Engineering Psychology

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Week-08

Lecture-21

Course Review

Over the past eight weeks and twenty lectures, we have covered the basics and advanced principles of engineering psychology. As I explained in the first session, engineering psychology has little to do with traditional engineering; rather, it focuses on how to modify and apply principles of psychology to address engineering-related problems. This lecture will review and summarize everything we have covered in the past twenty sessions. My aim here is to provide you with a concise overview of the course content.

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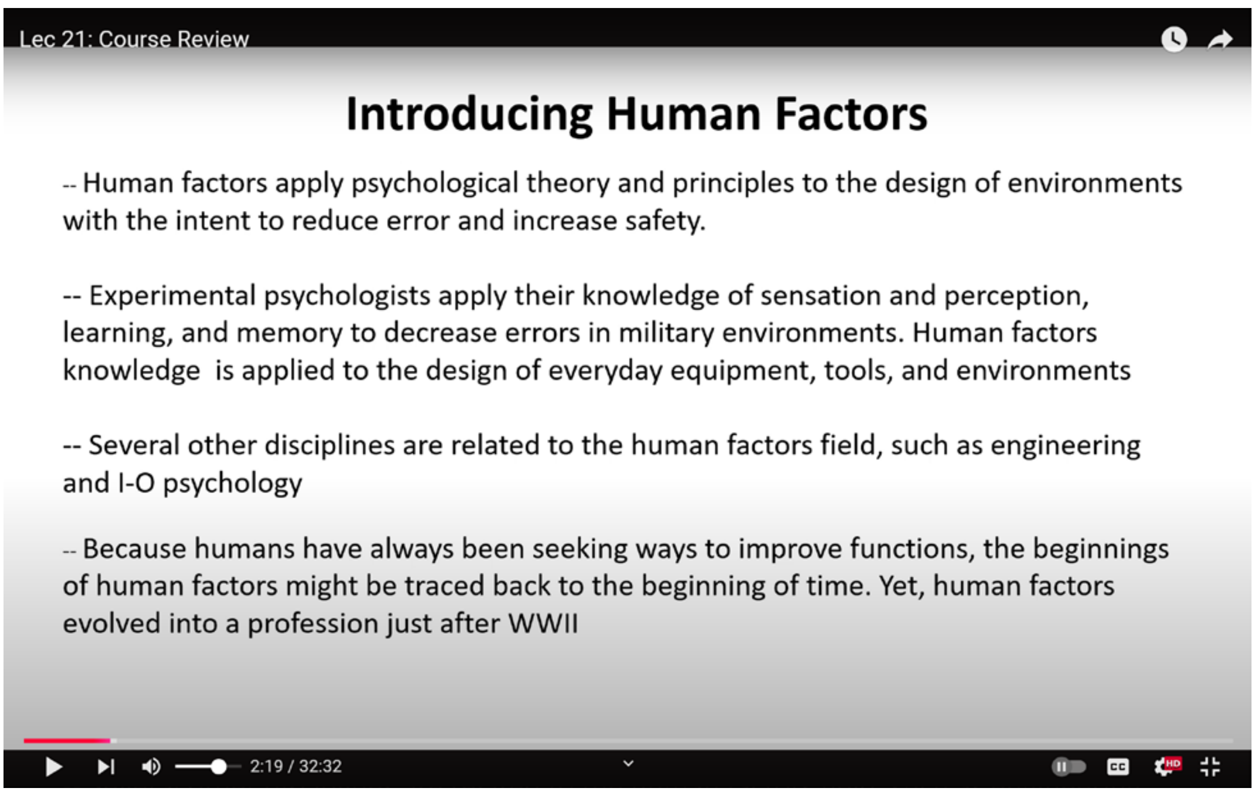

Let us begin. The first section I introduced was the field of human factors. I explained that human factors is an applied psychological science that utilizes principles and theories from psychology to design environments and systems, ensuring a non-error-producing relationship between humans and systems. The primary goal of engineering psychology is to modify and design existing and new systems to minimize errors arising from the interactions between humans and machines, prioritizing safety in these interactions.

We also examined the origins of engineering psychology, noting how experimental psychology contributes its knowledge of sensations, perceptions, memory, learning, and other cognitive processes to develop theories and system modifications that benefit both operators and systems. Engineering psychologists aim to create systems that produce fewer errors, and this focus began with studies in military environments. Initially, engineering psychology was applied to military settings and nuclear power plants. However, over time, it has evolved into a mainstream discipline, now central to many fields of science. Today, knowledge of human factors is applied to the design of everyday equipment, tools, and environments.

Using insights from experimental psychology, we can better understand both the limitations and capabilities of humans as well as those of systems. This understanding enables the development of improved and more interactive system-operator relationships. It is believed that by applying this knowledge, we can create more error-free and safer environments, which can enhance personal mental health and increase productivity. The study of engineering psychology and human factors encompasses multiple disciplines, spanning civil, mechanical, electrical, and other engineering fields, as well as industrial-organizational (IO) psychology.

On one side, we draw input from the engineering disciplines, which provide insights into the limitations and capabilities of the systems with which humans interact. On the other side, we utilize principles from industrial-organizational psychology to develop training methods that help individuals adapt to these systems. The quest to improve human functions can be traced back to the dawn of humanity, but the evolution of human factors into a formal profession occurred shortly after World War II. In this context, I aim to illustrate how the history of engineering psychology has progressed.

If we consider a broader historical perspective, engineering psychology can be traced back to the beginning of human tool use, as people began employing equipment, environments, and tools to facilitate their progress. However, a more focused examination of engineering psychology's history highlights its emergence as a recognized discipline during World War II, when its practical applications became evident.

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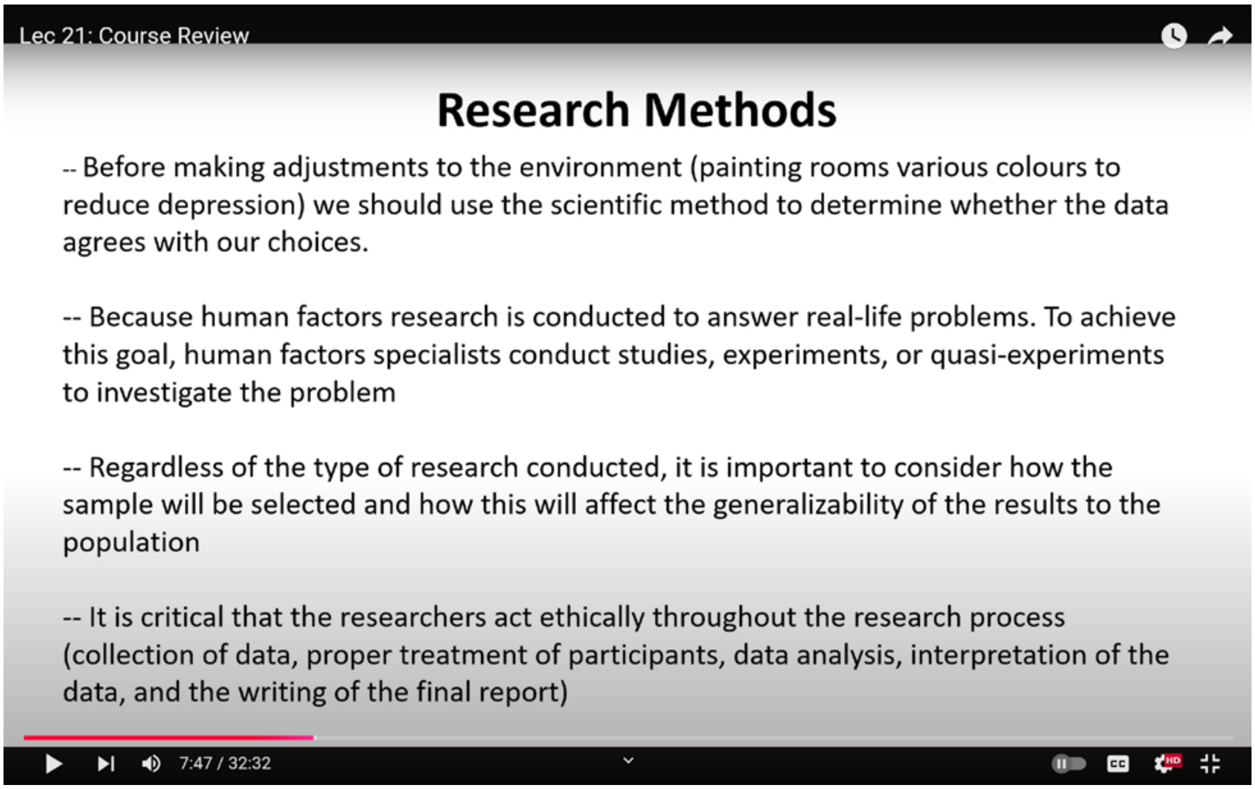

visualIn the second session, we explored research methods that inform adjustments to environments to improve operator-environment interactions. We emphasized the importance of employing the scientific method to ensure that the data aligns with proposed modifications. Engineering psychologists analyze data before suggesting any changes to environments, seeking to verify that the information obtained from sample studies supports their proposed modifications.

Because human factors research aims to address real-life problems, human factors specialists conduct studies, experiments, and quasi-experiments to investigate these issues. I also discussed the various data collection methods utilized in experiments and quasi-experiments, highlighting their role in collecting data and verifying modifications. Several research designs can be employed, but regardless of the type of research conducted in human factors studies, it is crucial to consider how the sample will be selected and how this choice will affect the generalizability of the results to the larger population.

Generalizing results and making blanket predictions regarding how a design will function stems from the selection of a sample from a larger population. The greater the variability within the sample, the higher the likelihood that it accurately represents the population. In simple terms, the inclusion of a diverse range of individuals in our sample study increases the chances that the design modifications we implement will lead to a more enhanced and productive relationship between the machine and the operator, making the design more applicable to the broader population.

It is critical for researchers conducting human factor engineering studies to maintain ethical standards throughout the research process. A key aspect of this is to avoid biases. If researchers harbor biases, it could undermine the entire process of human engineering and the design modifications made by human engineers. Significant efforts are invested in ensuring that research is conducted ethically. This involves collecting data, treating participants, analyzing and interpreting data, and writing the final report in a manner that is free from bias and errors. Any biases present could result in a prejudiced view of the research findings, rendering the predictions ungeneralizable and ultimately unhelpful.

In the third section, we discussed displays. This section focused on various types of displays, including visual displays, olfactory displays, and others. We reviewed the design principles of visual, auditory, tactile, and olfactory displays, along with the criteria that guide the selection of the appropriate display for specific applications. We examined four distinct types of displays and the principles that inform their design. For instance, the effectiveness of visual displays is influenced by factors such as visual acuity, color vision, and visual sensitivity. These are fundamental principles that define the visual system.

Similarly, the tactile system relies on factors such as the amount of pressure applied and the sensitivity of the system. We reviewed these principles to understand how they can lead to improved displays tailored to specific modalities. The four modalities we discussed in this section include visual, tactile, olfactory, and auditory, the latter of which will be addressed in the subsequent section.

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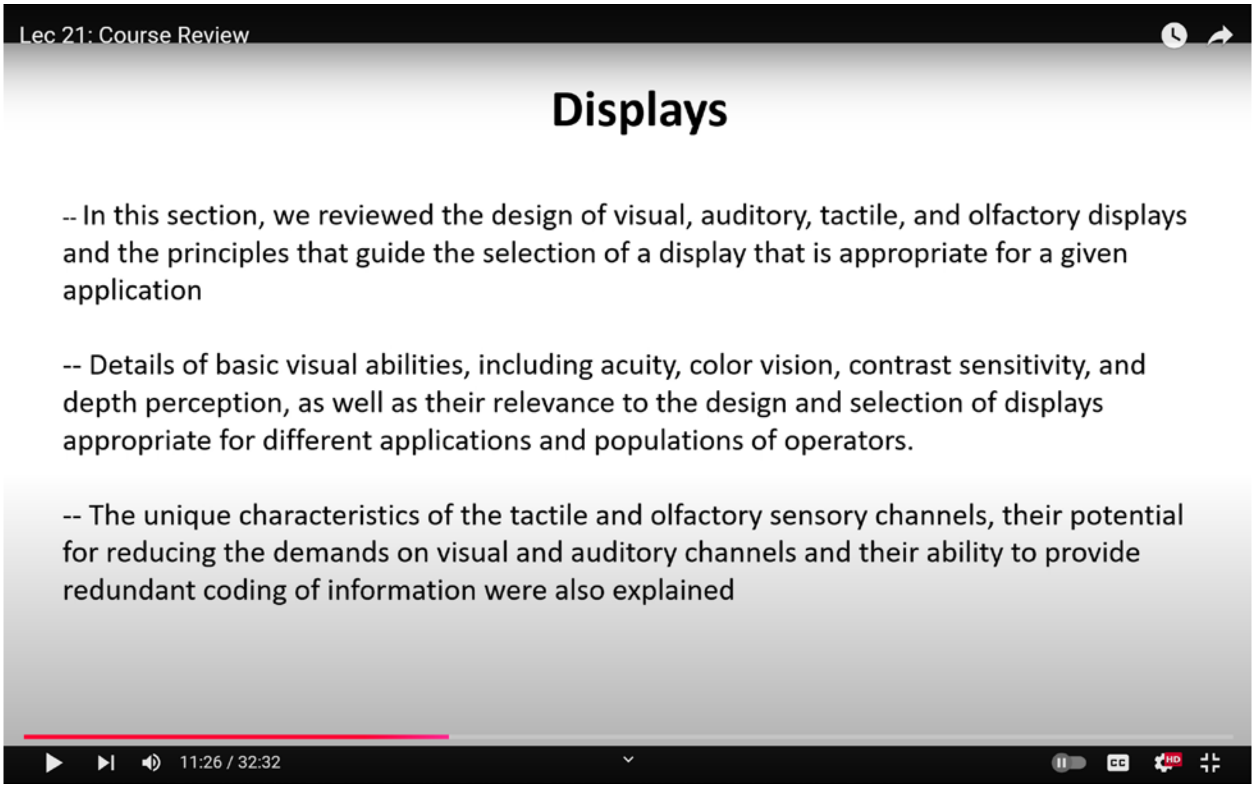

We focused on the principles governing visual displays, detailing visual abilities such as visual acuity, which refers to the ability to distinguish two objects that are spatially separated, color vision, contrast sensitivity, and depth perception. We also discussed how these principles relate to the design and selection of displays suited to various applications and the operator's population. In addition to visual displays, we examined the unique characteristics of tactile and olfactory sensory channels, their potential to alleviate demands on visual and auditory channels, and their capacity to provide redundant information.

This redundancy in tactile and olfactory displays can enhance the operator's ability to notice critical information, especially when combined with visual displays. The role of a display is to effectively present information to operators. Therefore, we explored ways to improve displays to enhance the likelihood that operators will notice them, thereby contributing to an error-free system.

The next section focused on auditory displays. While vision is our dominant sense, we possess remarkable auditory capabilities. Auditory systems serve as effective warning mechanisms, exemplified by alarm clocks that alert us in the morning. Sound provides a rich and complex source of information; however, the auditory channel is often underutilized for conveying information and exploring complex datasets. In this section, we examined the composition of sound, the application of auditory displays, and how we can leverage auditory principles to enhance the effectiveness of these displays.

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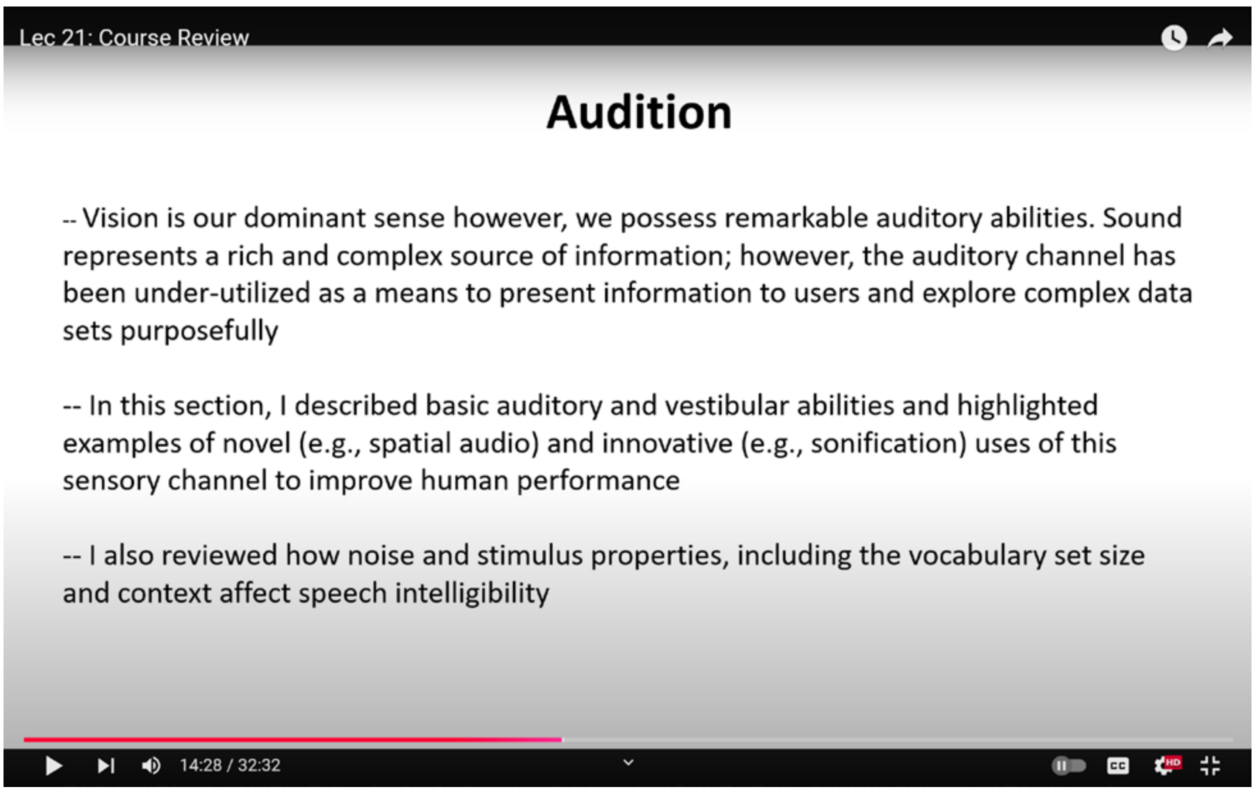

Additionally, I described fundamental auditory and vestibular abilities, highlighting innovative examples such as spatial audio and sonification that utilize this sensory channel to improve human performance. We also reviewed the properties of noise and stimuli, including vocabulary set size, context effects, speech, and intelligibility. Overall, we discussed both the auditory and vestibular systems, emphasizing how understanding their limitations and capabilities, along with the guiding principles, can facilitate the design of better displays and more effective speech message systems.

The final section addressed evaluation methods for design, focusing on a principle method known as user-centered design (UCD). Human factor practitioners utilize UCD to incorporate user needs into product design. This approach involves gathering key needs from the target end users and thoroughly understanding the tasks they will perform with the product. User-centered design aims to identify the specific needs that arise during the interaction between a system and a user, followed by an analysis and understanding of the user's requirements.

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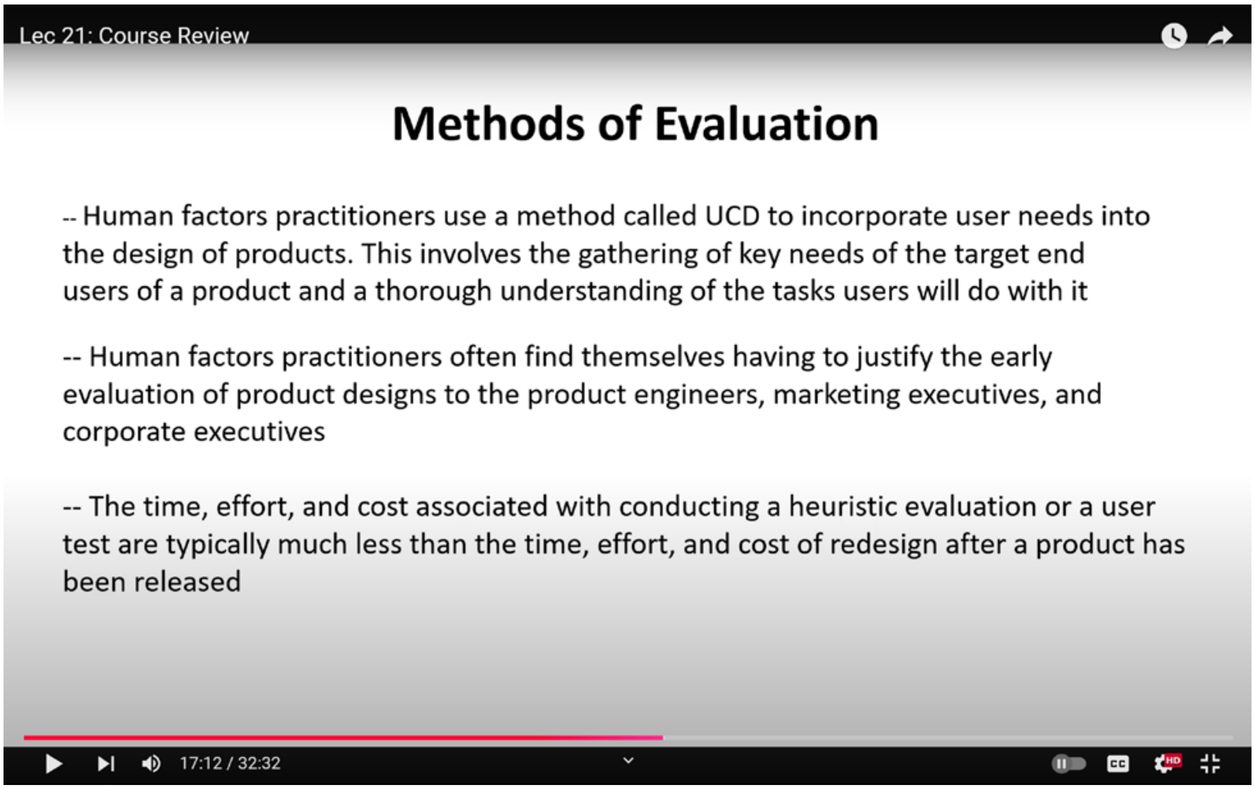

User-centered design is a design principle that places the user at the center of the process, modifying the surrounding system to meet the needs of both the system and the user. This concept is fundamental to this section, where I explain how various evaluation methods can assist us in creating a better user-centered system and design. Human factor practitioners often find themselves needing to justify the early evaluation of product designs to product engineers, marketing executives, and corporate leaders. While engineering psychologists can develop effective user-centered designs, many system designers remain skeptical of human factor engineers until they experience a loss.

When these designers incur losses, they turn to human engineers to understand why the product is underperforming. Numerous examples of such situations are evident in everyday life; if you observe the systems around you, you will likely notice many that fail to function as intended. Human factor engineers provide designs aimed at improving usability, but convincing others of their effectiveness can be challenging. Thus, the principles of human-centered design and its effectiveness are elaborated upon in this section.

The time, effort, and cost associated with conducting a heuristic evaluation or user testing are typically much lower than the time, effort, and cost of redesigning a product after it has been released. One compelling reason to engage human engineers or human factor specialists is that the investment in user-centered design (UCD) is significantly less than attempting to resolve issues once the product is on the market. This serves as a critical argument for manufacturers and system designers to prioritize UCD principles and collaborate with human engineers to create better systems.

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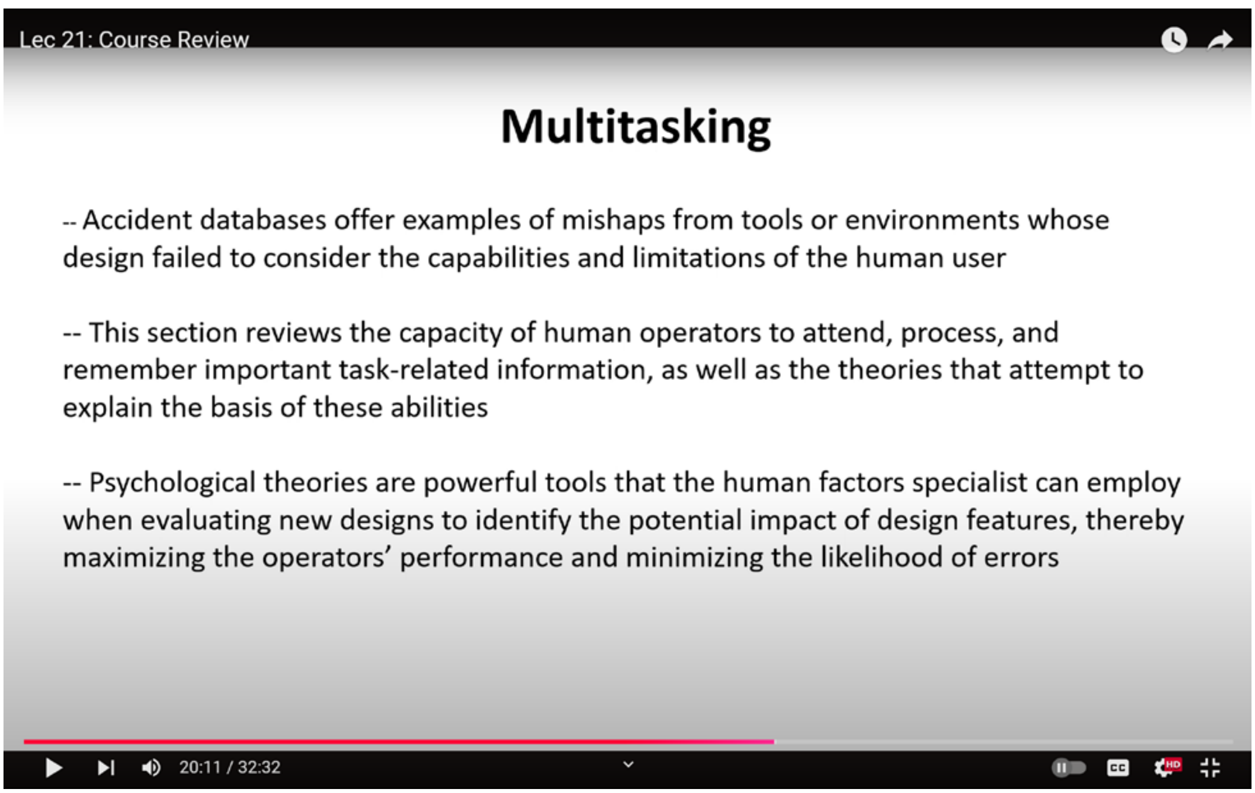

The next section focused on advanced cognitive processes such as memory, attention, and multitasking. We explored how these principles can manifest as both disabilities and abilities for users. The accidents database provides examples of incidents involving tools or environments whose designs failed to account for the capabilities and limitations of human users. A review of accident reports often reveals that many incidents occur because system designers neglected to seek input from human engineers knowledgeable about human cognitive systems.

In this section, we reviewed the capacity of human operators to attend to, process, and remember important task-related information, along with theories that explain the basis of these abilities. This section was rich with theoretical coverage and discussions about principles that define human higher cognitive systems. Psychological theories serve as powerful tools that human factor specialists can employ when evaluating new designs, allowing them to identify the potential impacts of design features, thereby maximizing operator performance and minimizing the likelihood of errors.

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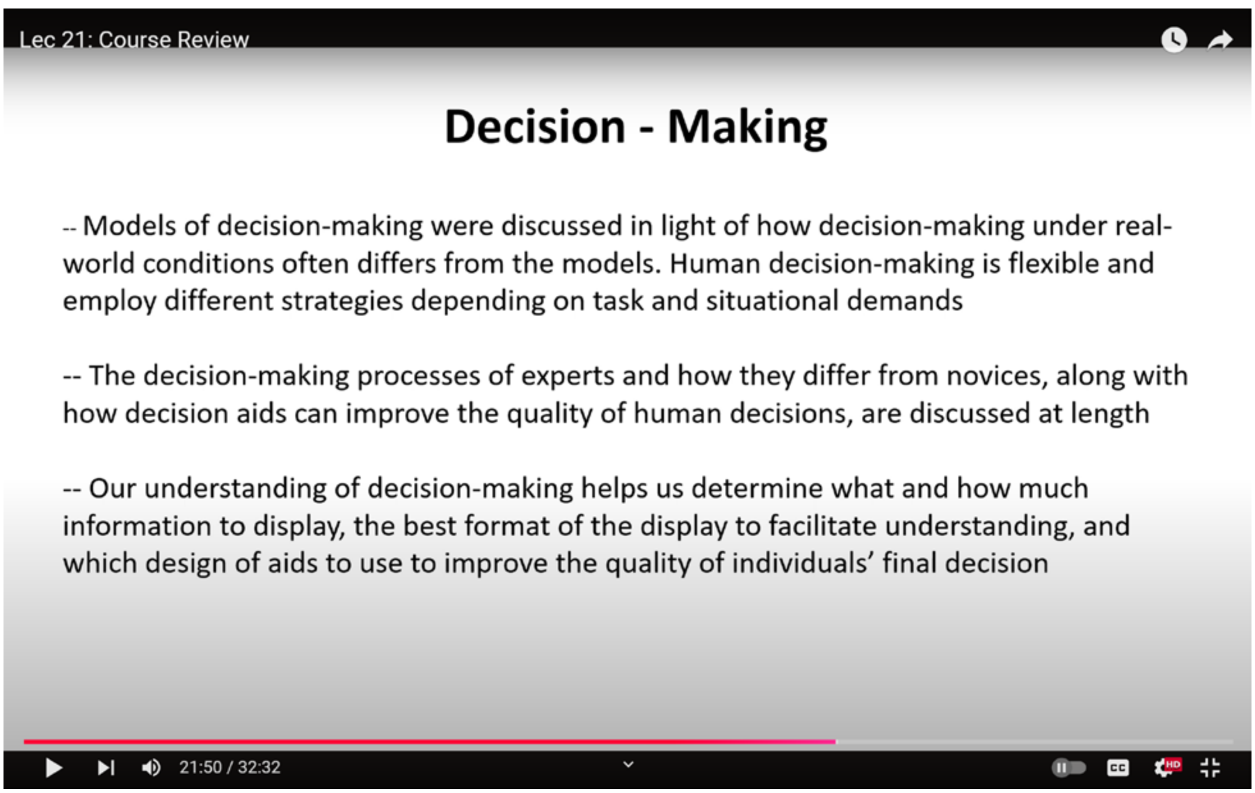

Within this section, I demonstrated how to apply these theories to the actual design of a system. A well-designed interface can help maximize profit and minimize errors. The following section addressed another advanced cognitive system: decision-making. During this session, I explained how models of decision-making often differ under real-world conditions compared to theoretical models. We examined both normative and prescriptive methods of decision-making.

We also discussed biases and their effects on decision-making abilities. Human decision-making is flexible, employing various strategies based on task demands and situational contexts. All these factors were thoroughly explored in this session, including the decision-making processes of experts versus novices and how decision aids can enhance the quality of human decisions.

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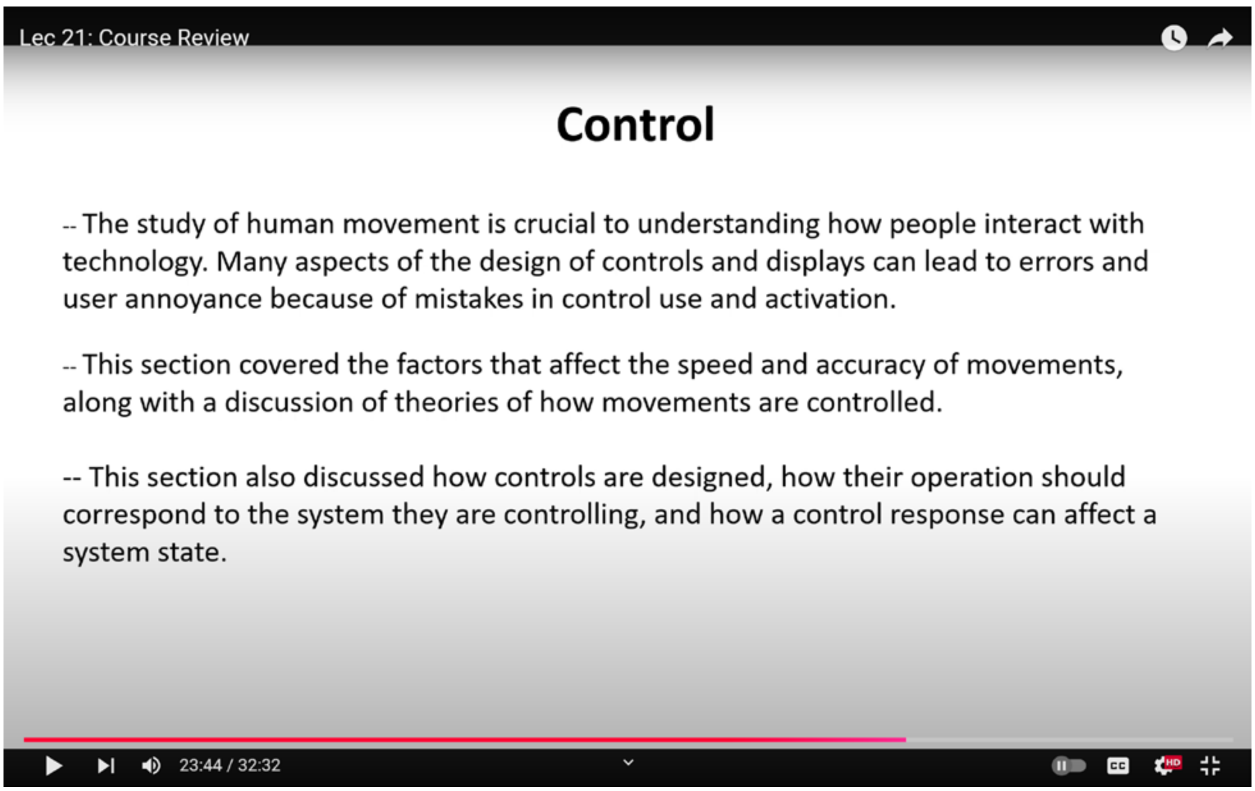

Within this section, we analyzed how experts and novices approach decision-making differently and what can be learned from these distinctions. Our understanding of decision-making informs us on how much information to display, the optimal format for that information to enhance comprehension, and which designs of aids can improve the quality of an individual's final decision. Overall, this section elucidated the nature of decision-making, discussed the principles involved, and examined how to apply these principles to enable operators to make more fruitful decisions that maximize profit and minimize errors.

The subsequent section focused on control, particularly the study of human movement, which is crucial for understanding how people interact with technology. Many aspects of control design and display can lead to errors and user frustration due to mistakes in control usage and activation.

This system was centered around how control should be designed and which principles of human cognition should be incorporated into control design. The section covered factors that affect the speed and accuracy of movements, alongside a discussion of theories regarding movement control. Additionally, it explored how controls are designed, how their operation should align with the system they govern, and how a control response can influence the state of the system. In detail, we discussed the concept of control, the principles that guide the design of better controls, and the underlying principles on which controls operate.

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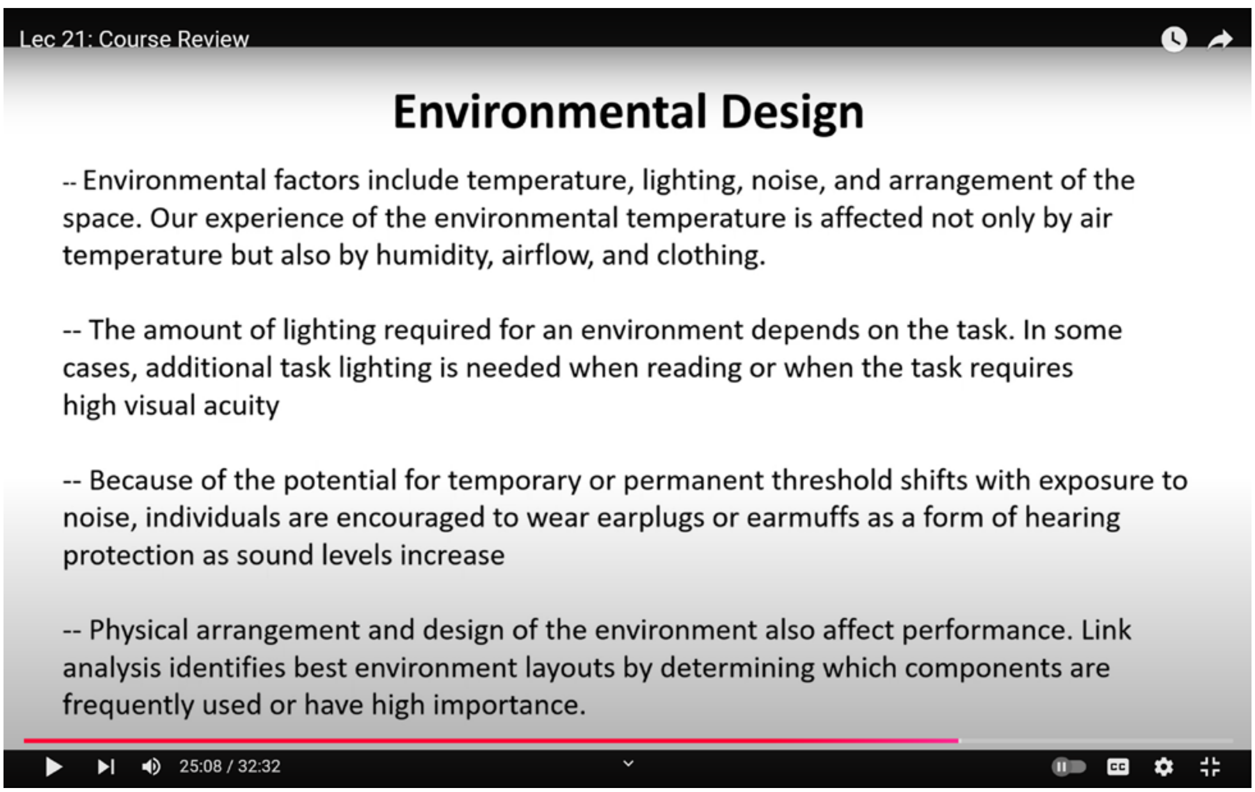

The subsequent section focused on environmental design, examining environmental factors such as temperature, lighting, noise, and spatial arrangement, which are key components of human factors engineering. In our exploration of the environment, we noted that temperature is influenced not only by air temperature but also by humidity, airflow, and clothing. We discussed four or five environmental variables, with temperature being one of them. I explained how temperature is affected not just by dry air but also by humidity, airflow, and what individuals wear.

Moreover, I elaborated on how the lighting needed for an environment varies based on the tasks being performed. Different tasks necessitate different types of lighting, and I discussed how the amount of light and the type of illumination impact various tasks. In some instances, additional task lighting is required when reading or when tasks demand high visual acuity, illustrating how different tasks are performed under varying lighting conditions.

Given the potential for temporary or permanent threshold shifts due to noise exposure, individuals are advised to use earplugs or earmuffs as a form of hearing protection as sound levels increase. We also discussed noise and emphasized how it can be managed by employing both earplugs and earmuffs, as sound serves as an environmental factor that can diminish productivity.

Physical arrangements and environmental design also significantly affect performance. We examined how the surrounding environment and the operator's interactions with different machines impact performance. This led to a discussion on how to analyze these interactions using a method called link analysis.

What is link analysis? It identifies optimal environmental layouts by determining which components are frequently used or are of high importance. Therefore, link analysis serves as a means to explain how operators interact with various objects in their environment and how to strategically place equipment or components within the system to minimize hindrance and maximize productivity during operator interactions.

The final section focused on human error. After we completed our explanation of the principles of human engineering and the capabilities and limitations of humans concerning higher cognitive processes, the last topic to address was the concept of error. This section thoroughly covered what human error is. Human error refers to intentional or unintentional behavior that results in an undesired outcome, as it does not align with the system's goals. Thus, errors can be both intentional and unintentional.

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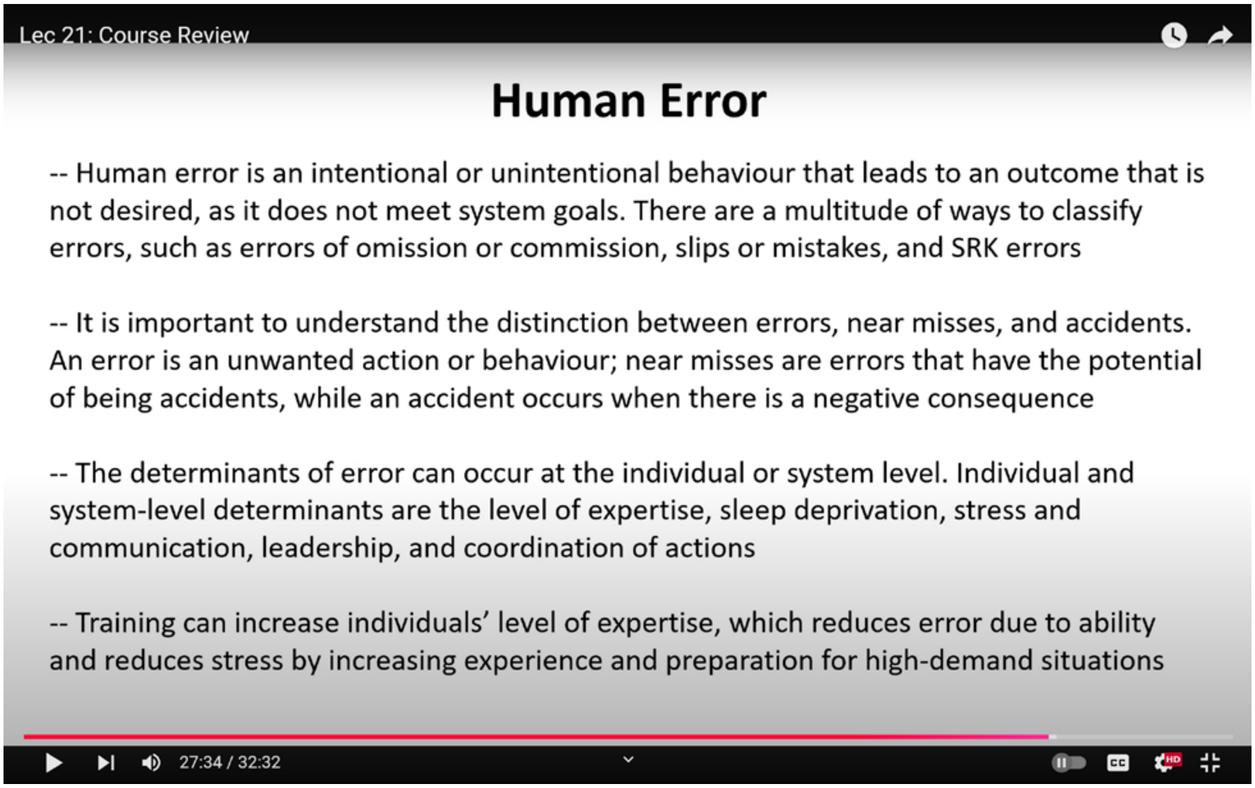

There are multiple ways to classify errors, such as errors of commission, errors of omission, slips, mistakes, and skill-, knowledge-, and rule-based errors. Each classification provides a different understanding of the type of error. This was a primary focus of the section. Additionally, understanding the distinctions between errors, near misses, and accidents is essential. Not all errors lead to accidents; sometimes an error may only result in a near miss.

The differences among these three terms were defined in this section. While an error is an unwanted action or behavior, a near miss refers to errors that have the potential to escalate into an accident. In contrast, an accident is a negative consequence of an action that can result in loss of life or property. We provided a detailed explanation of how these three terms differ from one another, emphasizing that not all errors necessarily lead to accidents; in some cases, errors do not result in accidents.

In this section, we examined these classifications. The determinants of errors can occur at both the individual and system levels. We described how errors can originate from both individual and system-level factors. Examples of errors occurring at the system and individual levels were further discussed. Individual factors include expertise, sleep deprivation, and stress, while system-level factors encompass communication, leadership, and coordination of actions.

Both individual and system-level factors interact to produce errors. It is not always the case that individual factors lead to errors; sometimes, individuals may be highly qualified, but systemic issues, such as red tape or policy-related constraints, can hinder their performance, resulting in frustration and decreased efficiency. In this section, I explained the distinctions between system-related and individual-related errors, as well as how they interact to contribute to the overall error component in human engineering.

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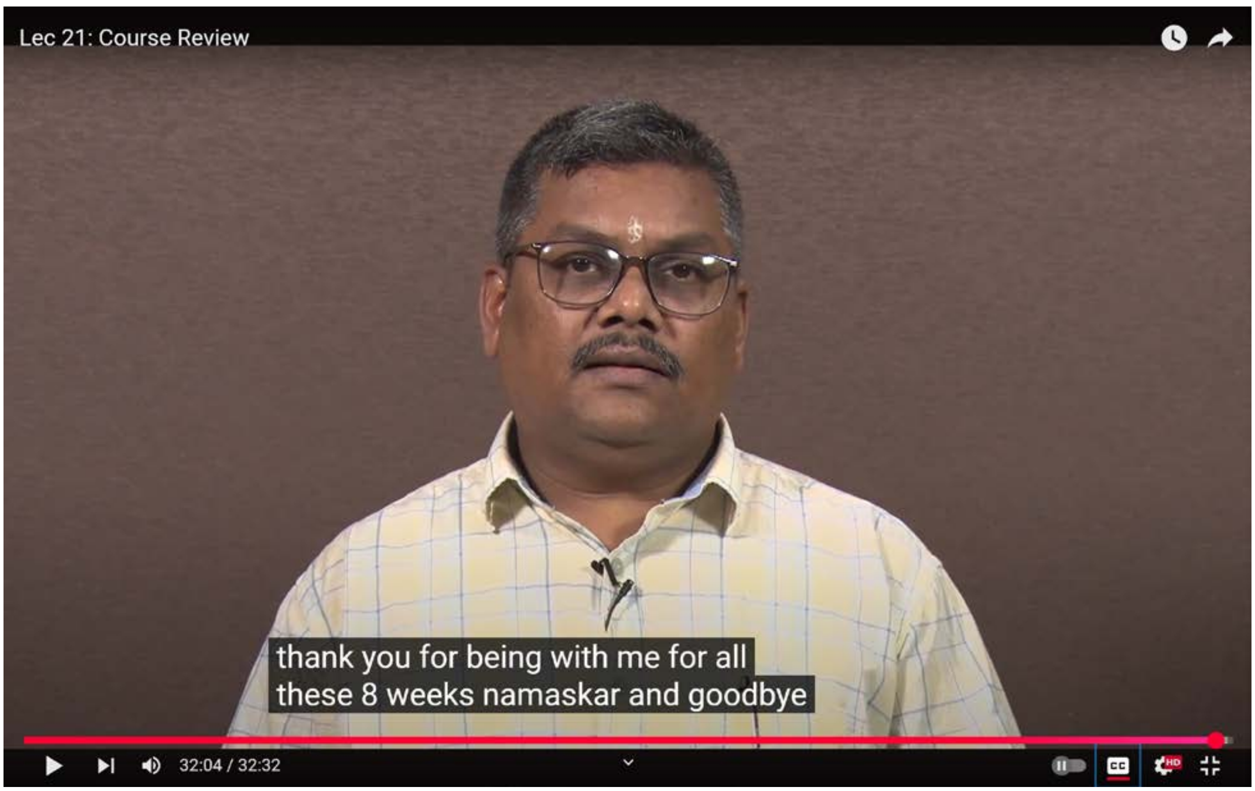

Furthermore, I described how these errors can be minimized or mitigated and how training can enhance an individual's expertise, thereby reducing errors related to ability and decreasing stress through increased experience and preparation for high-demand situations. I explained how training individuals can help them become experts, enabling them to make quick decisions with fewer errors. On the other hand, I also discussed how managing stress and other intrinsic factors can foster error-free interactions between humans and systems, ultimately leading to improved performance and a better human engineering experience.

This encapsulates what we covered in this course and across the various sessions of the human engineering program. Thank you for accompanying me throughout these eight weeks. Namaskar and goodbye. Thank you.