Forests and Their Management
Dr. Ankur Awadhiya
Department of Biotechnology
Indian Institute of Technology, Kanpur

Module – 04
Forest Mensuration
Lecture – 11
Measurement of Tree Attributes – I

[FL]. In today's lecture we will have a look at 'Measurement of certain Tree Attributes.'

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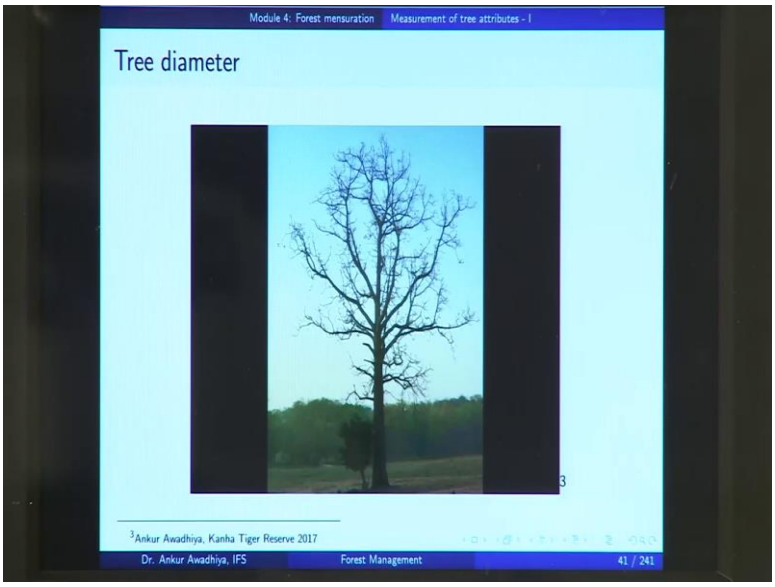

The first attribute we will consider is the diameter of the tree. Now, if you have a look at this tree; which is devoid of leaves, we can see that at the bottom region the diameter is much greater than the diameter at the top. We call this phenomenon as the taper of a tree. So, this tree and a number of trees taper as we move from ground up.

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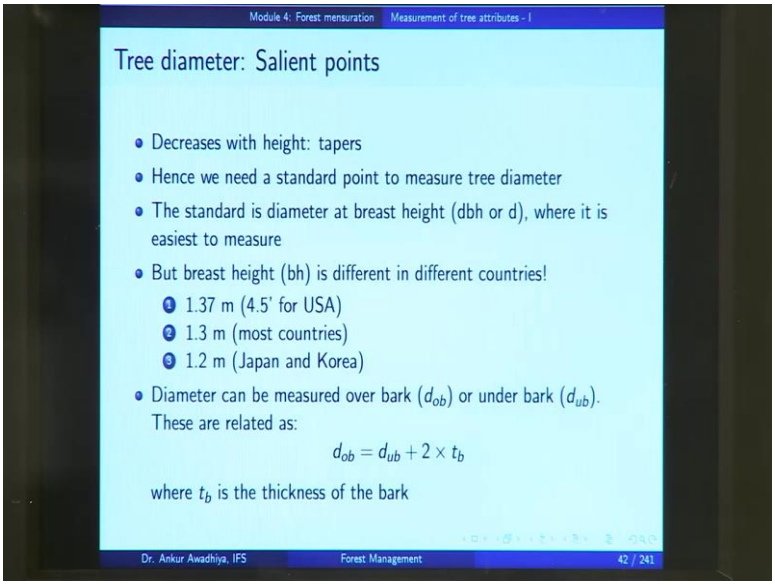

So, the question that comes up is, where do you measure the diameter of the tree? Because, if you measure it at the bottom, the diameter will be greater. If you measure it at the top, the diameter will progressively go on reducing. So, the salient points in the measurement of tree diameter are that the diameter decreases with the height the tree tapers, and hence, we need a standard point to measure the tree diameter. Because, if I am making a measurement at, say a height of 1 meter; you are making a measurement at the height of 2 meters, then both of our readings are not going to tally. So, we need a standard.

Now, this standard diameter is known as diameter at breast height, which is represented as dbh or small d, where it is easiest to measure. So, what do we mean by breast height? If you consider a tree, and if you want to measure its diameter, the easiest way at the easiest height at which you can measure the diameter is this height. So, we can put a tape here and we can measure it, and we can even look at the readings.

So, this is known as the breast height, and we make the measurements here. But then how do we define the breast height? The breast height is different in different countries. It is taken as 1.37 meters in some countries, or in the united states it is taken as 4.5 feet.

In most countries, we take a simplified measure of 1.3 meters. Whereas, in Japan and Korea, the breast height is defined as 1.2 meters. Another salient point in the measurement of tree diameter is - do you measure it over the bark or under the bark?

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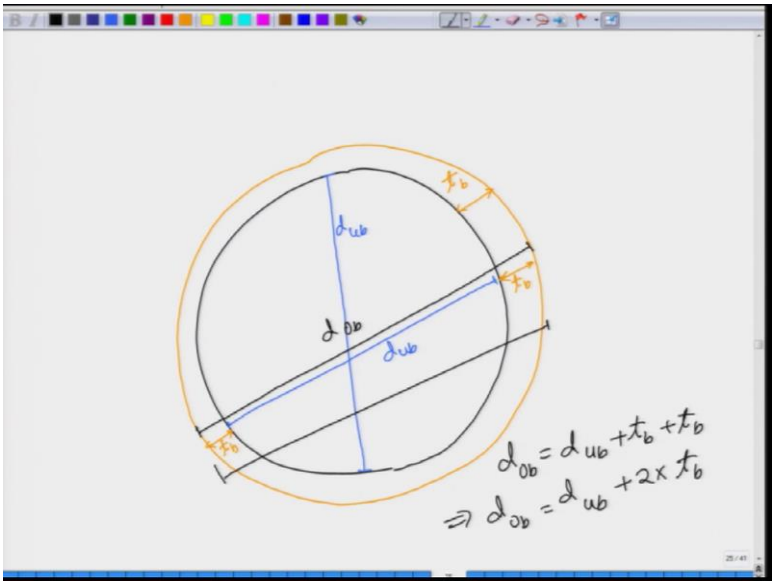

So, if you look at a cross section of a tree, we will find that a tree is surrounded by a bark. Now, if we measure this diameter, we will call it diameter over bark or diameter ‘ob’, but if you measure it like this, we will call it as diameter under bark or diameter ‘ub’, and the thickness of the bark is given as ‘tb’.

Now, if we look at dob; so, here you have a tb here. We have tb here, and you have a d ub here. So, we can easily say that the d ob, or this complete thing is equal to d ub plus tb plus tb, or d over bark is equal to d under bark plus 2 into the thickness of the bark. So, whenever you are doing a measurement of the tree diameter, you should define whether you are measuring the diameter over bark or the diameter under bark, because they will be different.

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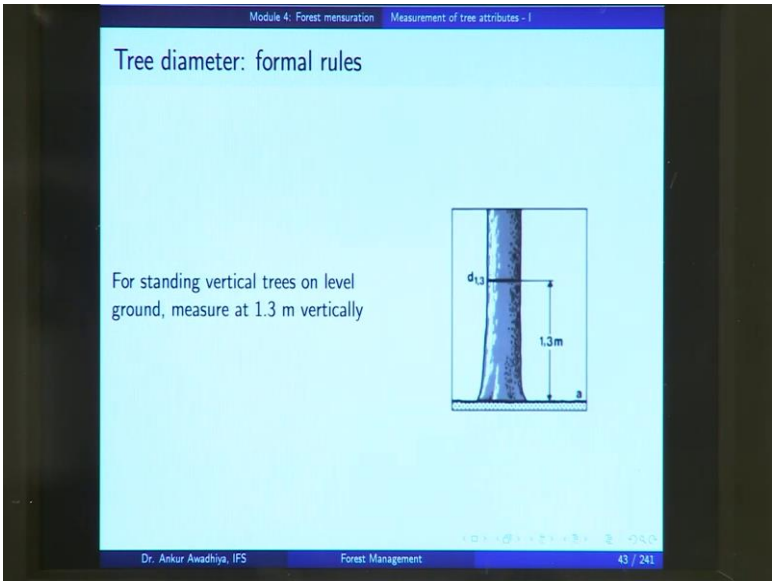

Now, trees do not look like a tapering pole in all the cases. you can have trees of different configurations, different forms, and so, there are some formal rules that have been that have been devised on how and where to measure the tree diameter. So, for a standing vertical tree on a level ground, you measure it at 1.3 meters vertically. So, this is your breast height 1.3 meters, and you take the diameter at this height.

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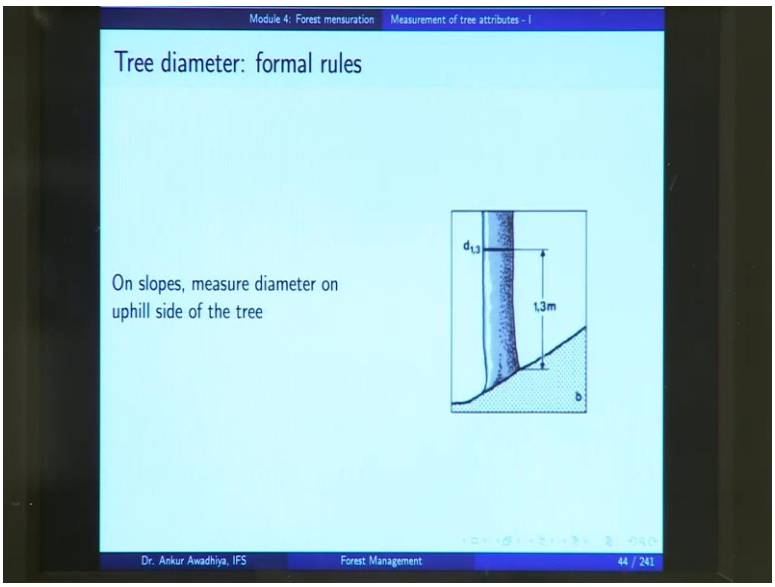

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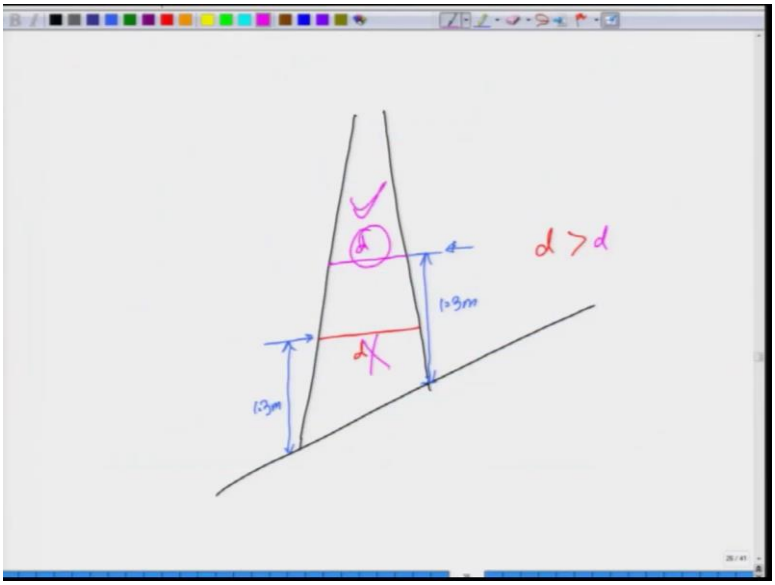

But then, what do you do for a tree that is standing straight, but on a sloppy ground. Because, in this case, if you took a measurement at this point, your d = 1.3 will come at a lower position that is if you have a tree, so, let us make a taper tree and this tree is on a sloppy ground. Now, if you made; if you take 1.3 meters from this position, so, you measure 1.3 meters here to reach at this height, but if you take this 1.3 meters here, you reach this height.

Now, it is quite evident that this diameter small d, and for if you consider this diameter; then we can very easily see that d is greater than this d. So, in this case, you have to devise a rule; where do you measure it on the up slope or the down slope? So, the rule is says that on the slopes measure diameter on the uphill side of the tree, so you have you will measure it here, and so, d is the correct value and this is not the correct value.

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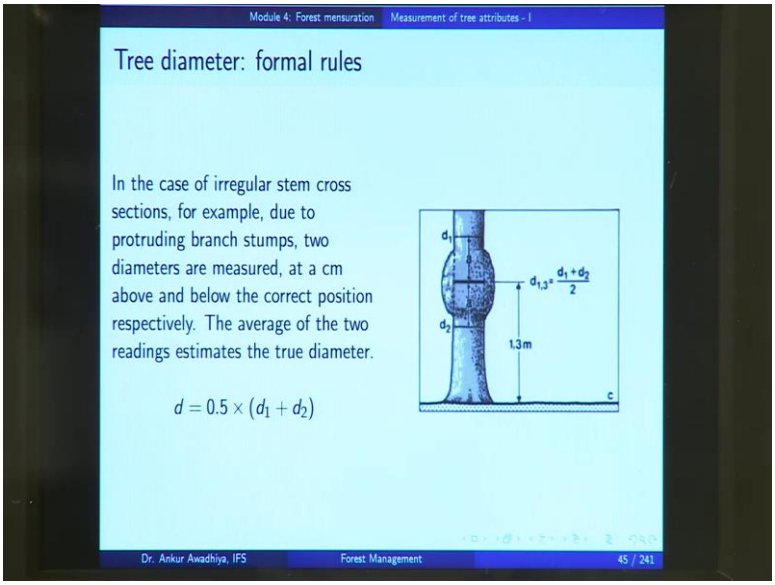

In the case of an irregular stem cross section, for example, due to protruding branch stumps, two diameters are measured at a centimeter above and below the correct position respectively, and the average of the two readings estimates the two diameter. So, in this case, your 1.3 height is having a protuberance. So, you take a reading of ‘a’ centimeter below and ‘a’ centimeter above.

Now, this value of ‘a’ will depend on how big your protuberance is; but, what it says is that you take a measurement here, you take a measurement here, both are equidistant from the from the breast height of 1.3 meters, and you take an average of both of these to get the correct diameter at breast height. So, it is half of d 1 plus d 2.

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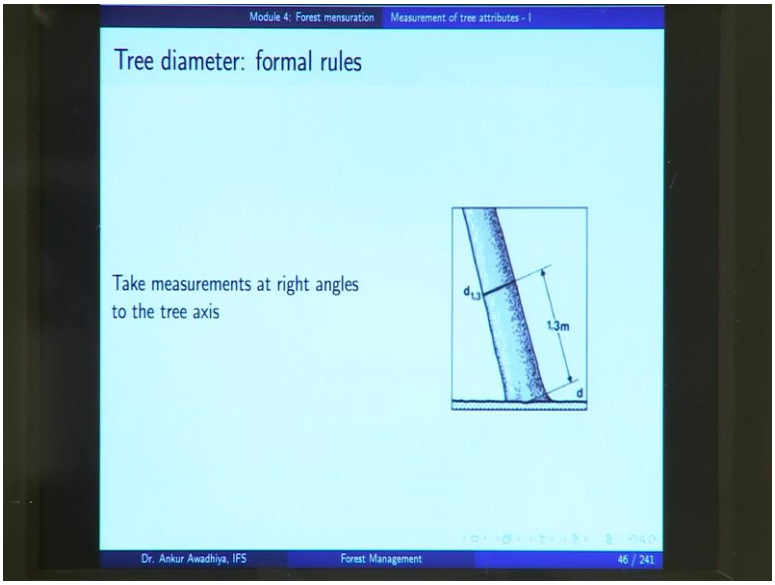

If your tree is standing on a level ground, but your tree is not upright it has tilted, what do you do then? In that case, you take measurements at right angles to the tree axis. So, if this is your tree axis, and you take measurements at right angles to the tree axis to get your 1.3 meters.

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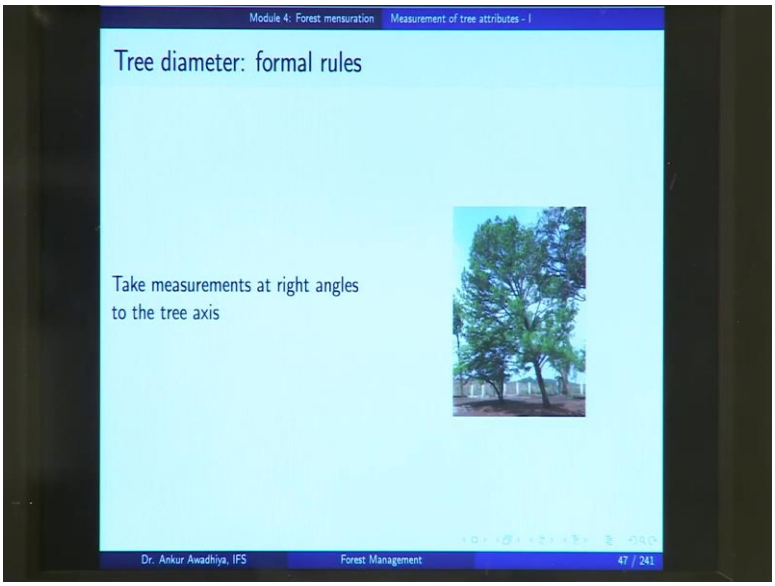

So, for instance, in the case of this tree, this tree is a sloppy tree. So, this is an upright tree, but this is a sloppy tree. In the case of a sloppy tree, we will take measurement at 90 degrees of the tree axis.

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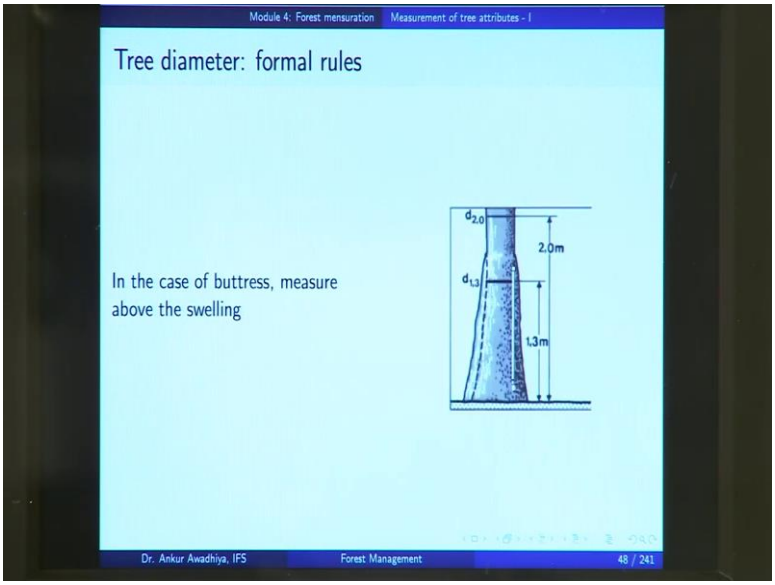

In the case of a buttress, now buttress is a root that is x that is expanded to support your tree. So, in the case of a buttress, you take measurement above the swelling. So, for instance in this buttress, your 1.3 is height has a buttress, so you take it at some position that is above your buttress position.

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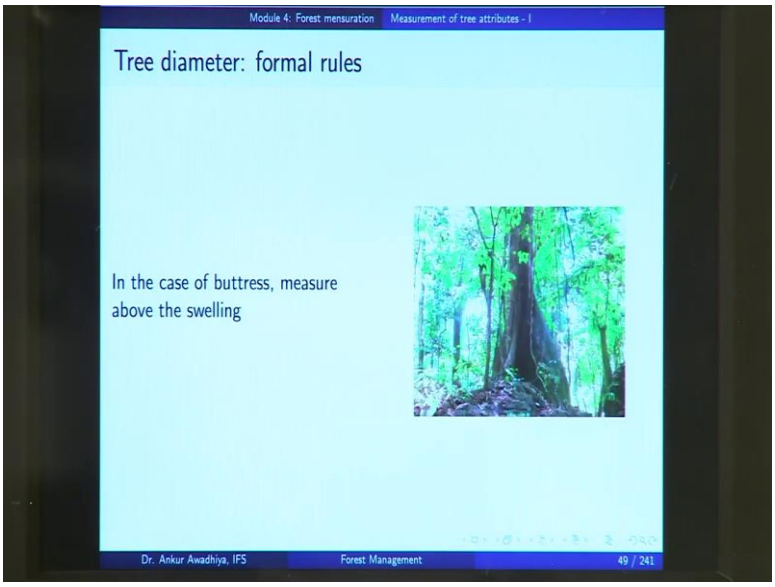

A good example would be this tree from Andaman's. And, in this tree, you have this huge buttress, and so, you will take a measurement above this buttress so at this position.

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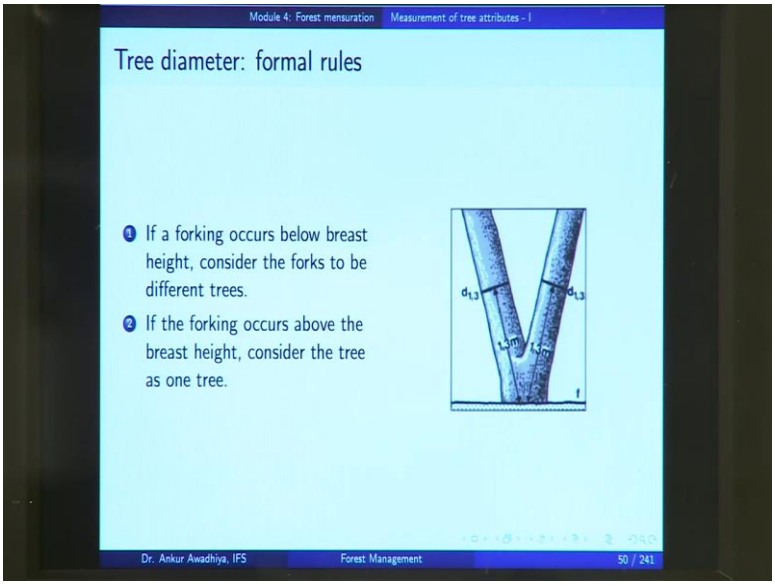

Now, what if your tree is having a forking? So, if you if you have a forking that occurs below the breast height, consider the forks to a different trees. So, here we are seeing a tree that has a fork, but if this fork, if the is originating at a height that is less than the breast height. So, in that case, you will consider these as two trees, and you will take two different measurements, and you may call them as d 1 and d 2, but if the forking occurs above the breast height, then you consider the tree as one tree.

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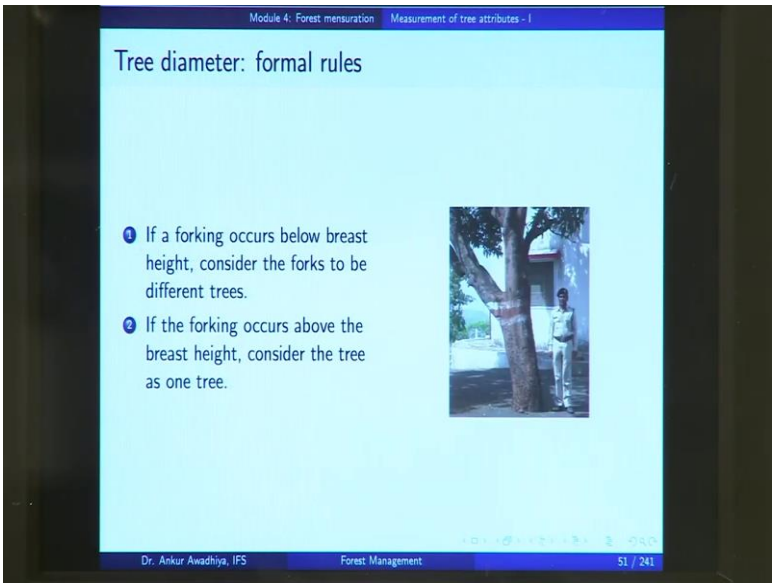

So, in the case of this tree, because the forking is occurring above the breast height, so, this is one tree.

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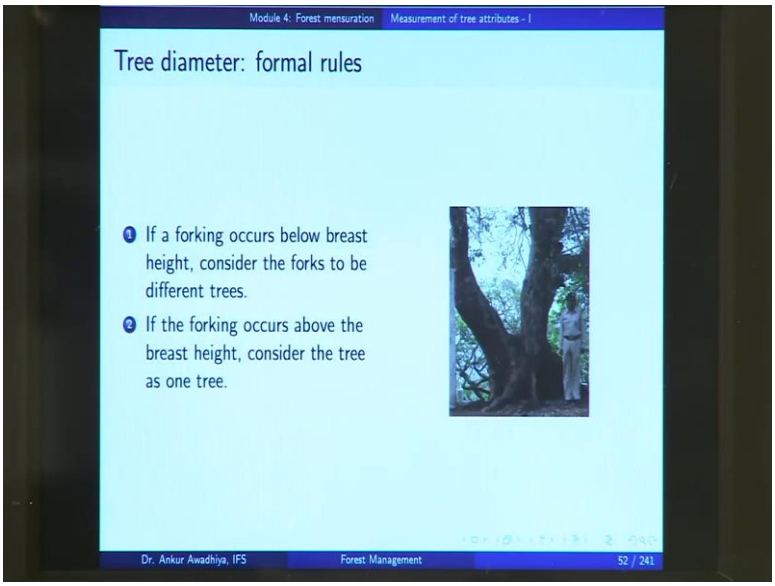

But, in the case of this tree, because the forking is occurring below the barest height, we will consider that this is one tree and this is another tree. So, with all these rules how do you take the measurements? So, one instrument to take the measurements is the calipers.

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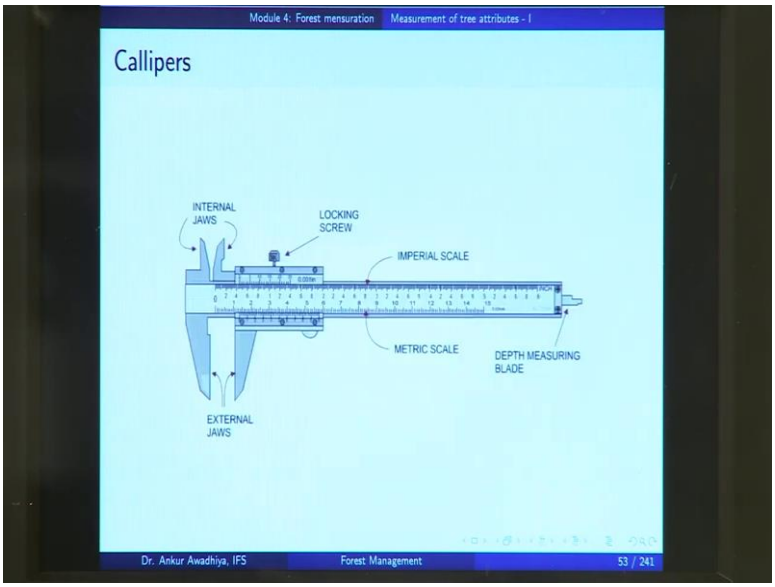

Now, in the case of calipers, we have a scale. It may be an imperial scale or a metric scale. And, then you have these jaws; one is a fixed jaw, one is a moveable jaw, and this jaw may be locked with a locking screw, and then you can when you want to take a measurement you can move this moveable jaw to this position. Place your tree such that the diameter comes between both the jaws, pull the movable jaw to towards the fixed jaw, and then measure the reading from the scale.

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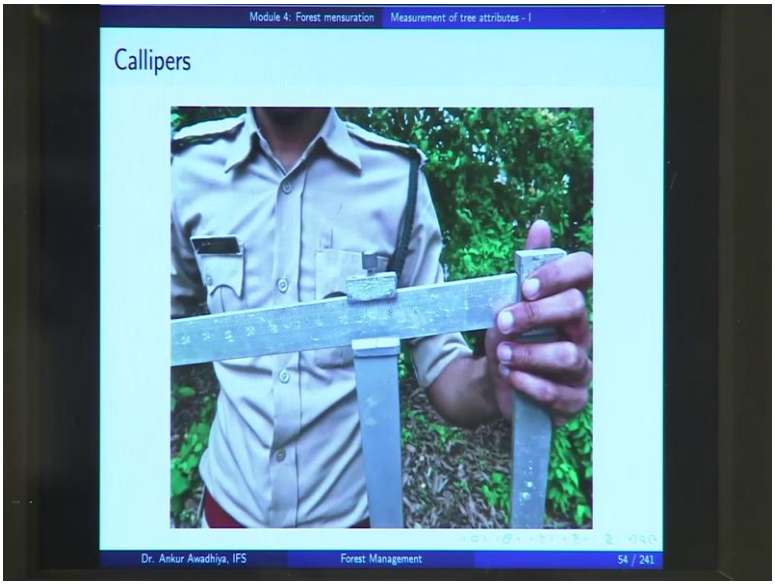

So, this is how the calipers look physically and this is the locking screw.

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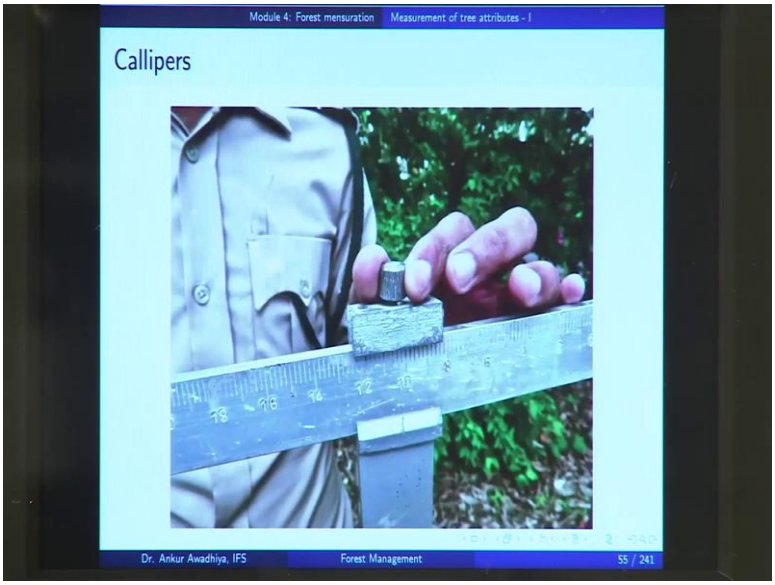

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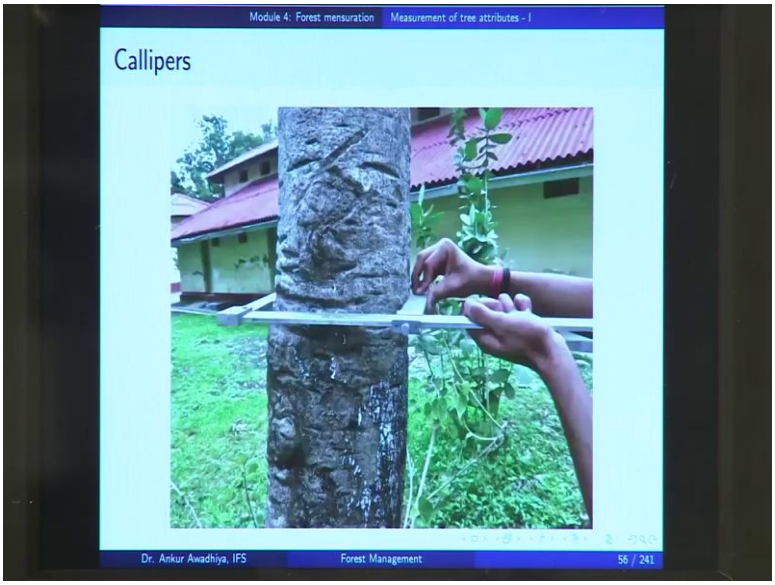

So, how do you take the measurement? You put the caliper in such a way that your tree is coming between the fixed jaw and the movable jaw. Then, you move the moveable jaw such that it, such that both the jaws are able to touch your tree at the designated breast height, and then you take the measurement directly from the scale; that is easy, but then there are also certain issues.

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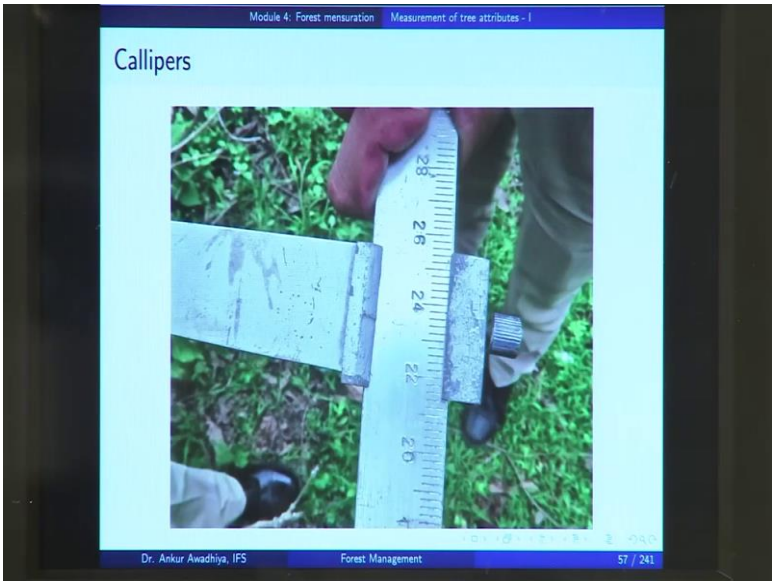

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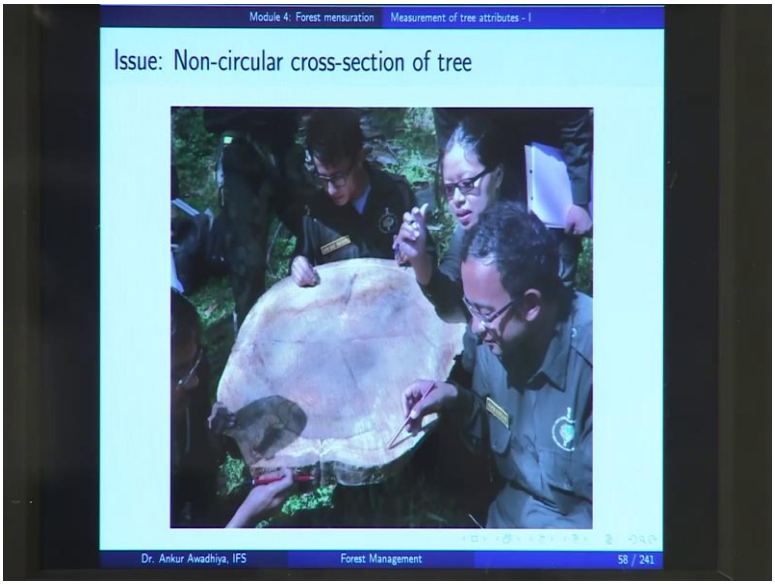

One issue is the non circular cross section of a tree. Because when we are talking about a diameter, we are considering the tree to be having a circular cross section, but in practice most of the trees have an irregular cross section; a non-circular cross section, such as this tree. So, in this case, where do you take the measurement? Well, you may take measurement at a number of different points take the average, or you can take measurement at two points that are 90 degrees to each other; take the average, or you may even go for just a single measurement. So, these things are not that well defined.

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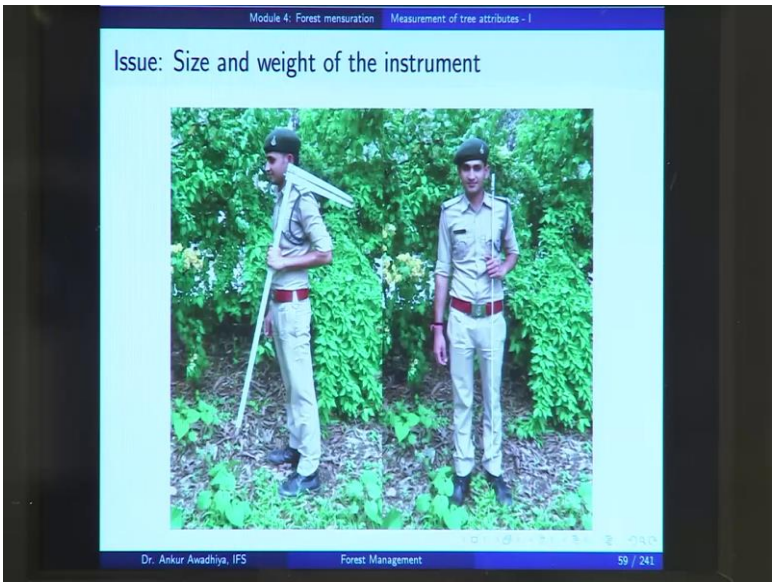

Another issue with calipers is the size and weight of the instrument. So, this instrument is made out of metal; it may also be made out of wood, but you can see that it is a very large sized equipment, and it is also a heavy equipment. So, for instance, if you want to take it into a forest that is full of wines; that is full of undergrowth, and you want to take multiple measurements with this instrument, especially on in hilly areas, it becomes very difficult; it becomes very physically exhausting.

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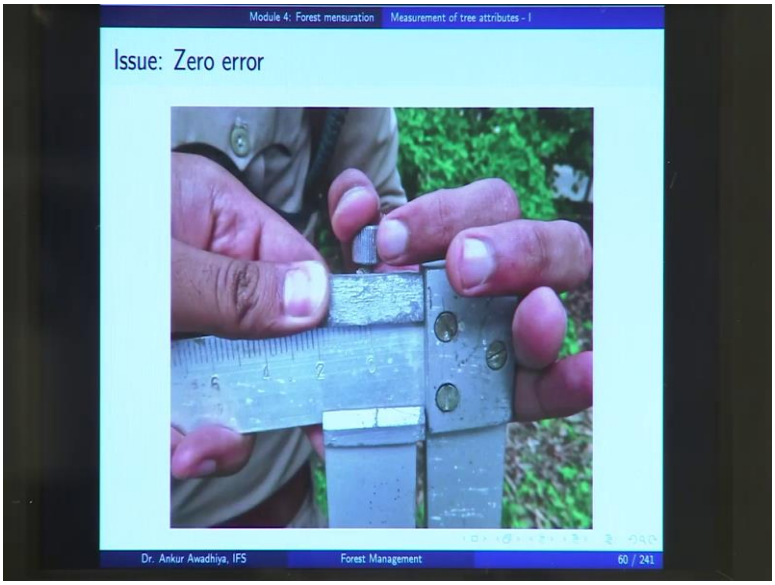

A number of these instruments also have zero errors, which means that when you bring both the jaws together they do not match at the zero point.

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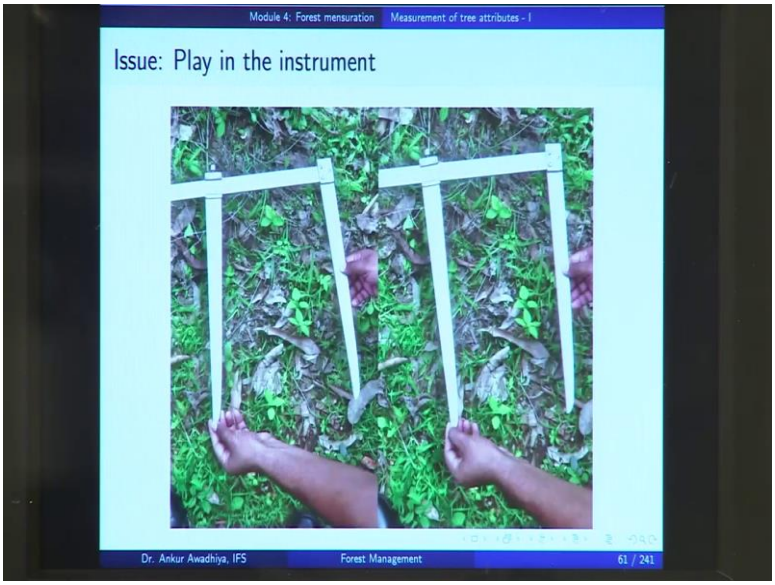

Also, in a number of instruments you have a certain amount of play in the instrument. What do we mean by play? It means that this moveable jaw which should be at 90 degrees to the main axis - it is either inside or outside, or it can even swing.

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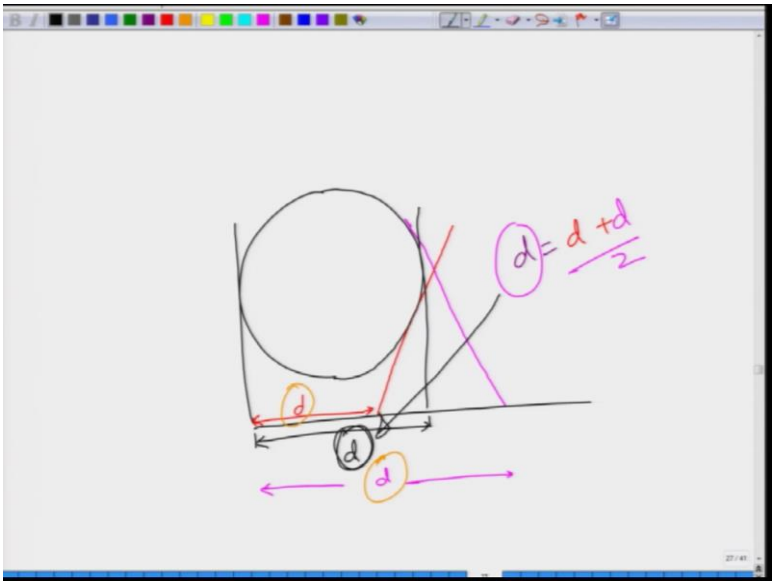

Now, if you have an instrument with a play. This was the diameter that had to be measured, and the correct reading would have been this, but it is also possible if your instrument is having a play that your movable arm comes like this. So, it is touching on the your you tree on our at two locations. So, you will think that yes this is the correct

measurement, but what you will actually be measuring is this, which is less than your actual value of d.

So, or if your instrument has play on the other side, then it is possible that you take a measurement at this location. So, in this case, this will be the d which will be greater than the actual d. So, a play is a serious situation when you are using this instrument. Also, because the movable arm needs to move it should move freely, but in a forest situation because you have moisture; because you can have dirt, when you are measuring different trees. So, if you have dirt, if you have water inside, then the movable arms might tend to stick, and in that case, it becomes difficult to use this instrument.

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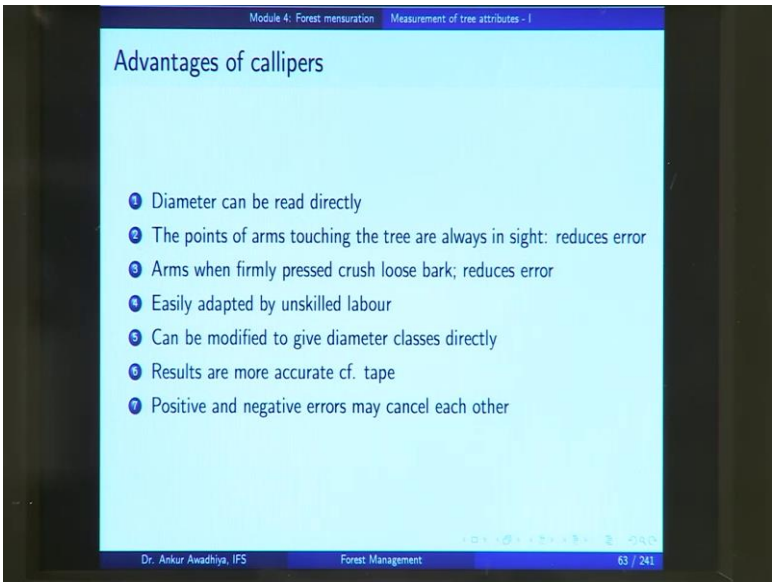

However, we still use this instrument because of certain advantages of this instrument. One is that the diameter can be read can be read directly. So, for instance, if you use a tape to measure the perimeter. So, another instrument that we could use is a tape.

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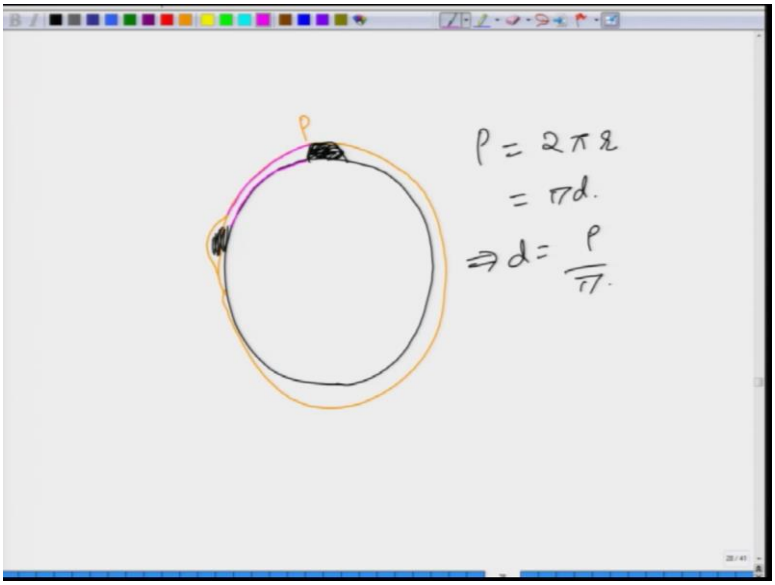

So, if you have a tape, it is difficult to measure the diameter directly, but what you can do is that you can put your tape all around this your trunk, and get the value of P, which is the perimeter.

Now, in the case of a circular cross section, P is equal to 2 pi r or pi d, and so, in this case, d is equal to P by pi. You take a measurement with a tape; you divide it with pi, and you get the reading of d or the diameter, but in the case of the calipers, you can directly read it; there is no need to divide it with pi or anything.

Secondly, the points of arm stretching the tree are always in sight, which reduces error. What we mean here is that in the case of your tape, it is possible that this region add a protuberance, and when you were measuring it with the tape you were not able to see that. But, in the case of a calipers, the points of the arms that are touching the tree are always in sight. So, you can always move your instrument to ensure that you are not putting your instrument at a location where you have a creeper or where you have a protuberance.

Then arms when firmly pressed crush loose bark, which also reduces the error. Now, what it means here is that in the case of a tape, if you have a loose bark somewhere, so here you have a loose bark, but then your tape will go over this loose bark. And so, you will overestimate the diameter or the perimeter. But in the case of calipers, when you are pressing the jaws together, they crush the loose bark, and so, the reduce and the error is

reduced. It is easily adapted by unskilled labour, because they do not have to divide it with anything. It can also be modified to give the diameter classes directly.

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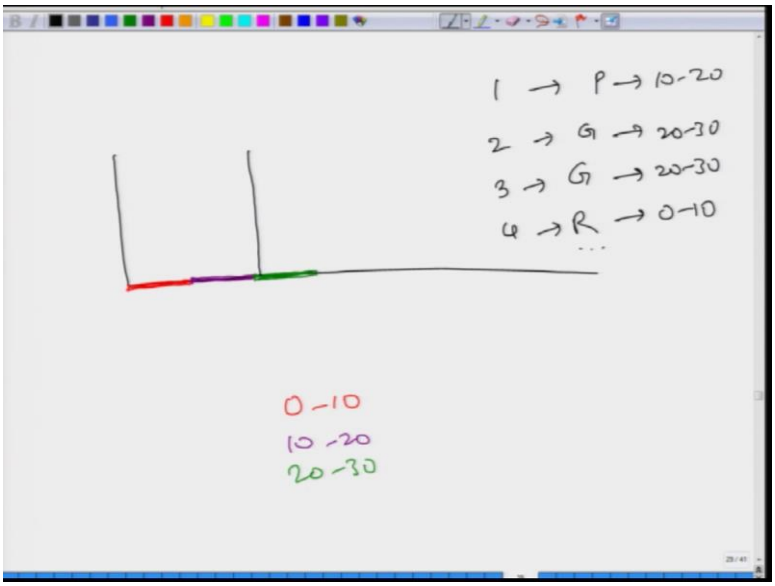

Now, what that means is that in a number of situations we do not need the exact diameter. So, here you have the calipers. This is the fixed arm this is the movable arm, and what you want is a diameter class. So, whether your diameter is between 0 to 10, or is it between 10 to 20, or is it between 20 to 30, and so on.

Now, if you are ok with having the diameter classes, what you can do is that you can paint your scale in such a way that this is red in color; this region is purple in color; this region is green in color, and so on. Now, what your unskilled labour will do, in this case, is that he or she will directly note that for your tree 1 it is purple, tree 2 is green, tree 3 is green, tree 4 is red and so on. And, then you can directly convert this P as 10 to 20, G as 20 to 30, 20 to 30, 0 to 10 and so on.

So, you can directly - you can modify this instrument in such a way that it gives you diameter classes directly without going to; without going through any further computation. And, if you paint your scale with these different colors, even an unskilled laborer can give you the diameter classes directly. Next, the results are more accurate as compared to tape, and the positive and negative errors may cancel each other.

Now, what do we mean by positive and negative errors? So, when we looked at the play the instrument, you have one error in which you are measuring the small d, in other case, you measured this other small d. Now, because you are measuring these two readings, if your instrument is having a play; you can take the average of both of these readings. So, let us represent it as d plus d by 2, and in that case, your value of d will be very close to the original value of d.

So, the positive and negative errors even though they are here in the instrument, in if you take two readings, you can make them to cancel each other.

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The second instrument that we use normally to measure the diameter is the tape. So, here we see a forest guard who is using a tape.

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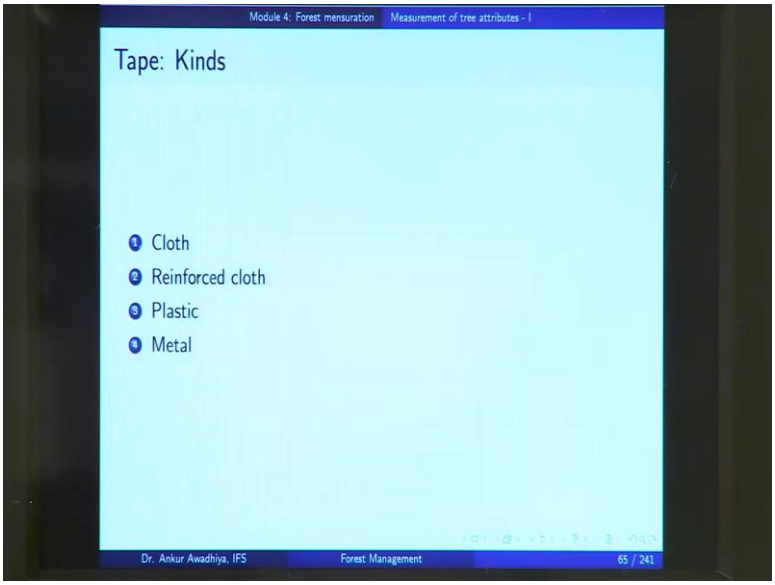

Tapes can be of different kinds. you can have a tape that is made out of a cloth. This cloth may be reinforced, especially with metal; so, that its life increases. You can have a plastic tape or you can even have a metal tape. So, there are these four common kinds of tapes.

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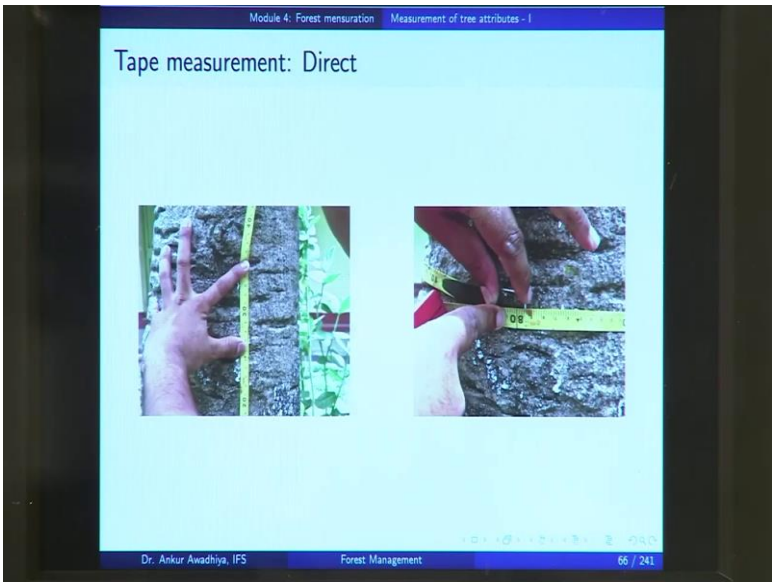

The measurement is taken directly. if you want to measure a length, you just lay your tape on the tree to get your height of 1.3 meters, and at that point you make your tape go

around the trunk to get the perimeter at breast height - you divide it with pi, and you get the diameter as d is equal to p by pi.

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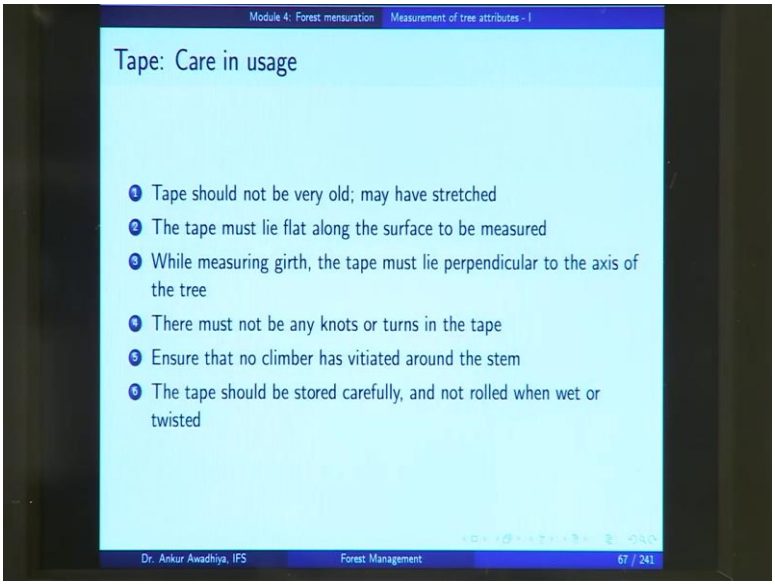

However, there are certain care in its usage. You should not use a tape that is very old, because it may have become stretched with time. Now, what we see generally is that your tape when you are laying it flat on a surface, people tend to stretch the tape. Now, if a tape is made out of a plastic like material, in that case, the plasticity of the tape may result in it yielding, so that the length increases.

So, if you have a stretch tape, if you have an old tape that is stretched, it will not give you the correct readings. Secondly, the tape must lie flat around the surface to be measured. At times, your tape does not lie flat on the surface. So, we saw the situation here, in which your tape should have been straight like this, but in effect, it was going like this. So, this is one care that needs to be considered when you are using a tape. When measuring girth, the tape must lie perpendicular to the axis of the tree.

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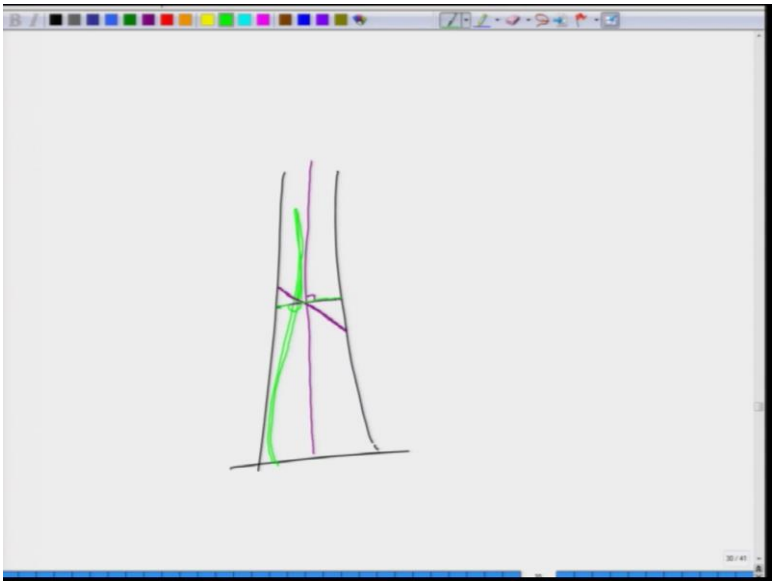

So, what we are saying here is that when you are taking a girth measurement; your tape and this is your tree axis. So, your tape must be perpendicular to the tree axis, if you keep a tape like this, you may overestimate the girth. So, this is another care that should be kept in mind.

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There must not be any knots or turns in the tape. So, that is something that we very commonly find that when you are using a tape, because you are unable to see the whole

surface, it is possible that there might be some knots in the tape. And, in that case, you will overestimate the girth or the diameter of the tree.

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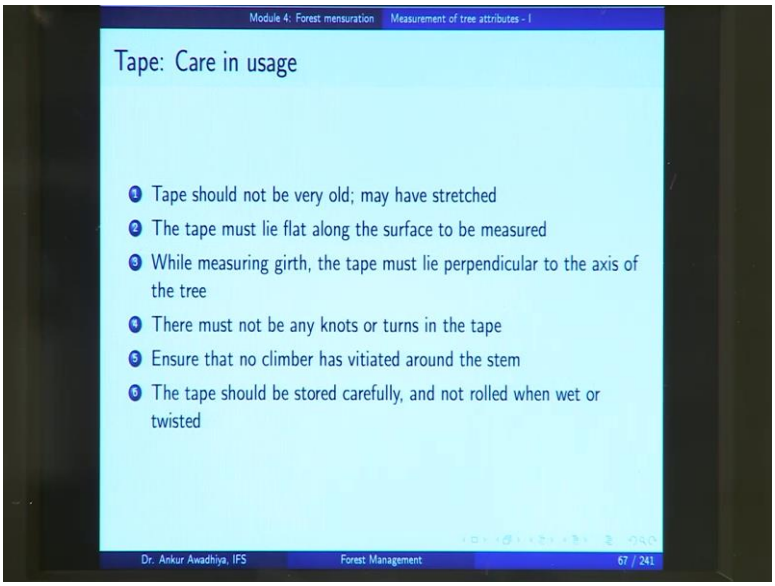

Ensure that no climber has vitiated it around the stem. Now, what we are saying here is that, if you have a situation in which there is a thick climber that is going up this tree, and when you take the measurement, your tape will go around this climber, and in this case, you will overestimate the diameter of the tree. So, either you should perform a climber cutting operation before you are taking the measurement with the tape, or you should put your tape in such a manner that it comes between the climber and the tree.

So, this is another care that should be kept in mind. And, the tape should be stored carefully, and not rolled when bit or twisted. Because, if you roll a wet tape or when you roll a twisted tape, in that case, it might get stressed in certain locations, and because of that the readings will not come to be the correct readings, when you used this tape in a later stage. So, there are certain cares that need to be kept in mind.

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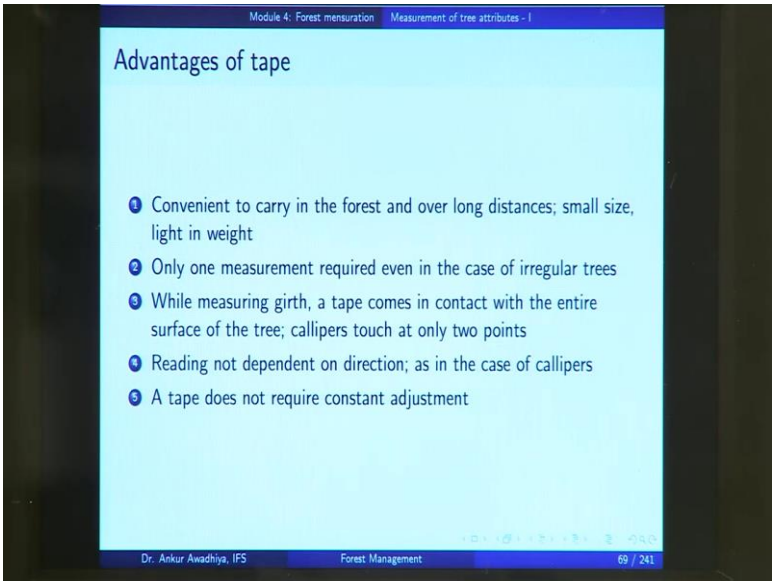

However, we still use these tapes because they are very convenient to carry in the forest, and specially over long distances because of their small size and their lightweight nature. Especially, in the case of the plastic tapes, they are very small; they can be kept in pocket; they are very lightweight; they are not like the calipers that you need to carry over your shoulders, which makes tapes a very popular means of measuring the tree diameters. Another advantage is that you need only one measurement even in the case of irregular trees.

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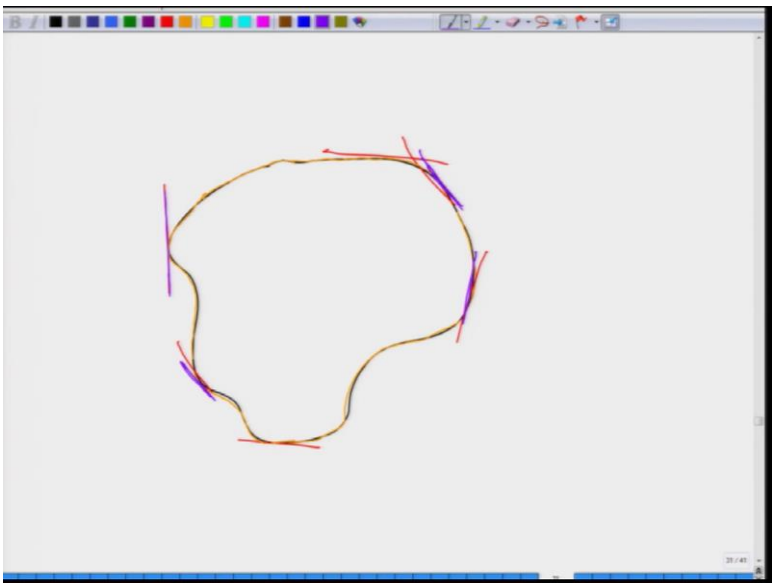

So, in the case of an irregular tree; so, suppose this is the cross section. If you used calipers, then probably you will take a reading here, you will take a reading here, you will take a reading here, and so on. So, you require multiple readings, and then only you will be able to get to an average. Whereas, in the case of a tape, you only need one reading, because you will start at this point, and then you will just make your tape go along the surface of this tree. So, even though it is irregular in shape, but you can make your tape go along the surface, and in that case, there will be only one reading that is needed.

So, in place of multiple readings - when you are using calipers, here you have only a single reading. So, that is another advantage of the tape. While measuring girth, a tape comes in contact with the entire surface of the tree, whereas calipers touch the tree at only two points. So, if there is any irregularity, a tape is much more capable to take that irregularity in to consideration, as compared to the calipers.

Reading is not dependent on the direction as in the case of calipers. So, as we saw here, if you took a reading in this direction, your measurement will be very different from a reading in this direction. Whereas, in the case of a tape, the direction is immaterial; so, even if you are using unskilled laborers to take the readings, they can very easily use the tape, especially in the case of the irregular trees. And, a tape does not require constant adjustment. As in the case of the calipers, where you have to adjust for the play, so that the positive and the negative errors cancelled each other out. But, in this case, you do not need to go for any adjustments.

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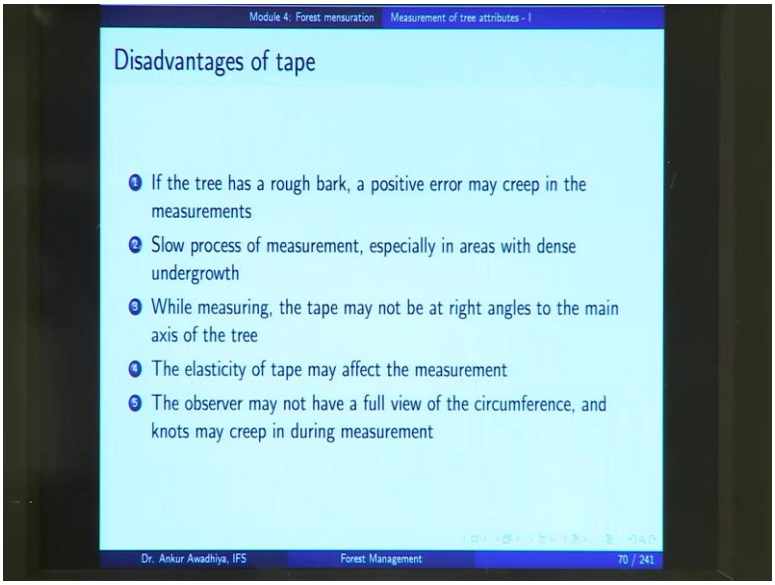

So, these are the advantages of the tape. However, there are also certain disadvantages. If the tree has a rough bark, a positive error may creep in the measurements. So, we have seen this before, if your tree has a rough bark; so, in that case, the tape will go over that bark, and in that case, you will overestimate the girth of the tree; the perimeter of the tree. And, in that case, you will overestimate in the diameter of the tree. Then, it is a slow process of measurement, especially in areas with dense undergrowth.

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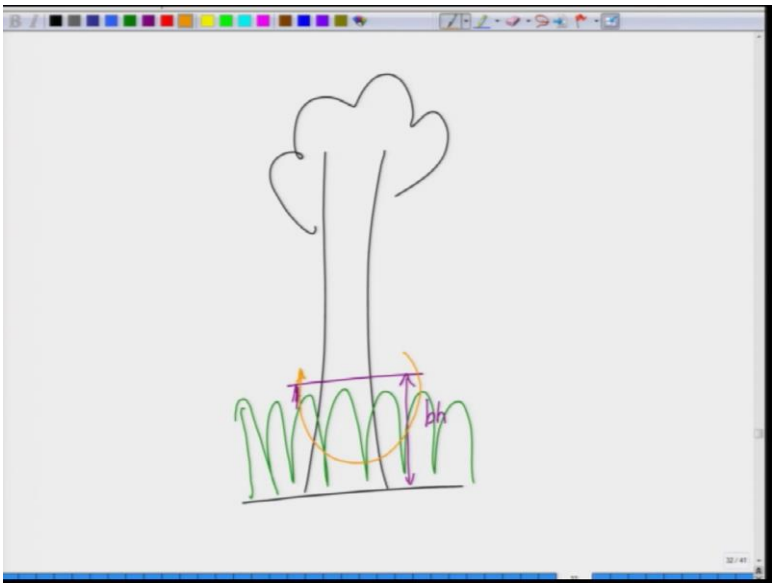

Now, what we are saying here is that suppose you have a tree and you have a dense undergrowth in this region. Now, if you wanted to use the calipers, you only have to go at one location. So, suppose this is your breast height; so, you only need to get at one position, and at this position, you will place your calipers; so, that your two arms are able to touch the tree, and you take the measurement; there is no need for a second measurement. Whereas, in the case of a tape, you will have to move around this tree with its diameter. And, in this case, you have to go through a lot more of the undergrowth, as compared to when you are taking the measurement with the calipers.

So, the measurement in the case of an area with dense under growth becomes very slow, because you have to either clear this undergrowth to move around this area, or you need to traverse this undergrowth. In both of these processes are very slow, and both of these are also very risky, because there might be certain reptiles creeping inside.

Another disadvantage is that while measuring the tape may not be at right angles to the main axis of the tree. Now, this is much more prominent in the case of a tape as compared to the calipers, because when you are taking readings with the calipers both the arms are within your sight. So, you can very easily cross check whether your two points are perpendicular to the axis of the tree or not.

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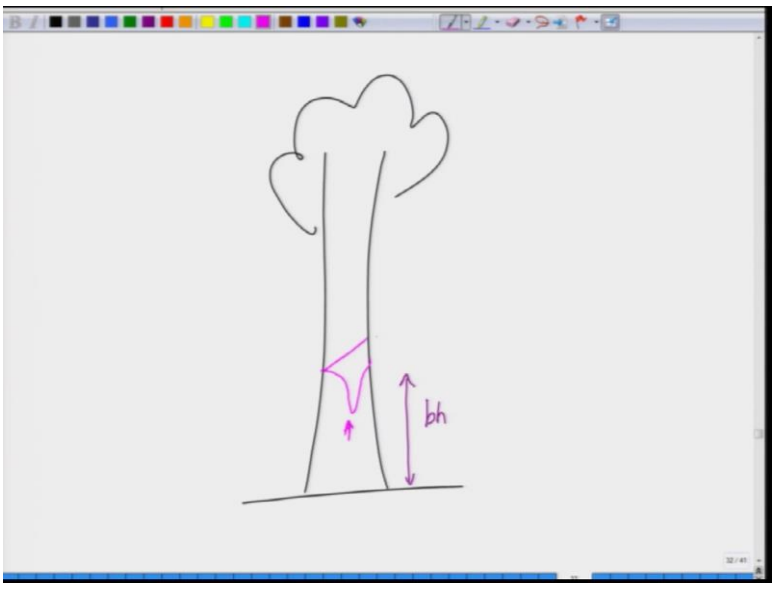

Whereas, in the case of a tape, it is possible that you started taking a reading at breast height, you started taking the reading, and probably your tape sagged like this, and then because you are unable to see this point. So, it is possible that your tape may not be at right angles or may have sagged in certain locations. So, you can have a reading that is taken like this because you can only measure.

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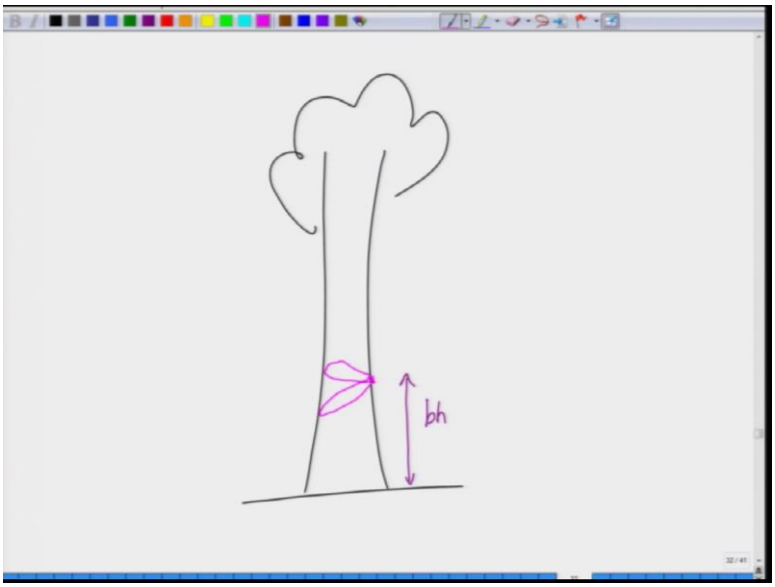

So, suppose you are standing at this location. So, you are seeing that your tape is like this, but your tape actually went like this or your tape went like this, and you have no way of finding out whether this was the case. Because you are standing here, and you can see that this point is at breast height, but the other points are not in the breast height.

So, while measuring the tape, may not be at right angles to the main axis of the tree, and this is much more prominent, in the case of tape as compared to in the case of calipers. The elasticity of the tape may affect the measurement. So, what we are saying here is that if you have a plastic tape and you by measuring you stretch it. So, it will it get stressed because it is much more elastic in nature.

So, in that case, you will have a reading which is different from the actual reading if your tape was made out of an in elastic material. Then, the observer may not have a full view of the circumference and knots may creep in during measurement either knots make

creep in or you can even have situations where loose bark or climbers can also creep in the measurement because you are unable to see the whole circumference at in one go.

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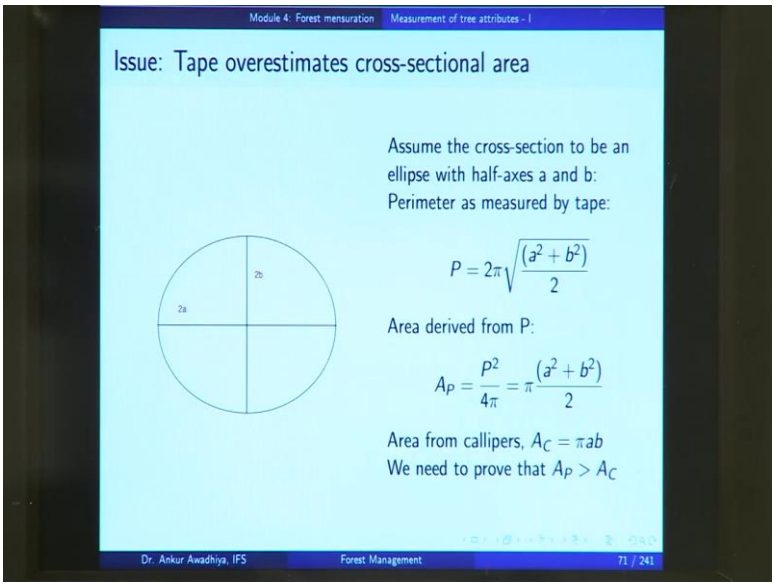

Now, there is also another issue that tape overestimates the cross-sectional area, especially in the case of trees that do not have a circular cross section. Now, why is that so? Now, remember that we are using a tape to get an estimate of the diameter of the tree. We want to have an estimate of dbh. we do not want to have an estimate of the girth and breast height or gbh, but what we measure using a tape is the girth and breast height.

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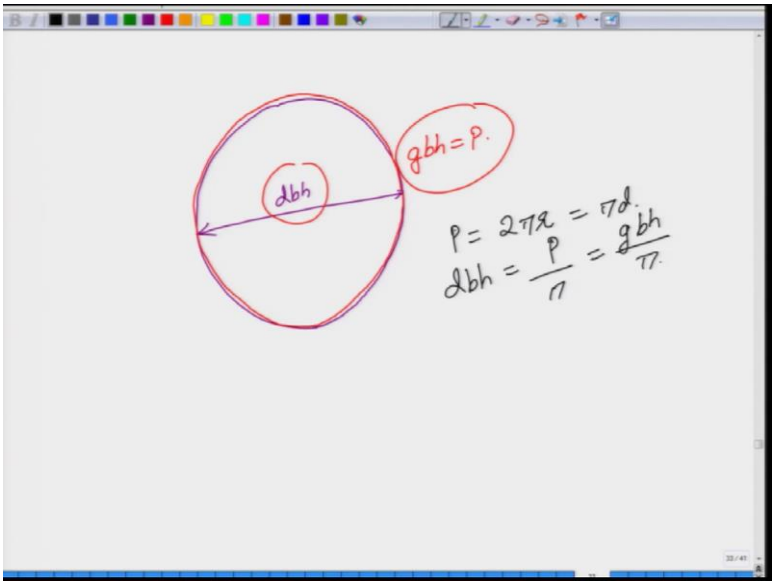

So, what we are talking about here is that if you have a tree with a circular cross section, and add the breast height, this is the diameter. So, this is dbh, and the perimeter of this tree is gbh or the girth at breast height or P. So, we want this reading, but we are only able to get the gbh. So, what is the relation between both of these? As we saw before, you have perimeter of a circle is 2 pi r or pi d, and so, your dbh is p divided by pi or the girth at breast height divided by pi.

But this is only true if you have a tree with a circular cross section, and that is an approximation that we make whenever we are deriving the diameter at breast height from the girth at breast height. So, whenever we need to get the value of d, we always divide P or P or gbh with pi. Now, if you have a tree that has a non-circular cross section; so, let us say that your cross section is elliptical.

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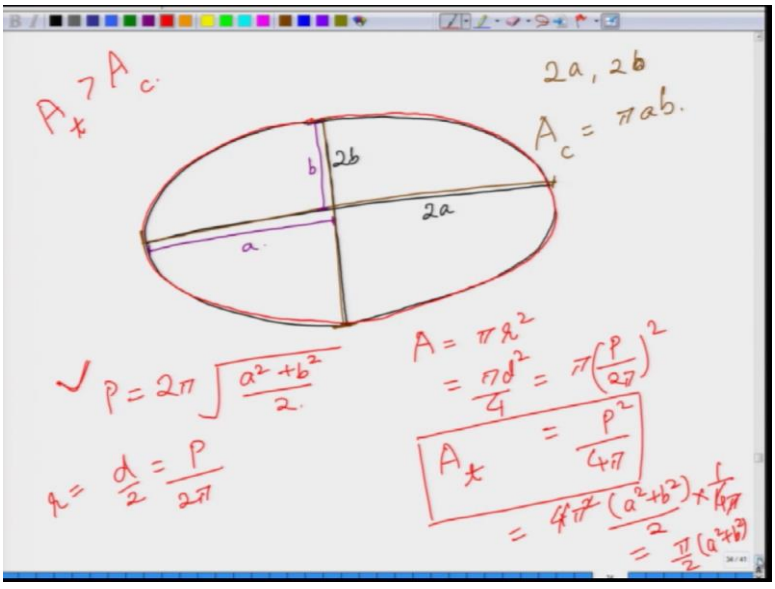

Now, in the case of this ellipse, you will be having a major axis and a minor axis. So, let us represent the major axis as 2 a and this is 2 b. So, what we are saying here is that this is b and this is a. Now, when you use your tape to measure the perimeter; so, this is the perimeter of the ellipse. So, how do we get the perimeter of an ellipse?

So, the perimeter of an ellipse is 2 pi root over a square plus b square divided by 2. And, when we take the diameter the dbh, it will be P divided by pi, or if we have the radius the radius is given by d by 2 or P by 2 pi. Now, the area if we consider that this the cross

section is a circle, in that case, the area would be given by pi r square, is pi d square by 4 or pi r is your P divided by 2 pi square is P square by 4 pi.

So, that is the area of the cross section of your tree, if it were a circle. Now, when you are using a tape, this is the area that you get or this is. Now, when you are using the calipers what you are measuring is two of these lengths. So, you measure it at the major axis, you measure it and the minor axis. So, when you are using calipers, you are getting the direct values of 2 a and 2 b, in which case, you can get the area of with calipers as pi into a into b.

Now, what we are saying is that if you measure the area using your tape, you got this area, and the area that we got from the calipers is pi a b. Now, what we are saying is that your; A that is measured from t is greater than A that is measured using the calipers. So, how do you; how do you prove that? Now, a with t is P square by four pi P is given by this value. So, it is 4 pi square into a square plus b square by 2 into 1 by 4 pi. So, 4 and 4 cancel out, so this is pi by 2 a square plus b square.

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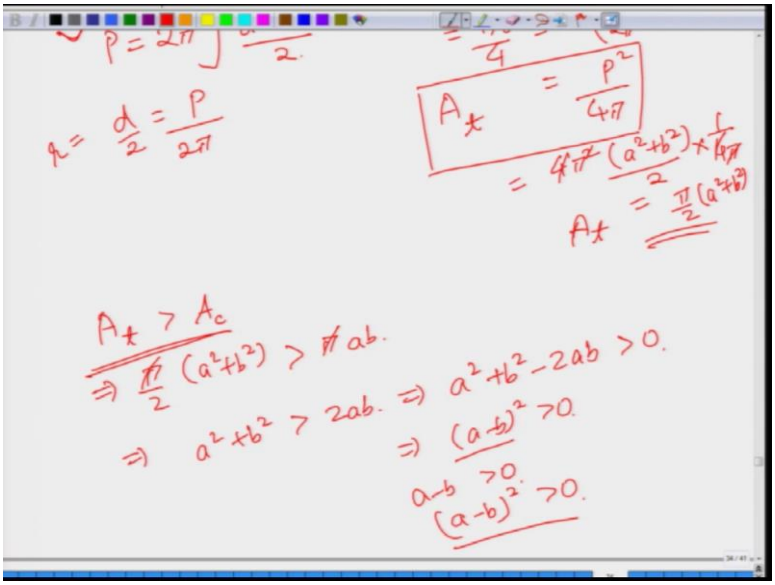

Now, we are trying to prove that this value of A that is measured with t is greater than A that is measured with the calipers or we want to say that pi by 2 a square plus b square is greater than pi a b, which means that we want to say that pi and pi canceled out a square plus b square is greater than 2 ab or we want to prove that, a square plus b square minus 2 ab is greater than 0, or a minus b square is greater than 0.

Now, remember that we took a as the we took 2 a as the major axis, and 2 b as the minor axis. So, a is greater than b now, if that is the situation a is greater than b. So, a minus b is greater than 0. So, within that case a minus b square is also greater than 0. So, if this is true, this has to be true which means that the cross-sectional area that is measured using a tape is always greater than the cross-sectional area that is measured using the calipers in the case of an elliptical cross section.

Now, remember that an are natural trees are much more complicated than then in (clique) then an elliptical cross section or a circular cross section.

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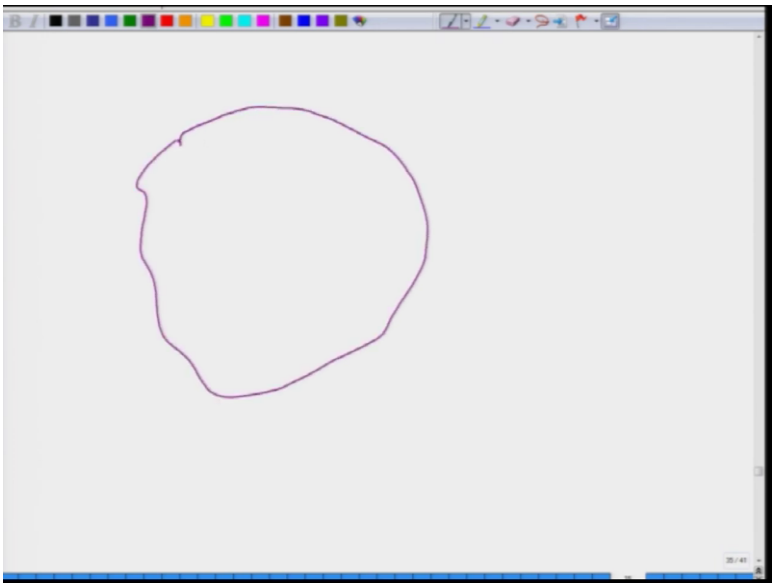

The actual trees would have a cross section that may probably be like this. So, the amounts of errors that creep in, or the amount of over estimation that creeps in with a tape goes on increasing with all of these irregularities. And finally, what we have a situation is that the area or the is that the basal area or the cross-sectional area that is measured using a tape is very much greater than the cross-sectional area that is measured using the calipers.

So, this is something that you need to keep in mind that the tape overestimates the cross-sectional area as compared to the calipers. So, in this lecture we had a look at how do we measure certain tree attributes, and we began using the diameter. Now, we saw that in the case of natural trees the diameter goes on decreasing with height. So, the tree

is taper, if you measure your diameter at any position that is closer to the ground the diameter will be greater as you go up the diameter will go on reducing.

So, we had to formulate a standard height at which we are going to measure the diameter, and that standard height is known as breast height. Because, if you measure it at this height, it is very easy to measure, and it is also very easy to take the measurements or see the measurements directly. Now, this breast height is different in different countries. We normally take the standard to be 1.3 meters in most of the countries. And, there are some formal rules that have been formulated. So, as to enable that all the measurements taken by different people are the same.

So, we looked at the formal rules that you have to take measurements at right angles to the axis; you have to take measurements on an upslope area, as if your tree is on a sloping area. You have to count trees as two trees, if there is a forking that is below the breast height. But, if there is a above the breast height, then you take your tree to be a single tree.

So, we looked at all of these different standards that have been formulated. Next, we looked at the instruments that are used to take the diameter of the tree. And, we looked at two instruments calipers and the tape. In the case of calipers, it is easy to take the measurements by non-skilled people, especially if you want to have a measurement based on the diameter classes, because you can very easily paint your main skill. So, that it directly gives you the diameter classes.

However, your calipers are very heavy instruments. They are large size instruments and it is difficult to carry them over long distances, especially on hilly areas and areas that have huge amount of undergrowth, using this instrument is much simpler as compared to a tape. Because, in the case of a tape, you have to go around the tree; you have to clear a lot more of the undergrowth; you have to ensure that your tape is not having any knots; your tape is calibrated again and again; your tape does not go over a wine, it does not go over a loose bark and so on.

So, both these instruments have their own advantages and disadvantages. A tape is very easy to use if you want to take it over long distances, because it is small in size. Especially, in the case of plastic tapes, you can just roll them and keep them in a pocket.

Then, we looked at the kinds of errors that we see in the measurements, and we saw that in the case of a tape, we generally tend to overestimate the diameter or the area of the cross section of the tree as compared to measurements using the calipers.

So, both these instruments have their own pros and cons. We cannot say that one instrument joined it is just that whenever you are we are using an instrument we should keep in mind their limitations. So, that we are able to avoid those limitations as far as possible. So, that is all for today.

Thank you for your attention [FL].