welcome to the lecture module on optics ah in the last lecture we discussed about formation of fringes expression for the fringe width and with white light interference in a young double hole or young's double slit experimental arrangement we get linear fringes like this when the path difference delta is much smaller than the path difference in the condition when delta is much smaller than d which is much smaller than capital d under this assumption we have seen that we get linear fringes like this of course this corresponds to two holes which are side by side not up and down that we have discussed if we had the holes up and down then we would get linear fringes in the vertical direction that is x axis along the x axis here the fringes would come like this but if we take the holes side by side then we will get linear fringes like this but if the above condition namely path difference delta much less than d much less than capital d is not satisfied then we get hyperbolic fringes

So i have shown here these are of course computer generated hyperbolic fringes

So we can see that the fringes start curving as you go away from the center

So this is strictly speaking they are hyperbolic fringes

So these are the hyperbolic fringes in young's double slit experiment and as before

So when we have discussed if the two holes were up and down then we will get fringes in this direction

So this is the x direction this is the y direction today we will take it further and we had also seen in the last class that if one of the sources if the source is offset actually offset then there will be a shift in the fringe and today we will take it further and because this fringe shift can be measuring the fringe shift can be used in an important application of determination of the thickness of thin films and therefore we will discuss this a little bit further and proceed

So fringe shift in the two hole interference experiment

So let me recall what we had discussed

So in the last class we discussed that if i had a source s here and if it is offset with respect to the here is the screen and here are the other two slits

So the slits are symmetrically placed about this which reaches o here but the slit was the source s

So these are s one and s two the source s was slightly offset and then we saw that the fringe the central peak would shift to a point o dash here the same thing would happen because we have seen that because of this difference there will be a phase difference between the two sources because the distance from here to here will be different from the distance from here to here consequently there was a phase difference delta phi between the two sources and therefore the fringe would shift the same thing would happen if we had the source s here on the axis here

So this is the source s on the axis and the two slits are slightly offset that is one slit is here and the other slit is here in other words the the line s o is not exactly along the perpendicular bisector or s 1 and s 2 are not symmetrically placed if s 1 and s 2 are not symmetrically placed with respect to this then also we would have a fringe shift and in this case we will see that the fringe would have shifted here because the midpoint between the two slits is here and therefore the fringe would have shifted the central fringe would have shifted to a point o dash which is here

So in both cases we expect a fringe shift now there can be other situations where for example the setup is completely symmetric that is s s 1 and s 2 are symmetrically placed

So let me draw that again

So here is s the source s and is the screen and this is the point o and the two slits are placed symmetrically with respect to this line

So s one and s two now if we introduce a thin sheet for example

So let me show the path

So these are now equidistant and therefore s one and s two are perfectly in phase

So s one and s two are in phase are in phase because it is placed symmetrically about the source s s is the source here

So they are in phase and therefore we would have got the central fringe right at o and fringe variation

So if i show here the fringes

So then i would have got a fringe pattern these are the cos square delta by two type of fringes

So symmetrically on both sides of

So these are the fringes here now suppose we introduce a thin sheet a thin sheet on the

path

So if i show a point p if i take an arbitrary point p here or in this case i have taken it corresponding to the maxima

So if we take this as p then s one p here and s two p this

So this we had designated as r one and r two and the path difference is r two minus r one and if it corresponds to maximum then this would have been an integral multiple of lambda where lambda is the wavelength of the source but now if i introduce a thin sheet of say plastic or glass a thin sheet here of thickness t then what would happen obviously we expect that there is a difference in phase the phase difference r two minus r one is now different because we have introduced a thin sheet of a material whose refractive index is n when the sheet was not there the refractive index is that of air which is almost one and identical but now we have introduced a thin sheet and therefore that will lead to an additional phase difference or an additional phase of del phi or delta phi in this arm the arm s one p and therefore the condition although the condition path difference equal to n lambda is the condition for bright fringes will hold good but the path difference itself will now change because the path that we are talking of is the optical path we will come to this in a minute optical path reference optical path reference he will take into account the refractive index of the medium in addition to the geometric path reference between the two parts it will also take into account the effect of refractive index now the optical path difference will be different from the geometric path difference because here there is another medium which has been introduced

So we will discuss this ah this particular issue in a little bit more detail as i mentioned because this has some important applications

So let us see this carefully a little bit carefully and here lets go first light waves in a medium

So let me slowly go point by point here light waves in a medium

So psi is the the wave is represented by a disturbance psi which is equal to a by r cos k r omega t is a spherical wave we have already seen this and a plane wave psi is equal to a cos k x minus omega t is a plane wave propagating in the x direction we have discussed this now what is k k is equal to 2 pi by lambda where lambda is the wavelength in the medium however in a medium of refractive index n lambda is equal to lambda 0 by n where lambda 0 is the free space wavelength or the wavelength of light in vacuum or free space therefore k is equal to k 0 k 0 is 2 pi by lambda 0 k 0 is 2 pi by lambda 0 into n for example lambda air is equal to lambda 0 by n air however we know that n air is very small it is 1.303 approximately and this is almost equal to lambda 0 lambda 0 is the wavelength of light in free space or vacuum

So normally when we specify that the a source is of wavelength lambda is equal to

So much 600 nanometer or 500 nanometer then we refer to the wavelength in free space that is lambda 0 whenever the wavelength of a source is specified it is in free space or it is lambda 0. therefore if it is entering a medium then the corresponding lambda will have to be taken into account or the corresponding phase constant 2 pi by lambda k is equal to 2 pi by lambda has to be taken into account

So that is what we are discussing here and therefore lambda air we consider as nearly equal to lambda 0 in other words k air k the phase constant 2 pi by lambda in air is assumed to be equal to k 0 which is the free space phase constant 2 pi by lambda 0 however k in a medium therefore will have 2 pi by lambda 0 divided by n because 2 pi by lambda that is 2 pi by lambda 0 by n and that will be k 0 times n k in the medium will be k 0 times n and therefore with this keeping this in mind we dis we determine the path difference and hence the phase difference between the two paths due to an introduction due to the introduction of a thin sheet in one of the paths

So here it is a thin sheet in front of s one

So the diagram is shown here

So let us first see the diagram the source the two slits and they are symmetrically placed

So the normal geometric path difference here would be zero at o and the geometric path difference will be r 2 minus r 1 as if it were of the same medium but now a thin sheet of thickness t t is the thickness of the sheet and n is the refractive index has been introduced in front of one of the sources one of the sources here s one this could be introduced on this side or this side it could be introduced on any side

So we can we have introduced this here in front of the source s one d is the separation between the double slit and the screen

So the phase difference at the point p at the at the arbitrary point phase difference is delta is equal to first in air what is the path difference the path difference is k 0 into r 2 minus r 1 minus t r 1 was the path in air earlier but once the sheet has been introduced r 1 minus t is the path in air therefore the phase difference is k 0 into path difference in air minus k 0 into n that is k into thickness of the sheet
So k 0 into actually this is r 1 plus
So k 0 r 1 plus
So k 0 into r 1 minus t plus k 0 into n t therefore the phase difference is k 0 r 2 minus all of this that is why we have minus here
So minus r 1 minus t in air and minus k times t because of this
So that is the phase difference in other words we can write it as k 0 into r 2 minus r 1 r 2 minus r 1 is the geometric path reference r two minus r one plus k zero t into one minus n where n is the refractive index of the medium
So this term is like del phi delta phi that we had introduced earlier that a path an additional phase difference of delta phi is exactly like that there is a phase difference of delta pi phi t is a constant for the given film refractive index is a constant and k 0 is constant for a given source and therefore this is like an additional constant phase difference and immediately we expect that the fringes should shift if there is a constant phase difference introduced
So lets see what is the shift in this fringe
So i take it further therefore delta is equal to k 0 into r 2 minus r 1 plus t times 1 minus n
So this k 0 has been taken out t times 1 minus n and this phase difference must be equal to plus minus an integral multiple now i have used capital n earlier i have used a small n but now small n we are using for refractive index therefore i have used capital n which is nothing but an integer 0 1 2 3 etcetera plus minus n times 2 pi for bright fringes in other words if we write this as 2 pi by lambda zero then what we have is two pi two pi cancels on both sides and we have r two minus r one plus t times one minus n is equal to plus minus n lambda zero when is the order of the fringe
So for the central fringe or the zeroth order fringe this is equal to zero and what we have is r two minus r one equal to t times n one minus one ah this is taken to the other side therefore t times we have enter g in this n minus one
So this will give us the condition for the bright fringes in the presence of the sheet and what is the fringe shift that we will have due to the introduction of the sheet
So here i am writing for the central fringe again
So let us look at this for the central fringe therefore r 2 minus r 1 is equal to t times n minus one r two minus r one the geometrical difference r two minus r one we have already calculated ah if this is x if the position is x and if d is this and the separation between s one and s two e small d in the last lecture we had calculated that that path difference is x by d into d which is equal to t times n minus 1 or x is equal to d by d into t times n minus 1.
So this x is the position because this is the condition for central fringe and therefore this x is the position where the central fringe will appear if the sheet were not there x would have been 0 and the central fringe would have appeared at the point o here but because of the introduction of the sheet the central fringe would now appear at a point such that x is equal to d by d into t times n minus 1.
So x not equal to 0 now because of this represents if there is you can see here either if n goes to 1 that is if the refractive index becomes same as air then x will be 0 or if t goes to 0 that is if the sheet does not exist again x will become zero that is clearly seen here and represents the fringe shift in the presence of a thin sheet of thickness t let us take an example and see what kind of numbers we have here
So here is an example
So i have taken t is equal to 10 micrometer is a thin sheet and n is equal to why this has to be thin because the it depends on the wavelength of the source wavelength of light is typically of the order of 1 micrometer or 0.5 micrometer for visible light and therefore this t should be typically of the order of wavelength or few times the wavelength
So that a few fringes are shifted if we take a thick sheet here then the number of fringes shifted will be very large and it also breaks down certain approximations involved and therefore example here t is equal to 10 micrometer refractive index is 1.5 d that is the separation distance between s 1 and s 2 the 2 sources is 1 millimeter typical

number which we had taken in the last class last lecture and d is equal to 1 meter that is the source is at a distance of 1 meter and separation between this is small d we use the same notation which is about one millimeter

So if we calculate the fringe shift then we get one meter into ten micrometer into point five

So here is this is one point five minus one one point five minus one is point five divided by d one millimeter

So which is ten power minus three meter that comes out to be five into ten power minus three meters or equal to five millimeter

So the fringe the central fringe is shifted by five millimeter the shift note that the shift in the central fringe is independent of the wavelength of light the shift which is shown here does not contain the wavelength of light anywhere

So it is independent of the wavelength of light therefore how one can determine this

So note that if the shift is experimentally determined then we can determine the thickness t of the given sheet an unknown a sheet of unknown thickness particularly this very important when the thickness is very very small like few micron when we have sheets which are thick we can use normal instruments like screw gauge or one of the thickness measurement devices but when the thickness becomes very small a few micron then this is one of the nice way of determining the thickness of thin films there are other techniques which are available but this is one of the ways by which you can determine the thickness of a thin film and therefore we see that the thickness the shift is independent of the wavelength and therefore we can immediately use white light to determine the shift of the central fringe

So we have already discussed the what happens when we use white light for formation of fringes and white light can be used to determine the shift and hence the thickness of the material if you know the thickness and if you can measure the shift then one can determine the refractive index of the film if we did not know the refractive index of the film but we knew the thickness then by measuring the fringe shift we can determine the refractive index very accurately the refractive index of the film two important applications

So let us see one by one

So here is the

So first to determine the wavelength lambda of a monochromatic source by measuring the fringe width we have worked out this formula that lambda is equal to beta into d by d where beta is the fringe width d is the separation between the two holes and d is the distance to the screen and by measuring the fringe width one can determine the wavelength of a monochromatic source if lambda is unknown the second important application is to determine the thickness t of a thin transparent sheet by measuring the print shift delta x

So we have derived this expression that t is equal to delta x divided by n minus 1 into d by d n here is the refractive index and delta x is the fringe shift d is as before separation between the two holes and d is the distance to the screen before i proceed i want to before i wind up and take up some examples i want to discuss one important issue that is whether it is a double hole experiment or a double slit experiment as we had discussed earlier that young's original experiment in young's first experiment he had used double hole a first hole followed by a double hole where the double hole was placed symmetrically along the line linking the single hole to the screen and he determined the he obtained linear fringes we have already seen that the locus of constant part difference are straight lines which are which form linear fringes now what would happen

So let let us look at the lets look at the experimental arrangement again

So here i am trying to draw it in three d

So that ah

So here is the axis are shown this

So this is our x axis and this is the y axis in each plane

So is the first plane and then let me draw the time to i am trying to show it in three d and

So here it is the second plane where we have the source the two sources

So here is the center point and the two sources are located let me draw the axis first

So here are the axis x axis and y axis of course at a different

So this is the propagation direction is the z direction we have taken this as the x axis and this as the y x and in different planes and the screen is located here

So here is the screen and as before x axis and y axis
So this is our point o the point o is here at the intersect now we had the two sources i will show by red here
So we had the first source here s
So there is a small pinhole
So this is s and here we had placed symmetrically about the y axis two sources s one and s two
So s one here and s two here
So s one s two this is s one and this is s two and then on the screen at a distance d
So at a distance d
So this is the separation d we had seen that this gives us a bright fringe here parallel to the y axis and then we have fringes which are parallel to the y axis fringes are formed parallel to the y axis
So fringes are formed parallel to the y axis because of the two sources if the two sources are placed symmetrically this distance is the same as this distance therefore s one and s two will be in phase and from s one to o s one o and s two o will also be identical therefore this is the central fringe the path difference is zero here and we have path differences whenever the path difference is n lambda that is this the first fringe is formed when the path difference s one to this point to s two to that point is lambda when it becomes two times lambda we have the second bright ring and in between of course we have the dark fringes now suppose we have two more points which are here i am showing two points which are separated by the same d
So let me draw the two lines parallel to the y axis here the separation between them is d between these two lines
So if i have one pin hole here and a second pin hole here symmetrically placed about this or with the same separation d now again the pin hole here that is let me call this as s 2 dash
So s 2 dash and s 1 dash these are also equidistant from s and therefore the sources will be in phase here and because these are symmetric about this line then we would also have this point equidistant s 1 to o s 1 dash to o is equal to s 2 dash 2 o and
So on and therefore because of these two points we would get again the same fringe pattern or the fringe patterns are superposed because of this as well as this that is because these two sources are in phase these two sources are also in phase although there will be a constant phase difference between these two because of their distances but they will be in phase here and therefore we get the same fringe pattern if i had another two points which are here on the same line with the separation of d we will again get the same fringes here and therefore if i have a large number of points here a large number of points which are symmetrically placed about this y axis with the same separation of d the fringes due to all these pairs of points will be the same they will be exactly superposed one over the another wherever right fringe due to one pair is there bright fringe due to another pair would also be there and in the limit if we the the pin holes are continuous what we will have is a slit
So we will have one slit here and a second slit here and we will have the same fringe pattern but with the difference now
So i want to give a title as double hole
So double hole versus double slit double slit in the youngs interference arrangement
So if we have two slits here the only good thing is that the amount of light which is now entering through the two slits is much higher than that which would have entered because of only two holes and therefore the fringes will be bright in this case
So the fringes will be brighter if we go for a double state fringes will be brighter brighter in this case of double slit otherwise we will have the same fringe pattern we will have the same fringe separation same fringe width
So long as d is the same wavelength is the same and capital d is the same if we now extend the same argument and if we have instead of one pin hole here if we have a pin hole here then this would that any pair of points on this line here which are on the vertical line here any pair of points will have the same will be in phase because of this source and
So on and we will get again the same fringe pattern if we have a number of pin holes here and consequently we will instead of having a large number of pin holes we could as well have a slit here if we have a slit here now the wave front which is coming out will not be spherical but cylindrical wave fronts will come

So if i can show here if i have a slit instead of a single point source s then the wave fronts which come out here will be in the form of let me show the blue color they will be in the form of a cylinder

So this is on the plane

So cylindrical waves if you have a long slit then this is a cylindrical wave which is coming out

So what we get if i if we have a horizontal slit like this or if we have a vertical slit like this then we will have cylindrical waves which are coming

So the wave front will be cylindrical because of the long slit that if we have two more slits which are parallel to this and which are symmetrically placed we will get the same fringe pattern again the added advantage being we have now much more light intensity available for formation of the fringes and therefore all the experiments which are being done subsequently are all by using double slits rather than two holes because in two holes the intensity of the fringes is very low and therefore the double seat now it is known as young's double slit experiment

So we see that we get the same fringe pattern and all conclusions fringe width all expression would remain the same whether it is a double hole experiment or a double slit experiment thus in the final arrangement for the youngs double slit experiment we have the youngs double slit experiment arrangement looks like this

So we have an extended source usually a sodium lamp here extended source extended monochromatic source which is followed by the slit an arrow slit here which is followed by two slits here and then we have the interference fringes formed on the screen

So if the slits are like this we see the interference fringes parallel to it

So the intensity of course is maximum near the central region and the intensity decreases to the sides as we go

So we can recall and we just see even in the computer generated slide here you can see that the intensity is maximum here and the intensity decreases to the sides

So this is the kind of fringes which are observed in a young's double slit experiment and if we measure the fringe width here and measure the distance d and the separation d here then wavelength of light can be determined by the expression lambda is equal to beta d by d in practice there are other there are different ways of getting this double slit there may not be physically a double slit sometimes they use a byprism ah to generate two vertical to virtual slits here and get the same fringe pattern as before we will now discuss some problems that gives a better feel for the understanding

So let me take the first exercise here

So this is from the textbook and lets see the problem in a young's double slit experiment the slits are separated by 0.28 millimeter and the screen is placed 1.4 meter away distance between the central bright fringe and the fourth bright fringe is 1.2 centimeter determine the wavelength of light used in the experiment the last the diagram that i have showed the final diagram that i have showed gives you a good picture about the young's double slit experiment you can see when we refer to the distance between the slits it is d here separation between the slits and the fringes are formed here

So the central fringe is here and then we have first fringe second frame third fourth maxima on this side and similarly the first maxima second maxima third maxima on the other side

So this picture if should be kept in mind in solving all these problems

So let me repeat again in a youngs double slit experiment the slits are separated by 0.2 mm that is s1 and s2 separated by 0.28 mm and the screen is placed at 1.4 meters away from the slits distance between the central bright fringe and the fourth bright fringe is given as 1.2 centimeter determine the wavelength of light used in the experiment let us work this out

So we see in a young's double slit experiment

So here is the example or exercise in a young's double slit experiment we have arrangement the slits are separated by

So the slits here are separated by this separation is given as point two eight millimeters point two eight millimeters and the screen is placed the screen is here placed at a separation of one point four meters we had taken typical number of about one meter

So d is given as one point four meters

So this is the point o where the path difference will be zero

So the question says further data the distance between the central fringe and the fourth

fringe is one point two centimeters
So just to recall we know that there are fringes which are formed here central fringe will be a maxima will be a maximum which is followed by like this
So there is a cos square delta by 2 fringes which are
So what is given is the distance between the central fringe and the fourth maxima that is one two three and four
So zeroth one two three four the fourth fringe here is given to be one point two centimeter this distance is given as one point two centimeter determine the wavelength of light
So lambda equal to how much this is how we the given data is now reflecting and we need to determine what is the wavelength of light
So as we can see peak to peak separation is one fringe width
So two three and four
So what is given in this data is four beta is equal to one point two centimeter or beta is equal to 0.3 centimeter and lambda is equal to beta into d by d
So we have all the information that is required
So we have this equal to point three centimeter multiplied by point two eight millimeter
So this is point zero point two eight millimeter
So zero point zero two eight centimeter i am writing everything in centimeter divided by one point four meter
So this is one thousand
So one point four hundred and forty centimeters here
So one point four meter which is hundred and forty
So this i can write as straight away we can write this as twenty eight into ten power minus three or two hundred and eighty
So this is equal to two hundred eighty into ten power minus four into point three divided by one forty
So everything in centimeters
So one forty goes twice
So we have two into
So we have point six into ten power minus four centimeters this is nothing but 10 power minus 4 centimeter is micrometer
So this is equal to 0.6 micrometer or equal to 600 nanometer
So that's the answer
So the wavelength of light lambda is equal to 600 nanometers quite a simple experiment example and only one need to identify the given data and we can obtain the wavelength of light let us now take another problem a different problem
So in a youngs double slit experiment using monochromatic light of wavelength lambda the intensity of light at a point on the screen where path difference is lambda is k units this is given what is the intensity of light at a point where the path difference is lambda by 3 obviously there are no numbers involved therefore the intensity should be expressed in units of k
So let us read again in a young's double slit experiment using monochromatic light of wavelength lambda the intensity of light at a point on the screen where the path difference is lambda which means it is referring to the first bright fringe is k units what is the intensity of light at a point where the path difference is lambda by 3 that is less than lambda which means somewhere between the central bright fringe and the first bright fringe we are asked to find out the intensity of light let me take one more example
So one more example again from the book
So in a young's double slit experiment now in a young's double slit experiment what is said is monochromatic wavelength lambda is used and the intensity at a point
So lets draw the moment the question says young's double slit experiment its first always better to draw the arrangement
So this is here o and we know that the fringe system is here the sinusoidal cos square delta fringe systems
So the intensity variation is given by i is equal to four times i zero assuming that these are i zero four times as each one of them is of the same ah slot ah the amplitudes are equal then we have seen that i is equal to cos square delta by two
So this is cos square delta by two where delta is the phase difference delta is equal to k zero into path difference k zero into path difference now the question is it says the

intensity of light at a point on the screen where the path difference is lambda which means we know that here at this point path difference is 0 and at this point path difference is lambda that is the first bright fringe where the path difference is lambda is k the intensity i is equal to k at a point where the path difference is lambda which means the maximum value is k the maximum value is four times i zero

So this value is given to be k we need not write it as four times i zero

So it is given as this maxi i max is k when path difference is lambda

So delta is this is lambda and therefore delta is equal to two pi by lambda zero into path difference lambda

So these cancel and delta is equal to two pi

So obviously we have cos square cos delta by two is equal to ah minus one and cos square is one

So maximum is four i zero the question is what is the intensity of light at a point where the path difference is lambda by three

So here path difference is 0 here path difference is lambda with at some point the path difference is lambda by 3

So if path difference is lambda by 3 i is equal to what is i when path difference is lambda by 3 path difference is equal to lambda by 3 this is the question path reference is equal to lambda by 3

So we already have delta is equal to k 0 into path reference substitute for path difference lambda by 3 and determine the intensity therefore let me do it right here

So therefore delta is equal to k zero that is two pi by lambda into path difference which is lambda by three which is given

So lambda by three

So we have two pi by three and delta by two is equal to pi by three that is sixty degrees and therefore cos delta by two is half cos square delta by two is one fourth and therefore we have the maxima

So intensity i is equal to i max i max into cos square delta by two

So we have seen that delta by two is sixty and therefore cos square delta by two is one fourth

So this is equal to i max into one four i max is already given to be k and therefore this is equal to k by four

So this is a second example

So example two both examples i have picked up from the textbook there are large number of examples which are possible

So which can be taken we now take another problem exercise three

So let me read again in a youngs double slit experiment the light source used was emitting two distinct wavelengths of 440 nanometer which is actually in the blue region and 660 nanometer which is in the red region

So we call this as the blue wavelength and this as the red wavelength actually as we have discussed there is no single wavelength which is assigned to a color blue does not mean 440 blue could be 450 also 450 nanometer 430 nanometer will also look like blue

So here they have given two specific wavelengths 440 nanometer and 616 nanometer there are only two wavelengths in the source the 440 we call as blue and the 660 we call as red now the interference fringe pattern on a screen placed at a distance d is equal to 90 centimeter showed two bright red fringes on either side of the central bright fringe if the separation between the two slits of the double slit aperture of the double slit aperture is 0.3 mm what is the separation between the two bright red fringes let us try to understand this this problem that is what is given is we have at a distance d is equal to 90 centimeters you see the central fringe

So let me use all right the central fringe the central fringe will have blue as well as red both at the same place blue and red at the same place because we know that the path difference is zero

So this is the point o x is equal to zero

So this is the central fringe now what is given in the problem is that a red fringe a red bright red fringe is seen at a point on this side as well as on the other side

So what is the separation between these two

So this is the question

So separation between these two this is the central bright frame central bright fringe of course will be a mixture of red and blue color but it is given that at a certain point x1 here we see only the red fringe on this side bright red frame as well as a bright red

fringe on the other side and what is the separation between these two now let us keep a couple of points in mind here and try to understand what is being discussed
So here
So let us see this recall that at x is equal to 0
So i am discussing now the solution at x is equal to 0 both colors will satisfy the condition for maxima as path difference is 0 implies there is a bright fringe due to red color as well as due to blue color the second thing is we will see a bright red fringe at any point x if the red color satisfies the condition for maxima namely path difference at x must be equal to an integral multiple times n into lambda red wavelength of the red light and the blue color should satisfy the condition for minima namely path difference at x must be equal to m plus half times lambda blue
So both the conditions have to be satisfied simultaneously now in the problem
So if we see in the problem the wavelength given is 440 nanometer and 660 nanometer for blue and red now note that the lambda red 660 nanometer is one and a half times lambda blue one plus half times lambda blue and therefore if we put n is equal to 1 and m is equal to 1 the condition is satisfied automatically if you put n is equal to 1 then path difference at x is equal to lambda red if you put m is equal to 1 because m and n are take integer values if you put m is equal to 1 this will be 1 plus half that is one and a half times lambda blue and indeed it satisfies the requirement that the path difference this is equal to this
So therefore we have
So this is like this is like the situation that we had discussed earlier in the previous lecture we had discussed that lambda red 600 orange color i had taken 600 nanometer and for the blue i had taken 400 nanometer and we had seen how the fin systems form
So therefore the problem is
So now let me show you the problem
So the problem here is i have shown only the two colors see this
So at x is equal to 0 the central maxima blue and red both of them are coinciding therefore this will be a bright fringe but a mixture of blue and red whereas the blue color because lambda is one lambda red is one and a half times lambda blue blue will satisfy the condition for minima but the red will satisfy condition for maxima
So we will see a red bright fringe here and a red bright fringe here and the question is to determine what is the separation between these two
So we are asked to find out this separation s this is the separation between us to is to be determined in the problem therefore let us calculate x 1
So the separation x 1 is given by d by d into lambda red we have already seen this this is x one is the first maxima due to red color is given by one standing for the first maxima this is n equal to zero maxima central maxima n equal to one maxima and therefore x here x one is given by this and x minus one that is on the other side is given by minus of d by d into lambda red and the separation therefore x 1 minus minus minus x of minus 1 order that is this side will give you 2 times x and 2 times x 1 that is d by d into lambda red and if we substitute the numbers 2 into it was given 90 centimeters
So lets look back at the problem here now the interference fringe pattern on a screen placed at a distance d equal to 90 centimeters
So d is here 90 centimeters showed two bright red fringes on either side of the central bright fringe if the separation between the two slits of the double slit is 0.3 mm that is small d is 0.3 mm what is the separation between the bright fringes
So here we are
So 2 into 90 centimeter is converted into 900 millimeters 0.3 millimeters and 660 nanometers
So we get 3.96 millimeter the separation between the two bright red fringes is three point nine six millimeters let us take one more example go with a different concept
So here we have in a young double slit experiment in a young's double slit arrangement with the monochromatic light source the separation between the two slits is 0.5 mm and the screen is placed at a distance of one meter
So we have already identified that small d is point five mm and capital d is one meter that is hundred centimeter or thousand millimeter when a thin transparent plastic of refractive index n is equal to 1.5 a plastic sheet is placed over one of the slits the fringe pattern is shifted to one side through a distance of 5 centimeters
So the fringe shift is 5 centimeters what is the thickness of the sheet
So let us work this out

So let us work out this and recall
So let me work it out here
So exercise four we recall that we have derived an expression t into n minus 1 is equal to the fringe shift i call it by delta x into d by capital t here this expression we have derived it is quite straightforward basically this is the additional
So this is additional path difference additional optical path reference additional optical path difference optical path difference because the film has a thickness t refractive index n therefore the additional path difference will be equal to n minus one one is the refractive index of air that is if the film were not there difference due to the film due to the sheet due to the sheet will be equal to fringe shift into d by d fringe shift into d by d how did we get this we know this that we have derived that the path difference r 2 minus r 1 is equal to path difference at a point x is equal to x into d by d we have derived this expression path difference is equal to x into t by d path difference at a point p whose coordinate is x is d x into d by d now if you have an additional path difference namely add the additional path difference here t into n minus 1 then because of the additional optical path difference x will shift the position x will shift such that this will be equal to x plus delta x i call this as delta x into d by d and therefore this term additional path difference is equal to delta x into d by d
So basically total path difference will be equal to geometric path difference r 2 minus r 1 plus additional path difference due to the sheet of refractive index n will be equal to an additional position shift fringe shift delta x into d by d that's why therefore this term is equal to this term
So that is how we have got this expression
So we have to calculate the we have been asked to calculate the thickness of the film and therefore the thickness of the film t is equal to delta x that is fin shift divided by n minus 1 into d divided by d
So all the parameters are given we look at the problem again the two slits small d is 0.5 mm
So let me write here d is equal to 0.5 mm capital d is equal to 1 meter
So 1000 mm
So 1000 millimeter and n is given n is given as 1.5 delta x the fringe pattern shifts through 5 centimeters
So 50 mm let me write everything in 50 mm 5 centimeters
So 50 mm therefore t is equal to we are asked to determine the thickness of the sheet
So this is equal to 0.5 divided by 1.5 minus 1 which is again 0.5 into d small d 0.5 mm sorry delta x is
So this is point five ok let me let me rewrite this again
So this point five is d
So this is d small d this is n minus 1 delta x is here 50 mm
So 50 mm and capital d is 1000 mm
So this is everything is in mm therefore
So many m because this is point five m m
So we can see that this is point five point five point five and we have 50 divided by 1000 mm
So this is equal to 5 into or 50 into 10 to the power of minus 3 mm which is equal to 50 micrometers 50 micrometers
So the answer is 50 micrometers
So we have seen four different examples here one to determine the wavelength and the second problem was related to the intensity distribution in the interference pattern the third problem was related to the wavelength if there are two wavelengths how would the fringe system look like and the fourth one is to the application to determine the thickness of a transparent sheet
So through these examples and our discussion on the young's double slit interference we have tried to bring in various aspects of interference phenomena the phenomena of interference next we will consider diffraction and discuss the various aspects of diffraction thanks you