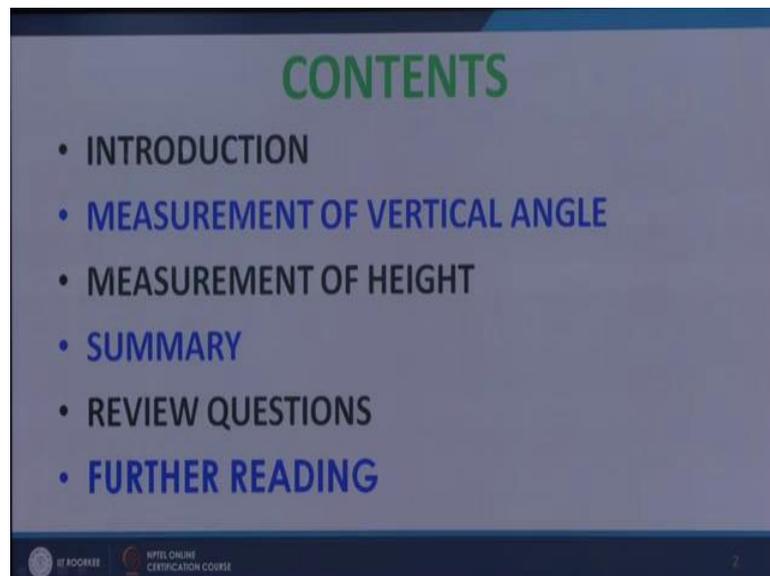


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Lecture - 24
Measurement of Vertical Angle and Height Using TS

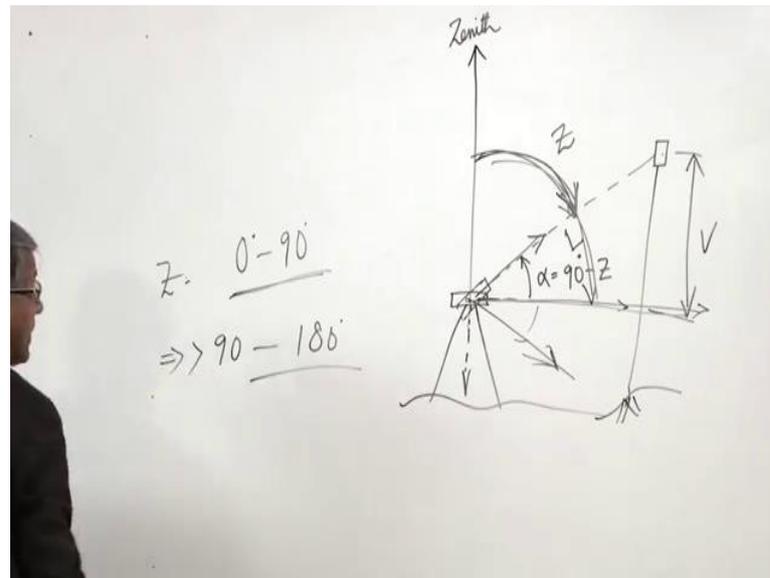
Welcome students. This is the lecture number 24 in which I am going to discuss about how to Measure the Vertical Angles Using Total Station, and also how to compute the height or how we get height from total station. The lesson will be discussed under the following has first I will introduce about this.

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And then measurement of vertical angle and then I am going to explain measurement of height using total station followed by summary, review question and further reading. And during this discussion also I will demonstrate using the total station how to measure the vertical angle as well as how to measure the height. Now, we know that total station measures vertical angle, which is in a vertical plane. Actually total station provides us the vertical angle in terms of zenith angle. Now, what is zenith angle, zenith angle is the vertical angle measure with reference to zenith line.

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So, if our instrument is this one and it is perfectly centered then this is the plumb line. So, the line opposite to plumb line is the zenith line and we do get the angle if the telescope is point towards like this, suppose this is the object. So, then this is the angle zenith angle. So, actually total station provides a zenith angle and also total station measures the slope distance l . Now, from this zenith angle and this slop distance, it divides change in height or vertical height. So, this is the fundamentals behind our zenith angle. And actually about vertical height also we can go get the altitude angle by considering 90 degree minus Z .

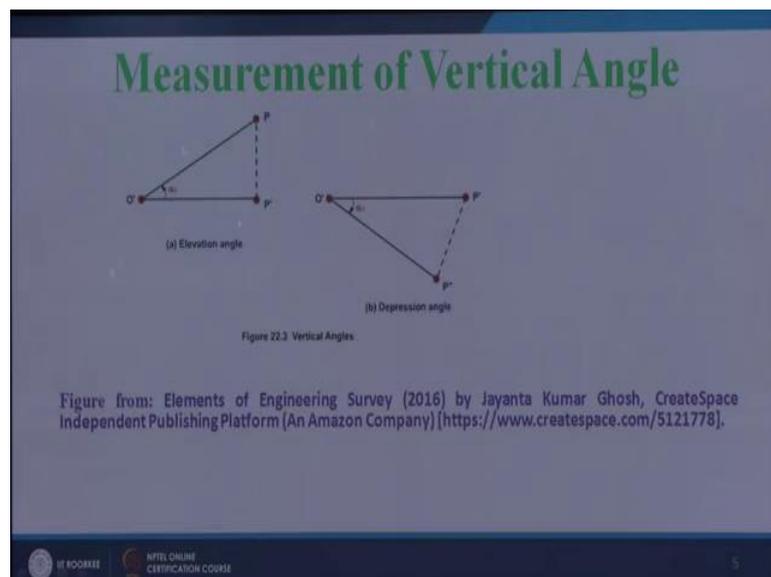
As I told you in earlier classes that before taking any observation using total station we need to go for temporary adjustment of the instrument means the instrument should be exactly centered over the station as well as it should be perfectly horizontal. So, when you make the instrument horizontal plate perfectly horizontal then automatically the vertical plate which provides us the vertical angle gets in a vertical plane. This is done automatically and there is a automatic system inside it. So, by through that automation, we get it vertical plate truly vertical.

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So, in case of total station the measurement of vertical angle like its horizontal angle are automatic. So, if we make it perfectly horizontal then and the telescope or if we make it perfectly to our zenith direction then we will get the zenith angle 0. And when we will make it perfectly horizontal the axis of the telescope then we will get the zenith angles 90 degree. So, these were we get the vertical angles but.

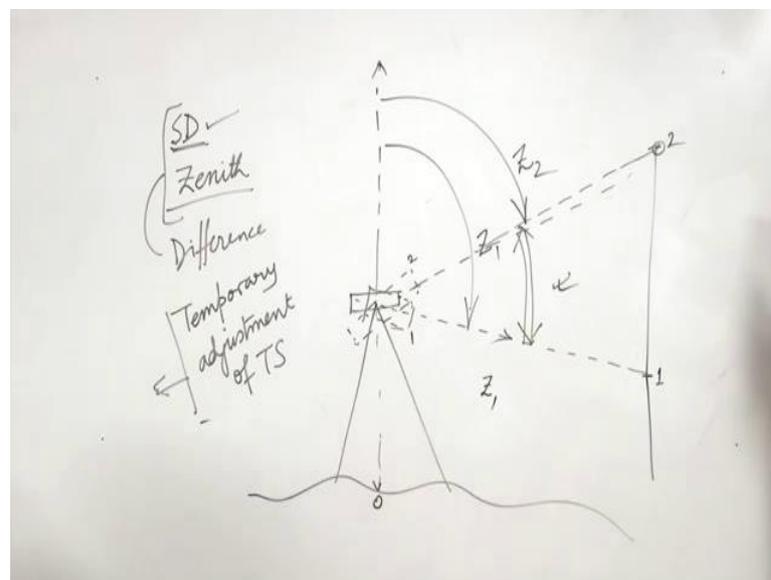
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Now, the vertical angle may be up to two types as we see that in case of total station, we do get the zenith angle. And this is if it is about the horizontal lines, then it is the as the

telescope is pointed from zenith towards horizontal line, the angle will increase from 0 degree to 90 degree, and sometimes it is the angle of depression. So, it is called angle of elevation. So, where it is angle of elevation when for zenith angle is 0 degree to 90 degree where it is angle of elevation. And if it is below the horizontal line, then it will get the angle from 90 more than 90 degree to 180 degree. So, this is the angle of depression. This is the most fundamental thing about the vertical angle. So, the basic behind the measurement of vertical angle is that, whenever we will want to want to measure the vertical angle using total station what we need to do.

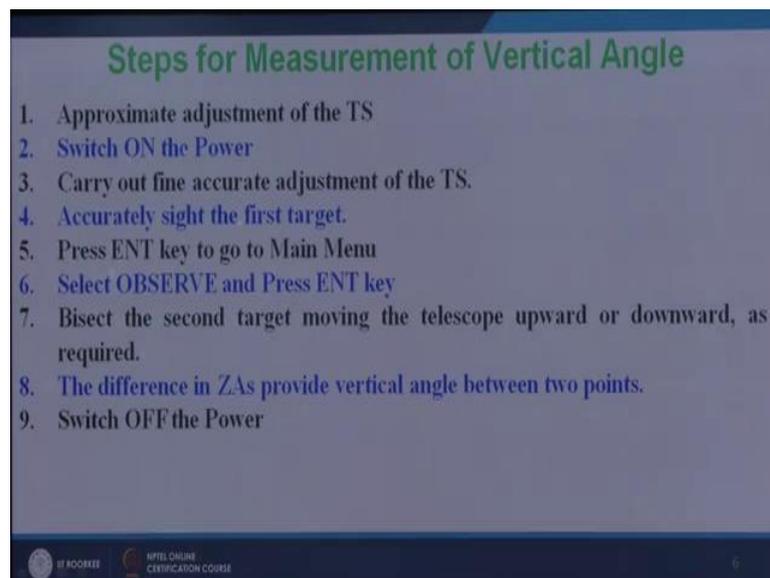
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Suppose, I want to find out the vertical angle between two points suppose this one and this one. So, if my instrument is like this, so first this is the target number one and this is the target number two. So, after setting of the instrument on the point about which we want to find out the vertical angle, we will perfectly go for temporary adjustment, temporary adjustment of the total station. And this will make the vertical circle totally vertical then we will direct this telescope towards the first point, first target and we will bisect it, and we will get a zenith angle z_1 . So, we will get an angle like this, zenith angle z_1 . Then we will change this and we will focus this instrument to this second point, and bisect the second point. And the total station will automatically provide another zenith angle that is z_2 .

So, if we note down z_1 and z_2 , then this angle can be found out by taking a difference of z_1 and z_2 . So, this is the way how we do measure the vertical angle, but in case of total station actually we do not need to measure vertical angle. In fact, it measures the slope distance and it measures the zenith angle. And from the zenith angle and slope distance, there is a program inside the computer, inside this total station which directly provides the height or difference in height.

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So, anyway, let me first show you how to measure the vertical angle using total station. So, as I told you for making the vertical angle measurement first we need to make this instrument temporarily adjusted. So, in order to make the instrument temporarily adjusted first the tripod legs should be widely spread as it is shown here. Then the footy screw should be kept middle before you fixing it to this instrument tripod head. And then we have to adjust these legs to bring our circular bubble in between in the middle. So, there is a circular level as I have already told, and the bubble should be placed here inside it using these tripod stands in tripod legs.

If it is then, then we have to look in a through this optical planet to find out whether the center of the instrument is exactly over the center of the station. If it is not done we have to open it and we have to shift this and then we can make it. Now, already we have done our temporarily adjustment approximate adjustment. So, it is now I can find that the bubble is in the middle as well as the centering is the center of this instrument exactly

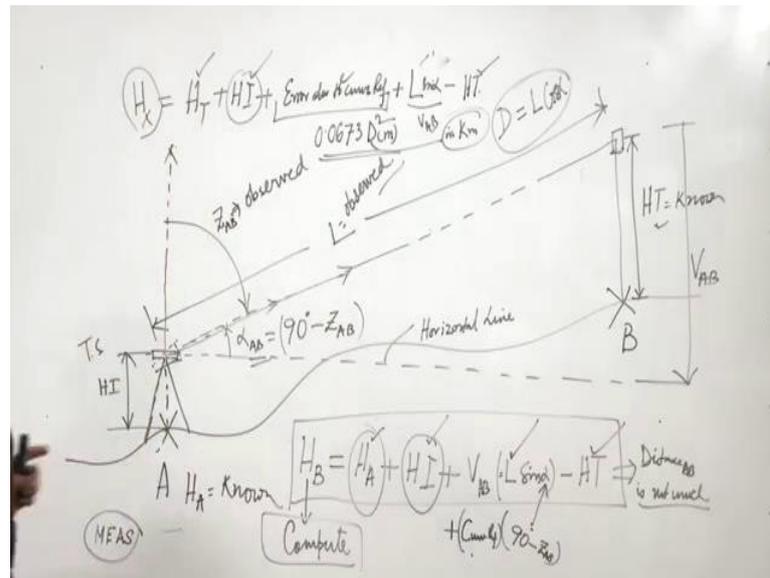
about the center of the in station. So, you do not need to do anything more. Now, after that means, approximate leveling and centering has been done, now we have to find results centering and leveling; in doing that we have to first make the power on as I have already done in our previous classes.

So, from there here with this provides us the indication that whether the cross bubble in the x-direction and y-direction are in the middle or not. So, here I can find that the cross bubble is in y-direction is. So, there is a very little adjustment we need to do. Now, another thing I have told you that this part of the display shows it whether you need fine adjustment or not if it is in red in color that means, there is a need. So, we are in need of the in this. And now I have to bring the bubble in the x-direction to be at the center. So, you can say this indication is blue that means, our centering and leveling is nice now. In this way already now our centering leveling is done properly. Now, again I have to look at and I can find that this centering is. So, centering and leveling is fine.

After this are to go to the now I need to go to the main menu. So, this is the main menu. Before going further, let me first oriented the object the angle. So, I will like to find out the angle vertical angle between the center of this point and the center of that point So, first I will bisect, I will oriented my instrument towards this object, using the (Refer Time: 13:14) many screw. So, now this telescope is perfectly bisected, the center of the prism. So, now I can start observed. Now, if I take it the observed than inside EDM, I can make the prism reflector is prism captures here.

So, I can see the zenith angle for this object is 84 degree 45 minute, bisecting the instrument to the object we can directly get zenith angle. So, once it is done, now I can go to the second object. And by opening it, I can look at that. So, now it is the zone or it is perfectly centered, so we can get zenith angle 81 degree 32 minutes 14 second. So, the defined between these two we can get the angle difference between these two objects. So, this is how we do this is the we can go for measurement of vertical angle between two point, but for total station actually we are not much interested to measure the vertical angle whether we are interested to measure the height. So, let me now explain about measurement of height.

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Now, in case of total station actually we measure the relative height. Like suppose this is the terrain and we want to find out the height of any point b suppose then another point say a, whose height is required to be known. So, instrument will be placed centering on this point whose height is known. So, height of the point a is known. Now, what it is done, this is our total station. And this is the height of the instrument. Hold a suppose we want to go for reflector based height measurement and the reflector is placed at some point, suppose this reflected place and this is the height of the reflected height of the target. Now, this is known height of the target we can measure it we known, so it is known. Then we do bisect the target, this is the center of the prism, we bisect it using our telescope of the total station.

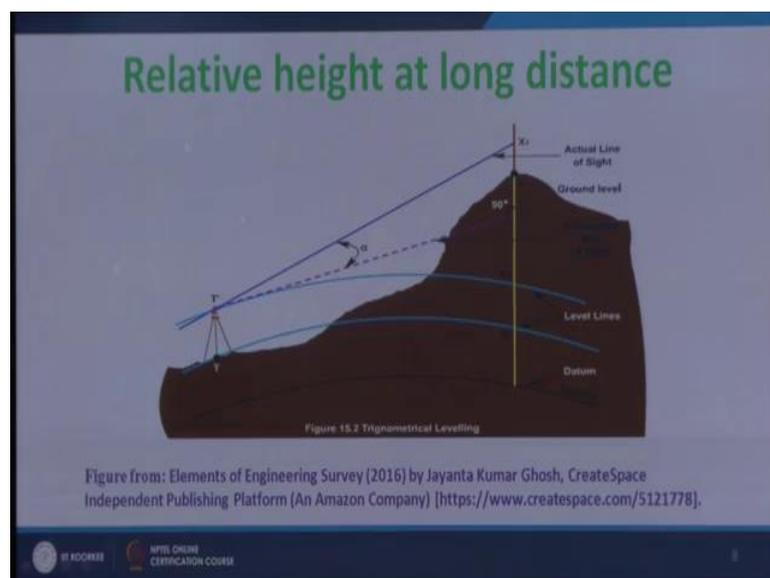
So, if whenever we measure this distance, so we can get this L, this L is known. So, now, from this L, if we also as I have a already told the zenith angle Z AB are observed, L is observed. Now, if this zenith angle is known, then we can get the altitude angle within the total station, this program is there, so which computes the altitude angle from the zenith angle. Now, as you know from this that if we have this sloped distance and the altitude angle, then we will be able to find out the difference in height between this point and that point, so V AB. So, this is the horizontal line this is the horizontal line.

So, now, we can say that the height of the point B is equal to height of the point A plus height of the instrument plus this V AB defines in which is L sin alpha then minus height

of the target. So, this is the expression which the instrument makes use. So, this is the parameter to be input, what is the height of the point in which these two main instruments has been setup. This is the height of the instrument whenever we will set up the instrument, we can find out the height of the instrument up to this point, we will measure the distain height of this point from the station. And this is the height of instrument. This is the height of the target. What is the height of this from this; I can get this value, so this is known.

Now, whenever we will make it on and we will bisect the target and by using the key measure then a laser beam will go or it will come back. And from there this L we can get and also this alpha is also computed from 90 degree minus Z AB. So, in that way whole of this we can find out we can compute or find out. So, this is the basis behind how we find out the height of a point using the total station. Now, in this case actually we consider that the distance between A B is not much. So, by the word much we mean that the then this line of sight should be straight. If the distance is more than the line of sight gets curved due to curvature of the earth as well as their being a we get the reflection. So, when the distance between the station A and B is far off then we need to consider the line of sight not the horizontal, not the linear, but it is a cut.

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So, you can see this figure. So, when the distance in more than instead of this line, this is the actual line, but actually there will be level lines. So, in that case, the height of the we

have to take into consideration, the error due to curvature this is the error due to curvature as well as error due to refraction. So, one parameter comes into picture which is plus error due to curvature minus reflection.

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Measurement of Height

1. Relative height of a point.

$$HB = HA + HI + DAB - HT$$
2. Relative height at long distance.

$$HB = HA + HI + Cur + DAB - ref - HT$$

$$Cur - ref = 0.0673D.D \text{ m (D in Km).}$$
3. TS computes difference in height from slope distance and zenith angle.

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So, this is the another thing which comes into picture error due to curvature, actually the leading is less due to not being when it is curvature we should get more leading, but. So, it should be hidden and it reflection actually there is the way. So, we have to add this with respect to curvature than in this figure we can see if we want to find out the height of the point X then and height of the point T is known. And this is the datum, so height of the point X will be height of the point T plus height of the instrument T dash. And that will be equal to this point which is the level line and done we have to end from here to here.

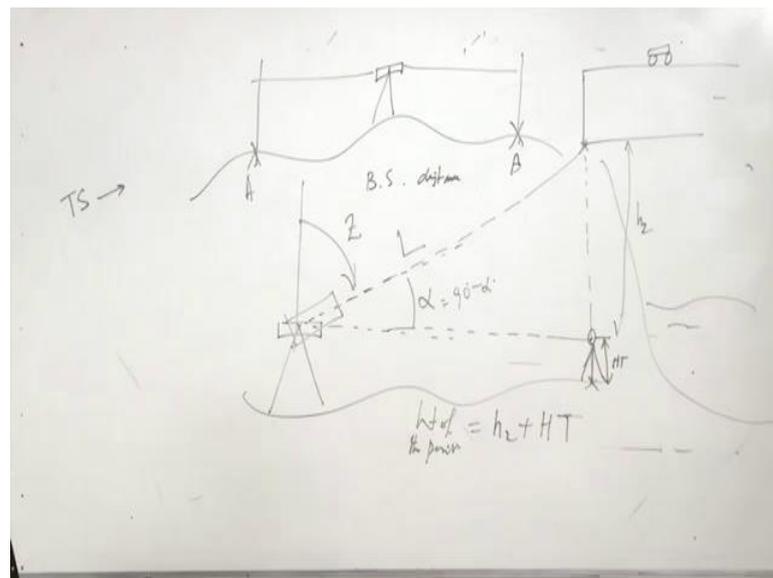
Now, this is the line of sight actually this is the horizontal line or main line of sight. So, this is the curvature error which we should end to get this and then this is the distance this is the horizontal line, this is the slope distance. So, this is our V L from the slope distance and this angle will be able to get this thing in sin alpha and then this is the height of the prism. So, we have to subtract it.

So, we can say that a height of the X is equal to height of T plus height of instrument plus error due to curvature and refraction plus V A B sin alpha minus height of the target. So, this error due to curvature and reflection actually it is equal to 0.67, it is given

here $3D^2$ square in meter or D is in kilometer. So, this is the thing we have to mark. So, now, height of the point like in this case it is the height of A , in height of the instrument known, error due to curvature we can calculate from this where D is in kilometer. D is actually the $L \cos \alpha$. So, we know the horizontal distance between the two stations, so it is known. VAB be also VAB sorry this is not VAB , this is $L \sin \alpha$. So, this is VAB , so this is also known and height of the target also known slope. In that way when the instrument location and the target location is far off then we need to take into consideration the error due to curvature and reflection and the combined error is to be added.

In that way we can find out that distance between we do find out the distance between two stations, when it is far off. Total station provides us they the height of a point.

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So, for a point, suppose this is the bridge, the corner of the bridge that means, we have the bridge the cars moves here. We are here this is the river, this is the river. So, we want to find out what is the height of the base of the waves. So, what we need to do this as exactly these things below we should hold our prism. And our total station is somewhere here. So, first what we will do, we will first know what is the height of this point, height of target or height of our this prism we know. We will first measure this value and then we will pass at the telescope to this point.

Now, this is the slope distance. And from zenith angle, zenith angle then altitude equal of 90° minus α . It will be able to compute h^2 and then h^2 plus height of the target will give you the height of the accessible point. So, this is a very simple method. So, I will like to demonstrate what is the height of this roof. So, for that, I will first consider the height of this point, this point is height is 1.8 meter. So, and from there I can go for that. So, how it is done it is given there. First we have to make the temporary adjustment already it is done. I suppose already and then we will make it on fine adjustment of the temperature has been done, it is there.

So now, what we will do bisect this telescope to the center of that. So, now this is perfectly bisected. When it is bisected then I will like to go to the main menu to the observed menu. So, under the observed menu, there will there is a part phase one, phase two, phase three. So, I will like to go to the phase three where there is a special function call REM. So, once it is there, then now I have to give the input the height of the instrument as our height of the instrument is 1.5 meter, so I am giving it 1.500. And the height of the target we are finding it 1.800. So, now, we see here that the total station has measured the slope distance as well as zenith angle as well as horizontal line.

So, after this I will now go for bisecting the telescope to the roof corner. So, now I will go for REM, now it is measuring and slope and then it go as provides us the height of 2.408 meter. So, height of this room is 2.408 meter. So, in that way we can also measure we can make use of total station to measure the height of some point which is not accessible. And another point which is important when we will make total station measurement to when if we want to reduce the error, and if we want to measure two distances far off suppose A and B, we should try to place the instrument in between. So, that the backside and front side distances are more or less equal. So, if the back side distances and front side distances are more or less than equal then the many of the errors will be canceled each other, and we will be able to arrive at, but height differences.

With this, I like to conclude today's class. The summary: that actually total station does not measure the height directly it computes the height from slope distance and zenith angle. Height can be also measured using some for the inaccessible points. And height distances between two points having long distances, we should apply the error due to curvature and refraction. And the error in measurement in height or difference in height

between two points can be reduced by taking the backside and front side distances of equal. With this, I like to conclude today's class.

Thank you.