Illumination Engineering and Electric Utility Services
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Lecture No. # 19
Lighting Applications

This is course on illumination engineering and electric utility services. Today we take up lecture lesson 19 which is titled lighting application. Having gone through the need for lighting, how artificial lighting has extended our activities round the clock which used to be only confined to sunset, I mean sunrise to sunset has a wall and we have seen what are the various applications that could be physical phenomena that can be used for artificial lighting. And as a result what are the components of the lighting installations, how we quantify these and how one calculates and we had also had a look at various recommendations for both interior lighting and exterior lighting. And in fact today we are trying to address or summarize all these things in one thing called as a lighting application and in principle this could be a very vast topic, there can be n number of lectures.

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We are trying to have a brief over view in a single lecture and therefore the instructional objectives could be list the various lighting applications, understand the need to integrate lighting with other applications. As I have been all the time telling, emphasizing right through the course that lighting which artificial lighting is invariably employing electrical energy and electrical energy is used for other applications too in our environment and therefore there is a need to integrate lighting with other applications that is what we understand here. And further the lighting pursue could be for industrial applications so its classify the industrial lighting, classify office lighting and list requirements for lighting for educational institutions, auditoria, hospitals, hotels and restaurants.

In that sense one may say that if we had a look at the instructional objectives, we are not trying to take exterior lighting any more into account because we have extensively covered by way of two lectures, one meant for sports specifically other meant for street lighting. Here the interior lighting basic principles were introduced in an earlier lecture. It must be mentioned that most of these recommendations have been based on the international recommendations based on CIE and in all countries they have the local standards which adapt the CIE recommendations. Similarly in our country we have the Indian standards which are specified by Bureau of Indian standards. And this lecture at some point would like to give you an idea of few of the standards that are applicable for various lighting applications, not very exhaustively in fact it gives broad number and some of them have more than one part. The idea is to make the audience aware of the standards available but details can be obtained from the handbook of Bureau of Indian standards.

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Coming to the lighting applications let us take the first of its kind, the one of the most important things the industrial lighting. Industrial lighting has been a very important issue because as we have been telling, trying to make the activity round the clock we are able to have a more production that's one important thing. And therefore there are various types of visual tasks and unlike offices and schools where essential task of reading and writing is the major task in most of the schools and offices. And requirements are quite different compared to what you have in industry. Industry there may be precision production.

So there could be extremely small objects in industries dealing with large scale integration to a very large object where industrial products are being developed are conventional engineering industry. It could be dark or it could be light components and there could be surfaces which are regular, irregular, they could be flat or contour. So all these things make the lighting requirements quiet different and in fact this would form one class of interior lighting and in fact we did mention the kind of lamps that are used invariably wherever the colour rendering is not very important, we try to use where the base are very high, we use sodium vapour lamps which has a characteristic orangish colour. Now here the tasks are graded depending on the degree of

fineness that is the precision that is involved whether it is a micro component or macro component depending on that in the industry.

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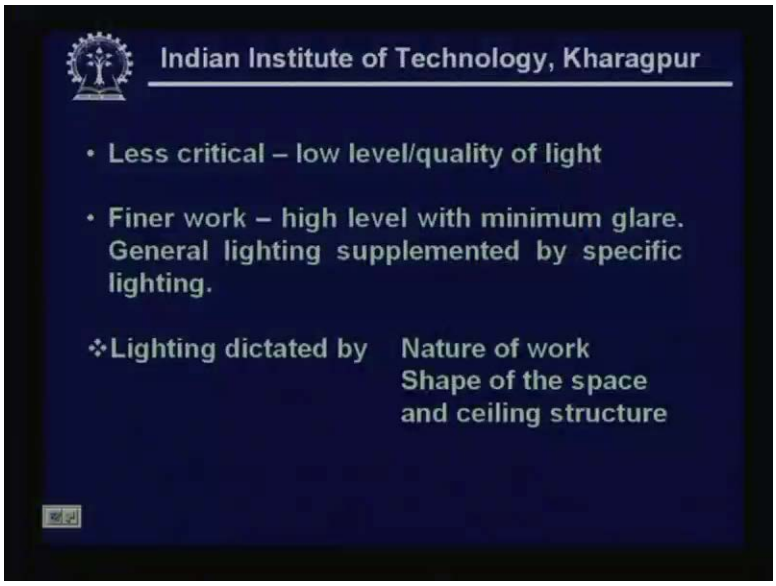

Less critical, you can do with low level, low quality of light whereas fine work like PCB soldering high level with minimum glare and invariably in such fine work environments there is a supplemented local lighting or specific lighting. As we have been telling this is in addition to the general lighting required for the movement of the people. And hence as emphasized several times the lighting requirements are dictated by the nature of the work, shape of the space and the ceiling structure. Actually we are quite familiar I mean quite used to having lights being brought from the roof or the ceiling and any light which goes to the ceiling, if not fully reflected goes waste. So the ceiling structure makes a lot of importance. And secondly we said to the extent possible, the way we design the openings and what you call are the glass area of windows such that we avail the natural day light available to a very large extent.

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So the classification could be for an industrial thing single storey without any skylight, meaning is fully enclosed environment which entirely depends on the artificial lighting. As opposed to this you could have a multi storey that is number of levels are there, large industries invariably have various levels. So, it is quite possible that some portion in the right in the interior may not have access to the natural light any manner. Then you have single storey with skylight, without skylight and with skylight. And lastly you have very high bay industries where large industrial objects are produced.

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Now single storey without skylight, normally you have workshops, factories and they typically have floor to ceiling heights varying from 3 to 7 meters. This is the typical workshop for small products 3 to 5- 7 meters is the height. And in at such low this thing and where in fact the colour rendering becomes important, possibly the production is involved is with small components. It's preferable to use fluorescent lamps and which are mounted anywhere up to the height of 5 meters. Maybe in talking about the various ways they can be mounted, one is the surface mounting, the other is recessed and the third is a suspended. Suspended mounting used to be in conventional thing when the roof heights are very large. And they could be placed in a continuous or broken row or as discussed in the last lecture could be in a matrix where depending on the, what we call the room index, we could have in the form of a matrix.

Ideally it's believed lamps when placed perpendicular to the plane of work, they give a good effect and they could be either directly mounted or suspended as I said it could be recessed in the ceiling and ceiling is invariably made as reflecting as possible. The moment this height exceeds 5 meters, we use the discharge lamps. Earlier it used to be mercury vapour lamps but you know that mercury vapour lamps have, are being fast replaced because of the low utilization efficiency factor compared to the sodium vapour lamps by sodium vapour lamps. And the two categories of lamps which are often used these days are either metal, metal halide lamps which have good colour rendering compared to mercury vapour and sodium vapour with reflector luminaries. And typically the separation between two such lamps is maintained around 1.5.

So no matter whatever the lamps may be used, they all are discharge lamps, fluorescent or mercury or sodium. Therefore they will need accessories which we have discussed, starting devices, the current limiting devices they are arc discharges. And as mentioned, luminaries are best mounted perpendicular to the work benches that gives the best this thing without form. And in order to have good illumination, it's necessary how the control is done. Control essentially means the way of operating these lamps they are all electrical, they need to be connected by the cables or wires and needs to be switched on or switched off according to the requirements. So there is a trunking system used which enables efficacy of illumination and hope we believe in the next half of the course where we talk about the illumination, utility principles we would cover more on the way it is done.

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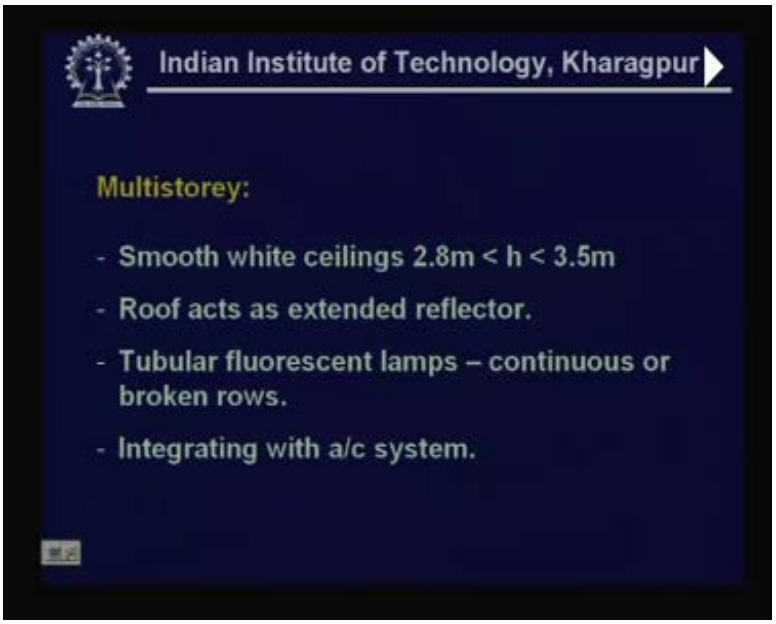

If you consider the multi storey, there could be smooth white ceilings with ceiling height ranging between 2.8 meters to about 3.5 meters. The roof itself acts as an extended reflector and it is adequate if you have tubular fluorescent lamps, continuous or broken rows. And in fact it must be mentioned here that these particular kind of a low height industrial systems are no different from general offices in that sense expect that if the fine work is involved, the level of the illumination required may be higher. And as already told these could be clean rooms or they may be need to work in a dust free environment and in doing that control environment where temperatures and humidity needs to be controlled which is often done using the air conditioning system. And therefore there is a need to see the waste I mean the heat radiated is integrated because if you use lot of heat radiated in the room by way of illumination, it adds to the air conditioning load, so there is a need to integrate. This is what we meant by calling it as integration of systems in an illumination of interiors.

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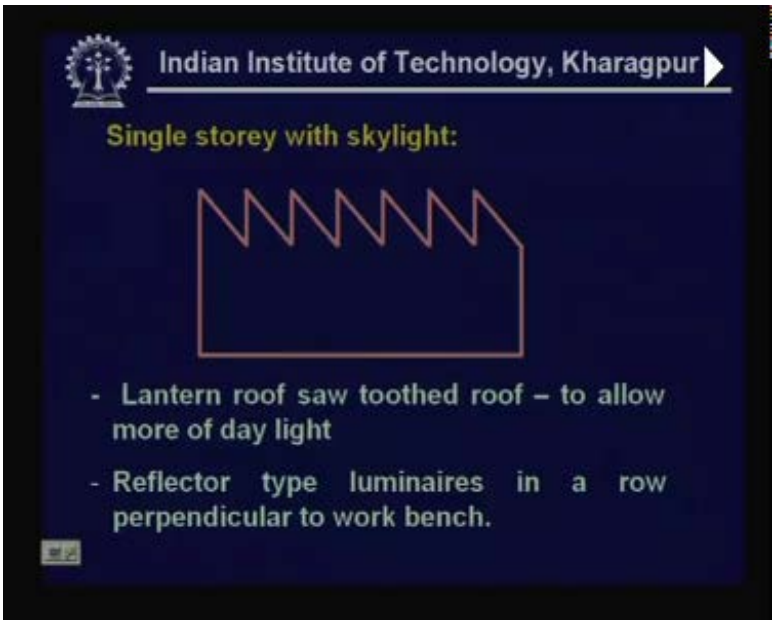

Now coming to single storey with light, this shows us typical picture of a typical industry having a roof which is provided with skylight. And here what we observe is a saw tooth roof and so that way the advantage is that from the roof, there will be glass windows in a saw tooth fashion which enables quite a bit of natural day light available and therefore the artificial lighting requirements may be less. And here as has been the case with other types, a reflector type luminaire in a row perpendicular to the work bench. As already told any light going to the roof unless roof is very well prepared white surface will lose the light that is going towards that and therefore either the roof should be made with good reflectance.

Alternatively we use luminaries which come with what are have good reflectors in fact sodium vapour lamps and the metal halide lamps they all come with inbuilt reflectors. And if you take the modern energy saving fluorescent lamps which are luminaries, they come with what is called as mirror optics. There is a mirror kind of a reflecting surface behind inside the luminaire that take ensures that the no light goes towards the upside and most of the light is directed downwards towards this surface.

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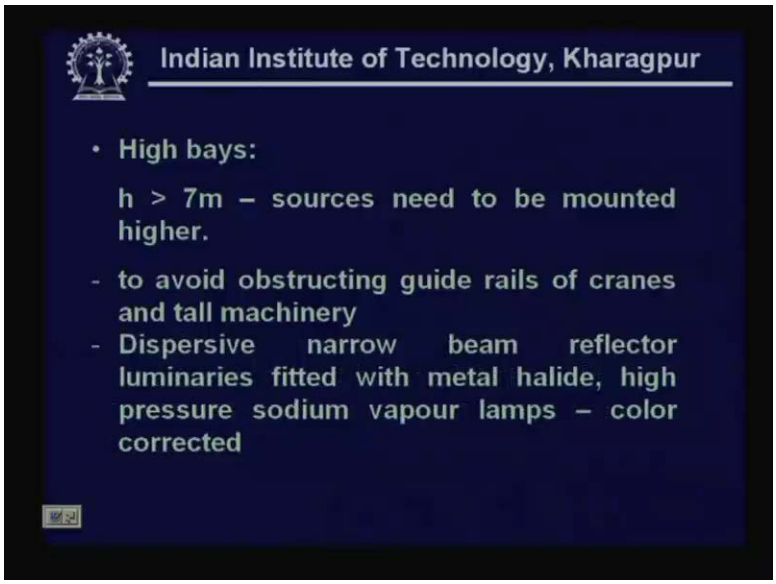

Coming to the high bays, what do we call as a high bay? High bay is base where the height is more than 7 meters and it becomes necessary to mount at higher heights. Here I must remind once again the concept that illuminance at a surface due to a point source varies with the square of the distance to the point source location whereas in the case of a line source, it varies inversely with the distance and in the case of a large sheet of light, it would have be independent. So that is how we say that sources need to be mounted higher, this is one thing. So whenever, what could be the other reason for us to mount at a higher height in high bay industries.

It's possible that there are large objects which need to be moved around and in case you need to move such large objects, you need they should not come in the way. Okay. So that's what we write as to avoid obstructing guide rails of, guide rails of cranes and tall machinery. This again becomes integration of lighting systems with the building systems in the interiors. So, this is what we mean by integrating various systems. This apart, you will have if it is an industry involving with gas manufacture or gas plants, so the gas handling systems you have cooling systems, heating systems all. So there it's believed that you have dispersive narrow beam reflector luminaries with metal halide or high pressure sodium vapour lamps which are colour corrected.

Let me reemphasize that the addition of halides in the mercury vapour lamps has enabled us to improve the colour rendering ability and they are what we call as a colour corrected lamps. So what do we mean? We mean that anything having heights, ceiling heights more than about 7 meters in an industry is what we call high bays and high bays because of trying to integrate with other resources, other services like provision of cranes and movement of machinery and avoid obstructions we try to have high bay lights. And in that case as I was telling you if one needs to have good illumination on a work plane independent of the mounting height, the best thing is to do a matrix of lamps located within a luminaire don't have a single lamp. If you have a point source we know that the illuminance varies inversely with the square of the distance. If you have

a line source which is the fluorescent lamp, it's going to vary inversely with the distance and if it is a matrix of lamps forming what you call as sheet of light, it will be independent.

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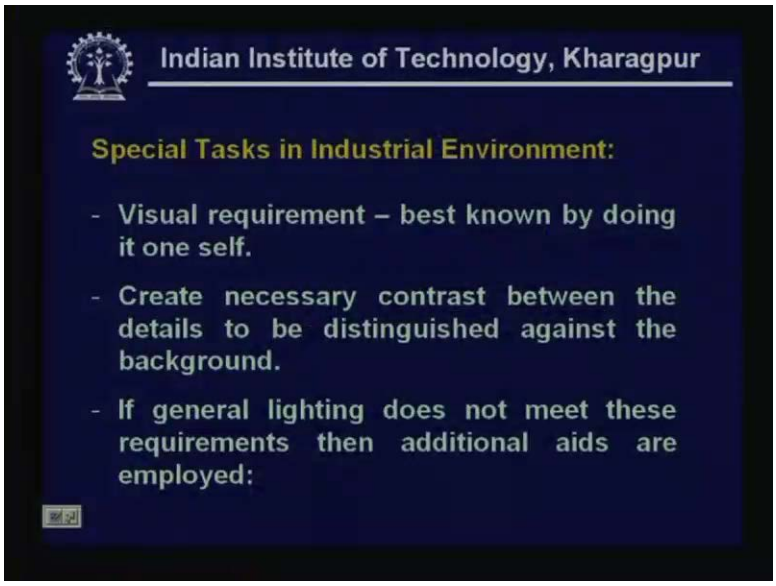

Now there could be some special task in industrial environment, there we know lot of visual requirement and this would require some kind of a control because depending on the operator the requirement levels vary unless I mean the designer can provide, there are recommended levels designer can provide but then actual requirement can be known only by the operator concern. And there is always a need to depending on the type of product to get the details to the best of the ability and there is a need to create appropriate background. Therefore their level also means it. Control issues and this is where I say we come back to that concept of what is called as a general lighting together with what is called as local lighting. In fact the statement says lighting, general lighting will not completely meets this requirement and additional aids are employed. What do I mean by additional aids? Additional aids are in the form of a local lighting and plus the ability to control.

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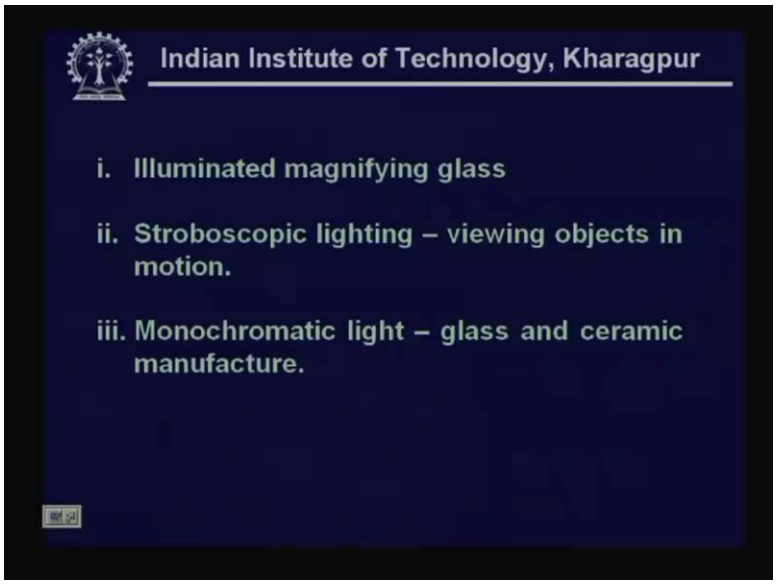

These could be in the form of an illuminated magnifying glass, all of us have visited at least one time or other a dentist's office where we do find that in order to look into the tooth crown, the dentist uses specific light which has got a magnifying lens, so that the you are able to ask. At times when you need to observe objects in motion, you should have a lamp which has the radiation, oscillating in the same frequency as the movement of the object and this is what we call as a stroboscopic lighting. In fact most of us electrical engineering students, we are aware when we are doing experiments in the electrical machines laboratory in trying to study a synchronous machine, we use the stroboscopic lamp to synchronize with the frequency of the system.

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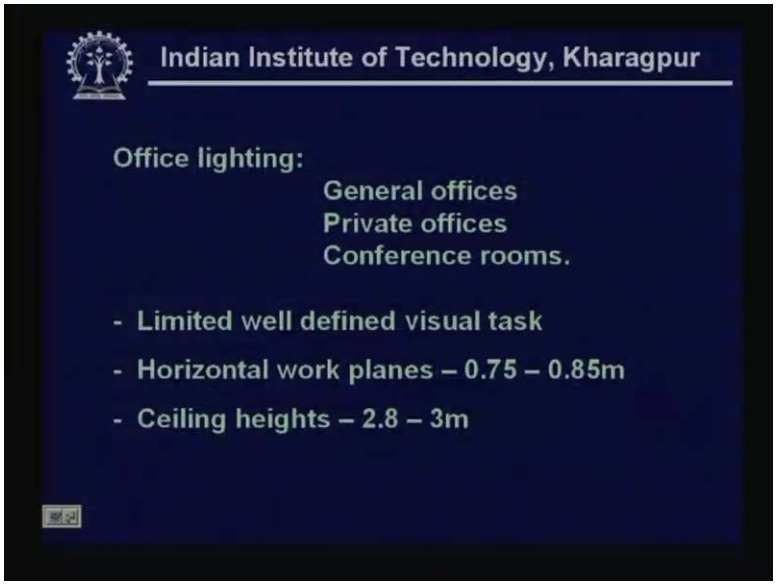

The monochromatic light glass and ceramic manufactures do need monochromatic light and all these are the special aids that are employed in addition to general lighting I mean in an industry. So, we have seen at the industrial lighting requirements and we say that the low height industries lighting levels, lighting concepts are somewhat similar to what we have in the offices. Now coming to the office lighting, we have the three categories which come up. The general offices, we have large offices where several sort of people work together. Private offices which have the top level executives who need some privacy confidential discussions go on. Conference rooms where large discussions are held, each of them have their own requirements but unlike the industry, we visual tasks are well defined. They involve reading and writing and these days of course operating a desk top computer.

Typically with all these applications, the work plane is around 0.75 to 0.85 that's why one could see that most of the commercial packages available for lighting calculations assume a work plane around 0.75 to 0.85 meters. The only situation where the work plane is assumed to be vertical for interiors is in a class room for the teacher to write on a chalk board or a screen, otherwise most of the and all these offices invariably these days are having ceiling heights within 2.8 to 3 meters.

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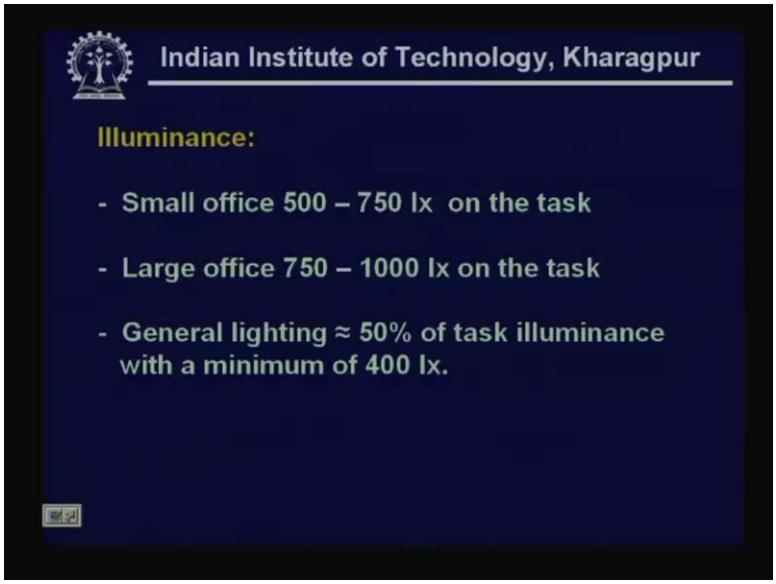

And therefore illuminance levels if you see a small office may have somewhere between 500 to 750 lux on the task which means it could have depending on the number of tables located in the office, some kind of a local lighting which provides on the work tables around this with a general lighting of about 300 to 400 lux in the room. The large offices this could be more and as already told in the industrial lighting, the lamps could be in the form of a row continuously or best is as we discussed in the last lecture in the form of a matrix decided by the room index which depends on the room width, length and the height. And large offices the requirements can go high anywhere from 750 to 1000 lux whereas this is the recommended illuminance on the work plane.

Now there is a further recommendation in fact I was telling that in small offices, there could be a general lighting of above 300 lux. In fact here the recommendation says at least 50% of task illuminance must be there with a minimum of around 400 lux. That is what we see.

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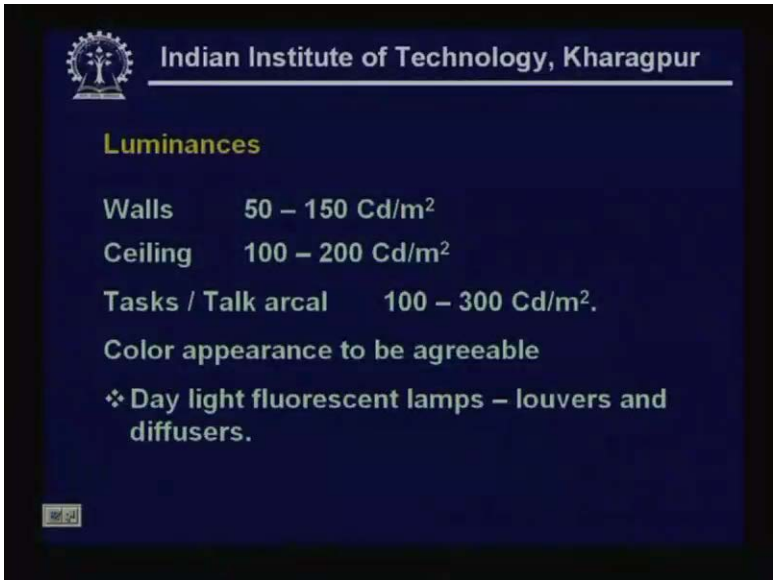

Apart from specifying illuminance levels, luminance levels are also specified for the lamps, the walls are expected to have lamps and the surfaces, walls are expected to have 50 to 150 cd per meter square. It is an indirect way of specifying your reflectance's in fact we have seen how the reflectance's are specified in the last lecture on lighting calculations where we said the very low reflectance is tolerated on the floor and very high reflectance is expected from the ceiling and reasonably high from the walls. Ceiling is expected to have 100 to 200 cd per meter square, tasks or task area should have 100 to 300 cd per meter square.

And one important issue which was not so very important in a high bay industrial environment is colour appearance. Colour appearance in an office environment needs to be agreeable in fact unless it is there; it will not produce the required efficacy in working. And often therefore the most common lamps that are used are what we call day light fluorescent lamps. We know fluorescents lamps are those lamps which use the ultra violet light using the fluorescence principle into the visible spectrum, they have louvers that which basically direct and diffuses which disable glare, in fact we know that the glare levels are much lower in fluorescent lamps. No doubt, the CFLs have a little higher glare level than, the general offices they are moderate to large area and work planes are not well defined.

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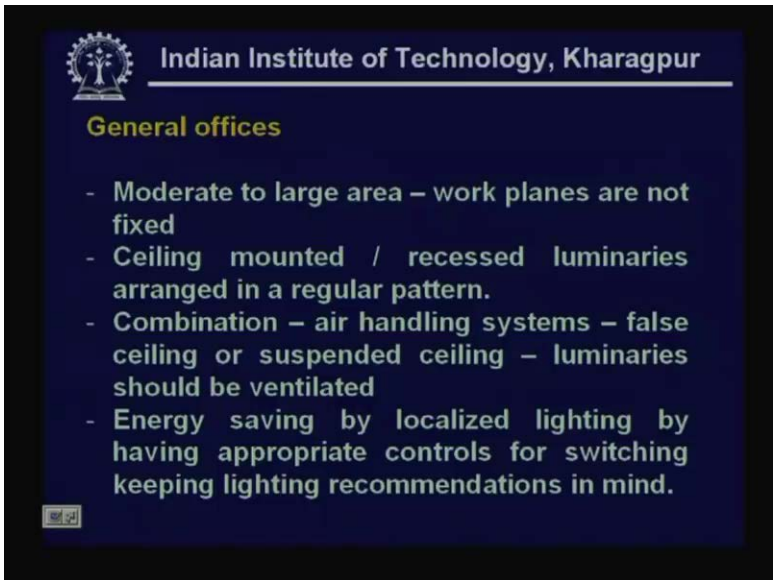

The tables could be not fixed they will be moving. If you take class room desk and chairs are fixed but in large office, the table location does change. In this case the kind of a thing that is used, employed could be ceiling mounted or recessed luminaire's which are arranged in a regular pattern and perpendicular to the work plane is a very good way of providing the light but then it may not be assured that the table would be located all the time that way because it's not fixed in large office. So, some of the large offices do adapt alternate rows perpendicular to one another. It's a matrix of lamps located and invariably each luminaire has more than one fluorescent lamp.

In early days it used to be twin lamps and these days we do have three fluorescent lamps placed together and in fact from point of view energy saving, the trend these days is to use compact fluorescent lamps in the luminaire's. And this has to be combined with as always been emphasizing with air handling system and this air handling system should also enable in ventilating these luminaire's. So that there is no undue heat generated in this luminaire's which adds to the air conditioning load and in fact when the ceiling heights are very high, we adapt false ceilings in which these are recessed and false ceiling themselves are made with good reflectance levels as close to pristine white as possible.

As already told the energy saving is obtained by having required level of localized lighting with controls. Controls could be using pro-electronic switches. Switches, which could be conventional or these pro-electronics but all the time keeping in mind the comfort of the operator i and the recommendations which have been laid as per the CIE.

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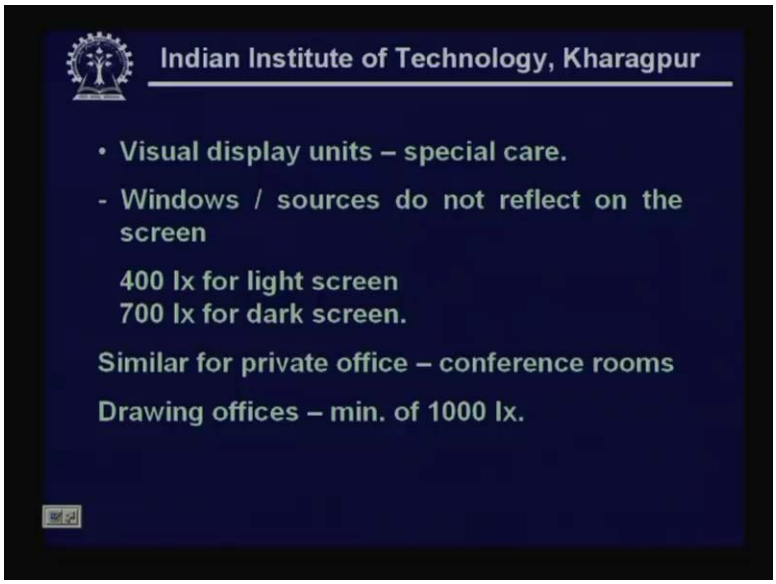

One has to, the early days it was only reading and writing but these days as I was mentioning you have desktop computers or if you are in the laboratory you have oscilloscopes to observe the signals. The monitors which are basically visual display units, there needs to be special care and already as mentioned windows and the sources should not reflect on the screen. Once they reflect in the screen they trying to give, see in fact it is advisable to provide proper interiors or drapes along with the windows to see that you do not have such reflections. And it is believed an illuminance of a light located in the direction opposite direction of the screen with the level of about 400 lux is recommended. If the screen is very dark, one could declare I mean have about 700 lux and a similar requirement is used for private offices and conference rooms.

Private offices invariably would mean office of a particular executive, it may mean it could be small so there could be a fixed location for the table and therefore local lighting could be fixed and arranged accordingly. Drawing offices are may be obsolete these days with the computer drawings coming in computer design coming into picture but these were the offices which were used in earlier days to produce drawings especially in engineering design offices. There in view of the pencil task that is involved in drawing, a minimum of 1000 lux is recommended.

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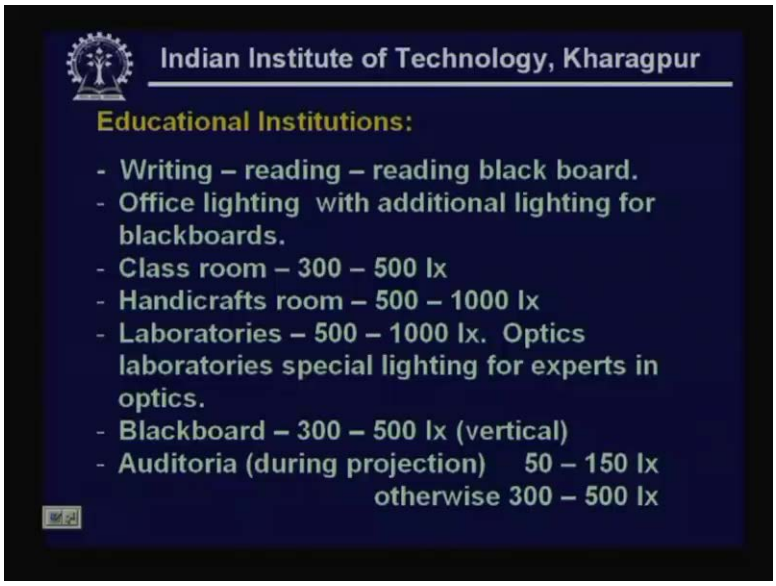

Coming to the next important area is of thing is educational institutions like ours, educational institutions the writing, reading is the major task and reading black board though it's says black board these days it is green board or white board any of these boards and this follows typical office lighting principles with an additional light provided over above the black boards or the chalk boards or the screens. Basically they need a vertical illuminance on the board and once it is placed right above the board, it enables the glare free observation. Typically such an environment, the recommended illuminance levels are to be between 300 to 500 lux. And if you are having handicrafts rooms in fact because there are some work vocational training in educational institutions where children are made to do some work experience kind of a activities where they could be handicraft training. There, because the, it involves could possibly be involving precision task a higher level of illuminance between 500 to 1000 is recommended.

Laboratories once again will involve critical observation and therefore are maintained within those levels. Of course optics laboratories are depend on the kind of experiments they have, kind of optics they have, special lighting and there are recommendation available for those things. As already mentioned, the vertical illuminance is required on the screens or the black boards or chalk boards and the level is similar to what is expected on the horizontal illuminance in the task plane in a class room between 300 to 500, these about the educational institutions.

Coming to the auditoria, auditoria are used for observing large presentations. So there is some minimal lighting required when there is a projection going on and in fact that is how this recommendation does talk of having 50 to 100 50 lux during the projection so that the audience do not get distracted by the activities around and they concentrate on the screen, otherwise there is a general lighting requirement of 300 to 500 lux. And often times you think of having dim ability in which case you cannot use fluorescent lamps, one may have to use metal halide lamps or incandescent lamps.

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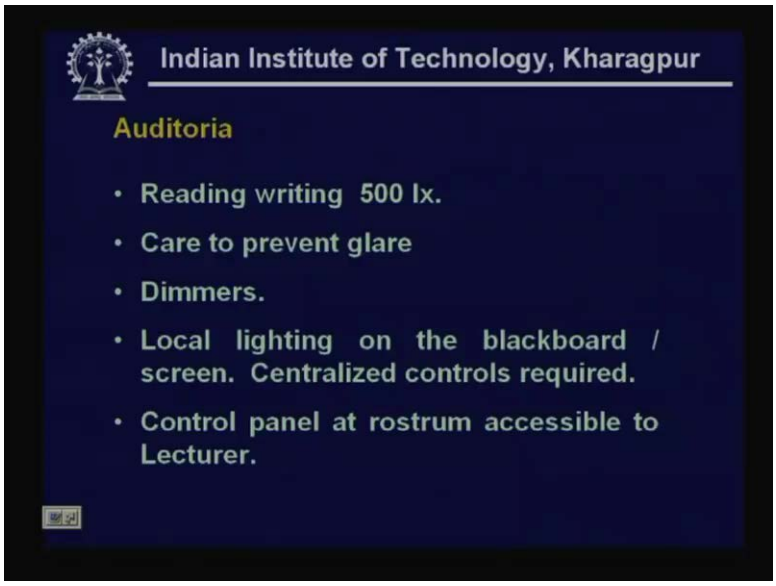

The recommendations for auditoria therefore if involve reading and writing around 500 lux and there should be adequate care to prevent glare. And one has to remember auditoria would also mean a room, class room accommodating large number of people which would amount to having to take care of the public address system or the sound systems, so both have to be integrated together with the air conditioning. So there in fact as I was mentioning a little while ago dimmers, in fact dimmers as we said in a previous class could be in a simple sense an auto transformer because it is in ac voltage which is being used.

An auto transformer is a way of producing variable ac output and that is how in fact these auto transformers were at one time called demostats because they were first developed for lighting applications where the dimming was required. So you have a local lighting on the screen with centralized controls required and then in fact the best thing to enable speaker, the control panel for this should be accessible at the rostrum. So the lecturer has or the speaker has complete control over them.

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Now let's look at the commercial thing where shops and stores I have categorized the general lighting, in fact if we talk of a large shopping center should have 500 to 750 whereas other areas that is the corridors with circulation areas can be around 300 to 500 lux. Local lighting, where do you need local lighting? You need local lighting in the shopping windows where you want to highlight the new products; you in fact have as high as 1500 to 3000 lux. When we mean other areas, the other areas include smaller shopping malls in the neighborhood, larger shopping centers. Show case or windows again you see general lighting is around 1000 to 2000 and 500 to 1000, for show case is one thing which brings the clientele to the shopping area. So we see that the levels required are much higher and of course all of us are aware that the modern shopping centers are glittering with lot of illumination and there is lot of energy that is spent there.

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The show case as already said brings out special features of the product and therefore the kind of lamps that are used are diffused fluorescent lamps are used. If you see the, if you are having a hardware you use diffused fluorescent lamps. Jewellery is one place where in a show case you would always use incandescent lamps to take the advantage of its continuous spectrum and ability to have good colour rendering, so that's about the shopping and things.

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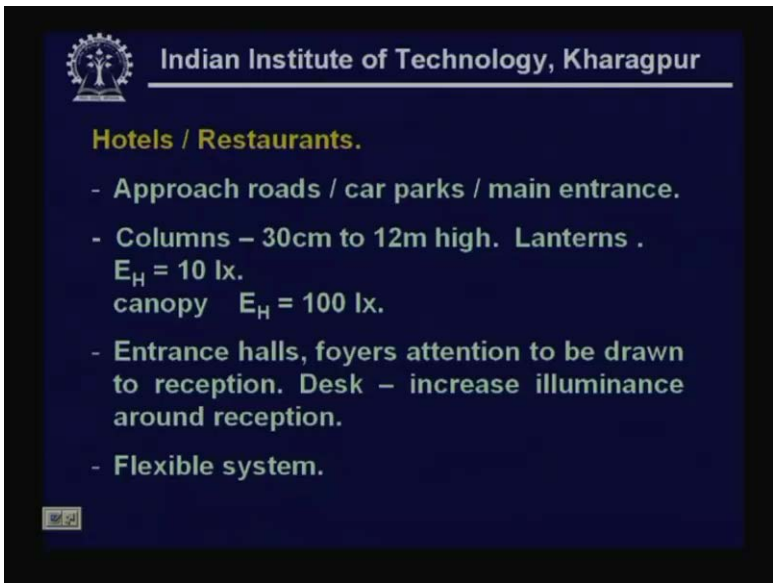

Now next comes the hotels and restaurants. See approach if you see hotels and restaurants, the whole lighting can be categorized into the approach roads, entrance, car parks they are normally used what are called as the columnar lighting with horizontal this thing of 10 lux or a canopy

lighting with 100 lux. These are basically those posts of lanterns we were talking about, we had seen a picture earlier. The heights could be anywhere from 30 centimeters to 12 meters height and in fact some of the outdoor gardens we have seen small low height lanterns employed. The entrance halls, foyers they need to have lighting so that people are drawn to the reception desk and therefore desk needs more increased illuminance around the reception than the general lighting in the foyer, it should be completely flexible.

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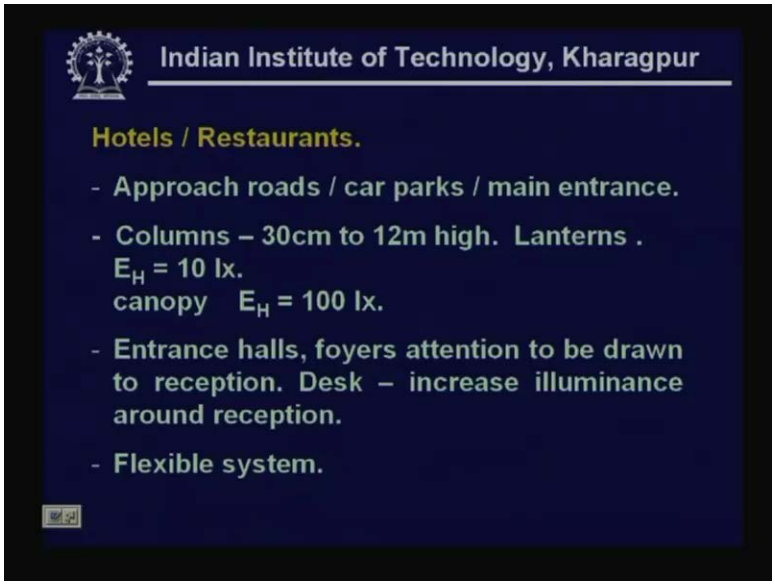

Coming to a restaurant, you could have the fluorescent lamps all around the dining area with local lighting at tables, in fact some of the restaurants people would like to have dim lighting or low level lighting all around with locally higher lighting so that you see what you are eating. And this could be at lower; therefore there should be provisions for dimming and switching. And therefore it's observed that in order to have dim light levels, the average illuminance that's specified is as low as 100 lux.

However the cashier needs to have good illuminance to be able to, so he may have a desktop, desk light which is around 300 lux. Corridors and stairs should have the artificial lighting, in fact as I was telling as it was in the case of a tunnels and closed corridors even during day time you need higher illuminance levels. So you will see that recommendations are you need about 150 lux during the day time whereas it's only 75 lux during the night. This is essentially to enable our human eye to adjust when coming from outside, night time it will be dark.

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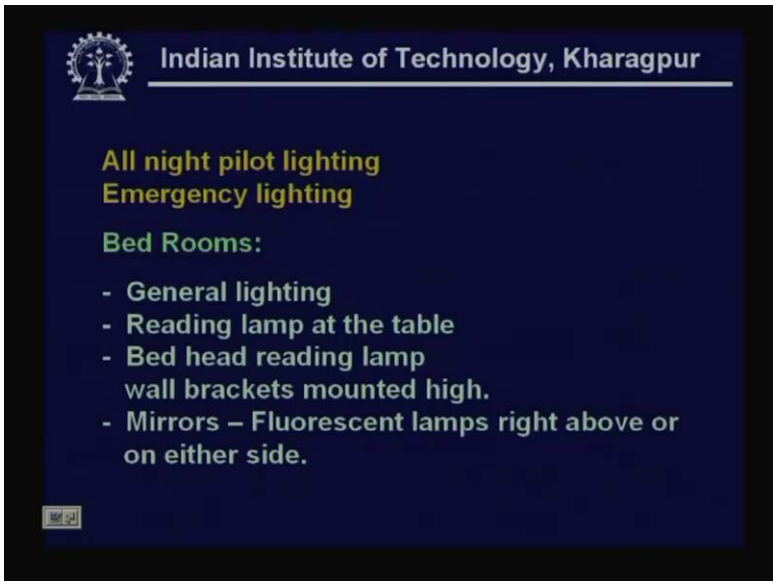

And these apart, all night pilot lighting is required in a hotel to direct and emergency lighting is obviously there require for evacuating. If you consider the rooms or what you call as a bed rooms general lighting, there should be a reading lamp at the table, there should be a bed head reading lamp and wall brackets are mounted reasonably high for general lighting. So this is a typical bed room in a hotel we are talking about. So, hotel we have seen there is a need to have some approach lighting and which is normally in the form of a post of lanterns.

General lighting in the foyer and entrance, entrance should have a little increased illumination to attract towards the entrance and reception desk is necessarily should have more lighting. And the coming to the restaurant you have the perimeter of the dining area could be with fluorescent lighting giving some average illuminance levels of about 100 lux with some local lighting on the tables to enhance and able the diners to see observe what they are eating but cashiers certainly needs very good levels at least around 300 lux.

Now these apart, the hotels should have pilot lighting, pilot lighting is basically trying to set direct which way it's, which way the rooms are and emergency lighting for evacuation. The coming to the rooms which is termed as bed rooms here is the main occupant rooms in a lodge or a hotel. There should be general lighting reading lamp at the table better reading lamp, wall brackets should be mounted high and the mirrors should be provided with fluorescent lamps right above if not on either side.

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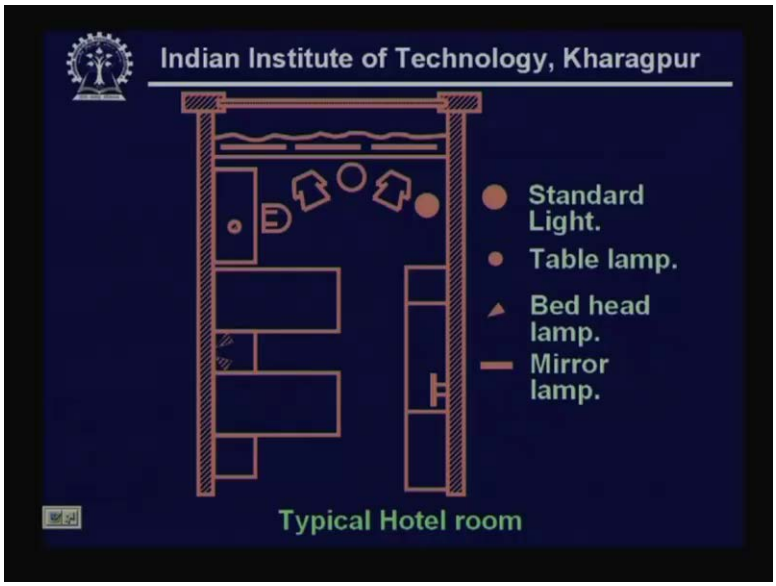

So this shows a typical hotel room. As you can see there is a standard light provided for general lighting, there is a table lamp provided on the table to the left corner, the top and there are two bed head lamps on each of the bed and there is a mirror located to the right towards the bottom, there is a fluorescent lamp placed on top. So this is how as recommended in the case of a hotel one does lighting.

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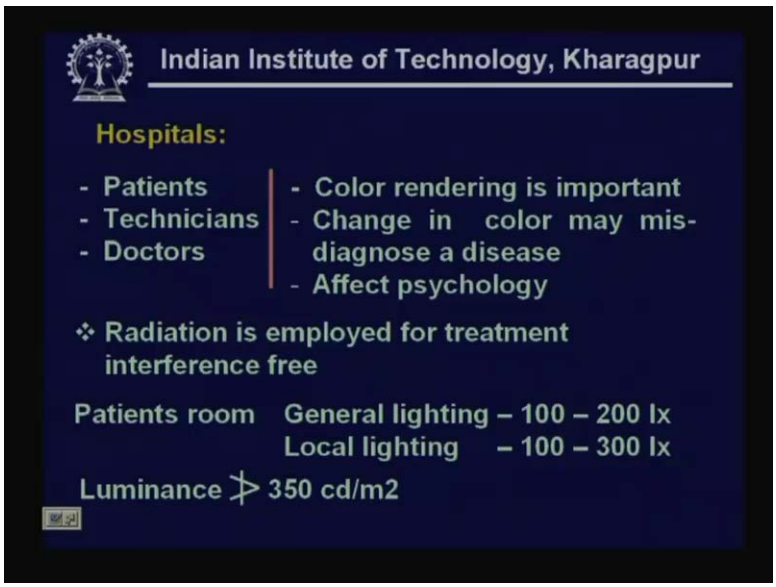

Now let us look at another application that's the hospitals. The hospital lighting involves three categories of users that is the patients who need to relax and recoup. Technicians who need to perform certain task under the supervision of doctors, third the doctors. In these colour rendering

is important because if there is any change in colour, one may miss diagnose a disease and it could affect the psychology of the patient. So the radiation is sometimes employed for treatment so it should be interference free. These are some of the issues. So considering all this one has in a patients room, a general lighting varying from 100 to 200 lux whereas a local lighting required for the technicians and doctors around 100 to 300 lux. Luminance at no point not greater than 350 cd per meter square.

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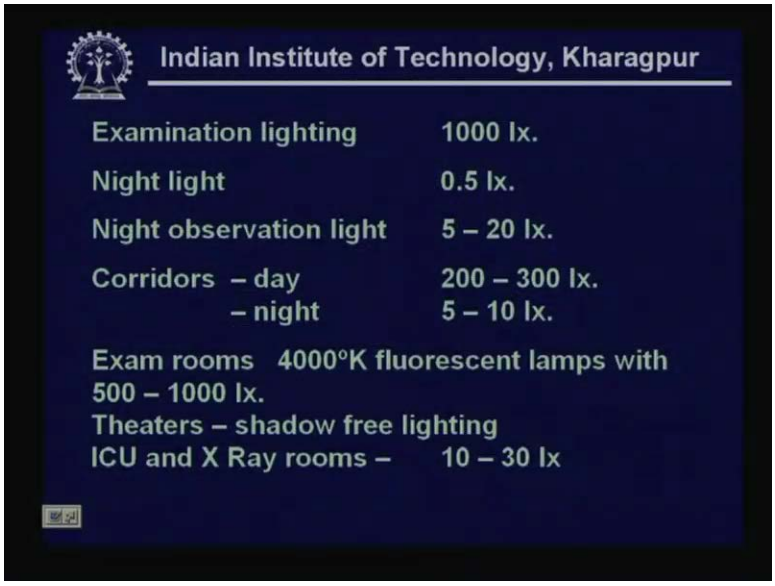

The examination lighting yes, when examination lighting requirements are very high it can go up to about 1000 lux, night light should be around 0.5 lux, night observation light in the nurses' station could be 5 to 20 lux. Corridors as already told day time you need higher levels that is 200 to 300 lux whereas night time it could be around 5 to 10 lux. Examination lighting is necessary because it could be an interior examination and these are in fact may be provided with magnifying lenses, so that being the case examination rooms are invariably provided with what we call 4000 K fluorescent lamps with 500- 1000 lux. Theaters that is theaters here mean operation theaters should have shadow free lighting. ICU and X ray rooms can have low level of lighting; it's mainly for the X rays should not be exposed to any light whereas ICU the patient needs good recovery relaxation for recovery 10 to 30 lux.

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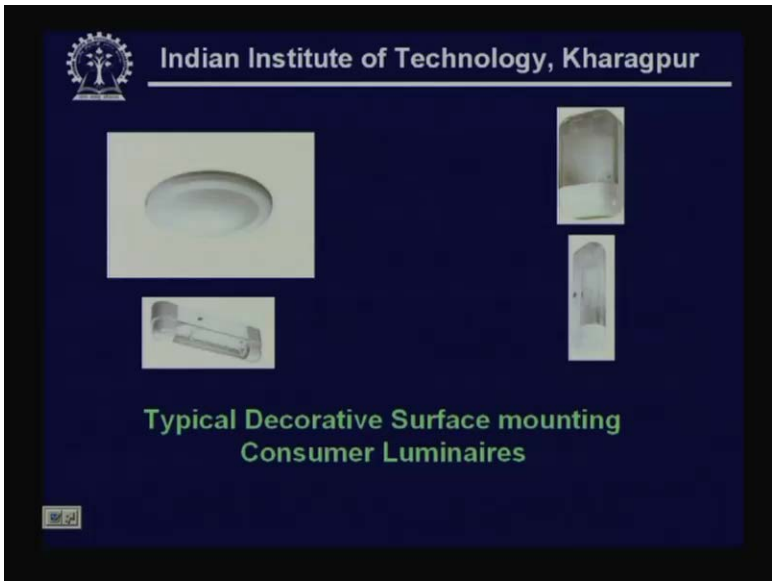

Now here having covered all these recommendations, it's felt that let us have some look at some of the luminaire's that are there for these lighting purposes. The picture out here shows decorative luminaire's which are called surface mounting luminaire's. As can be seen the top one is a circular one then there is a, so some of these are suitable for decorative purposes and they are surface mounted. They can be vertical, horizontal and these particular examples which are taken they are useful for providing what are called as CFL or compact fluorescent lamps.

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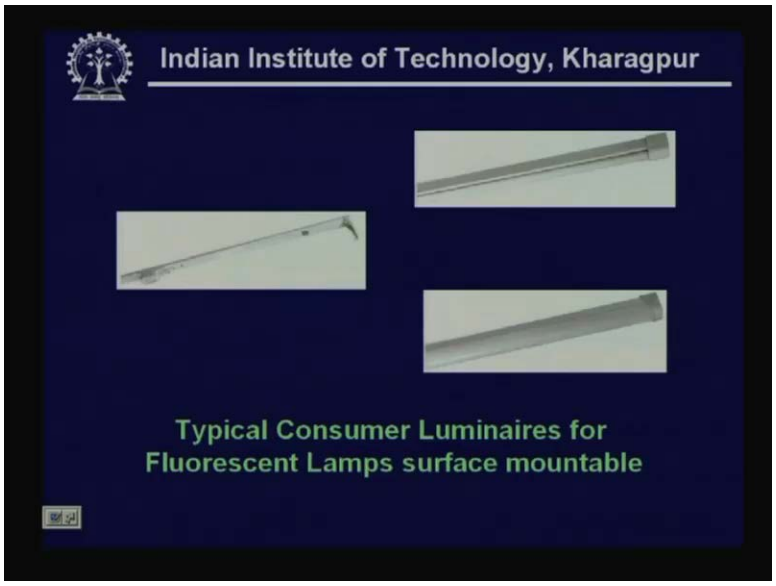

On the other hand the consumer luminaire's meant for fluorescent lamps with surface mountable are shown in this picture as that left one is an open batten type with all the accessories shown.

The right hand side you can see the accessories are enclosed but the lamp is naked whereas the third one you have a diffusing collar placed.

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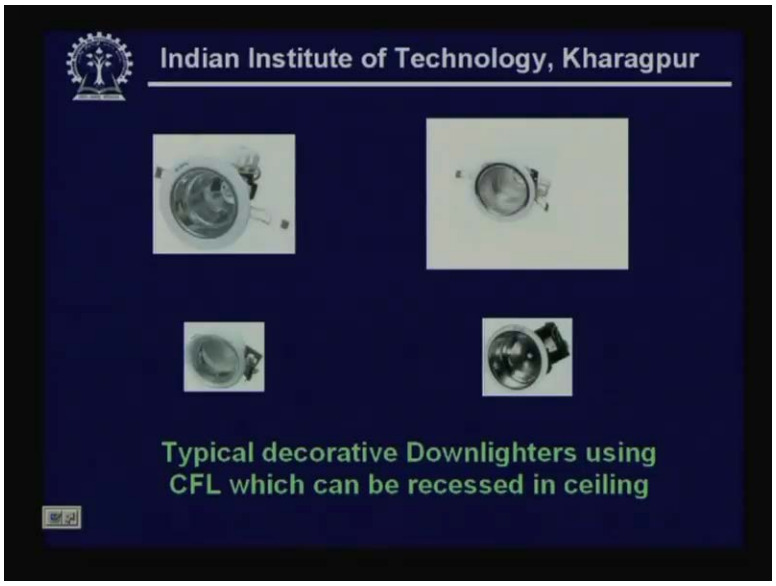

These are some decorative down lighters using compact fluorescent lamps. These could down lighter, we call it a down lighter because when you have a narrow beam and direct it directly on a task surface as we talked about having that in case of a higher, in high bay industrial application.

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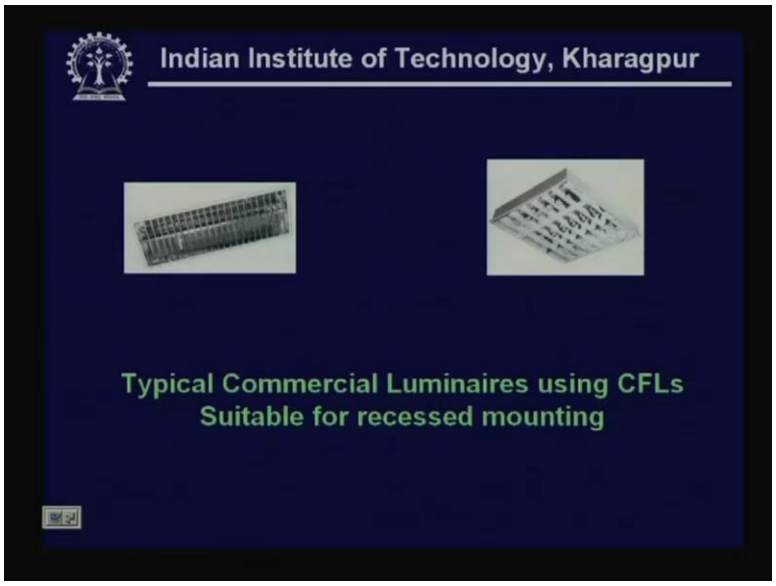

These are commercial luminaire's using CFLs suitable for recessed mounting, in fact I was telling you creation of what is called as a sheet of light would be the ideal thing because where

you can mounting height becomes independent and most luminaire's adapted are for using more than two lamps these days with mirror optics and some of these though it's a CFLs similar luminaire's are available for even normal fluorescent lamps or energy saving fluorescent lamps.

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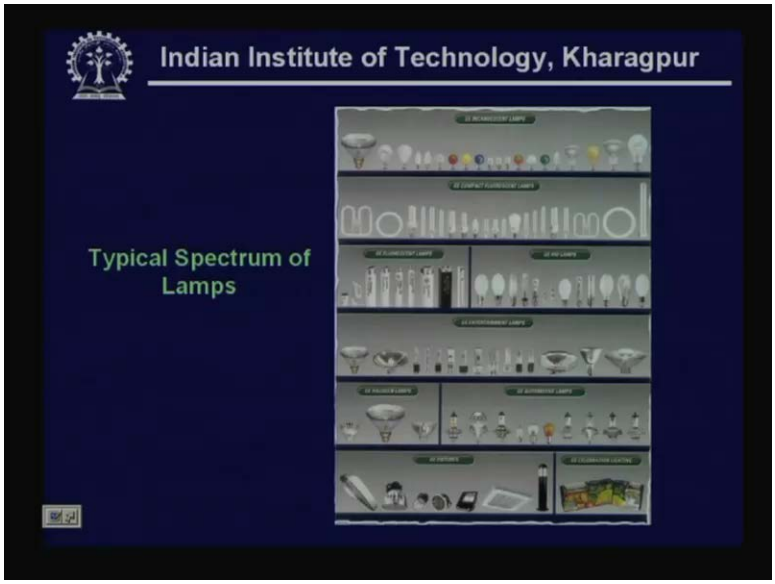

Now this is a picture which shows spectrum of lamps that are available right from incandescent lamps, compact fluorescent lamps, fluorescents lamps and therapeutic lamps and all kinds of lamps. One could see fluorescent lamps of various shapes circular I mean and u shaped etc. So, this is some of the pictures. Now having said all this, I said there is a recommendation have been obtained and these are all based on the CIE recommendations which are adapted with the national standards and therefore we would like to mention some of the standards.

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I must emphasize here that each of these standards has more than one part, I have its briefly mentioned here. As can be seen vocabulary electro technical vocabulary for lighting is given in IS 1885 whereas the recommendations required for street lighting in fact if you see carefully though I have titled it as street lighting, it talks about recommendations for thorough phase that means streets roads etc is in IS 1 944. Lighting for ships which though we have not really covered is included in IS 2592, its onboard lighting. Libraries are places large reading rooms so IS 2672, hospitals we did mention hospitals have three categories of users where the lighting requirements could be based on the user requirement, patients require low lighting to be able to relax whereas technicians and doctors requires higher levels, IS 4347 gives the recommendations for hospital lighting.

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Continuing with the recommendations, the one is aspect which we said is the lighting photometric standards are covered in 7678. Now in fact airport itself is a big industry and airport lighting requires considerable amount of integration of various kinds of lights, these are covered in IS 7785. Dam lighting is covered in IS 9297 and we did say wherever there are large number of people involved there should be some form of emergency lighting which is covered in IS 9583. Educational institutions we had a look IS 10894. This is not the exhaustive list of standards but these are some of the standards which relate to the recommendations which we have tried covering in this course and which are taken based on the CIE recommendations and most of these are in countersense with CIE adaptive for our local conditions. And I must reemphasize that these are not the exact tittles of the standards though they cover recommendations for that particular task or that particular application.

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So, in total the summary is industrial lighting is dictated by the nature of work, shape of space and the ceiling structure. It could be classified as single storey without skylight, multi storey, single storey with skylight, high bay light.

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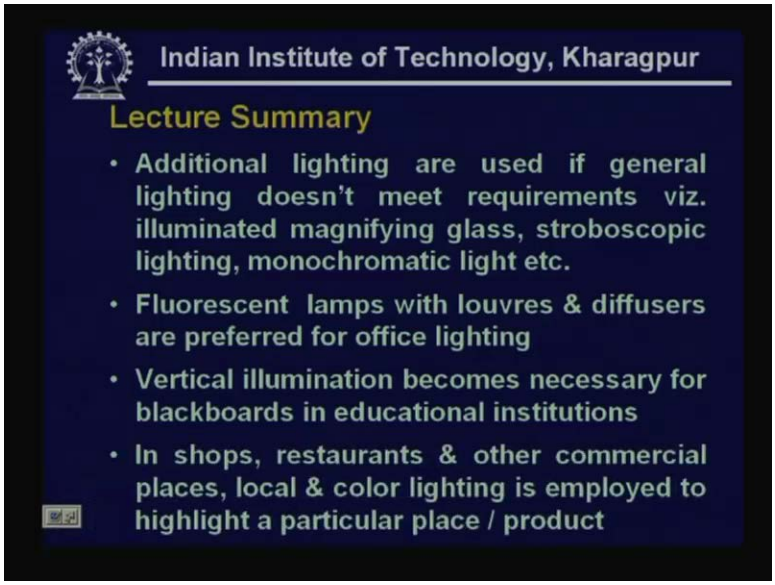

And continuing with the summary, additional lighting are used if general lighting doesn't meet requirements illuminate by illuminating by magnifying glass stroboscopic or monochromatic light. Fluorescent lamps with louvers and diffusers are preferred for office lighting and vertical illumination is very important in auditoria and educational institutions on the chalk boards or

black boards. In shops and restaurants and commercial places local and colour lighting is employed to highlight a product or a place.

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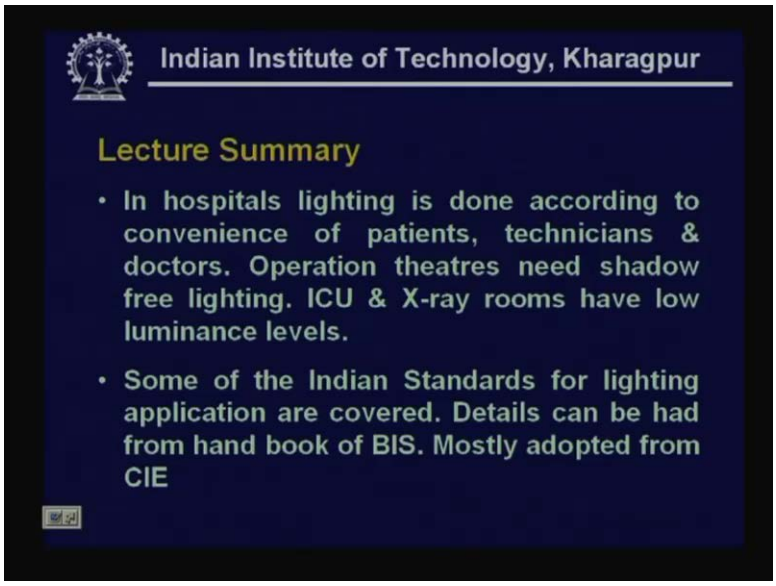

In hospitals lighting is done according to convenience of patients, technicians and doctors, operation theaters need shadow free lighting, ICU and X ray rooms have very low illuminance levels and some of the Indians standards for lighting applications have been mentioned in this lecture. Details can be had from the hand book of BIS and these are mostly adapted from CIE.

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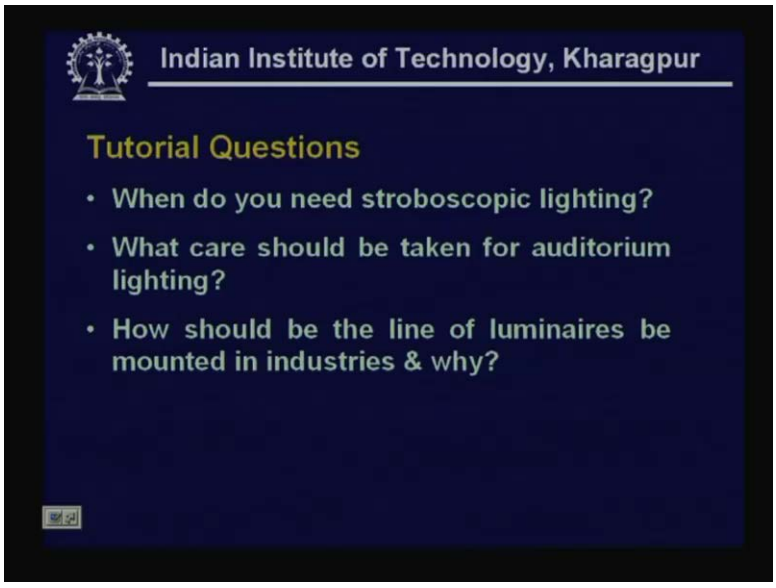

Coming to the tutorial questions. When do you need stroboscopic lighting? What care should be taken for auditorium lighting? How should be the line of luminaire's be mounted in industries and why?

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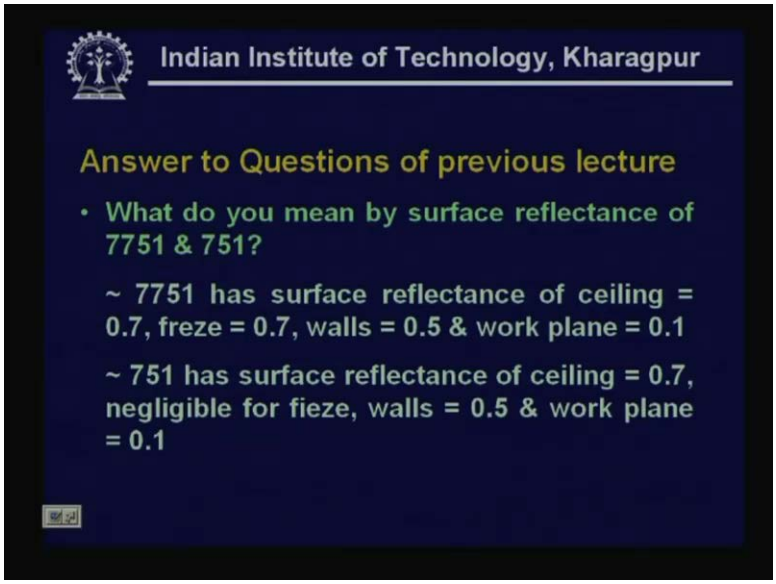

Answers to questions in the previous lecture. What do you mean by surface reflectance of 7751 and 751? It means 7751 means surface reflectance of ceiling is 0.7, freezes 0.7, walls 0.5 and work plane is 0.1, in fact fieze is a wall surface over the plane of mounting lamp whereas when they are recessed in the ceiling 751 is what it means 0.7 for ceiling, there is no frieze, walls 0.5 and work plane is 0.1. Work plane or the floor always has very lower reflectance.

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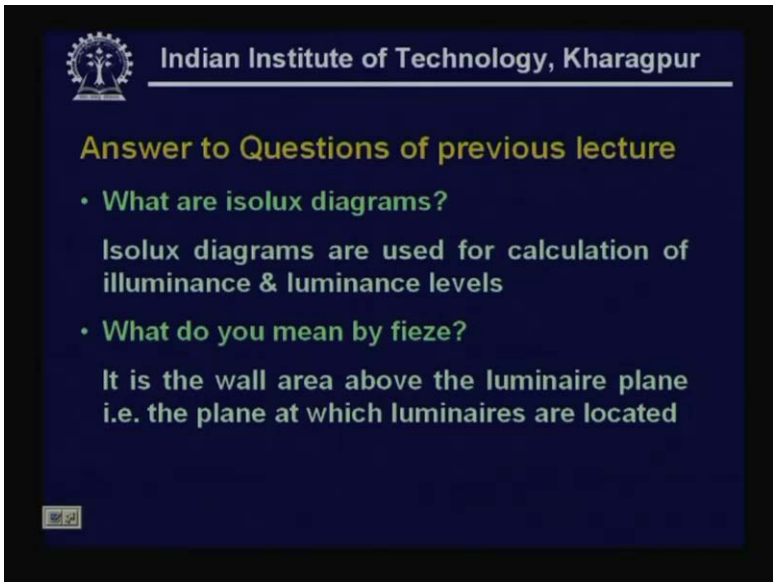

What are iso-lux diagrams? Iso-lux diagrams are used for calculation of illuminance and luminance levels. The equal lux levels are equally luminance curves. What do you mean by fieze? Fieze is the wall area above the luminaire plane that is the plane at which luminaire's are located. Thank you.