Applied Ergonomics
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Lecture – 21

Plays a very important role in the system performance or human performance and if the physical work environment is not appropriate then the whole systems performance will be affected. So, we will go in detail what kind of component are required in order to have a proper study of physical work environment and whatever the task you performed whether it will be a social or physical activity that physical work environment is necessary.

So, as for as ergonomic system is concerned, it consists of human, machine and environment so the system which is consisting of the combination of any these 3, so as I say ergonomic system. So, environment is one of the component in that particular system. So, those environment may be related to this lighting system and auditory, performance and as well as there are many other factors that we will discuss.

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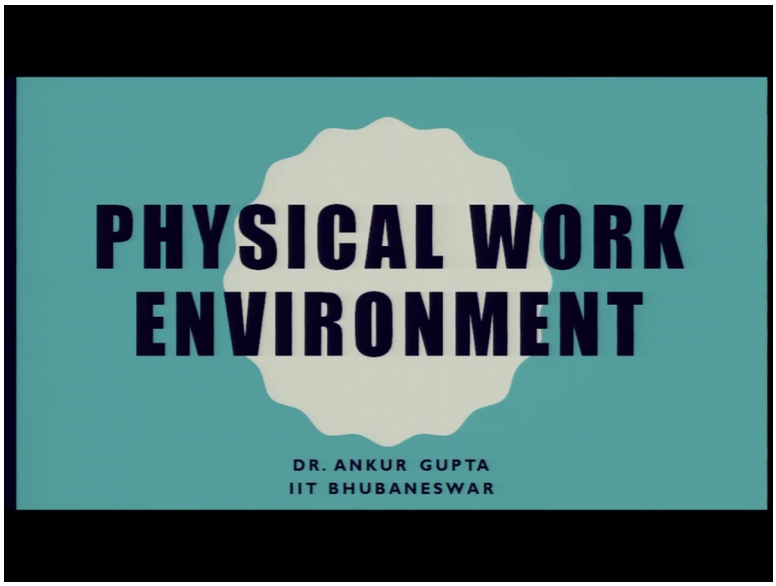

So, apart from these physical and social aspects we will also try to learn about the lighting, noise and our surrounding or climatic conditions.

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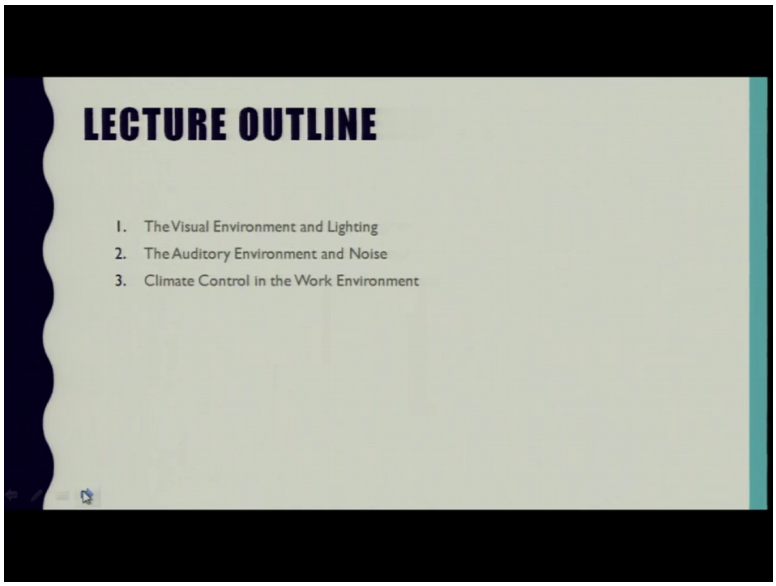

So, to start with this lecture this whole lecture has been divided into 3 topics, those are visual environment and lighting, auditory environment and noise, climate control in the work environment.

So, whether work is physical or cognitive that role of important, role of this environment is important. So, any kind of activity is performed in a certain kind of environment. So, here, firstly, we will take a visual environment and lighting.

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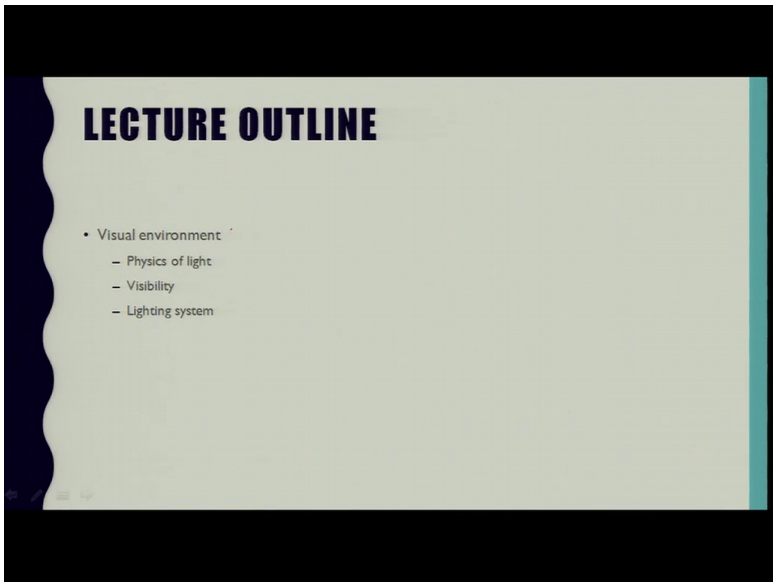

So, in that visual environment, we will learn about the physics of the light, visibility and lighting system. So, first we will take the topic visual environment.

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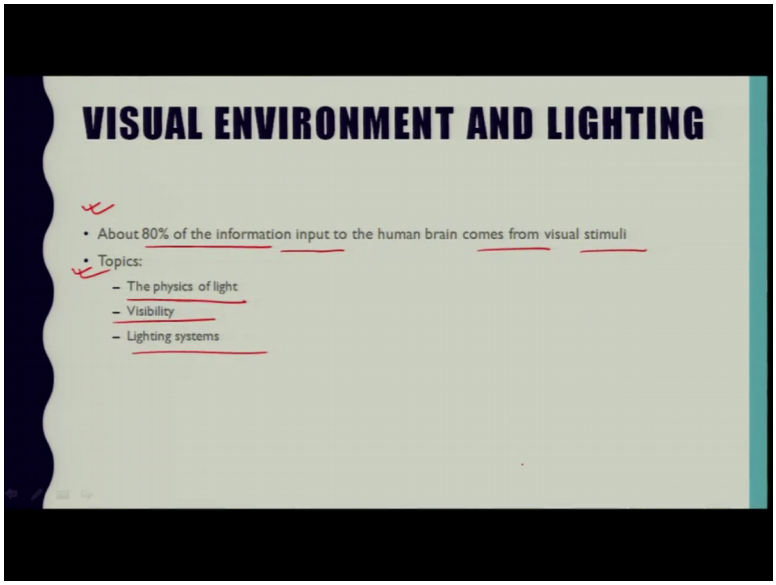

So, this fact we have understood when we started our discussion towards cognitive ergonomics in which human senses we defined and understood that 80 percent of the human information input comes from visual stimuli.

So, the introduction of some of the physical concepts about light as a source of stimulation for the sense of light we will discuss here and the visual environment thus the topics include physics of light, visibility and lighting system. So, in this particular section we will understand about the visual environment and work and how the lighting can improve that particular performance. So, first we will take physics of light.

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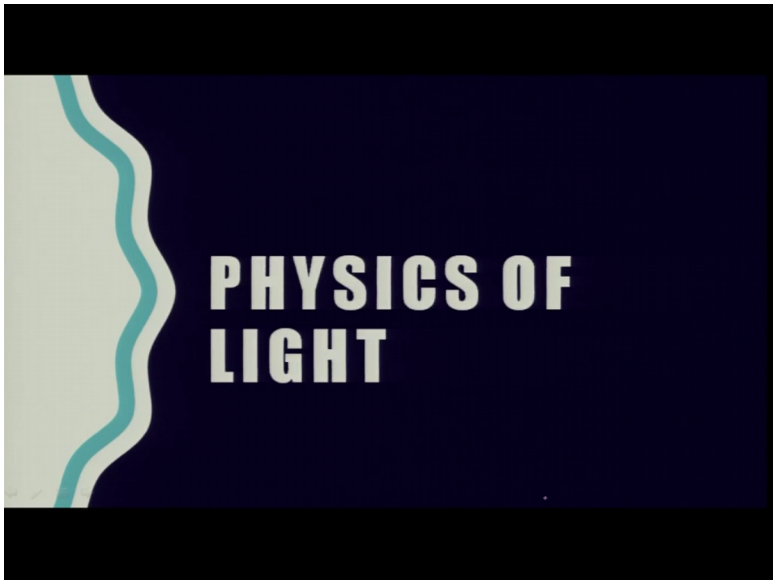

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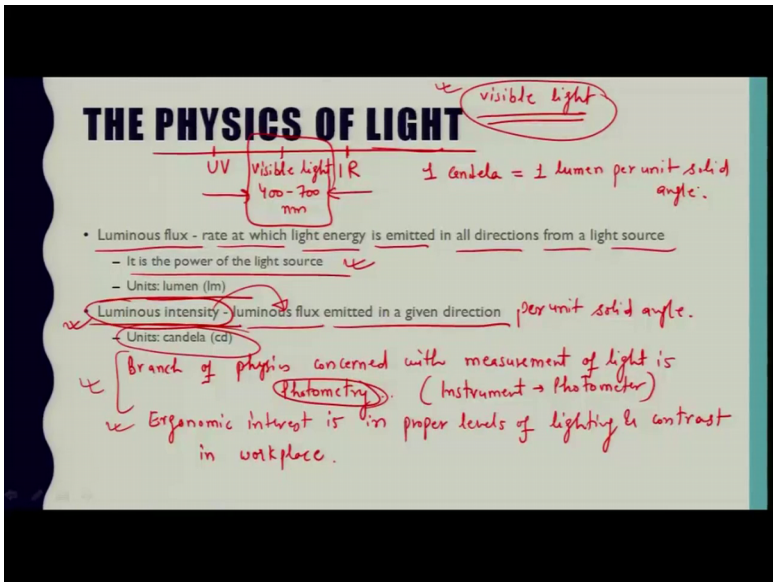

So, what is light? So, light we have we already defined that light is the part, light energy is basically a part of the electromagnetic spectrum. So, there are various sort of radiations around us. So, the compiler compilation of the all the radiations have been given and illustrated with the help of the electromagnetic spectrum chart in which in fact, human is only capable of visualizing just limited portion of that electromagnetic spectrum and those radiations are defined in terms of their wavelength. So, around and for our human capacity only certain portion of the light having wavelength, a certain portion of electromagnetic spectrum having wave length of about 400 to 700 nanometer is only visible, that is known as visible light. Other part of the electromagnetic spectrum

which includes microwave, gamma rays, infrared radiations, u v visible, u v radiations, x rays and so on forth.

So, these are the radiation which cannot be detected by a normal human eyes and it requires some the specific instruments that has been developed and for a particular spare, for a specific radiation there is a specific instrument to, so that those rays can be detected. So, back to our visual light scenes, this visible light is only responsible for visualizing our surrounding. So, we will focus and we will confirm our discussion of visible light throughout our lecture. So, here you can see that in fact, this in this particular visual light is in is within this ultraviolet, if you plot let us say electromagnetic spectrum.

So, it is in between u v and infrared radiation. So, here is visible light and that too is near about 400 to 700 nanometer of wavelength so this is the range of visible light. So, as a definition we can say that the branch of optical physics that is concerned with measurement of light is known as photometry. So, here we can in fact, we can write here also that the branch of physics, basically branch of optical physics the concerned with measurement of light is known as photometry. In fact, an instrument that measures this light is known as photometer. So, the instrument is, instrument to measure the light is known as photometer.

So, now as for as understanding of physics is concerned is, but what is its ergonomic interest. So, the ergonomic interest in a photometry is to provide the proper, proper level of lighting and contrast among objects in specific work place, where workers are performing their work. So, ergonomic interest we can say, ergonomic interest is in providing proper levels of lighting and contrast in workplace of any industry or any in any organization. So, in particular this photo meter measures the luminous intensity that is emitted by a source of light or reflected from the object surface.

The basic quantity in this photometry is luminous flux, this luminous flux is defined as the rate at which light energy is emitted in all directions from a light source, it is the power of light source, power is rate quantity and luminous flux is measured in lumens. So, a closely related term is this luminous intensity which can be defined as the luminous flux emitted in a given direction. So, specifically luminous intensity is the luminous flux radiated per unit solid angle, we will understand what this solid angle is defined per solid

angle and its unit measure is candela and this 1 candela is equal to 1 lumen per unit solid angle.

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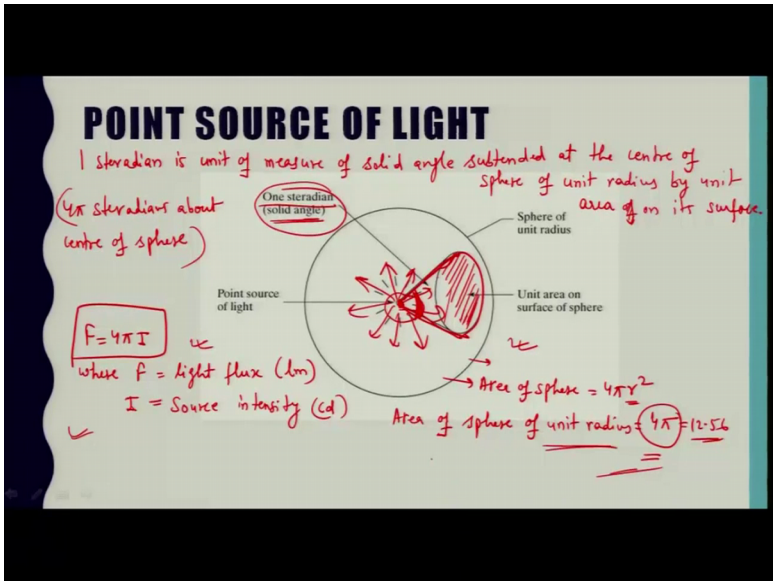

So, now let us have a clear understanding of what is solid angle and how a particular, this is a point source how a particular point source of light which is at the centre of the sphere let us say of unit radius also shown in a solid angle of one steradian which intersect the surface to create an area of one square meter.

So, now, we will understand these terminologies in a clear way. So, 1 candela is define and there is another unit is a 1 steradian. 1 steradian is equal to the solid angle subtended at the center of the like this is a sphere and suppose if we have cut out 1 unit area of on the surface of this sphere and this particular center is providing some tangle that angle is known as solid angle. So, 1 steradian is defined as, 1 steradian is defined as the unit of measure of solid angle subtended at the center of a sphere of unit radius by unit area of in fact, unit area on its surface. This is illustrated here in fact; it is showing that a point source of light at the centre of the sphere and the cone shape of cone shape of 1 steradian that intersects the surface of sphere to create an area of one square meter.

So, the point source radiates uniformly in all direction and since the total area of this spear we can defined as, how we can define there is a specific formula for that that is 4 pi r square and. So, the area of a, area of a sphere of unit radius how we can define? Area of the sphere of unit radius then r equals to 1, here if we will put then it will come out as a 4

pi that is something around 12.56. So, thus there are basically 4 pi steradian we can say about the centre of the sphere and analogous to 2 pi radian about the centre of a plane circle. So, here if steradian united yes is there so you can say that then there are 4 pi steradian, 4 pi steradians about the center of sphere. So, in terms of luminous intensity and luminous flux 1 candela point source of light radiates of total of 12.56.

So, here we can defined as the in fact, that those facts can be reduced one to one equation that is F equals to 4 pi I, where F is the light flux and that is basically light flux can be defined as the lumens and high is the source intensity, this source intensity is defined as the cd that is candela. So, now, in practice there is no apps such an isotropic point source of light. So, luminous flux radiates from a real light source with different entities in different directions so using a photometer basically.

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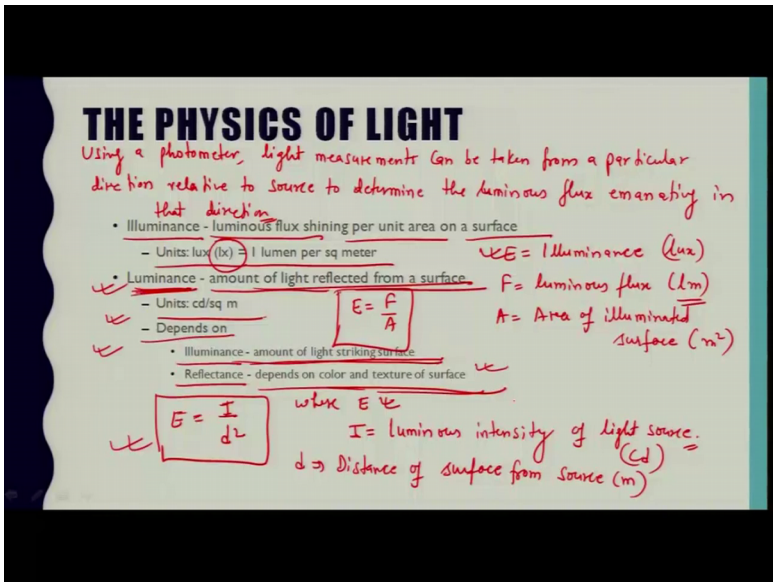

So, if we take let us say a photometer so light measurements can be taken. So, let us say using a photo meter light measurements can be taken from a particular direction relative to source to determine the luminous, luminous flux emanating in that direction. So, the amount of light shining on a surface is can be referred as a in ill luminance. So, now, so ill luminous can be defined as the luminous flux shining per unit area on a surface, unit can be as an lux l u x and in short form you can write as an lx. So, 1 luminous, 1 lumen per square meter it is defined as and then another term that is defined in the describing light that is luminance. So, this luminance is defined as the amount of light reflected

from a surface. So, here that particular a unit is candela per square meter and it depends on the ill luminance that is amount of light is striking the surface, reflectance it depends on the color and texture of the surface.

So, in equation form if you want to write that is E equals to F by A you please note down this formula because this formulas are somewhat necessary in order to predict the exact value that is required whenever we define any workplace environment in terms of it its visual abilities. So, E equals to F by A, there E is the illuminance that is expressed in lux and F is the luminous flux that can be defined as a lumen and A is the area of a ill laminated surface that can be defined as the meter square. So, this illuminance decreases as the distance from the light source increases. So, that is the deduction is proportional to the square of the distance has expressed in this written equation. So, where E is the illuminance is defined and I is the luminous intensity of any light source that can be expressed in the candela cd.

So, d can be defined as distance of let us lux surface from source that is expressed in meter. So, this equation assumes that the surface is perpendicular to the line of distance between source and surface that we will clear in the next slide. So, here you can see that.

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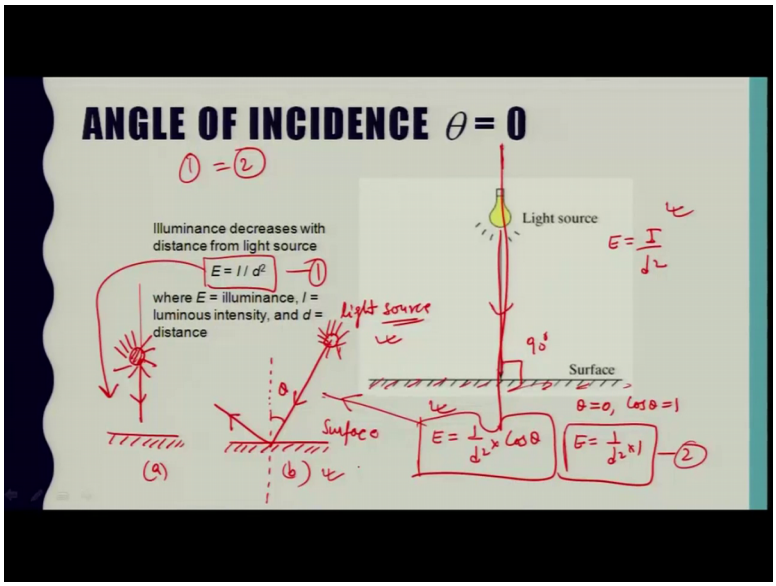

We assumed that this particular surface and the light is falling a perpendicular to the surface making 90 degree so for those reasons that formula is coming out as an equals to I by d square. So, this figure is giving you the angle of incidence defined for particular

equation, this equation and since a always say it is mentioned from the perpendicular. So, from this line of direction so theta is defined with the perpendicular line of the distance from the source and surface, so since another line I can add here. So, that the understanding could be more clear, suppose this is the source and this is the light source. In fact, and light is incident on this surface and let us say if this particular light is in clients giving some angle to the falling light so.

So, this particular angle and it is reflected from this to this. So, this particular theta is the some angle. So, here is this surface so you can find the difference between this a and b so this is the light source. So, if the angle of incidence and that is this is other than the perpendicular. So, illuminance must take the angle of incidence into the account and it can be determined as E equals to I by d square into cos theta. So, far this case this formula is applicable, on for this particular case on angle of incidence is other than normal then you can, you will use the formula that is e equals to I by d square times cos theta. So, where theta is angle of incidence and note that when if you can see this particular equation where if you will put theta equals to 0, then cos theta will be 1 and this particular equation will be reduced to equals to I by d square into 1, that equation and this equation are 1 equals to 2. So, the angle of incidence should be in the direction of the normal that has been put from the surface.

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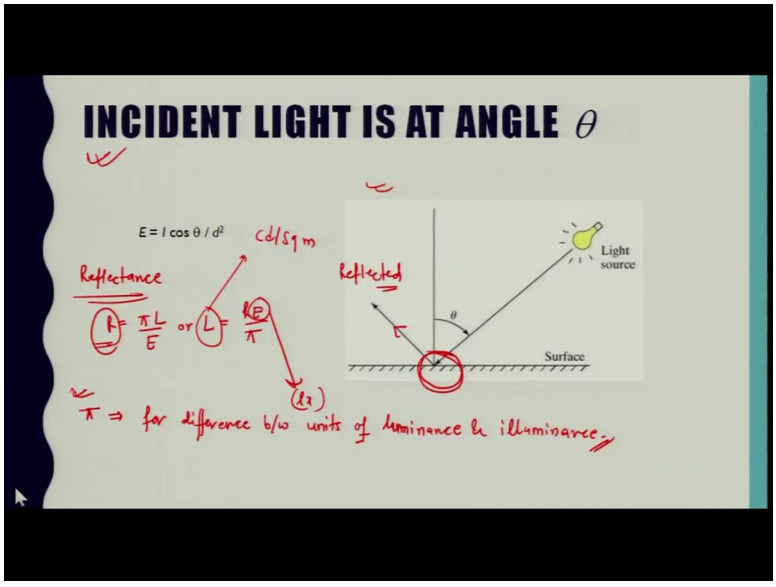

So, this particular incident light at some some sort of angle let us say theta. So, that we have described and now another aspect that we need to understand that when light shines on a surface some of the light is absorbed into the surface, where light is particularly incident and light is absorbed here and some of it is reflected from the surface.

So, in addition for material that are translucent some of the light is transmitted through the material, the light that is reflected from an object is what allows human to visually perceive it. So, the amount of light reflected from the surface is luminance and its unit of measure is that we have understood in this particular. So, luminance is, luminance is defined as the amount of light reflected from the surface and its unit is, its unit of measure is candela per square meter and this particular luminance of a surface depends not only on the amount of light striking amount of, light is striking surface or amount of light shining on it and also on the color and texture of the surface.

So, the proportion of the light reflected from the surface to the light striking it is the property of the surface known as reflectance. So, we have also to define this reflectance. So, reflectance is also necessary to be understood and that is defined in the side system of unit as follows that r equal to pi L upon e or capital L equals to r E upon pi. So, where r is the reflectance this the dimensionless fraction and l is the luminous luminance that is expressed in candela per square meter and capital e is illuminance that is expressed in lux and the pi term in the numerator is the conversion factor to account, for the difference in the units between for difference between the units of luminance and illuminance.

So, basically there are some values for various objects and paint colors. So, that is defined so that s all for the in fact, we can also solve 1 numerical based on that. So, we will try to solve 1 numerical then we will close this lecture. So, let us have a 1 example or one question based on the light from isotropic source. So, let us say 1 isotropic source, it has a intensity of.

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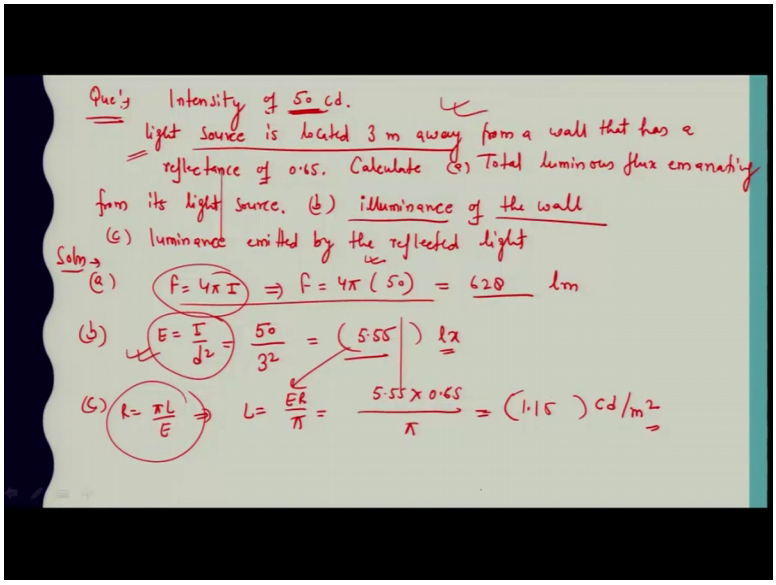

So, 1 isotropic light source has an intensity of 50 candela and the source is located, let us say 3 meter away, this particular light source is away from a wall that has a reflectance of 0.65. So, calculate, the first is total luminance flux emanating from its light source, b you have to calculate the illuminance of the wall and also you have to calculate the luminance emitted by the reflected light, to these things is the theory of these 3 aspect we have discussed in the previous slide.

So, it is very, it will be very easy for you to solve this particular problem. So, try to solve it I am giving you some time to solve it and you try it at your own end and then I am giving you the solution of that. So, that a complete understanding of the topic discussed is could be developed. So, the solution I am discussing here. So, the total luminous flux emanating from the light source can be defined as the F is equal to 4 pi i. So, you have the value of I as an 50 candela.

So, you can put here as 4 pi times 50 candela whatever will be coming has an lumen, the b that you need to find is illuminance of the wall that can we find out as E equal to E upon d square that is 50 upon it is since local light source is located 3 meter away. So, distance is 3. So, in this way you can find out the number that can be expressed in the lux and the c is the reflected light that can be determined by this equation that is basically r equals to pi L upon E since we have to calculate l. So, E r upon pi that can be defined as the so the value that will be coming as a F is equal to 4 pi I will be if you multiply these factors.

So, 628 here what it will come out as e is 5.55. So, the 5.55 value will be putting here. So, in this way the 5.55 into 0.65 upon pi which will give you the value that will be expressed in candela per meter square so that is this is a very simple question that over anyone can solve if you are in above 12 level standard qualification. So, this can be solved based on the simple formula putting the things are given in the question itself you need to recall these formulas and put the values and get the answers. So, it will be something around 1.15 candela per meter square. So, I am closing this lecture.

So, just a fact which I used to add in maximum slides possible.

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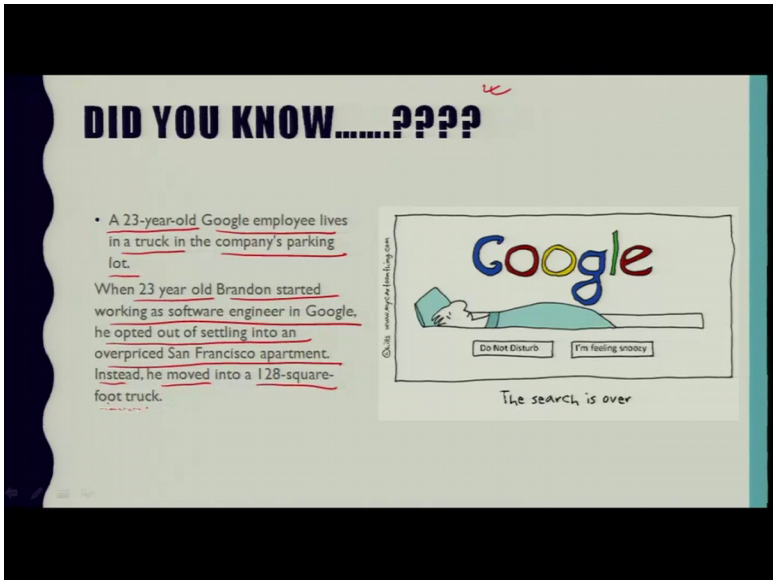

So, did you know that a 23 year old Google employee lifts in a truck in the companies parking lot, 123 year old Brandon started working as software engineer in Google he opted out of settling into an overpriced San Francisco compartment instead he moved into a 128 square foot truck.

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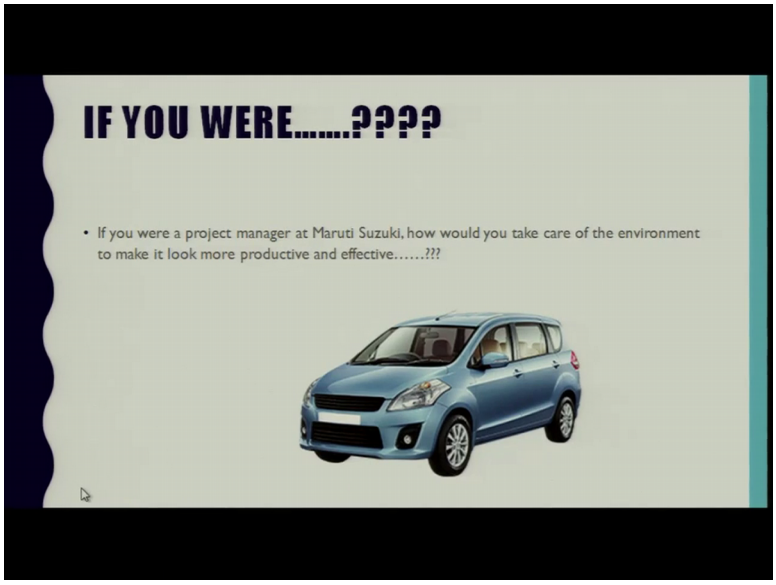

Since we have started very fresh lecture of physical work environment so, now, it is time to cultivate your thinking. So, in that series I am giving you one task, if you were a project manager at Maruti Suzuki let us say and how would you take care of the environment to make it look more productive and effective. So, think about that perspective and that is a graffiti for you enjoy it that is all for now.

Thank you.