Illumination Engineering and Electric Utility Services
Prof. N. K. Kishore
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Lecture No. # 15
Interior Lighting

Welcome to this course on illumination engineering and electrical utility services. Today we take up the fifteenth lesson titled interior lighting. Having understood the need for artificial lighting, having looked at various artificial sources of lighting, the ways to measure and how to control the light on the objects, it's time we had a overall look at how these artificial lights can be employed.

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The ands (Refer Slide Time: 00:01:37), the instructional objectives for this lesson would be, the first one list the factors that are responsible for interior lighting. We were talking about the interior lighting in fact today most of the times when you are working indoors, there may be need to eliminate using artificial sources even during day and that's where it becomes necessary. 2, state recommended requirements for good lighting, 3 the various factors that govern the light output in case of an interior illumination. So 4, what are the, state the maintenance procedures proper for interior lighting, needless to mention that any system which may be used for the benefit of humanity needs certain maintenance procedure.

So, this objective essentially looks at understanding the maintenance procedures that are necessary for proper interior lighting and lastly enumerate recommended illuminance levels. Obviously the eye is the way organ that enables us to perceive the information from the external world more than 80% and that's to facilitate that we are having illumination sources which try to emulate as close as possible to the natural light. So there are certain illuminance levels.

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So coming to interior lighting, the lighting that is required for interiors inside a building could be inside a hospital, school or walking interiors, any building we may take has some form of an artificial lighting to make it usable for the purpose which it is. Therefore it's a very complex problem, the lighting indoors is a real complex problem. It has varying factors depending on the purpose of service. For instance inside a temple where the meditation is being done the requirement of lighting levels could be different compared to a factory shop floor where precision components are being sold out on to a pcb. Therefore one of the first factors that may be necessary is the service for which the interiors are being used. Then the problem comes in terms of class of interiors that is type of interiors, type of furnishings, type of walls, the openings and occupancy level. Then is the necessity of looking at the luminaries.

Now depending on the height of the building or the interior, one can look at and based on the application let us recall that a point source of light essentially has illuminance reducing inversely as one over the distance square whereas if you had a line source of a light, it reduces inversely as the distance. On the other hand the sheet of light has independent of the distance. So depending on the requirement one may have to have a luminaire which can accommodate the lamps to produce the required effect and then of course colour effect, colour rendering in fact in the last lecture we saw is a very important issue which tries that in the presence of this light it makes the object appear as natural as it is in the natural light. Then comes the issue of how much of light is used, how much is wasted. This is where the interior surfaces come into picture. The moment we say we have walls, ceiling, floor, so where the light is observed, where the light is reflected and how it is reflected and in fact one other issue which becomes very crucial and one of the common mistakes in a lighting design is glare and that can arise from the reflections. If proper reflection factors are not chosen and the colours of the furnishing service the walls are not matched, these are some of the issues one needs to keep in mind.

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What constitutes a good lighting that's a very important issue? Having said that there are so many factors which decide the kind of a lighting which we will have for the interiors, let's see what constitutes a good lighting. Good lighting should have intensity which will make us see clearly and distinctly. Let's say we are talking of lighting a class room. What's the purpose of the class room? Purpose of the class room is for students to learn, so they should be able to clearly the black board there and observe what the lecturer is writing on the board. So the intensity should be designed in such a way it is enough to create clear and distinct images of the objects that need to be seen.

Distribution of light again should be uniform, in fact that is why you find that in good lighting installations, it's never a single lamp in a large room, it's a number of lamps so positioned that at least due to one particular lamp you get a uniform over a part of the room. So distribution is the second important aspect which constitutes good lighting. And obviously the diffuses are used to make light, not to hurt the eyes of the observer and make it soft and therefore diffusion is the third important aspect of good lighting. The colour pursuit depends on purpose and taste. Remember that there are certain applications where clear observation of colour may not be necessary. When you are trying to distinguish say the conductors in an electrical circuit, often we use a colour code which connotes the green is the earth conductor, red is the phase conductor, black is the neutral conductor and the illumination in the room if it is not able to distinguish between them in a laboratory it's no use.

On the other hand when you are just relaxing, listing to the music, the colour of the object in the vicinity does not match. However the approach would be to have as close to day light and in fact which has a peak around yellowish region to have yellow. And we said glare is one of the common mistakes and how does it occur? It occurs by virtue of presence of bright source of light in the line of vision; therefore preferably the lamps are to be located well above range of vision. So, these are the factors which constitute good lighting one has to keep these in mind.

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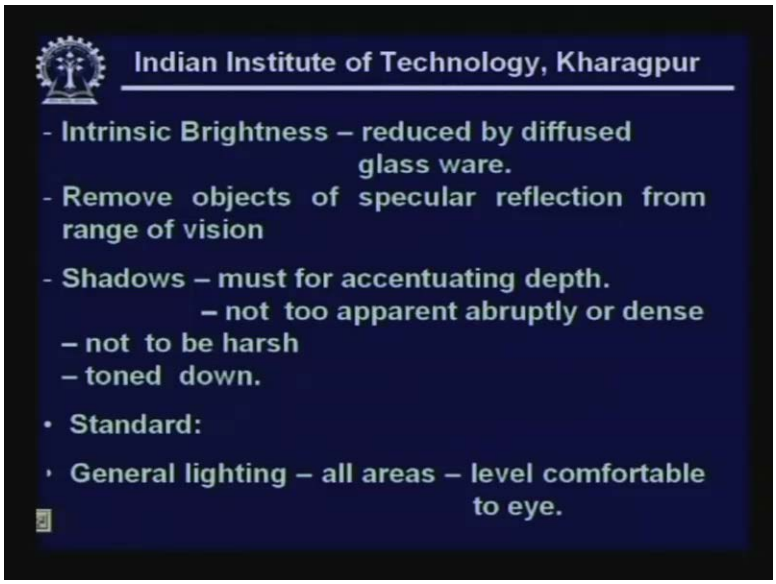

However and the brightness of its lamp of course is reduced by providing diffused glassware. We have those spherical shells which are diffused or oval shells which we have seen. And always avoid having objects which can give specular reflection in the range of vision. One in other issue which is very important is that when we are observing objects, we are observing objects in three dimensions. We need to have an idea of the depth and one of the important way is to perceive depth or accentuate depth is through shadows. So the shadows selectively have to be included. They should be there but not apparent abruptly or they are not supposed to be very dense, not harsh and they are toned down that is mild shadows are required.

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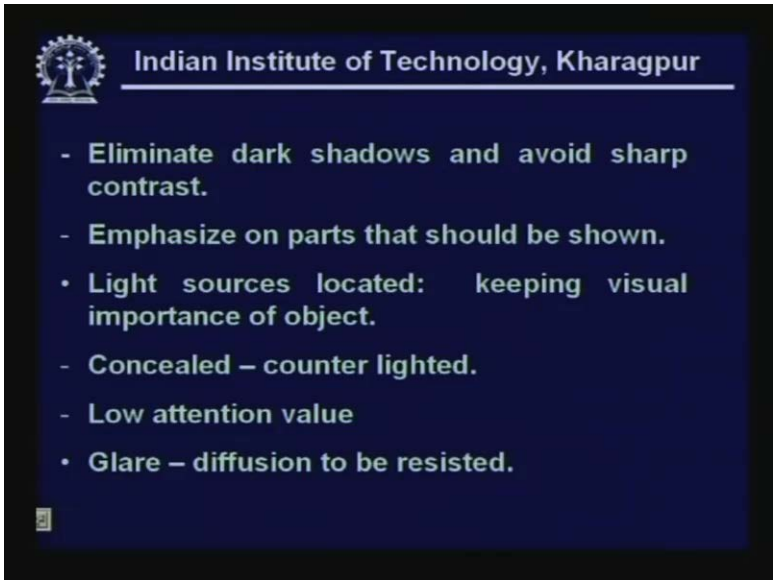

Therefore a standard lighting in an interior domain would consist having two schemes, one, a general lighting for the entire arena which is comfortable to the eye and enables free movement of the people around and a local lighting depending on the task specific. And always by having this, it eliminates dark shadows and also enables there is a certain abrupt change in contrast between two objects. And of course there are certain applications where certain parts should be shown. We are talking about a lecture theatre; the emphasis should be on looking at what's on the screen or if you go to a shopping mall there will be a display window. The items placed in the window need to be emphasized and therefore lighting should be in such a way that emphasizes the parts that need to be shown. Hence we recommend that sources been located keeping the visual importance of the object.

For instance you need a lamp placed right above the black board in a class room so that the students are able to see what is written on the board. This is often achieved through the process of what we call concealed lights, we have seen light lamps located in the recess of the ceiling are counter lighted that is in order to avoid strong shadows light placed on the two opposite sides of an object enables eliminating unwanted shadows. And at the same time unless the lamp itself is archival or I mean the it nature or its got attention to be drawn to it as a form of an antique, it should have a low attention value like as I said in a work in a reading room what needs to be felt is the reader should be able to read or write on the desk but he should not be distracted by the lamp. So the source itself should have a very low attention value and glare of course, we had a complete lecture on glare where we talked about what constitutes glare which is essentially intense bright light in the line of vision and this should be resisted and this is the common source of mistake in what you call most of the lighting installations.

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Before we proceed further, it would be appropriate to look at some of the recommendations made for the good illumination pertaining to interiors. These recommendations are taken from the, as suggested by American institute of architects, let's see one by one. The first recommendation deals with general lighting. It says a general lighting is one which illuminates

all the objects and areas within an interior keeping in mind relative importance, okay. So what is a general lighting? It is a lighting which eliminates complete interiors keeping in mind relative importance of the various activities within that interior. It has to be at a level which is comfortable to the eye throughout the room eliminating dark shadows and avoiding sharp contrast. We have already said there should not be abrupt change in contrast.

In fact we will see the trend is from the brightest object to the darkest object there is a particular recommended ratio of brightness which is between 10 to 1. This ensures that there are no sharp contrast and dark shadows are eliminated. You of course must have soft shadows or mild shadows which helps you in accentuating depth or trying to know the three dimensional aspect of the object that's being observed, roundness of the object is a must. And the lighting must emphasize only the object that needs first attention. So the relative brightness must be in such a way that the observer is drawn to that object which needs to be.

In fact if you go to a shopping arena the show case or show, show room windows I mean where they show the new products, the most recent product gets highlighted more than the others, so that the buyer gets attracted to the recent item or the new arrival. So the first recommendation deals with general lighting which says it should eliminate all areas keeping in mind the relative importance of the various parts at a comfortable level eliminating dark shadows and sharp contrast, keeping sharp shadows so that you are able to perceive the depth and emphasizing only on those parts that need first attention.

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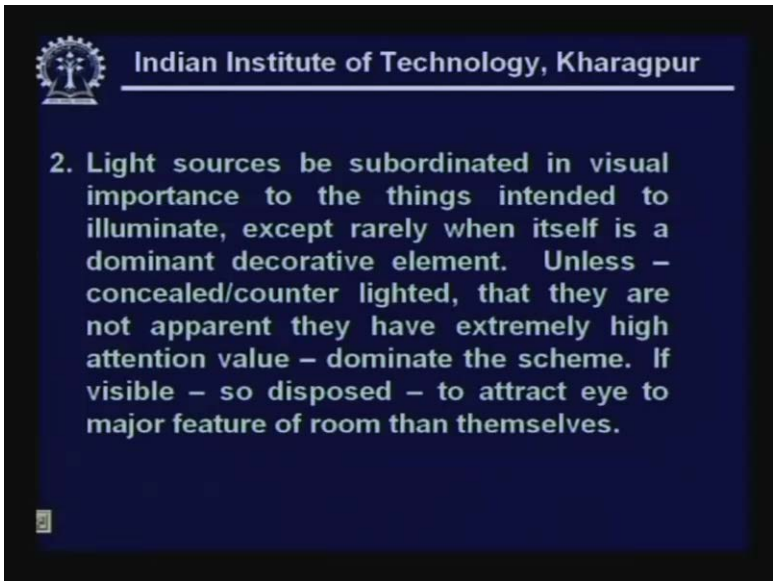

The second recommendation is to do with light sources. We said light sources should never draw attention to themselves. Light sources should be subordinated in visual importance to the things intended to illuminate. There may be rare exception when the light could be a decorative element. It could be an antique then it is to be emphasized unless concealed or counter light they are not apparent, they have extremely high attention value and dominate the scheme. So otherwise if they are located, if they are not concealed they are not counter lighted they should be

located in such a way that the observer is not drawn to the lamp but he is drawn to the object which is lit by the light coming from this source. So essentially what it means is you should not get distracted by the way the lamp is located. One simple thump rule would be because most common way of locating lamps is suspending from the ceiling. Let them be suspended at a height which is well above the line of vision.

So unless a person observer directs his head towards the ceiling he is not disturbed by these lamps. The third one is to do with glare, I said though the recommendations talk about glare, it is the common error in most lighting schemes. It must be eliminated and results out of the intense bright light within the line of vision. This is more so the higher the candle power of the lamp, higher is this scope for glare. In fact this is where diffused in where helps in reducing this.

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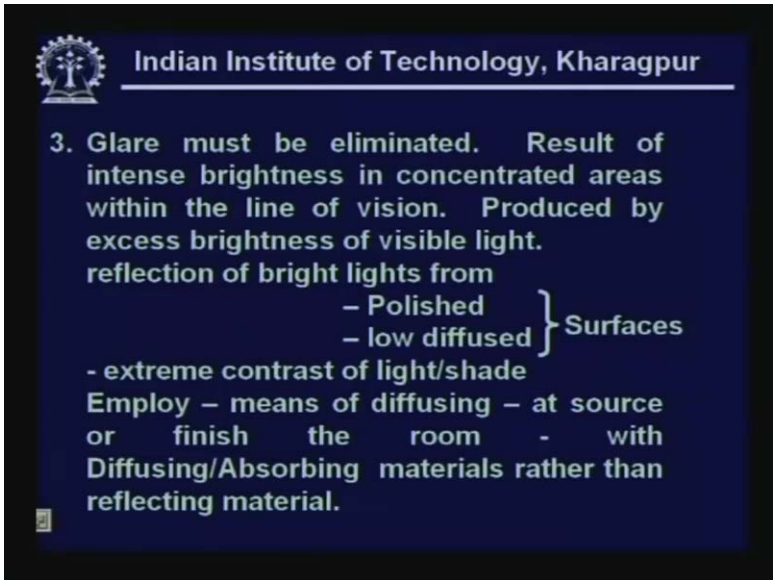

And instead of locating the point sources you have large number of sources distributed trying to come as close to as possible as a sheet of light. So this also arises in the form of reflections from polish surface and arises more from the design where contrast between light and shade is very large. So this is where diffuses have to be adapted and the entire room interiors including the furniture have to be designed with what we call diffusing or absorbing materials rather than reflecting materials. So if you see the most of the walls are not made highly reflecting, we will come to the typical recommended reflectance levels. We have seen earlier also in talking about the glare reduction. So the first one was to do with how a general lighting should be, the second one talked about how the light should not or the lamp should not draw attention to itself and the third talks about the glare, the glare control.

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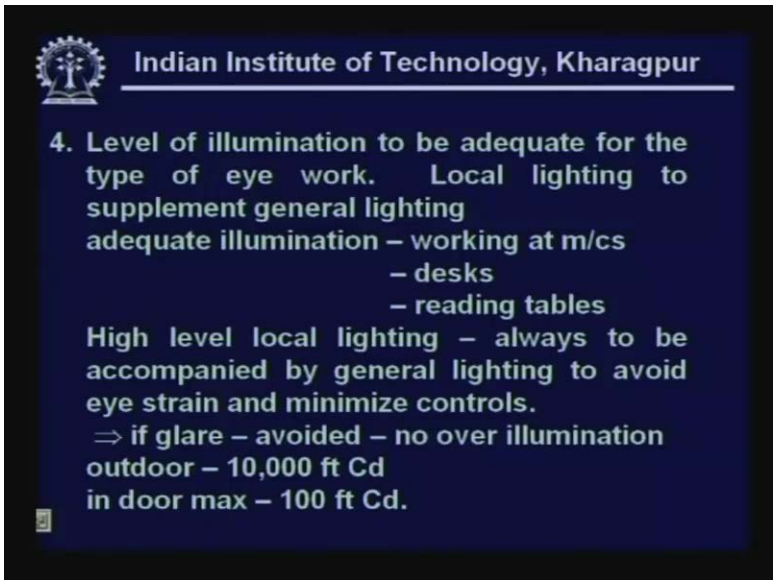

And needless the fourth recommendation talks about the illumination level. So, depending on the type of service the illumination level needs to adequate for the type of eye work. In fact we talked about these levels when discussing about the functioning of the eye and there we did mention the comfortable levels in terms of illuminance for various applications and this is where it also says a local lighting is to be supplemented with general lighting. One may question why have two sets of lights? As already told in order to avoid abrupt change in contrast, it is necessary that there is some general lighting in any interior to create ease of movement and that as per the recommendation number one.

Now this elimination should be adequate depending on the nature of the work for working at the machines, working at the desks, reading tables. If you are just watching a film with visuals there may not be requirement of large illumination. On the other hand if you had to read fine print or one has to work at assembly line trying to assemble precision parts, there is a need for more intense illumination. So its local lighting is invariably a high level and as already told is always to be accompanied by general lighting, this avoids an eye strain and minimize controls. This is very important otherwise it becomes very difficult and if glare is avoided there will be no over illumination. Keeping this in mind the sort of a upper limit which can be put, here we are though talking about indoor illumination, we are suggesting certain maximum that may be there is outdoor conditions.

Remember in outdoor conditions it's all open and there is ample scope of light being lost by way of absorption into the atmosphere. So we find the recommendation is around 10000 foot candle as the maxima for an outdoor application whereas its 100 foot candle for indoor. So, this is the thing, so we talk this is the sort of an upper limit which we get.

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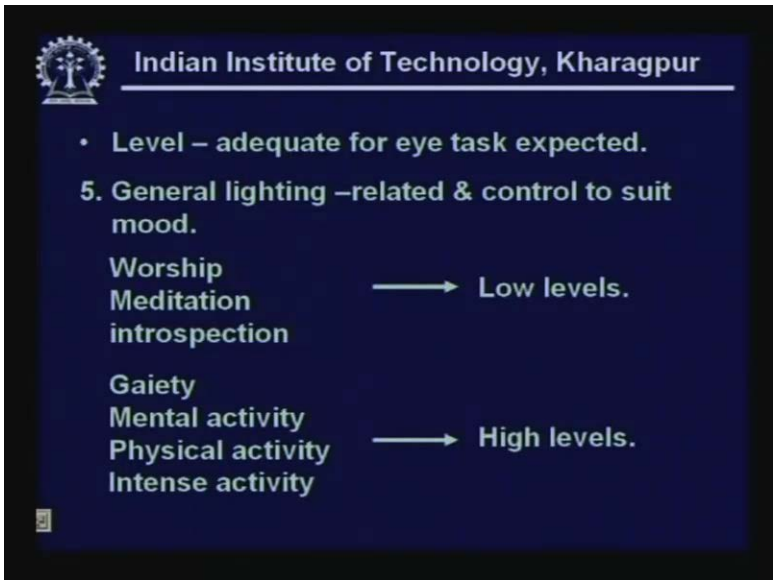

This level we say it should be adequate for eye task. The general lighting as already brought out is related and its control in fact there is no control for the local lighting, it's an intense light of the required level for that particular task. General lighting can have illumination level altered depending on the mood. Now here we have grouped the applications into different groups. The first group which we are looking at is what that requires very low levels, it could be for say worship, meditation, introspection. In fact this is a situation where one does not really observe what is there or what is moving. The light should be adequate enough to warn of the observer about the way to go out or come in to the room and see if there is any disturbance. So, very low levels are adequate enough in fact the meditation which they say is calls for completely shutting off any inputs through the mind to the eyes.

On the other hand the physical activity, mental activity, gaiety, gaiety we see the dance clubs, disco clubs, physical activity playing when you are playing let's say you are playing badminton, you need to know how the shuttle is moving, compared to the players the size of the shuttlecock is very small, smaller the object the more light is required to track its movement. Faster it is you need more light, slower it is lesser light will do. So, all these come under a group which involves certain intense activity for instance intense reading and writing working on it. These are all involving precision eye task which needs for high levels. Now there are certain third group which comes between the two. So we have seen on one hand we have worship, meditation, introspection which needs very low levels. There are the intense activity involving physical or mental activity, gaiety involved with high levels.

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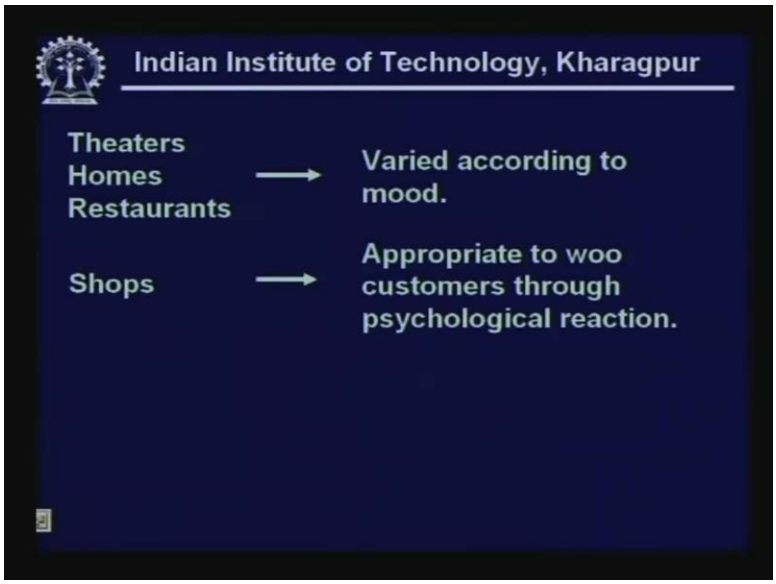

The third group is where theatres, homes, restaurants. Homes depending on the nature of the activity, the room could be lit little low or high. The various ways to do would be to use dimmers; we talked about dimmers which essentially control the voltage input. This holds good if you are using lamps otherwise you could have discharge lamps with different elements, low voltage elements or high voltage elements depending on the mood you could, restaurants is again a place where depending on the mood the light levels can be adjusted. As supposed to this you have commercial sectors involving shops.

Shops would have varying levels and they need to light in such a way that the customer is attracted to the object that the shop wants to sell. Now depending on the, in fact we said a new arrival should have an illumination in such a way that it draws first attention when the customer enters. So that's why the recommendation says we should be appropriate to who customers through psychological reaction that means by very its appearance, it should makes the buyer think of buying it. Now the last group which we have listed here consists of officers, factories, schools, all these are working towards efficient production of certain products and efficiency depends on making the working conditions as comfortable for the work people concern as possible. And in all this environments there is intense activity involving precision use of eyes. So this is where one has to have illumination which causes least eye strain.

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Lastly it's necessary to match the sources with the interior walls, ceiling, the style and considering the architectural nature of shape, finish and other issues. With all this, we said in a particular interior there can be dark corners, bright corners and the general recommendation talks about a general illumination level which is comfortable for the eyes and keeps this thing in mind. With all this the trend would be back if you have a task, let us say we take a class room the task there would be to work based on the subject being taught, so the reading and writing is the basic task. So the brightest surface in the room should not be more than 3 to 4 times brightness of the task question and in the similar way the task brightness should not be more than 3 to 4 times darkest surface. What does this lead to? I told you there should be a relationship between the darkest object, brightest object and task. So the brightness ratio which is believed to give rise to this kind of a thing would be 10:3:1. So when you have a mix of general lighting, we service a task lighting.

The task lighting are the local light source at the point where the source is located could be viewed as the brightest surface and for this point from the general light source could possibly be the darkest. So they should have a ratio of 10:3:1 but all this should be done eliminating glare which will result in good visibility and enables easy viewing and as a whole produces a pleasing psychological effect which enables the observer or the user to effectively function for the purpose for which he is or she is using that particular interior.

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Now all this says that in fact for general lighting would call for large light sources which cover entire ceiling. In fact in many offices we do find the large luminaries are used in which the number of fluorescent lamps are placed. They are source placed in such a way that this surface simulates as close to a complete sheet thereby it results a uniform good general lighting. The other way to achieve this is which is most of our houses in fact have, we call it white paint the ceiling is painted white we use white, white wash we call it and then you have semi indirect luminaries. The light from this lamp is directed through a reflector onto the ceiling and the ceiling reflects the light onto the objects below where you have the work force.

In fact, this is also achieved by having a false ceiling which is white or off white with a translucent diffusing material placed on which number of lamps are located, no doubt, all this involves complex wiring. And now if you look at, the apart from the glare another defect is to use very bright luminaries with dark floors and dark furniture this is where it's going to create. Recall the ratio which we have suggested between the darkest to the brightest should be between 10:3:1 that is if you have light colour interiors and large sources that is having line of sheet sources of low brightness, you can get a good uniform illumination all over.

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In fact the one issue which comes is day light illumination. Especially when you are using in interiors, how do we allow day light to come in? We have windows, in fact if we are able to suitably locate our windows and get the day light, there will be tremendous energy saving too. However the illumination due to natural illumination changes with weather, season, time of the day. And as you go higher and you find that the lower day light levels on the upper levels. So it's observed that around 20 to 25 feet from the window, the day light essentially falls. So the window height has to be kept in mind, keeping in view whether the windows are located or possible to locate on both the walls, opposite walls and the width of the room.

Then second thing is whenever the illuminance level falls below 10 lux at any point on the surface, in fact if you see, if you have a room with windows only on one side, you can find that the point on the floor closer to the other wall would have the minimum illuminance. But if you had windows on either side it would be the midpoint which has the minimum illuminance and whenever it falls below that there is a need to turn on the general lighting. Now this is one thing which you can take care in fact sometimes we do not allow the windows to be used in an open mode, we partially screen them, so that you have uniform general lighting independent of the time of the day that's what is the common practice.

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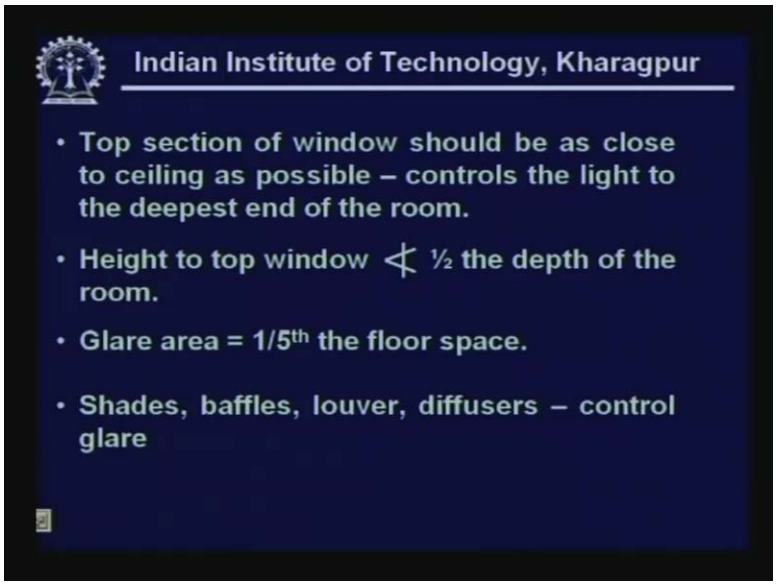

So in order to have the good illuminance due to the day light, the top of the window should be as close to the ceiling as possible, thereby it enables controlling light to the deepest end of the room, so this is one thing. So you have as close to the ceiling as possible. In fact one guideline which is followed is that the height to the top of the window should not be less than half the depth of the room. So if the depth of the room is 10 feet high to top window should not be less than 5 feet that's the index. And the window opening is one source of what you call the reflect, the glare area the light bright sun light coming. This should be around one fifth the floor space, if you have a floor space of 10 feet by 10 feet 100 square feet, it should be around 20 feet. So this is the guideline in arriving at the… Then as already told to have nearly uniform brightness independent of the day light conditions one could have a mixed partially screened things by using shades, baffles, louver, diffusers so that there is no glare whatsoever and making the top of the window as close to the ceiling as possible. This is done.

Let's say if the artificial illuminance that may be sufficient for the task is x, the minimum illuminance what one should expect from the day light should be 2 x. So if that be the case, if one has windows located only on one wall, it is width of the room should be less than two times height to the top of the window. So, width of the room should be less than two times height to top of the window. Let's say top of the window is located 5 feet, 2 times that is 10 feet, so the room width should be around 8 feet.

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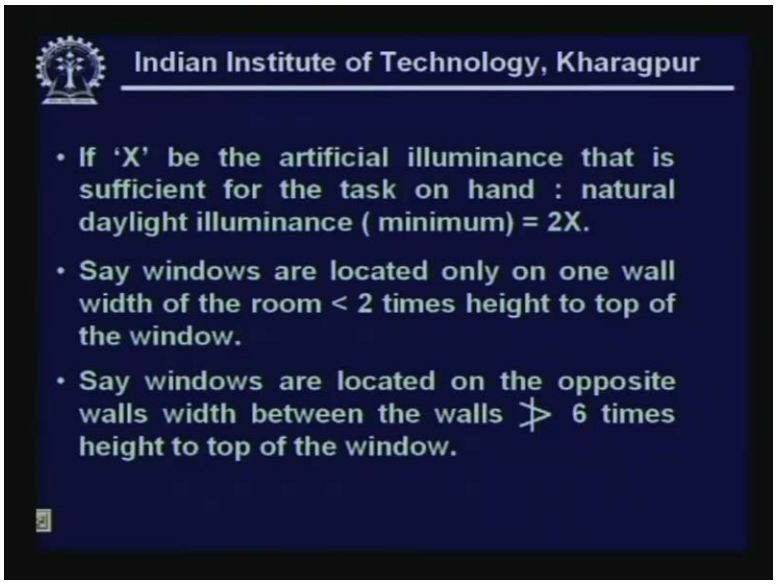

On the other hand if the windows are located on opposite walls, the width between the walls should not be greater than 6 times the height to the top of the window. Going with the same argument, if the top of the window is around 5 feet, 6 times that would be 30 feet, so it should be less than 30 feet between the two walls. These are some of the guidelines.

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Having said all this, the next thing that comes is the location of the lamps that depends on the candle power. The maximum allowable spacing between the lamps, the height at which to be located. Remember too large spacing would involve what is called dark shadows or dark space between. Remember the aim is to locate have as uniform lighting as possible, lamps best fitted

closer to the ceiling and that way they are clear of obstructions and they could be suspended, mounted at the surface or could be recessed in the ceiling.

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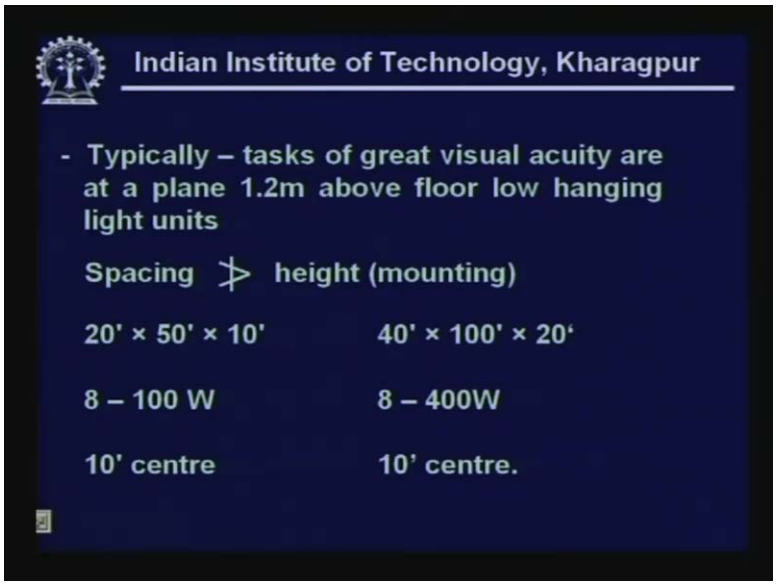

Most of the task which are intense visual activity are on tables like reading and writing which may be typically about 1.2 meters above the floor. They can have local lighting in addition with low hanging lights but keep in mind when multiple lamps of their spacing should never be more than the height of the mounting. Consider the 2 rooms 120 feet by 50 feet by 10 feet, other 40 feet by 100 feet by 20 feet, in fact with number of lamps located with same center to center distance of 10 feet you find this, the number of lamps remaining same. The smaller room would need a 100 watt lamp whereas the larger would need a 400 watt lamp.

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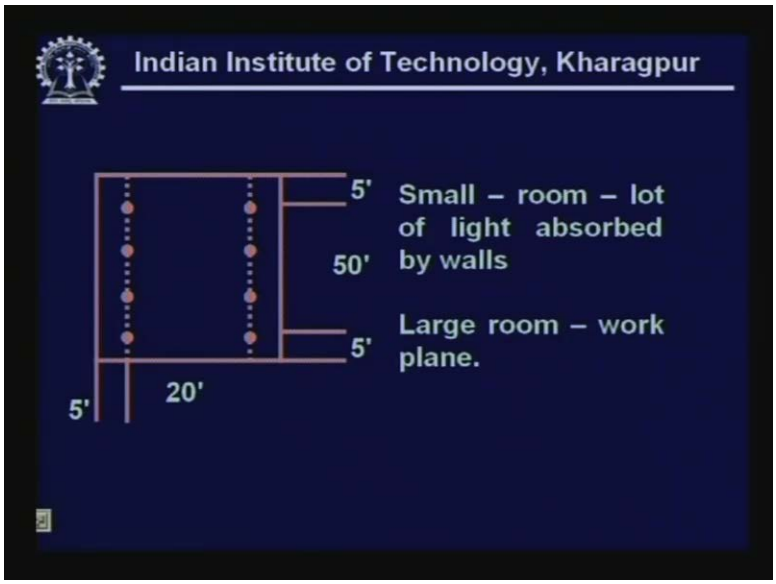

This shows a typical small room and in fact you find the way it is marked this is that 20 feet by 50 feet. The observation to be made here is that in a small room lot of light is observed by walls. When you have the large room, the emphasis would be to have good lighting on the work plane.

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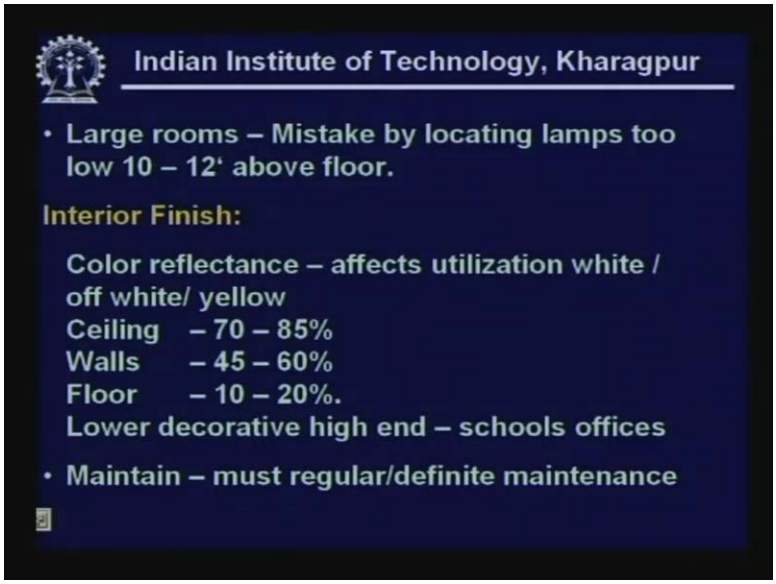

Large rooms never locate lamps in fact the mistake, common mistake which is done by placing lamps to low, it's not required. Remember if you try creating sheet large source of light, it is independent of the distance from the lamp. Now coming to the finish, we said the interior finish does effect and in fact colour reflectants effects utilization and often whiter, off white or yellow are preferred. The reflectance levels which one expects, you expect most of the light from the

ceiling to be reflected under the object whereas walls and the floor are expected normally to have very lower reflectance, walls have typically around 45 to 60% where the floor has a least with 10 to 20%. Now in fact schools and offices have lower decorative kind of a thing, high end utilization. Now an additional issue which comes is how do we maintain? We design considering all this, come up with the situation then comes the maintenance, there must be a regular definite maintenance.

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Periodic check could be by way of using light meters and whenever there is a reduction by 20 to 25%, it's time to replace. Replacement individually may work at home but not in larges installations, it's preferable to do it in group. The source of depreciation in light output is luminaries, they collect and they collect the direct light, therefore after reflection at least one and half times minimum requirement must be there. The other issue is the lamp survival which depends on the voltage, if maintained properly it will be good otherwise energy costs go high. In case the voltage available is greater than the labelled voltage, the life is shortened. On the other hand if the voltage is less than the labelled voltage, light output is low, no doubt energy costs may be low but due to inefficient this thing that may increase other costs.

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The lamps and luminaries need to be maintained, luminaries they could be washed, cleaned. In direct case there is less dirt, in indirect case there is more dirt so there is more periodic requirements. This could be wiped with brush or dry cloth or damp cloth.

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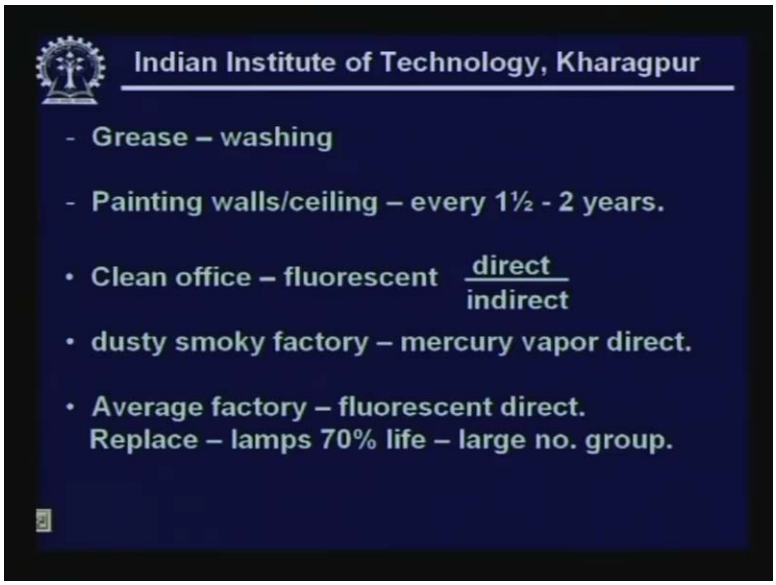

Grease should be washed and that is as for the lamps but the interior, that is a walls and ceiling are preferably painted every one and half to two years to create. With all this the offices interiors could have floors and lamps with direct or indirect luminaries. The dusty, smoky, factory environments could have mercury vapor lamps with direct luminaire and average factory could

have a fluorescent direct but remember replaced lamps when 70% of them have lost their life. So you have group replacement there.

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In effect what we have seen in this lecture is that good interior lighting is governed by intensity that's ample to see clearly and distinctly, creating nearly uniform distribution which is soft and well diffused light. Colour of course depending on the purpose and taste, keeping the sources well above the plane of vision to avoid glare.

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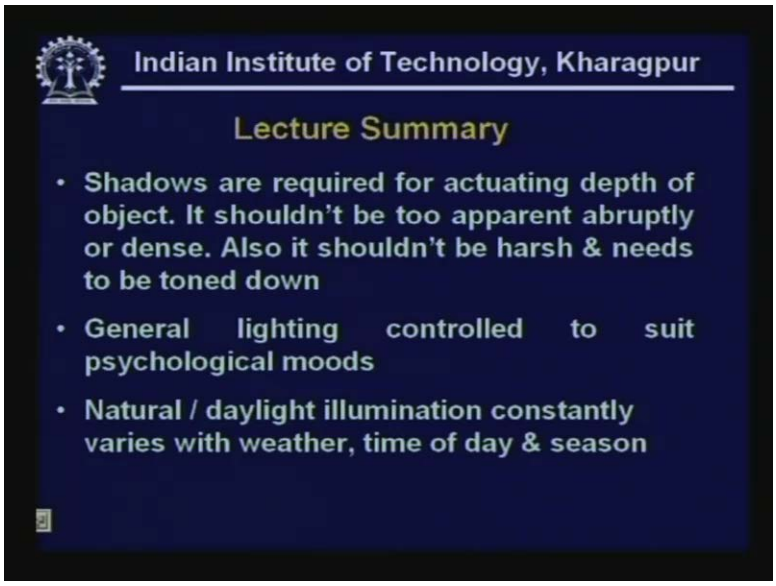

Shadows are always required for accentuating the depth of the object, should not be apparent or dense. They need to be toned down that's why they are called soft shadows. The general lighting is provided which controls to the suit psychological moods. The natural light or day light illumination varies with the weather, time and season.

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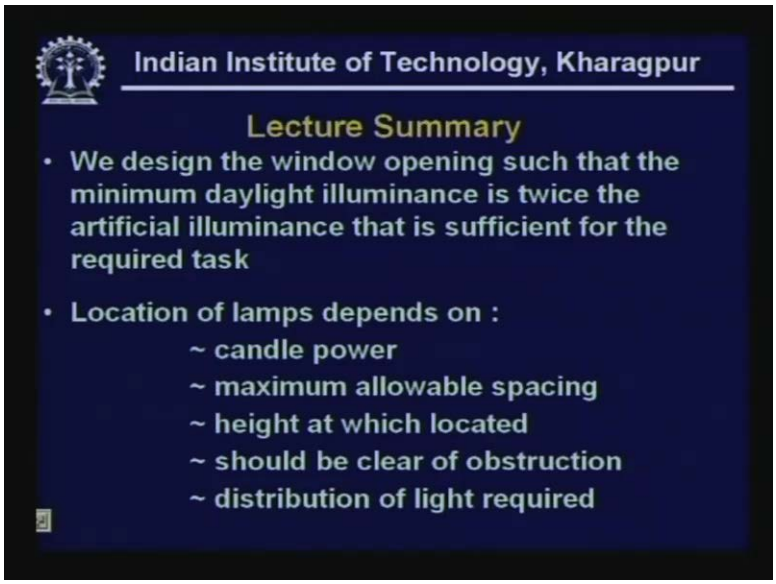

Therefore windows are accordingly designed, windows opening such that the minimum day light illuminance is twice the artificial illumination sufficient for the required task. The location of damps depends on the candle power, spacing allowable, height at which located. Keeping in mind they should be clear of obstruction and provide the required distribution of light.

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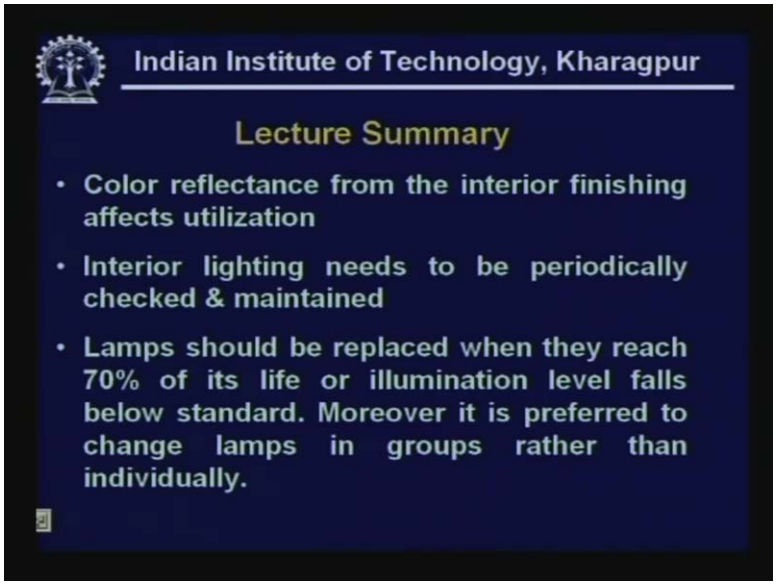

Colour reflectance from the interior effects the utilization and interior lighting needs to be periodically checked and maintained. Whenever they reach the 75% of it life or illumination level falls below standards say 20 to 25% preferable to change, it's preferable to change lamps and groups rather than individuals.

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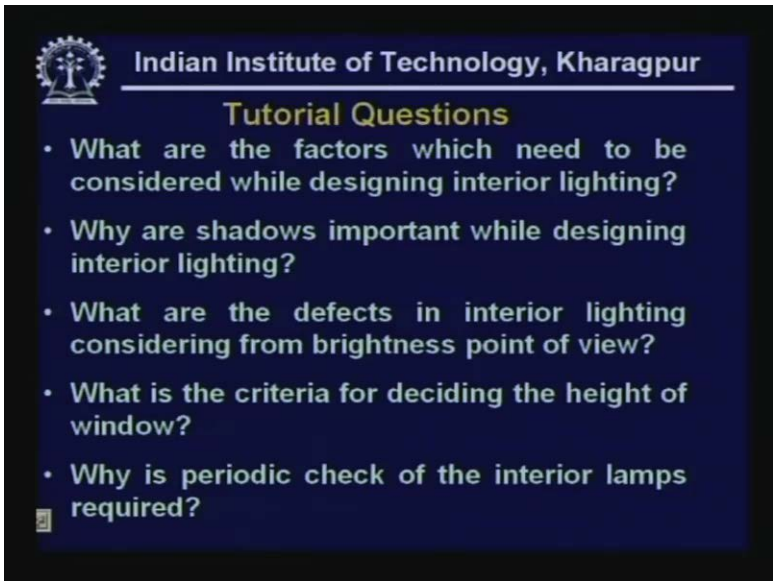

The questions. What are the factors which need to be considered while designing interior lighting? Why are shadows are important while designing interior lighting? What are the defects in interior lighting considering from the brightness point of view? What is the criteria for deciding the height of a window? Why is periodic check of the interior lamps required?

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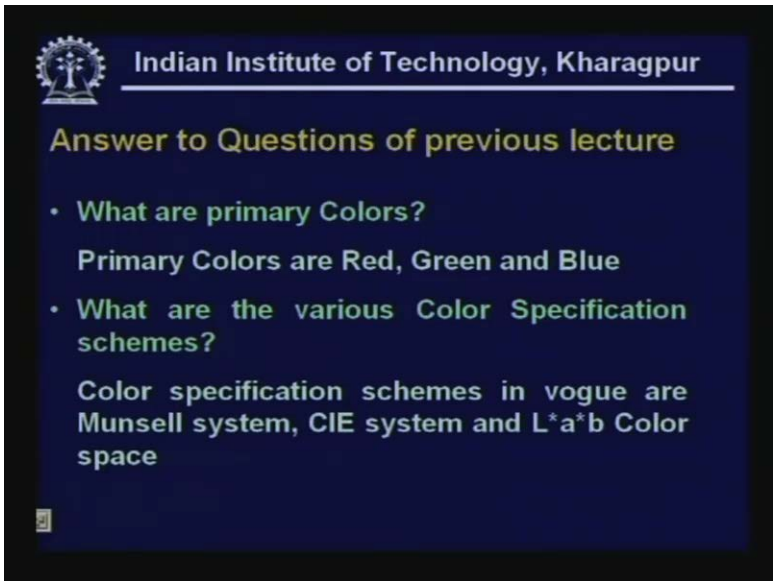

Answer to questions of the previous lecture. What are primary colours? Primary colours are red, green and blue. What are the various colour specification schemes? We saw in the last lecture, colour specification schemes in vogue are Munsell system, CIE system and L a b colour space.

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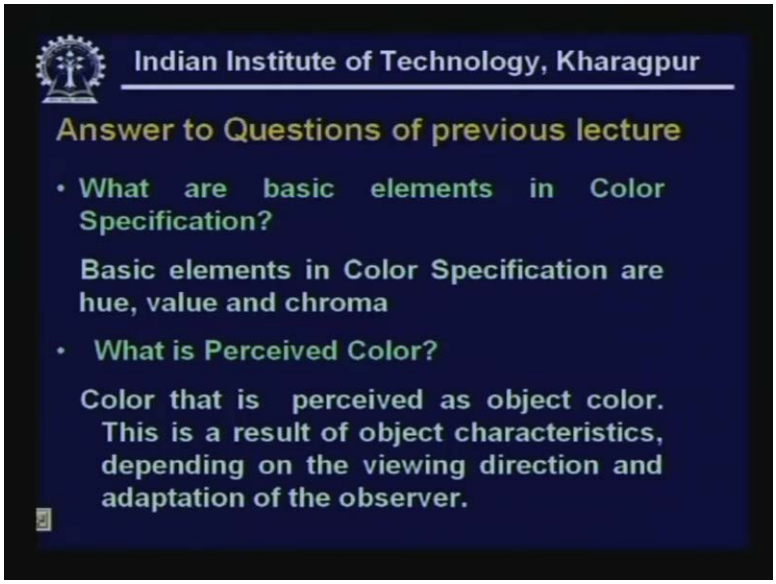

Continuing with the answers. What are the basic elements in colour specification? The basic elements in a colour specification are hue, value and chroma that it is three dimensional. What is a perceived colour? The colour that is perceived as object colour, this is the result of the characteristics depending on the viewing direction and adaptation of the observer.

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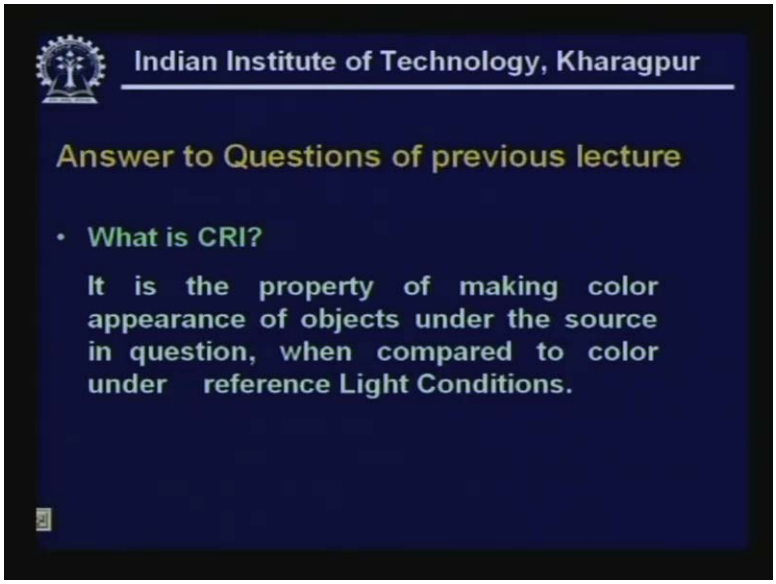

What is CRI? CRI stands for the colour rendering index, it is the property of making colour appearance of objects under the source in question when compared to colour under reference light conditions. Thank you.