Human Factors Engineering

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Lecture - 33
Measurement of Illuminance, Luminance and Contrast

So, now that we have come to know that why a visual environment should be appropriately and ergonomically designed. Now we should discuss that how to assess a visual environment visual environment at a work place. And in respective assessment, given a job, given a workplace, given a visual environment system or illumination system, you need to focus on the human performance.

And to what extent the visibility of the characters or the jobs or the workplaces are affecting the human performance. The focus is human performance in job and job-related work environment and within this work environment that visual environment visual environment which to be judged by the humans.

So, now in the last the lecture sessions we have referred to three typical parameters, you have to be aware of, you must be able to say the measure and assess. For assessing the visual environment three parameters are illuminance, the luminance and the contrast. So, we will be discussing the details about these three measures or the three parameters.

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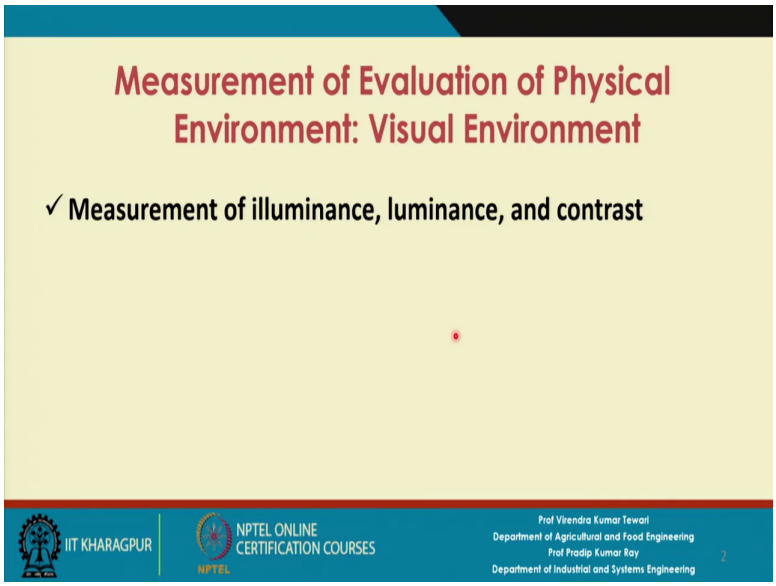

So, our topic of discussion is Measurement of Illuminance, Luminance and Contrast.

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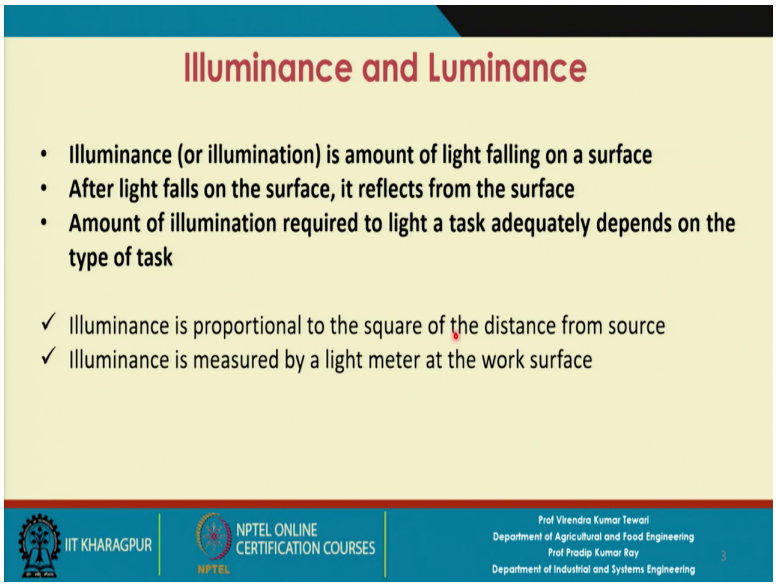

Illuminance is amount of light falling on a surface. When light falls on the surface it reflects from the surface, amount of illumination required to light a task adequately depends on the type of task.

The task could be the hammering or the task could be a working on the microscope workstation, So, the kinds of illumination or say illumination system for exacting jobs and they will be different from one another. So, job requirements you must know and

accordingly you create the illumination system in such a way that the persons the interface with the job is also the best or the perfect.

So, it is the task wise you have to define the illumination level required. Illuminance is proportional to the square of the distance from the source, just you note it down. Many of you may be knowing this the how the distance from the source is affecting the illuminance or the illumination. And illuminance is measured by a light meter at the work surface. Just you note it down that this light meter is widely used.

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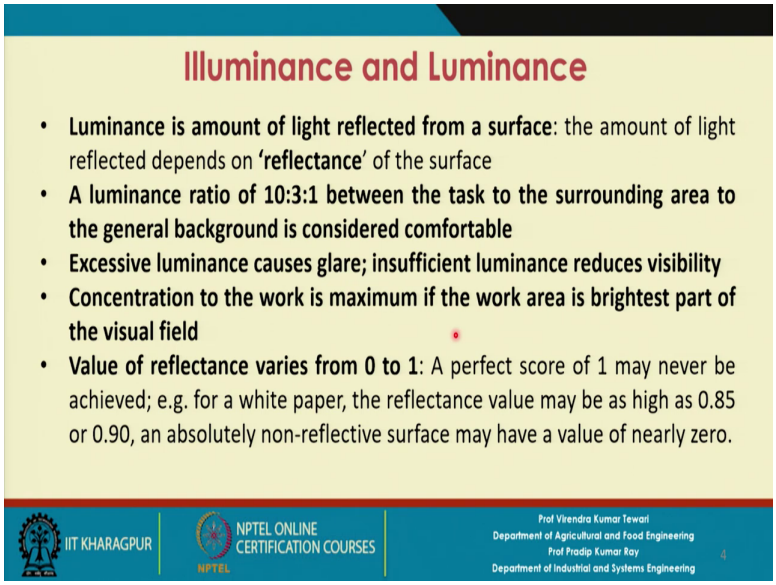

Luminance is amount of light reflected from a surface: the amount of light reflected depends on 'reflectance' of the surface.

A luminance ratio of 10:3:1 between the task to the surrounding area to the general background is considered comfortable.

Excessive luminance causes glare; insufficient luminance reduces visibility.

Concentration to the work is maximum if the work area is brightest part of the visual field.

Value of reflectance varies from 0 to 1: A perfect score of 1 may never be achieved; e.g., for a white paper, the reflectance value may be as high as 0.85 or 0.90, an absolutely non-reflective surface may have a value of nearly zero.

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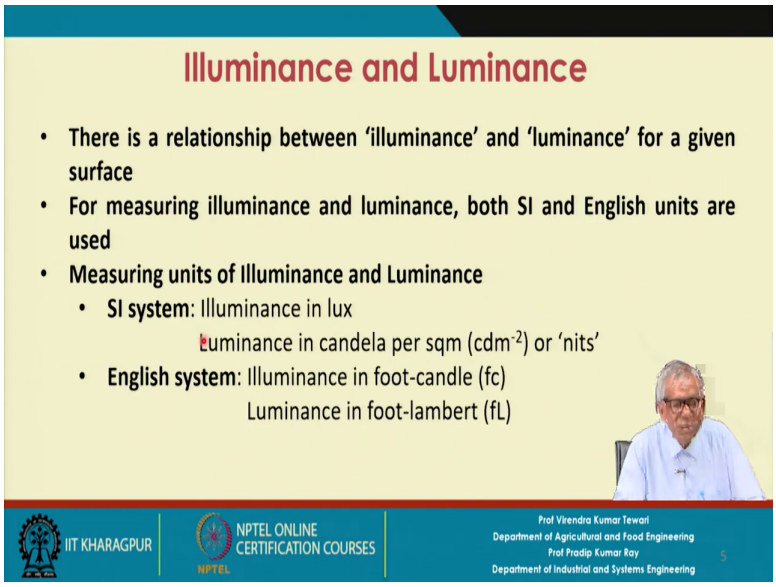

There is a relationship between 'illuminance' and 'luminance' for a given surface.

For measuring illuminance and luminance, both SI and English units are used.

Measuring units of Illuminance and Luminance.

SI system:

Illuminance in lux

Luminance in candela per sqm (cdm-2) or 'nits'

English system:

Illuminance in foot-candle (fc)

Luminance in foot-lambert (fL)

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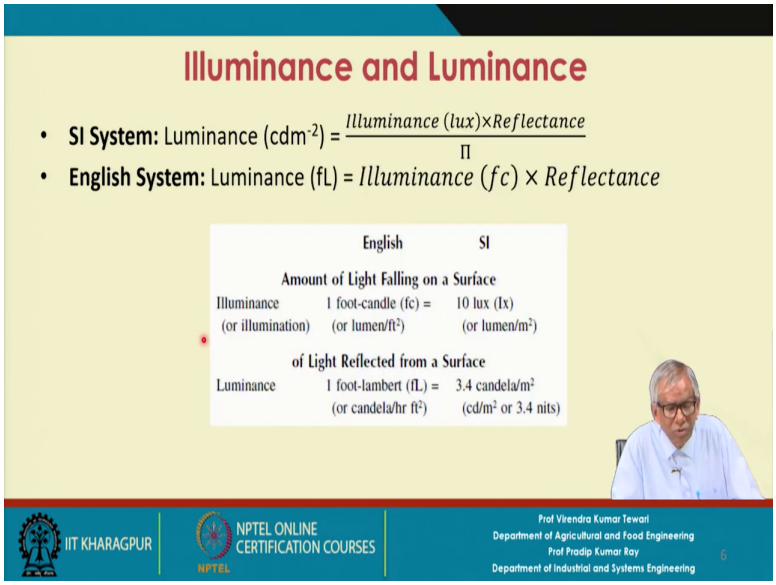

1. **SI System:** Luminance $(cdm^{-2}) = \frac{\text{Illuminance (lux)}\times\text{Reflectance}}{\Pi}$
2. **English System:** Luminance (fL) = Illuminance (fc)×Reflectance

	English	SI
Amount of Light Falling on a Surface		
Illuminance (or illumination)	1 foot-candle (fc) = (or lumen/ft^2)	10 lux (Ix) (or lumen/m^2)
of Light Reflected from a Surface		
Luminance	1 foot-lambert (fL) = (or candela/hr ft^2)	3.4 candela/m^2 (cd/m^2 or 3.4 nits)

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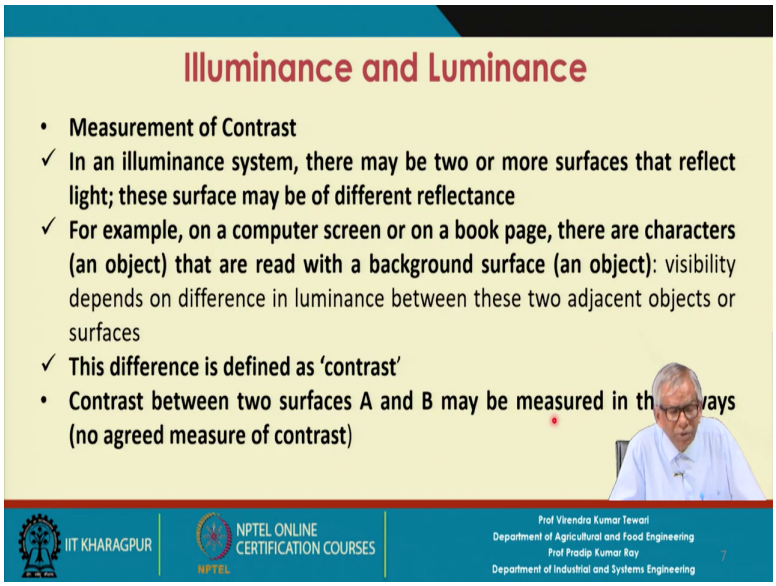

So, this is the measuring units in both the systems Now, once you have the luminance now the next important measure is the measurement of contrast. And the contrast basically determines the kinds of the level of visibility that you may have. So, the characters are usually black and the background color is white in textbooks. So, what is the contrast ratio? The contrast ratio is 1:40.

Whereas the same sort of the materials you started reading on the computer screen, So, the contrast ratio could be 1:8 or 1:10. So, what happens that if the contrast ratio is 1:40. So, your visibility is perfect and while you read a certain material, written on a book interface is perfect and you do not feel any inconvenience. So, your reading and learning ability is not at all affected.

Whereas if the same materials you just go through, written on the computer screen and as the visibility is poor the contrast ratio is poor, learning quality also will be poor, in other words you take more time to go through all these the materials

So, your performance will be affected. With respect to the job, if you want to the assess the performance obviously, you need to consider the contrast and to what extent the contrast is affecting your performance. In an illuminant or illuminance system there may be two or more surfaces that reflect light, these surfaces may be of different reflectance.

For example, on a computer screen or on a book page there are characters, each character is an object that are red with a background surface. Visibility depends on difference in luminance between these two adjacent objects or surfaces.

This difference is defined as ‘contrast’

Contrast between two surfaces A and B may be measured in three ways (no agreed measure of contrast)

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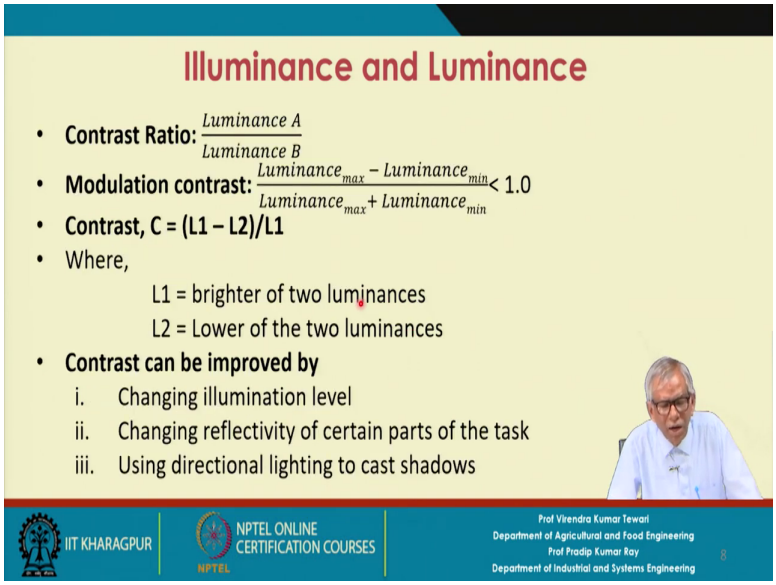

Contrast Ratio:

Modulation contrast:

Contrast, C = (L1 – L2)/L1

Where, L1 = brighter of two luminances

L2 = Lower of the two luminances

Contrast can be improved by

A. Changing illumination level

B. Changing reflectivity of certain parts of the task

C. Using directional lighting to cast shadows

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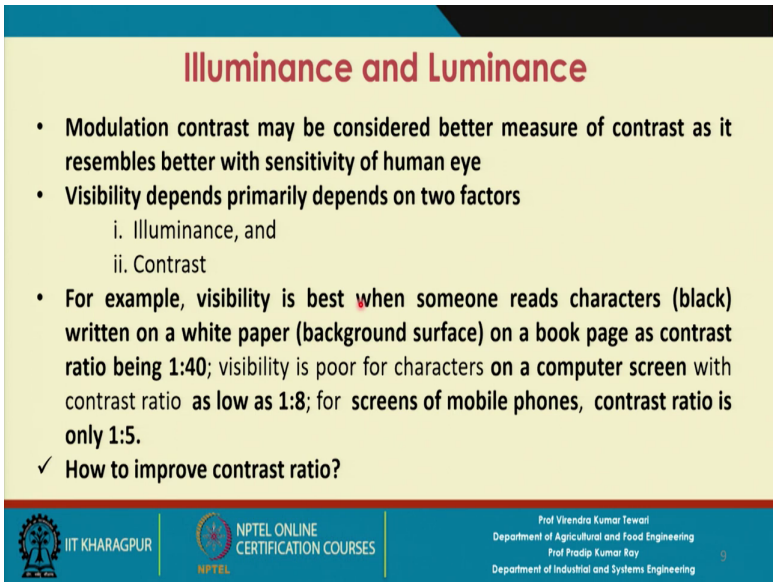

Modulation contrast may be considered better measure of contrast, this is the general conclusions we make, as it resembles better with sensitivity of human eye. Whenever you propose certain measure sound pressure level and there you will find that sound pressure level can be measured under the different scales such as scale a, scale b, scale c.

Now, if you use the scale a, what advantage do you have? That is basically these measures, the values you get it perfectly by it balancing with the sensitivity of the human ear. Visibility depends primarily depends on two factors that is: Illuminance, and Contrast

For example, visibility is best when someone reads characters (black) written on a white paper (background surface) on a book page as contrast ratio being 1:40; visibility is poor

for characters on a computer screen with contrast ratio as low as 1:8; for screens of mobile phones, contrast ratio is only 1:5.

How to improve contrast ratio?

You just cannot avoid the use of mobile screen or the computer.

So, based on fit man to job you cannot avoid 10 percent of the cases, if you can the change it to fit say job to man fine, but many cases it is not possible at least 10 percent of the cases. So, similarly here also already the job is designed on the screen, mobile screen you cannot avoid.

Alternative is that the corrective measures should be taken and the corrective measure should be taken as promptly as possible that means, if I am looking at compute screen for 10 minutes or say 15 minutes or half an hour, immediately I have to the stop doing and take some rest. Similarly, for say the mobile phones.

So, the continuous exposure to such conditions may create lot of problems. So, what are the problems? Like your fitness could be affected, your health could be affected and those are the main issues, we should consider when you talk about ergonomic design or human factors design.

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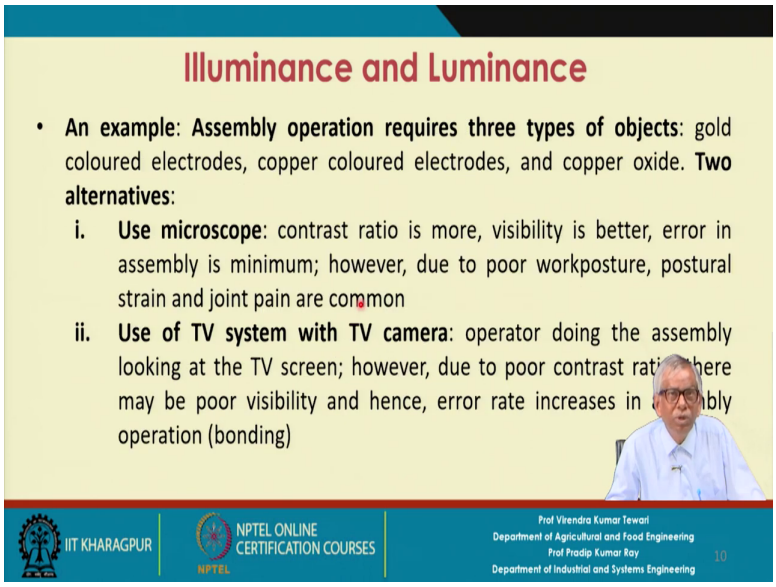

So, how to improve the contrast ratio- An example: Assembly operation requires three types of objects: gold colored electrodes, copper colored electrodes, and copper oxide. Two alternatives are:

Use microscope: contrast ratio is more, visibility is better, error in assembly is minimum; however, due to poor work posture, postural strain and joint pain are common.

Use of TV system with TV camera: operator doing the assembly looking at the TV screen; however, due to poor contrast ratio, there may be poor visibility and hence, error rate increases in assembly operation (bonding).

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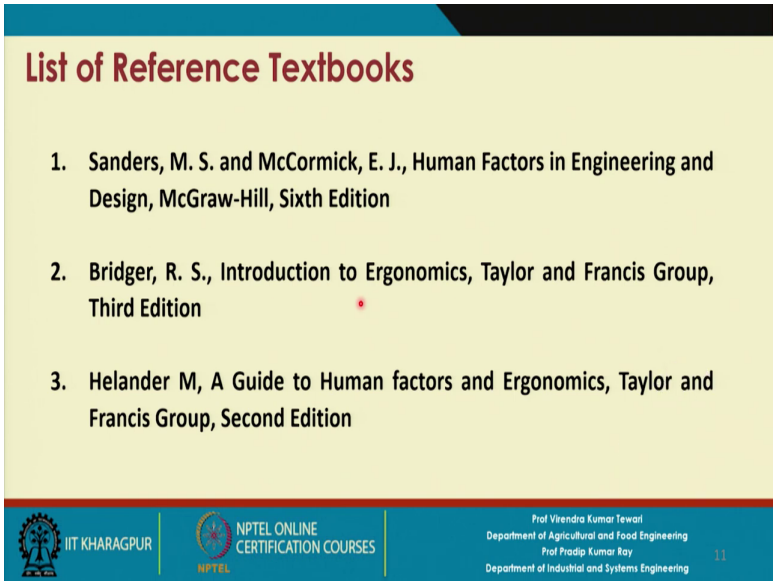

So, in detail we have the discussed the three important issues, related to the visibility. That is illuminance, luminance and the contrast ratio and the focus is on the contrast ratio and illuminance So, visibility is dependent on these two factors. So, other important issues related to contrast ratio and all, related to the job design.