Basic Surveying
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Module No - 09
Lecture No. # 01

Computation and Adjustment

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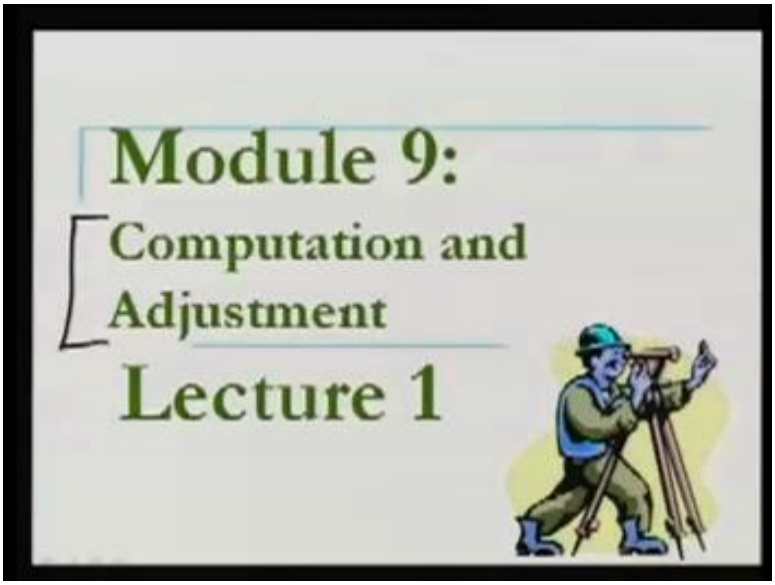

Welcome to this another video lecture on basic surveying. Today, we are in module 9 and in module 9 we will be covering computation and adjustment. First we will start with lecture number 1. This is our entire schedule of all the lectures.

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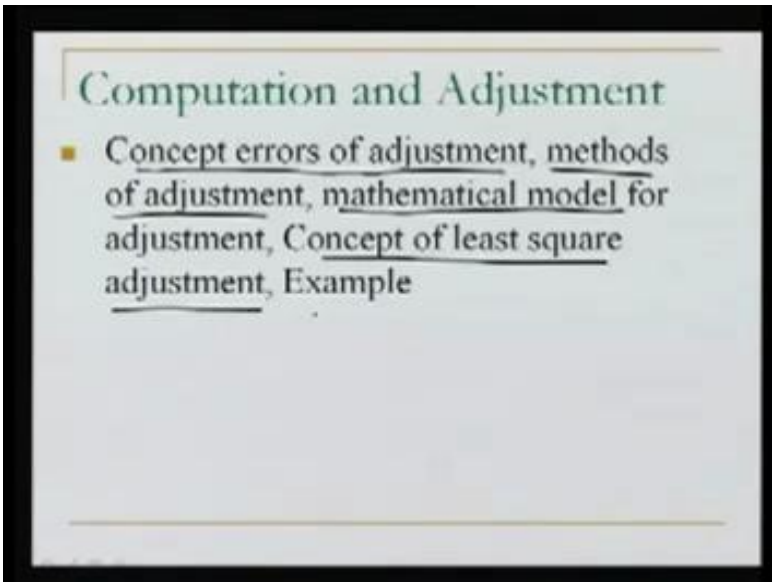

Now, in lecture number one what all will be covering - the concept of error of adjustment methods of adjustments. Will see that we need a mathematical model for the adjustment and a little bit about least square adjustment we will see all these with examples. Well, let us start with the very basic question; the question is why do we need the adjustment in surveying whenever we are taking the observations in the field what happens? As we have seen in taking observations what about we measuring? We always make use of some you know instrument then a person is involved then there are various kinds of conditions, because of the climate weather atmosphere.

Now, the end result of all these is we want to measure for example, a distance, because of the limitations of the instrument chain tape or EDMI, because of the limitations of the observer or because of the problems in the weather. There is some you know weather is not very good or may be for the kinds of the ranges for which a temperature range for which the chain has been designed the weather is not like that or the temperature there in the field is more. So, what happens? The end result of all these is our measurements will have some error we have seen this. Now, errors as we can see here in this slide

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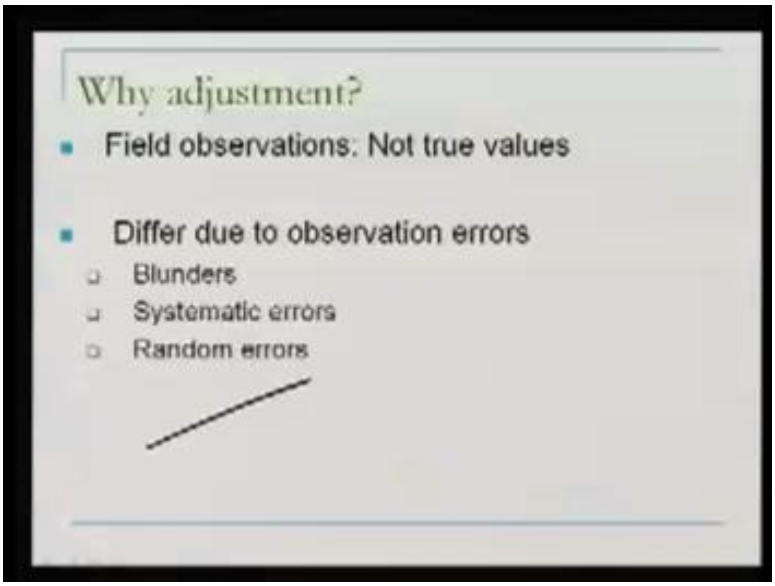

Errors can be we define in 3 categories. Number 1; blunders those which can be detected by some stochastic method. Blunders mean they are very you know far away from the main group of values or observations. We can scan the observations we can find no there is something wrong with this particular observations. So, that is a blunder their methods of detecting those eliminating those. Then the other kind of error, we know about that that is the systematic error means for that error we can write a physical model. We know the reason why this error is there? By taking the measurements for example, the temperature measurement in the field and we know the temperature at which my tape has been designed. But finding the difference of these 2 what we can do? We can apply a correction for the expansion of the tape, because the temperature difference.

So, what we are doing? We are writing a mathematical to model here or physical model. Using this physical model we can eliminate the error. So, all those errors about which we know their source and can be eliminated easily we see them systematic errors, because we can eliminate those. Well from the observation the blunders have been eliminated the systematic error has been eliminated, but still there are errors in the observations. We know this we have already discussed it is still our observations are not the true values. True values mean the distance between 2 points, what is their exact distance? The true distance we are not able to measure it, because a still there are many sources of errors about which we do not know those errors. We cannot model which we say accidental errors or the random errors. So, as we can see here, we do not make the observations

which are true values rather our observations will have the errors. The errors are of these categories.

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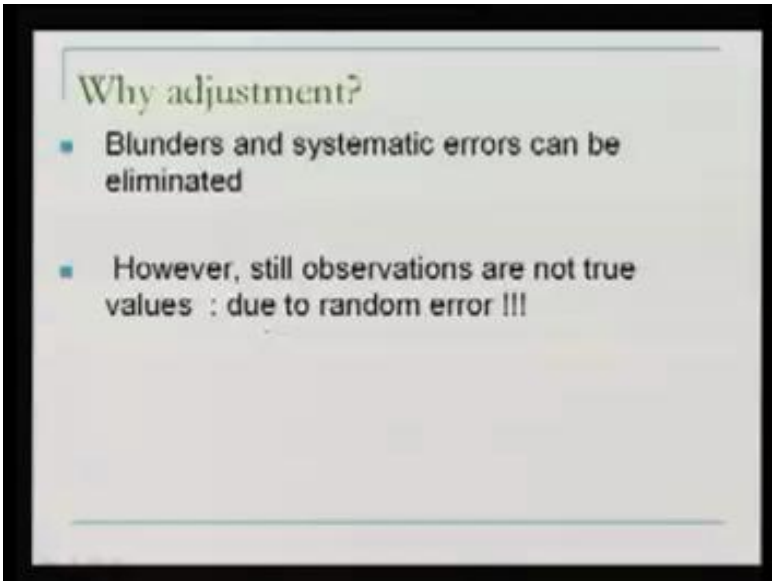

Now, we have seen that random error will remain in the observation even if we can eliminate blunders and systematic error.

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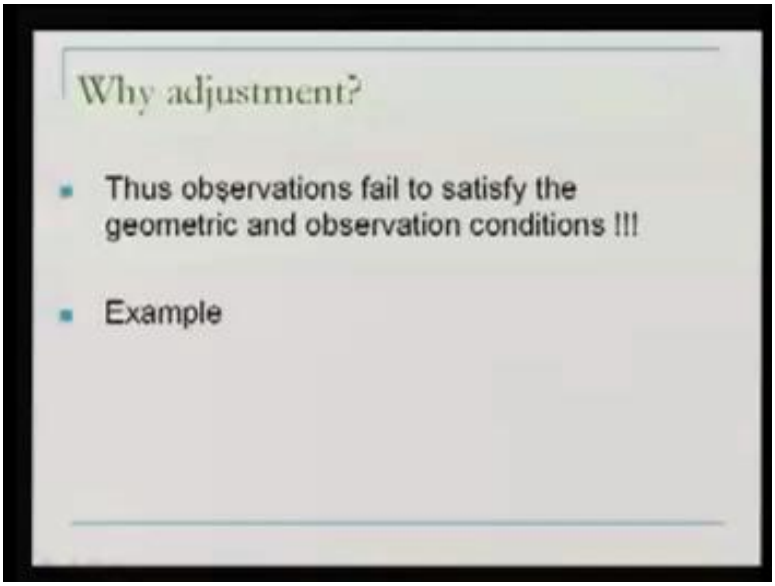

So, what the observations this is very important here? The observations, because of the error present in the observations fail to satisfy geometric and observation conditions. Now, let us look at that what is the meaning of this, we will talk about this one by one.

Let us first talk about the geometric condition, what is the meaning of geometric condition? Well here in the slide.

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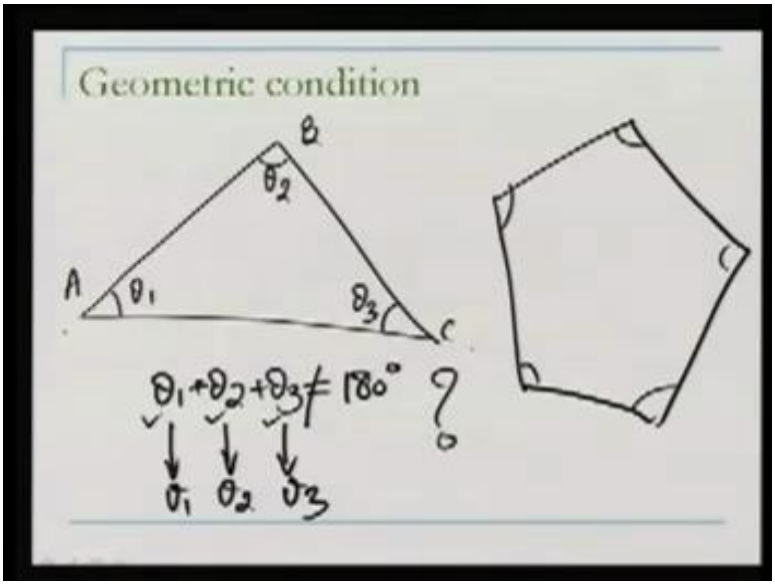

You will see there are 3 points A, B and C. Now, these 3 points A B C are physically there in the ground you can look at 3 points in the ground. What we are doing we are measuring the angles which are forming this triangle A B C. So, as you can see the angles theta 1 theta 2 and theta 3 have been observed in the field. All right now, that meaning of geometric condition is, because we have 3 points in the field they form a triangle. And we know the sum of internal angles of the triangle if you say theta 1 plus theta 2 plus theta 3 this should be 180 degrees.

This is the geometric condition, because there are 3 points on the ground forming a triangle, but do our observations satisfy this? If theta 1 theta 2 and theta 3 are our observations this will not be equal to 180 as you can see here. This will not be equal to 180 why it will not be equal to 180, because in theta 1 there is some error in theta 2 there is some error in theta 3 there is some error. Let us say v 1 v 2 and v 3. So, because of that our observations are not satisfying the geometric condition now. There may be many more geometric conditions depending what kind of figure we are talking about. If we have a polygon, we can also define a geometric condition for the polygon. Similarly, many more these conditions are of formed, because of the angles, because of the lines also sometimes well the next condition.

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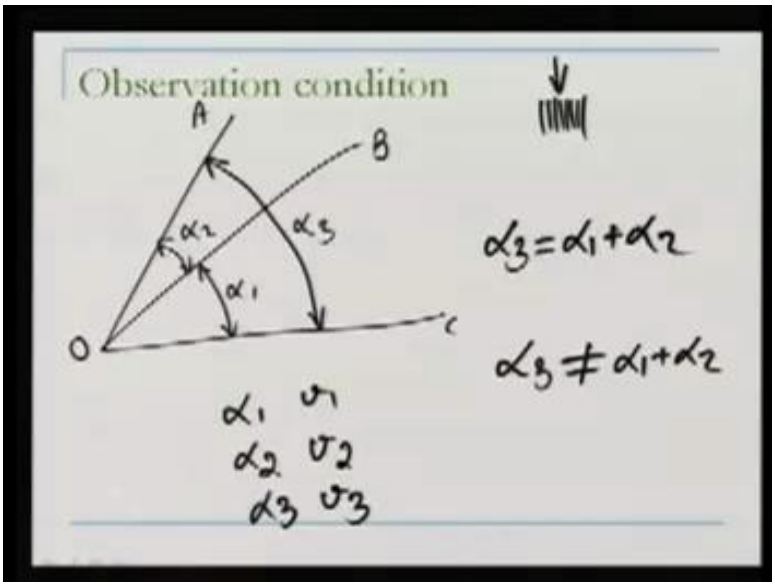

Is the observation condition now, as you see over here? We have a point O at that point we are measuring the angles alpha 1 which is between point C and B. And alpha 2 which should between point B and A as well as we have also taken one more observation that is alpha 3. So, alpha 3 is observed in the field between C and A now, just think of the case of theodolite what we do in the theodolite? We will take the theodolite will set the theodolite at point O. It should be exactly have a point O the vertical axis of the theodolite it should pass exactly over the point O will it be so. No there are problems in centring we cannot centre truly well there is some error.

We need to keep some ranging rods at A B and C if we keep the ranging rods there in at A B and C. Can we keep the ranging rod exactly above A B and C? No, well now, we are taking the observations we need to bisect can you bisect exactly? The centre of the ranging rod no again there are problems you know the problem, could be when we are reading the observations if we see here, we are trying to read somewhere here oh what is the reading? Can we read exactly no. So, what is happening in this process they are managed sources of sources. And those which we cannot model source of random errors.

Now, if that is the case what will happen alpha 1 will have some error? Let us say v 1 similarly alpha 2 will have v 2 and alpha 3 also will have v 3. The observation condition means had these been true values no errors at all in taking the observations. Then alpha 3 should have been equal to alpha 1 plus alpha 2 yes if they are true values, but no we are

not observing true values. So, no more alpha 3 is equal to alpha 1 plus alpha 2. So, this is the observation condition. So, what we said? We said well our observations should satisfy the geometric condition and observation conditions. Well now, the important thing we have seen the geometric condition and observation condition. Also we have seen the observations which you are taking in the field do not satisfy these conditions, but that is not desirable. You know we have a triangle there in the field.

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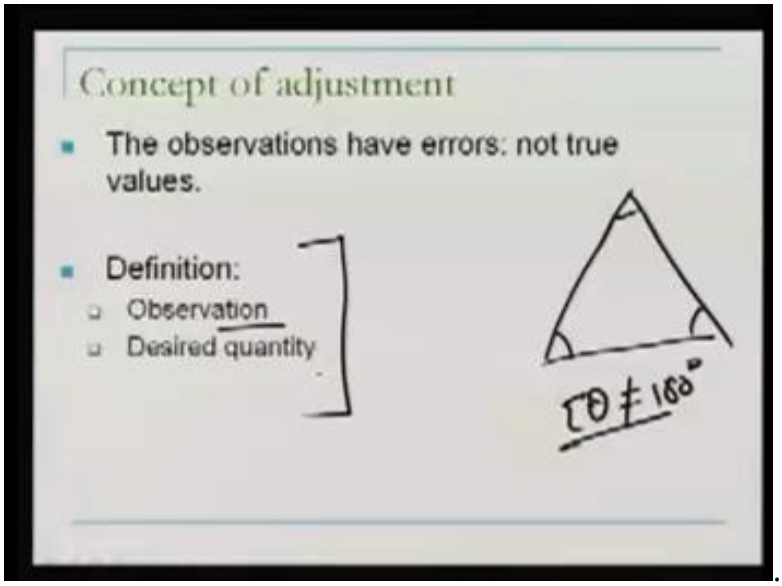

And for this triangle we observed these 3 angles and now, we find that sigma of these angles is not equal to 180. Can we live with that? No we cannot go further with that, because there in the field we are observing a physical quantity the shape of the triangle is not? The sum of 3 angles has to be 180, but observations do not say. So, what should we do now? Here comes the concept of adjustment? We need to alter our observations change our observations in such a way that they start satisfying this particular model or the condition. We will see how we do that latter on, but right now, we will see some definitions one is observation and the second is the desired quantity what these are?

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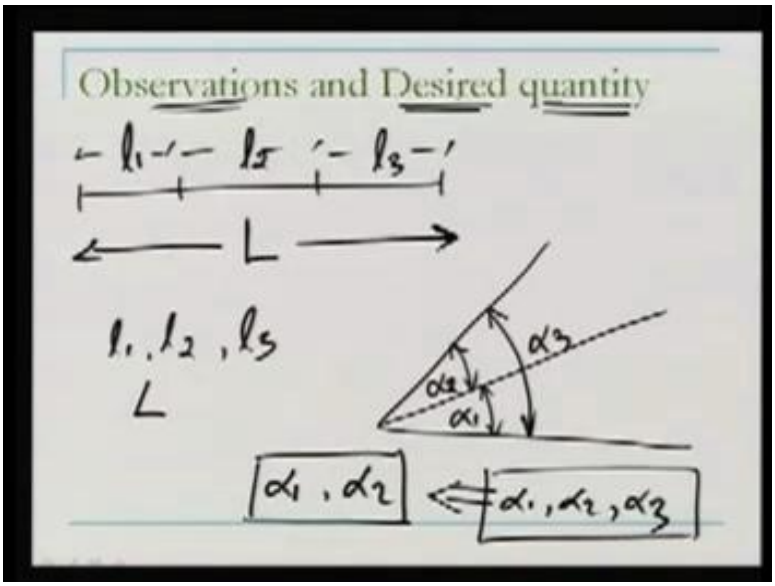

Observation means if let us say first talk about the desired quantity. Desired quantity is we want to measure this full length L, but we have a tape which is smaller in length then this full length capital L. So, with that we are observing this in parts we are observing first l 1 then l 2 and l 3. So, our observations are l 1 l 2 and l 3 and the desired quantity is L. Similarly, here let us say we want to our desired quantity is in this case are alpha 1 and alpha 2, but we have also observed alpha 3. So, desired are alpha 1 and alpha 2, but in the case of the observations, our observations are alpha 1 alpha 2 and alpha 3, because we can find the values of alpha 1 and alpha 2 which are desired by these three observations. So, what we are doing here in this case, we are introducing a redundancy in the observations all right. So, right now, we should understand the difference in observations and the desired quantity well next.

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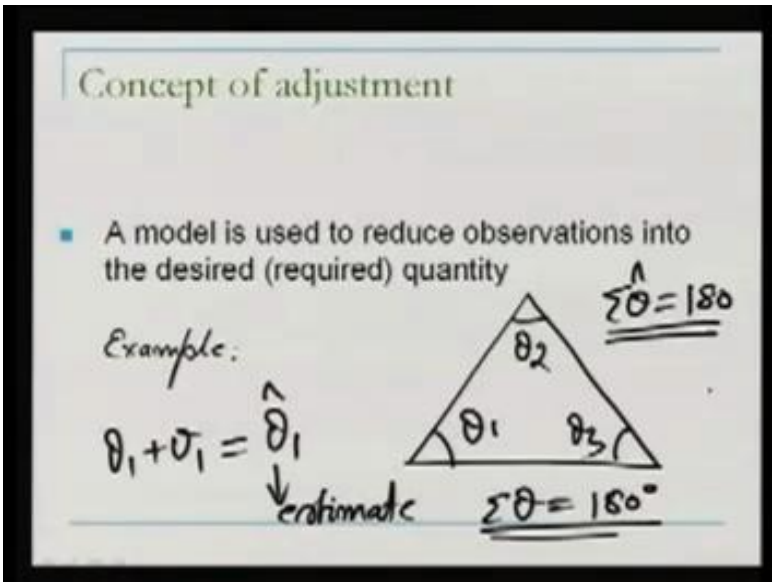

As we have seen earlier also. And as I was talking you know our observations should satisfy a model. The model in this case was sigma theta is 180 that is the model observations are theta 1 theta 2 and theta 3 and sigma theta should be 180. So, what we are trying to do? We are trying to alter our observations correct them apply some corrections to the observations in such a way that the estimates. So, what we are doing in observation if theta 1 is the observation I am applying a particular correction to this. So, that I get theta 1 hat. So, theta 1 hat is the estimate, what is the meaning of this?

In observation we applied the correction by some method we get an estimate. So, this estimate now should satisfy our model; that means, sigma theta hat should become 180, because we have applied the corrections. Now, this process is called the adjustment. So, for the adjustment we need that model and our estimate should start satisfying that model now. Now, other some more things the model which we take or which we you know make use of in adjustment are of 2 types; one is functional model the second is stochastic. Now what is the difference between these two, what these are?

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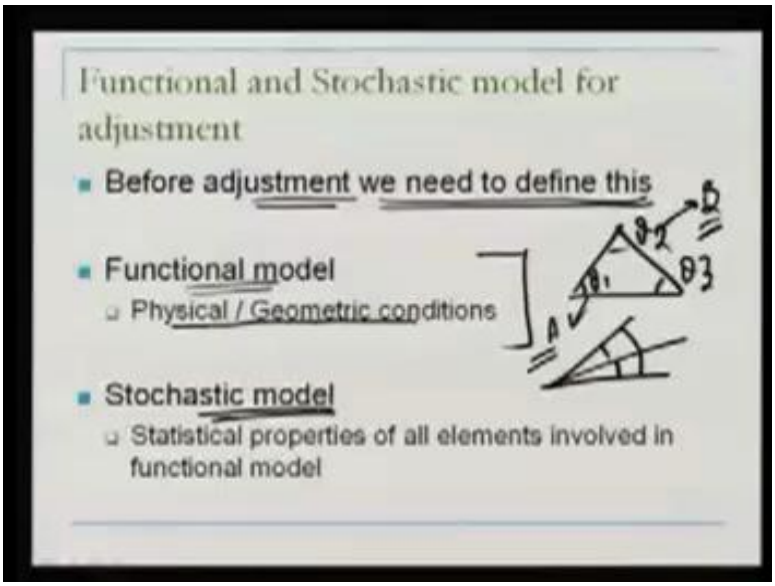

This is very important before the adjustment we need to define this model. We need to be very clear about the model, the model which our observations should satisfy or estimates should satisfy. We need to know about that model. The functional model is as we have seen earlier also sigma theta is 180 is a functional model. Similarly, alpha 1 and alpha 2 is equal to alpha 3 whether by condition sorry the geometric condition or the observation condition as we have seen previously also these are the functional models which are because of physical or geometric conditions.

Now, the stochastic model is. So, far in our functional model we did not talk about the quality of the observations someone who was capturing theta 1. You know this gentleman let us say his name is A and gentleman who is capturing theta 2 is B theta. The gentleman A is very sincere than the gentleman B and then they come out to me with 2 sets of observations one for theta 1 one for theta 2. If I know about these 2 gentlemen or may be let us say A was working with a very precise instrument while the B was working with a non-precise instrument in that case what can I do? I can differentiate now in theta 1 and theta 2.

I can say theta 1 observations are better are more precise theta 2 are not. I can give weights theta 1 observations have higher weight while theta 2 observations need to be given less weight. So, in my functional model when I am putting this data, I need to also take into account the quality of the observations. So, the way we take the quality of the

observations into account we say that as stochastic model. So, we need to define that model also about the quality of the observations. Now, we will take one example here. Now in this example as you can see.

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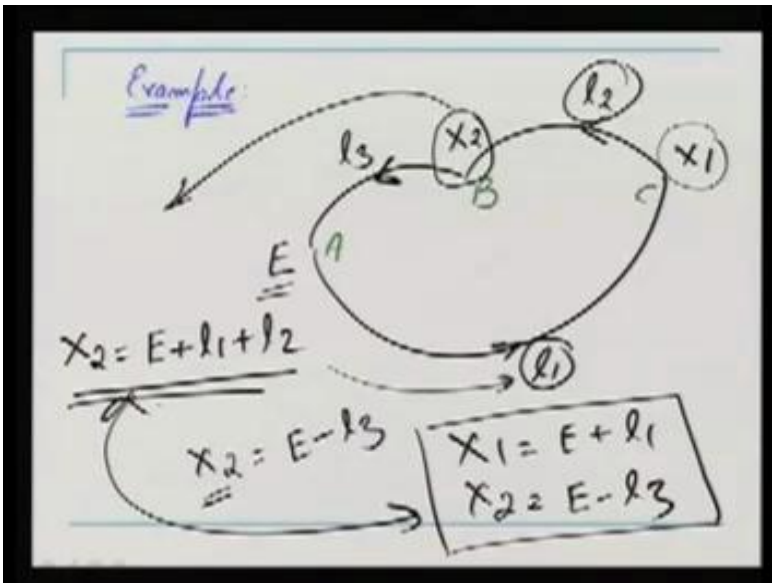

A B and C they are 3 points point A point B and point C there on the ground. What we are doing A is the benchmark and elevation of A is known it is capital E using this benchmark we want to determine the elevation of A sorry B and C this A point is known is the benchmark. So, what do we do? We know the process. We carry out starting from A will carry out the levelling it could be fly levelling up to B. So, we know the difference in elevation between these 2 points if I know the difference in elevation between A and B, I know the elevation of RL we say RL of A I can find the RL of B.

Similarly, starting from B I can go to C and then again I can find the difference between point B and the C the RL difference I add it to the RL of B I can find the RL of C. One more procedure is possible this way we can determine these 2 A and sorry B and C their RLs. One more way is possible I can straight away I go from A to B as well as I go from A to C. So, what we are seeing here we are doing the same thing. We have done this over here from A we found l 1 l 1 is the difference between RL of A and C using that we can find the value of X 1 X 1 is RL of C. Now, from X 1 I went to B the difference in RL between C and B is l 2. Now using this route I can determine the RL of B also, but what

we did? Again from B we went back to A. So, now, the RL of B can also be determined directly by taking into account this l 3 it is a very simple thing.

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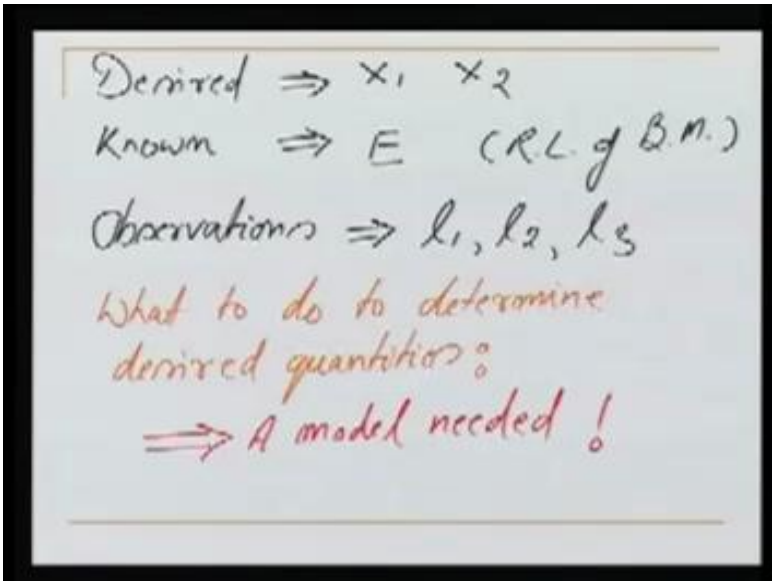

Now, here as per our adjustment X 1 and X 2 are the desired quantities. What is the meaning of that? We want to determine the RL of B which is X 2 and the RL of C which is X 1 these are the desired quantities. We know E, E is RL of A; that means, RL of A well the observations are l 1 l 2 and l 3 you know what all observations. We have done here we have observed the difference in RLs l 1 here l 2 here and l 3 here. So, what we want to do? We want to determine X 1 and X 2 now. So, what we will need? We need a model now, in order to determine this. So, what model we can make use of a model is required? We can write this model in order to determine this desired from the observe one observed quantities and the known.

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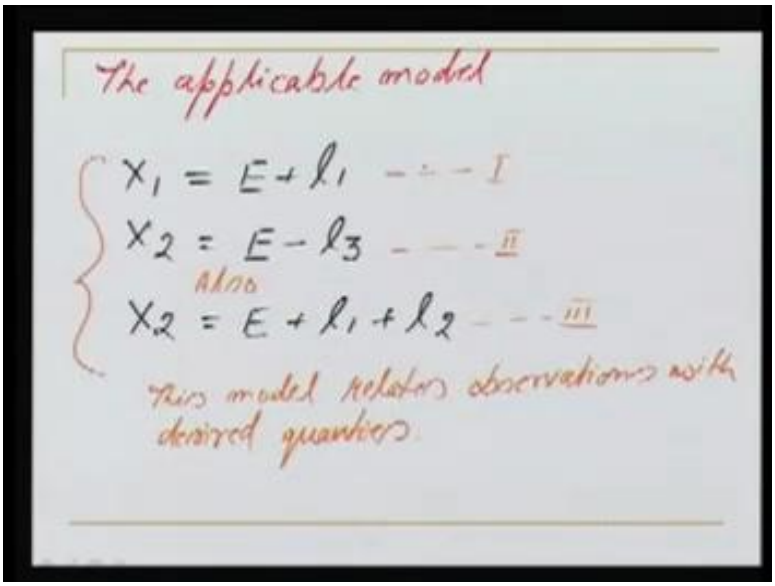

The model could be I can determine X 1 as E plus l 1. What you can do? You can go back to the main figure. For example X 1 is E plus l 1 this I am m writing now, X 1 is E plus l 1 next X 2 is E minus L 3. I want to determine X 2 which I am writing as X 2 is E minus l 3 minus, because this we have done the survey this way B to A and this we are writing as positive. So, we have to just take into account this sign that is why I am writing minus here. So, X 2 can be determined this way also. So, X 1 and X 2 both are known E plus l 1 and E minus l 3 all right.

So, what it will do? It will give me one unique solution, but at the same time what we observed we can also find? You know also X 2 by E plus l 1 that is RL of that is X 1 plus l 2. Now what is this? X 2 can be also determined as E plus l 1 plus this observation here l 2 all right one more way of determining the X 2. Now, we have a model now and this is, the model which defines this entire set of observations. And using this model we can determine X 1 and X 2, but there will be some questions now.

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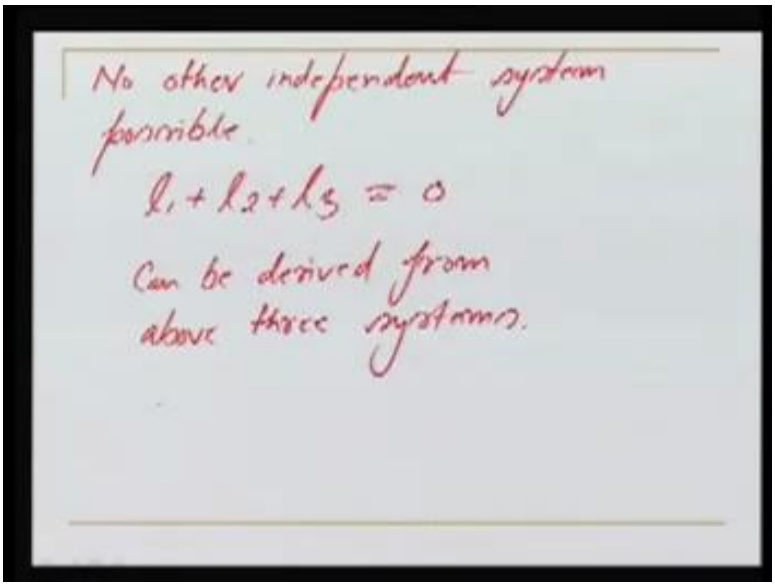

What are the questions one more thing which is important here we have so, far come out with these three system within our model is there any possible. For example, I can write 1 as l 1 plus l 2 plus l 3; obviously, you can make a guess now, that this will be equal to 0, because why l 1 plus l 2 plus l 3 will be 0. We started from this point that difference of the l 1 is difference between these 2 points A and B then l 2 then l 3. So, what we are doing? They are starting from a point again coming back to the same point. So, if we sum up all these wherever we go we have seen this in our loop concept also when you are talking the levelling l 1 plus l 2 plus l 3 that should be equal to 0. But this model or this system is not independent. The meaning is I can derive it from these three equations. So, it is not independent we are looking for systems which are totally independent. Over here all these 3 are independent well after forming this model.

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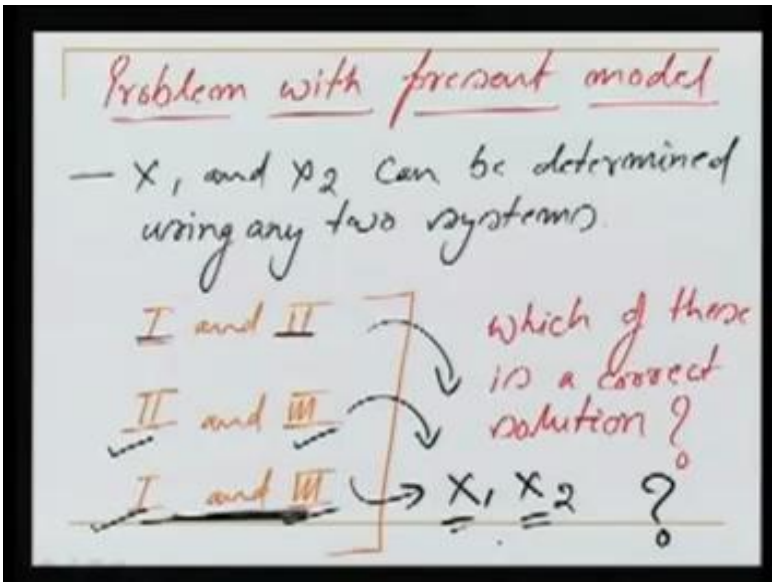

What you want to do? We want to determine X 1 and X 2. How can we determine that? In order to determine that what we can do? We can make use of equation 1 and 2 over here I am talking about this equation 1 and equation 2 and by solving these 2 I can find X 1 and X 2 that is very easy. But at the same time I can also do it for I can also do it by taking equation 2 and 3 also I can do it by taking 1 and 3. So, what ((refer time: 24:20)) here the solution for X 1 and X 2 can be formed by these 2 routes. Now, the problem is which out of these 3, because this first set will give 1 value of X 1 and X 2. Similarly, the second set will give 1 value of X 1 and X 2 and the third one also over here that will also give 1 value of X 1 and X 2. Now, the question is out of these 3 possible solutions for X 1 and X 2 which one should we take. Why this problem is coming here?

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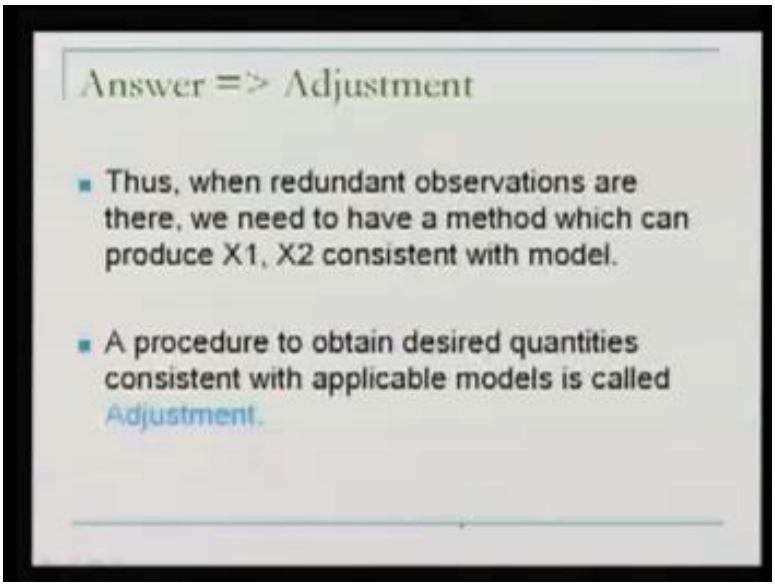

This problem is coming here, because we have redundant observations. What is the meaning of redundant observations? We have seen this before, but let us talk about it once again.

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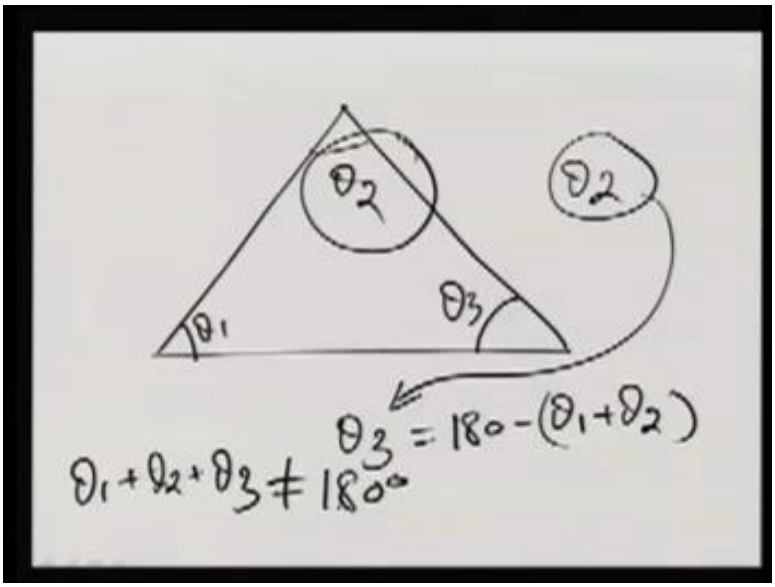

In this triangle is theta 1 theta 2 and now, the triangle is defined I can find these value of theta 3 as 180 minus theta 1 plus theta 2. So, this gives a unique solution there is no redundancy here, but the problem with this is if theta 2 has some error very large error. Errors are always there, but a very large error is 3. This large error will also creep in

theta 3 we do not have any method of checking that, but if we are also observing theta 3 now, we are observing it. So, if there is a very large error in theta 2 theta 1 plus theta 2 plus theta 3 this will not be equal to 180 as well as it will very much away from 180, because in theta 2 there is a large error. So, by this redundancy what we are able to say we are able to check for the errors.

So, redundancy is always to help us. So, same is the concept here now, to solve for this problem you know a problem with the model here what the problem was X 1 and X 2 can be determined by 3 routes which one is better? It is not a problem really rather we need to find a way to solve for that. It is not a problem. The way to find an answer in these cases is through adjustment. We want redundancy in the observations, because it has as to look for the errors number 1 in case of redundant observations we need to have a way.

So that we can find a solution the solution which is persistent with the functional model which, the observations should satisfy that we can do through the process of adjustment. So, over here the definition is a procedure what is the adjustment? Adjustment is a procedure to obtain desired quantities our final aim is to obtain desired quantities not the observations. Which are consistent with the applicable models is called adjustment that is important. Now, how do we do that? How do we carry out the adjustment? What should be going you know how should be going about. We will see one approximate method for that in order to understand the process then we will go for other method. This is an approximate method.

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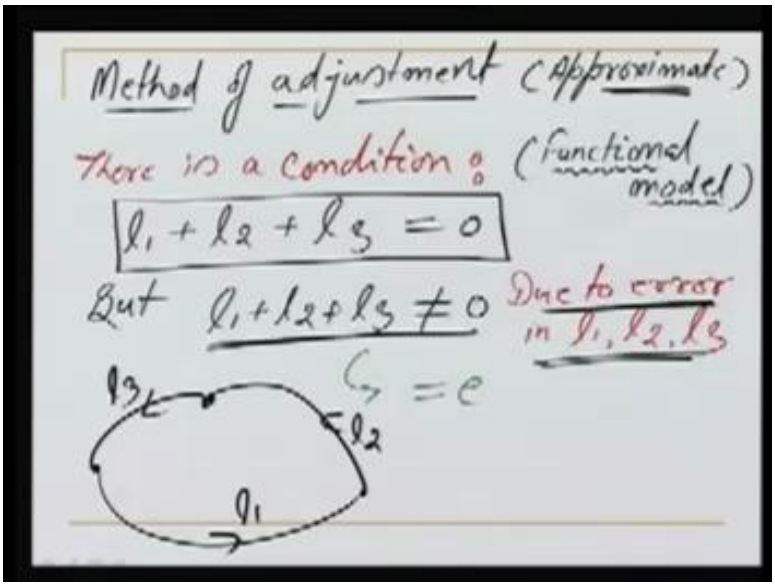

Here and in this method of adjustment let us say we are talking about our previous problem only when we had taken the differences in elevations between A B and C. You know l 1 l 2 and l 3 our case was like that and we know we know that in that particular problem where it is l 1 l 2 and l 3 l stands for difference in levels. So, in this problem we know that l 1 plus l 2 plus l 3 this should be equal to 0 if the observations do not have any error, but due to error in l 1 l 2 and l 3 it will not be so. We also understand this; because our observations whatever the procedure we are applying in the field it is still the random errors will be there. Yes there will be less amount will be less, but they will be there.

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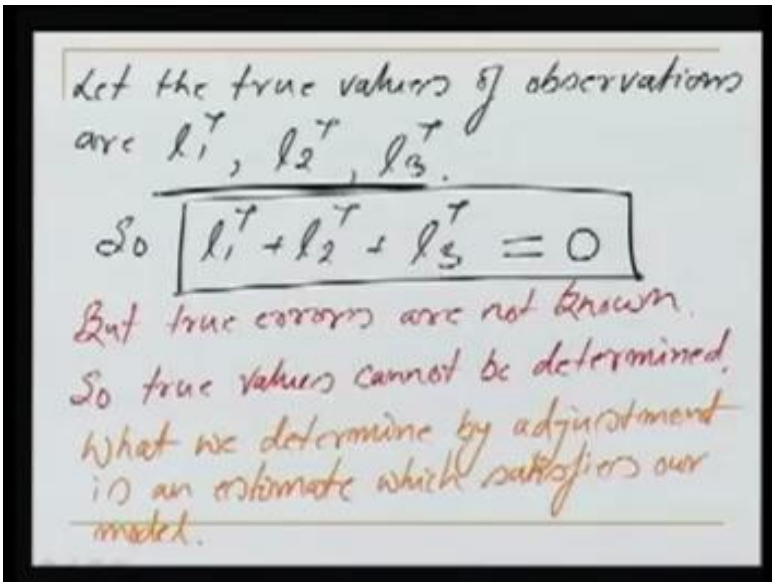

So, let us say if for l 1 l 2 and l 3 the true values are l 1 T l 2 T and l 3 T these are the true values had there been no error at all. In that case this model will be satisfied. You got true values means there is no error, but do we observe true values? We cannot what we observe is some with some error. So, observations are with some error. One more important concept we are going to talk here. Our observations are with some error not the true values. Now, formulae observations we try to reach true values or I rather we say we try to reach the most probable values those values should satisfy the model.

So, what we are trying to do? We are trying to reach from the observations and estimate l hat as we had seen before also. And estimate. So, that our estimates are the best and that it condition of the model. The adjustment should give us the best possible solution of the estimates there should not be any another solution which is better than that. That is the, you know desired goal desired aim which you want to achieve by our process of adjustment. Now, this is why? So, what we are writing here.

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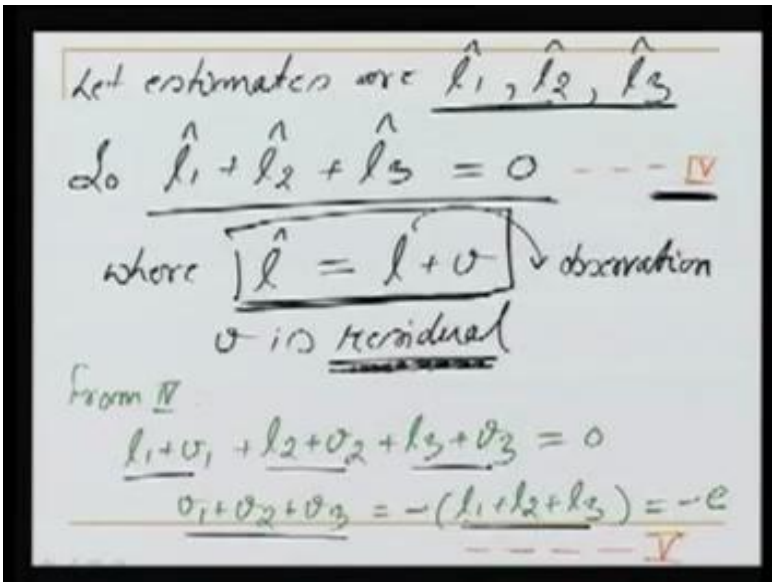

Our estimates if we, because we denote the estimates by hat. So, l 1 hat l 2 hat and l 3 hat these are the estimates. So, finally, our estimates also should satisfy this l 1 hat l 2 hat and l 3 hat. The sum of these should be equal to 0, because our desire is that they should satisfy the functional model. Now, we write l hat as l plus v here l is the observation we know about it. Something which we are measuring in the field observation and v we say as residual.

So, in observation if we add the residual with at the estimate now using this, what we can do? Using this, this particular you know l hat is l plus v and the equation four you can write l 1 plus v 1 plus l 2 plus v 2 plus l 3 plus v 3 should be equal to 0. Now, you can further write v 1 plus v 2 plus v 3 should be equal to I am taking all these observations on the right hand side should be equal to minus l 1 plus l 2 plus l 3. Let us say this minus l 1 plus l 2 plus l 3 is equal to minus e. Now in this case where is the functional model? The function model is this. Is not the functional model in this particular problem is that means.

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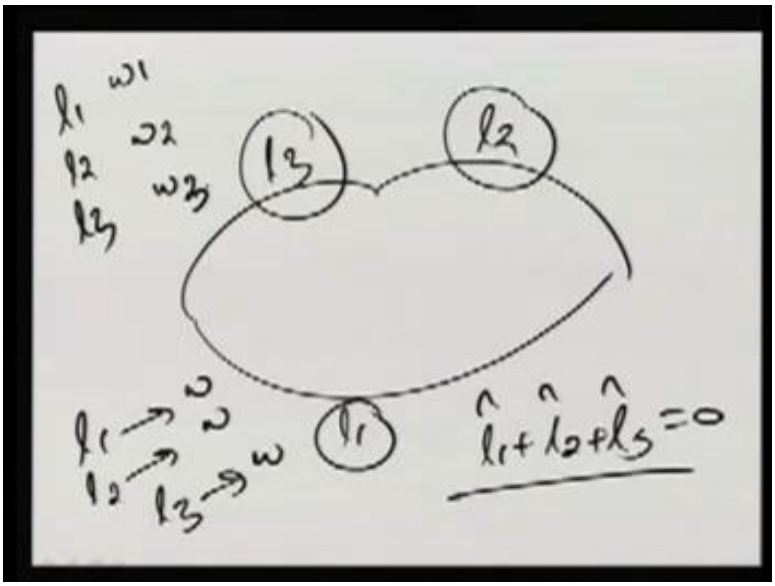

Describe that problem again you know l 1 l 2 l 3. So, functional model is l 1 plus l 2 plus l 3 should be equal to zero. That is the functional model now, what is the stochastic model in this case. Stochastic model we will talk about the quality of l 1 l 2 and l 3 if l 1 l 2 and l 3 all are observed with same precision. We will say well all of them have the same weight. If l 1 l 2 and l 3 are observed with different precisions, we can say these observations have different weights is not. So, that is the stochastic model.

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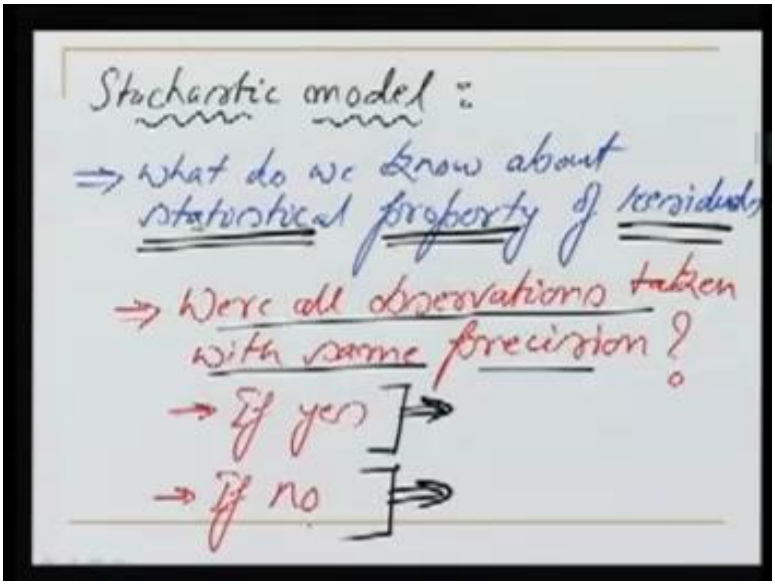

So, a stochastic model means you know do we know about this statistical property of observations of residuals? Now, in this case 2 cases as we have seen. If all the observations have been taken with same precision or not; the question is, were all observations taken with same precision? Well there could be 2 answers; yes and no.

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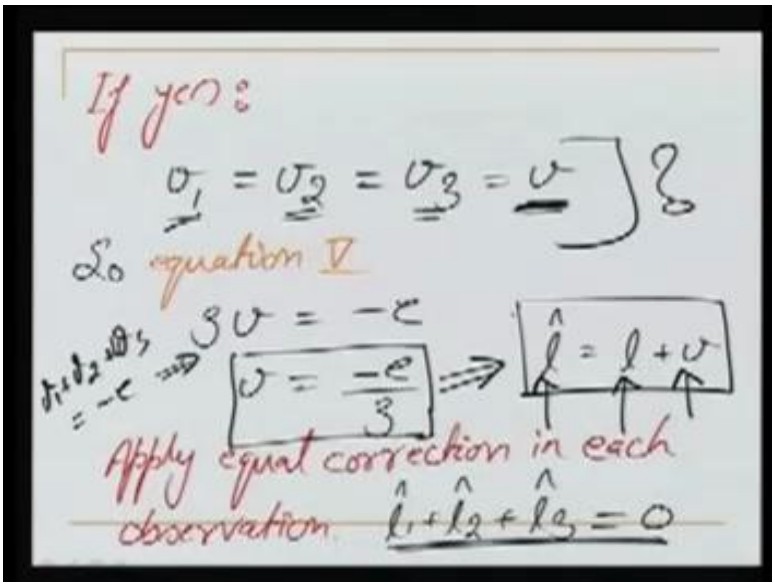

If the answer is yes, all the observations we have taken with the same precision. Then we can say the residual in all the observations will be same. Now, why we are saying this? You know there in the field we are observing l 1 l 2 and l 3. Now, we conclude that l 1 l 2 l 3 have been observed with same precision means whatever is the error in l 1 same is the error in l 2 and l 3 that is the assumption here. If it is so, that is why? We are writing that v 1 v 2 and v 3 should be equal to let us say v. So, we can write now, because earlier we are writing as v 1 plus v 2 plus v 3 that was minus e. So, we can write this as now, t v is equal to minus e.

So, we get the value of residual as minus e by 3. Now, with this, what we can do? If we know the value of residual I can apply it on the observation l this v is being applied to get the estimate. So, the estimates will now, satisfy my functional model. So, what we have seen in this example. In this example we saw a method of adjustment we had these 3 l 1 l 2 l 3 we made an assumption that l 1 l 2 and l 3 had been observed with same precision.

So, the error is same. We found it total error, because l 1 plus l 2 plus l 3 is should equal to zero, but it was not? Whatever is the total residual? We say that is the total error now

this total error is being divided in l 1 l 2 and l 3. So, accordingly we are applying the correction is not. So, by finding the correction by applying the corrections in l 1 l 2 l 3 we are finding the estimates l 1 hat l 2 hat and l 3 hat and that way this l 1 hat l 2 hat and l 3 hat these 3 will satisfy our functional model obviously.

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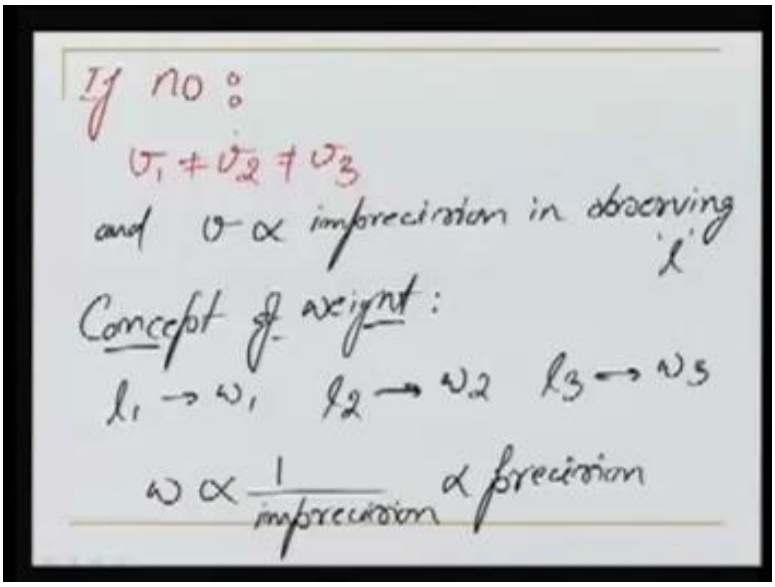

Well here the case was, if the observations are taken with same precision if it not so if the observations are not taken with the same precision. Now, what could be the case the case could be?

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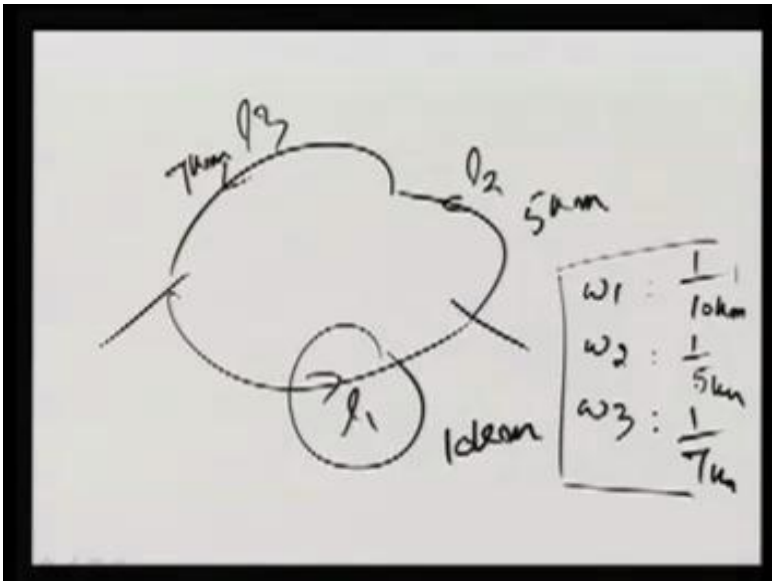

When these were observed l 1 l 2 and l 3 when these 3 were observed in the field over here let us say this is the very large length 10 Kilometre length while it is only 5 Kilometre and it is 7 Kilometre. If you recall in our levelling excise we were giving precision to the levels you know depending how many numbers of settings of the instrument over there also by the length of the level land. So, what we can do here? We can assign the weights w 1 w2 w 3 as per the length for the length is 1 by 10 Kilometre. Let us weight here 1 by 5 Kilometre and 1 by 7 Kilometre.

So, what we are doing more the length lesser the weight. Of course, this a special way of doing this which we have discussed in levelling, but here we want to see it yes individual observations can be given the weights as in this case. Now, if these individual observations are of different weights what to do? How to apply the corrections? How to adjust the observations in this simple case? So, we know that v 1 will not be equal to v 2 will not be equal to v 3 the residuals the corrections will not be the same.

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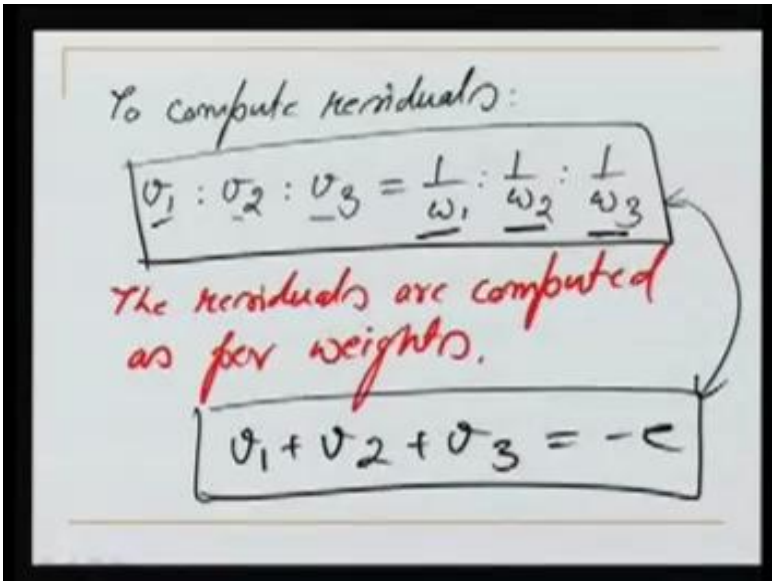

Now, if they are not same in addition to the equation v 1 plus v 2 plus v 3 that was equal to minus e that we have seen we will also have to use these equations. So, now, we are using these two to find the solution. Over here we see v 1 v 2 and v 3 are having the values which are related with their weights of the observations. So, what we have seen in this case that we are adjusting the observations. You know we are finding the l 1 hat l 2 hat and l 3 hat the estimates and these estimates they satisfy the function model. At the

time we also took into account the stochastic model. You know we took into account the quality of the observations if the observations were of same quality or different quality. So, we started giving the weights there are methods that how we can apply the weights? Now, next

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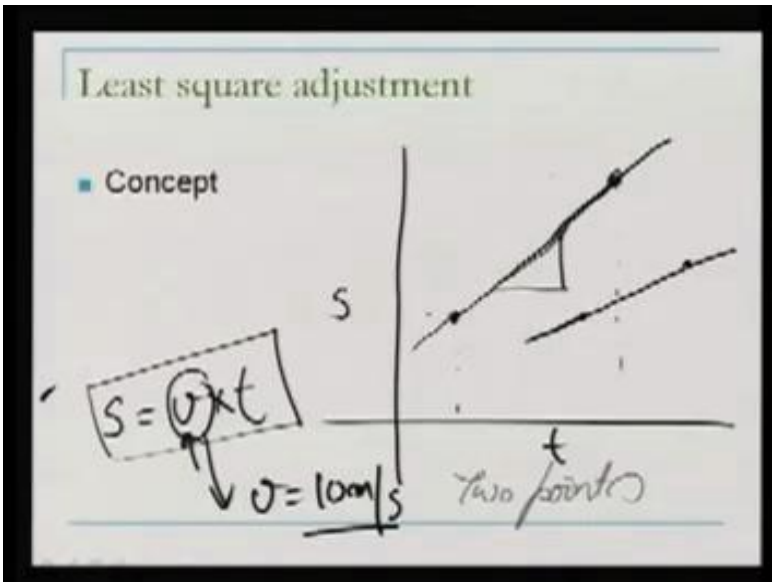

We go for the concept of least square adjustment. What we will do today? We will try to understand it the least square adjustment and then later on we will get deeper into it, because we will be mostly making use of this method of adjustment. We do not go by this approximate method, but in the previous example where we have seen this approximate method. Actually if you find the solution for that problem widely square the answer will be same. Let us say well what is the least square adjustment? Over here, I am giving you just concept. Let us say this is time of travel t and this is the distance s now, how s is related with t as s is v into t v is the uniform velocity. Let the uniform velocity no acceleration and these are related like this s is v into t.

Now, there in the field we have a stop watch and we have seen something moving with the uniform velocity. What we are doing? We are observing the time and the distance? We are observing how much it has moved? All right and we are observing the time at what time we are taking that observation. So, in this stopwatch I say time is 1 second it has moved by certain distance time is 2 seconds it has moved by certain distance 3 seconds and 4 seconds. Now, in this process where the sources of errors? The sources of

errors are in observation of the time. Because I am taking the time is not also the source of error is in observing the distance how much it has moved? I am saying it has moved 10 centimetres, but am I really able to observe that level is not.

So, they are sources of errors here. And these are we are considering as the random sources of error if in this process I take only 2 points. I observed a point here at this time it has moved the distance at this time it has moved this much distance. So, what will have will have only 2 points here while using these 2 points, if I want to find v the velocity what I will do I will simply join these 2 points is not and the slope of this line is known. So, this is also a problem of line fitting we always do it if we have 2 points and I need to fit a line to these I can fit a unique line I have a unique solution. Now, in this case for this v I have a unique value let us say 10 metre per second that is the unique value. I do not know any other value of v; because you see unique solution I made the observations only at 2 points. So, if we have 2 points over here I can always fit a line through this unique line.

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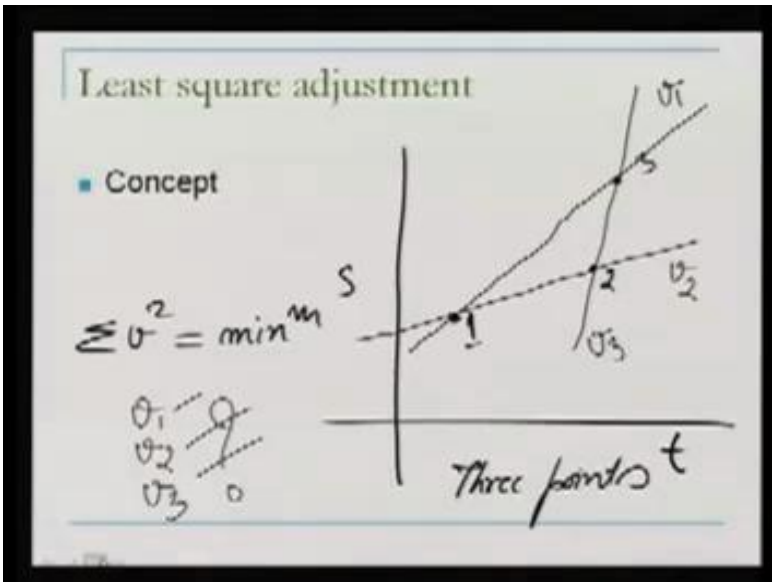

Next if we have now, more number of points, more number of points means we are taking the observations here at this distance t 1 is s 1 distance t 2 s 3 s 2 distance t 3 s 3 distance if it is so. Our first point our second point and our third point I have displaced these points further here. So, that we can understand the process otherwise this points should be also somewhere here there is some error. So, it will be displaced a little bit I

have displaced this more. Well if this is the case and we have to fit a line what I can do? I can fit a line through these 2 points. So, that gives me 1 value of the velocity.

I can fit a line through 1 and 2 it will give me the second value of the velocity. I think also fit a line through 2 3 points it will give me a third value. So, the same question which we were talking earlier out of these 3 v 1 v 2 and v 3 which 1 is more correct. How to take a decision here is not? I cannot ((refer time: 44:33)) values. I have the 3 lines fitted to these points which 1 is more correct value we cannot say anything about that which is this is this v 1 v 2 or v 3. Similarly, over here we had only 3 points we can also have the situation where we have a large number of points.

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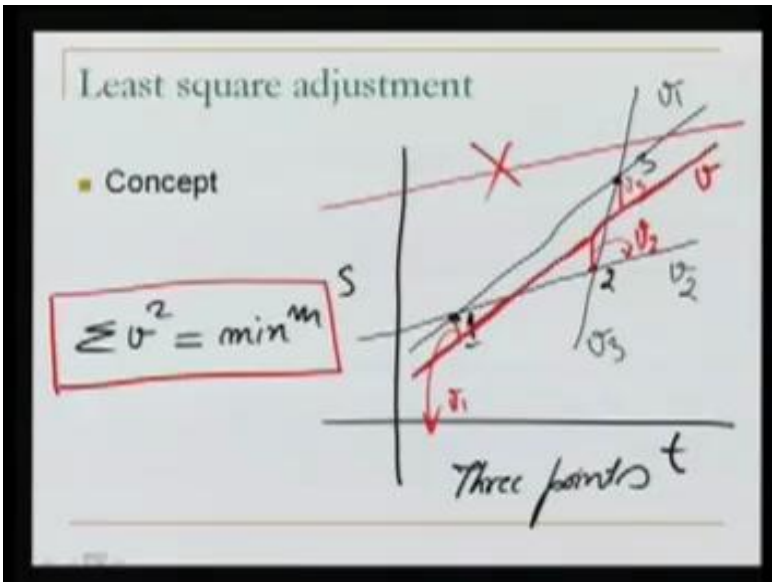

I can have one line another line another line another line you know all values of the velocity so, v 1 to vn which one is more correct so, in these problems what we try to do? We try to find a solution which satisfies our model which is the best possible solution in this condition. Now, the meaning of best possible solution that is what I am going to give you fine. What we do we try to fit a line here let us say we fit a line which is like this and we say this value v is the most represented value what is the meaning of that? The meaning is if you fit this line to these 3 points they are deviations of the line from these points. So, these deviations I can say as let us say v 1 over here v 1 is stands for residual or the deviation v 2 not for the velocity and v 3.

Now, we will go for a line as over here I have seen the line by red colour. I am saying this line is the best line which can be fitted in these 3 points. We will say this line to be the best line only if when we will say it best we will say it best only if this line deviates, because it is deviating from point number 1 point number 2 point number 3. Its deviation is such that that overall deviation of this line from all the points is least is minimum is not. I can have a line over here for example, this, but this is not a best this is not a best solution.

So, what you are looking for our fitted solution? The value of the v which we are finding the line which we are fitting should be such that is deviation from our observations should be least all the observation taken into taken together now, how to realise that? These deviations are some are negative and some are positive is not. So, we are we want to take all the deviations into account. So, the way we try to achieve it is we say that sum of v square of all the residuals all the deviations should be minimum. So, as we have seen in this problem similarly as we are talking of the other problem.

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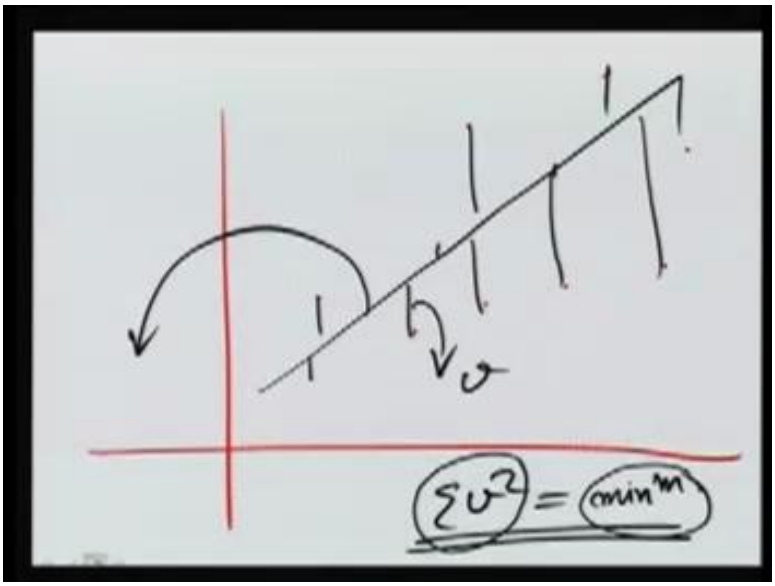

If we have several points here the line which is fit among these let us say this is the line which is the best the meaning is sum of a square of all these residuals. These residuals let us say we say as v. So, sigma v square should be minimum. And if we are able to find this line we say this is the line which we are fitting over these points by method of least square. The least square that is been communicated by this sigma v square and this

minimum thing here. So, the same thing we will try to do in our observations also. You know observations means as we are talking of the case of a triangle.

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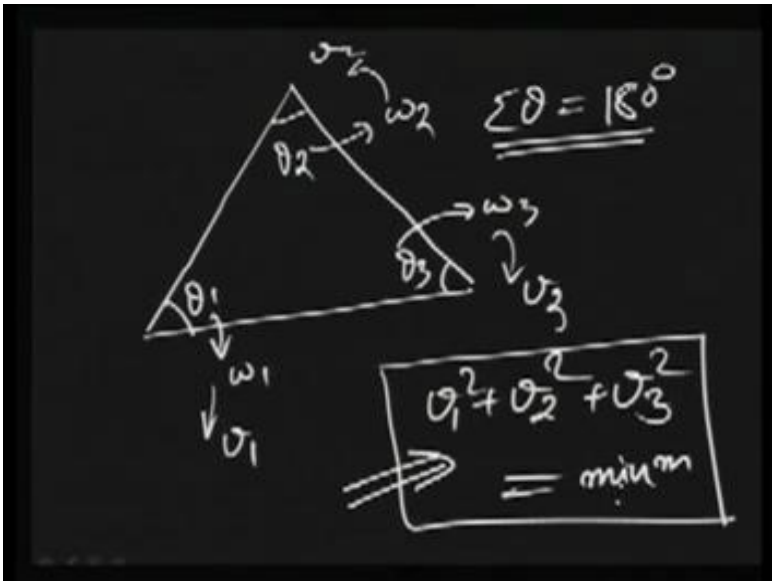

We are observing there theta 1 theta 2 theta 3and our functional model was sigma theta should be equal to 180 is not. So, what we try to do? We try to apply we first know somehow the weights of these observations. These are the weights then as per the weights we find corresponding to each observation the residual v 1 v 2 these are the residuals. So, these residuals should be such that that v 1 square if I write it this way v 1 square plus v 2 square plus v 3 square this should be minimum only for if my solution if my no v 1 v 2 and v 3 are coming from the proper method of adjustment. Then in that case 1 and unique solution will satisfy this for any other solution this sum of squared residuals will not be minimum.

So, in our method of adjustment we will try to realise that. What we are doing you know we are trying to change the values of theta 1 theta 2 and theta 3. The observations in the field in such a way alter them in such a way that they start satisfying our functional model as well as the changes which we have applied to them by means of these residuals are such that that we reach the best solution in the least square sense. So, what we are discussed today? We talked about the concept of adjustment why we need the adjustment, because they are errors.

We can eliminate blunders, systematic errors, but random errors are still there. We also say then, accidental errors cannot be eliminated, but if our observations have the random errors they will not satisfy our functional model. We cannot go with, you know, observations which have errors we need to adjust them. In order to adjust it we have to take into account the functional model which the observations should satisfy as well as we needs a method which should give us the best solution. So that we saw today is the least square method.

Thank you.