Rock Engineering
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Lecture-06
Spherical Representation of Geological Data-01

Hello everyone. In the previous class we had the discussion on the various geological structures and discontinuities. We discussed about faults, folds, bedding planes and unconformities and I explained you that why it is important for us to know about the exact properties, elements of these geological structures. And why it is important for us to represent these graphically, so that proper planning of any civil engineering project which is to take place, which is to come up on the rock material, it can be done properly. So, today in this lecture we are going to learn some of the basics related to the geological representation in the graphical manner.

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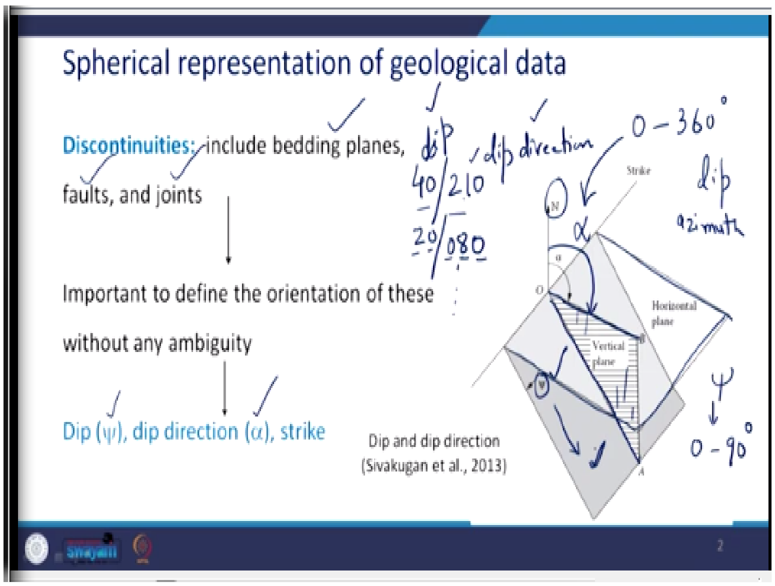

So, to start with I mentioned to you that we have various discontinuities, these include bedding planes, faults and joints. It is important to define the orientation of these without any ambiguity. And we have already seen that to define the orientation of these discontinuities what we need is dip, which is represented by the angle ψ, dip direction represented by angle α and strike. Take a look at this figure, this is a plane which is dipping, that means this is a plane which is representing maybe either the bedding plane or the rock slope or any faults or joints any plane which we want to represent as the geotechnical data.

Now let us consider a vertical plane through this line OA and you consider a vertical plane that is this one which is hatched from OA, which intersects the horizontal plane along this line OB. So, you see that I take a vertical plane and that would intersect the horizontal plane along this line OB. The direction of this line OB with respect to north, that means this is the north with respect to this north direction of this line that is angle α, which is the dip direction.

And this can vary between 0° to 360°; now this dip direction is also known as dip azimuth. It is the direction of the horizontal trace of the line of dip which is measured clockwise from the north. Then dip is the angle, that is this ψ, dip is the angle the inclined plane, this plane makes with the horizontal. That is this is what is your horizontal plane. So, whatever is this inclined plane making an angle with the horizontal plane that would be called as dip which is represented as ψ.

Now this angle ψ can take the values between 0° to 90°, we have already seen that a horizontal plane will have a dip of 0° and a vertical plane will have a dip of 90°. Now the plane can be specified as, any plane can be specified as in this particular manner, let us say 40/210 or let us say 20/080 and so on, where the angle before and after the slash they denote, like before it denotes dip and after it denotes dip direction.

The dip is always specified in two digits, one and two and in order to differentiate dip direction from dip, dip direction is denoted in three digits. So, even if it is let us say 80°, so we will add one 0 before that and then 080. This is how the representation is going to be. This is what that we are going to follow. So, if there are two quantities on either side of the slash, the first one will represent dip and the second one will represent the dip direction.

Now in some of the books you will see that it is either way round, so on one side that is before the slash they have dip direction and after that they will present dip. Again, this is a just a matter of choice. But then this is what that we are going to follow as the convention, dip and dip direction.

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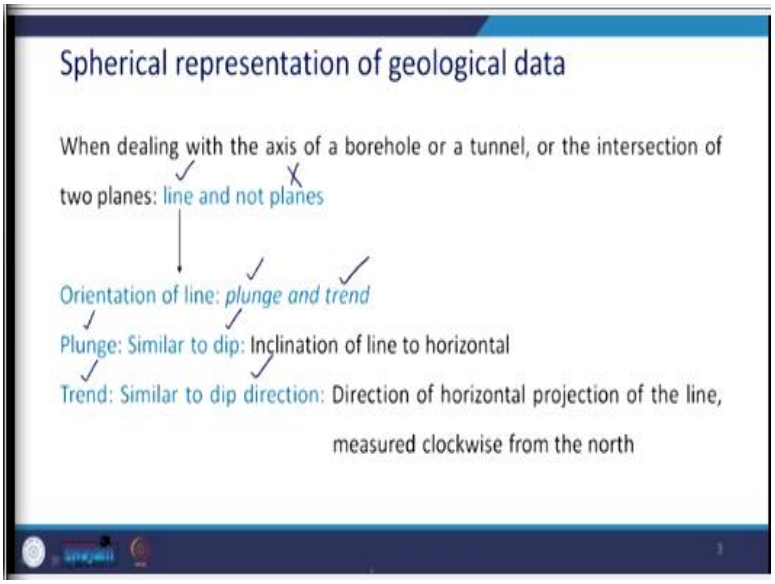

Now this was like when we are dealing with the plane, when we deal with the access of a borehole or a tunnel, it is a line or the intersection of the two planes. You know from your engineering graphics background, when the two planes intersect, what is the result that is a line but not a plane. So, therefore when we deal with the axis of a borehole or a tunnel or the intersection of two planes, it is the line and not the planes.

Now for the planes, we saw that we need dip, dip direction and strike to represent the plane. In case of the line the orientation is represented by its plunge and its trend. The definition of these two terms that is plunge and trend they are very much similar to dip and dip direction respectively. That is plunge is similar to dip which is defined as the inclination of line to the horizontal.

Trend is similar to dip direction which is defined as a direction of horizontal projection of the line which is measured clockwise from the north direction. So, please remember for a plane we need dip, dip direction and strike for its representation. However, in case of line we need plunge and trend. Coming to the coordinate system with longitudes and latitude.

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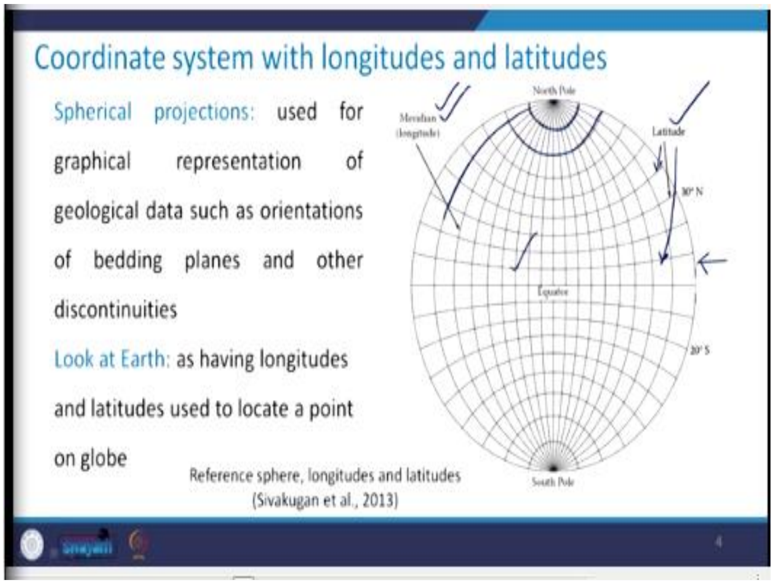

So, we will make use of these spherical projections for the graphical representation of the geological data. What do we mean by that geological data? That means, that it is the orientation of the planes or any discontinuity. It can be faults, folds anything, it can be a slope phase as well. To first get the idea about this coordinate system, take a look at earth, consider a sphere which is shown here.

Earth has latitudes and longitudes, so you can see that all these lines they represent latitudes, all these lines. And these in this direction they show the longitude or meridian. So, we are going to make use of these spherical projections in order to represent the graphical data related to the various geological structures. So, if I need to locate any point on this space, that is this space, then I would need two things: one is the latitude, another one is the longitude.

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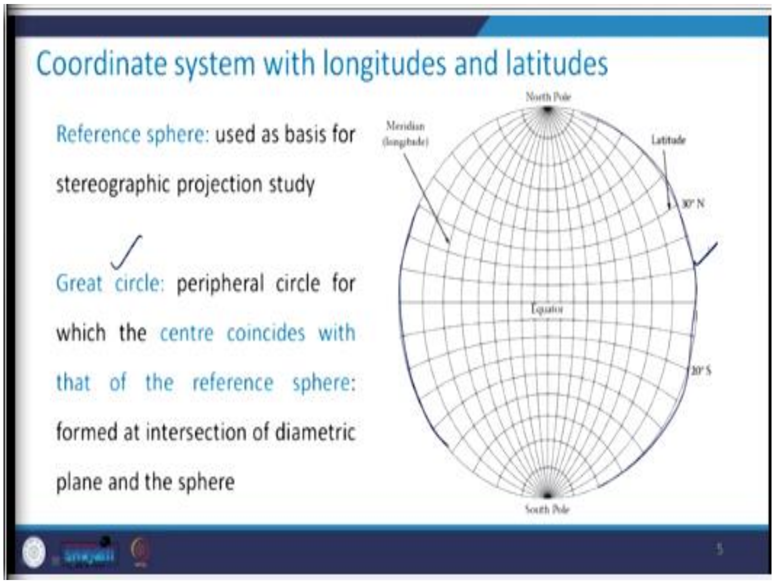

Let us see how to make use of these with respect to geological data. So, first we talk about the reference sphere which is used as a basis for any stereographic projection study. Now the next one is great circle. Please understand it very carefully. It is very important because throughout this wherever we will have this stereographic projection and their application later on in this course, we will be referring again and again to some of these terms, that is the first one is the great circle.

So, it is the peripheral circle for which the center coincides with that of the reference sphere. So, now we take this as a reference sphere, this one. So, any peripheral circle which has or which share the same center as that of the reference sphere, that we are going to call as the great circle. The great circle can be formed at the intersection of diametric plane and the sphere, that is this sphere.

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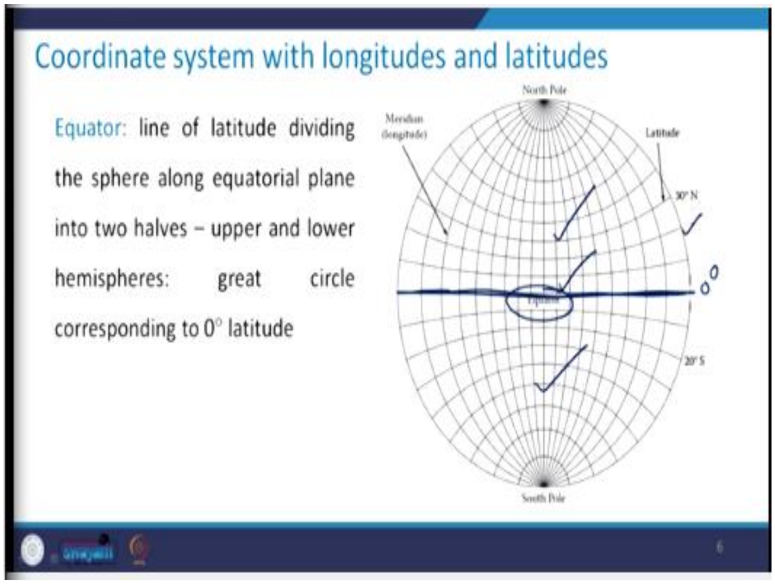

Coming to the next term with reference to earth, you all know about this equator. It is the line of latitude because it is in this direction. It is the line of the latitude which divides the sphere into equatorial plane having two halves. That means this is an equatorial plane which divides the sphere into two halves, one is the upper hemisphere, another one is the lower hemisphere. So, the great circle corresponding to this 0° latitude is going to represent the equator. Keep that in mind, that here you can see that it is the great circle, why this is great circle? Because it is an intersection of a plane with the reference sphere both having the same center.

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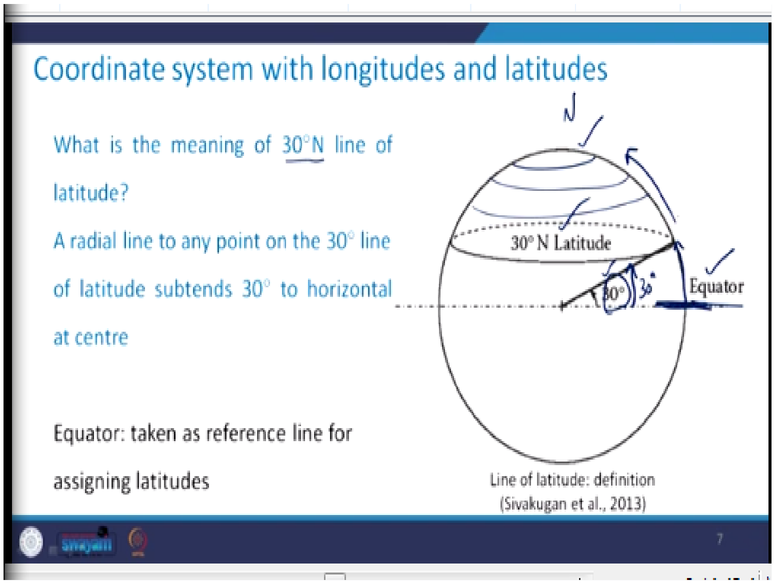

What is a meaning of 30° north line of the latitude? So, here this picture shows you that what does this mean? So, you see this is the reference sphere and the equator is there. Along the periphery you measure 30°. Since it says 30° north, so, we are moving towards the north, this is north. Whatever is this circle, that is, this one that we will call as 30° north latitude.

So, a radial line that is this line to any point on the 30° line of latitude subtends 30° to horizontal at a center. So, you see this is with the horizontal and this angle is 30°, this is what is called as 30° north of latitude. So, basically this equator is taken as a reference line for assigning the latitude. Now what should be the range of this latitude then in that case? You see, it can vary from 0° to 90° because you know that you can have circles like this.

So, it will start this is a 0° latitude then we will keep on increasing and it can go up to 90° latitude. Similarly, as we had equator as a reference plane for latitude, there is a need to have a longitudinal line as a reference line, any one of the longitude lines, as a reference line.

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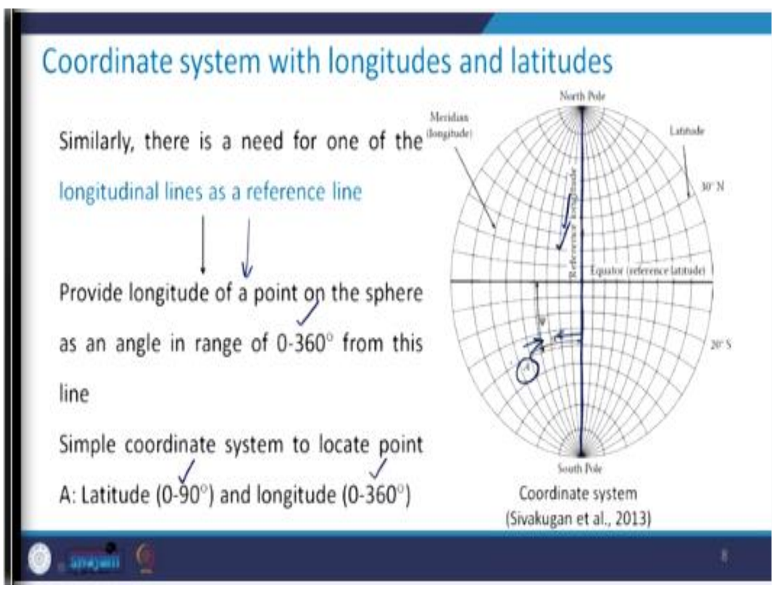

So, what that will do? That will provide the longitude of a point on this sphere as an angle in the range of 0° to 360° from this line. Have a look at this figure, say this is your reference longitude, this is the line reference longitude. Now you have the angular measurement all along the periphery of this with reference to this reference longitude. And then you will realize that you are able to traverse through the complete sphere.

That is why what we say is that 0° to 360° from this line is going to give me the longitude of a point on the sphere. So, we can define a simple coordinate system to locate any point A. Let us say this is the point A that I want to locate, having some latitude and some longitude. So, this latitude can be from 0° to 90° and the longitude can be 0° to 360°. That is when you measure along this alpha is giving you the longitude.

And ψ , that we are representing dip by this angle, ψ , that will be latitude. So, now coming to the next part of this is that, once we have understood this coordinate system how to obtain the intersection of a plane and a sphere? So, here this figure shows first of all take a note of it, this is what is the reference sphere.

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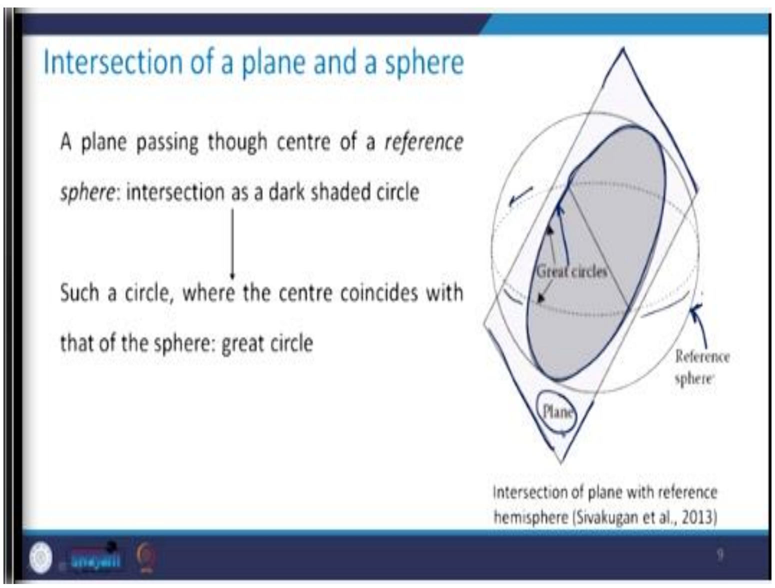

Any circle having the same center as that of the reference sphere we are calling that as great circle. Now this is the plane, that we want the intersection with the sphere. So, this is the reference sphere, this is the plane, how that intersects? A plane which is passing through the center of the reference sphere, that means whatever is the center of this reference sphere that plane is passing through that and that is given by this dark shaded circle. You see, this one.

So, we call it this as great circle, because it is the plane which is passing through the center and any circle on this plane will also pass through the center of the reference sphere. So, this is going to be the intersection as a dark shaded circle. Now such a circle when the center coincides with that of the sphere is called as the great circle ok, so this is what is one of the great circle. Now in this figure you can see that there is this dotted portion, this dotted one that is another great circle. So, what is that all about? It is the second horizontal great circle which is separating the reference sphere into upper and the lower half.

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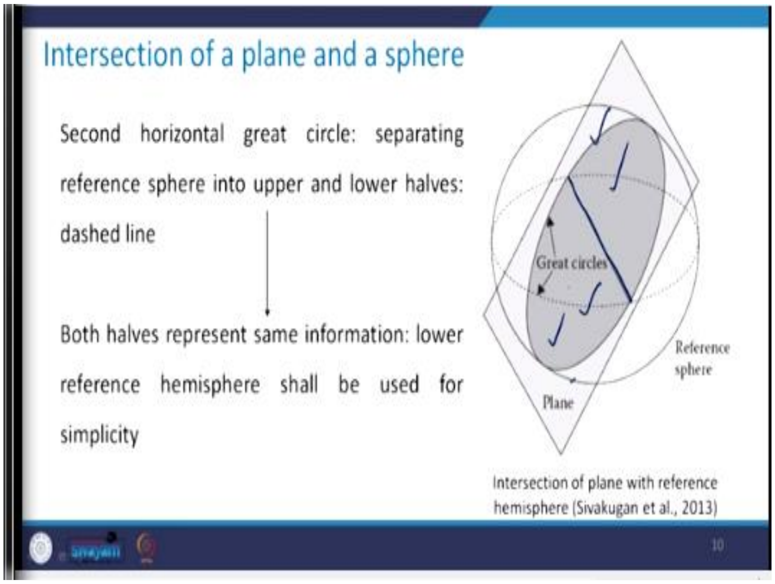

So, that is passing from that equator. So, that is therefore we have two great circle. One is this one and another one is this one. Now take a look at it this line, this portion will lie in the upper hemisphere and this portion will lie in the lower hemisphere, but the plane is same. So, both of these hemispheres, they are giving me the same information. So, therefore why to have this duplicate representation?

So, in order to avoid that, from now onwards we will take the lower reference hemisphere for representation of all the geological data for simplicity. So, now we have done away with the upper portion of the reference hemisphere.

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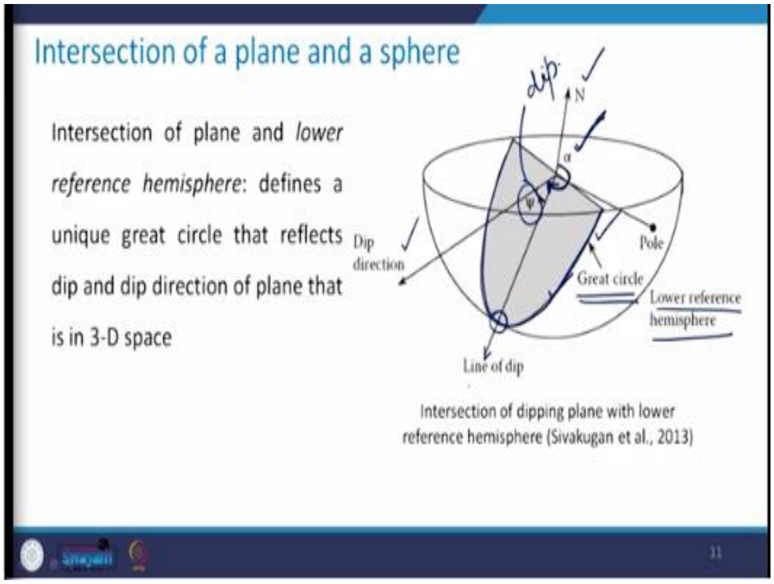

So, we have only lower reference hemisphere. This is the plane of the intersection, so how to define this? So, this is defined by this unique great circle and since we are taking only the half or the lower portion of the reference hemisphere, the remaining half is lying in the upper reference hemisphere and we are not going to consider that, so focus here. This is defining a unique great circle which is representing the plane or the intersection of the plane with the sphere.

This defines obviously this is going to be a unique great circle which will be reflected by dip and dip direction of that plane, that is in 3-D space. So, you can see that, this is the line of dip in which that means here it is you see that it has the maximum curvature at this point. Join it with the center and that is what is going to give you the line of dip. Then that is the horizontal one, that is a dip direction.

Now from the horizontal, this angle which is measured up to this line of dip which is this, this will define dip of this plane. If this is what is the north direction, then in the clockwise direction you move up to the dip direction. And whatever is the angle you follow this arrow, whatever is this angle that is given by dip direction. So, that is what is your dip and dip direction of intersection of the plane and a sphere.

So, in this class what we discussed is about the coordinate systems with reference to the earth, we took the help from that latitude and longitude. And then we tried to see that how we can have the two reference planes, one is equator and another one is reference longitude, in order to define the coordinate of a point. And then we saw that how we can determine the intersection of a plane with that of the sphere.

Now, in the next class we will be discussing about the intersection of the sphere with the line. Then we will take that what will be the intersection of two planes? How to represent them graphically? If we have two lines in the space, let us say, representing the axis of the tunnel or any other such thing, then what is the angle between these two lines? How to determine all these on 2-D plane or graphically using these stereographic projections?

All these things we will learn, but then before that we will learn about the equal area net and we will see how to make use of that equal area net in order to get the graphical representation of these geological structures? And how to obtain some of these quantities, like what should be the angle between two lines etc. So, all these things we will discuss in the next class. Thank you very much.