Theory of Elasticity

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Lecture – 55
Photo – Elasticity (Contd.)

Welcome we are discussing Photo Elasticity. So, in this in the previous class, we have just introduced the photo elasticity, what it is and we introduced with respect to our different techniques, that we have already learned except the numerical technique that, we have not discussed in this course. And, the here in this lecture essentially, we will understand the basics of optics, it is very basically a review of optics.

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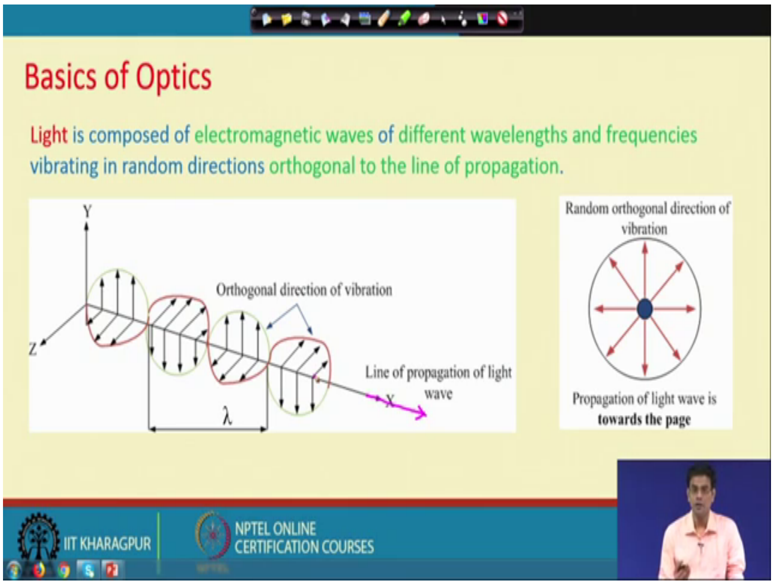

So, some of which we already know. So, as for instance light is an electromagnetic wave and of different wavelength and frequencies vibrating in a random direction orthogonal to the line of propagation. So, if this is a line of propagation. So, if this is a line of propagation so, and this is a different direction orthogonal means you know so, which is perpendicular to the line of propagation.

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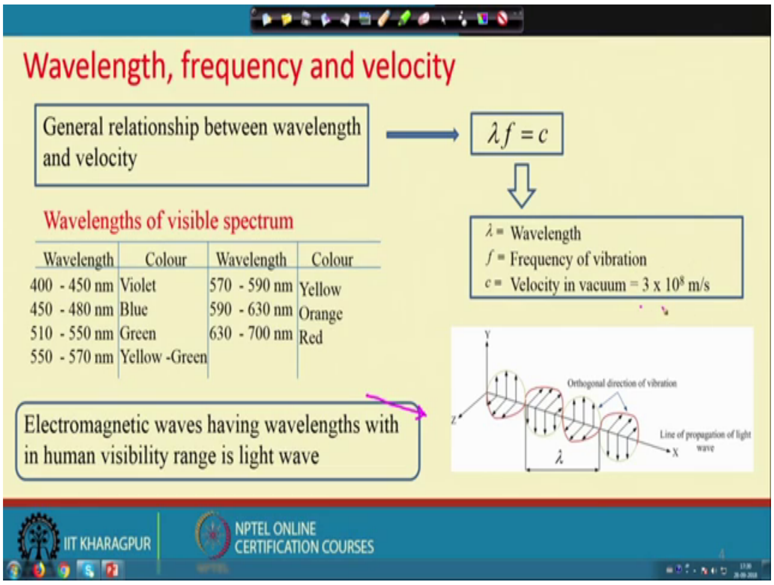

So, in this so, this is a perpendicular to this line is a line of propagation and this is a vibrating in the random direction. So, these light between 2 these things, you know which is lambda, the wavelength of light and all those things. So, we just know the relationship between the wavelength and the velocity. So, if lambda is the wavelength and if it is the frequency of the vibration and c is the then, lambda f is constant which is known as a velocity in vacuum of the light.

So, that is also known to us 3 into 10 to the power 8 meter per seconds. So, the wavelengths of visible spectrum, which is from 570 to 700 nanometer. So, which color it present? So, probably in our childhood, we have understood it and this 400 to 700 range, we know is a feasible spectrum of the light. And this essentially, it is a light can be defined as a radiation of electromagnetic wave and it is human visibility range so, visibility range.

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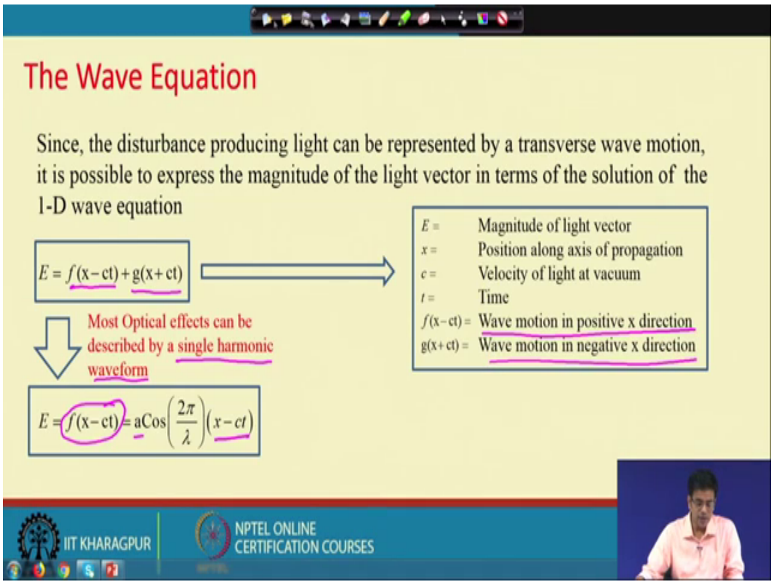

So, this is the basics of a light and so, essentially it is a wave light is a wave. So, is a wave and so, we it can have, it can propagate in 2, 3 or 1 direction. So, to start with in 1 direction propagation it so, it is a wave equation that is essentially one need to solve. So, this wave equation will not discuss it detail here so, but the wave equation represents the light vector, the magnitude of the light vector E and this can be represented as the forward traveling wave and backward traveling wave or the right traveling wave or left travelling wave. So, this is the if x t is the forward traveling wave and then right travelling going x plus c t.

So, these 2 functions are essentially represents the solution of that wave equation. So, this or sometimes, it is called a wave motion in the positive x direction and wave motion in the negative x direction. So, E is the light vector x is the position along the propagation and c is the velocity of light at vacuum and t is the time. Now, most of the phenomena that we will be talking about here can be approximated or most of the optical effects we will be discussing here, can be approximated by the single harmonic wave form. So, that means, with the forward propagation only I can express it with a harmonic function. For instance, I can write a cos some a cos some term. So, here, I have used 2 pi by lambda x minus c t. So, this is harmonic and this a is the amplitude of the wave.

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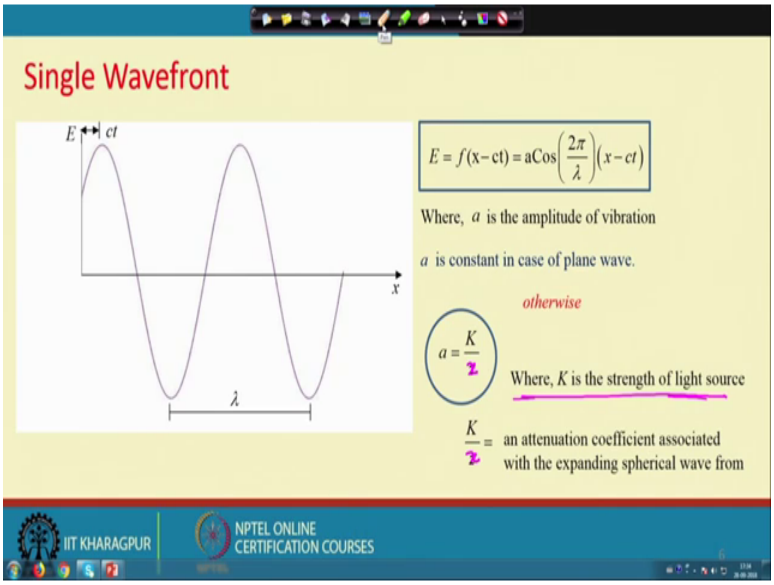

So, now this thing we know for this is very similar to the simple harmonic motion. So, now this we can is known as the amplitude of vibration. So, if we see this is a x axis and this is E axis or the light vector and then the a could the constant a equals to K by z and or the attenuation coefficient K sometimes it is known as the attenuation coefficient. So this if it is a constant in case of a plane wave and this will be I think x this will be x. So, this K by x will be attenuation coefficient, which is dependent on x. So, K is the source of the light source.

Now, this thing essentially nothing, but a simple harmonic wave for us; now we have to know, if we superpose these because in the later part when we study the photo elasticity, you will have to know if you superpose these 2 simple harmonic motion, what will happen, what will be the resultant wave essentially; whether it is in the same plane or it is in out of plane wave. Then, if you superpose these 2 what will happen to the simple harmonic motion.

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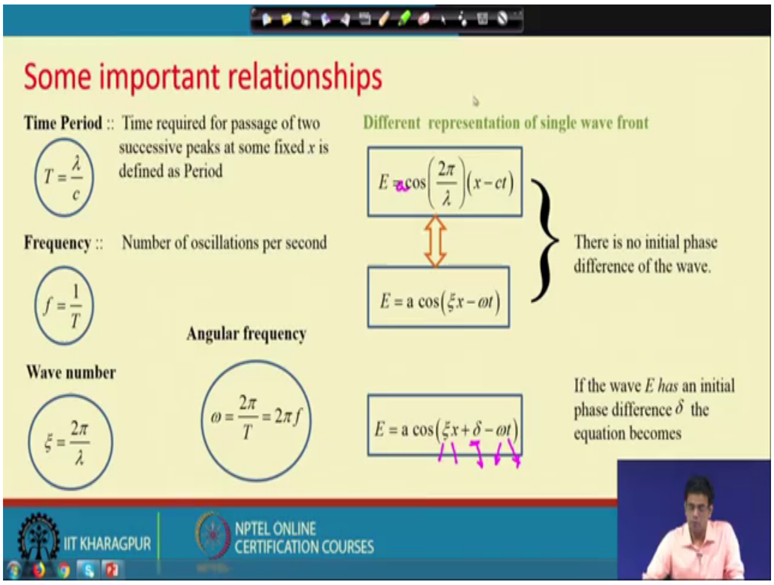

So, we all know it is result from our basic physics knowledge. So, for instance let us discuss some of the relationships that for instance, time period which is lambda by c, you know lambda is the wavelength and c is the speed of light and vacuum and then frequency number of oscillation that, f is 1 by time period. So, angular frequency, we know that is omega 2 pi by T which I can write 2 pi into f, the frequency and the wave number, which is 2 pi by lambda.

So now, different representations of the wave front so, this is the our solution of the wave the equation that we have assumed and this simple harmonic motion can be written in terms of these quantities. So, for instance here, there will be an a. So, a cos 2 pi by lambda x minus c t, I can write in terms of 2 pi by lambda, I can substitute it by wave number psi and then subsequently the angular frequency.

So, finally if there is a phase difference so, if there is initial phase difference so, that will be delta will be there. So, this equation finally, becomes this. So, where a is a magnitude epsilon psi is my wave number x is the propagation direction and delta is the phase difference and omega is my angular frequency and t is my time. So, this is final the solution of the simple harmonic case.

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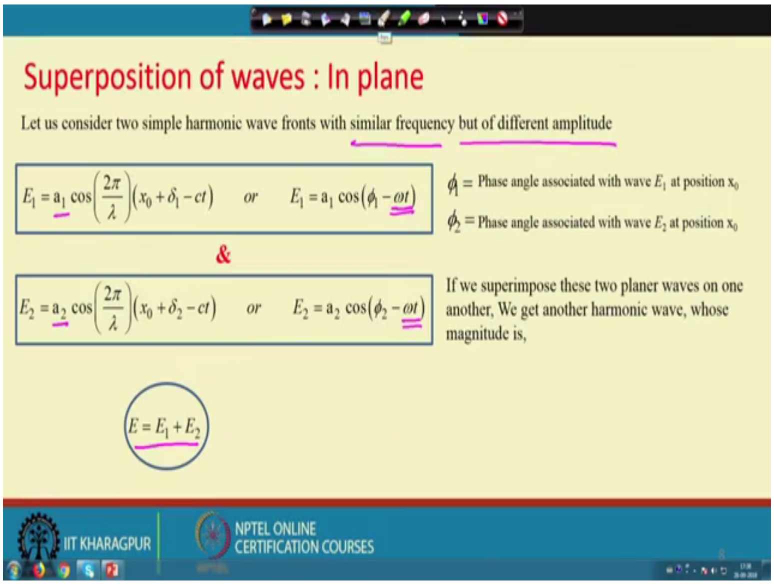

Now, if I want to solve this problem, if I want to consider now 2 such cases where, superposition of 2 plane waves in the plane for instance, if we consider x y plane then, in this plane itself is waves are there. So now, suppose let us consider 2 simple harmonic motion or wave fronts and these wave fronts having similar frequency, but different amplitude. So, this is essentially, a 1 is the amplitude for this E 1 and E 2 is the amplitude for this for the second wave.

Now, x 2 pi by 2 pi lambda x 0 plus delta 1 is the phase for light wave 1 and delta 2 is phase is for second one. So, this i 2 pi by x 0 lambda plus 2 pi delta 1 by lambda I called phase angle associated with E 1 and phi 2 is my phase angle associated with E 2. And then this omega is a frequency angular frequency, which is same for these 2. So, if such 2 waves superpose each if I if we such 2 waves in a plane is so, if I try to superpose this and try to find out the resultant wave then, it is just simply an addition.

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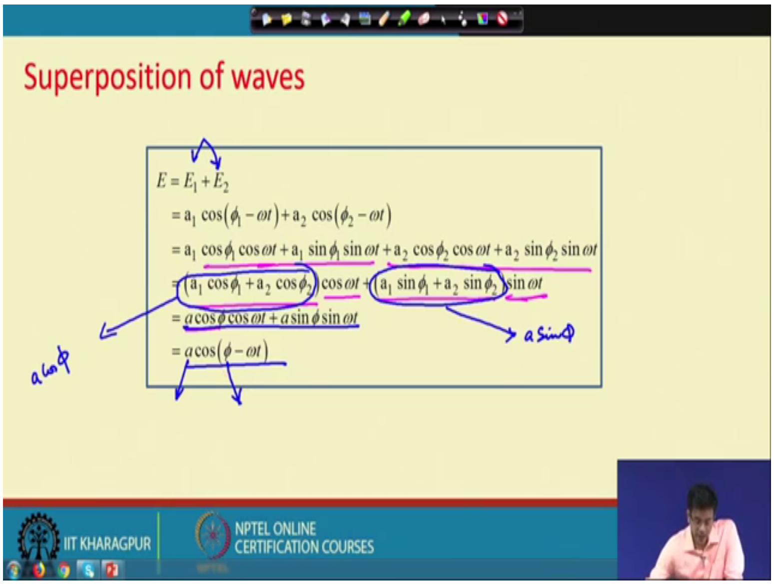

So, this addition will if I now simply add these and see what is the resulting wave. Then we can simply write that a 1 cos phi 1 minus omega t a 2 cos omega phi 2 minus omega. So, if we just expand it in a trigonometric function and these thing, if you just expand it is and then write it in a cos omega t and sin omega t form. So, this becomes a cos phi and this becomes a sin phi. So, what we assume is this quantity and this quantity is essentially, the a cos phi and this is a cos phi and this quantity, this quantity if I assume that a sin phi.

So now, this becomes my a cos phi minus omega t. So, the resultant magnitude is a and phase angle is phase difference is phi. So, this is again you see there are 2 simple harmonic waves. So, the resulting waves I can also say it is a simple harmonic wave.

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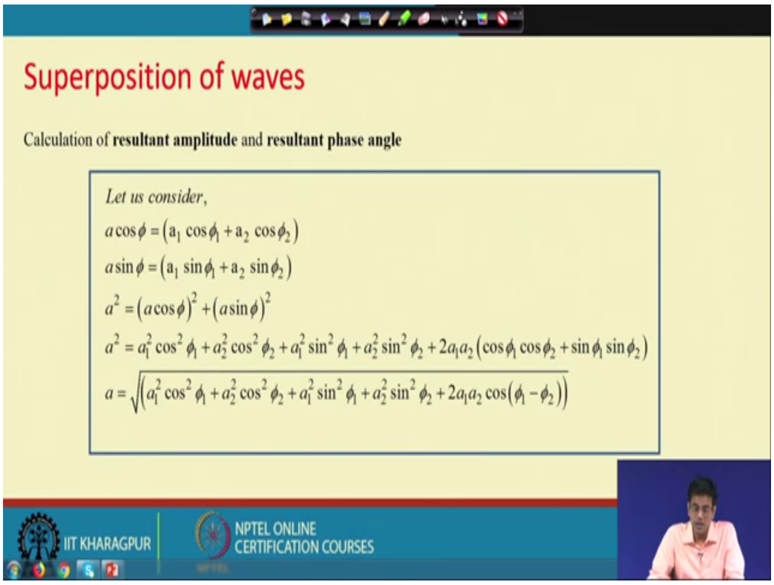

So, we will see this, what a and phi looks like. So, this looks like simple things. So, yes this is the resultant amplitude and resultant phase angle. So, with this I can write that a square is this. So, a square if I now that is the cos square phi sin square phi and then a square can be expressed in this form after some manipulation. So, this form we it is important for us and we will see, when the photo elasticity when we will discuss the photo elasticity.

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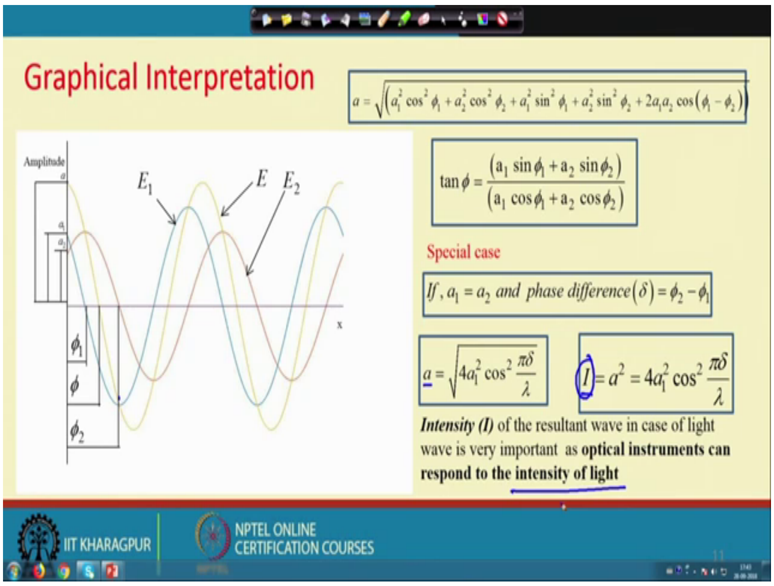

So, this is the magnitude the resultant magnitude and this is the phase difference. So, tan phi is just this. So, we know phi 1 and phi 2 a 1 and a 2 so, we can compute tan phi. And if there is a so, essentially this is the phase difference for phi 1 and phi and this is the phase diffusion for phi 2 that is the second resultant wave a second wave and that is. So, first one is blue one, second one is the brown one and the yellow is the resultant one. So, the resultant one will have the phase difference phi. So, the amplitude we will also be a for the second the resultant one.

Now, in a special case when the phase difference is delta that is phi 2 minus phi 1 I phi, I can consider as delta and a 1 and a 2 is equal then we get the, we get this the magnitude is this and I is the intensity that is square of this magnitude and the resultant I of the resultant wave in case of a light wave is very important as the optical instrument can respond to the intensity of the light. So, when you use an optical instrument then the intensity, there is a term called intensity of the light and this intensity of the light is essentially I and this I is nothing, but a square.

So, this here that is also with that can also be calculated for a 1 and a 2 different and phi 1 and phi 2 are not related case. So, the intensity of light is a very important quantity here and this also leads to the effect of the polariscope, where we design the polar scope based on this theory. So, these in same plane when the light propagates and the resultant way so, it is linear polarization that also we will see when we consider out of plane a superposition of light. So, here I stop today. In the next lecture actually, we will study the out of plane polarization of the resultant light.

Thank you.