Forest Biometry
Prof. Mainak Das
Dr. Ankur Awadhiya
Department of Biological Sciences & Bioengineering & Design Programme
Indian Institute of Technology, Kanpur

Lecture – 18
Distance measurements: foot, tape, rangefinder

[FL] in today's class we shall look at some methods of distance measurement, especially foot tape and rangefinder. So, what do you do when you get into a forest and you do not have any instrument? And you want to measure some distances, say the distance to the next tree. So, do we can we use some parts of our body to do that. When the answer is yes, we take one step to be 0.7 meters

So, for instance if I had to measure the distance from this point to the end of the wall, I would just walk from here to the end of the wall and just count the steps 1 2 3 4 5. So, when we have 5 steps it means that the distance is 0.7 into 5 or approximately 3.5 meters. So, this is when we do not have any instrument.

Now, what is the simplest instrument that we can carry with us at all times into the forest to take measurements that would be the tape.

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So, as we have seen in a previous class we can use a tape to take measurements along the ground as this forest guard is doing in this picture. So, he is holding the tape in his hands one end of the tape is fixed to the point from which he wants to take the measurements, then this tape goes on rolling and he can take the measurements using the tapes.

Another instrument that is being very highly used in forestry is the rangefinder. So, this is the picture of a rangefinder.

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Now how does a rangefinder work? This rangefinder well suppose this is your rangefinder and this is your tree.

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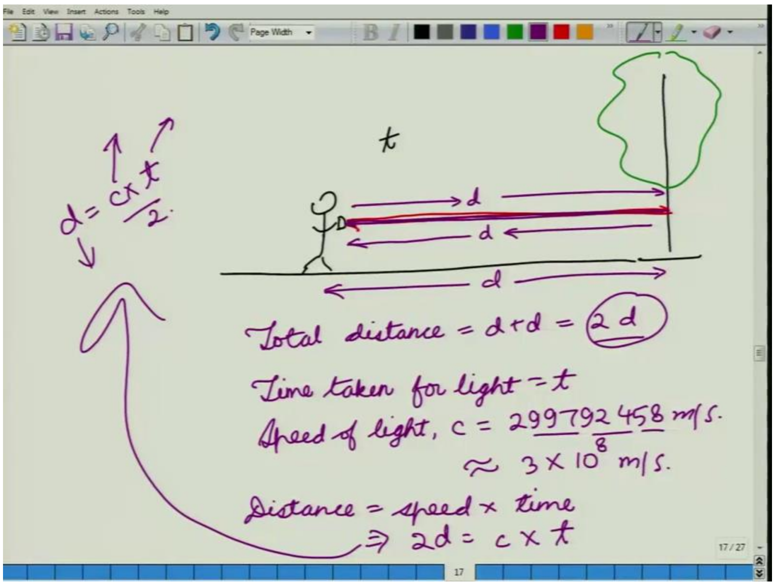

So, this is the point to which you want to take the measurements. And suppose you are standing here with the rangefinder in your hands. So, how would this rangefinder measure the distance? It would give out a ray of light. So, it is a laser light, this light would go interact with the surface of the tree and then get reflected back.

Now, this rangefinder would measure the time t between the emission of a pulse to the time this pulse comes back. Now when this ray of light is going from the device to the tree and back. So, it is covering a distance that is equal to d here and it is going towards the tree and also another distance d when it is coming back.

So, the total distance is equal to d plus d or 2 times d, where d is the distance between the tree to the point where the observer is standing, and the time taken for light is equal to t. Now we know that the speed of light c is equal to 2 9 9 7 9 2 4 5 8 metres per second. Or approximately it is equal to 3 multiplied by 1 2 3 4 5 6 7 8 into 10 to the power 8 meters per second.

So now the distance is equal to speed into time. Which implies that the distance is 2 d. So, 2 d is equal to the speed of light c multiplied by the time t. So, this would give us that d is equal to c times t by 2. Now c is a constant t is something that your rangefinder measures. So, you can calculate d from here. So, that is the theory of using this rangefinder.

So now we will come to a demonstration of a rangefinder, we shall not be using a laser rangefinder, but we shall be using an ultrasonic rangefinder. So, let us now have a look at how a rangefinder works. So, this is a rangefinder.

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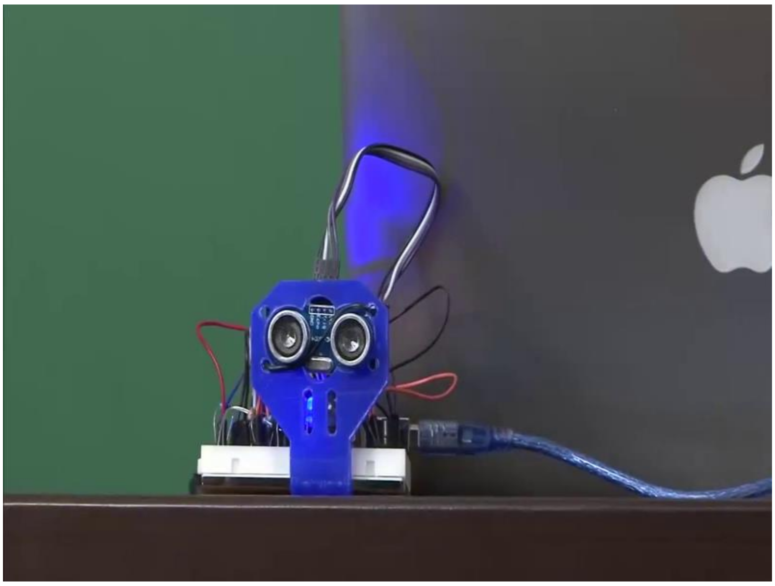

This is an ultrasonic range finder. So, it has got 2 ends. So, when end gives out ultrasonic pulses. They interact with the object in front of it and then they get reflected back to the instrument and the time that is elapse between the emission of a pulse to this pulse coming back to the device is used to get an idea of the distance of the object from the instrument.

So, for instants if we keep it close to the object. So, it is giving us the sound signals at a very fast rate. So, that is telling us that the object is very close by if you increase the this distance this pulse decreases in time. So, let us now have a look at the codem how let us now have a look at the code,

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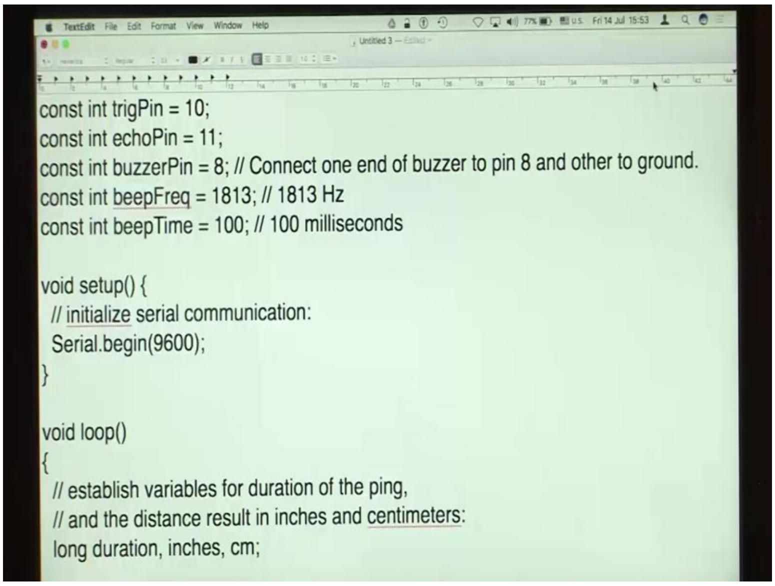

So, we have in the code we have defined are trigger pins. So, because this device is connected to hard you know. So, we have defined it is trigger pins and the echo pins we have also defined a buzzer pin and a beep frequency and beep time. So, when we initialise this code.

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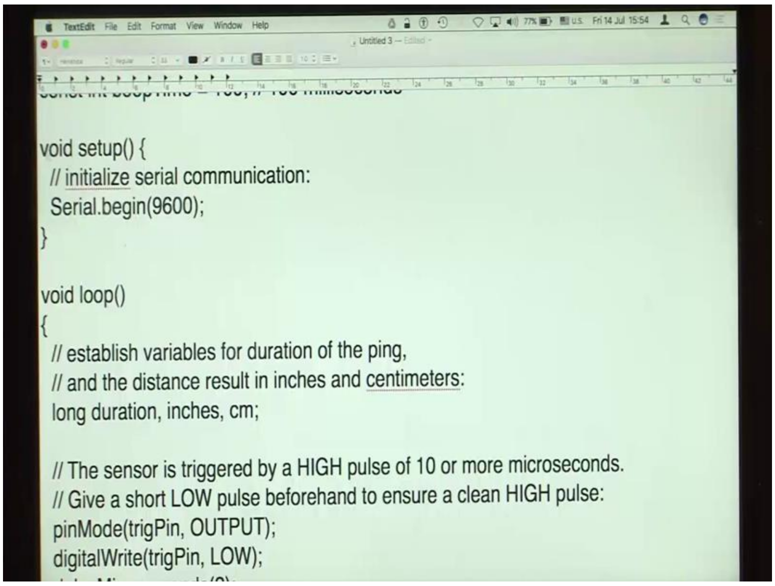

So, we setup a serial communication and just put 9600.

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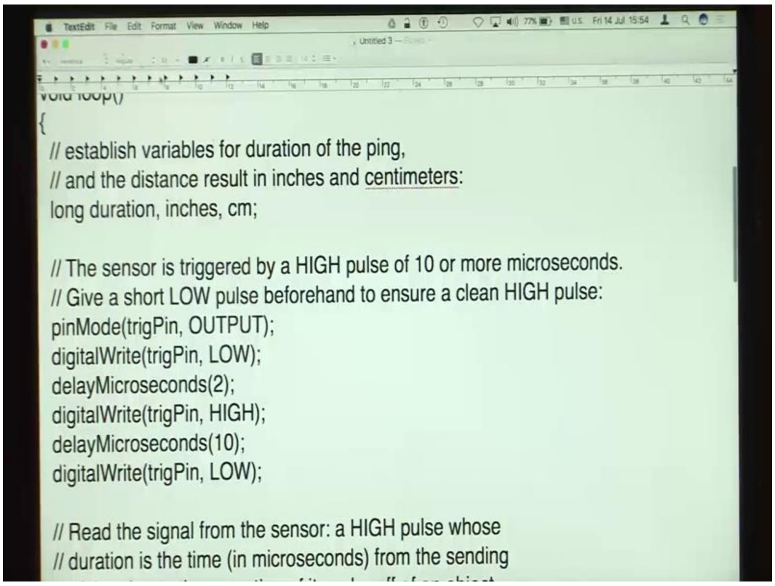

Then it goes into the loop in the Loop we have defined our variables as duration inches and centimetres.

The sensor is triggered by a high pulse of 10 or more microseconds. And then it is and we give it a short low pulse beforehand to ensure a clean high pulse. So, as you can see here we have set the pin mode of the trigger pin as output. So, we first said this output too low for 2 microseconds, then we set it to high for 10 microseconds and then we set it to low again. Now because this portion of the code is in the loop. So, it will go on repeating it again and again.

Then till take the signals from the sensor a high pulse of whose duration in time in microseconds from the sending of the ping to the reception of it is echo of an object. So, in this case we have set the pin mode of the echo pin as input. Now duration is the variable that we had defined before. So, it is a long variable. So, duration is the pulse in for the echo pin and high.

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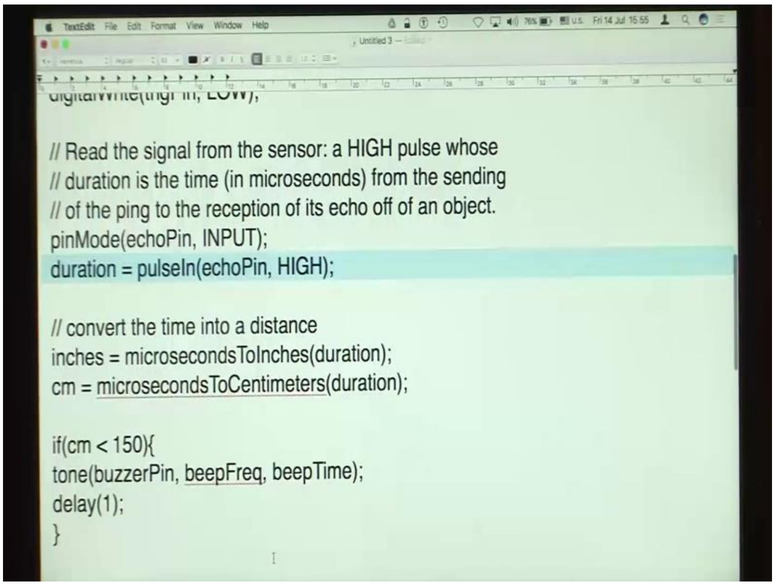

So, it will measure the time during which the echo pin is set to a high. Then it will convert this time into a distance. So, we can measure these distances in inches or in centimetres.

So, let us look at the centimetres part. So, we have defines a function here microseconds to centimetres and we gave it an input as the duration. So now, let us have a look at this function.

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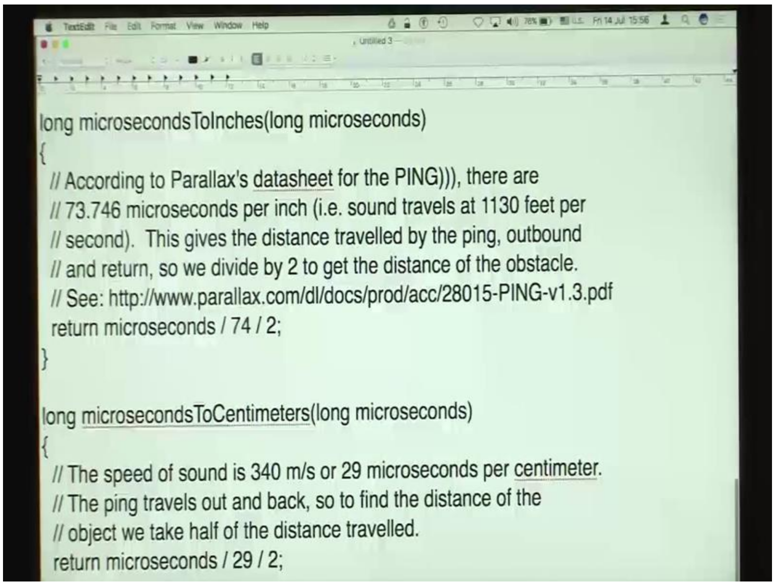

So, here is our function long microseconds to centimetres which takes an input variable in long microseconds. So, the speed of the sound is 340 meters per second or 29 microseconds per centimetres he ping travels out and back. And so, to find the distance of the object we take half of the distance travelled. So, we so, to travel one centimetre it takes 29 microseconds. So, how many centimetres will it travel in one microsecond? It will be 1 by 29. So, if we take these microseconds which is the input variable for the for the time elapsed between the emission of the pulse and it is coming back, if you if we divided by 29 we get twice the distance from the from our device to the object. And dividing it by 2 will get the distance of the object from the device.

So, once we have converted it into micro this time duration of microseconds into centimetres we can ask our device to give us a serial output, of distance in centimetres which will be given as centimetres.

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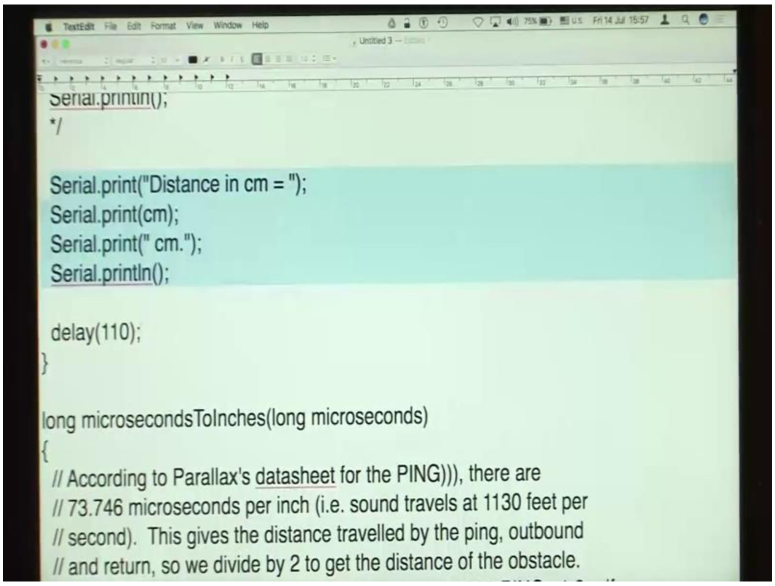

And then we give it a short delay and then this loop goes on again and again.

So, let us now have a look at how this distances would appear.

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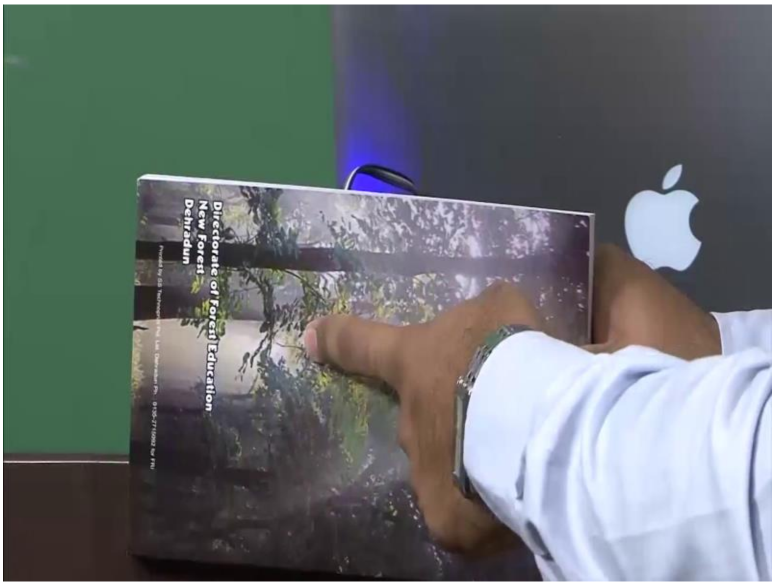

So now in front our device we keep a book which will act as a reflective. So, the ultrasound pulses, will that are emitted from the device will go and interact with the book and then they will go back to the device. And we can change the this distance of our book from the device. So, I will keep it close to the device and then I will go on extending the distance.

So now let us have a look at how what distances are being measured. So, if you go to the screen now, we can see that it is giving out a distance of 5 or 6 centimetres. So, we if we wanted to measure it is distance we could take these values 5 and 6 and then take out an average.

Now, remember that because this is a physical device and we are taking the measurement of a of a physical parameter will not be getting an exact distance, but every time that we measure this distance will be getting some value. And the average of these values would be the correct value.

So now let me take this device this book away from the device. So now, it is measuring it to be 11 or 12 centimetres. If we extend it is distance further now it is measuring 16 to 17 centimetres. Again extending it further now it goes to 20 or 20 one centimetres. So, this can measure any distances up to a maximum. So, for instants it is it is now gone to 40 centimetres. So now, it is gone to 40 centimetres, here we can go on and extending it, but now it is accuracy will go on decreasing. And after a while it is not getting any signal back from the book to the device. The signals are getting lost. And so, it is not able to measure the distance. So, every device has it is own range. So, this rangefinder can measure till a few centimetres, but if we used a laser rangefinder it would be able to measure till many metres.

Now, let us look at something different. So now I am if you focus on the book now. So, in front of our device I have kept the book now what will happen if I stealth this book So that the signals they reach this book and then they are reflected out to some other location.

So, let us now have a look at the screen now at the distances. So, it is showing me as 20 centimetres now let me stealth this book. So, it went to 170 centimetres. So, if you look at the book now again. So, I am just turning it from here till here. So, I am not changing it is distance. So, let us move back to the screen now. So, when it is when it is kept vertical it is showing me as 20 centimetres when it is deflecting it has gone to any orbit value 200 plus centimetres. So, it is some value that it is unable to measure. So, it is giving it as any orbit value. So, this was 20 centimetres and this is some orbit value.

So, why does that happen? So, if we now look at the tablet.

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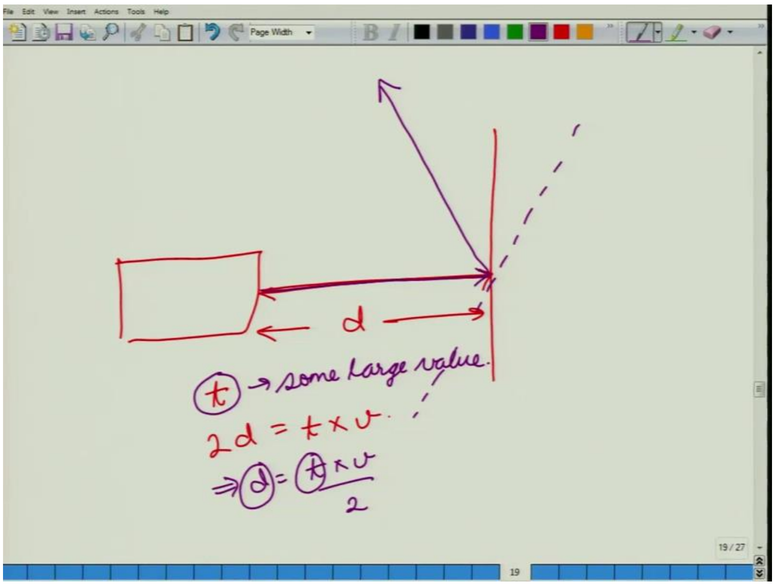

So, our device so, it is giving out a pulse that is going to the object. And this pulse when it returns it takes the time t and then calculates distance as 2 d is equal to t times the velocity.

Now, what happens when I tilt this book? So, when I am tilting this book then these rays of then these pulses they are going and then they are getting reflected to some other point. When they get reflected and this device is not getting any pulse back. So, it is unable to calculate this vale t this t come to be some large value. And so, it will measure the this distance d is equal to t times v upon the 2, when t becomes some large value this d will also become some very large value.

Now, this phenomenon in which your beams are getting reflected to some other location, is also used in the case of stealth devices.

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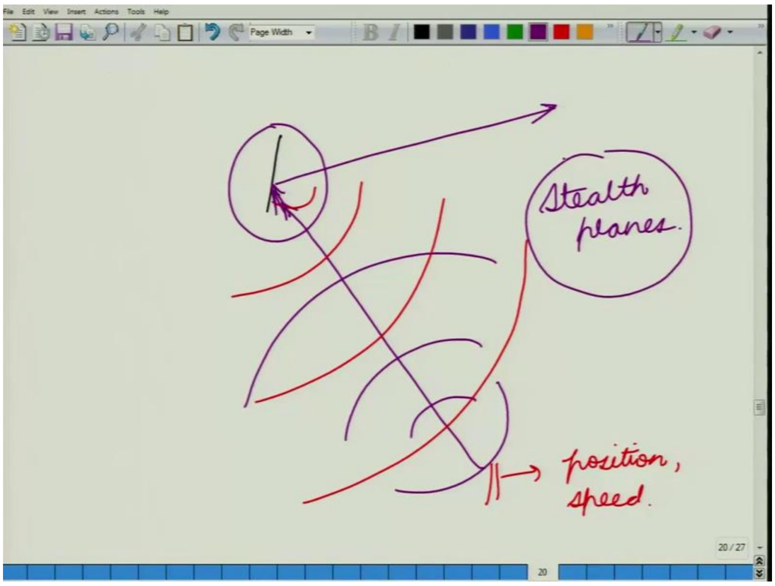

So, for instance if you had an aeroplane and if you had a radar. The radar also works on a very similar principle. So, any beams of microwaves that are emitted. They interact with your device and then they are reflected back. And this reflections are then measured by your radar to get the position and the speed of the object in front. What if this device in place of having a very smooth surface that was able to reflect these waves back had very sharp surfaces that work at some other angles. So, for instants suppose it had a surface like this.

So, what will happen this would be that this radar beam it went to the object and then it got reflected somewhere else. So, this device will not be able to get the single back. And when it does not get any signal back, what it senses is that there is no device in that is there is no object in front of this device. So, this is used in stealth planes or for other stealth applications, but why do we need to keep this point of the stealth planes in mind in the case of forestry.

So now suppose we have a tree.

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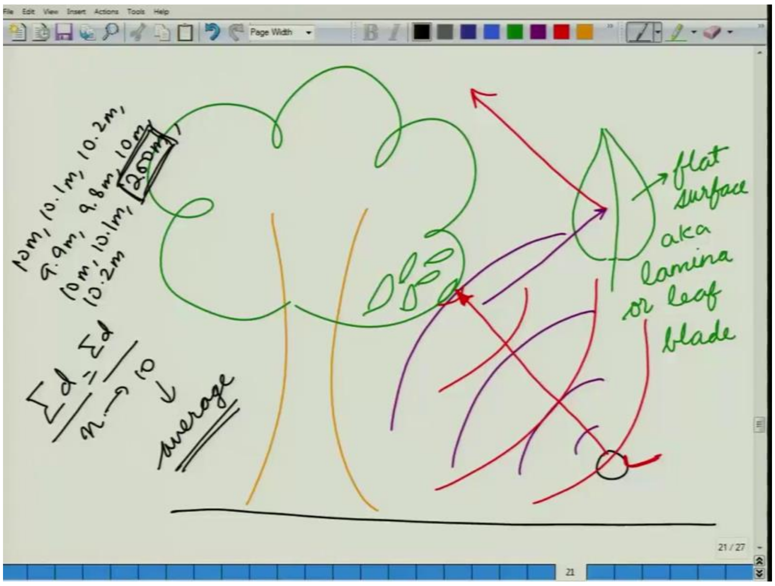

And we are standing on the ground and we use our rangefinder here. So, it is giving out some pulses which will then interact with the tree and they will get reflected back. And they will then be measured by the device, but in the case of a leaf. So, a leaf gives it a flat surface. Now in the case of a leaf if we considered it is lamina. So, this is a leaf and this is a flat surface. Also known as the lamina or leaf blade.

So now if our signal interacted with this lamina. So, if our signal interacted with this lamina and it got reflected to some other location. Then probably our device will not be able to get the correct distance of the device from the tree. So, this is one source of error that we get in the when we are using the rangefinders. So, how do we solve this error will be take multiple readings. So, because we have a number of leaves here we will take multiple readings. And we will then average out those readings. So now, this is where your averaging comes into play. So, some of distances divided by n. So, suppose you took 10 readings. So, you get 10 distances you sum them up and then you divide them by 10 to get an average. And because an average is also affected by the extreme values. So, suppose you got readings as say 10 meters 10.1 meters 10.2 meters 9.9 meters 9.8 meters 10 meters 10 meters 10.1 meters and say 200 meters.

Now, if we consider this value of 200 meters d it would. So, these are 9 values. So, let us take a 10 value. So, 10.2 meters. So, if we consider this value of 200 meters it would deflect our average by a lot. So, whenever we are taking readings with the rangefinder we should take a number of reading then we should exterminate these extreme values and then take the average to get the correct distance. Now that we have seen the demonstration of the rangefinder.

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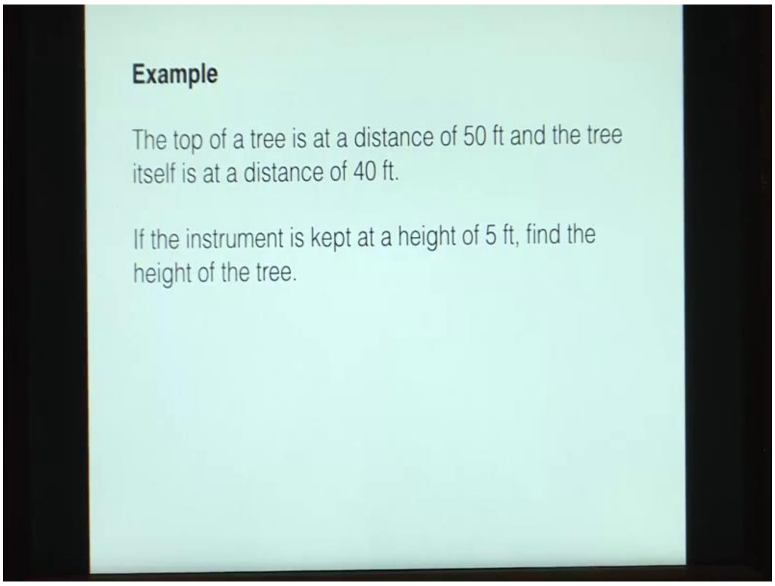

Let us now look at a few examples. So, this is the example as you can see on your screen the top of a tree is at a distance of 50 feet. And the tree itself is at a distance of 40 feet. If the instrument is kept at a height of 5 feet find the height of the tree then essentially when you are using a rangefinder it can not just be used to measure the distance parallel to the ground, but it can be used to measure any distance. So, for instants you can take the distance from this point to the top of the ceiling or to the wall or to the front or anywhere.

So, using that how can we calculate the height of the tree? Now in this problem we are given that we have a tree.

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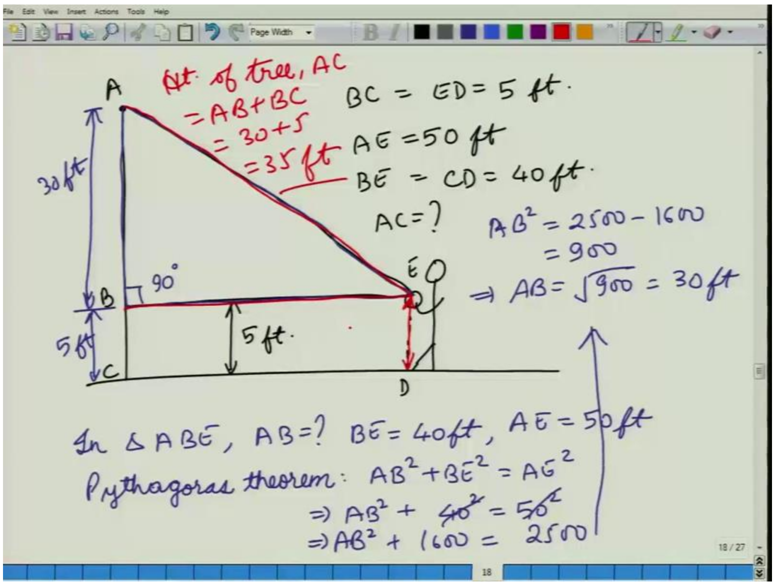

This is an observer holding a rangefinder in his hands. This rangefinder is at a height of 5 feet from the ground. The observer uses the rangefinder to take this distance. So, this distance let us call it let us make a triangle out of it A B C D and E. So, we are given that B C or E D is equal to 5 feet. The top of the tree that is a the point a is at a distance of 50 feet. So, we have a e is equal to 50 feet, and the tree itself is at a distance of 40 feet. So, we have B E or C D is equal to 40 feet. We need to find A C.

Now, how do we go about doing that? In triangle A B E. So, we are considering this triangle. So, in this triangle we have this angle is 90 degrees. And this is a right angled triangle we have A B is unknown. B E is given as 40 feet and A E is given as 50 feet.

So, can we calculate A B using these values well yes we can calculate that by using Pythagoras theorem. So, because this is a right angle triangle we have A B square plus B E square is equal to A E square. Or A B square plus B E is given as 40 feet. So, 40 square is equal to 50 square now 40 square is 1600 50 square is 2500. So, you will have A B square plus 1600 is 2500 which would give us that A B square is 2500 minus 1600 is equal to 900 or A B is the square root of 900 is 30 feet.

So, we know now that this distance A B is 30 feet. This distance B C is equal to 5 feet. So, the height of the of the tree height of tree A C is equal to A B plus B C is equal to 30 plus 5 is 35 feet. So, just by using a rangefinder and measuring 2 distances, one is this distance the second distance is this distance. And knowing the height at which the rangefinder distance which can also be measured using the rangefinder itself. So, just by using these 3 distance we can calculate the height of the tree.

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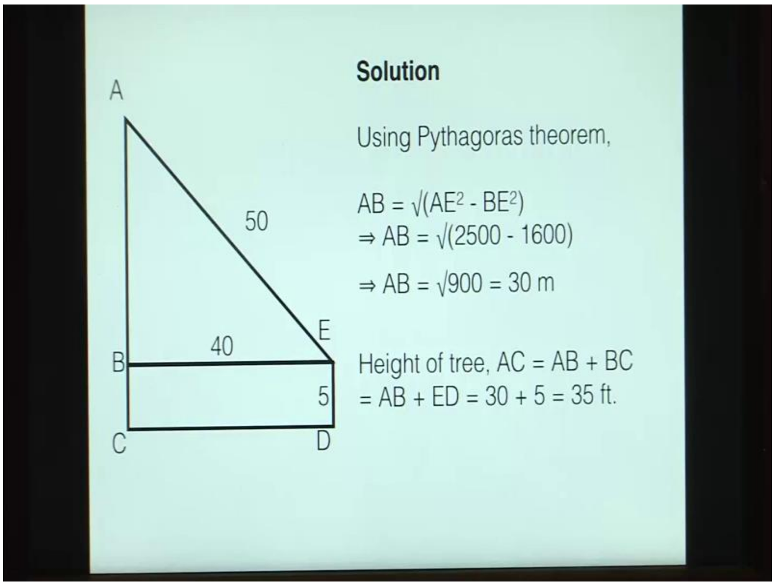

So, this is how it would look using Pythagoras theorem we calculated A B to be equal to 30 feet 30 that should be feet, and the height of the tree is 35 feet.

Thank you for your attention. [FL]