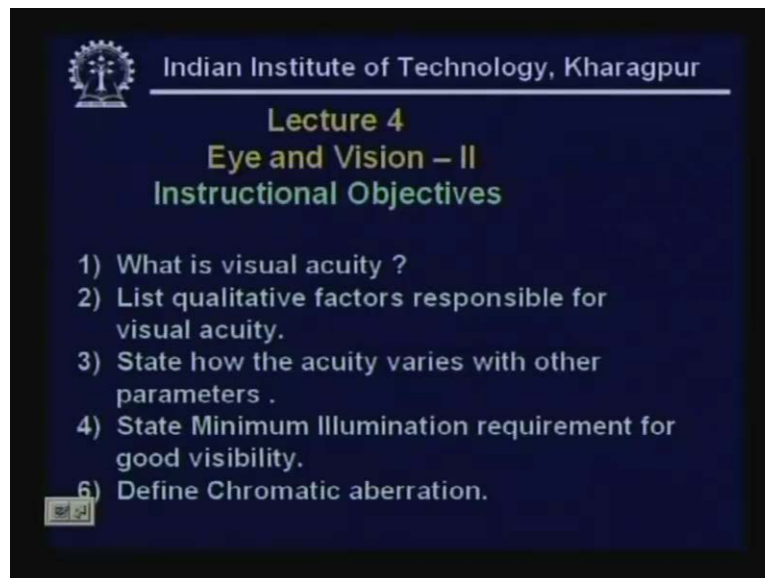



Illumination Engineering and Electric Utility Services
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Lecture No. # 04
Eye and Vision – II

Welcome to this course on illumination engineering and electric utility services. Continuing with previous lesson, we go on to the next lesson, lesson number 4 on eye and vision part two.

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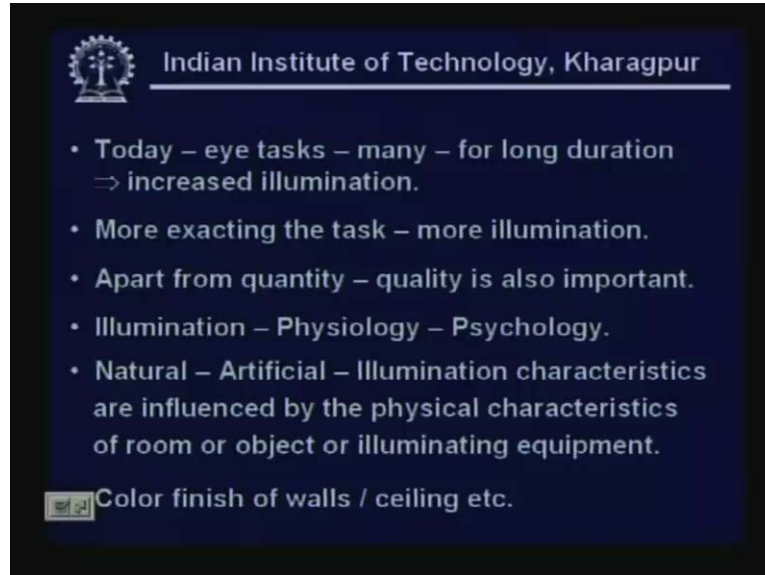
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Lecture 4
Eye and Vision – II
Instructional Objectives

- 1) What is visual acuity ?
- 2) List qualitative factors responsible for visual acuity.
- 3) State how the acuity varies with other parameters .
- 4) State Minimum Illumination requirement for good visibility.
- 6) Define Chromatic aberration.

The instructional objectives for this lesson are number one what is visual acuity, two list qualitative factors responsible for visual acuity, three state how the acuity varies with other parameters, four state minimum illumination requirement for good visibility and define chromatic aberration. Recall that in the previous lecture we had a look at the general structure and function of eye wherein we saw that eye has three important components that is iris, lens and the retina. And all the light that gets into the eye is communicated to the brain through the set of nerves located on the retina and the most important point on the retina is the fovea where the maximal sensitivity is there. And the two set of nerves that are responsible are cones and rods. Cones are responsible for a dim I mean the, in bright light and they are responsible for the formation of details and the formation of details and in bright light where as rods are responsible for the overall appearance that is orientation is taking care of by the rods.

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- Today – eye tasks – many – for long duration
⇒ increased illumination.
- More exacting the task – more illumination.
- Apart from quantity – quality is also important.
- Illumination – Physiology – Psychology.
- Natural – Artificial – Illumination characteristics are influenced by the physical characteristics of room or object or illuminating equipment.

Color finish of walls / ceiling etc.

Now we observe that today the tasks are predominantly involving eyes that is as already told the most common task is reading and writing which involves observing fine print and may be over a longer duration in fact every sphere of our activity involves some form of writing and reading and is much longer than what it was in the prehistoric times. All these calls for increased illumination and therefore one observe that finally the task is more is the illumination requirement, we have seen how the focal ability of eye is adjustable in the sense that unlike a camera lens the human eye lens can change its shape, it flattens when there is dim lights and becomes convex when there is a bright light. Accordingly, adjusting the amount of light entering the eye also sensitizing the appropriate set of nerves on the retina.

See the quality of light is also equally important. It is not just illumination alone that is if you have more light flux we say that we can see more critical reading or writing but it is not enough. It is the kind of light or quantity of light is also important as already told right in the beginning that illumination not only helps in observing and acquiring information, recall that information acquisition through eyes is the most important sense organ. And it plays not only in the physiology and psychology, the environment also is affected and psychological requirements do play on emotions.

The artificial illumination whether aims at bringing it close to natural illumination and is affected by not only the type of source we use, type of environment we have and the place where it is placed that it is physical characteristics of the object been viewed or room being illuminated. That is how physical characteristics of the room come into play where the physical characteristics could be in the form of the finish walls whether the light gets reflected or absorbed. All of us are aware, most of our residential rooms are with white roof, so that the most of the light impinging on the roof or the ceiling gets reflected and is available for tasks on the ground or on the table that is how and even in the walls, see most of the light is allowed to reflect and is... Now on what factors does quality depend? Quality depends on the factors namely glare.

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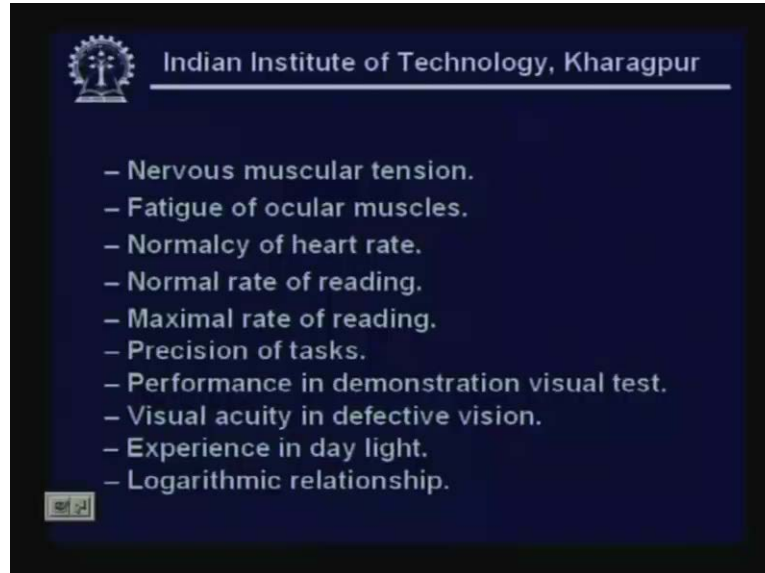


Glare we said is the intense light flux in the plane of observation. Let's say we are reading a board. If there is intense illumination on any portion of the board then the discomfort felt by the observer is what we call glare. Diffusion we all understand the light diffusion, in fact the diffusion to some extent enables uniform spreading of light flux direction naturally the way the light is oriented. Composition, it pertains to mixture of the light colors whether the combination like we talked about the physical environment that is the ceiling, ceiling color, wall color and the texture.

So the composition of the lights and how it is distributed, these are the things which talk about the quality of illumination, quantity per say would be the light flux that is coming out of the lamp and if efficacy is what we talk in terms of lumens per watt of energy that is consumed. And considering various aspects, the quality impact parameters and through exhaustive study by researchers, it has been found that for equal visibility, under varying conditions the illumination has to be at least hundred foot candles or more. What are foot candles will become clear as we go along and study in the next lesson on the standardization and measurement quantification of light.

Now various factors that come in to play in looking at the light quality or visual light quantity or quality or ability of eye to respond to the light are visual acuity. Discrimination, visual acuity we said is ability of our eyes to perceive things in the given situation depending on the external physical conditions, illuminations available and the requirement of observation. Discrimination of brightness difference that is one should be able to distinguish between the two different objects, one may be bright other could be not so bright. Speed of retinal impression obviously we said the image perceived by the brain is a result of countless impressions obtained by the human eye. Therefore every person has his own way of getting the impression. On an average all of us have the similar speeds but it does have an importance in the way we perceive the things.

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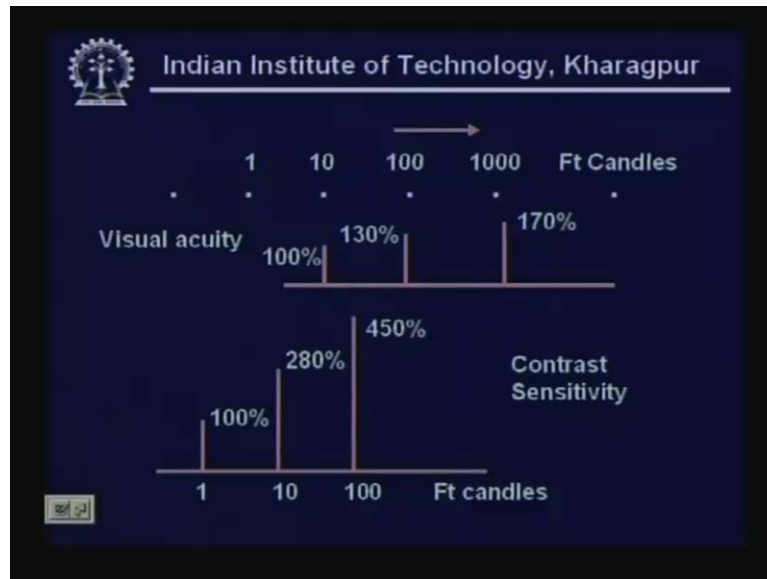
Obviously seeing is not essentially getting light into the eye. It is the response on the nervous system, double nervous system on the retina and communicating with the brain and therefore nervous muscular tension does play a lot of role. We didn't mention in the earlier lecture that fatigue can really reduce the ability of distinguishing details or alternatively it can call for increased illumination levels. As we said there is always the requirements become quadratictory and it is possible to achieve the end target by making a compromise in one or two of factors that are involved. And we said adjusting ability or accommodation ability of the eye is essentially because of those muscles which tend to open or close the pupil or iris through which the light enters and of the ability of the lens being flattened or being made convex with the help of ciliary muscles.

Now depending on how fast or how slow we do this process, accommodation and adjustment is called upon the fatigue set in the muscles. Therefore the fatigue ocular muscles, the ocular muscles means the eye muscles. And of course just as any other activity of the human beings, heart rate plays a vital role and it is necessary for good illumination I mean perception by the human eye, normally heart rate is important. And obviously we have a certain rate of reading in fact some of us read very fast, some of us read very slow but there is an average rate of reading which we could call it as the normal rate of reading considering that is based on the font size or the font size of the text that is written and ability of average comprehension considering that its and obviously you are expected a times to read faster, there should be peak rate of reading.

In fact the well-known information can be read faster like you have an abbreviated text some times. And how precise the task is? Say we are trying to solder some electronic circuit on a printed circuit board; the task has been precisioned task because we are going to solder components over a small area which is calling for more microscopic precision involved. The other task which is involving precision is by the tailors when they try to thread the needle that's a very trick task because through the small eye of the needle, one has to thread it. And

all these is assist by taking the demonstration in visual test and sometimes some of us because of may be due to age, use or abuse we do develop defects. And these defects normally which are corrected with the help of a glasses are called refractory errors and you can have look into the visual acuity in defective vision. And all these has to be correlated with our experience in functioning in the normal daylight because all our systems are trying to arrange artificial illumination system which is as close to the natural light as possible and one can see that the illumination requirement, this service, the visual parameters are logarithmically related. We take some of these and see how they work.

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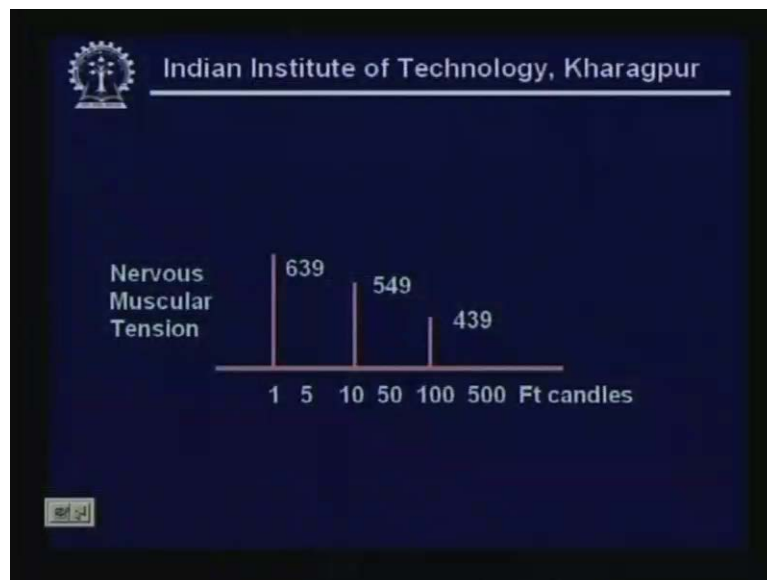


Now here is a graph which shows the visual acuity in the vertical axis and the illumination levels on the horizontal axis, it is marked as 1 10 100 1000 foot candles. Now here it is assumed that whatever visual acuity you have corresponding to the first vertical line is marked as 100%, it corresponds to one foot candle. If we standardize the visual acuity of any individual of course how did, how was these things measured? These things measured by considering normal adults of a large group measured over a long period of time and the average is taken. If that be 100% it's found that if we increase the illumination by 10 fold logarithmic increase by one decade to 10 foot candles, the visual acuity increases by about 130%. And if we go further on to 100 foot candles we find it goes to 170% and it can be seen, its observed though it is not marked in the graph further increase does not really enhance visual acuity very much that it is tends to saturate. So anything between 1 to 10 foot candles, if we said the certain activity is 100% at one foot candle, it becomes 130% by going to 10 foot candles.

So if a particular situation the tenfold increase in the illumination did improve the visual activity but 100 or 1000 fold increase would not really make that much of a difference. The next parameter is the contrast sensitivity. We said our eyes should be able to distinguish irrespective of the background.

Now we understand it's very easy if you had to read a white letter on a black board but if you had to read a light orange color letter or yellow colored letters on white board, it would be very difficult, contrast is not very clear. As you can see the illumination requirements service contrast sensitivity, if I define the contrast sensitivity to be 100% corresponding to a illumination level of one foot candle, I find by an increasing illumination level 10 times for 10 foot candles that is 1 dk increase I find the contrast sensitivity of the eye increases 280% and by increasing to 100 foot candles the sensitivity of contrast sensitivity becomes 450% that means even if the colors are close by, it is ability to distinguish becomes more and more as we have our illumination. This is some of measurements that have been made to enable and understand the quality of light required based on the human eye performance. See after all this particular talk we are looking at how the human eye responds.

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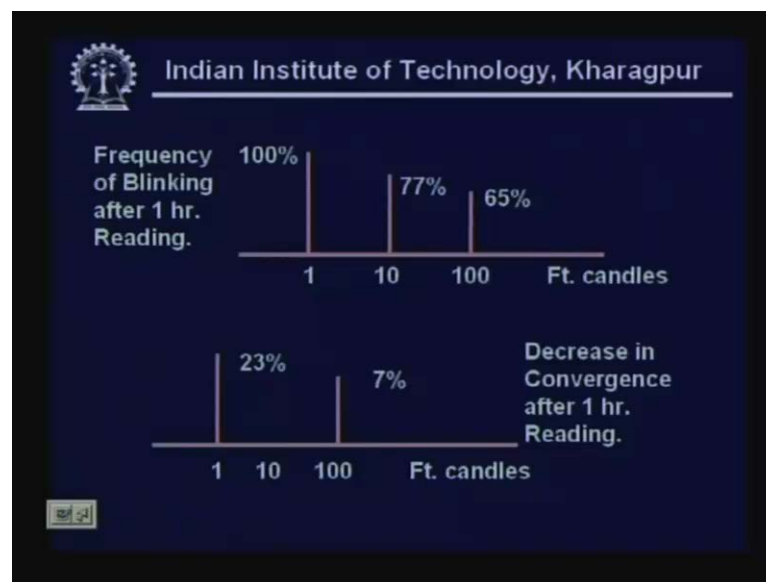


The next important thing I said in trying to adjust to varying levels of illumination and varying levels of requirements for the observation. The muscles have to move, make certain movements whereby they change the line shape or open or close the pupil all this leads to some kind of a muscular tension. Now we know tension is nothing but is a kind of pressure, it's measured in terms of say mmf mercury similarly in terms of pressure can be measured in terms of kg force per unit area. So to some arbitrary unit if I find that the muscular tension corresponding to one foot candle is 639, I find by increasing the illumination to 10 foot candles that is increased by one order or by one decade I find it comes down from 639 to 549 by about 100 in about 600 that is one sixth, one sixth would approximately mean 16% reduction. You further go down to go higher in illumination to 100 foot candle, you find it comes down by 200 that is about one third reduction so it becomes 66% of what it was.

So what do we see? We saw in the previous one that visual acuity improves with the increased illumination though it does not really improve much beyond 100 foot candle and ability of distinguishing in near close contrast also improves; see we found it has become four hundred and a half times when you go from one foot candle to 100 foot candle and visual acuity has

become 170%. And we find that the muscular tension has reduced by about 30% to an initial value of 639 to final value of 439 at 100 foot candles. These are some of the things that mean there is a certain advantage in terms of the functioning of the eye by having increased illumination. And one other thing which you find if there is requirement of reading or doing exacting tasks and adjusting the eyes we find that there is a certain rate of blinking that is necessary because of varying levels of illumination or varying levels of requirement. And this frequency of blinking after reading for an hour is observed and if it is standardized at some level as 100% for illumination is equal one foot candle you find that when the illumination increases to 10 foot candles or 100 foot candles it reduces. As can be seen it's around 77% for 10 foot candles and 65% for 100 foot candles that means there has been a decrease of 30%, 35% in blinking rate because of increased illuminations.

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All these helps and however other important issue, remember that the eye is able to capture fine details by converging the incoming light rays from the object on the central point of the retina which we call fovea which is located or where the nerve cells responsible for the micro details are cone vision, cones. And in doing this one has to basically does by the help of ciliary muscles which make the lens convex in nature and this ability of converging the incoming light... So what, how does do, eye? It basically closes its pupil, makes it closer and then there by light gets converged, if the lens becomes convex and you get the light converged on to the focal point.

Now this ability convergence is less if the illumination is low. As can be seen the decrease in convergence is high at one foot candle whereas it is much lower at 100 foot candle. The fig is given here are 23% for one foot candle and 7% for 100 foot candle. So we see if you can recall once again, we see the visual acuity improves with the increase in illumination, the contrast sensitivity improves and the increased illumination is able to reduce the muscular tension and also the blinking rate reduces. And obviously the error in convergence, what does it mean, decrease in convergence amount to meaning, that if you continue reading for a long

time in reduced illumination, eye start paining that is what was is a nervous muscular tension. And you start reading erroneously; you don't read what is there. Probably you read what is there in your mind; you do not read what exactly is written. That is the error in convergence. These are some of the issues which come up, so you can look at some of the recommended illumination levels based on the experience, keeping this visual conditions or the factors responsible for visual acuity, you see the recommended foot candles for the various operations.

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Task	Foot Candles
Black thread on black cloth	800
News paper – stock equation	100
Typing on dark blue paper	80
Telephone directory	60 (Yellow pages)
News paper – text	40
Excellent printing 6 pt.	10 Contrast
8 pt.	8 very
Well formed letters 10 pt.	6 large
on pristine white 12 pt.	5
background.	

Now this is a very critical task which has been listed here. Observe we are looking at observing a black thread on a black cloth which means contrast sensitivity has to be very high and that's why we did find that when compared to what was the contrast sensitivity at one foot candle, it becomes 450% at 100 foot candle but these two being very close in wavelength, we will need much higher. The newspaper, these stock equations which are put in bold print you need about 100 foot candles, stock equations are normally written in very small print, you must have seen that, it is very difficult and some of the elderly people are forced to use glasses.

Typing on a dark blue paper, typing is usually done in using black or blue ink; again it calls for about 80 foot. Telephone directory we know these are yellow pages, they are thin pages and large number of information is tried to be put into a single thing. The only advantage here is the contrast is large, the black and white though they are yellow pages. The newspaper text, the white background with reasonably big text about 40 foot candles, the printing is good well shaped letters, you find for a 6 point you need about a 10 foot candles and you go to 8 point, you get 8 foot candles and if the paper is very good pristine white background 12.5 foot candles. See here you find that there is a statement mentioned along with this print corresponding to 6 point, 8 point, 10 point and 12 point which says contrast is very large that means you really have a very large contrast that is you are looking at white background with black letters.

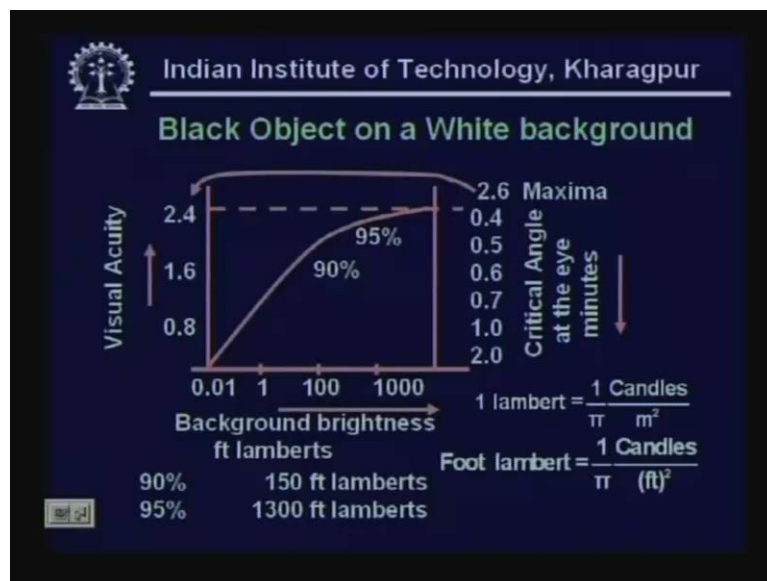
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- Visual criteria apart from illumination
 - Visual acuity
 - Visual efficiency
 - Visual speed
 - Visual health.
- Acuity – Distinguish detail depending on brightness of the object
 - Characteristics of light entering the eye
 - Contrast details.

So the other criteria which are the necessary for the functioning of the eye from the point of view of an observation apart from increased illumination levels. What we are trying to say is yes we did find the eye functions better with the increased illumination but that alone will not do. The factors that are responsible are visual acuity which we have seen how it varies, visual efficiency that is depending on how efficiently one is able to observe the required object, speed ability of observing the required time, health depending on use, abuse or age. Now here we have been talking about acuity quite a bit but still we haven't really defined acuity. So it is better we formalized what we understand by acuity.

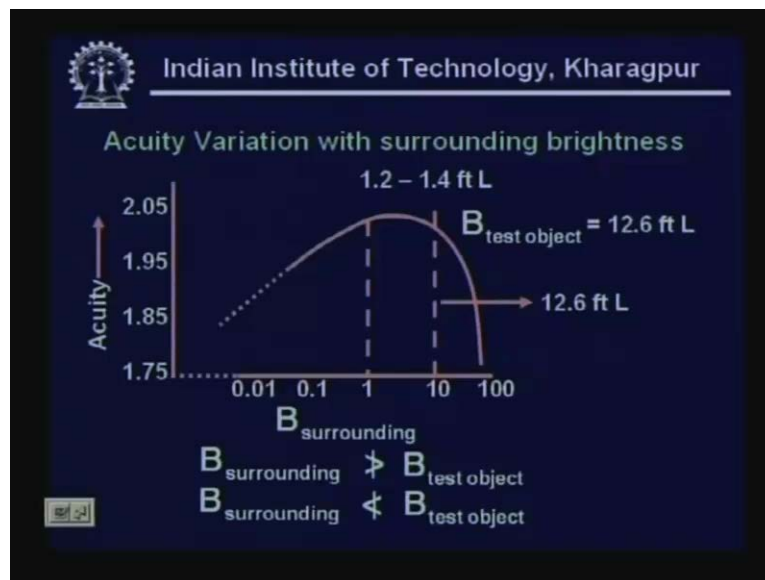
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Acuity is the ability of the eyes to distinguish the details depending on the brightness of the object and keeping in mind the contrast details and the nature of the light that enters the eye. Now black object on a white background, you can see how the visual acuity varies with your background brightness. Background brightness is given in terms of the, what you call foot lamberts. As can be seen it's going from 0.01 to about 1000 foot lamberts. Recall, one lambert is one over pi candles per meter square candles, I said the standard of light is **try can as a wax candle** and therefore you can say the light flux to be proportional to a candle and amount of light incident on one unit area in meter square is considered in terms of a lambert. And supposing the area as against meters is taken in fpa system, it becomes foot lamberts.

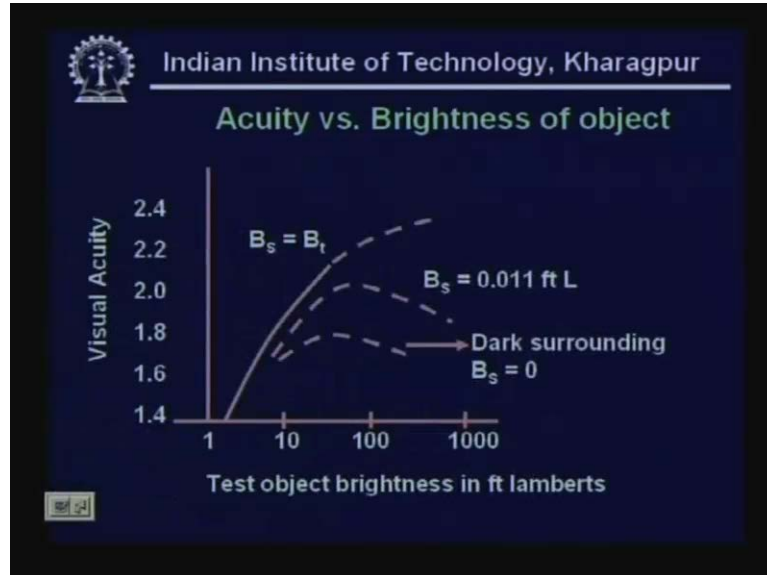
What do we observe? We observe that the maximum acuity of 2.6 is around above 1000 foot lamberts and see 95% acuity, 95% of the maxima is coming around 1300 foot lamberts where as 90% acuity is possible with 150 foot lamberts. So what does it mean? So the requirement to get good acuity does increase with increased illumination but beyond some point it tends to saturate. In fact this particular curve also talks about the critical angle at the eye with respect to you're the, what we call the background brightness.

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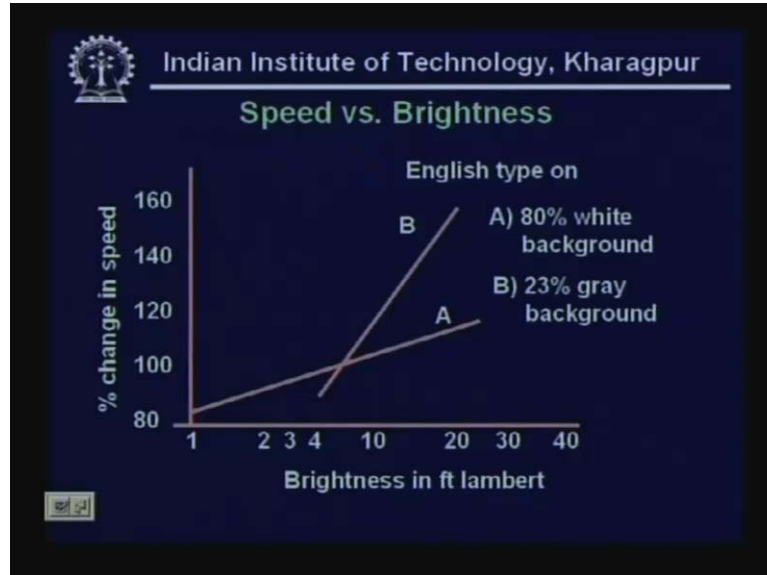
Further acuity also depends on the surrounding brightness. This is how the, what you call your contrast comes into picture. Again here the acuity is drawn along the vertical axis and we find that the maxima in this curve is seen to be around 1.2 – 1.4 foot lamberts. Okay? What do we find is the background brightness? Now this particular curve corresponds to the test object brightness of 12.6 foot lamberts. What does it say? It says that approximately one tenth surrounding brightness enables good acuity of observation; this is a very important thing. What it says is the brightness of object vis a vis this surroundings, how should it be related. If you see this statement given below, these surrounding should not be much larger than the test object. At the same time it should not be very small, smaller than test object. And what we find? The peak in this particular case has been between 1.2 – 1.4 foot lamberts of the background brightness. Here the object itself is 12.6 foot lamberts; that is the important issue.

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Now this particular thing looked at the other way around, in fact the previous diagram we had a look of variation of the surrounding brightness for a fixed test object brightness and that variation of the acuity. Now let's take the brightness of the object vis a vis visual activity and how it is varying? We find there are three curves here, the first one the bottom most corresponds to $B_s = 0$ meaning it is a dark surrounding, brightness of the surrounding is negligible. And you do find the acuity is around 1.8 but still it is not high that corresponds to somewhere close to 100 foot lamberts of the test object. On the other hand, we do find when the surrounding brightness is increased to 0.01 foot lamberts, the acuity reaches a peak value of 2 at about 100 foot lamberts of the test object. But should we make the surrounding brightness equal to the test object, the visual acuity keeps on increasing but that may not be all the time possible.

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Then the last thing that needs to be done, looked at is how the ability of observing or reading goes with the brightness. If you see the brightness is marked along the x axis, the two examples have been taken, curve A or the line A corresponds to a situation where 80% white background and B is 23% gray background. What do we observe? We observe the percentage change in speed when the background is white considering a standard English type is not much with increase in brightness. On the other hand in the gray background we find there is a rapid increase in change in the speed, we have around 100. If it is 100% at 10 foot lamberts, it comes to close to 160 at 20 foot lamberts.

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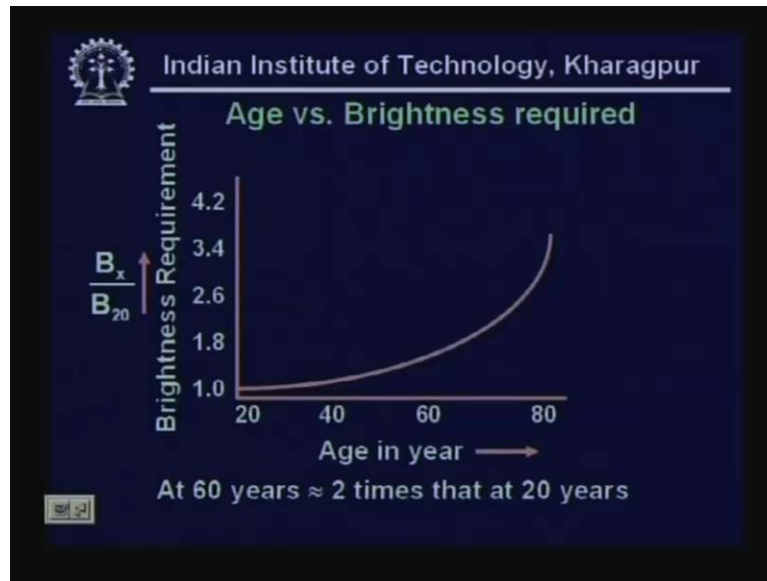
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- Age vs. Vision.
 - Visual acuity reduces
 - decrease in pupil size
 - decrease in elasticity of pupil
 - decrease in flexibility of optic lens

⇒ decrease in adjustment of local length leading to higher illumination requirement in older people.

Lastly one has to look at the thing that age has its own impact on the visual acuity. With increase in age, vision reduces. This because of decrease in pupil size which is mainly due to the elasticity of the pupil being decreased or the muscle, muscular elasticity reduces. And as a result even the optic lens becomes less flexible and all these results in difficulty of adjustment of the focal length. And hence one needs higher illuminations as age increases.

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In fact we find the curve given for brightness requirement at any age considering a 20 year old as the reference, we find that as you go higher and higher, it is much higher requirement. As can be seen from this curve at the age of 60 typically when one takes retirement from active life, it is that two times that at 20 years. So this is the way age effects.

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- Monochromatic light and acuity
 - Distinct images on retina.
 - details are distinguished well.

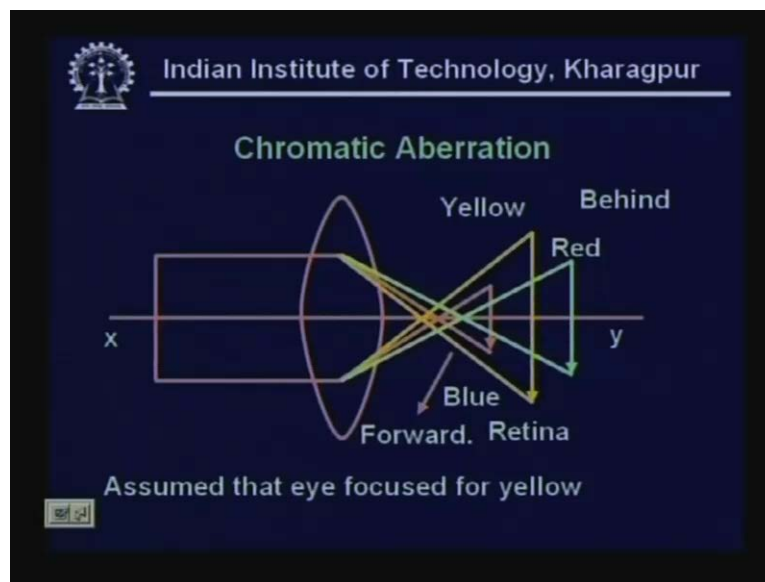
Gaseous source – Mercury – Sodium.

Three primary colors – Red
Green
Blue

- Combination – reduces acuity

Now this is a part, our eye comfortable and perform best with the monochromatic light and they are able to form distinct images on retina and are able to distinguish details well. However the monochromatic light essentially is obtained from the physical process of electro luminance which is used in gas sources, the lamps are mercury or sodium. In fact the fluorescent lamps are nothing but low pressure mercury vapor lamps. And one must observe that it is the three primary colors red, green, blue which mixed in a particular rate can give rise to all the necessary colors, in fact this is... But as the eye has an ability to have good acuity for a monochromatic light, the combination tends to reduce to acuity. This can be understood by this diagram which shows supposing that eye is focused for yellow. You remember that the sensitivity of the human eye is maximum around 550 nanometers which in yellow green color.

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Now we find that if it is focused for yellow, the red having a larger wavelength would go behind and blue having a lower wavelength would be ahead of the retina. And this would give rise to error in observation which we call chromatic aberration and there is a lag in sensing this color.

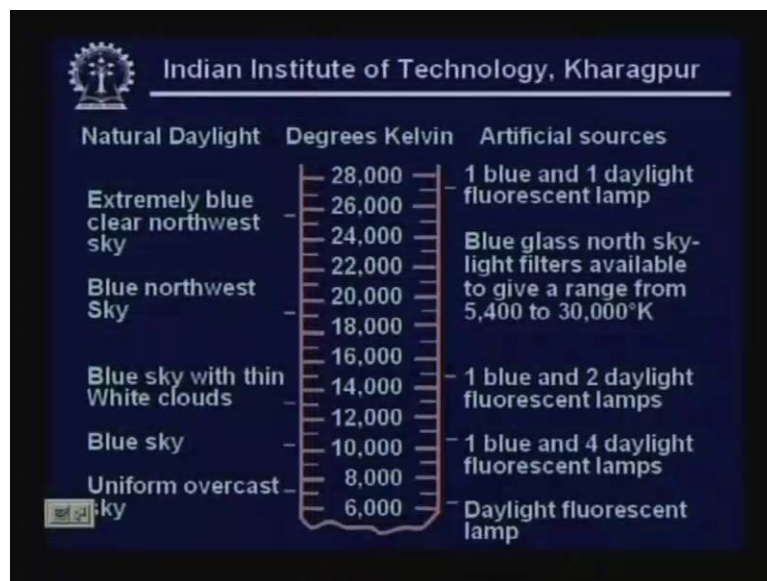
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- Color Sensation.
 - Lag exist.
 - Depends on presentation and cessation of stimulus – presentation of the object
 - rate of rise / fall – different colored
 - G – Green slowest
 - B – Blue fastest.
- Simultaneous Contrast – max. when adjustable e.g.: Red and Green.

And again all the time one has to remember that it is the time of observation matters a lot and therefore depending on the presentation and cessation of the stimulus, the colored objects are felt. And all these together is what we call the chromatic aberration and the sensation vice the eyes are able to sense blue, the fastest because of the smaller wavelength and green this lowest. Simultaneous contrast maximum, when the colors are away in the spectrum. If they are close by, it's difficult.

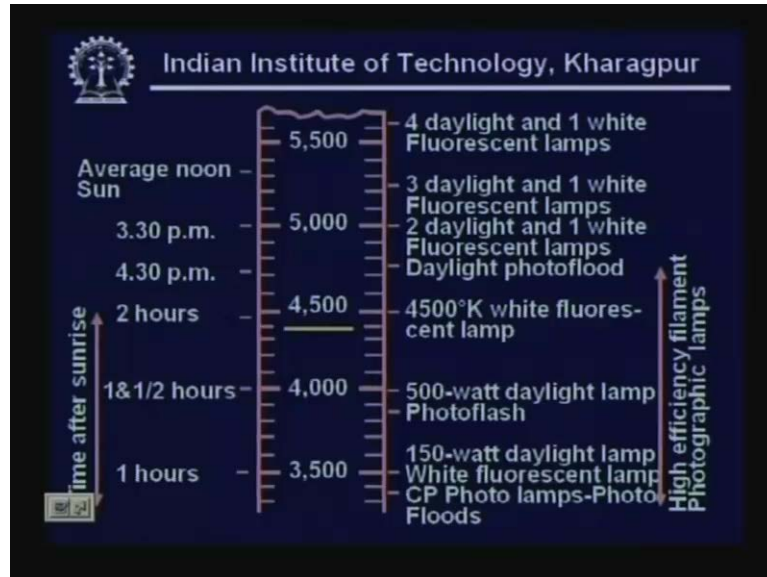
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Now once again let us have a look at how these color temperatures are located and where our eye is. So we saw how this natural light and the artificial sources are put along with the color

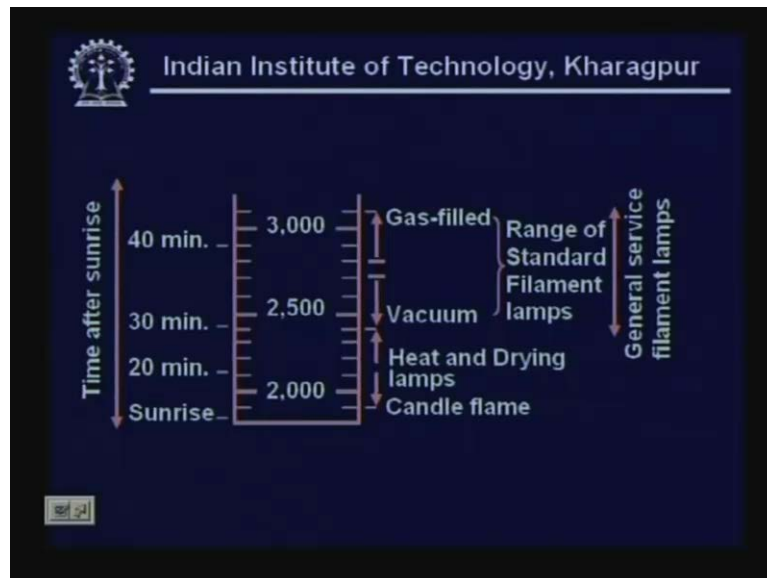
temperature scale. As we can see the blue North West sky is around 20000 degree Kelvin corresponding to a fluorescent lamp with blue glass filters. Now if you see on the right hand side, day light fluorescent lamp is around 6000 degree Kelvin.

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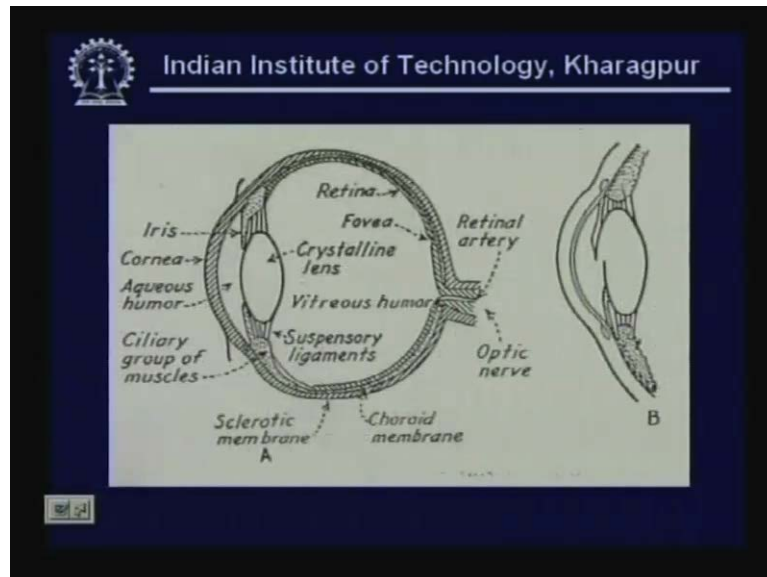


Similarly, you have the noon time sun around 5300 degree Kelvin and you have the high pressure or sorry white fluorescent lamp marked around 4500 degree Kelvin. And the candle flame comes at the bottom most with 2000 degree Kelvin.

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So with this, once again before we close we look at the eye. Eye has a three major parts similar to a camera, one is iris which allows the light to go in or go out and two, the lens is similar to the lens in a camera which can change its shape, flattens for dim light and becomes convex for bright light and three is the retina where the image is formed which is sensed or communicated through the brain with the set of double nerves which are called cones and rods. A lot of cones are present at fovea which is the point of maximum sensitivity.

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- Illumination affects physiology as well as psychology, hence quality lighting is important
- Factors governing illumination quality :
 - ~ glare
 - ~ diffusion
 - ~ direction / focus
 - ~ composition
 - ~ distribution
- Minimum lighting required for good visibility is 100 ft-cd or more

So we saw that the illumination has role in affecting of physiology as well as psychology and therefore it is not enough if you look at the quantity of light but quality of light is also

important. The quality of light is affected by the glare present, glare we said by definition is intense light present in the plane of observation. The way it is diffused and how the illumination is directed or focused together with its distribution and composition. Minimum lighting required for good visibility is 100 foot candle or more considering all aspects of the human eye functioning.

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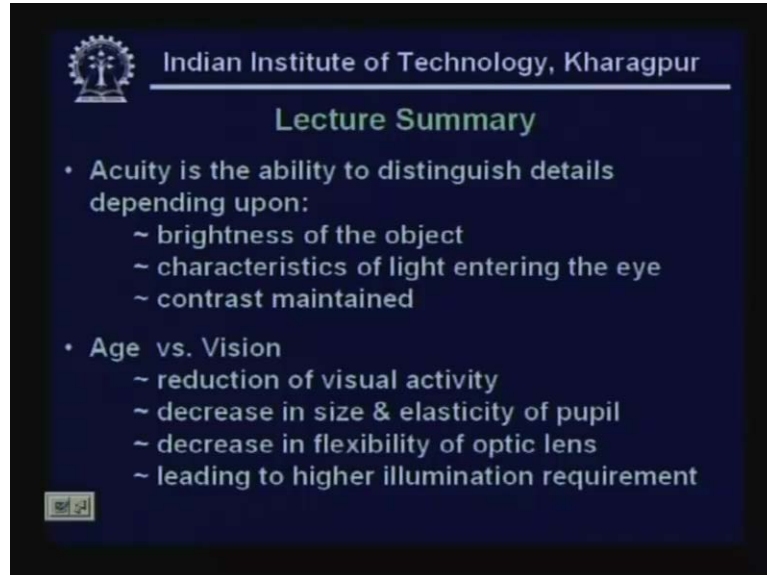
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Lecture Summary

- For good visibility, brightness of surrounding should be greater than 0.01 ft-L & also should be less than that of test object
- Apart from illumination, visibility is talked in terms of :
 - ~ visual acuity
 - ~ visual efficacy
 - ~ visual speed
 - ~ visual health

Now we also saw that for good visibility, brightness of surrounding should be greater than 0.01 time foot lamberts or it should be less than that of the test object. Now here we saw that there should not be a large difference in brightness between the surrounding and the test object, ideally one tenth of the test object should be the surrounding brightness for getting good visibility. Apart from the illuminance, illumination the vision or the visibility of human eye is talked in terms of visual acuity, visual efficacy, speed and health. Health basically talks about the errors that are possible and fatigue that's certain.

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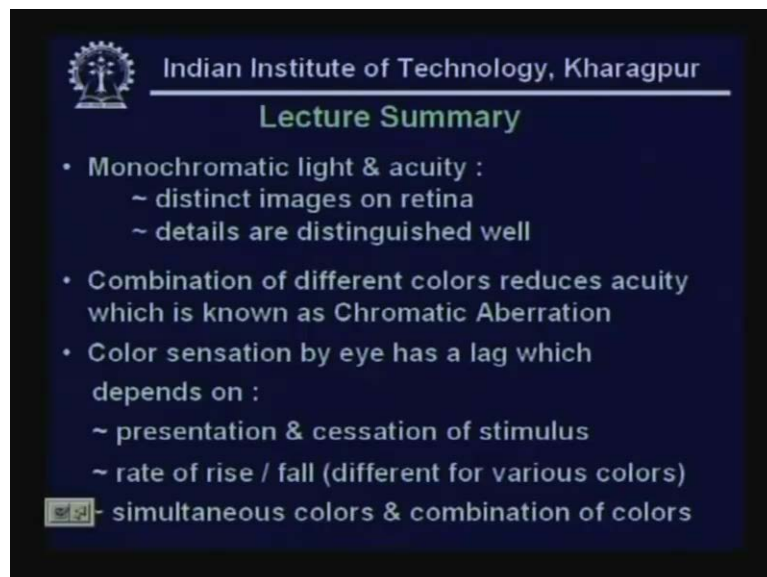
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Lecture Summary

- Acuity is the ability to distinguish details depending upon:
 - ~ brightness of the object
 - ~ characteristics of light entering the eye
 - ~ contrast maintained
- Age vs. Vision
 - ~ reduction of visual activity
 - ~ decrease in size & elasticity of pupil
 - ~ decrease in flexibility of optic lens
 - ~ leading to higher illumination requirement

Acuity is what? Acuity is the ability to distinguish details depending upon the brightness of the object, characteristics of light entering the eye and contrast maintained. Now, one important thing to be kept in mind that with age, the visual acuity reduces, this is because of the decrease in size of the pupil and elasticity of the pupil. This is essentially because of the reduction in elasticity of the muscles and ability to flux the optic lens reduces, this all this leads to higher illumination requirement. We saw taking reference to a 20 year old, at the age of 60 for same conditions one needs two times the illumination requirement.

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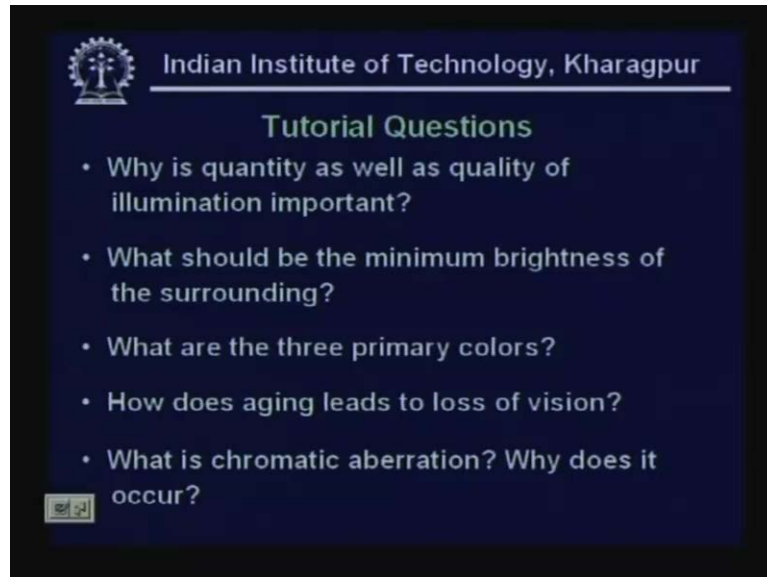
Lecture Summary

- Monochromatic light & acuity :
 - ~ distinct images on retina
 - ~ details are distinguished well
- Combination of different colors reduces acuity which is known as Chromatic Aberration
- Color sensation by eye has a lag which depends on :
 - ~ presentation & cessation of stimulus
 - ~ rate of rise / fall (different for various colors)

simultaneous colors & combination of colors

Monochromatic light means what, I mean monochromatically the eye functions or activity is at its peak and forms distinct images on retina. And combination of colors does reduce the acuity, we saw how when the eye is focused for a yellow light, if you find a red signal or a blue signal how the images formed behind or ahead of the focal point and thereby there is an error. The error due this is what we call chromatic aberration and there is a certain time lag for sensing the colors and this depends on the way it is presented, the way stimulus is removed and it is different for different colors.

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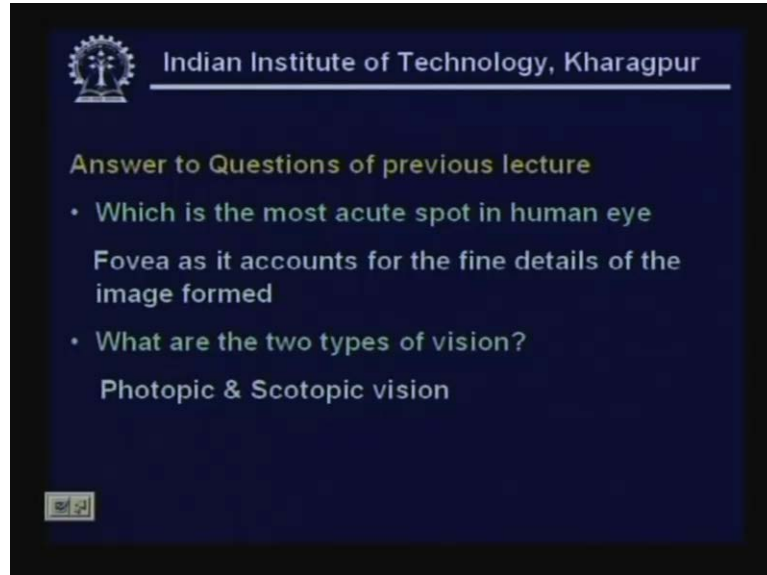
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Tutorial Questions

- Why is quantity as well as quality of illumination important?
- What should be the minimum brightness of the surrounding?
- What are the three primary colors?
- How does aging leads to loss of vision?
- What is chromatic aberration? Why does it occur?

Some of the questions, why is quantity as well as quality of illumination important. What should be the minimum brightness of the surrounding, what are the three primary colors, how does aging lead to loss of vision, what is chromatic aberration, why does it occur.

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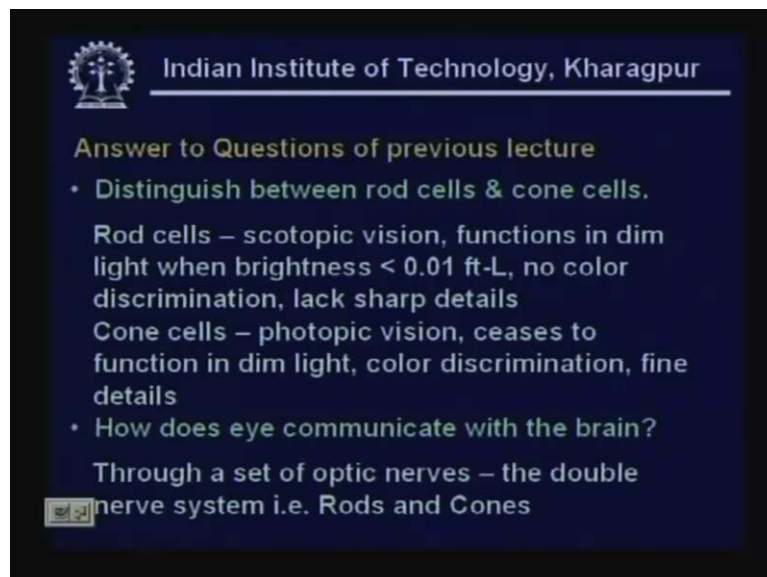
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Answer to Questions of previous lecture

- Which is the most acute spot in human eye
Fovea as it accounts for the fine details of the image formed
- What are the two types of vision?
Photopic & Scotopic vision

Coming back to some of the questions, answers to the questions of the previous lecture which is the most acute spot in human eye. The fovea as accounts for the fine details of the image formed is the most important or acute spot. What are the two types of vision? The two type's vision human eye has are photopic and the scotopic vision that is pertaining to cones and rods.

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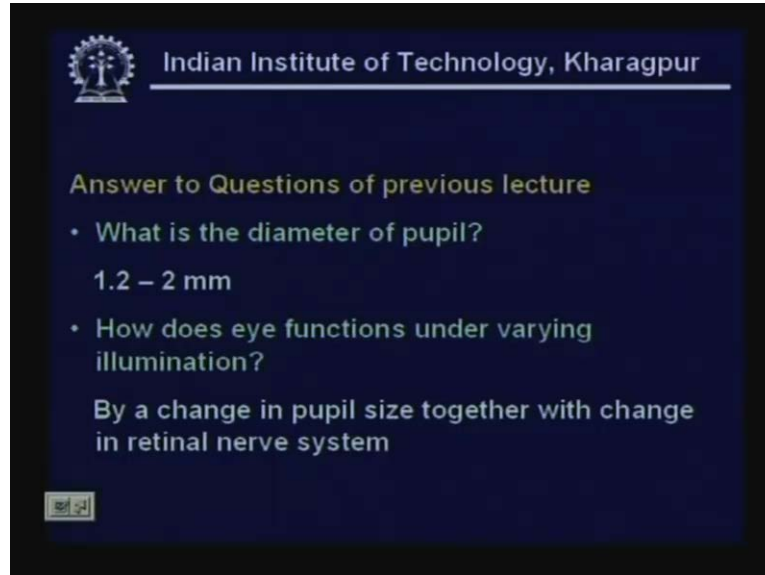
Answer to Questions of previous lecture

- Distinguish between rod cells & cone cells.
Rod cells – scotopic vision, functions in dim light when brightness < 0.01 ft-L, no color discrimination, lack sharp details
Cone cells – photopic vision, ceases to function in dim light, color discrimination, fine details
- How does eye communicate with the brain?
Through a set of optic nerves – the double nerve system i.e. Rods and Cones

Distinguish between rod cells and cone cells. Rod cells scotopic vision function in dim light when brightness is less than 0.01 foot lamberts, no color discrimination ability exists during this vision and lack sharp details. And one observes in the form of a silhouette and grayish appearance. Cone cells on the other hand have a photopic vision cease to function in dim

light, color discrimination and fine details are their ability. How does eye communicate with the brain? Through a set of optic nerves the double nervous systems what we call rods and cones.

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Answer to Questions of previous lecture

- What is the diameter of pupil?
1.2 – 2 mm
- How does eye functions under varying illumination?
By a change in pupil size together with change in retinal nerve system

What is the diameter of pupil? The diameter of pupil is around 1.2 to 2 mm. How does eye functions under varying illumination? By a change in pupil size, together with change in retinal nerve system, it must be mentioned that here the ciliary muscles are the ones which help in changing in the pupil size. And why is red color used for stop signal? The eye can easily sense red color from a distance due its large wavelength, so that one can get enough time to react and stop. Thank you.

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Answer to Questions of previous lecture

- Why is red color used for stop signal?
The eye can easily sense red color from a distance due to its large wavelength so that one can get enough time to react & stop.