welcome to the lecture module on optics in the last two lectures we have been discussing about the young's interference experiment we will take it a bit forward and today we will continue and see interference with coherent and incoherent sources

So the topic of today's talk is interference with coherent and incoherent waves we will quickly recall what we have studied in the last lectures

So we quickly recall that youngs in youngs experiment we have a source s here passing through a aperture here which is a small hole and there are two more apertures s one and s two here and the waves which are emanated from s one and s two interfere on a screen which is here depending on the path reference that is r 2 minus r 1 we may have interference maxima and minima we have discussed this in detail

So s 1 and s 2 are point sources drawn from the same wave front please see there is a point source here and these two are drawn from the same wave front these blue curved circles represent the wave front here and as you can see the wave front reaches s 1 and s 2 simultaneously and s 1 and s 2 are drawn from the same wave front that means they are from the same phase front or s 1 and s 2 are in phase in phase means with the phase term here cos omega t without loss of generality if i assume that this is x equal to 0 this is z equal to 0 then we have a 1 cos omega t and psi 2 is equal to a 2 cos omega t the phase term is the same they are in phase now we see that we recall the conditions for bright and dark rings that we have already derived in detail the conditions for bright and dark rings at the point p here psi one is equal to a one cos k r one minus omega t r 1 is this distance and psi 2 that is disturbance due to the second source s 2 is a 2 cos k r 2 minus omega t and delta therefore is the phase difference this is the phase term phase term

So the difference between them is simply k times r 2 minus r 1 and r 2 minus r 1 is the path difference we have also seen that whenever r 2 minus r 1 is equal to plus minus n lambda where n is an integer it is the condition for bright fringes at points p where r 2 minus r 1 is an integral multiple of the wavelength then that condition is that point would be bright and whenever it is n plus half times lambda then we have the condition for dark fringes where n is equal to 0 1 2 and

So on the plus sign here represents the fringes the maximas and minimas on one side and minus sign represents maximas and minimas on the other side at the point o where r 1 0 i have shown it as r 1 0 and r 2 0 are identical because this is a perpendicular bisector of s 1 and s 2 and therefore r 1 0 is equal to r 2 0 the path difference is 0 and that corresponds to a maxima which is called the zeroth order bright fringe we have discussed all this detail in detail in the previous lecture

So we now look at a different situation slightly different situation where the source s has a finite offset

So here is the new discussion that we want to make that the point the source s if the source s here

So let us look at the diagram first

So if the source s has a small offset it is not along this line here instead the source s now i am calling it as s dash as dash as a small offset it is a little bit upward here and then obviously we see that the distance as dash s1 and s dash s2 will be different because there is an offset in terms of the wave front what we note is that when the wave front look at the blue wave front here and the blue wave front reaches this plane the plane containing the apertures s 1 and s 2 we see that the wave front has reached the point s 1 but it has not reached the point s 2 the blue one

So the wave front has not reached the point s 2 it will reach the point s 2 at a later time

So the wave front here has reached s 1 but it has not reached it it will reach s 2 at a later time it means the wave front here is lagging it is lagging in phase at a later time it will reach here and therefore there is a initial phase difference of delta phi del phi here between delta phi between the sources s one and s two please see that the wave front would reach here at a later time which means let me explain this

So which means if i had cos omega t as the initial phase then we will get the same wave front at s two this is at s one at s one i have dropped the amplitude at s two the same wave front will come at a later time or when i have a phase term cos omega t s s 1 we have the phase at s 2 will be cos omega into t minus delta t that is at that instant on the plane here one wave front the wave front has reached here at the point but at the second point here it has not reached now i have expanded enlarged it a little bit

So this will this is behind or at this instant at a particular instant when this is in

phase the phase front of the earlier travelled wave would be like this in other words this phase front will reach here at a later time or at a given instant the phase at s1 and s2 are related by this in other words we have the phase as s 2 as omega t minus omega times delta t and this one i am calling as delta phi and therefore the phase difference between the two s 1 and s 2 will be equal to omega t minus omega t here

So phase difference

So omega t omega t will cancel

So we have omega t minus delta phi delta phi is this phase lag

So this is delta phi and therefore we have delta phi that is why i have this term here that i have shown that this the second wave has k r 2 minus omega t plus delta phi there is a phase lag which is delta phi

So delta phi is the initial phase difference it is the initial phase difference between the two waves its also shown here in a different way the blue wave front as we can see it has at this point the blue wave front has reached the red wave front will come at a later time although i have shown it in front blue has passed by and the red wave front has reached here and therefore the red wave front is behind the blue one and there is a phase lag of delta phi the phase lag is the same delta phi here and therefore the net phase difference is now not just k r 2 minus k r 1 but also there is a phase difference of delta phi all of this is because s dash is offset here therefore this propagation distance is different from this property this is smaller compared to this and therefore at the point o now therefore at the point o r one is equal to r two

So this distance is the same r one is equal to r two but delta is not equal to zero at the point o r two is equal to r one here but delta phi remains and therefore at the point o delta is not equal to zero if delta is not equal to zero we will not have the zeroth order bright fringe here delta may be zero somewhere else the phase difference may be 0 somewhere else and therefore the 0th order bright fringe will not appear at o because there is a phase difference at o let us look at this a bit more carefully

So let me put the condition for bright and dark fringes again here

So let us see at the point p at a general point p we know that psi one is equal to a one cos k r one minus omega t and psi two is equal to a two k r two cos omega t that is this i am showing only this and delta is the phase difference k r 2 minus k r 1 and r 2 minus r 1 is the path difference we have already seen this in detail and r 2 minus r 1 is equal to plus minus n lambda is the condition for bright fringe and the condition for dark fringe here

So this we have already seen now with the delta not equal to 0

So let me show this slide now

So this slide we have seen and i have shown that there is a finite delta phi here and at this point delta is not equal to zero

So let me keep let me take this here therefore for delta is equal to 0 k into r 2 minus r 1 is equal to minus delta phi please see that for this to be 0 this will be equal to minus delta that is what i have written which means r two must be less than r one and therefore i have shown a point o dash here where r two is less than r one and at this point o dash the point o dash is such that s dash s 1 plus s 1 o dash that is the total path here path length is equal to s dash s 1 plus s 1 o dash if it is equal to s dash s two plus s two o dash then we have path difference is such that delta phase difference is equal to zero

So the position of the zeroth order maxima or the central fringe will be shifted to a new position which is o dash therefore the condition for maxima is delta is equal to k r 2 minus r 1 plus delta phi is equal to plus minus n 2 pi n times 2 pi or r 2 minus r 1 is equal to the path reference which is equal to i have taken the delta phi to the other side and we have divided by k everywhere and therefore k is 2 pi by lambda therefore lambda by 2 pi is here

So we have divided by k

So n times 2 pi divided by k minus delta phi divided by k we have taken this and therefore we have the new condition now that the path difference r 2 minus r 1 r 2 minus r 1 is equal to n lambda minus delta phi by 2 pi into lambda for the nth maxima there is an extra term now because of the finite delta phi please see that if delta phi is equal to 0 that is if this were on the perpendicular bisector here the original position s then we would have had delta phi is equal to 0 and the condition remains as path difference is equal to n lambda now there is an extra term which depends on the phase difference what is the effect of this on the fringe weight let us see the effect of this on the fringe

width
So for the nth bright fringe here
So lets look at this lets look at the for the nth bright ring if delta phi is a constant then path difference r 2 minus r 1.
So this difference we have already calculated in terms of the x coordinate there
So it is x n dash d by d for the nth fringe the nth fringe if n x n is the coordinate x n dash i have written x n dash just to distinguish that now we are dealing with a case where there is a finite delta phi that's all otherwise it is the same x n as before
So for the nth fringe the condition we had earlier derived was x n d by d equal to n lambda now because the position of the nth maxima has changed i am calling it as x n dash
So that is equal to n lambda minus c where c is that constant that is delta phi by 2 pi into lambda
So please see that we had n lambda minus this this constant i am calling as c if delta phi is a constant constant with time then this is a constant c and therefore n lambda minus c where c is a constant for the n plus one fringe that is for the next ring it will be x n plus one d by d is equal to n plus lambda minus c because c is a constant
So dash is only to represent the next the case where we there is a finite delta phi it is not derivative or anything and therefore therefore the fringe width beta is equal to x n plus 1 dash minus x n dash
So from 2 and 1 if we subtract this then we have d by d into n plus 1 lambda minus c minus n lambda plus c which is equal to this is the fringe width which is equal to d by d into lambda as before i have written here as before as before means the case when there was no phase shift no initial phase shift that is the case when the source s was on the perpendicular bisector there is no change in the fringe width even if there is a offset in the source but the fringe pattern is shifted the fringes are shifted the fringe width remains same which means the fringe pattern is shifted for example if we have all linear fringes bright dark bright dark the entire pattern is shifted otherwise it looks identical now that is the fringe there is a fringe shift each fringe is shifted but no change in beta
So what does this mean let us calculate this first what is the fringe shift beta in terms of the geometry
So let me calculate the fringe shift therefore the fringe shift here the fringe shift is given by x n dash is the new position of the nth order bright fringe in the presence of a constant phase difference delta phi between s1 and s2
So x n dash by d is equal to this condition remember that x n into d by d was equal to n lambda when there was no phase shift when there was no delta phi or delta phi was equal to zero therefore for n lambda i am substituting x n d by d the original position of the nth bright fringe now the nth bright fin has changed to a new position x n dash but the original position x n is here and then this into d by d is n lambda therefore we have written replace this by this minus c which means if i take the x n to the other side x n minus x n dash that is the fringe shift that the shift of the nth fringe x n minus x n dash by d is equal to c the constant which is equal to delta phi by 2 pi into lambda or the fringe shift delta x n this is the fringe shift delta x n is equal to delta phi by 2 pi into lambda d by d and lambda d by d is the fringe width and we have seen that the fringe width does not change whether delta phi is 0 or delta phi is a finite number and therefore we see that this side is independent of n whether it is the first fringe or fourth fringe or fifth fringe it does not matter it simply says the fringe shift is given by delta phi by 2 pi into beta what does this mean this means that the fringe shift delta x now i drop the n because it is independent of n therefore the fringe shift delta x is equal to delta phi by 2 pi into beta it depends on delta phi this is now completely understandable we can see that if we put delta phi here is equal to zero then delta x is equal to zero if delta phi is zero delta x is equal to 0 means there is no fringe shift and if delta phi is a finite number then there is a fringe shift for example if the phase shift is 2 pi delta phi is 2 pi then delta x is equal to beta which means the bright fringes would shift by one that is nth fringe will take the position of the n plus one spring or n minus one three depending on whether it is to that side or this side
So the fringes would shift by delta x is equal to delta phi by 2 pi into beta lets see the geometry of the problem more carefully now
So we will see the geometry of the problem when the source is offset
So let me first show only the geometry here
So this is the geometry of the problem original position was s which is on the

perpendicular bisector here s 1 and s 2 symmetrically about this line s o now the source has shifted to a position s dash and therefore we have the fringe shifted to a new position o dash and the path difference total path reference will be 0 if this plus this equal to this plus this then the net path difference will be 0 and o dash will be the new position of the central fringe corresponding to delta equal to zero path difference equal to zero

So s s dash there is the offset here is l we denote it by small l o dash is x that is o is here o dash is x dash x dash is nothing but delta x because x position is 0 originally and the new position is x dash therefore delta x is equal to x dash the coordinate of the new position of the central maxima s 1 s 2 the separation here is d small d between the two sources and l let l be the separation between these and d is of course the distance to the screen from the two sources s one and s 2 and therefore now let us see that for the central fringe the path difference is equal to 0 if the condition this plus this is equal to this plus this the length here are equal which means i can take this s 2 o dash to the other side or s 1 o dash to this side and write s 2 o dash minus s 1 o dash s 2 o dash minus s 1 o dash this separation is equal to s 1 s dash s 1 s dash minus s 2 s dash

So that is nothing but s 2 o dash is r 2 r 2 minus r 1 is equal to i am denoting this as q 1 and q 2 is equal to q 1 minus q 2.

So r 2 minus r 1 we know the path difference between these in terms of the separation here this and d and that is x dash d by d x dash is the position here of o dash

So r two minus r one is x dash d by d similarly q 1 minus q 2 q 1 minus q just like this q 1 minus q 2 will be equal to l the offset divided by l into d because it is from this triangle this part difference we had calculated from this part difference now we are calculating from this triangle and that is identically l by l into d this implies please see here this implies that x dash by d

So d is common and therefore x dash by d is equal to l by l x dash by d x dash by d is this angle theta the angle theta tan theta is equal to x dash by d tan theta of course in is very very small here because the fringe shift is much smaller this is of the order of hundred centimeters one meter and the fringes are only moving a few millimeters or

So so this is x dash by d is very small even if we do not make the approximation it is valid because x dash by d is tan theta and l by l is tan theta dash here

So i have shown theta dash here this angle tan theta dash and they have to be equal

So tan theta is equal to theta is equal to theta dash which means if theta is equal to theta dash that simply means that these are opposite angles which means that s dash o dash is a straight line passing through the point m here

So we have x dash by d this divided by this is equal to the offset l divided by l

So s dash o dash is a straight line passing through m now let's see now the fringe shift now in terms of we see the fringe shift now in terms of the geometry that is the offset earlier we have seen the fringe shift in terms of the phase shift delta phi by 2 pi into beta now we see we get an expression for the fringe shift in terms of the offset

So let's see that

So here fringe shift due to the source offset

So we have l as the source offset here and delta x is equal to x dash minus 0 0 is the original position which is the fringe shift and we have just shown that x dash by d is equal to l by l and therefore delta x x dash is delta x the fringe shift delta x the fringe shift delta x is equal to d by l into l in other words if an offset is given if it is given to you that the source s is offset by a certain amount and the corresponding separations d and l are given then you can determine what is the fin shift

So it is the fringe shift due to source offset by l take an example put some numbers typically d is about 100 centimeters this could be tens of maybe 10 20 centimeters i have taken l is equal to 10 centimeter for an offset of 1 mm just 1 mm offset here

So this is the perpendicular bisector an offset of 1 mm leads to a delta x a shift of 10 mm here 100 by 10 into 1 that is 10 mm almost 1 centimeter shift a typical idea to see how the friendship take place in other words if you are setting up the experiment if the source s is not exactly normal and on the perpendicular bisector here if there is a small shift then the central fringe will shift to this side the same thing would happen if instead of the source moving to this side if the source had shifted offset to this side then we would have got o dash here that is the central fringe would have moved here the same thing would also happen

So let me show you the same thing would also happen if i have

So the source is right on this source is here but the s 1 and s 2 there is an offset

between s1 and s2 that is s1 the perpendicular bisector is here now this is shifted a little bit to this side then also we will have a corresponding print shift because now the distance s to this and s to s one

So s two s one here and s two s two will be different and correspondingly there will be phase shift of delta phi between the sources here the wave front which is reaching here will be at a different time the wave front will reach here therefore there is an initial phase shift of delta phi and correspondingly we will have the fringe shifted here which will be on the line here joining this

So the fringe will be shifted to a new position o dash if it is if this aperture is shifted downward then the fringe shift would occur here this kind of shift is called the lateral shift it is because the alignment there is an offset either in the source or in the double hole aperture then we have a corresponding shift in the central maxima and this is called lateral shift

So here we are the fringe shift will also occur let me come back the fringe shift will also occur if the aperture plate q q dash is offset with respect to offset with respect to this line s o this type of fringe shift is called lateral shift why i am discussing this is we will soon see another type of fringe shift its fringe shift because of let us say introducing a delta phi due to an external plate for example if we introduce a glass plate on one of the paths we will see that there will be a fringe shift

So this fringe shift is simply because of the offset not because of introducing any other thing the offset introduces a constant phase shift of delta phi and due to which there is a fringe shift which is called lateral shift lets therefore just let me summarize what we have seen

So summarizing the fringe shift issues the fringe shift delta x due to a constant phase difference delta phi if there is a constant phase difference why i am insisting on constant is next i will take up when the phase difference is changing with time

So the constant phase different delta phi including the delta phi could be zero between the interfering waves then there can be sustained observable interference fringes when delta phi is zero or constant we will have a sustained observable interference pattern the phase difference is 0 means the interfering waves are in phase and if the phase difference is pi we call it out of phase here i have shown this that waves with a constant delta phi among them are called coherent waves

So i have shown here delta phi is equal to 0 which means whenever the first wave is maximum second wave is also maximum

So this is phi or time

So the maximas are coinciding the minimas are going that is crests and troughs come at the same time at any given position if the phase difference delta phi is equal to pi it is a constant but it is pi then we have the crest of one wave corresponds to the trough of the other wave at that point at that point the phase variation what i have plotted is the phase variation of the two waves with time

So at any given point if the crest of one wave coincides with the trough of the other it means the two phase two waves are out of phase and the net amplitude we have already seen in another chapter that the superposition of waves the net amplitude will be the sum of the amplitude which will be zero and if there is a constant phase shift delta phi here which means the waves there is a constant phase shift all the three cases correspond to coherent wave whenever delta phi is a constant we will be able to see sustained observable interference fringes this is the first point the second point that we have is the central fringe here and all other fringes let us look at this the central fringe and all other fringes would shift by an amount delta x which is proportional to delta phi but the fringe pattern and the fringe width does not change delta x is equal to we have derived this delta x is proportional to delta phi but the fringe width remains the same and the fringe pattern remains the same now therefore there is a question how to measure the fringe shift in practice particularly when delta phi is several times two pi in practice we see a fringe pattern as i showed earlier let us say bright and dark linear fringes the fringes are shifted because of a finite phase difference delta phi but how to measure the fringe shift because it looks identical and if the phase shift delta phi pi delta phi is let us say eight pi then four fringes will be shifted

So we do not know where is the central fringe now

So how to locate the position of the central fringe because they all look identical all the fringes look identical and the fringes have been shifted exactly by four fringe which means the pattern again looks the same how to locate the central fringe the answer here

is use of white light interference we will discuss this shortly but before we go to white light interference i want to come to the next question that is what if delta phi varies randomly with the time what if delta phi varies randomly with time it varies with time means delta phi is a function of time till now i had assumed a constant delta phi but now it is a function of time at any point and when do we have such situations where delta phi is varying with time we will discuss this in a minute if s one and s two are two independent sources or derived from an extended source then we will see that delta phi will be varying randomly with the time
So let me discuss this a little bit more
So let us look at light sources and waves coming out
So if i have a light source there is a light source here a bulb let us say and this is giving out light radiation we know that in any particular direction light comprises of waves which are travelling but these waves are not sinusoidal from end to end the electromagnetic wave is not sinusoidal end to end because it depends on the mechanism of generation of light for example if we take a sodium lamp let us say this is a sodium lab n a lamp there are sodium atoms which are excited
So if i consider the ground state of sodium is here
So this is one is ground state and two this is energy axis
So i am plotting the ground state and the excited state sodium atoms are excited here by electric discharge and the excited storium atoms come down that is they get de-excited and come down to a lower energy level and the energy difference here is given as a photon or an energy packet of energy h nu which is equal to the energy difference if i say that the energy here was e two and energy of the second first level was e one then h nu is equal to e two minus e one we know this we have already studied this
So energy is given in terms of photon packets now these are not infinitely extended because infinitely extended means it will contain infinite energy and therefore these are finite wave trains which are emitted
So we have continuously excitation taking place and de-excitation taking place emission of photons coming out of the sodium lab and these are therefore wave trains which are travelling off up to a finite duration it means if i take a several wave trains
So let me plot several wave trains
So one wave train is this and another wave train they they are emitted at different times there are continuously atoms getting excited atoms getting de-excited
So they are emitted continuously at different times which means the sine waves originate at different times all of them are of the same wavelength but they are emitted at different times and therefore if i look at
So these are the different waves which are travelling individual waves corresponding to photon
So all of them are of the same wavelength lambda same lambda but they are discontinuous
So if i look at two waves any two waves lets say there are two ways
So let me consider two waves one and two these two waves over this period you can see that there is a constant phase difference between them but after some time there is another wave which is here which has no phase relation with this
So this is time access
So with the time we see that over a certain time period there is constant phase difference but if i look at the time here the phase difference between these two waves is different from the phase difference between these two waves this may be coming from the source s one and this may be coming from the source s two and therefore there is no phase different the phase difference changes with time in other words delta phi is a function of time let me come back to this and now show the diagram of the let us look at the young's double slit experiment now this is the same sodium lamp which is giving out radiation here and we have the double slit here
So i am showing the double slit s one and s s2 this is an extended source this is not a point source this is an extended source extended source and therefore there are wave fronts where the wave fronts have no correlation what do i mean by that if i have a point source this should give spherical wave fronts like this and if my aperture is here s 1 and s 2 we see that this is s 1 and s 2 we have emphasized several times that the wave front reaches at the same time to s 1 and s 2 but if there are this not a point source but an extended source which comprises of number of point sources which are radiating independently then the wave which is entering here and the wave which is entering here have no phase relationship no fixed phase relationship it changes with the time which

means delta phi is a function of time when the source is extended source that is why in young's experiment what did we do we have a point source there was a first aperture here this was acting as a point source which was giving out spherical wavelets which are here and we placed the second aperture here with the two apertures the double hole or double slit is here before that there is a single hole which is like a point source we did not place an extended source directly in front of this or nor even this that you take two s one and s two two holes and we keep one bulb let me show the bulb like this here which is giving light and another bulb here in front of this

So this is giving

So what is the point if we have two independent sources or an extended source from which s one and s two are derived s one and s two are derived then delta phi will vary with the time at different times delta phi will vary because the light which is emitted from here has no phase relationship with the light which is emitted by the other source these are independent sources if there is an extended source different parts of the source independently give out light and therefore there is no phase relationship and phase varies with the time

So that is what i have stated here that if s 1 and s 2 are two independent sources or derived from an extended source then delta phi will be a function of delta phi will be equal to delta phi of t it is a function of time because there is no phase relationship between the two sources

So with this let us understand let us come back to the

So i have described both the sources and therefore what would be and therefore what would be the interference intensity

So we have derived the expression for intensity i is equal to 4 times i zero into cos square delta by two cos square delta by two delta here is changing with time

So delta where delta is now a function of time this is a phase difference

So this delta contains a path reference plus

So this delta contains a path a phase term due to path reference this is fixed this is not changing but there is a second phase difference term delta phi which is a function of time and therefore delta will be a function of time and this delta phi is varying randomly or rapidly with the time and therefore this function to see the intensity we have to take average of this rapidly varying cos square function delta is randomly or rapidly varying and therefore we have to write intensity i is equal to four times i zero into time average of cos square delta by 2 and we have already discussed that this time average is nothing but half in the earlier class we have discussed that time average of a rapidly varying term is half cos square term is half because cos square varies between zero and one and therefore i is equal to two times i zero i zero is the intensity due to the individual sources i is the intensity at any given point

So now this is independent of the phase and therefore independent of the path difference what does this mean this means that if i see here

So each of these two sources s one and s two here the intensity of the source is i zero here and i zero here then on the screen on the screen at any point here we have simply two times i zero in other words if i plot the intensity this is the x direction the screen

So if i plot the intensity along the x direction here i of x x direction here instead earlier we had very nice fringes here maxima minima maxima minima now we simply have we simply have

So let me take a different color show that this is two i zero compare this with what we had earlier with x at x equal to 0 there was a maxima and then it was 4 times 0.

So we used to have intensity variation like this

So this is when delta phi is not

So delta phi is a constant constant and this is the case when delta phi varies rapidly with the time which means there is uniform intensity in other words we will not be able to see any fringes there will be no sustained fringes fringe pattern interference takes place but the interference intensity distribution is varying

So rapidly that we will not be able to see any fringe batter and therefore the summary is if we have incoherent sources

So in the last lecture we had seen that there are two requirements for interference that the first requirement is that the sources should be coherent or they must have a constant phase difference between them and there is a second requirement

So we have already shown that if the phase difference delta phi is changing with time

then we cannot have sustained interference fringes
So that is if we have if the sources are incoherent is delta phi phase difference between them varies with time randomly then we do not have any interference the second requirement which we had pointed out is that the wavelength of the interfering sources must be the same
So we take up this the second issue now and wavelength of interfering sources must be the same
So let us look at the this issue
So let me take up two wavelengths one blue and red
So lets let me plot this with the time here here i have
So i am now looking at interference
So interference with two wavelengths interference between between two different wavelengths is it possible that's what i want to see two different wavelengths lambdas let me write this interference between two different is it possible i am not saying that it is possible i am saying i am discussing interference between two different wavelengths
So lets look at the wavelengths here
So the a the red wavelength starts like this
So i am showing the amplitude variation with the time
So this is with the time amplitude variation and the blue wavelength it has a smaller wavelength
So time or x
So we know that the maxima to maxima that is this is the wavelength lambda the face here if i write this as an amplitude a one into sine omega one t omega one times t sin omega one t and for the blue one
So this is red and for the blue one this will vary more rapidly
So we know that blue varies more rapidly because the wavelength is smaller it will vary like this if the face here is 0 then this maxima here the red maxima here corresponds to a phase of pi by 2 and the 0 here corresponds to a phase of pi because when phase omega t omega t is the phase this is the phase phi and phi equal to zero the total amplitude psi one is equal to zero and when phi is equal to pi by two the amplitude is maximum a one the displacement psi is maximum again at pi it is zero and
So on
So the phase points if i were to plot this as five then this would be three pi by two point and this would be correspondingly the two pi point for the blue if we see because for the blue one we have psi 2 is equal to a 2 the amplitudes can be same or different sine omega 2 times t now omega is two pi times the frequency omega is the angular frequency omega two is equal to two pi times the frequency f f two of the blue line and therefore because the frequency corresponding to the blue wavelength is larger because we know that the wavelength is smaller blue is about 400 to 450 nanometer and red is around 650 nanometer therefore the frequency is higher and therefore this is oscillating rapidly this is varying rapidly because this number is larger in the same time this varies rapidly which means the point pi by 2 corresponds to this phase and in terms of phase this will correspond to three pi by two this is pi and two pi
So what is happening there is a phase difference between the two waves and the phase difference is continuously changing with the time if we look at any point if we look at any point x
So if i plot as a function of x if i look at any point any position x then between the blue
So blue is varying rapidly like this and red is varying slowly
So red is the face of the red is varying slowly they of course both of them are travelling with the same speed if i consider this as vacuum or free space they are travelling with the same speed but the face if we take any plane will be continuously changing because this is varying rapidly that is varying slowly
So if we see the phase phi phi will be continuously changing if i say that delta phi is a function is the phase difference between phi blue minus phi red phi red then it is changing with the time
So we can see from the expression here
So we have a sine omega 1 t and a let me assume the same ampli or a 1 a 2 sine omega 2 t omega two t this is the phase term of the first wave this is the phase term of the second wave at any given point
So i can without loss of generality i can write this as x is equal to zero point and

therefore that's why i have not written omega t minus kx that term i have not written because i am looking at a particular point and what is the phase difference the phase difference between them the delta phi

So the delta phi will be equal to omega 2 t minus omega 1 t or omega 2 minus omega 1 into t

So this will be continuously varying with time

So omega 2 minus omega t

So delta phi we can see that delta phi is a function of time and it is varying very rapidly remember that omega 1 and omega 2 are light frequencies which are very big numbers these numbers are very big numbers because the light frequency f 1 and f 2 of blue and red are of the order of approximately 10 to the power of 14 hertz 2 into 10 power 14 hertz 5 into 10 power 14 hertz and

So on therefore this is a huge number multiplied by time which means delta phi is varying very rapidly and therefore the phase is varying very rapidly what this means is interference is possible

So i simply write the conclusion here interference is not possible is not possible possible between two different wavelengths between two different wavelengths that is why we had written different wavelengths that is why we had written this was the second requirement for interference when we started interference we had given two requirements one is that the sources should be coherent or there has to be a constant phase difference between them and the second is interference interfering waves must be of the same wavelength now i want to take up a interference with a source of multiple wavelengths suppose a source we just said that interference is not possible with between two wavelengths between two wavelengths but if i have a source interference with the source emitting multiple wavelengths for example we pick up here consider three different wavelengths 400 nanometer 500 nanometer and 600 nanometer one is near blue color this is very close to green and this is orange length

So recall that blue interferes only with blue in other words blue will not interfere with green we have just now discussed that the two different wavelengths do not interfere but blue will interfere with blue and therefore if we see the interference in the double hole arrangement the due to blue color we will have fringes with fringe width beta is equal to 0.4 nanometer i have assumed a distance d equal to one meter and the separation between s one and s two as one millimeter typical numbers which we use in practice and therefore the fringe width is given by d by d into lambda substitute for lambda is equal to 400 nanometer we get the fringe width 0.4 mm if we substitute 500 nanometer we get

So for the green we get 0.5 mm and for the orange color we have 0.6 millimeter how would the fringes look like

So lets see the diagram

So the fringes look like this

So what am i showing i am showing the interference due to blue interference due to green and interference due to red if only red were present then we would have got the intensity varying like this this is the x direction that is on the screen varying like this if i had only blue color i would have got this but with the multiple wavelengths such as white light if i have white light then it would have all colors from blue to red at the other end from violet to red at the other end and then we would have got interference due to each color here how would it look like but we see that at o here at o all of them have the maxima at the same point o but the maxima of blue is here the minima of red is here and after sometime we see that when blue is minimum red is maximum

So they are at the maximas are occurring at different positions what will be the net sum the intensities the amplitudes will will add in such a way that please see that the maxima and minima occur at different points for different wavelengths except the central maxima is the same position for all the colors

So what to expect the net effect

So here i have the net effect which is shown here which is white light interference pattern

So its a qualitative representation

So i have qualitatively drawn this that because all all the colors are having the same position of maxima at this point all the colors will be bright i will add up to have a white light a bright white fringe and that is what we have i have simply plotted intensity as a function of x

So this will be the central bright white maximum and then because most of these are

passing through minima here there will be a dip in the intensity total intensity there will be a dip then we have the blue maxima orange green maxima and red maxima and therefore we have slight variations bluish color reddish color and finally of course all of them vary in such a way that we simply have uniform illumination this is the young's first experiment when he did with sunlight what we see this is the first interference experiment of young he saw one bright fringe some colors and then uniform illumination it is then that he switched to the sodium lamp or the spirit lamp with the sodium salt sprinkled over the spirit lamp to see multiple fringes

So what is the conclusion the conclusion is that if you perform the experiment with white light you will be able to locate the central fringe where the path difference is 0 and the phase difference is 0 for all the wavelengths and therefore the final conclusion is thus the central fringe can be easily identified and the fringe shift delta x due to a phase change delta phi can be measured accurately using white light interference i had posed this question earlier how how therefore to determine the shift in the central fringe the answer is from white light interference thanks you