fields that contribute to the discipline of engineering psychology. For instance, **computer science** offers insights into the most efficient ways to process systems and achieve desired goals with minimal errors. From architecture, we gain inputs on how to design buildings that house machines, optimizing spaces for effective human-machine interaction. The layout and design of buildings significantly influence the efficiency of these interactions.

Moreover, **biological sciences** provide critical information on human physiological limitations and capabilities, such as stress tolerance, workload capacity, and the causes of fatigue. Insights from the interdisciplinary field of **medicine** help address small and large injuries, enabling operators to return to work more quickly. For example, in cricket, when a player is injured, physiotherapists or sports doctors promptly assess the injury. If it's minor, they provide immediate on-field care; if it's severe, the player is taken to a medical facility for further evaluation and treatment.

Additionally, **biomechanics** focuses on how the mechanical systems of the human body and physiological capacities interact to determine the most efficient way of performing tasks.

I will conclude my lecture here for today. In the next session, we will delve into various other disciplines that serve as the knowledge base for engineering psychology. We will also explore the history of how this field has developed, and finally, we will consider the future directions for engineering psychology.

Thank you, and goodbye.