Surveying
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Module – 5
Lecture – 1

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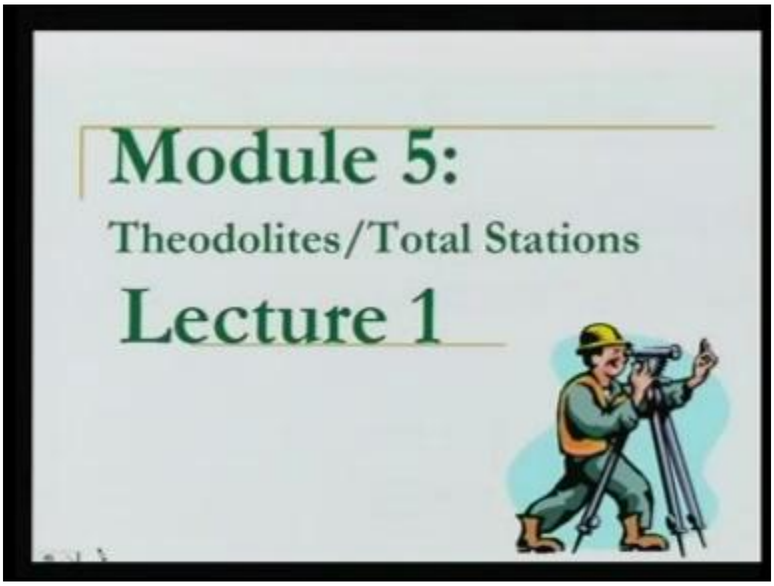

Welcome to this another lecture on basic surveying. Today we are going to start a new module. This is module number 5, and we will be talking about theodolites and total stations in this module. These are the instruments, very important instruments, and we cannot think of doing surveying without these instruments. So, this is really very important module of this entire lecture series on basic surveying.

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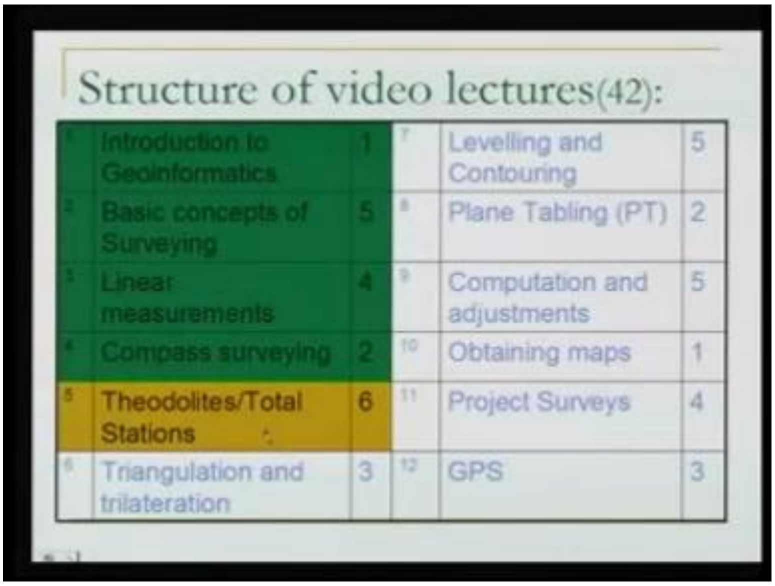

Today our first lecture, will deal with something about the theodolites - some introductory remarks about the theodolite. But before we go into theodolite, we will like to see what we have done so far. Particularly, in our last two lectures or the last module, the last module was about compass surveying and we had two lectures for that. And before we discussed about compass surveying, we also saw the why should we go for compass? You know not always it was possible we saw it, that we can do surveying with only chain or tape.

There are many occasions, when we need to carry out measurements which are angular measurements also in the field. Now, in all these cases whenever the angular measurement is required, we need an instrument which can carry out angular measurement, and compass was one such instrument. So, we saw about this in your construction of the compass, what are the various parts of it? How to take observations, the errors in the compass, all this things you have seen.

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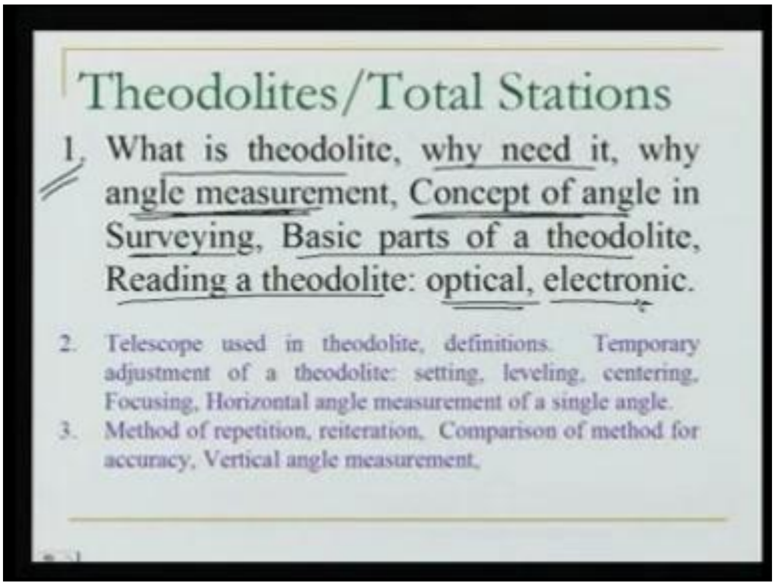

Now, today in theodolite total station, though they are several lectures will you start today, in our first lecture with the what is the theodolite, then why we need it. As I was saying that, we need to carry out angular measurements, we can carry out angular measurements with compass also, so why we need theodolite. Then you will again look into this basic thing, then why angle measurement, so far we saw only the case of a map making there are many other possibilities in surveying, where we need to carry out angle measurements.

Then, this is very important concept of an angle in surveying, what do you mean by an angle, then we will look into the various parts of the theodolite the structure of the theodolite what it is like, and then of course finally, how to obtain how to take the reading from a vernier theodolite. We will see also some electronic circles or the measuring circles, and we will see how they give you the angle value.

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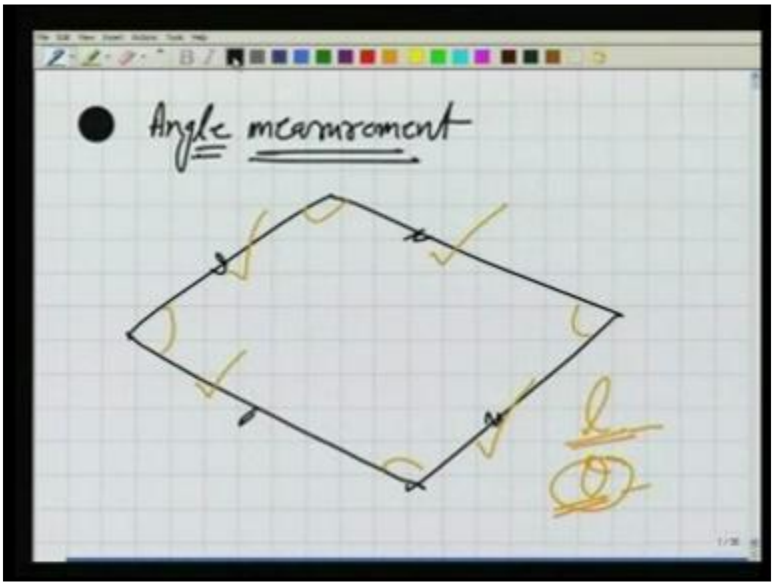

So, before we get into the theodolite, let us talk about something of angle measurement. In angle measurement, you have seen that why we need it just in one example of traverse, in case of bringing the ground to the laboratory or to the computer, or on to a sheet, the drawing sheet the map. We can bring the ground also in the form of, I can say the skeleton of the ground or traverse, traverse is the control network to the control or the skeleton of the ground can be brought into the sheet, we have seen it.

And in order to do the traverse in, we need to carry out these measurements, all these lines and all these angles. So basically, the linear measurements and the angular measurements, we know about the instruments, which we can use for the linear measurement these are the chain, tape or electronic instruments. We have seen one instrument, which was the compass for carrying out the angular measurements.

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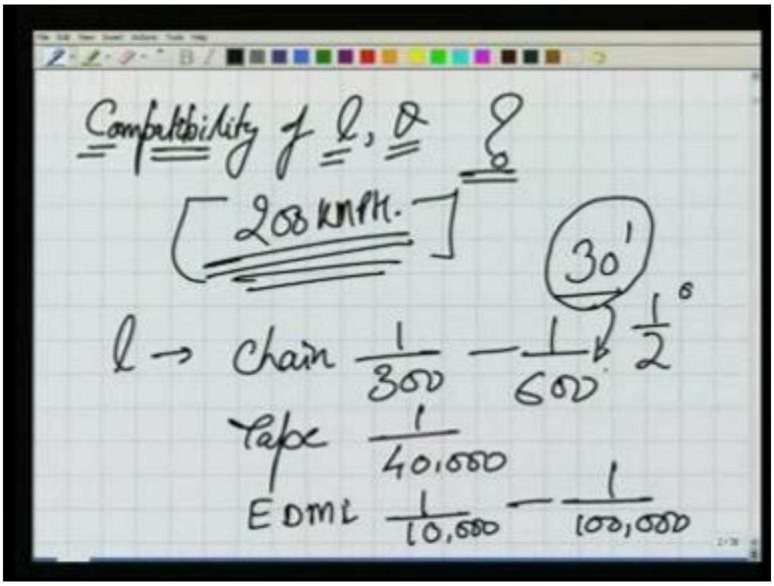

Now, let us see something very interesting, and that is a term call compatibility of angular instrument and linear instrument. We have some instruments, which can majorly linear dimension some to measure the angular value or the angle value, we need to know are they compatible. Now, what is the meaning of compatibility first of all, compatibility if I can give you an example, let us say you are driving a very good car is a very good car very posh car, and it can reach the speed of for example, let us say 200 kilometre per hour, but the road where you are driving this car is having several pot holes.

So really, that car is not compatible with the road, so you cannot achieve your desired thing that is the speed of 200 kilometre per hour. You cannot achieve that, because our road and car they are not compatible they had to be compatible, in order to achieve the result the desired result. So, a similar concept slightly similar concept, not exactly into the same is about the compatibility of our instruments also.

For the linear measurements, you know if you are using chain, we can get accuracies ranging from these are the relative precisions or relative errors, or relative accuracy we can say. So, chain can give you this kind of relative accuracy; then about the tape, tape can give us up to most of 40,000. You can start from 1 is to 10000 to 1 is to 40,000 that kind of accuracies are achievable with the tape with EDMI, we know it we have seen we can carry out the measurements, let us say on the ((Refer Time: 06:09)) at 1 is to 10,000 to also 1 is to 100,000.

Well, so far the instrument which we have seen for angular measurement was compass, and the least count of the compass was 30 minutes or half a degree. Well if you have a instrument of 30 minutes least count is it compatible with chain, or is it compatible with tape, or is it compatible with EDMI.

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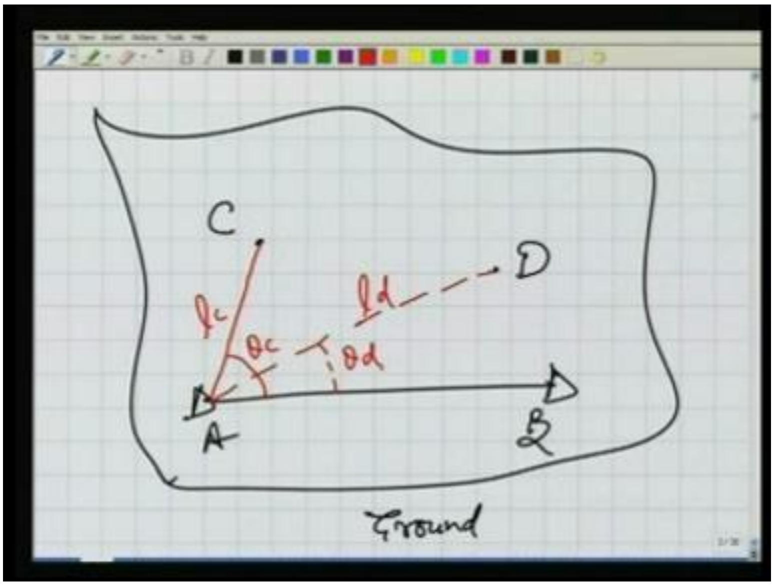

Now, what is the meaning of compatibility here, well let us say this is our ground, and there in the ground we have our survey line A and B they are two points. Point number one which is C, and point number two which is D this is our ground, and we want to plot these 2 points A and B on a sheet or a map. Well, if you are plotting it, what we will try to do, we will try to measure these distances, as well as the angle. Similarly here also, if I show it by dotted line the distance and the angle, let us the distance is l c and l d, and the angles are theta c and theta d.

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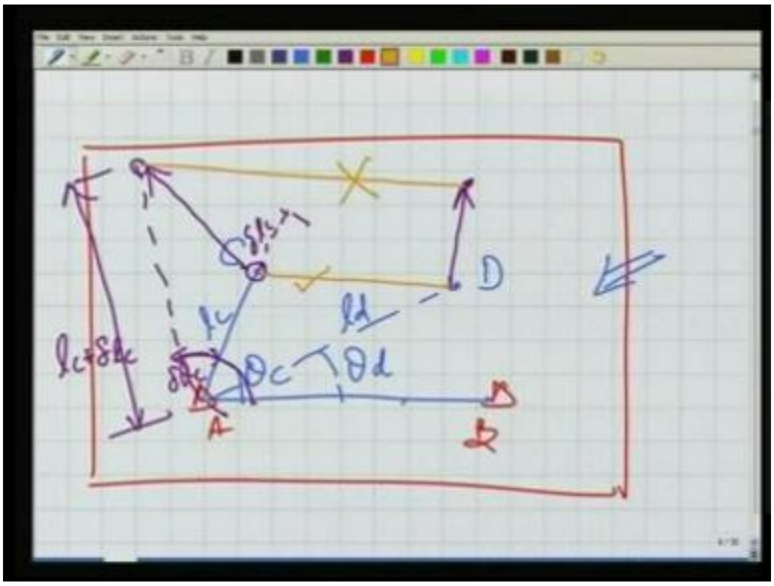

If it is possible that we can measure these values without any error, so what will happen in our map, this is our map we start plotting. So, first of all we plot our control control is A and B, and we know that we have carried out the measurements without any error. So, I will plot l c at an angle of theta c, so the location of c is fixed similarly, I will plot l d and theta d, so locus of D is plotted. Now, in this case of course, whenever we are taking these linear measurements for plotting, we are converting them to the scale, because this is our sheet, so we are converting them to a certain scale.

Well, if there is error, while we are taking the observations here in the ground, our instruments because all the instruments, they introduce some error. So, if you are introducing that error, what will happen instead of l c, we will add up measuring let us say l c plus some error. And here also theta c plus it is l c and theta c, and for l d we can we under placing l d plus l d, and for theta d plus del theta d, so these are the error components. So, what we are doing, we are measuring our observations the required things with some error.

If this is the case what will happen here. Well, if I plot now with the error, so instead of l c I am also measuring del l c, instead of this theta c I am measuring some extra value, it is theta c. So, if this is so the length measure it, this value and the theta angle measured is this, so what will happen? This particular point C will be plotted now here, because this total length which l c plus del l c at an angle. This particular angle is theta c plus del theta c, so instead of this point being plotted here, it will shift it is position.

Similarly, this point will also shift it is position may be somewhere here, wherever there is a new position because of the error. So, what we see here the important thing, these two points with had some geometrical relationship h is now. So, this geometrical relationship here is not here, so the error in the instrument is resulting in this, coming back to our original thing the compatibility.

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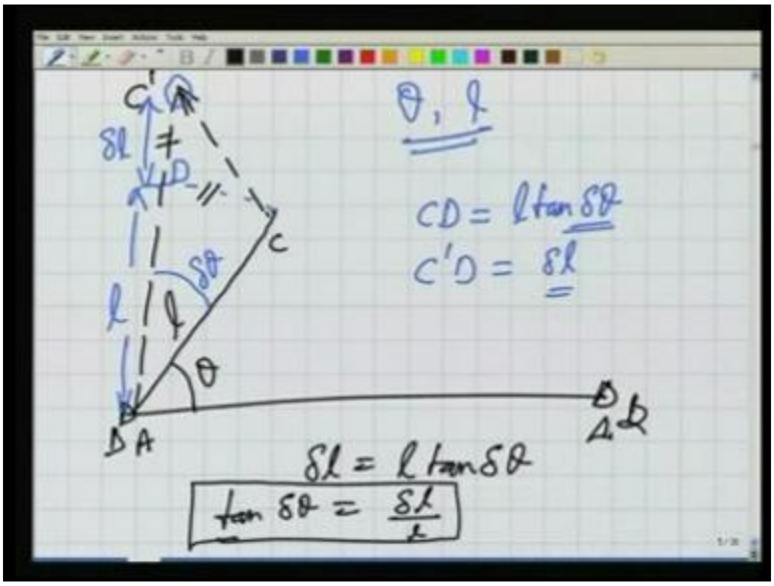

Well same line A and B, this A and here is B a point C we want to plot this point, let me write the C somewhere here, well this length is l and this angle is let us say theta. Now, with the error, what will happen as we have seen with the error, this particular point C is being plotted now, somewhere else, which we say as C dash. So, it is being shifted, thus the shift of the point from it is original position, and this shift is because of number one, if I take an arc here.

So, this length is l and this extra length is del l, the error not only this, this angle is theta and this extra angle is theta. So, what is happening here, as we can see here this is the shift of the line due to angle, while this is the shift of the point due to error in length measurement. So, due to angle error, length error and this is how our point finally, reaches here to the C dash. Now, in order to have the compatibility, compatibility means both the error in angle and error in length should be nearly same. If it is, so you can very well see over here.

Well, if I am write this point as D, so C D which l tan del theta, because this the angle is del theta and this length is l. And C dash D, C dash D is the value here, this particular value is del l, so this is the error because of angle, this is the error because of the length. So, this two values should be same. So, for compatibility if they are compatible, l should be same as l tan del theta. So, from here you can write tan del theta should be del l by l, so this is the condition this should be satisfied, if the instruments are compatible. Compatible means, this particular value the shift is as same as this shift.

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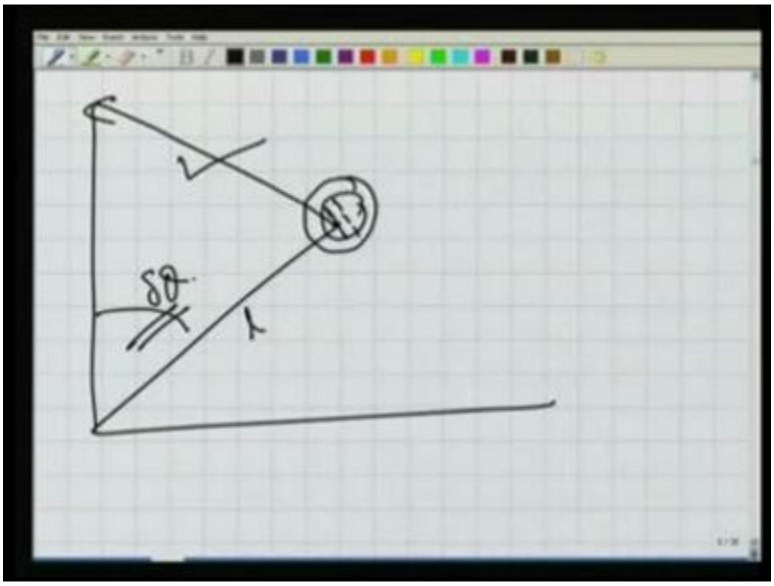

Well, if the instruments are not compatible, what will happen? There is very little error in length measurement for example, very little error how about the angle measurement, error is this large. So, what will happen, even if this error is very small this point is going to be shifted by this much amount, because useless, it is something like you know, we our one instrument is very poor in measurement, while the other one is very precise.

We should not use that kind of arrangement, because using this instrument or this precision instrument is useless here, because the other instrument, angle instrument is introducing the error, this is why the concept of compatibility comes here.

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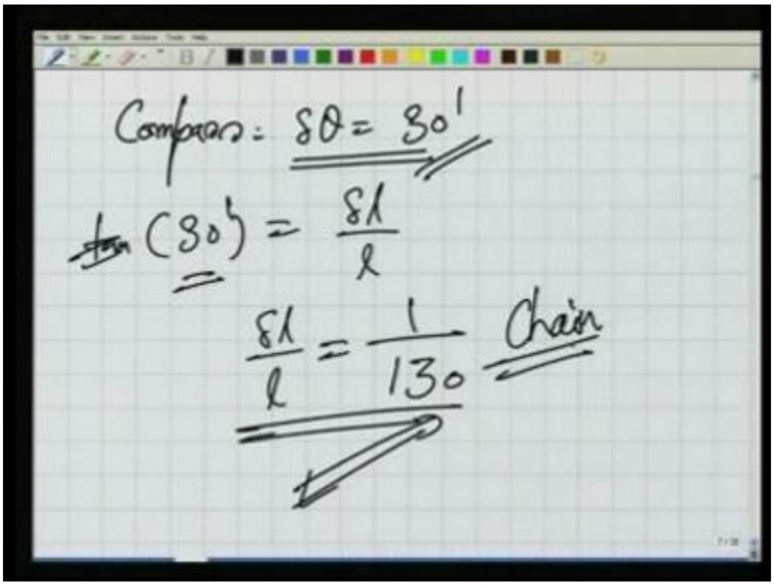

For our compass, let us consider del theta is 30 minutes, because the least count of that instrument is 30 minute and we are just considering right now it is 30 minute. So, if it is so 30 minutes should be equal to del l by or we can write tan of theta, but it is very small angle so we just leave it like this and radiance. And if you find the value, the value over here you will find del l by l comes out to be somewhere nearly 130, you can do the computation.

Now, what does it indicate, it indicates if we are using compass, we should use an instrument for linear measurement, which is giving this kind of relative error. So, of course chain, so when you are working with compass, we should not use along with that the EDMI, because they are not compatible have you understood this.

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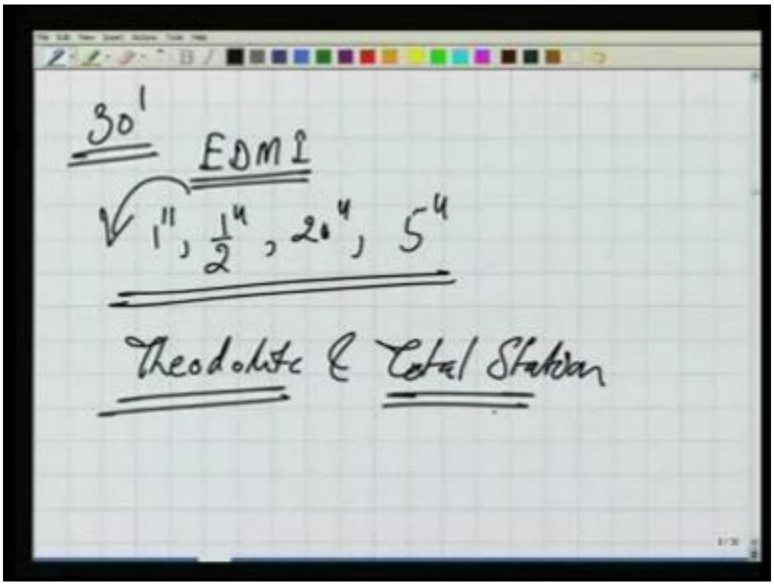

We know compass gives this kind of least count, there is because we have the EDMI, which are very precise instruments. So, we should have equally precise instruments for angle measurement also. So, are there in instruments for that, which can give the least count, let us say directly we can say least count at the moment, but we will always say in terms of the standard error or standard deviations of the measurements, which can give the least count of 1 second or half of second, or 20 second, 5 second are the instruments like this, yes the answer lies in theodolite and total stations now.

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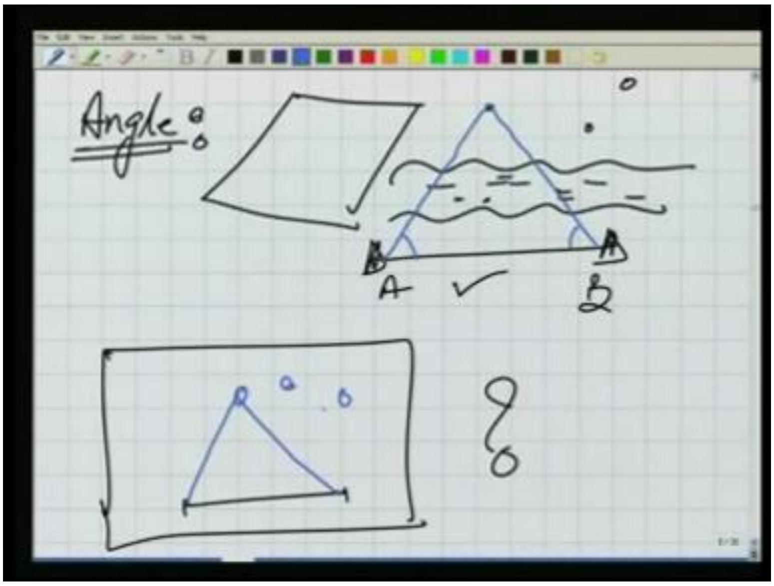

So, this is one reason why we need to go for the theodolite, the another reason why we need to go for the theodolite, is again we are re budgeting, why we need to measure the angle, we need to measure the angle for variety of reasons, we have seen to draw a traverse form a line, this is the survey line there is a river here. We know these two points A and B, and there are couple of towers here, we want to plot these towers with respect to this line. So, what we can do in our map, I can plot line A B.

Well, the question is how to plot these towers, we cannot measure the distance across this river, is not possible to go there. So, with the angle measurement now, if we can measure angles in horizontal like, this angle here and this angle. So, we can easily locate this points, so all these points which are not accessible, approachable can be look at it.

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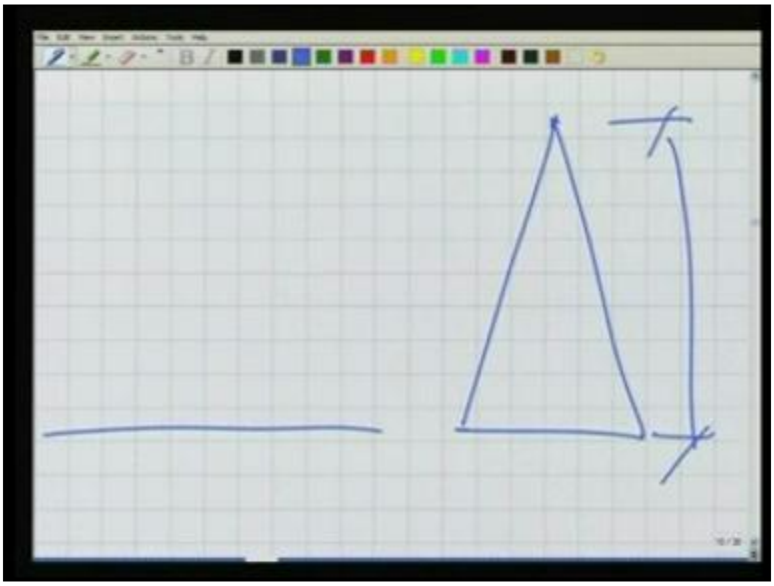

Similarly, another example you might have done in your trigonometry also, if there is a tower like this you cannot climb this tower, but it still you want to determine the height of the tower, how to determine the height? The interesting problem of the Taj mahal, one the towers of the Taj mahal it is said that they are getting eccentric, they know some inclination is being introduce in those, because of some foundation problem whatever the problem. So, if you want to observe monitor that how these towers are tilting, you need to carry out angle measurements.

So, you will go for some very precise instruments like theodolite or total stations for taking measurements like that, so because of these reasons we need to use the theodolite.

Now, till I reach totally station I will keep saying theodolite, because total station and theodolite basically the principles are same, total station is an advance version of theodolite, which also have some distance measurement thing within it, which also has some extra softwares in order to do some computations. So, we will go to total station later on, but henceforth will only talk about the theodolite.

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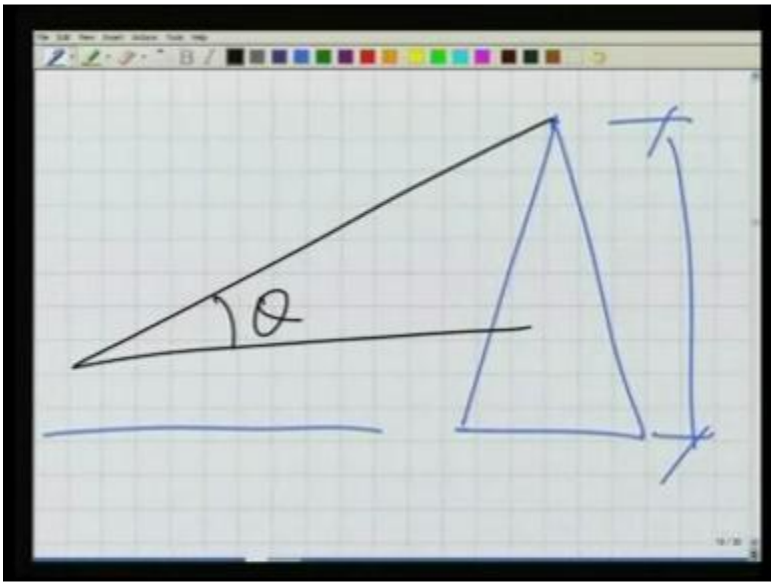

So, we have seen now, why we need the theodolite for vertical and horizontal angle measurement, because in a problem like this as I was saying here. We need to measure the vertical angles, not the horizontal angle. So, we can measure the vertical angle also with the theodolite.

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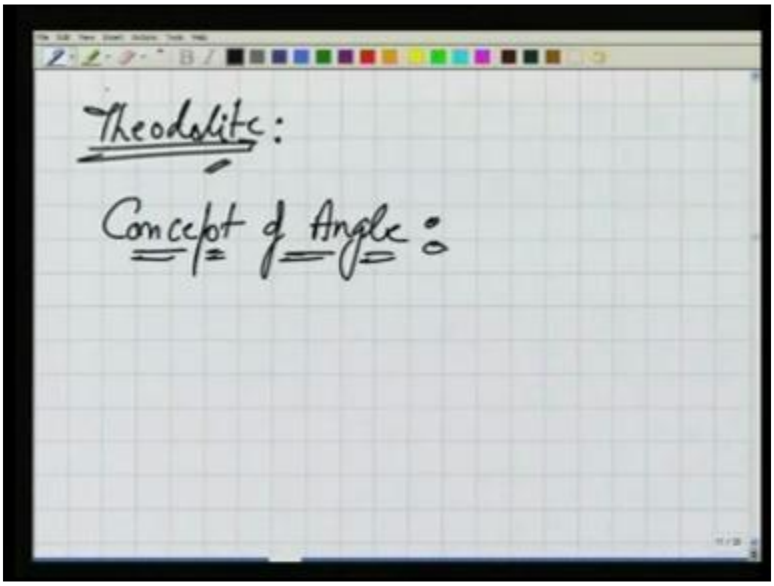

Now, I am coming to the one basic thing that is concept of angle, what do you understand by angle in surveying. It should be understood to you by this time, but nevertheless out thought that I think that, it is advisable to repeat this thing or to revisit this thing, that what do we mean by angle, when we talk about angle.

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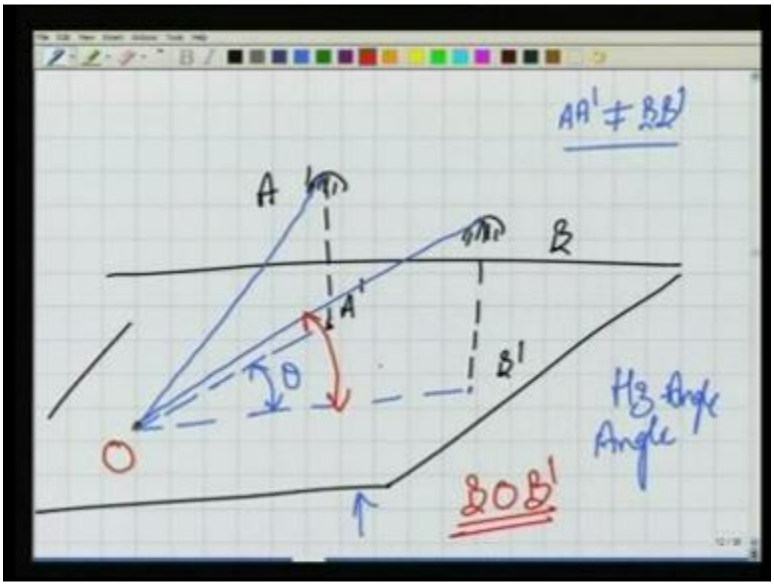

Let us say I am going to draw a little figure here, let us say there is a plane and there are two objects one and two this is A, and this is B. If I project these objects, they project at this point, at this point I write it as A dash and B dash, somewhere here we are standing.

Now, from this point I want to measure the angles, let us say the angle that I want to measure is two object A, and to object B also I rather let us put this problem this way. I want to measure the vertical angles for A and B, and as well as the horizontal angle between A and B. So, whenever we said this horizontal angle between A and B, what do we mean?

We mean the angle between the lines which are projected on this datum. So, the angle between A and B is this angle theta, which is on the projected plane on the horizontal, so whenever we say angle in surveying, we mean the horizontal angle, unless we specify that angle is an certain plane or something like that. So, it is always the angle in horizontal plane, we should always keep this thing in our mind. Now, here as we see the objects are at different elevations, this particular value A A dash is not equal to B B dash. So, the angle between A and B is angle between A dash and B dash, which are the projected points A and B on this plane.

Well, how about the vertical angle, this is about the horizontal angle or simply angle, what is the vertical angle? The vertical angle as you can guess easily, is the angle in vertical plane from the horizontal line. So, for B object at this point where observer is, the vertical angle is B O B dash is the vertical angle, and as is seen in the diagram this is an angle which is in the vertical plane. So, always we measure the vertical angle from the horizontal surface or a horizontal line, and thus our vertical angle. So, we should keep these things always in our mind, whenever we are talking about the angles.

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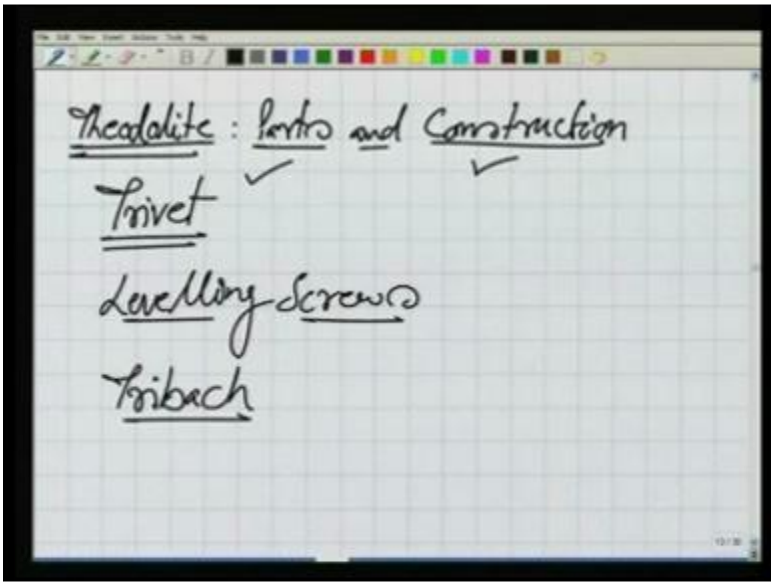

So, now we start talking about the theodolite, and here is a theodolite with us, what we will do first. We will start with the parts and construction of theodolite. As I told you that the theodolite is basically for angle measurement, the horizontal angle measurement and the vertical angle measurement. Well, looking into the parts of the theodolite, first of all if you begin will begin from the tripod, tripod is these three legs, we make use of these three legs in order to support the instrument on top of it.

We will talk about the tripod later on, however in the tripod besides these three legs, we have the tripod head, and in this head we will see it in some more advance kind of tripods, there is a centring head. So, we will see that centric head and use of that later on. Now, coming to the theodolite, here in the theodolite the bottom most plate which is fitted to the tripod, over here we can see this is called trivet, on top of that trivet we have levelling screws.

Now, where are the levelling screws, there are three levelling screws here one, two and three. We will see later on, that we can make use of these screws, in order to make the theodolite horizontal, what is the use of that? Why we do it? We will see all this things later on, but these levelling screws can be rotated in order to raise or lower the instrument, or the levelling to change the levelling on the instrument. On top of that, we have a plate that is called tribach, now this plate the tribach, if you go further up though going for the up over here I can rotate it also, so what is there over here is a horizontal circle, it is a graduated circle.

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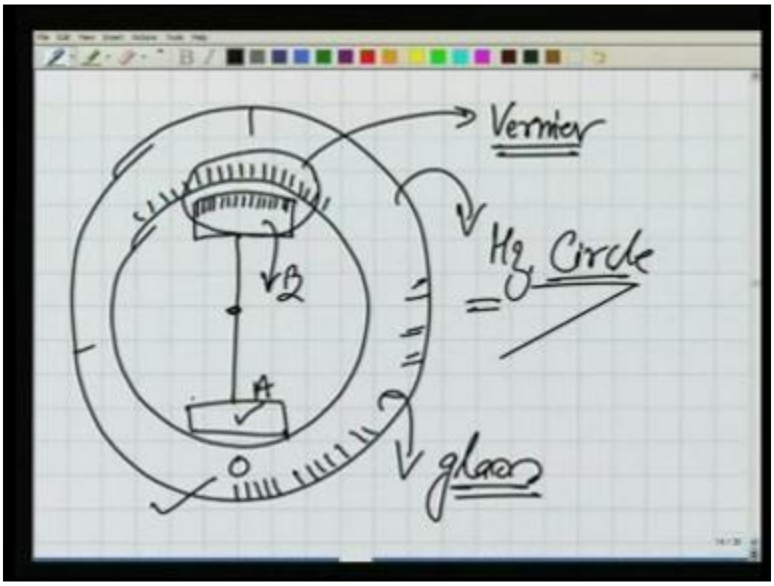

If I draw this, it looks like a circle like this and it is a glass circle made of glass, and it has got the graduations, it starting from 0, 90, 180, 270, and so on. So, all these are the graduations, so this is called horizontal circle, and we make use of this for measuring the horizontal angles as we will see in a movement. Now, further on top of this top of the horizontal circle or horizontal plate, we have we cannot see right now, but we have two windows here, one little window here and one little window on this side, but these two windows are basically to see the readings.

Because, as I was saying that we have the horizontal circle here, we need to read the angle values in this horizontal circle or this graduated circle. So, to read this horizontal circle, which is inside this cover, this is all metal inside this metal to read it, we have to look through the eye pieces, so this two are the eyepieces two diagonally opposite ones. We say generally vernier A and vernier B for this eye pieces, and using this eye piece I can focus it for my eye, and after focusing it I look through it, and I can see the reading there.

Now, it is very obvious, if you are seeing the reading, what you are seeing about. Well, in the case of this horizontal circle there is one additional thing, which we say index, index may look like this, what is this index there in the horizontal circle, we have the graduations. And depending the type of the theodolite this graduations will vary, while in the index, again further we have the graduations, and basically the job of these two is to some edge vernier. This particular assembly here A, and this one here B they ensure that the observations are taken with better least count; we will see this also in a movement.

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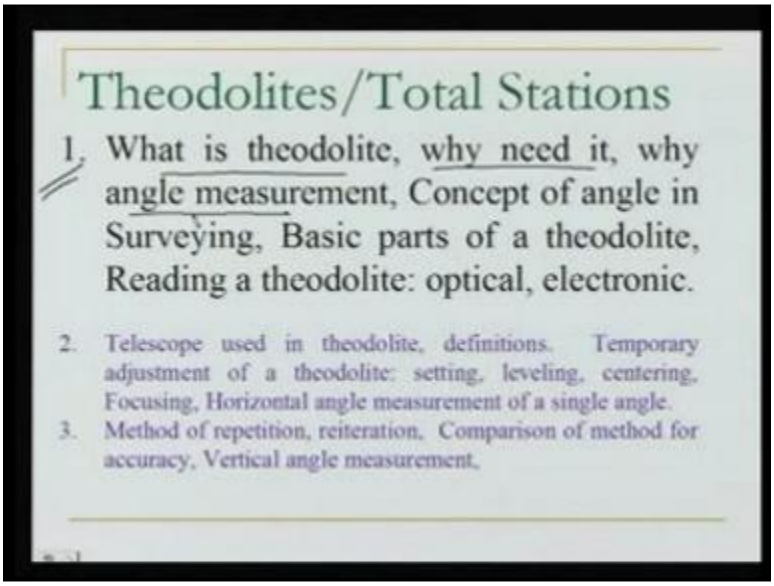

Now, what happens how it is measuring the angles, what is the thing which is going which happening there inside; we will try to look into that part now. Well you can see, if I can show you by my hand also, thus the horizontal plate or horizontal circle are we say lower circle also, because this is the lower one on top of this is the index.

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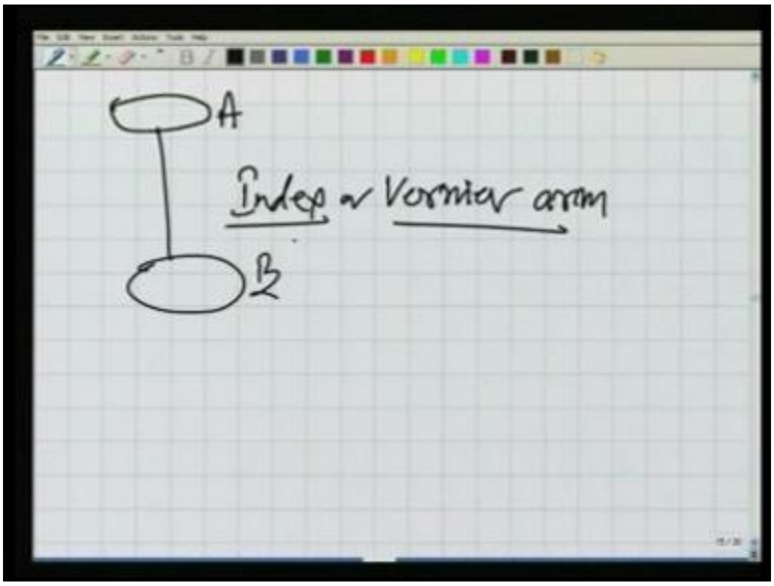

This assembly, which I had just plotted this also called index or vernier arm. Well, the index A and B vernier similarly here, for example we can imagine, let us this is A index and this is B index, thus the horizontal circle just for the sake of showing you here, I am showing you like this, otherwise in instrument it is this way. Now, when you measure the angle, we rotate our theodolite and we are sighting through this telescope, we will see this telescope in a movement, so we rotate it.

So, basically what is happening, if for example, let say this 0 degree, the reading initially for this vernier and this vernier are 0 and 0. We rotate our telescope, so what happens our index rotates, so once this index rotates the reading against this vernier over here, this angle and for this vernier this angle changes. So, what happens, by rotation of this we are able to measure the angles.

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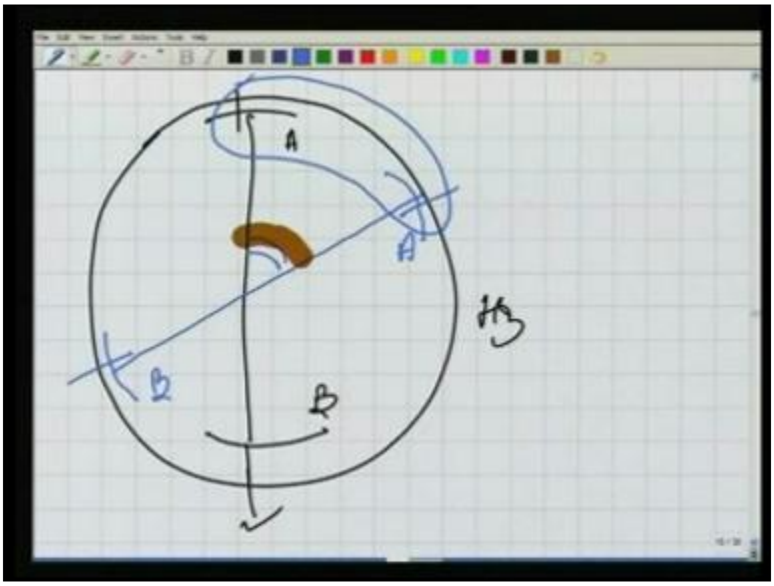

So basically, thus my horizontal circle the initial location of the vernier was like this, vernier A and vernier B, and there is some value of the reading. Well later on, after rotating the telescope the vernier A may reach here, and vernier B may reach here. And now, it will see the corresponding observation or the reading. So, the angle at this point can be seen by reading these graduations. Well, what was the value of the observation here and what is the value of observation over here. Now the difference of these two, will give us this particular angle, so this is what is happening there inside the instrument.

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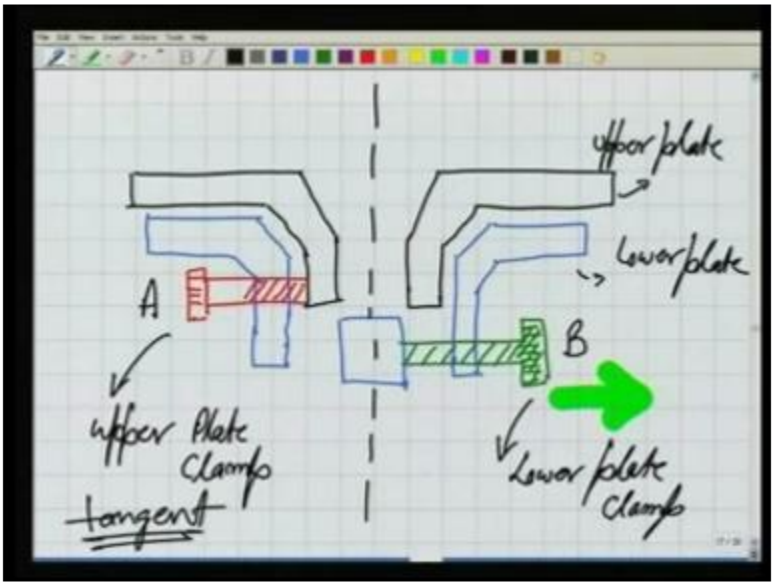

Well regarding the construction of this to for the construction, I will draw a diagram, here is the diagram and in this diagram what I am try to show, I am trying to show you how the instrument is constructed. Because, here in instrument, I will you can see in the diagram here. We have first, this is and this is the upper plate, upper plate means the index or the vernier, we have also down here. And this, because this is the cross section of the instrument, and this is the lower plate or the horizontal circle, which is the full circle as we are seeing.

Well, we have this screw A, which is a upper plate clamp, so this screw A is upper plate clamp and this B is lower plate clamp. Now, what is their role, if you can see in this diagram also, well let us start doing it. If you, for example unclamp this B, if this B is unclamped, that means B comes out to this direction this way, this how the B comes. If it is, so what will happen, this upper plate as well as the lower plate they are free now from this block. So, if I rotate my instrument now, so upper plate and the lower plate both will rotate, because this A is clamped right now.

Now, if I release this A also, I release this A, so A also comes out in this direction, what will happen, the contact between the lower plate and the upper plate will be lost. Now, in this case, if I rotate my instrument only the upper plate will rotate, so the case is I have clamped this B, I have unclamped A. So, not this total assembly, because I have clamped this B, so this lower plate is clamped with this spindle, while this upper plate is free to rotate, because we have taken this A towards this side. So, rotating the instrument only the upper plate will rotate.

So, how do we do with this instrument, here in the instrument if you see, we have the upper clamp and the lower clamp, right now I have, if you can see it better this way. This is the lower clamp and this the upper clamp, I unclamp the lower one, now I rotate the instrument. The upper one is clamped, so what is happening in this case, both the horizontal circle and as well as the index both are rotating together, because the lower one is unclamped and upper one is clamped, so both rotate together right now.

Well I clamp it, though lower one is clamped, lower one is clamped means this is now it cannot rotate, and upper one I unclamp, that means the upper one is free to rotate. Now, in this case if I rotate my instrument, it is still rotating, but the bottom plate is a stationary, is not rotating the only rotation is in the index arm or the vernier arm, only this is rotating. And this is why, you can guess it very well, if my upper is clamped, lower is unclamped, mind it both are fit together. Now, I rotate the instrument, is the angle value changing? The angle value is not changing, because what is happening here, these both of them they rotate like this together.

So, the angle value means, these the readings against vernier A and vernier B is not changing, but by clamping the lower one and clamping the upper one, the rotation is like this, and the angle value are changing, and this is what is happening here. So, this is how, you can change the angle readings, and this how you can observe the horizontal angle, we will see more about this in a movement. Now, along with these clamp screws, for example we saw this is the upper clamp, we have one more screw here, this is called upper tangent screw.

Similarly, for the bottom plate also, bottom clamp, bottom tangent screw. Now, what is the role of these tangent screws? This would clamp the motion, but many time to bisect the ranging rod, which we are sighting through the telescope. We need to give very mild rotations to the instrument, so those mild rotations can be given by the tangent screw. So, this is why we have got a tangent in both upper and lower. Well, we go further up having understood this construction of the bottom plate, upper plate, angle measurement. We look through this is vernier A vernier B; these are the glass windows here, so that I can see inside, and I can see these verniers and readings.

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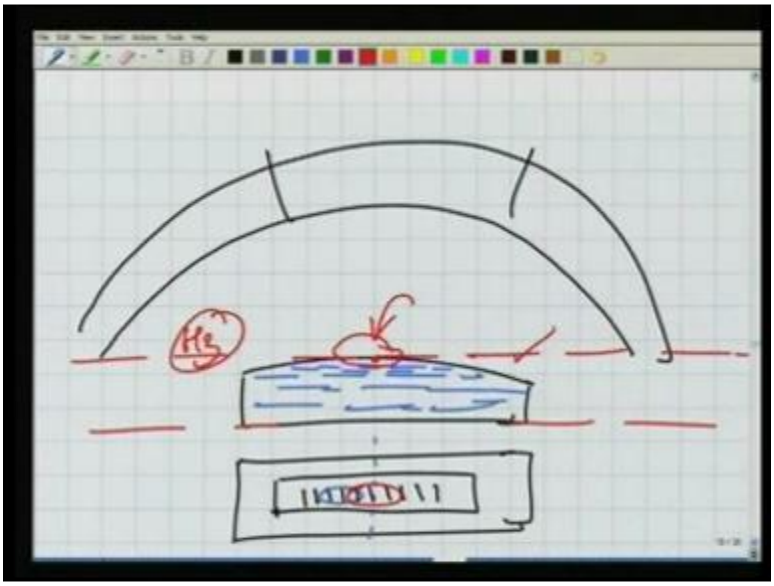

If you go further up here is a bubble tube, what is this bubble tube? Bubble tube as you might have seen somewhere also is a part of a large tube, which is circular, so we cut up little part of that and this part is the bubble tube, something like this and this is filled with some liquid. We will see later on about the bubble tube, what this liquid is, what should be the characteristic of the liquid, this we will see and a little space is left here.

Now, this little space over here, surf as the bubble or this little ear, it is surf as the bubble. So, depending, if my bubble tube is horizontal or may be let us say, this line is called the axis of the bubble tube, tangent at this point. If this line is horizontal line, the bubble will be in centre, how the bubble looks like in the plain view thus the plain view of the bubble tube. Well, here inside we have the bubble and there are some graduations, and the bubble may appear like this, right now the bubble is not in centre, because centre means it has to be here.

And, if we make this bubble in centre, the ear bubble will come over here, and once it is in centre this line is horizontal. So, it is how we use the bubble tube, and similar bubble tube is fitted here, because we want to ensure that this plate is horizontal. We want to measure the angles, all the angles are to be measured on a horizontal plane, we want make this plate horizontal that is how we make use of the bubble tube.

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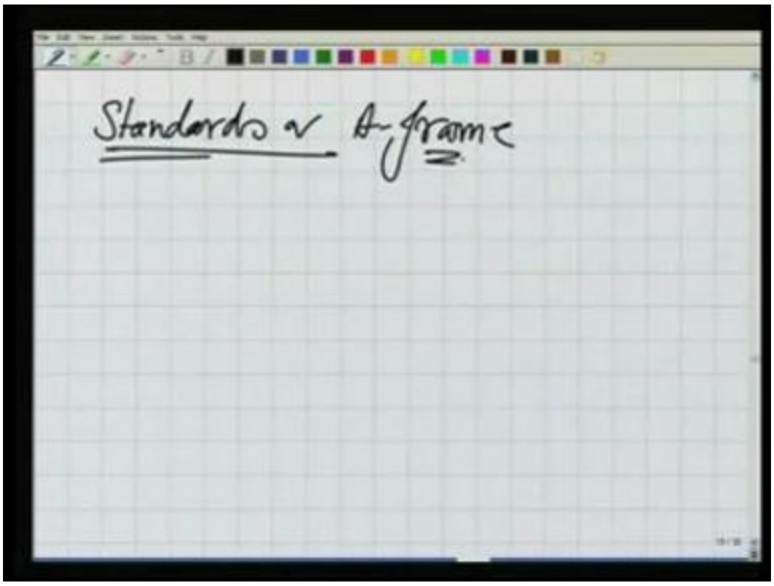

So, we will see about this in a movement, well going further up in the instrument. If you go further up, we have these parts are called the standards or a frame a standards or a frame. And they support, you can see over here a standard here and they are supporting on the horizontal axis, this axis of the instrument you can visualise it here. And axis of the instrument here about which this telescope rotates, you can visualise a line passing through here, this the horizontal axis. So, this standard or a frame supports the telescope, furthermore there are more interesting things here, we will talk about the telescope later on.

Well, what I can do here, I can rotate this telescope as we have seen that, while we are measuring the angle particular in the vertical angle, we need to sight some object. For example, like this and this should give me the amount of the vertical angle for a particular point here, so how do we observe that vertical angle? Well, we can see here, similar to the horizontal case, there in the vertical also we have a plate attached to the telescope, so if I am rotating this telescope along with this a plate is also rotating.

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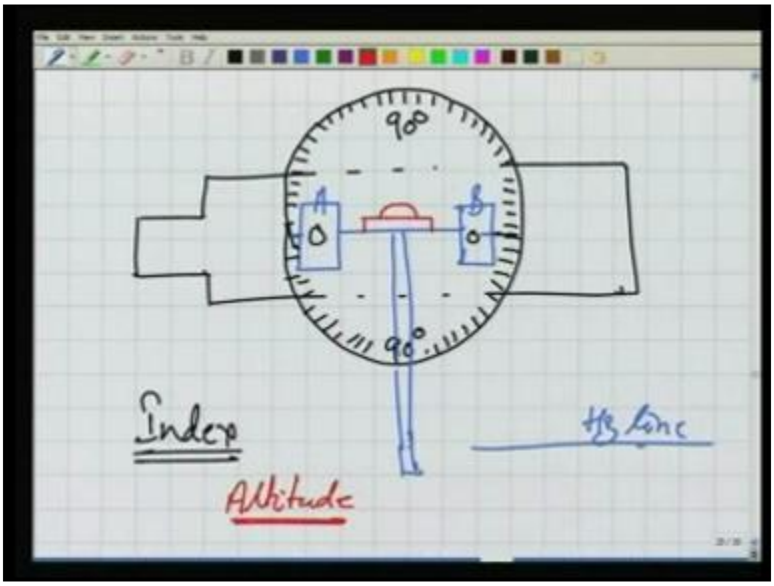

The construction of this vertical circle is, we have a telescope as we can see here, there is the telescope and I as I told you, that while we are rotating this is telescope, along with this a vertical circle is also rotating, where this vertical circle. This vertical circle is something like attached with the telescope, and this vertical circle is graduated, I just show it like this. So that you can have a feel of the telescope behind and thus the vertical circle, and we have the graduations in the vertical circle.

These graduations may start from 0, these 90 degrees here, again may have 90 degrees or may be a different arrangement 0 to 10 to 60 depending the theodolite, but right now I am taking as 0, and then 90 degrees here and there. So, this is the graduated circle, when we rotating it what is happening, this is the telescope and thus the vertical circle, and both of them they rotate together. So, how we are measuring the angle, what we are doing in order to measures the angle, there should be a reference, there should be an index, we need something called index.

And as we have seen for our vertical angle measurement, the reference is the horizontal plane. So somehow, we need to establish that horizontal plane or horizontal line here. So, in addition to this telescope and this vertical circle, we also have an additional index frame here, that index frame looks like this. Now, what is this index frame? This index frame basically, we say vernier A and vernier B and the line joining vernier A and vernier B will be a horizontal line. So, while we rotate our telescope this vertical circle also rotates, but our index remains stationary now.

Well, so this is stationary, these two points the vernier A and vernier B they give us a horizontal line of side, and I am rotating my vertical circle with the telescope. Well the initially, let us say the reading was 0 0 my telescope is horizontal, my telescope is like this and the reading is 0 0. Now, I rotate my telescope, so my vertical circle will rotate, so the angle between these two will be the vertical angle, and this what we are doing here, by rotating this we can see it again using this eye pieces.

We could not see those windows in case of the horizontal circle, but we can see the windows very well in case of the vertical circle. So, this is window for vernier A, this is the window for vernier B, so by making use of this window and this eye pieces, I can again focus this eye piece to my eye, and we can see through this and see the readings. So, right now for horizontal line of side the reading should be 0 0, if I change it as the angle is increasing the reading will change.

Now, in order to ensure whether it is horizontal or not, because our line of our reference for vertical angle is horizontal line, how do we ensure that this index frame, they it is inside is horizontal or not. In order to ensure this, we have an additional bubble tube here, this similar bubble tube to this, but it is more sensitive. We will talk about the sensitivity of the bubble tube later, but using this bubble tube we can make our index horizontal. So basically, the bubble tube is kept on the index, so by making this bubble tube horizontal this index can be made horizontal.

So, we can draw it here in the diagram also, over here is our bubble tube and this bubble tube is called altitude. Altitude bubble tube and you know, we have understood that we make use of this for measuring vertical angles. Well, we will see some more parts of this theodolite, here in the vertical circle what can I do, I think clamp it clamping means, in this particular theodolite it is here. Once, I have clamped it I cannot rotate my telescope, but using the tangent here, so this is the screw for vertical circle clamp, and this is the screw for vertical circle tangent, so this is vertical tangented screw.

So, using this is still I can rotate my theodolite, but by various small amount, while if I want to do it with large, I can use this one by unclamping this one. Now, here also in the case of the telescope, if you look at the telescope, will look into the optics of the telescope next time. But today, this part of the telescope is called eye piece, because I keep it towards me, and I look through this. And mostly, whenever we shut this instrument, we should ensure that the instrument is set in such a way that the eye piece is at the height of my eye or the eye of the observer, why is it important, because if you are working in a field.

And, if this instrument is set in such a way that your eye piece is here. So, every time you have to go up, in order to take the observations, or if it is down you have to bend, so this is not comfortable, because when we work with this instrument in the field, we work for hours. So, we should set to a comfortable height, as in this case without any bending or without anything I can see through the eye piece. Well, over here is the objective, so using this telescope, we can see and we can focus the eye piece over here, and focus the objective using this screw, so this is objective focusing screw. We will talk about the focusing phenomena, what is going on there inside, how the focusing taking place in our next lecture.

Well, along with this, if you look at this telescope very carefully over here, there is a little v and there is a little i. If I draw it here, what it looks like, there is a v and there is an i, basically why we use it, the v is here and the i is here. We use it for example, if I need to bisect an electric pole or a ranging rod, the field of view of the telescope is not big. The field of view for a human being is very wide, I can see that ranging rod there, but once I start bisecting that using the telescope, I will have to do many iterations of rotating it in horizontal, rotating this in vertical then only I will be able to bisect the particular point.

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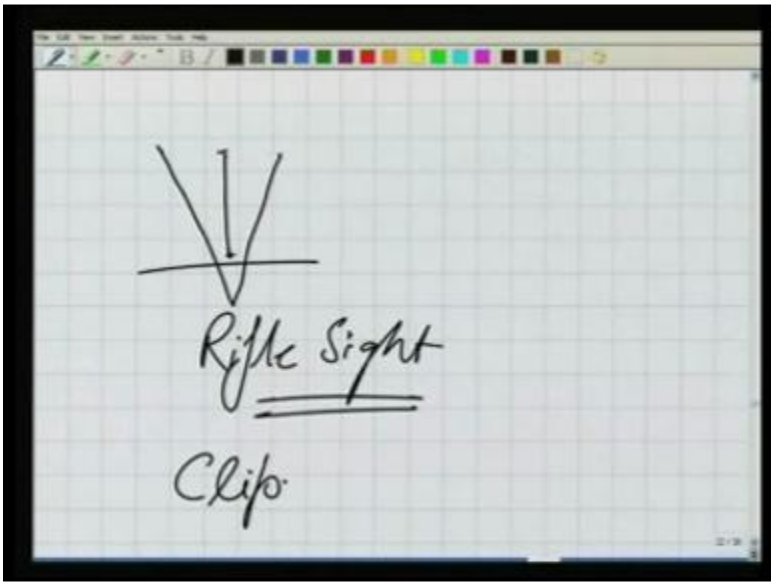

So, in order to save our time there, this target side is provided or this also called rifle sight. As you might have seen, over all the rifles this kind of site is there, in order to aim. So here, we make use of this, we make use of the v and the i will make it a w. And then we take this w to that particular object, because once you have taken that w our field of view is very large.

So, we can that way bisect the object fast. Along with this over here, as we are talking about we have our index here, vertical index arm. And in this vertical index arm, we have the altitude bubble fitted there, and this index arm becomes the reference for vertical angle measurement, and we want to ensure that this index arm is horizontal.

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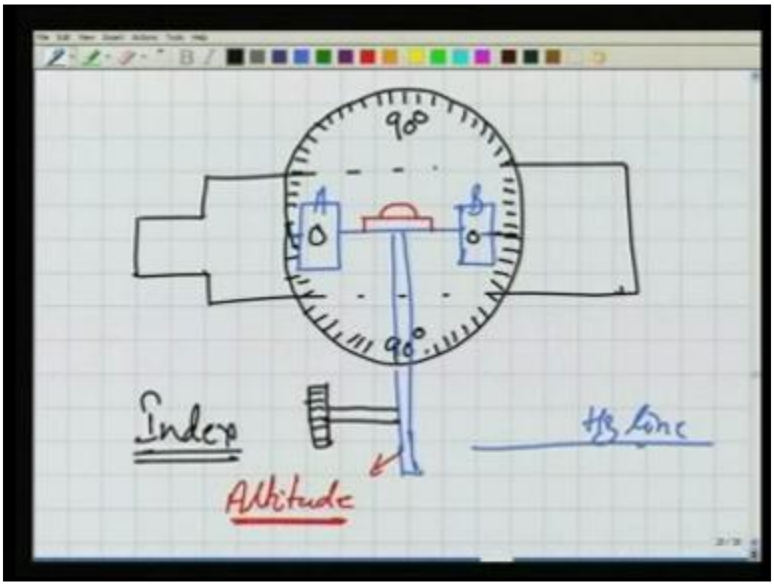

Sometimes, you know after working with instrument it might happen that this not horizontal in more, it has tilted, how to bring it back, to bring it back we have some one more screw here. We use this screw and this is called clip screw, this clip screw is basically fitted here, but rotating this clip screw it is possible that we can rotate our index frame, and we can make it horizontal. So, this is the clip screw, one more thing which you will observe here, all these screws are milled differently, here it is a smooth over here it is very coarse milled.

This particular screw is very coarse milled, and this is very fine milled, why is it, so whenever you are working with the instrument. For example, if I am looking through the instrument I am trying to bisect something, and I want to use a particular screw, for example I want to use the clamp. So, it might happen, because I am looking through the theodolite, it might happen the by accident I touch the tangent. So, if this happens the angle value will change.

So, in order to gives us an idea, while we are looking through the eye piece, we are engrossed in our work just by moving our hands here and here, by feeling these different milling of the screw. It is possible to work without looking at this screws, this is why the milling is different. As similarly here, the milling is very, very different, because we do not always want to use the clip screw. In order to use the clip screw, we had to use some additional needle then only we can use it.

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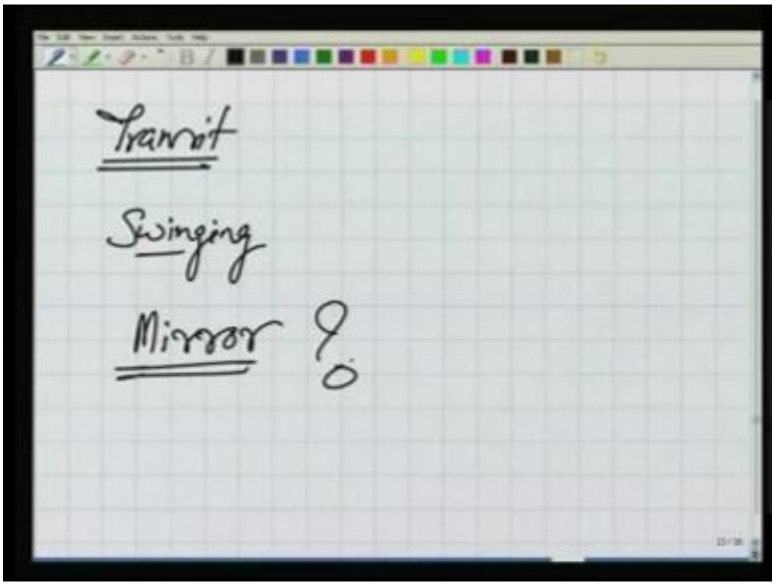

So, this is why the milling is kept different, one more thing about this theodolite, I can rotate this theodolite 280 degree, as you can see here, I can rotate it this kind of theodolite which we can rotate are called transit theodolite. And this procedure is also called transiting the theodolite, so we are transiting the theodolite. Well in addition, if I am rotating my theodolite in horizontal circle like this, this is called swinging in horizontal and transiting in vertical.

Now, along with this one last feature here at the top, over here this is a mirror, now what is the use of the mirror there. In this particular strip a mirror is fitted, and down there is the bubble tube, because my eye is here I cannot see this bubble tube, so in order to see the bubble tube, I have to go up to see whether it is in centre or not. So, in order to avoid that this mirror is fitted here, and I can see comfortably at from this sight only, whether the bubble is in centre or not using this mirror, and this is why the mirror is fitted there.

This particular instrument, which we saw today is the vernier theodolite, it has the vernier set up to take the observations the least count is 20 seconds. You will find in the field different kinds of theodolite, and all those theodolites they need to be read differently, depending upon what the instrument is. And, you will find the instructions in the manual of the theodolite, how to read that one, but the vernier one which is a very common one, we will see that how we read the vernier one now.

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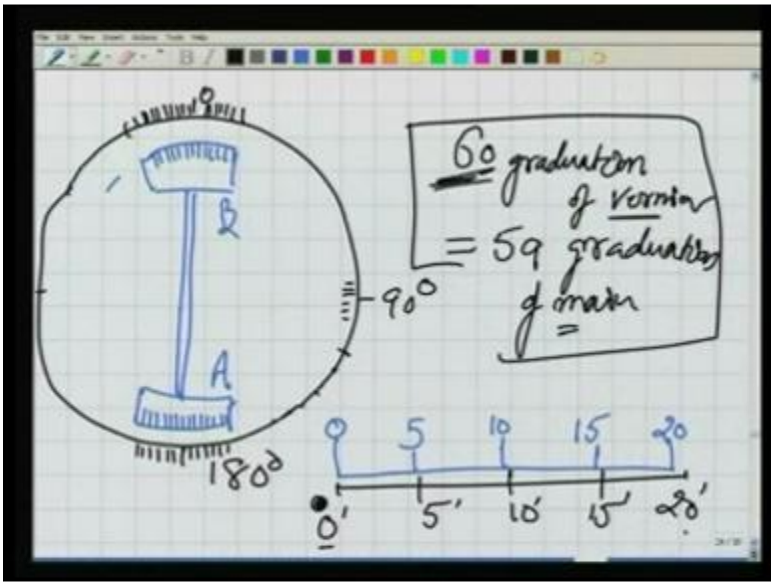

Well, as we have seen in the case of the vernier one, as we can see here this black one is the horizontal circle or it may be the vertical circle also. And this A B is the index, either in the case of the horizontal circle or in the case of the vertical. In any case, and what we do, we read the theodolite or the angle value against these verniers that what is the value of the reading, how to take these observations.

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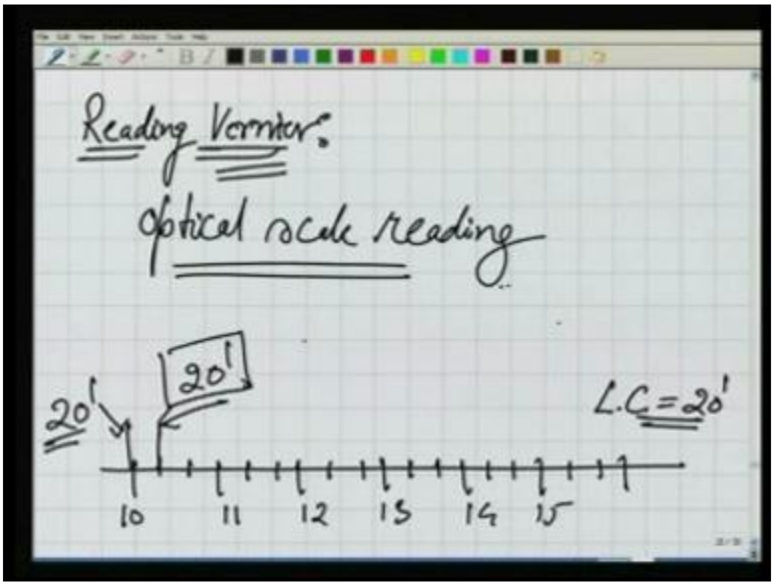

We will see that now, in case of our mini scale, if I am showing the mini scale here, in mini scale the graduations are written in such a way, then let us say this is 10, 11, 12, 13, 14, 15 all in degrees, we have got further subdivision. So, each degree is divided in further divisions of 20 minute, so the least count of mini scale is 20 minute. So, if you are using all in the mini scale, we can use up to 20 minute, but this is fitted with a vernier. As we can see here in this case, this A and B are vernier, how these verniers are actually there, and how we improve the position using these verniers.

Now, in these verniers, now this particular part of 20 second here, if you just look at this or any little graduation this is for 20 minute, I expand this 20 minute and I am showing you here now this 20 minute, so 0 and 20 so this is 20 minute. Now, in this 20 minute we have the vernier, and vernier is design in such a way that because in this 20 second, we have 60 graduations of vernier. So, 59 graduations on the main are equal to 60 graduations on the vernier. So, this is actually you can make use of this in order to find the least count of that.

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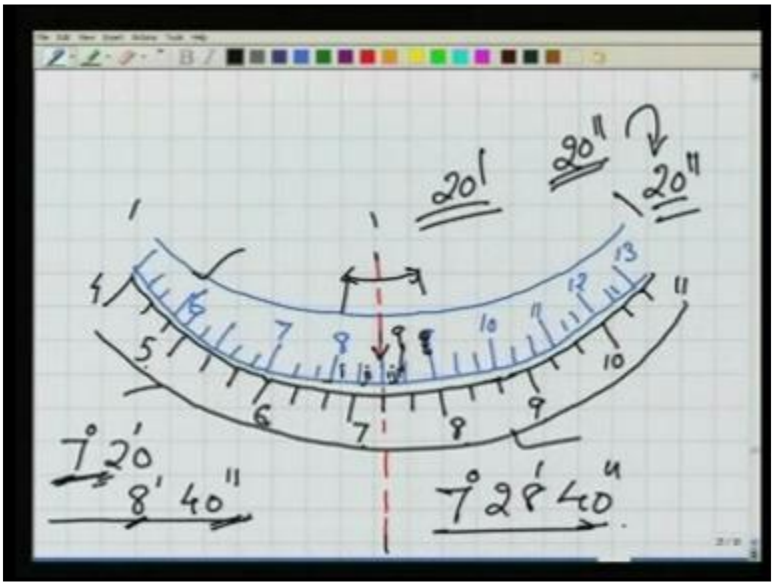

Now, how it take the observations here it looks like this. We can see 5 degrees, 6 degrees, 7 degrees, 8 degrees, 9 and thus our vernier here, this is the mini scale. And in vernier and in mini scale the graduation which meets or which gets aligned is over here, I point it. So, what is the value of the reading, well first we read in the mini scale, so in the mini scale we have passed 5, 6 and 7. So, reading is more than 7 degrees, and then also we are at this 20 minute, so 7 degrees 20 minute is the reading from the mini scale.

So, this is from mini scale then in the vernier, thus the graduation which is aligning with the graduation of the mini scale. So, what is the value there, we have 6, 7, 8, because this total is for 20 minutes. We have passed this 8th one, we have passed further if you can see in the vernier each minute is further divided in three: 1, 2 this should be 9 here. So, it is further divided in three: one part, second part and third part. So, each is corresponding to 20 second. So, you can see the least count in the vernier is 20 second.

Well, what is the value of the angle, the angle here in this case we have passed this 8 minutes already, 8 is per minute from 8 to 9 in between our this red line is there which is be aligning mark, and we have passed 1 and 2. So, the vernier says the reading is 40, so the total reading will be 7, 28 and 40, 7 degrees 28 minutes and 40 seconds, because 20 second is the least count of this instrument, so this is one way of reading the vernier.

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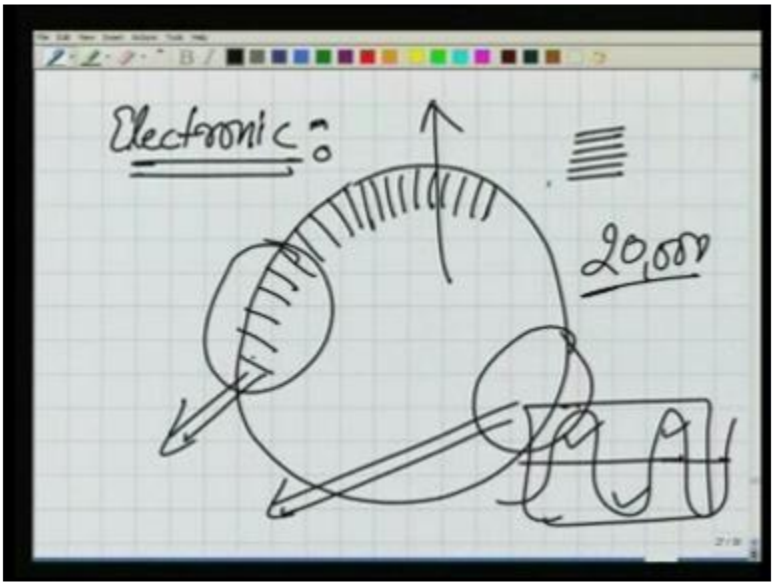

Now, there are different kinds of reading devices, they are some electronic also, if we are talking about the electronic instruments, we have some electronic devices which can read the instrument, which can read give you the angle value. The different kinds of constructions, the idea is one could be which is used a circle is there, this is the circle in glass, and they are very fine graduations; very, very fine graduations are there and underneath this glass.

If this is the glass, we have the graduations ashed into it, some 20,000 and underneath there is the photo diode, which is emitting the light, and the size of that photo diode is same as the size of the graduation. All theses graduations are basically the black and white lines like this very, very fine. So what happens, we initialize it at some value, and then once we rotate it, the light which is coming out of it, because somewhere the light will pass somewhere it will not pass.

So, what the light will do, it will generate a sinusoidal wave kind of thing, the light is there it is not there; the light is there it is not there. So, counting this and further doing some further you know, we can take the observation here; take the observation here, the wave form generated here; and the wave form generated here is super imposed, in order to achieve better precision. So, this is how, you know it can give the accuracy of the order of 1 second also, or the least count the precision this kind of precision is possible with this electronic device or electronic measuring plate.

So, we have varieties of these, so what we have seen today, starting from the beginning. We saw, the significance of the angle, because we need angle measurement in horizontal and vertical for many purposes. Then we saw that, we need to measure more, by more precision, because we need to have compatibility of the instruments, somewhere you need more accurate results more precise results, so we need to go for the theodolite.

So, in the case of the theodolite, we saw that it is really a very good instrument very useful instrument in surveying. And we can carry out, as we saw in the case of the theodolite the horizontal and vertical angle measurements. We saw the various parts of the theodolite starting from the tripod, tribach, levelling screws, trivet, horizontal circle, index arm and so on, up to the telescope and the mirror here, altitude bubble everything.

Then we saw, how we can take the observations using the vernier theodolite, I know it is difficult for you to understand it directly from the video screen. Please, visit your laboratory or wherever you can find a vernier theodolite, go and observe it handle the various part yourself with using your hand. Then only you have the feel of the instrument, and observe the vernier theodolite yourself, see the readings this is how you will know about the instrument in full. Well we end over this lecture today here.

Thank you very much.