Applied Ergonomics

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Lecture – 27

So, welcome to this problem session based on the topics cognitive ergonomic and physical work environment.

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So, so far theories we have covered. So, we will try to solve some of the problems which are the applications of our day to day life activities.

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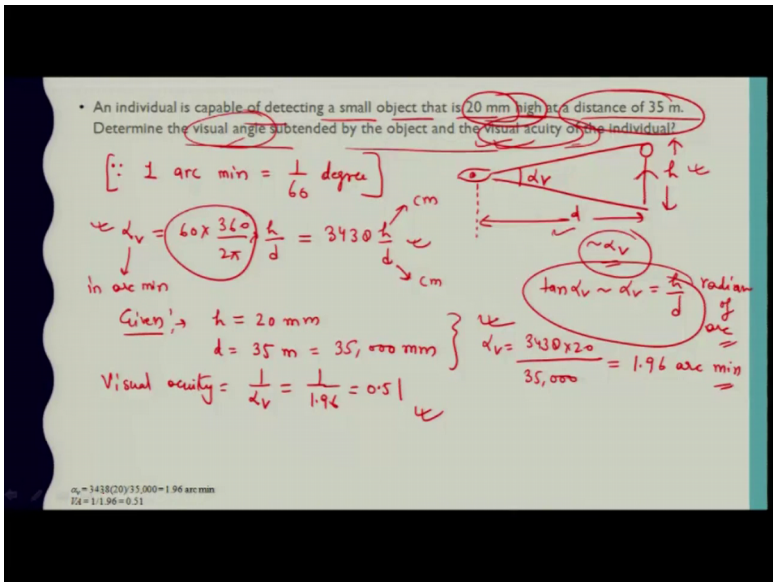

So, here the first kind of problem is you can see from this slide that an individual is capable of detecting a small object that is 20 mm high at a distance of 35 meter.

So, determine the visual angle subtended by the object and the visual acuity of the individual. So, how will you calculate this visual angle subtended by the object and visual activity of the individual. So, generally this particular as you can, as you may recall the theory of human sensory system in which we can we understood about the visual performance and visual acuity. So, here what like this is an eye and this is making and this is a particular object let say person. So, he is particular eye is making angle like alpha b this is a subtended by an object of height h and the distance t from the eye.

So, for a small angles alpha like this if the alpha b is a very small. So, alpha b is determined as a height of the detail divided by its distance from the eye that is usually expressed in radian, radians of arc. So, in that radian of arc is usually converted into arc minute. So, that arc minute how you will calculate, how will you convert in fact So, 1 arc minute is about 1 upon 60 degree. So, alpha b if it is expressed in as h upon d. So, this tan alpha b is very small so alpha b equals to h by d.

So, if it is expressed in radian of arc. So, if you have to convert it into arc minute. So, how will we convert this? So, we will have to multiply with 60 into 360 by 2 pi into h by d. So, that will be, this particular amount will be after multiplying come out as a 3438 h by d. So, in this way this alpha b in arc minute and height of the object is in centimeter and d is in is the distance from the eye which can be expressed in centimeter.

So, now our question is the small object that is 20 mm height. So, the given data is given data is like h equals to 20 that is mm and this distance d is 35 m. So, it can be treated as 35000 mm. So, if you will put these values in the formula. So, alpha b equals to 3438 into 20 upon 35000. So, that will be has an, if you will calculate it will come out as a 1.96 arc minute.

So, now the second is thing that you have to calculate is visual acuity, this is visual angle and now you have to calculate visual acuity. So, this visual acuity is nothing, but reciprocal of visual angle that is 1.196 equals to 0.51. So, in this way this visual acuity can be calculated and since vision is one of the most important sensor of all five humans sensory system. So, we need to take care of this visual angle and visual acuity, as you may recall of the fact that there are various standard methods for testing visual acuity which includes reading is allele chart and as well as we calculate the allele acuity and. So, these things we have already learnt in physical work in environment part as well as the cognitive ergonomics.

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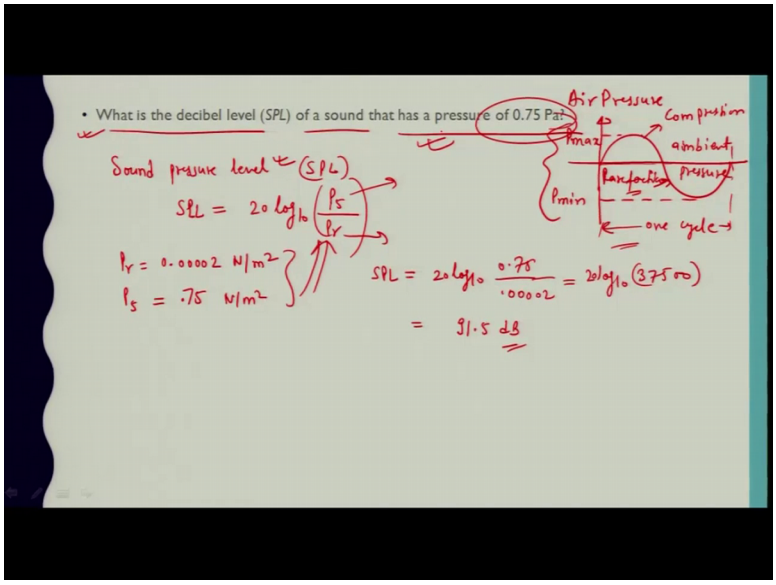

So, now the second question is that we have to understand that is what is the decibel level, that is SPL of a sound that has pressure of 0.75 Pascal. So, as to recall the theory of this particular hearing concept so basically this dentistry of the sound relates to the amplitude and that amplitude you calculate that the help of, this is basically air pressure and this is the maximum pressure and this is the minimum pressure and this is whole one cycle. So, here this particular upper graph is showing a compression and this particular level is ambient pressure and this particular nature of the curve is rarefaction.

So, in this way it this is a sinusoidal pressure oscillation of a simple sound generating source. So, in this intensity of sound is related to the amplitude, amplitude can be calculated by depreciating a maximum pressure and minimum air pressure of oscillation and the term this particular sound pressure level is measured as a logarithmic measure of sound intensity. So, thus one formula which we learnt in while discussing the theory of this particular topic so that is 20 log base 10 to the sound pressure from the source to the upon difference sound pressure that is Ps by Pr.

So, here we can calculate with the help of this particular data. So, this is a sound pressure from the source and this is a reference sound pressure. So, what the data we have as of now that usual reference level which is taken as Pr equals to 0.00002 Newton per meter square and the data is given as 0.75 Pascal. So, here as a sound pressure from the source we will take it as a 175 Newton per meter square now we put all these values in this particular formula. So, it will be coming out as SPL equals to 20 log base 10, 0.75 upon 0.0002. So, that will be as at 20 log base 10, 37500 and that will somehow come out as a

91.5 decibel. So, in this way this can be calculated and as far as single sound tone is concerned and if there are multiple sound there is a another way to solve that particular question.

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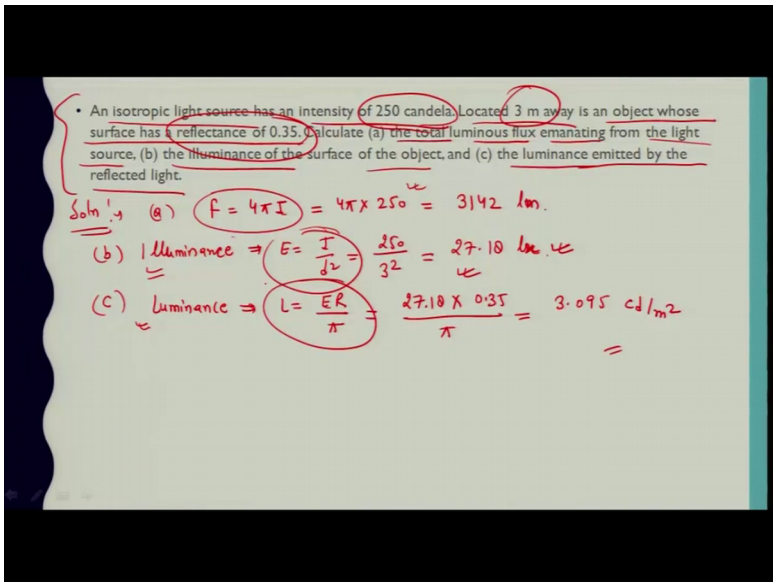

So, now another question which is based on the physical work environment that we are going to solve here and that is an isotropic light source has an intensity of 25 250 candela located 3 meter away is an object whose surface has a reflectance of 0.35. Now you have to calculate the total luminous flux emanating from the light source and b illuminance of the surface of the object c, the luminance emitted by the reflected light. So, since we learn the formula in the theoretical class that let say if we find out the solution. So, this particular total luminous flux calculation can be achieved by the formula F equals to 4 pi times I So, here this particular I is nothing, but the luminous intensity that is expressed in candela. So, here I equals to 250. So, in this way if you will multiply and so answer you will be getting as 3142 and that is lumen.

Now, the second question is how to find out the illuminance of the surface of the object. So, this illuminance has been calculated as E equals to I upon d square. So, that is 250 upon that is located 3 meter. So, that is 3 square equals to 27.18 and illuminance is expressed in lux so lx. So now, thus luminance emitted by the reflected light so this luminance can be calculated as so this particular E is illuminance and capital R is reflectance.

So, since illuminance we have calculated in the previous line that 28.18 into reflectance is what reflectance is 0.35 upon pi, but. So, that will come out as a 3.095 since the unit of luminance since is candela per meter square. So, in this way with the help of simple formulas you can calculate the various optical activities which is very useful concepts for having knowledge towards visual environment.

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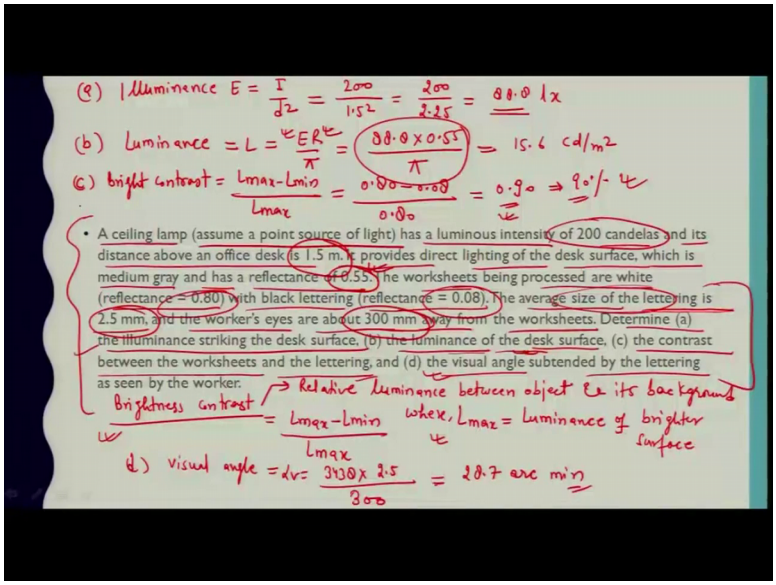

So, the again the next question is that is also based on the visual environment and that is ceiling lamp assuming a point source of light has a luminous intensity of 200 candelas and its distance between an office desk is 1.5 meter it provides direct lighting of the desk surface, which is medium gray and has reflectance of 0.55. Worksheets being processed are white whose reflectance is 0.80 with black lettering whose reflectance is 0.08, the average size of lettering is 2.5 mm and the workers eyes are about 300 mm away from the worksheets determined illuminance striking the desk surface, b the luminance of the desk surface, c the contrast between the worksheets and lettering and the visual angle subtended by lettering as seen by the worker.

So, in this way there are 3 sub parts of this particular problem and now one by one we will take. So, first we will take to calculate this illuminance is striking the desk surface. So, thus as we know that the formula to calculate this illuminance that is expressing in E equals to I upon d square. So, where I is luminance intensity and that is given as a 200

candela, now small d is what small d is distance above an office desk that is 1.5. So, here you can calculate as it will come out as something 88.8 and illuminance is lx.

So, now the question b is luminance of the desk surface. So, how you will calculate the luminance, that is L and that can be calculated as E R upon pi. So, here e has been calculated as illuminances so E R upon pi. So, e is calculated as 88.8 and this particular R is here it is given as, it provides direct lighting of the desk surface which is medium gray has reflectance of 0.55. So, here we need to this put this particular value in this. So, 88.8 into R is what R is 0.55 upon pi. So, if you will calculate this particular term. So, you will be having 15.6 candela per meter square.

Now, the next thing that we need to calculate which is contrast between the worksheets and the lettering. So, basically this contrast is brightness contrast. So, we can define this brightness contrast as, it is basically relative we can say relative luminance between object and its background. So, it can be expressed as L max minus L minimum upon L max. So, where this L max is luminance of brighter surface, an L minimum is the s for darker surface. So, in this way this particular value of brightness contrast can be calculated.

So, now the c is brightness contrast that is L max minus L minimum upon L max this particular value in the form of a reflectance we can see that that worksheet being processed or white reflectance is 0.80 with black lettering is 0.08. So, in the in the form of reflectance we can also express this by contrast and that is if we maximum is 0.80 and minimum is 0.08. So, here 0.80 so in this way we will be having 0.90. So, that could be express is 90 percent. So, this brightness contrast is 90 percent.

Now, we need to calculate this visual angle which is subtended by the lettering as seen by the worker. So, this particular visual angle is can be calculated as alpha b equals to 3438 times. So, here we can see that the distance and height is you can see here that average size of the lettering is 2.5 mm and workers eye, eyes are about 300 mm. So, so distance is 300 mm. So, here you can write as 300 and the average size of the lettering is 2.5 so that we will be putting as 2.5. So, now, we have to calculate and this multiplication and division like 3438 into 2.5 upon 300 which will come out as 28.7 arc minute. So, in this way this all analytical values can be calculated with the help of the

concepts that has already been developed with the by our researchers and young and intelligent minds

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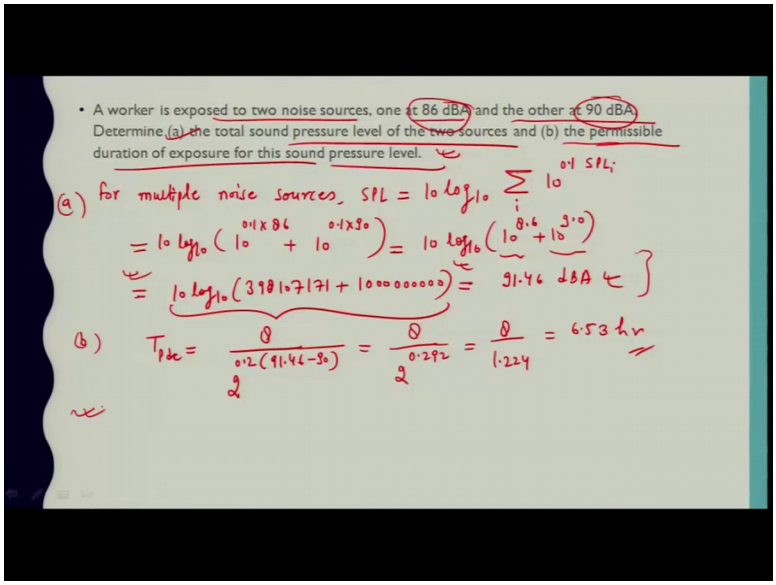

So, another question for you to solve that is basically based on the sound pressure level and that is a worker is exposed to 2 noise sources 1 at 86 ix decibel, other at 90 decibel determine the total sound pressure level of 2 sources and the permissible duration of exposure for this sound pressure. So, as we know that for a single tone sound pressure we have one formula that is SPL equals to 20 log base 10 Ps upon pr, where Ps is the sound pressure from the source and Pr as a reference pressure level.

So, but for multiple noise level we have some amended formula and that is for multiple noise sources, we have SPL equals to 10 log base 10, summation of 10 to the power 0.1 times SPL I. So, I number of sources. So, here since we have 2 pressure levels 86 and 90 decibels. So, this we can write it has 10 log base 10, 10 to the power 0.1 into 86 plus 10 to the power 0.1 into 90. So, this could be the expression and then 10 log base 10. So, this could be 10 to the power 8.6 plus 10 to the power 9.0, we will calculate this particular values. So, this will come out something like 10 log base 10,398107171 plus 10000000000 something like that.

So, now if you will calculate with the help of calculator this particular value, this will value this value will be coming out as 91.4 six dba and kindly check this value and correct it, if it is wrong. It is just a simple mathematics because as an engineer you can

calculate with the help of scientific calculator which has option to estimate the logarithmic value.

So, now the second part is to calculate permissible duration of exposure for this sound pressure level. So, where is another formula for sound this permissible duration of exposure for this particular sound pressure level and that is tpdc equals to 8 upon 2 to the power 0.2 this 91.46 minus 90 and that is 2 to the power 0.292 equals to 8 upon 1.224 that is 6.53 hours. So, this is a permissible duration of exposure for this sound pressure level. So, that is solve for now, I hope you have learned how to apply this theoretical knowledge that we have gained in the lectures of cognitive ergonomics as well as physical work environment. So, that is all for now.

Thank you.