Surveying
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Module - 5
Lecture - 2

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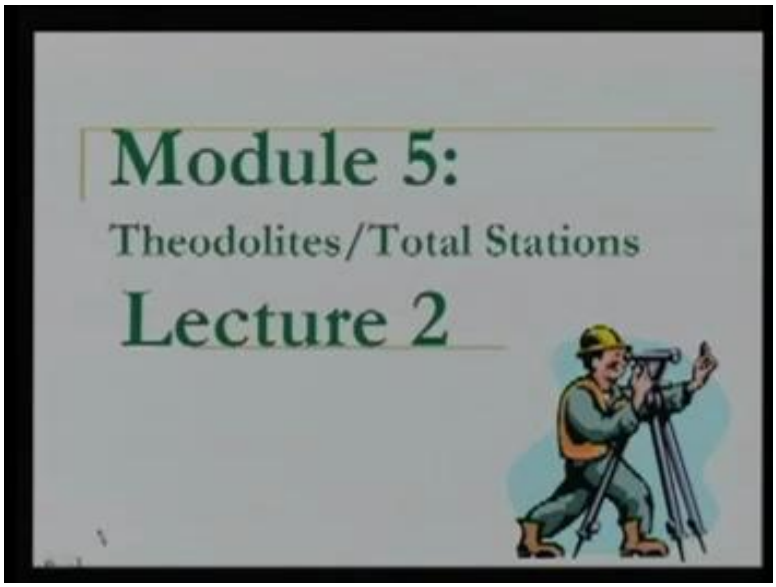

Welcome again to this video lecture series on basic surveying. Today, we are talking about the module number 5, which is on theodolites and total stations. We have already started this module in our last lecture. So, today our lecture is lecture number 2 of this module.

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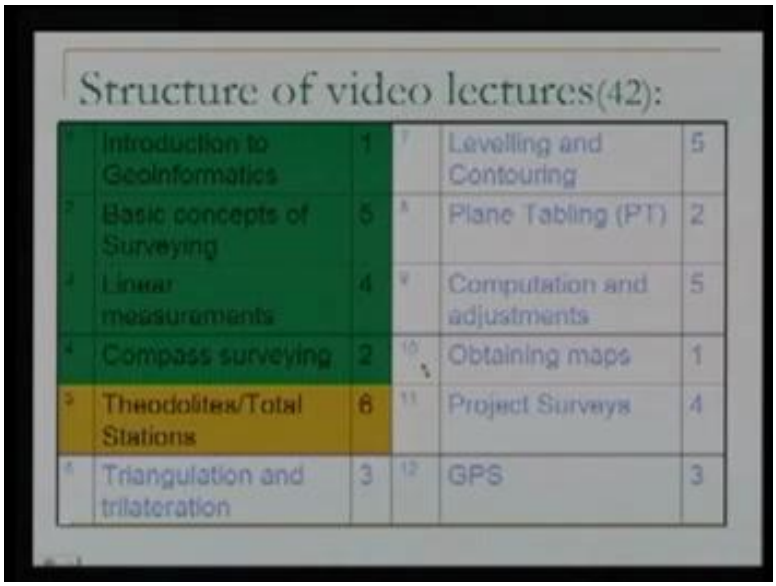

Now, this is the structure of all our video lectures, where we are talking at this place.

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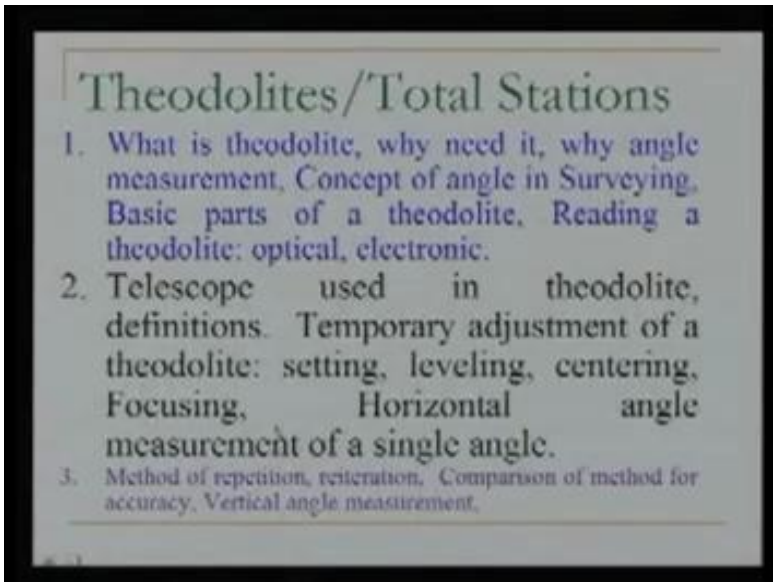

Now, what we have done so far, as first the theodolites and total station all this module is concerned. Today, we are going in the other part of it, we will start with the telescope, how it is constructed you know, what is there inside, what kind of telescope it is. So, we will look into this telescope, which is used in the theodolites. Then we will see some more definitions, which we need to know in order to go further, while we are teach reading about theodolite. Then we will see some temporary adjustments of a theodolite,

these are setting, levelling, centring and focusing. And then finally, we will see how we can make use of these in order to measure one horizontal angle. So, this is all we are going to cover today.

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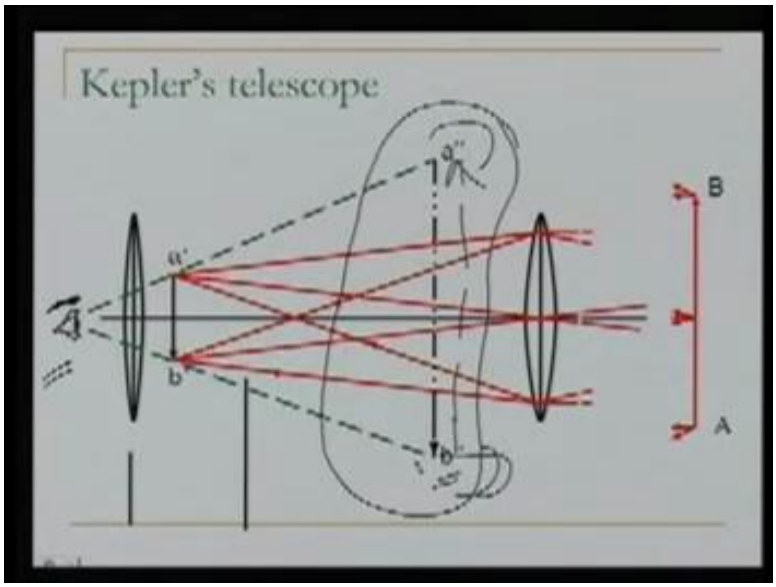

Now, to start with the telescope, what is the telescope is this? This telescope is Kepler's type telescope. You must have done in your physics classes that there are different types of telescope. This Kepler's type telescope and as you can see here, now we have seen in our last lecture also, this is the objective, objective lens, thus the eye piece here. Now, how it functions? The object is somewhere here on this side. The rays from the object are passing through the objective; they are creating an image somewhere inside. Now, this image is brought into the within the focal length of this eye piece or this lens here. And this is how the image is generated, the final image which you observe.

Now, we will see the line diagram of this. So, to see the line diagram here in this slide, you will see that AB is an object, from this AB that is our telescope. And the telescope means this is the objective lens, and this is the eye piece. The rays from the object, they will form the image of the object somewhere here. So, this is the image of the object, a dash, b dash for the object A and B, is a simple line diagram which you know from your basic optics. Now, this a dash, b dash is placed inside this telescope in such a way, that it is within the focal length of eye piece.

Now, why it done? It is done, if this is the focal length, this distance is the focal length of eye piece. It is done in order to ensure, now what will happen? If it is within the focal length, how the image will be generated. Now, these rays will go ((Refer Time: 03:32)) similarly, they will meet at the focus, now the rays from here passing through the optical centre will go like this, and will go like this. Now, these rays they do not meet on this side, rather they converge, appear to be converging on this side. So finally, we will have the image formed here and this is how the image is formed, and this how the image will look like.

So, for the observer, if the observer is here is looking through the eye piece, what he sees is, he looks at a dash, a double dash and b double dash, which is not the real image, is not the real image. So, this is actually the line diagram of Kepler's telescope, which is mostly used in our theodolites. They may be some extra lens, additional lens which will invert this image. At this moment, the image which you are seeing for a ranging rod, you are seeing a ranging rod inverted.

Though it does not matter for an experienced surveyor, it is all right, but he knows that how the image is generated, and he knows how to take the observations. But, in order to expedite the survey, in order to avoid this kind of confusion, the modern instruments are fitted with some extra optics in between extra lenses. And they will further turn it, and the image will look erected, it will look erected. Now, some definitions here about this Kepler's telescope.

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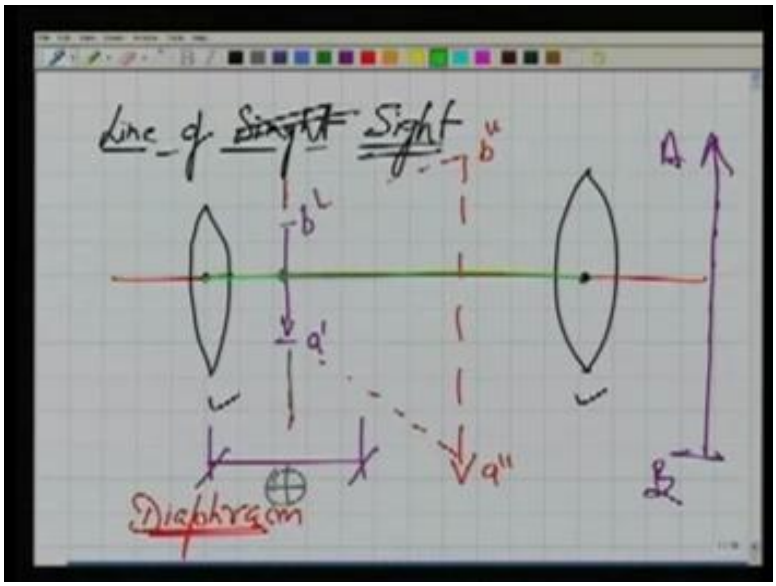

Now, from that terms over here where our inversely images being formed, this place we have one additional assembly, which we said a diaphragm. Now, what is this diaphragm?

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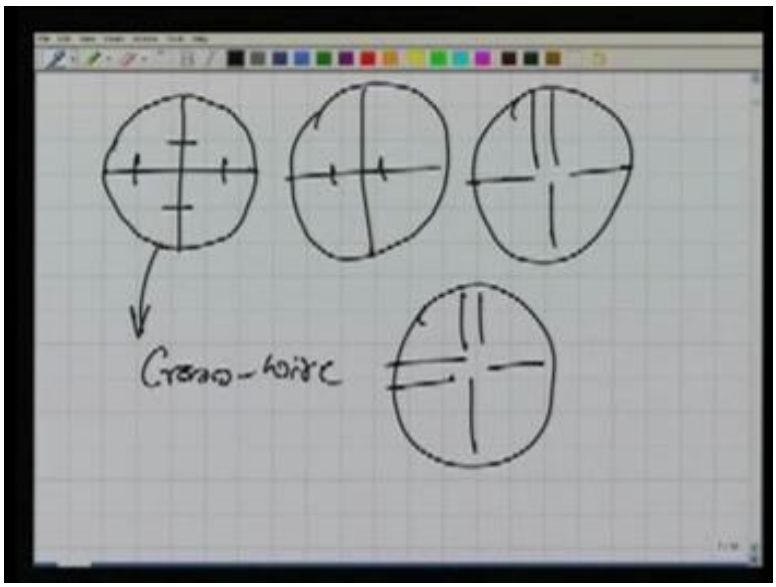

A diaphragm, if I draw. It is a glass sheet, circular in shape and it will have some wires. Sometimes, they are these are the wires or sometimes these are the on a glass plate some marks hatch on it. So, for example, this is the one example of the glass sheet or glass plate on which some marks are hatched. Now, this assembly is a diaphragm or cross wire, there may be various kinds of these depending the instrument or may be depending

the instrument. All these facilitate proper bisection, all these facilitate proper taking of some observations. So, when we look through the telescope what we see, when you look through the telescope for example, if I have focussed this telescope on a tree, let us say. So, what I see?

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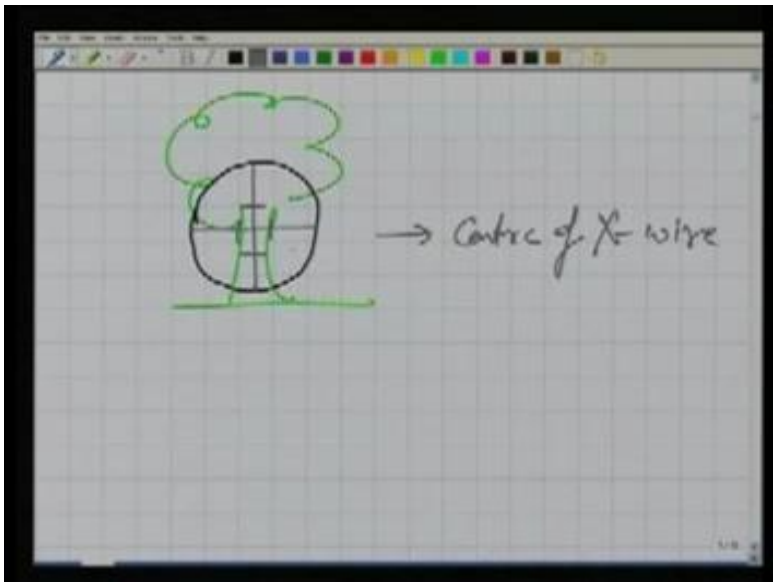

I see the tree and my telescope is focussed on this tree over here that is the field of view. I cannot see beyond this, I can see only this part that is the field of view of the telescope. Now, in this field of view, I will see my cross wires depending what kind of arrangement is there of the cross wires, let us say this is the arrangement. So, this is how, when we look through the telescope, it is looks like this. Now, here in this case, this particular point, if I this centre of here, this particular point is the centre of cross wire, where this is cross wire, and this is centre of the cross wire. Whenever we sight through the telescope, our line of sight is defined by this cross wire.

Because, we are bisecting anything with the cross wire, you see the cross wire, you see the object and you ensure yes, now this is my line of sight. So, the line of sight in the telescope is defined as, as you go here, somewhere here as I was telling you that we have the cross wire or diaphragm, this cross wire is fitted here over here. So, the point centre of the cross wire and the centre of the objective, joining these two, the line form is called the line of sight.

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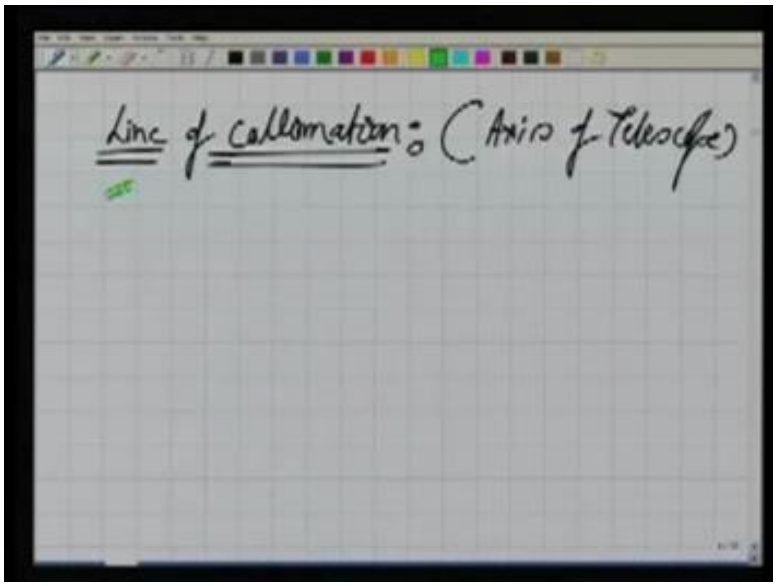

Now, another definition that is of line of collimation, now what is this? This is something of the telescope, this is also called axis of telescope. Now, what it is? Here a line joining the centre of the eye piece and the centre of the objective, if I join these two, then the line which I get is the line of collimation or axis of the telescope. Ideally these two lines, the line of sight and line of collimation should be same; this is how the instruments are made. But, there may be slightly in error also, they might be not consistent, so that is the line of collimation. So, we have seen the cross wire, the line of collimation, the line of sight.

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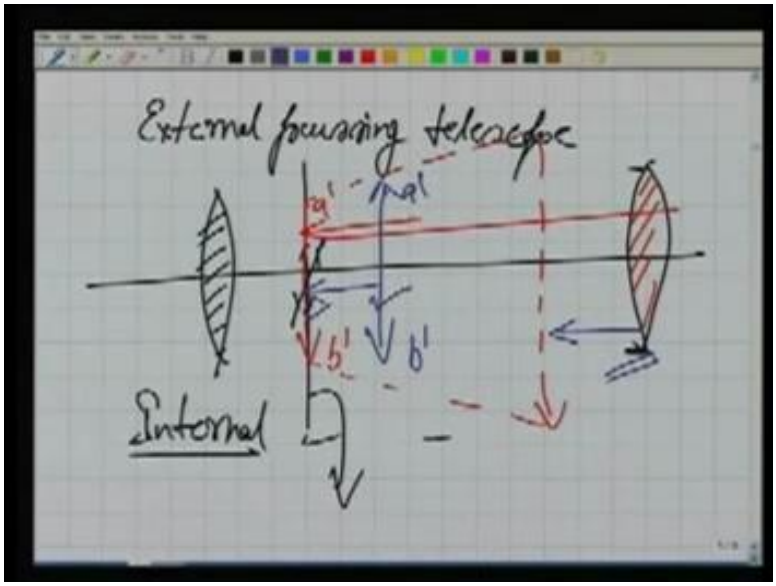

Well, we go further now. Two more definitions, in those definitions we may have an external focussing telescope or internal focussing telescope. Now, what this is, here in this case when I focus the object, what I do, I use the focussing screw here. And I see, when I sight through the eye piece I see the things are focussed. Now, what is happening, basically in the case of the focusing, if you look at the line diagram again, we have the eye piece, we have the objective. Now, the focussing means some where here is the cross wire.

Now, this cross wire is clearly seen by this eye piece, this eye piece is placed at such a distance from the cross wire, but we can see the cross wire very distinctly will talk about that in a moment. Well, what you want, because this cross wire is our frame of measurement, reference of the measurement, you want to bring the image which is formed from here on the plane of the cross wire. So, we want to bring the image here, this a dash and b dash. And then once this image is magnified, the cross wire is also magnified accordingly. So but images, image and the cross wire both are magnified by the same amount.

So, ((Refer Time: 11:09)) focussing this objective means bringing the image, which is formed by the objective they are at the plane of the cross wire, now how can we do it. Let us say, this very first image which is being formed is somewhere here, a dash and b dash. Now, you want to bring this image over here. So, we want to shift this image by this much distance. So, what we need to do, we need to shift this lens by equal amount. So, this lens needs to move, the objective lens needs to move in order to focus this image on the cross wire plane. Now, how it is ensured, this could be ensured let us say in one case.

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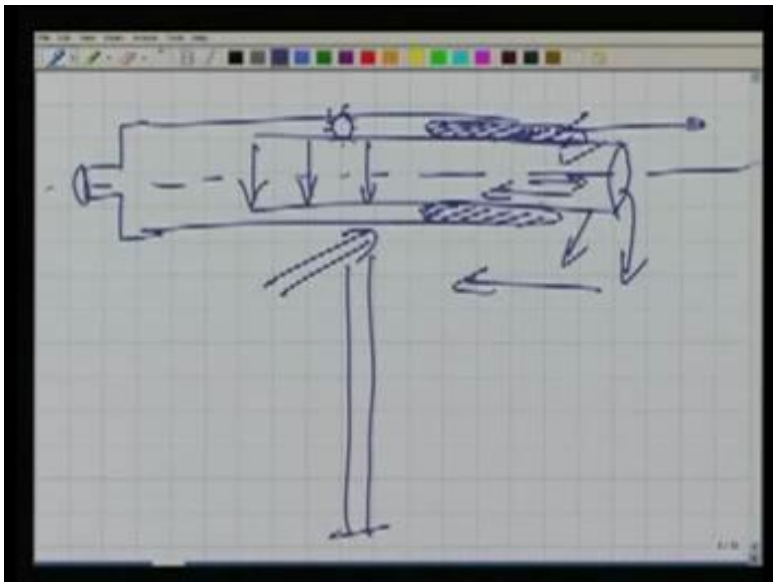

We have a telescope where we have two tubes and that is the objective, and somewhere here is the eyepiece. We have a gear, a gear mechanism and using this gear mechanism, this tube moves inside or outside. So, what is happening? Now, we are changing the location of the image, inside the tube as decide by moving this tube inside or outside. So, this kind of focussing is called external focussing. Now, in the case of the internal focussing, because there are some problems with external focussing, what the problems are? Problem is well, if the centre of instrument is here, now this tube is starts moving here and there, so the balance of the instrument will change.

Then there is a moving part more chances of the errors, you know more chances of this getting this oriented. It is all aligned initially, but this might come down, because of it is weight after sometime. Then this part which is coming out of the tube is exposed to the dust. So, they will be lot of dust in the telescope. So, because of these resonances, this external focussing telescope is not used anymore. Most of the instruments which you find, now will find of internal focussing type, what happens in the case of the internal focussing.

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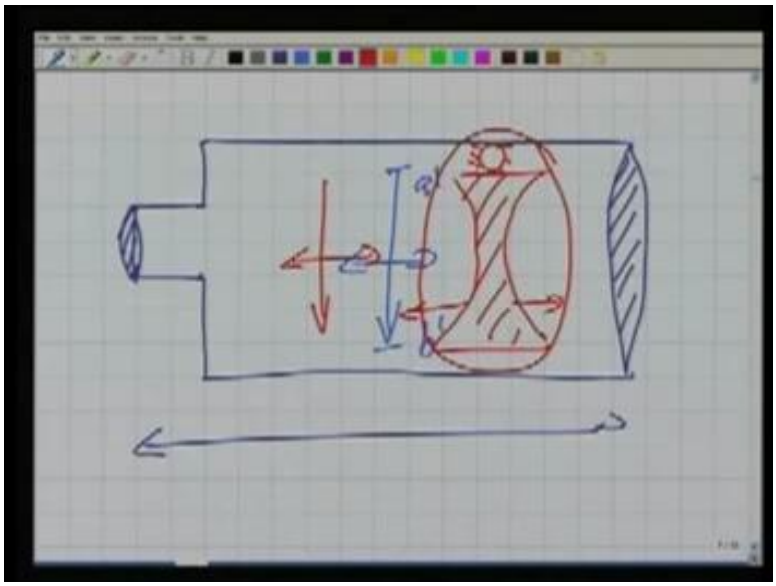

Now, our eyepiece is somewhere here, and that is our body of the telescope, and at the end of this body is the objective. Now, here in this case these two, the objective and the eye piece they are fixed here. Now, if it is fixed how to obtain the desirable thing, moving this image, if there is an image formed by objective, a dash and b dash, and you want to move this image here and there, how to reach at that. For that, there is an extra lens, and extra lens is fitted inside. And now, there is on gear mechanism, and this gear mechanism will move only this lens here and there.

So, because of the movement of this lens now, our image will move here and there. So, now what is happening? There is no tube coming out of the telescope, so the balance of the telescope is maintained. So, as we say in this case, in this case of the theodolite here, if I focus the objective there is no change in the length of the telescope. So, you can now, very well guess, what kind of telescope it is, there is no change nothing is coming out of the telescope. So, this is internal focussing telescope, having done this.

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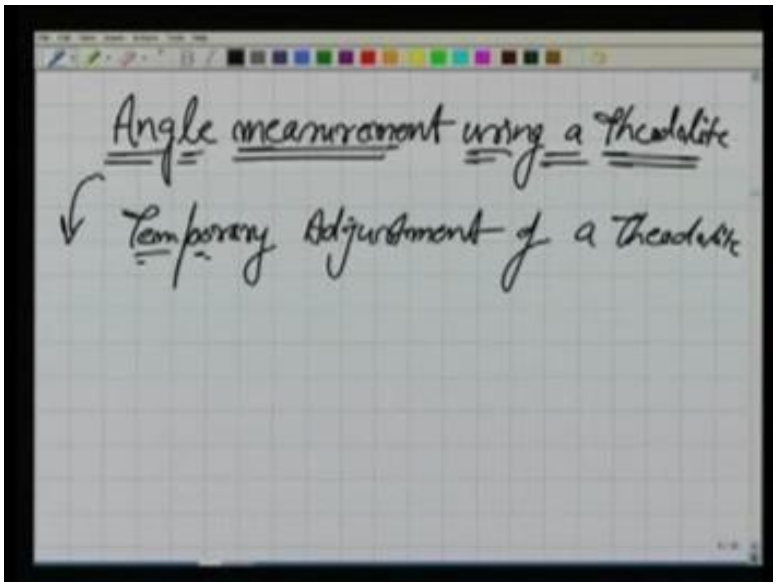

Now, we will go for more important thing. Now, that is called we want to measure an angle, angle measurement using a theodolite, what are the steps, what all we need to when we want to measure the angle using a theodolite. There are various you know it looks very simple, but there are so many steps involved, and that would control the accuracy of the angle that will measure, what are those steps? These steps generally we write as temporary adjustments of a theodolite, what these temporary adjustments are...

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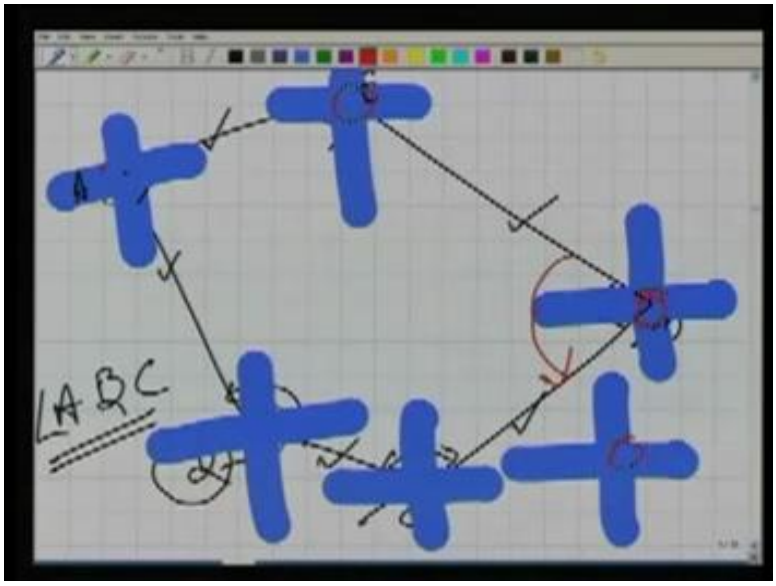

Well, I will give you a problem for example let us say, you want to do a traverse. And in this traverse, you want to you have an EDMI, you are using the EDMI to measure all these lens, you want to measure all these angles now using the theodolite. Now, in order to measure these angles if it is A, B, C, D and E, we have already know why we do the traverse, what kind of uses a traverse can be put to we know that already. Let us say our telescope, our theodolite is at point B over here and we want to measure the angle A, B and C, this angle is required.

So, what all should we do, and once we have measured the angle at B, we move our instrument to C in order to measure the angle B C D. So, again what all we need to do before we start measuring the angle, is it not that we can straight away carry the instrument put it somewhere near the B and we start measuring the angle, no. We need to do some steps before we can take actually the angle measurement. And though the steps which we repeat at each station B, C, D, A, E all the stations, these are called the temporary adjustments.

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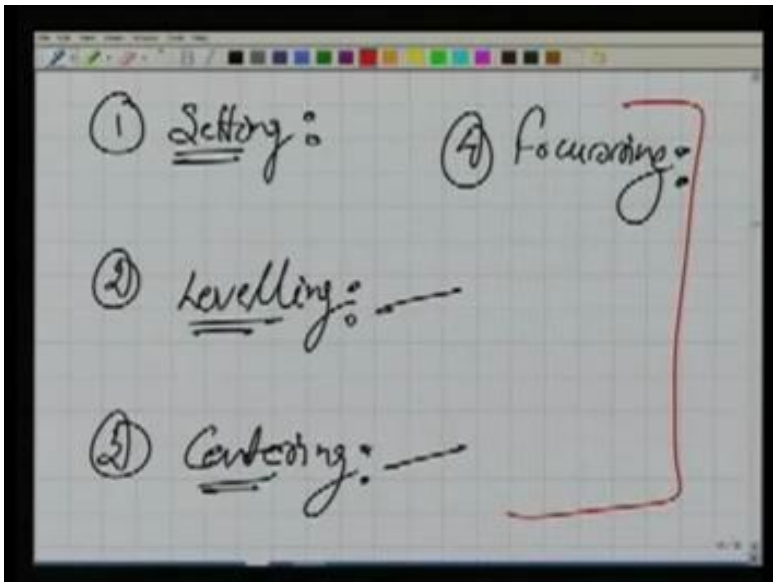

Now, what these temporary adjustments are, we will start with number 1 setting, number 2 will be levelling, and number 3 will be centring, and number 4 focussing. So, what all these are, we will now look into these one by one. Though, some of these are dependent on each other. So, if you do levelling, we have to do a centring after that again after doing centring we have to check our levelling, again after doing our levelling we have to

check our centring, because they are dependent. Now, what all these are and how we proceed with this, this one we are going to see now.

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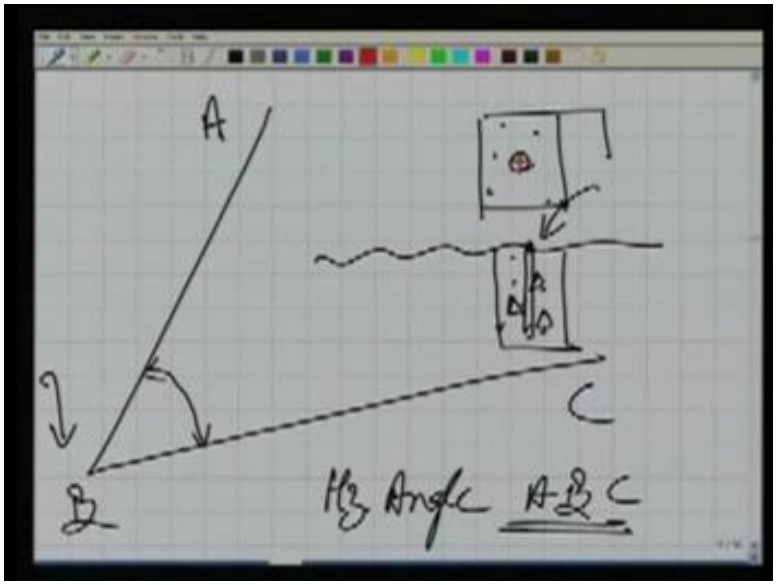

And the problem is we want to measure an angle, let us say A, B, and C this is the angle, which we want to measure the horizontal angle A, B and C. Naturally, first what we will do, we will come near to this station B. Now when I say B, you can see the B here in the drawing, but please think of the ground outside your room, where you are seeing this video lecture, think of that ground, think of the point at that ground, how that point will be identified.

Well, what you have done, because the traverse stations, when you say traverse stations or the survey stations, what do we do mostly? There in the ground we have decided, we are going to take a particular point as a traverse station. Generally we will put either a concrete block, and in this concrete block there is an ((Refer Time: 19:22)), which marks the centre of the station. So, in the plant, it might look like this might concrete block, there is the concrete block and there is a nail, and the centre of that nail is a station.

So, you can look at that centre physically there all these points. The traverse stations are marked like that on the ground or may be, if you are doing a temporary work, what you can do, you can take some paint. And using the paint, you can draw some lines there on the ground, my stations. So, these are the lines, which mark the point. And basically now the job is when you are occupying here, you want to put your instrument over these

points. And this is how you can measure these angles and this is why, we need to do all these temporary adjustments.

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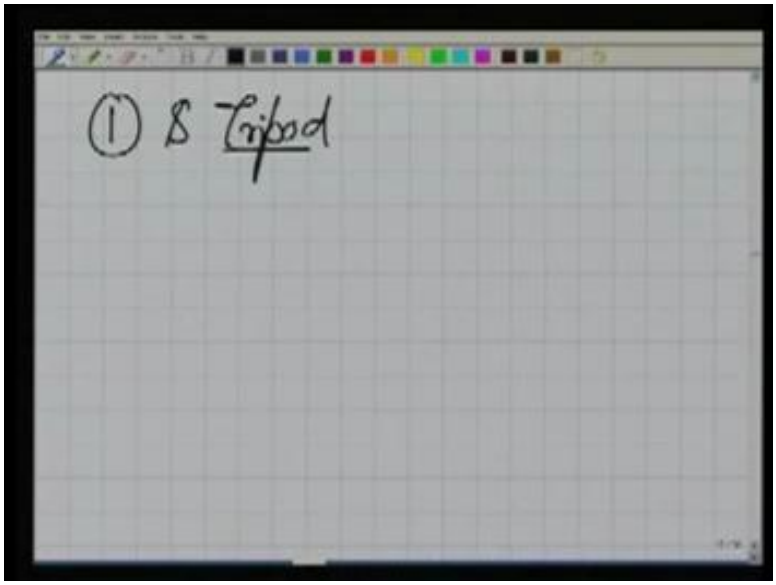

Now, in these temporary adjustments, we will start with 1 about the tripod, what we need to do with a tripod.

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So, here we are maybe we are in the field now, and we are over that point B at which we have to measure the angle. So, the B point is somewhere here in the ground, and you know how that B point is marked, that B point is marked like this may be you know, but

paint or may be on top of that ((Refer Time: 20:51)) nail that we are talking about. So, the point is marked there in the ground. Now, what my job is, because I need to measure the angle A, B and C.

So, I want to put my theodolite, in such a way, that the vertical centre or the vertical axis of the theodolite passes through the point in the ground. Because, the centre of the theodolite means where, when I rotate the theodolite in horizontal, when I rotate it, it is rotating about an axis, thus the point which is the origin about with your measuring all the angles. So, I need to bring that vertical axis of the theodolite over that point, and our theodolite has to be vertical and at the same time, the horizontal plate of the theodolite has to be horizontal, so well I occupy this point.

Now, when you occupy with this point, you start with a tripod. A tripod as you know as you can see here. Now, in this case we can change the length of the legs, we all have the arrangements and by this, you can change the length of the legs. The idea is you want to keep the length of the legs or the height of the theodolite, tripod. In such a way, that after keeping the theodolite on this, the eyepiece should be at my eye level. So, we know approximately well, that is the height of my theodolite and that is where the eye piece will be. So, this is how I decide about this particular height.

The next what we do, first of all we centre this tripod, how do we centre it? We can make use of if you do not have a plum bob, you know the plum bob, if you do not have the plum bob I can make use of even stone, I can drop that stone from the centre of the theodolite, whether it drops nearly around that point in the ground or not. If you have the plum bob, I can suspend this plum bob like this, and it will tell me whether this particular point is exactly over that point or not. So, all these things can be ensured, now having done this.

Next I want to, because this is approximate centring, it is not exact centring exact. Now, to do the exact levelling and centring, what we are going to do. Then I observe the head of the tripod that is the tripod head, I want to ensure that this tripod head is level, because this is required. I will put my instrument on top of this; I will need to make my instrument horizontal, what the horizontal plate of the instrument should be horizontal. So, before I do it in the instrument I should ensure that my tripod head is horizontal.

So, how do I ensure it, it is by visual examination. Now, there are two more movements of the tripod legs. One, I can move the tripod leg circumferentially. Basically, when I move it circumferentially what happens, it will change the levelling, it will not change the centring, so if I move it circumferentially like this. Generally, the centring of the tripod will not change so much, while the tripod head will change it is levelling. So, I can do it for any of the three legs depending their requirement or maybe I can shift the tripod leg a radially outward.

Now, when I shifted radially outward, what happens in that case? In this case, the levelling of the instrument will not change much or the levelling of the tripod head will not change much, while the centring will change. So, what is our aim, when you are working with this tripod our aim is we want to approximately centre it, approximately level it. And by using these legs, the movement of the legs, I gave you two movements, radial and this radial movement, and the circumferentially movement. By doing these, also may be at times by changing the length, you want to change the length of this leg a little bit instead of giving it a radial movement, so you can do that.

So, our finally what we will achieve, we will achieve our tripod is approximately levelled is adjustment, just by adjustment you can ensure it or and as well as, it is also approximately centred over that point. You know at that stage, we will bring our theodolite and put it on top of this. So, one more thing here in the tripod head that important is if I show you like this, we have a move an assembly which can move. So, once I bring my theodolite, I can put my theodolite in such a way that it goes into this bolt. So, this is the bolt for the theodolite. Now, I can bolt it into the theodolite bottom.

Now, having done that to do some fine centring of the theodolite, we use this and this assembly is called centring head. So, I can move it like this and just relax it, and move it like this, and that will do my centring very accurately. So, this is the centring head. So, we make use of this centring head, the theodolite is put just rotation of this and fine centring is achieved. So, we will talk about this again later on. Now, our theodolite is on top of the tripod, we fit it.

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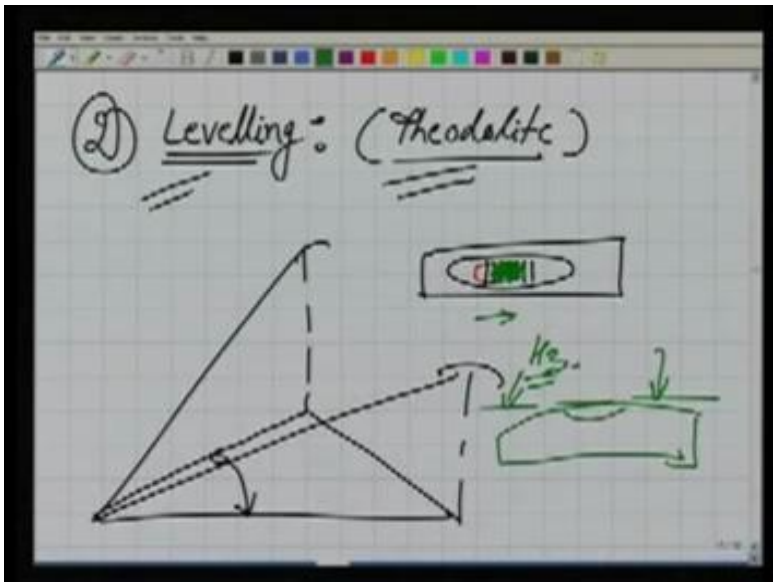

Now what is next, next step is levelling, levelling of theodolite, because so far our tripod head is levelled and centred. Well how to do that, we will follow levelling of the tripod we have three levelling screws, as you can see here 1, 2 or 3, and these are also called foot screws. Now how do we level it, and what is the purpose of it, purpose of the levelling.

The purpose of levelling is we have the horizontal plate here, you know the horizontal plate, and on this horizontal plate using the index we are measuring the angles as we have seen, you want to make this horizontal plate truly horizontal, why you want to do it as we have seen. If there are two objects, we want to measure the angle between these two objects, what the meaning of the angle is, the meaning of the angle is we want to measure that angle on the horizontal plane not on the inclined plane.

So, if there are two objects here, for this here one here, one here. The theodolite may bisect like this and bisect like this, we are interested in the corresponding angle at the horizontal plane, the projected angle on the horizontal plane. So, our measurement or the graduated ring has to be horizontal for this purpose, now how to ensure it. In order to do that, we have a bubble tube here, and we have seen what the bubble tube is, what you want to you know achieve using the bubble tube.

Now, in this bubble tube there is a bubble as we have seen in the diagram also, if I look at that from the top, it may look like thus the bubble that there are some graduations also.

Basically, this bubble needs to come to the centre, centre means it should be if it is levelled, it should be here in the centre this way. So, the bubble needs to be moved on this side, in order to make this bubble tube levelled. And we have seen this thing already, that the bubble is a part of a large circular tube and why it is, so because then only the bubble will be formed, and then only with the movement of the bubble tube here and there, the bubble will move here and there.

And at the and the time when the bubble is in centre for example, that is my tube here, the bubble is in centre at that time, if the bubble is in centre here at that time this axis of the bubble tube will be horizontal, this line will be horizontal. Well, you can think of the axis of bubble tube an imaginary line somewhere here that is the line. So, this bubble tube is fitted to the instrument in such a way, that this line is parallel to the horizontal plate. So, in order to make my horizontal plate horizontal or this lower plate horizontal, what I need to do, I need to make this line horizontal.

Now, there may be a case for example, just think here in this case, if this black pen is the bubble tube right now the bubble tube is horizontal, but how about this plane, this plane is not horizontal, this plane will be horizontal only in this case. So, there may be cases when the bubble tube is in centre that if I see the bubble is in centre, but we are not sure, whether the plate is horizontal or not. So, we have to follow a particular step you know particular strategy in order to ensure that this is horizontal, what that strategy is, first of all we put this bubble tube along to foot screws. So, this is the bubble tube, the axis of bubble tube, and these are the two foot screws.

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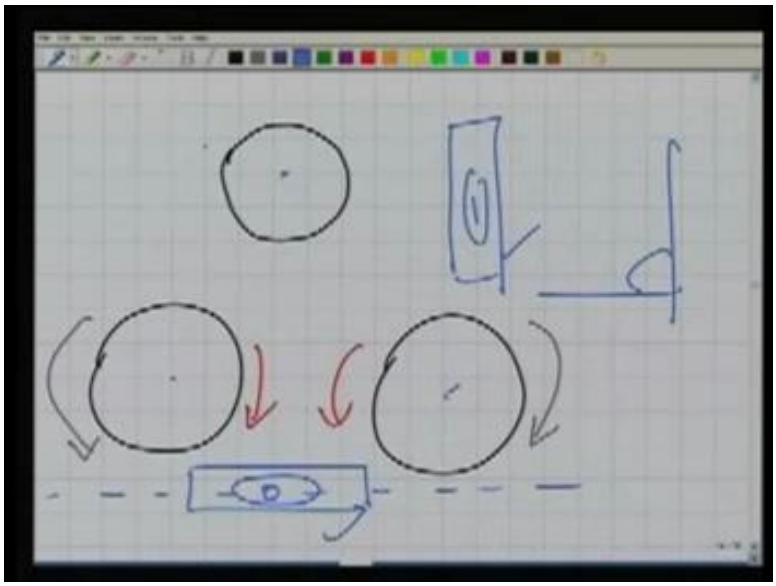

Now, I give the rotation to these two foot screws either inward or out ward together. Either inward or out ward together means these are the foot screws, number 1, number 2 and number 3. And the bubble tube is kept right now, this way parallel to these two foot screws that is the axis of bubble tube. So, then these two bubble tubes are given either inward rotation or outward rotation together. The rotation should be same either inward or outward, why is it done, if I give one outward one inward, then they nullify each you know effect of each other.

And, this is how what is happening, either this bubble tube is going up or going down, because this, what we need to do. Thus the bubble tube I need to either raise it or lower it in order to ensure that this comes to the centre, by doing it the bubble tube comes to the centre. Next, thus this is the case what we have achieved; we have achieved a case like this. A plane there may be plane for example, let us say we start with a horizontal plane, this is the horizontal plane.

Now, for this horizontal plane I can give it two rotations, one in this plane it is inclined, but again this all, this lines are horizontal. Then second rotation what I can give, I can give in this way. So, these two rotations combine together will form one rotation, second rotation. So, initially our horizontal plate may be like this. So, what I need to do, I need to make it horizontal first this way then this way. So, in order do this, what I am doing now, I keep my bubble tube in this direction, direction of the third one, what is the

meaning of this, I rotate it, the bubble tube is rotating now by hundred, by ninety degrees and is along this third screw, thus the bubble tube, thus the third screw.

Now, I rotate the third screw only the third one. Now, what is happening, the bubble tube is either going this way or that way, so that it is in the centre. Now, once it is in centre what we have achieved, it is starting from a plane like this, we first made this line horizontal, this line is horizontal now. Then what we ensure, we ensured we made it horizontal this way. So, if this is horizontal, this is horizontal, the entire plate is horizontal. So, this is what we achieved, by putting this level bubble tube in these two perpendicular directions and using these three foot screws.

This is how the instrument is made levelled. Now, after the levelling, because the levelling will change the centring a little bit, again we need to ensure using the plum bob whether the centring has changed or not, and we again need to centre it correctly. So, we will make use of the centring head, as we saw in the tripod. After doing this levelling as we are saying that we will centre it again.

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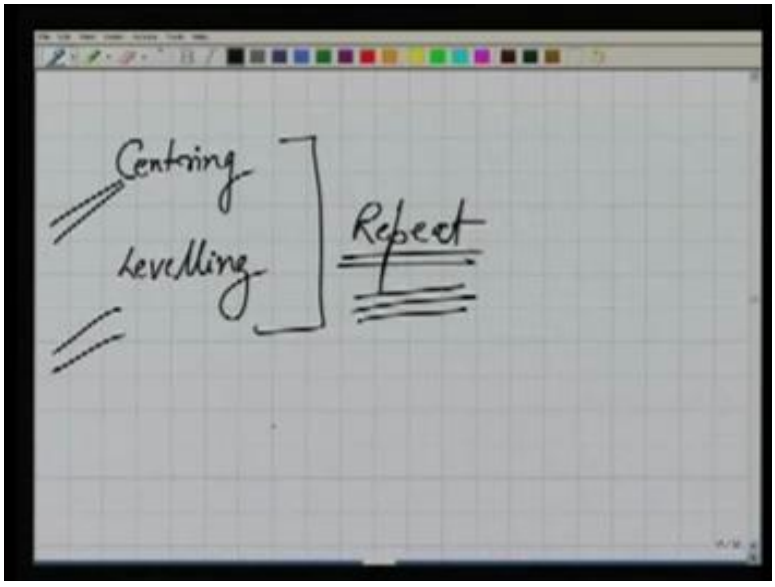

Now, this process of centring and levelling, we will need to be repeated time and again, till we achieve where both of them they converse. The centring is not changing with the levelling or centring as has been achieved, as well as levelling has been achieved, because they are dependent operations, so we need to repeat the each.

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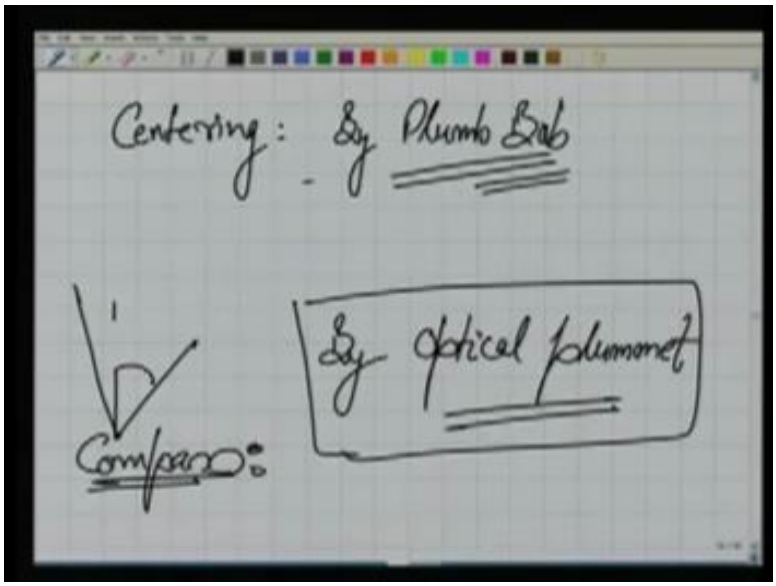

Now, this centering can be ((Refer Time: 33:47)) by plum bob as we saw. Now, one thing in the case of the compass, do we need centring or not, yes we need to do the centring. Because, in the compass also you wanted to put it at a point, you wanted to observe the bearings of the lines at this particular point, yes we need centring. But, in the case of the compass, because the least count of the instrument is very poor, it is not very accurate instrument. So, generally we go for the centring just by using a stone, we drop a stone from the centre of this compass just to ensure, whether we are on the top of that or not. If you want to be accurate, we can go for the plum bob.

So, the centring can be done in very, very rough cases, using a stone you drop it and it will fall over that point. Using plum bob, this gives you accurate centring, there is one more method optical plummet, because in the case of the plum bob there is a problem. If there is lot of wind movement, it is very windy weather and you are doing the surveying in the windy weather. Because, surveying means you are working in the field you have to work on those conditions of the field. So, it is very much windy your plum bob cannot be centred very easily, so you have trouble.

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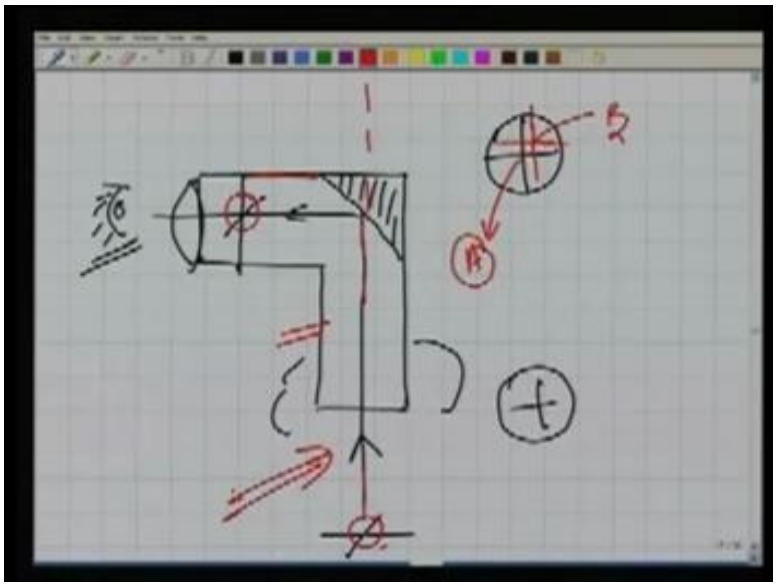

So, in that case we go for a instrument which is called optical plummet, what is this optical plummet, if I draw the line diagram of that it is a very, very simple instrument, it may look like this. Now, here we have a prism and this prism whole is whatever the rays are coming from here, coming from here like this it will transfer them, and here is our eye, now this is the point in the ground. Now, this instrument here in the case of the theodolite for example, if it is fitted with an optical plummet. So, what we will do in the case of the theodolite with an optical plummet, this end here in the diagram is looking towards the ground.

So, this end is looking towards the ground, and there in the ground we have a mark which is for the station. So, if I look through this eye piece here, eye piece of the optical plummet what should I see? I should see this mark. Now, here in the eye piece of the optical plummet, again we have the cross wire. So, the cross wire of the optical plummet which may look like this, and the mark there in the ground. Let us say that red line indicates the station there in the ground, there is a station, what we what our job is we want to align these two points, point A and point B.

Point A is the centre of the cross wires here, point B is the centre of the mark there at the station, and we want to align these two. Of course, the condition here in this cases it should be vertical. So, if it is vertical along the gravity and if it is horizontal, because this optical plummet is fitted to the instrument in such a way it is horizontal. So, this is

vertical and if it is just exactly over this point and we see these two A and B aligned. So, our instrument will be centred, also this vertical axis of the optical plummet is also the vertical axis of the theodolite.

Because, now you can see the vertical axis, the axis about which I am rotating my theodolite is the vertical axis of the theodolite, which you can think of as you passing like this, somewhere here a line can be thought about. Thus the vertical axis about which it is rotating, so we want to ensure it is there. So, this optical plummet will help us to centre the instrument even if it is windy condition, it does not matter, because is making use of the just line up side all the electromagnetic radiations.

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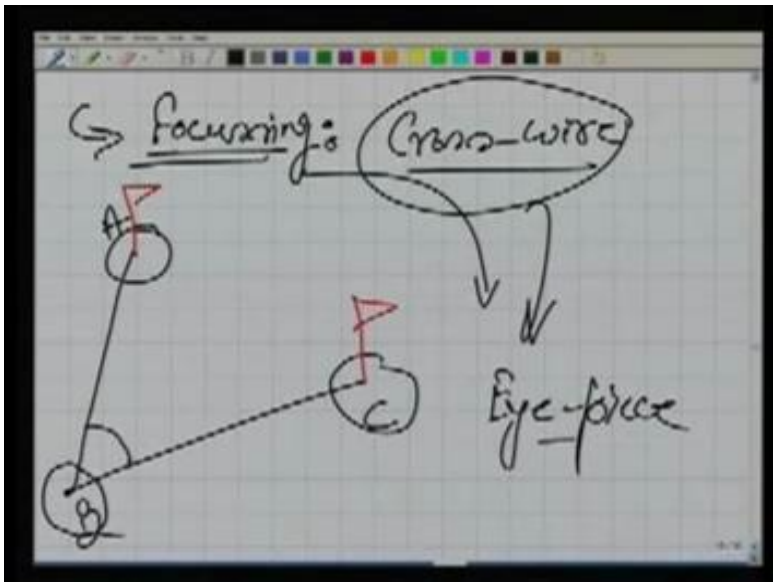

Now, having seen this, our next some more adjustments, which are related to the focussing, what we have achieved so far. Well, our problem was we wanted to measure angle A, B and C and we arrived at this B, we kept our tripod. And after keeping our tripod we centred it, we levelled it approximately then we put our theodolite on the tripod, we clamped the theodolite with the tripod. And then we levelled the theodolite and then we centred the theodolite also using precise centring using centring head of the tripod.

And then once it is finally centred and as well as levelled, we are ready to take the observations, because we have made our horizontal plate to be horizontal or this lower plate, where the graduated ring is it is horizontal now. Now, we can take the observations

for the angles. Well, what will be next step, next step will be well that for example, let us say this B point is where, where I am standing, A is somewhere in this room on that side and the C is somewhere in this room on this side. So, if it so what I will do, at A, there is something either a tree or a ranging rod some object is there which I need to bisect.

So, I am bisecting now the ranging rod at A. So, in order to bisect what we will do as we have seen. First, we will make use of the target sight, because the field of view of the telescope is very small. So, making use of the target sight, I bisect it. Well, that is bisected using the target sight, I clamp the lower clamp, the upper one is already clamped, I clamped now it cannot move. Now, I look through the telescope. Now, when I look through the telescope I need to see the object very, very clearly, also I need to see the cross wire very, very clearly.

The cross wire, because cross wire is the frame, we have seen the cross wire we know the utility of that, because the cross wire as such is somewhere here, the diaphragm is fitted here, the cross wire is fitted here, somewhere here. Now, what I need to do, I need to see this cross wire very, very distinctly why, because the image of the objective, we frame we form it on the plane of the cross wire. If I can see the cross wires very distinctly our see the image very distinctly. And we need to bisect the object, whether ranging rod or the pole very, very you know with accuracy, so I need to see distinctly.

So, the very first step in the focussing is, we need to focus for cross wire, and that we also say focussing eye piece. Now, how do you focus the eye piece, well to focus the eyepiece what we can do, we can make use of a white sheet, I put it in front of the telescope or you can turn this telescope towards the sky or any white background, where we can see the cross wires very distinctly.

Well once it is, so I now focus the eyepiece and this eye piece needs to be focussed, because it will depend upon my eye. So, if someone else is working will again needs to focus it. So, that we can see the cross wire very distinctly, once I have focussed this eye piece for my eyes. So, I can see the cross wire very, very distinctly, what will be the next job. The next job will be focussing the objective.

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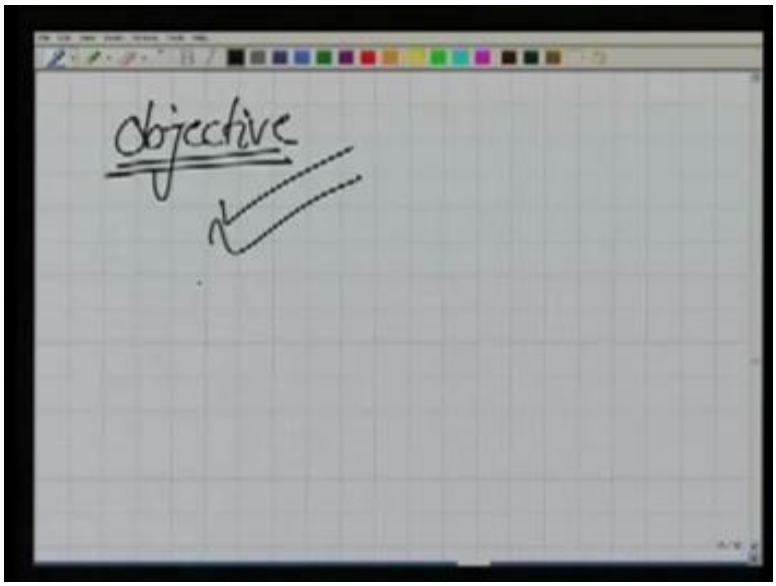

Now, focussing the objective lens, the meaning is in this case is, well we are looking through the telescope, now the object is somewhere in my field of view, what I will need to do, because so far I had bisected only using the ((Refer Time: 42:32)), I will need to bisect it more accurately, and before that bisection I need to focus it. So, I will focus using the objective focussing screw. So, when I am using it what is happening? There inside the telescope and extra lens is moving here inside.

So that, it is ensuring the image which is being formed inside this telescope of the object will finally form on the plane of the cross wire, because I can see the cross wire distinctly, I will also see the image of the object distinctly now. So, this is what is achieved by focussing the objective. That image is formed here in the plane of the cross wire. So, I will start seeing now the image very, very distinctly no forgiveness in that. And at that moment now, I will rotate my tangent screw of the horizontal plate here, as per the requirement to bisect that particular ranging rod exactly.

So, these are the steps, all these steps we need to do focussing the eye piece, focussing the objective and then final bisection. So, once I have finally bisected that particular point, I can see the readings here, what all these readings are? Then I change the upper plate, lower this clamp, we will talk about that in a moment, lower this clamp I change the upper one, same procedure we need to do for this also. I do not need to focus the eye piece anymore, because is the same user who is working with the instrument, but I will

need to focus for the object, because the object distance may be different, shorter or longer then the object at A.

So, again I focus for this particular object up, and then after focussing it I bisect it very correct you know precisely using the tangent screws. And now, I am ready to take the readings in these two verniers again, reading in one these two verniers. So, what it will give me, it will give me the angle value here in the horizontal. So, this is how you know we carry out all these temporary adjustments of the instrument. Now, we will see how we actually measure the angle, what are the methods of measuring the angles.

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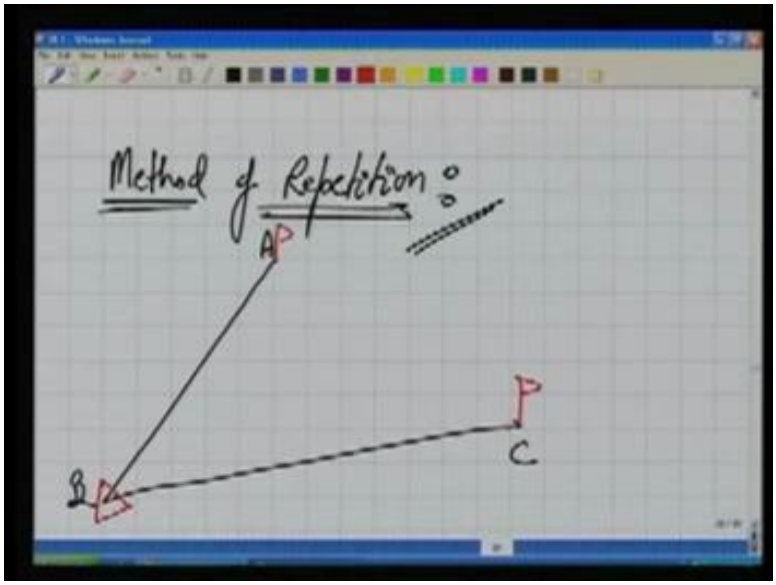

There is one method, which is called method of repetition. First, we will see how to measure one angle using this particular method. Basically well the job is, as we are building always we have A, B and C, there is a ranging rod or some object at B and C. And there at B, we have our survey station, A and C are the ranging rods. And we want to measure the angle A, B and C. We saw just now, this is simple procedure of taking the observation for this angle A, B, C by observing the you know readings on the verniers and taking the difference. Well, what is special about the method of repetition? So, we will talk about that now.

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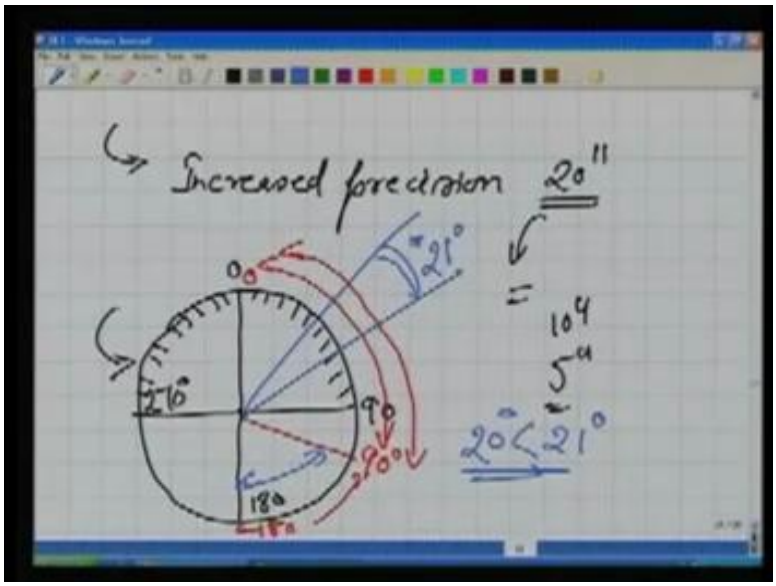

In method of repetition, we try to achieve some extra things. Number 1 we increase the precision, what is the meaning of this? The meaning is if our theodolite is 20 second theodolite, the least count is twenty second. We improve the precision, we try to increase this further down you know may be 10 second, 5 second that kind of you know we increase the precision by this particular method. Number 2, we also eliminate some errors which are in the theodolite.

We will talk about these errors in detail later on, but one error for example let us say, if this is our graduated circle, if you are talking of the horizontal one, the lower one that is the lower one and the graduated circle of this. Now, ideally speaking the graduated circle should be graduated in a very uniform way, uniform means all these graduation should be equally apart that means, if it is 90, 0, this is 90, this 180, and this is 270 and so on.

And also the graduations between should be uniform, but if it is not the case which might be sore, because this plate is manufactured somewhere, there in the manufacturing process there were some defects. And because of that what has happened now, this 90 instead of being here the 0 is here, the 90 is somewhere here, I am just exaggerating it. But, let us say if this is the case, this 180 is here itself there is no change in the 180.

So, the meaning is that the graduations from 0 to ninety or far apart they are larger, while the graduations from 90 to 180 they are nearer to each other. So, if you are measuring only once as we did the process here. We bisected our ranging rod A I took the reading,

then I bisected the ranging rod B or at C I took the reading. Now, if in between, we are only observing from 0 to 90 here what will happen, let us say the angle which was measured was this.

So, the actual angle value is if 21 degrees, what will measure it. We will observe it in the theodolite slightly less than that. Let us say 20, which is less than 21 why, because these graduations are far apart. Similarly, in this part if you are observing, we will be observing a smaller angle to the larger, so this might happen. So, we will try to also you know besides increasing the precision in the method of repetition. We can also eliminate a problem like this, while we are going for method of repetition.

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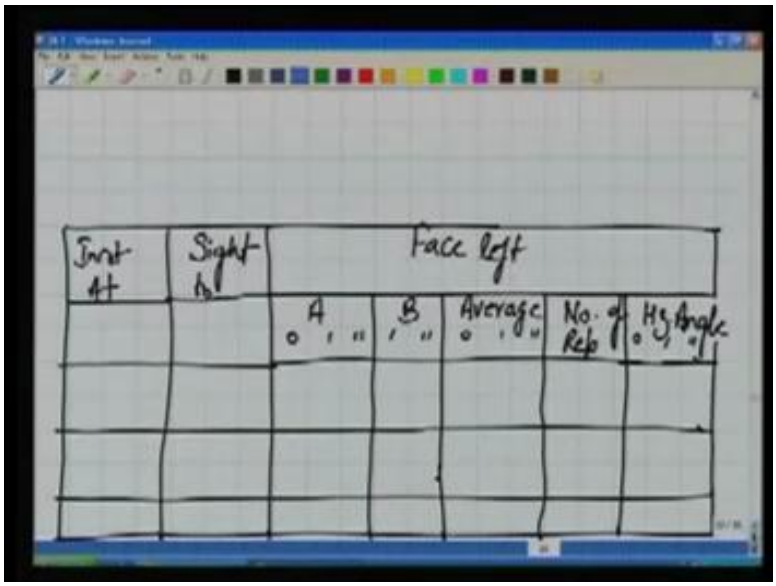

Now, how we do it and how we write the readings are what we do in that particular process, we will do it using this particular table here. And before the table, I would like to give you two more definitions.

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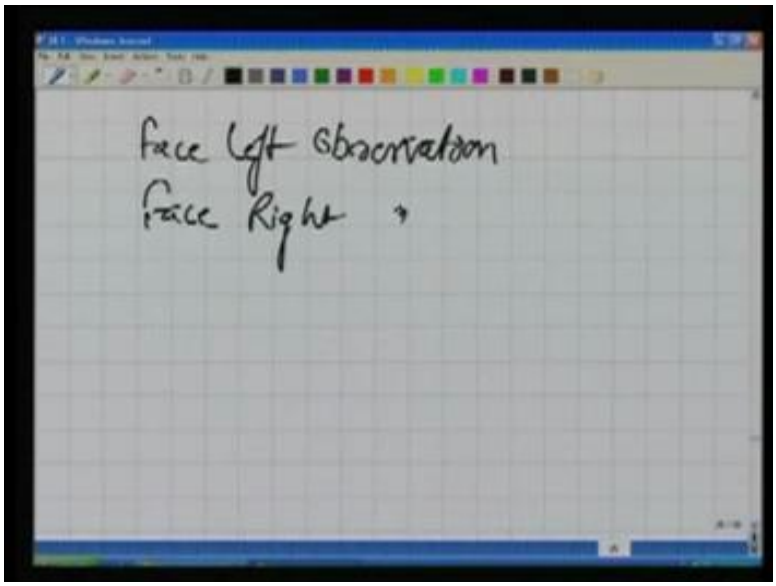

The definition one, number 1 is face left observations, and the second is face right, what these terms are? For me I am here right now, that is the vertical circle we know this is the vertical circle. And if this vertical circle is on my left, and now observations, all the observations which I am taking are called face left observations, how to turn it into face right, I can transit my theodolite. Now, for me to take the observations, I will have to bring the eye piece towards me, so the eye piece is towards me. Now, this face has turned towards my right hand side. So, all the angle observations which I will take now are called face right observations.

Now, it is very clear why we need to do it, we will see later on. There in the theodolite there are many sources of the errors, if you are taking the face right observations I am measuring couple of angles, then I change it, I change the face to face right, then I face left. And now I observe the same angles again, and by taking the mean of those two angles we can eliminate several errors, which are there in the theodolite. So, this will see later on when we are taking about the errors in the theodolite. So, right now we will take it like this, face left observations and face right observations.

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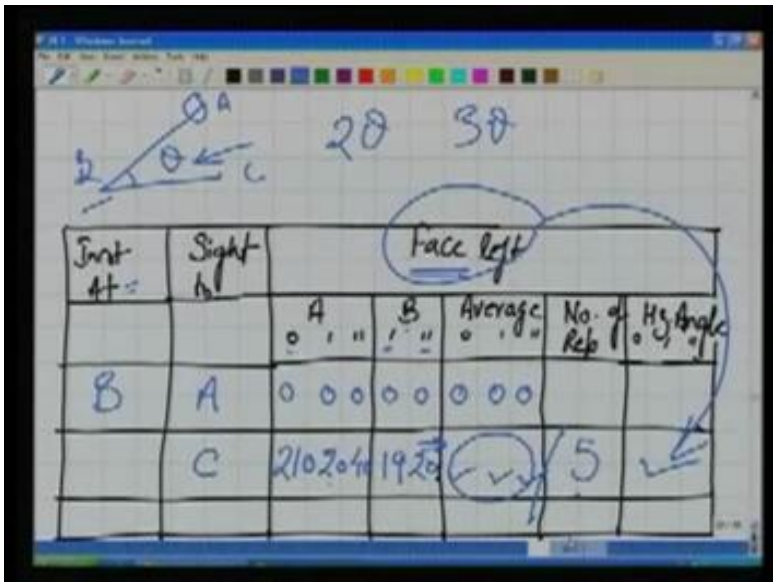

So, the table which I have made here is for face left right now, as you can see here face left observations. Now, what we do in the method of repetition, we will follow it here in the table, as well as with the instrument. And please, follow each and every step what I am doing. Well, as we have seen we have to measure the angle A, B and C, and we are at point B, A is there and C is there. So, very first step, right now you have to follow with me, what I am doing you have to imagine that what is happening in the instrument, because we have already discussed the construction of the instrument.

I clamp the lower one, lower one is clamped, I unclamp the upper one. Now, I can rotate my instrument what do you think, the readings are changing or not, if I look through it, they are changing. Because, what is happening there now, the lower one is clamped, upper one is free to rotate, and if I am rotating my telescope, it rotates like this. So, the readings, what the readings are? These in verniers they are moving on the graduated circle, and we will take the reading, we observing we read the angles against these verniers, because they are moving, so the angle values are changing there.

So, right now this is lower is clamped, upper is free to rotate. So, the readings are changing, what I do, I change the readings, looking through the window here, I bring it nearly to the 0, 0, 0 what is the meaning? The 0 of vernier and the 0 of main plate, they meet each other. So, now at this stage they nearly met each other and I clamp the lower one, we clamp the upper one, lower one is already clamped, I have clamped the upper

one. Now, I look through the eye piece at will see a magnified view of the scales here, then I use the upper tangent, and by using the upper tangent over here.

I am using the upper tangent what I am doing, I am giving very slight movement to the index arm on this verniers in order to ensure that the reading in the reading is exactly 0, 0, 0. Well, the reading is here is 0, 0, 0 this is vernier A, and this is vernier B, because there are two verniers, 1, 2. So, the reading at A is 0, 0, 0 over here the reading will be 180, so that here at the reading is 180, 0, 0, 0. So, what I do, my reading now is 180, so 0, 0, 0, when I say 0, 0, 0, I mean 0 degree, 0 minutes and 0 seconds.

Now, what I am doing, I am releasing the lower one, and I take it to my point A. Now, point A is bisected, let us say I have bisected roughly using the refer sight. I clamp the lower one, the lower one is clamped, I will use the tangent screw of the lower one in order to bisect A correctly that is now bisected. Now, in this process, because the upper one was already clamped, so these two plates they move together. So, there is no change in the reading, A is bisected still the reading is 0, 0, 0.

So, what I do, instrument at the very first thing here is instrument at we know we have kept the instrument at B. We have sighted A sight to A, and the readings at that point were 0, 0, 0 and here, this for vernier A, and this for vernier B, in vernier A and Vernier B. In vernier B, we write only in minutes and second, so it is 0 and 0. If it is not 0, 0 whatever the reading will be we will write that, because there might be some case where it will be, so why we do not write in degrees. Because, generally they will not differ in degrees, if it is 0 it will be 180 generally speaking.

So, only difference will be in minutes and seconds, so that is why we need to write it this way. And then we can compute the average, which will be 0 0 0. Next, now my B is somewhere here, so what I do, I release the upper one, upper clamp is released. And I rotate it to B what is happening now, in this case if the upper clamp is released only the vernier will rotate, while I am rotating this telescope only the vernier will rotate and the angle value will changed.

So, if this angle is theta, it has moved by theta I clamp the upper one. Then I sighting through the eye piece, I sight these C that the C is there, and I use the tangent screw to sight it or bisect it accurately. Now, there will be some reading. So, this reading will be equal to theta. So, I have sighted C, and I can write the observations here, but we are

doing the repetition, so we will not write the observations, you can record it of course, there is no problem. So, the reading here in the scale at the moment is equal to the angle here.

Now, what next we do, we release the lower plate, see upper one is clamped I am releasing the lower one. Releasing the lower one means if I rotate now, what these plates will rotate together, and what is the angle value, the angle value is theta. The reading which is being seen here is the theta, because it is not changing any more. Well, I rotate it, take it back again to the A, clamp the lower one. So, the lower one is clamped, bisect the A using the tangent of the lower one accurately bisected. Still, I am bisecting A, the reading in my instrument is only theta.

Well, next what I do, I release the upper one then I rotate the upper one, again bring it to C. Now, when I am rotating it, the reading value is changing, and once I have bisected C accurately using clamp and the tangent. The reading there in the instrument should be 2 theta. Similarly, if I keep doing it release the lower one, bisect A clamp it the reading is still 2 theta. Then I clamp the lower one, release the upper one, bisect C the reading will become 3 theta.

So finally, depending how many repetitions I have done, I write the final value of the angle here. Let us say, the final value is 210, 20 and 40 that means, 210 degrees, 20 minutes and 40 second. And similarly for the other one here, other one may be 19 and 20. And then I take the average of these two. So, the average of these two will reach here, and what about the average value I will write that average value here, how many repetitions, let us say I have done 5 repetitions. So, what is the value of the angle? Well, whatever is this total value over here divided by 5 will give me the horizontal angle.

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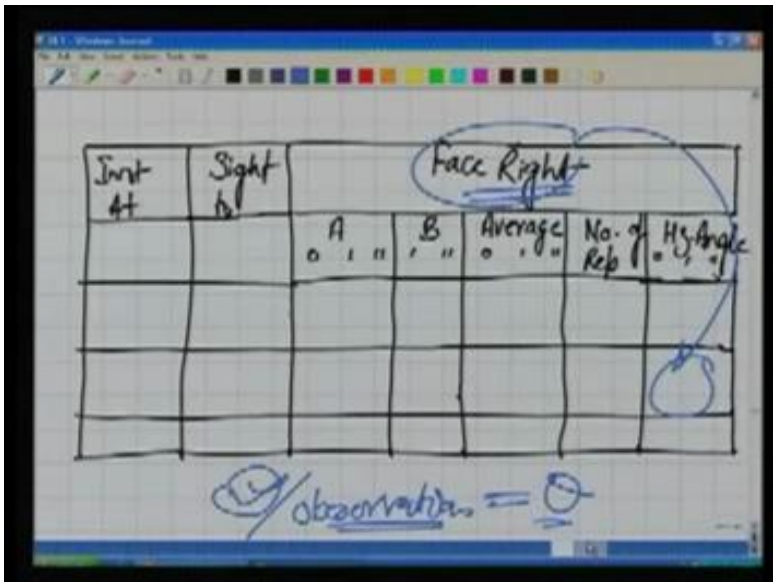

And throughout this process as you will observe, the face of the instrument is towards my left, we can do the same thing by keeping this face towards my right. Well, what I do now, I change the face, the face is towards my right and I repeat the same procedure. I make the readings 0, 0, 0 then releasing the lower one, I take it to the A, clamp it, release the upper one, take it to C and theta, 2 theta and all these process will be repeated.

So, what I am doing mechanically I am adding the angles here, mechanically just by using it theta, 2 theta, 3 theta, 4 theta, 5 theta I am just doing it and mechanically I am adding the readings, and that final reading divided by number of the observations. The final reading value they are divided how many observations were there gives me the angle value theta. So, we have now from our pervious table the angle for face left, and as well as from this table angle value for face right.

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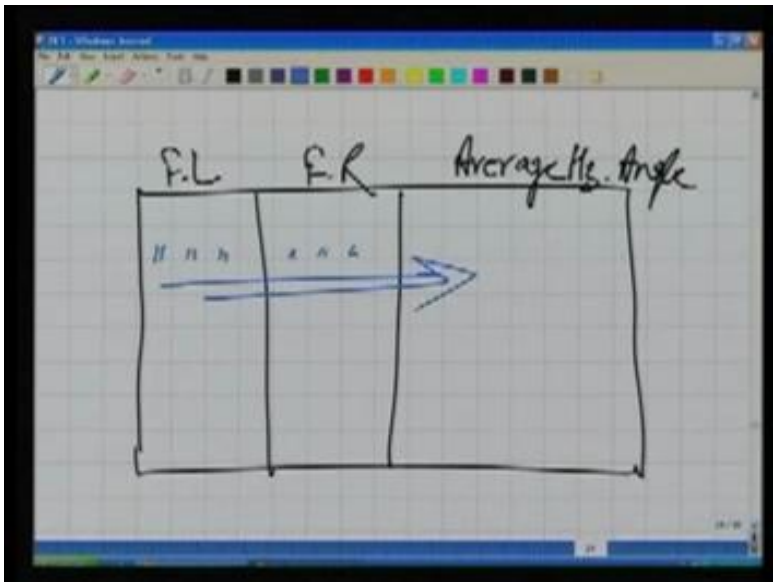

So, finally what we do, we take again we have the angle for face left, face right, and we take the average of these two. We will talk about this later on, why we need to take the average of face left and face right, so this is the method of repetition. Now, it should be obvious to you how we increase the precision, because we are mechanically adding the observation and dividing by number 5 or number of repetitions. So, we are in fact increasing the precision number 1, number 2 the same angle.

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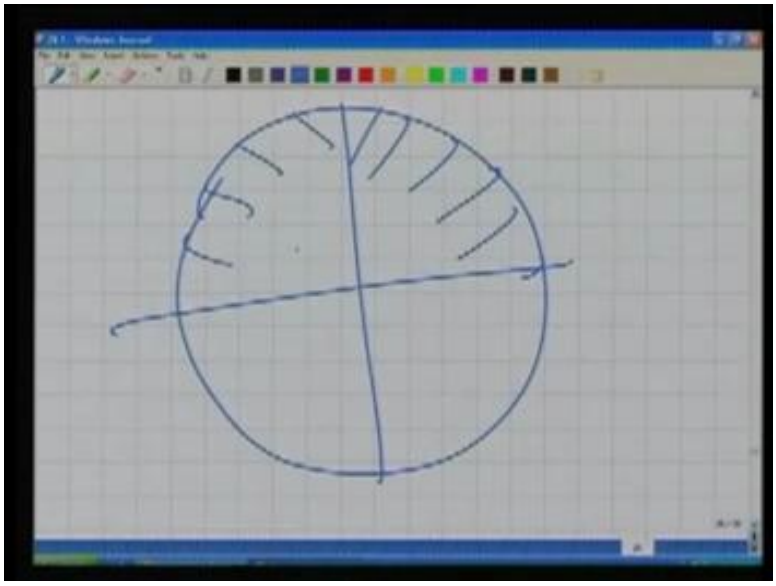

Now, here in this case what we are doing, you observing the same angle in different parts of the graduated circle that.