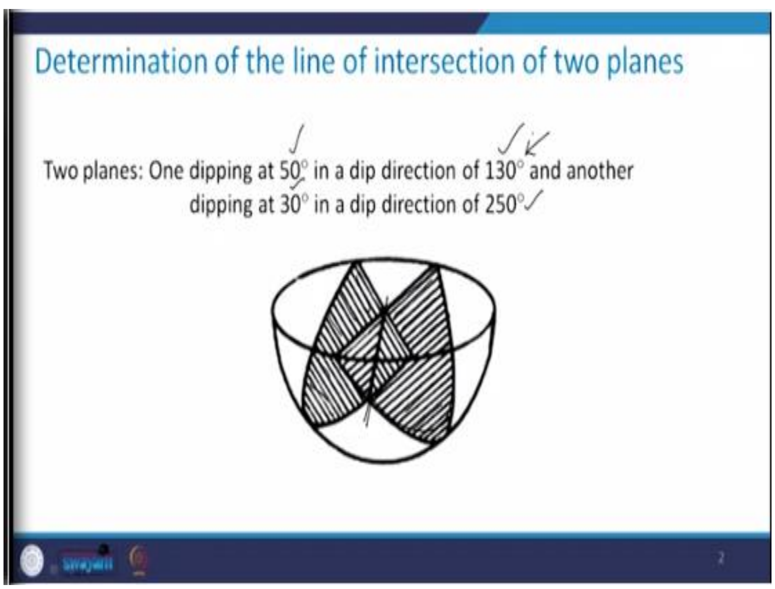
Rock Engineering
Prof. Priti Maheshwari
Department of Civil Engineering
Indian Institute of Technology-Roorkee

Lecture-08
Spherical Representation of Geological Data-03

Hello everyone. In the previous class we learnt about the equal area projection, we learnt about the stereonet. And we saw that how a plane can be represented by a great circle or a pole. So, today we are going to discuss about the projection for the intersection of two planes, then we will try also to see how to find out the angle between the two lines? So, let us start with that, again we will be making use of the stereonets.

I will be taking you through a stepwise procedure to enable you to do these things on your own with the help of a stereonet and a tracing sheet which are pinned at the centre. So, you see that when you have two planes, so here in this case those two planes have been shown by these hatched portions.

(Refer Slide Time: 01:37)

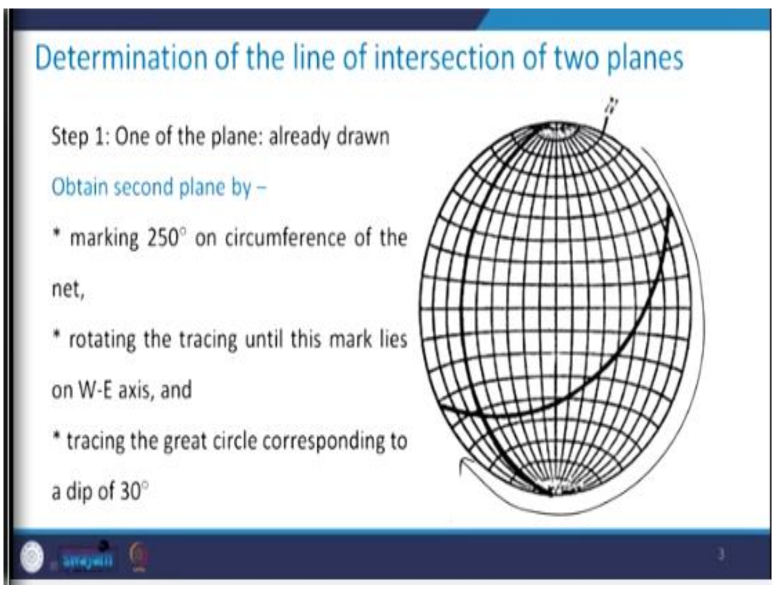


So, you can see that this is what are the two planes. This is the first plane and this is your second plane. And we already know that these two planes how they can be represented if they have to intersect the sphere. So, this is how the intersection will look like, now you all know from your engineering graphics background that when the two planes they intersect, the result is this line.

So, this is what is the line of the intersection, how to do this? How to plot it as a form of geological data? So, there are two planes which are given one is dipping in 50° and with a dip direction of 130° and another one has 30° and a dip direction of 250°. So, basically the first part that is this plane that is one dipping in 50° in a dip direction of 130° that we have already seen in the previous class.

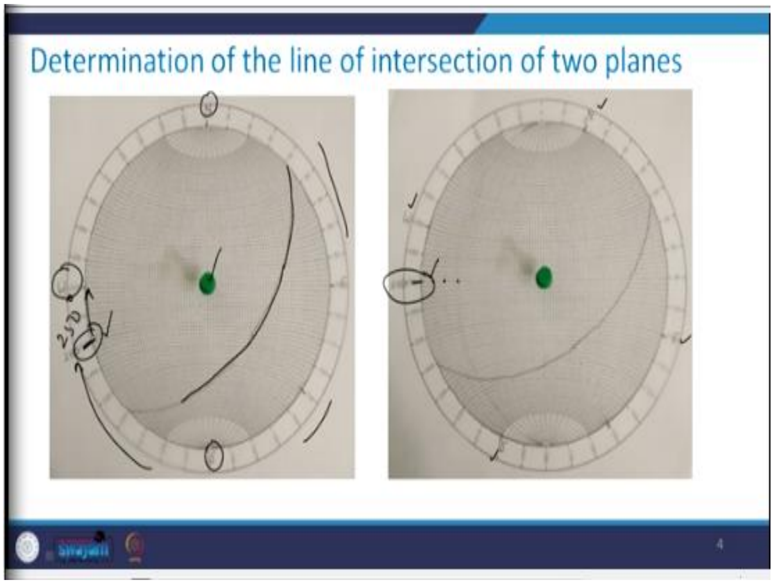
So, today what we will do is we will plot in that figure only, we will plot this additional plane and then we will try to see the line of intersection, how we can determine that? So, you see that, this one plane has already been drawn, so let us see that how we can draw the next plane which is having a dip of 30° with the dip direction of 250°. So, we have to follow the same procedure as we did in the previous case.

(Refer Slide Time: 03:29)



What we need to do is, we need to measure 250° along the circumference, then we need to rotate it in such a manner that it coincides with west east axis and then we will trace the great circle corresponding to a dip of 30°, let us see how we do this.

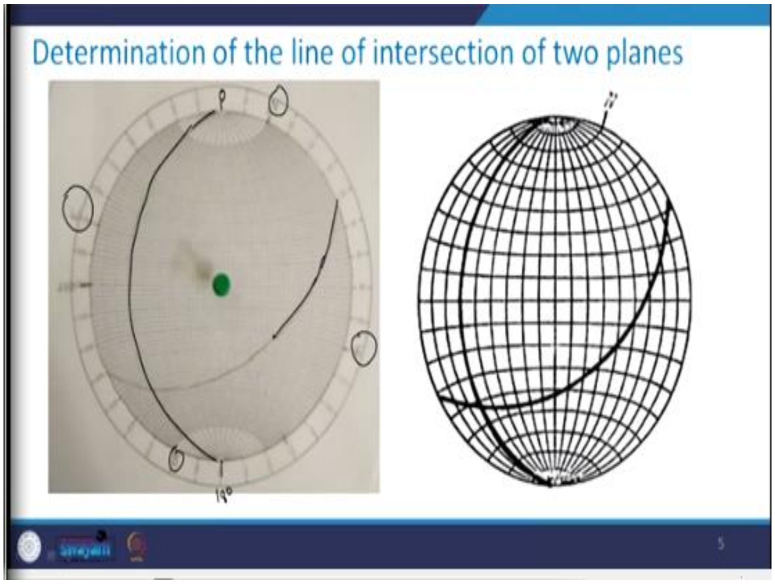
(Refer Slide Time: 03:45)



So, this is the one plane which we already have seen in the previous class how to draw. This is the one plane. Now see north is coinciding with 0 here and it is in the original position which is pinned at the centre. So, from here in the clockwise direction I come and then I mark a point as 250° having the dip direction of the other plane. Now the next task is going to be this 250° mark which is there I need to rotate it in such a manner that it coincides with this west direction or 270°.

So, this mark and this has been rotated, so you can see that the north has been rotated by 20° likewise east, south and west, so what is happening? The 250° mark which was there here at this location is now here at this location, this 250°. Now because the dip is 30°, so as I explained it to you in the previous class. From this outer surface you will take 30° towards the center, so this is your 10, 20 and then this is your 30°.

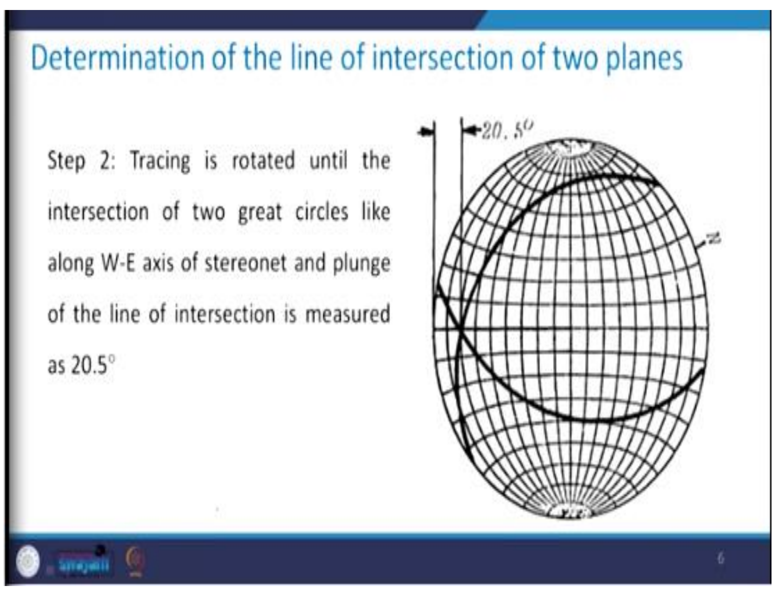
(Refer Slide Time: 05:15)



See, this is what that we have done. So, corresponding to this 30°, I draw another great circle which will be representing the plane having dip as 30° and dip direction as 250°. And obviously, this plane is having 130° dip direction and 50° dip as we have seen in the previous class. So, we have these two planes, so this is how it will look like, this is here your north is there south east and west.

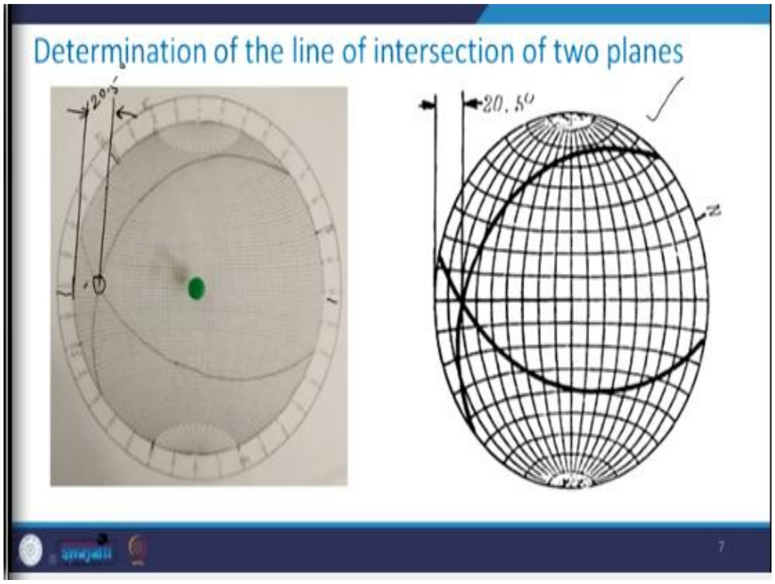
Keep a track of this. Keep that in mind, I am not rotating the stereonet it is position is always here like this is what is 0 and this is what is 180°, what I am rotating is only the tracing sheet.

(Refer Slide Time: 06:16)



Now you see what is done in this case, wherever point that these two great circles they are intersecting, we rotate the tracing sheet such that the intersection of these two great circles they lie along this axis that is west east axis of the stereonet.

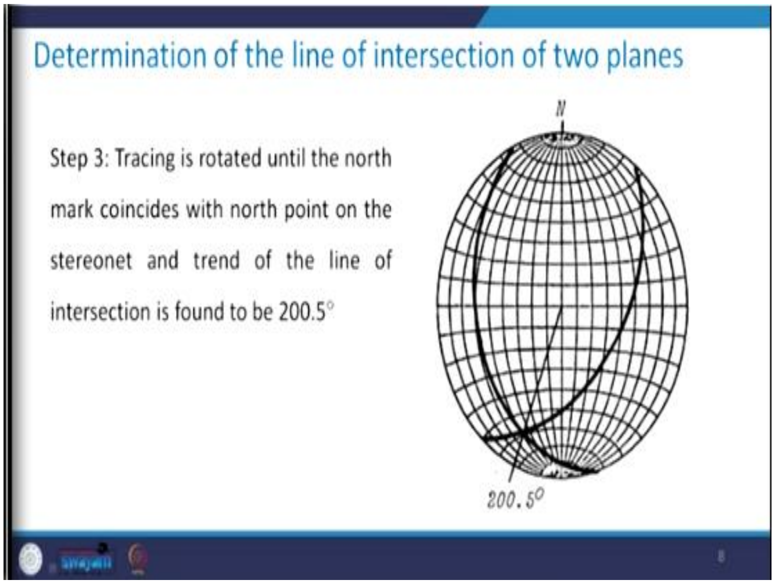
(Refer Slide Time: 06:45)



So, this is how we need to do? So, the point of the intersection was this point and we have rotated in such a manner that it is lying along you see this 270° and 90° point here. Now how to determine it is dip and the dip direction? So, you see from the extreme circle, you just measure of this distance radial distance, this is 10, 20 and little bit more than 20, so that is going to be 20.5°.

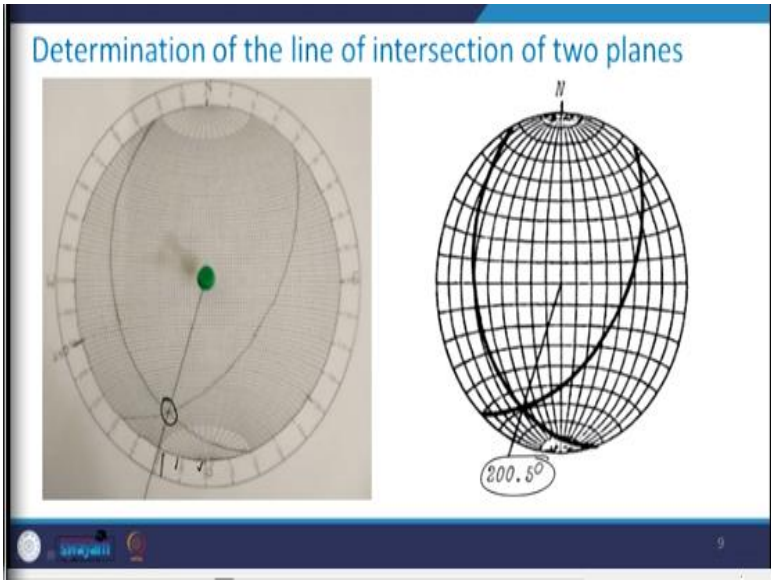
So, you see it is this distance this is 20.5°, this is what has been shown in this figure which has been taken from the book by Hoek and Bray. Then what we do is, we rotate the tracing back to it is original position such that the north of the tracing sheet coincides with the north of the stereo plot.

(Refer Slide Time: 07:51)



So, you see that this is how it will look like and then we draw a line from the centre joining this point of intersection.

(Refer Slide Time: 08:05)

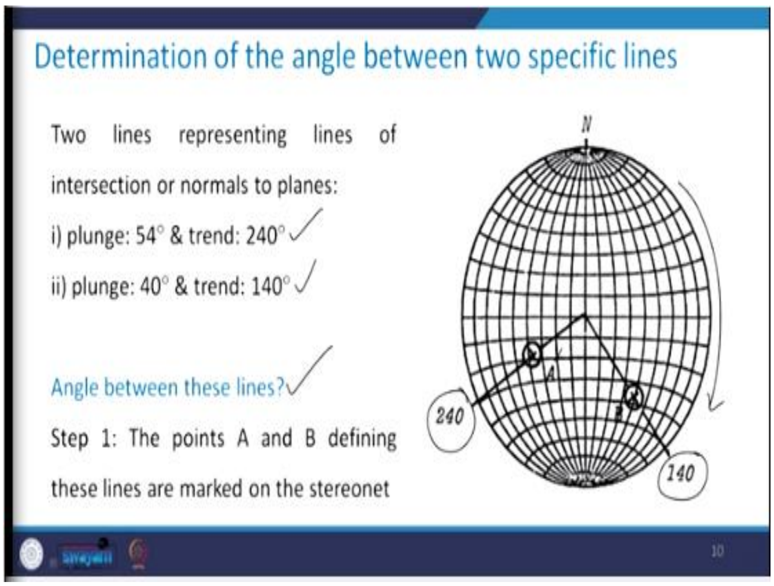


That means, this line this is how that it will look like here, I have drawn this line and the north is matching with 0 of the stereo net. South is matching with 180° and automatically the circle on the tracing sheet is on the circle of the stereonet, they are coinciding with each other. Now you see wherever this line is intersecting the circumference that is here, can you read it. Like this is 190°, this is 200° and little bit ahead of the 200°, so this is what is 200.5°.

So, after getting this like whatever is the line of intersection of these two planes which is represented as this particular point. That line will have it is plunge and trend and this is how you can determine it. So, this has 20.5° and 200.5° of the parameters with respect to line of intersection of two planes, so this is how it is done. So, let me repeat all the steps once again. First of all, you draw the two planes representing by their great circle, wherever the great circle intersects.

That point will represent the line of intersection of these two planes. How to determine the plunge and the trend of these lines? You have to follow the standard procedure that has already been explained. Now coming to the next problem, that is the determination of the angle between two specific lines. So, in this case, again we will make the use of the stereonet and the tracing sheet.

(Refer Slide Time: 10:17)

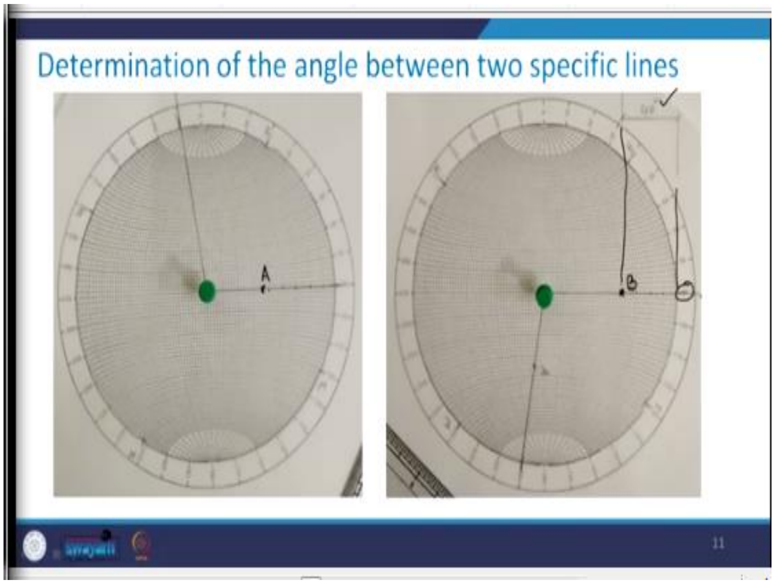


So, here we are taking the two lines with plunge of 54° and trend of 240°, that is line number 1. Then the second one is the plunge of 40° and trend of 140° that is line number 2. So, these two lines they may represent the axis of tunnel or anything or they can be the normal to any planes. Now the question is how to determine the angle between these lines? That questions answer that we are going to find out in subsequent slides.

So, in this case again we will do that first step for all these stereo plots, it is going to be the same. You place a tracing sheet on top of this stereonet draw the outline of this circle, mark 0, 180°, 90 and 270° on the tracing sheet. Now here you see that trend of the two lines, which is I have already told you that which is equal or equivalent to the dip direction. So, you see in this case, it is 140° and 240°.

So, from the north in the clockwise direction, I will mark two points that is 140° and 240° and join it with the centre of this circle. So that is how we are going to make use of this. So, first of all we have this trend. Now the question is how to locate this point A and B? Let us see.

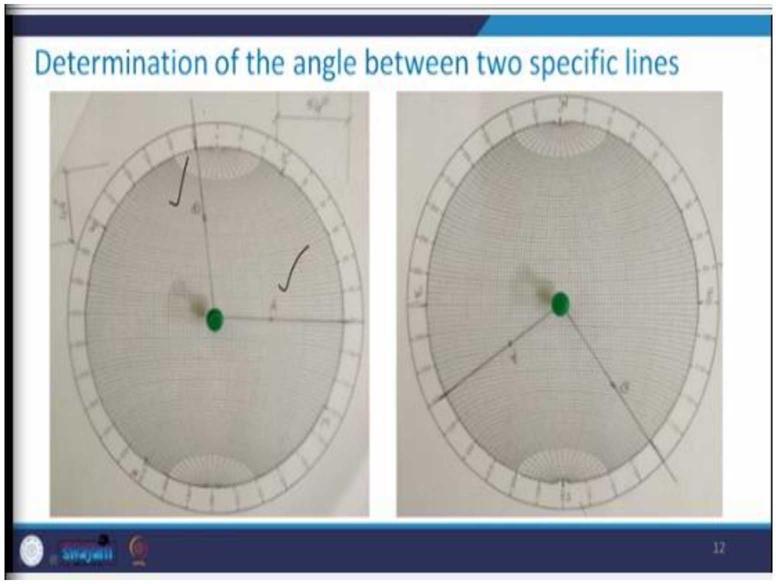
(Refer Slide Time: 12:09)



So, what is done here is we have this line 240° mark which was there, I rotate the circle, so that that 240° is matching here. And then I count from here, like 54° was the angle, so 10, 20, 30, 40, 50 and then 2 marks, so I will mark here this as A. Similarly, for this point B again, so I have that two lines, one was for 140° and another one was 240°, so this is what that we did with 240°.

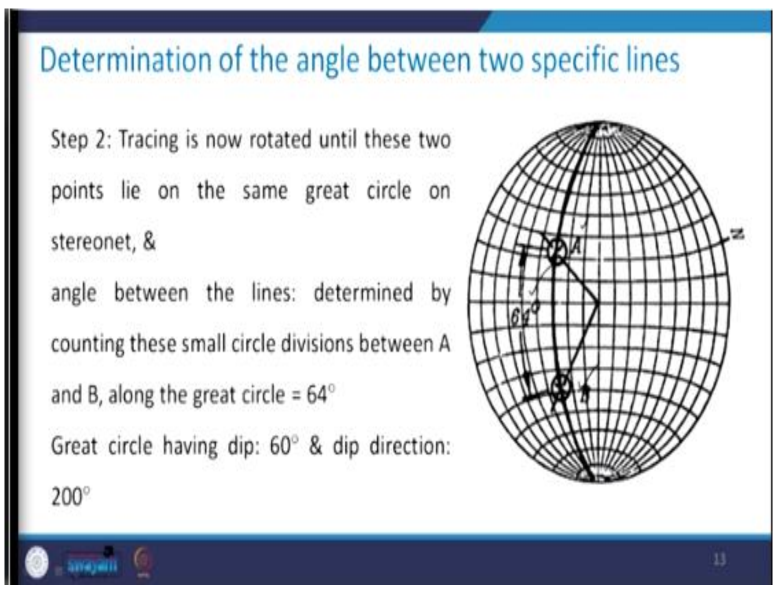
So now coming to the next one that is 140°, so again the same thing that we are going to do. So, I have rotated that tracing sheet in such a manner that particular mark corresponding to 140° is coinciding with this west east axis. And then from here that is from this outer circle you see here to here, this point, I count 40, 1, 2, 3, 4 and each are having 10° of measurement, so this angle being 40°, so I mark this point, which is B.

(Refer Slide Time: 13:33)



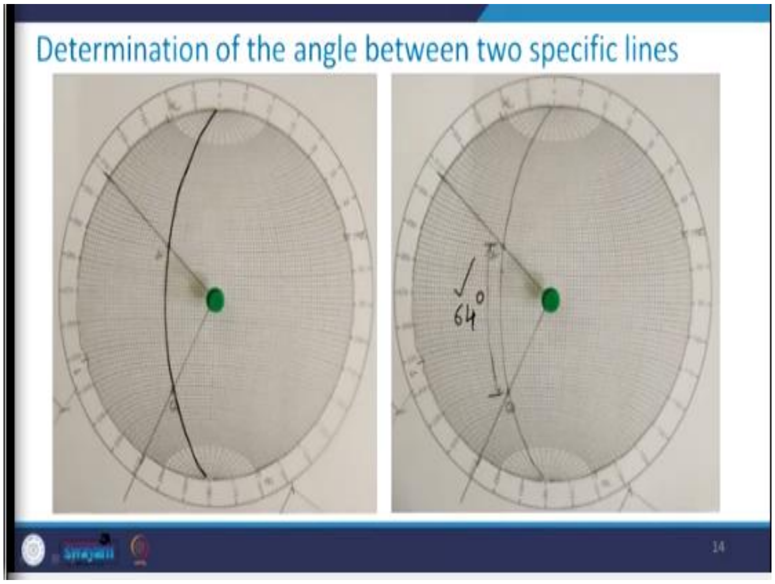
So, you see that we have these two points, one is A, another one is B, these are representing the two lines. I rotate it back, that means coinciding not with the 0° and accordingly south, east and west they will be coinciding with the respective angles. This is how the plot is going to look like. So, these two lines I have represented with the help of the points A and B, which were having some trend and some plunge. Now how to determine the angle between these two lines?

(Refer Slide Time: 14:23)



So, what is done in this case is, we need to rotate the tracing sheet in such a manner that these two points which we have marked A and B, they lie on the same great circle. And then what we do is we measure that how many points or how many intervals are there in between these two points along that great circle, not along horizontal direction, not along vertical direction, but along that great circle. That angular distance is going to give us the angle. Let us see how we do that?

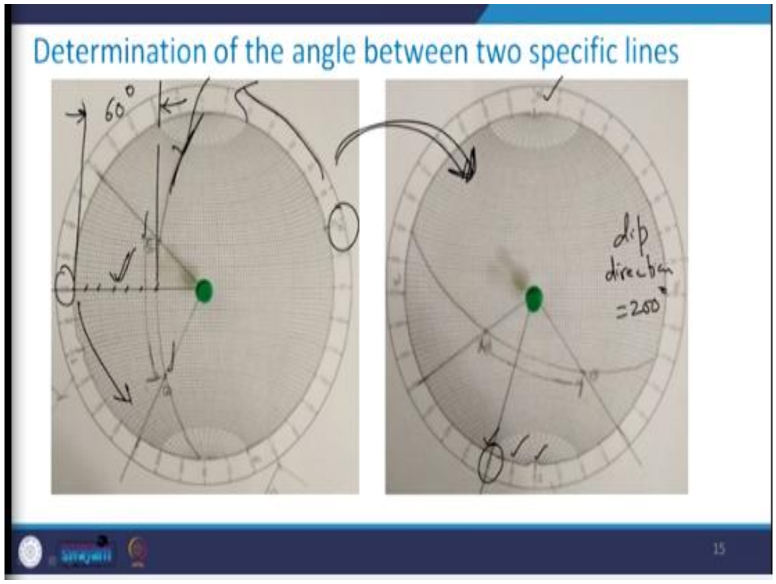
(Refer Slide Time: 14:56)



So, you see I rotated this tracing sheet in such a manner that the point A and B, they were lying on the same great circle. So, the moment it happens, I mark that great circle here with the help of the pencil, you see, like this. Now once I do that, what I do is I count the number of the intervals which are there along this great circle between these two points A and B. And if you just count it, these will be 32 intervals, now each interval is representing 2°.

So, we need to multiply that by 2, so 32 multiplied by 2 which is the 64°. So, this comes out to be 64°, you need to just count these numbers, these intervals you have to count, just multiply that by the interval of your stereonet that you have taken. Because here I have taken 2° interval stereonet, so therefore I am multiplying it by 2. So, the angle between these two lines is going to be 64°.

(Refer Slide Time: 16:22)



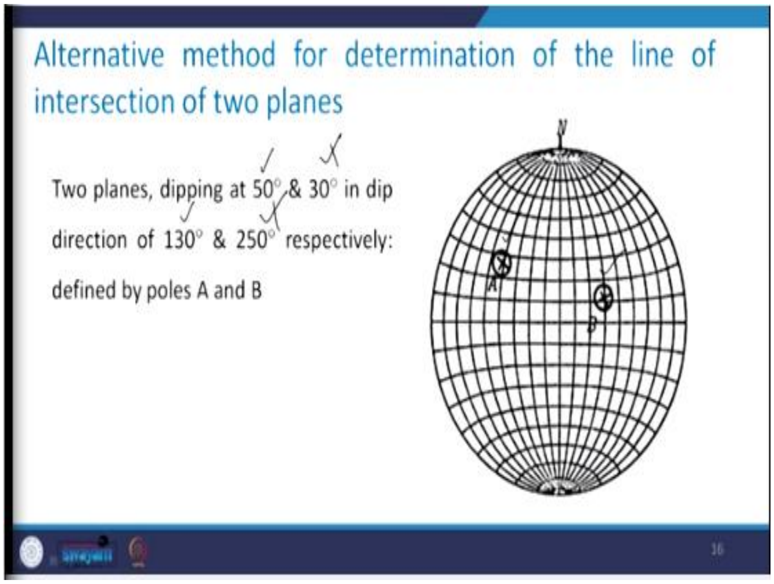
Now how we can determine the dip and the dip direction of this great circle? That means, this great circle corresponding to both the points they are lying on the great circle, what does that mean? Since the great circle represent a plane on the stereo plot, this will represent a plane which will be having both the lines A and B. Now what is going to be the dip and the dip direction of that plane? So, you see what we do how to determine that?

What we do is, in this position, where we have drawn this great circle on which A and B both the points are lying, we draw a radial line in this horizontal direction that is coinciding with these 270°. Now the next step is from here to here is, so you see that you can measure from this point to this point you can measure. So, you see that let us do that 10, 20, 30, 40, 50 and then 60. So, this distance you see, if I just try to give you the idea that is, this distance which is 60° in this case, this is going to give me the dip of this plane.

Now I rotate it back to this original position, that is north of the tracing sheet and 0 of the equatorial stereonet they are coinciding with each other. So, wherever this line, so you see when I rotate it back, so earlier the north was here, so we just rotated it back in this direction, so what will happen? That this line which was lying in this direction, it will get rotated in this direction.

So, you see that it comes to this particular position and then you can read that corresponding to this line, what is the angle on this stereonet? So, you see that here this is 180°, 190° and 200°, so it is dip direction of this plane is going to be 200°. So, this is how the angle between two specific lines can be determined. These two lines will be lying on a plane which is represented by a great circle like this. And following this procedure and this procedure, we can find out the dip and dip direction of this plane as well.

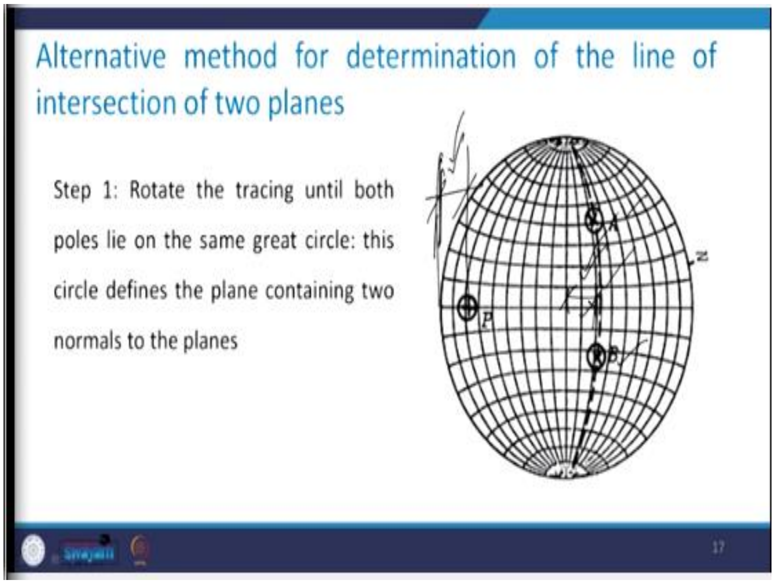
(Refer Slide Time: 19:44)



Now there is an alternative method of determination of the line of intersection of two planes. This we have already discussed using one particular method. But using the poles also, we can find out the line of intersection of the two planes. Because I mentioned to you that the planes can either be represented by a great circle or they can be represented by their poles, when we represented it by great circle, then how to determine the line of intersection of two planes that we have already seen.

So, the alternative method is using the pole, how we can determine the two planes? So, you see that in this case again we are taking the same problem, two planes are there, one is having a dip of 50° and dip direction of 130°. Another one is having a dip of 30° with dip direction of 250°. So, you see their poles have been drawn here, how to draw the pole? I have already explained it to you.

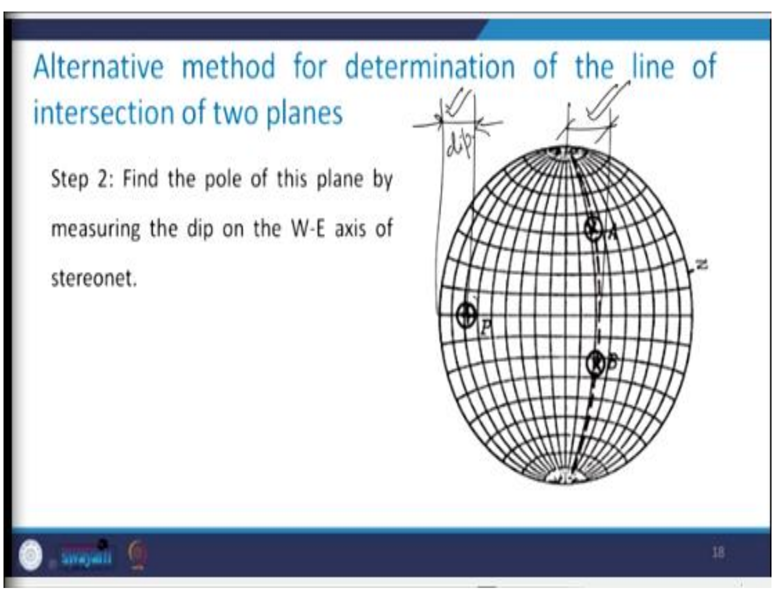
(Refer Slide Time: 20:57)



Then, what we do is following the same procedure as we did in the previous problem. We rotate the tracing sheet in such a manner that these two poles which are A and B they lie on the same great circle. So, what will happen that this great circle which has been drawn here by this dotted line, this will define the plane which will contain the normal to these two planes, that is A and B.

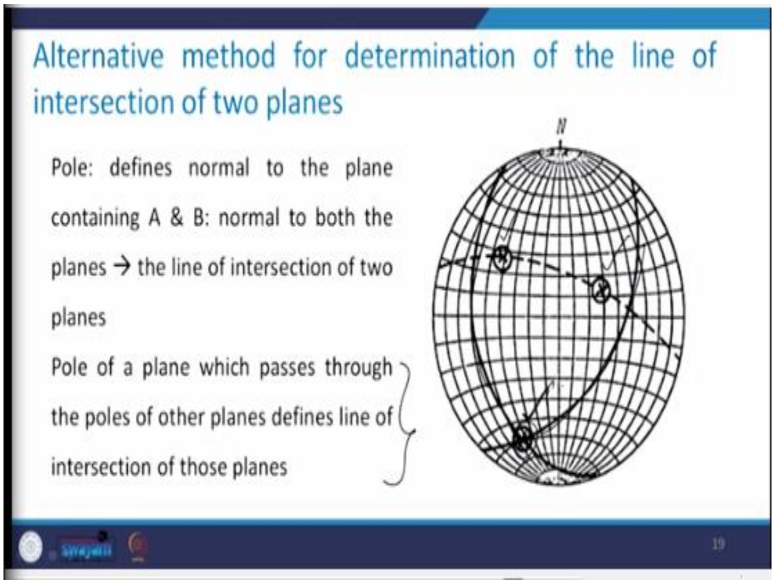
Because pole is representing the normal to that plane whatever is the distance of this from the centre. That means this much, whatever is this distance, you take the same distance from this outer circle that is, circumference. The same distance, this distance and this distance, they are the same. So, then we can locate the pole corresponding to this great circle.

(Refer Slide Time: 22:03)



Once again, let us see here I am taking whatever is this distance, say it is this distance and I am taking this distance as the same distance. So, this is how I can find out the dip. So, this is what is going to be dip of this and then the pole. So, this is the plane and this is what is your pole, this is how that we can determine it.

(Refer Slide Time: 22:33)



Then because this pole defines normal to the plane which is containing these two planes, that is A and B. So, which is normal to both the planes, so that will give us the line of intersection of these two planes. So, the pole of a plane which passes through the pole of the other planes define the line of intersection of those planes. So, please remember this, this is a very, very important statement.

That is pole of a plane which passes through the pole of the other planes, it defines the line of intersection of these two planes. So, you see one and the same thing, so in the previous way, we first obtain these two great circles. And wherever it was intersecting that was giving me the line of intersection of the two planes and using the two poles again we found out the same point as the determination of the line of intersection of the two planes.

So, today we discussed about the determination of the line of intersection of the two planes using the two methods, followed by the discussion on how to determine the angle between the two lines? So, this is how we can represent the geological data, which is 3-D in nature, but on 2-D and this is how using this graphical data, we can make use of this in the analysis of let us say, tunnels or the slope stability or the foundations. So, in the next class, we will learn about some of the application areas of these geological structures and their graphical representation. Thank you very much.