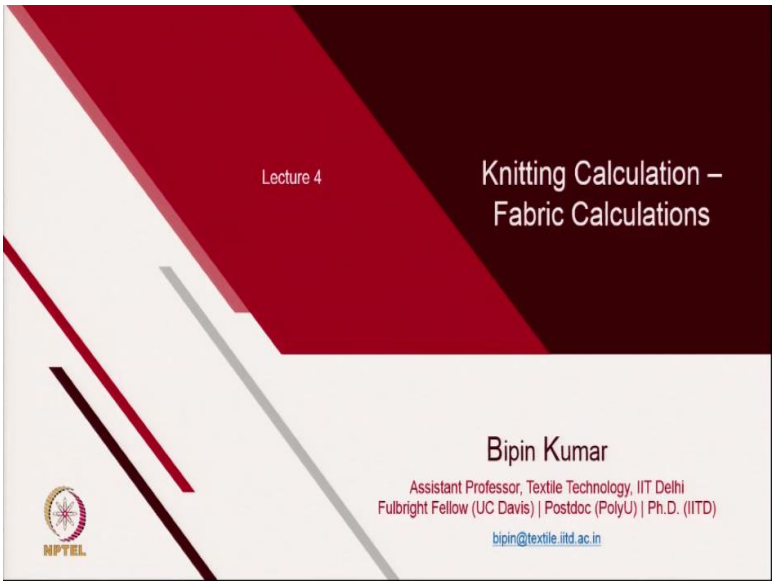
Science and Technology of Weft and Warp Knitting
Prof. Dr. Bipin Kumar
Department of Textile Technology
Indian Institute of Technology - Delhi

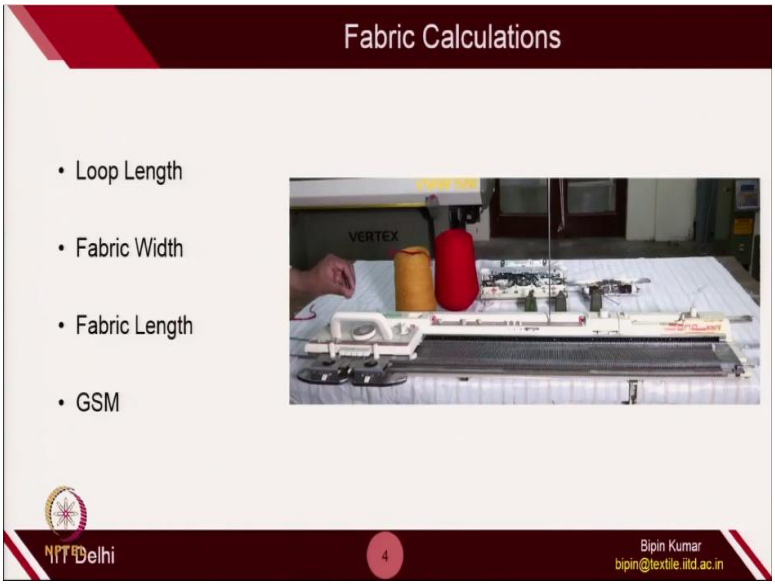
Module - 6
Lecture - 28
Knitting Calculation - Fabric Calculations

(Refer Slide Time: 00:17)



Welcome participants. Now, we are moving to lecture number 4 in week number 6. So, today the topic is fabric calculations. So, in this week, we are doing lot of calculation related to knitting. Today, I am going to introduce you some calculation related to fabric. So, some useful relations, I will provide to you, which will be very useful or especially very handy to express some fabric structural parameters. So, let's see what we are going to cover here.

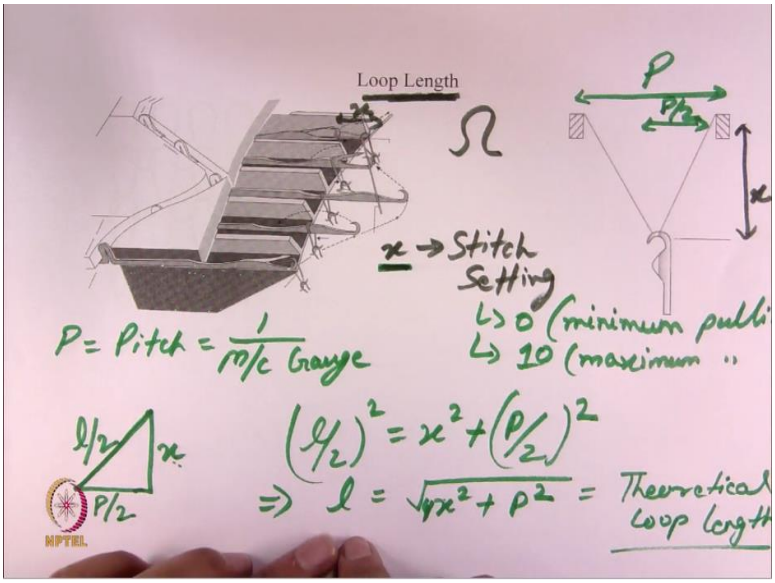
(Refer Slide Time: 00:55)



So, in fabric calculation, there are 4 things I would like to focus. The first one is loop length. So, how with the help of some machine parameters, you can be able to theoretically calculate the loop length, fabric width, fabric length and GSM. So, today's, I am going to give you some important relationship where you can theoretically measure these parameters. And you can compare those with experimental values.

So, experiment values, I have already introduced you in some of the lab demos, how you can calculate loop length, especially in week number 1 or week number 3, for single jersey fabric, double jersey fabric. I also help you to calculate GSM of the fabrics. But now, let's see how the relationship are defined for these, so that, when you do the comparison, you can have the fair idea of how these theoretical values can be very useful in predicting fabric properties. So, let's start with the first one, loop length.

(Refer Slide Time: 02:13)



So, we have seen that loop is the integral part of any knit structure. So naturally, loop length is very, very important for any knit fabric structure. And we have seen that, these loops are created on machine. So, on the machine, we have seen the needles which are placed on the tricks. So, you have seen the needles are placed on the bed, between the tricks. So, these walls are the trick walls.

And between these 2 trick walls, the needles are placed. And they are pulling the yarn inside the bed. Okay. So, to calculate the loop length, we can find out how much the needle actually pulls the yarn inside the bed. So, in one of the lecture, I might have given you one unit x. So, this unit x indicates how much the needle is pulling the yarn inside the bed. So, if you take one of the needle, I am projecting this needle on the right side.

And this is the 2 wedge, these 2 walls. So, these 2 walls are denoted here. And you can see it here, that this needle is pulling the yarn inside. So, when it is pulling the yarn, this is the actual length of yarn which is being pulled. And once the feeder goes away from the needle, this length of the yarn is actually making this loop. Because, when the old loop is knocked out, it bend this straight segment of yarn in the form of loop.

So, if we can find out the distance of this yarn length, that will be equals to loop length. So, to find out the theoretical value of loop length, 2 machine parameters is very, very important. One is x which is the distance moved by the needle or distance pulled by the needle to the filament inside the bed. So, from the bed corner, how much each needle is going inside? So, x is somehow connected with stitch setting.

So, if you change the stitch cam setting, x will change. So, in one of the lecture, I have also already shown you that, how you can change the setting from 0 to 10. At 10, it means that the needle catching or pulling the yarn to the fastest from the bed corner. And when, x is less when you keep the stitch cam setting 0. So, 0 means minimum pulling; and 10 means maximum pulling. Okay.

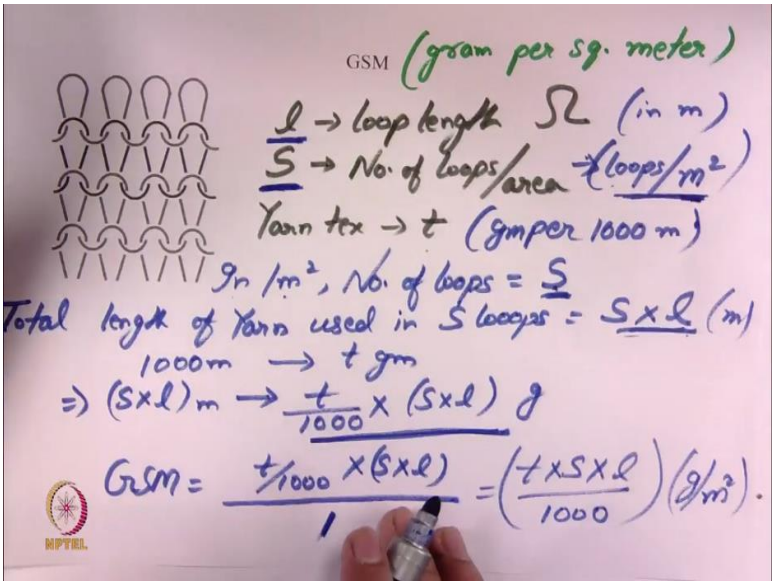
So, this stitch cam setting can be changed. And once you change the stitch cam setting, x will change automatically. So, once you know the x, to find the distance of this yarn length, we need another measurable quantity which is fixed on the needle bed, is the distance between 2 walls. So, distance between these 2 walls. So, this distance between these 2 walls is nothing but the pitch, which is defined as P.

So, **P = pitch**. And we have already defined the **pitch = 1/machine gauge**. Okay. So, to find the length of this yarn, we can make a triangle who's hypotenuse is half of loop length. This is **l/2**; l is the loop length. x is the distance which is being pulled inside the bed by the needle. And **P/2** is the half of the distance. This is **P/2**. Okay. So, once you know **P/2** and x quantity, which is directly dependent on the machine setting.

P/2= half of machine pitch. x is the, x depends on the stitch cam setting. So, these 2 variables are constant. It depends on the machine parameters. So, you can simply find out the loop length. So, $\mathbf{(l/2)^2 = x^2 + (P/2)^2}$. So, with this, $\mathbf{l = (4 * x^2 + P^2)^{1/2}}$. Okay.
So, $\mathbf{l = (4 * x^2 + P^2)^{1/2}}$. So, this is theoretical loop length.

So, once you know the theoretical loop length by machine parameters x and P, you can find out the experimental value of loop length, which I have already introduced in the previous lectures. You can then compare these 2 values and you can find out the actual loop length. So, this relationship is very, very useful. Now, let’s come to the second fabric properties, which is very, very important is GSM.

(Refer Slide Time: 08:29)



So, GSM is actually defined as gram per square meter. So, if you take a area of the fabric, what is the weight per unit area, that is defined by GSM. So, GSM, here the weight is in defined is in gram and the area is 1 meter square. So, to find out the GSM with respect to other parameters, there is a very useful relationship is derived, which I am going to express it here also. So, to find the GSM, there are 3 quantities we basically need.

First one is loop length. If we know the loop length, length of 1 loop; if we know the stitch density, which is nothing but number of loops per unit area. Okay. And yarn tex; let's denote this as a t. So, if you know these 3 quantity, you could be able to get the GSM, these 3 quantity. So, let's see how. So, obviously, since we are expressing this in gram per square meter, so, we need to also define the unit of measurement.

So, for example, let's suppose we are defining the loop length in meter. Naturally, in practice, we measure the loop length in mm; and then, we can convert this into meter. We measure the stitch density is number of loops per unit area as multiplication of course per inch and wales per inch. So, we can imagine, the unit of S is loops per meter square. So, I am keeping the unit of distance as meter.

And yarn tex t is defined as gram per 1000 meter of yarn. Okay. This is how we define the yarn tex. So, if you take 1000 meter of yarn, t is gram is there. So, gram per 1000 meter. So, this is the unit. So, to find out the GSM which by definition is the weight of the fabric per unit area. So, we need to first find out how many loops are there in 1 square meter. So, in 1 meter square, number of loops; this is nothing but stitch density.

So, S number of loops are present in 1 meter square. This is how we defined the stitch density. Okay. Because, S is number of loops per meter square. So, in 1 meter square, number of loop is S. So, in 1 meter square of the fabric, you know how many loops are there. So, you can find out **total length of yarn used in S loops= S * l**. Because, 1 loop require l length of yarn to make.

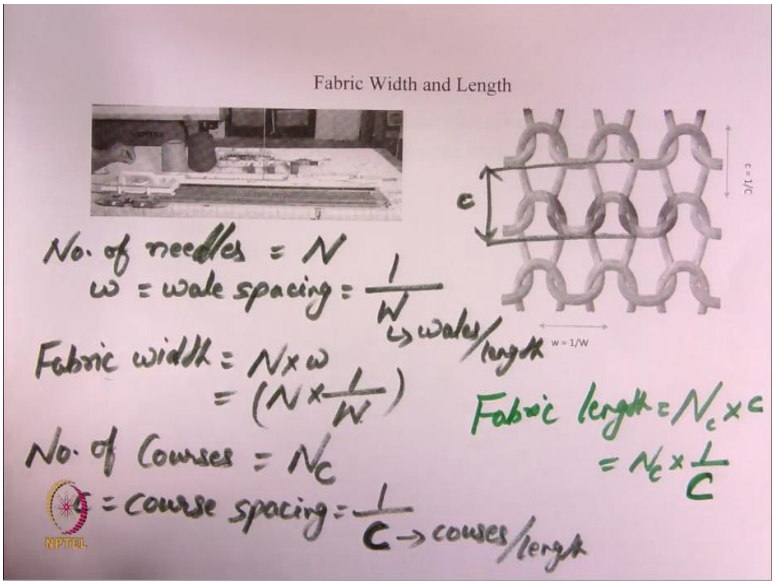
So definitely, when you want to make S loops, then you simply multiply with the length of 1 loop. So, **S * l** is the total length of the yarn which is consumed by the fabric in making S loops. So, once you know the length of the yarn, you can find out the weight of the yarn which is utilized here. So, 1000 meter has the weight t gram. So, 1000 meter has t gram. Okay. This is how we define tex.

So naturally, when you have **S * l**. This unit is also in meter. So, **S * l meter** should be having **(t / 1000) * S * l gram**. Okay. So, this much length of yarn is having the weight this. And we already know, this much length of yarn, the area is occupied = 1 meter^2. So naturally, the GSM is weight per unit area. So, weight is **(t / 1000) * S * l**. And what is the area?

Just 1 meter^2. Okay. So, **(t * S * l)/1000**. This is in **gram/meter^2**. So, t is the yarn tex, S is the number of loops per meter square, l is the loop length. Okay. And 1000 is just the unit. So, you, we need to be very, very careful, how you are calculating the loops; what is the unit of loop length; and what is the unit of S. So, if you change the unit; for example, if you are calculating number of loops per inch square, you need to convert S into loops per meter square.

And then, you have to use this formula. So, unit is extremely important. And I expect all of you to follow the unit properly. Now, let's see the third relationship which is directly connected with fabric width and length.

(Refer Slide Time: 14:48)



This is very, very easy. So, if you want to find out the width of the fabric, naturally width is related with the number of columns. So, if you have more wales, the width will be more. So, on the machine, 1 needle is making 1 loop or 1 column. Okay. So, if we know the number of needles which is, let's suppose N. N number of needles is used in making this fabric. And if we know the distance between 2 column as a w.

w is wale spacing. I have also introduced this in the week number 1, which is nothing but **w=1/W**. So, W is nothing but wales/unit length. So, if you know the distance between 2 column as a small w; and if you know the number of needles, you can find out the fabric width. The fabric width is nothing but **N*w**; or **N*1/W**. So, the unit of length, according to which you are calculating W, that will be automatically the unit of fabric width.

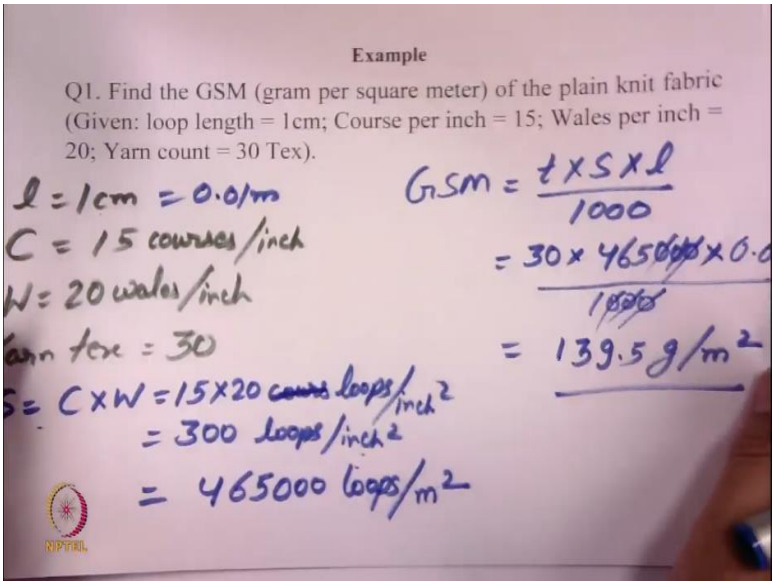
So, if you are calculating W as wales per inch, then fabric width will be inch. If you are calculating wales per meter, then the unit will be in meter. Similarly, if you know the number of courses which you make on the machine, that will decides how many times you traverse the cam jacket from one side to other. So, if let's suppose, if you have taken 100 traverse on the machines, naturally you are making 100 courses.

So, if you know the number of courses and if you know the course spacing, which is nothing but distance between 2 courses. So, this is first course, this is second course. If you know this distance, which is c, distance between 2 courses, you can. **c = 1/C**. C is nothing but courses per unit length. So, once you know Nc and small c, you can find out the fabric length.

So, **fabric length = Nc*c = Nc*1/C**. So, whatever you feel comfortable. So, this was the fabric width and length. So, you can see everywhere, if you understand the machine parameters and if you knows little bit of variables, you can be able to find out the GSM, theoretically, which is related with this. You can also find out fabric width and length.

So, fabric width is this much and fabric length is this. And also, you can find out the loop length. So, all the structural parameters, loop length, fabric width and length and GSM can be calculated. Let's now solve a very simple example; and then we finish this lecture. So, let's see this question.

(Refer Slide Time: 18:53)



Find the GSM. GSM is defined as gram per square meter of the plain knit fabric. Given loop length is 1 centimeter; course per inch is 15; wales per inch is 20; and yarn count is 30 tex. So, as per the formula of GSM, we have to use this equation, **GSM = t*S*l/1000**. So, to finding the GSM, the values which is given to us. Loop length is 1 centimeter. C is 15 courses per inch.

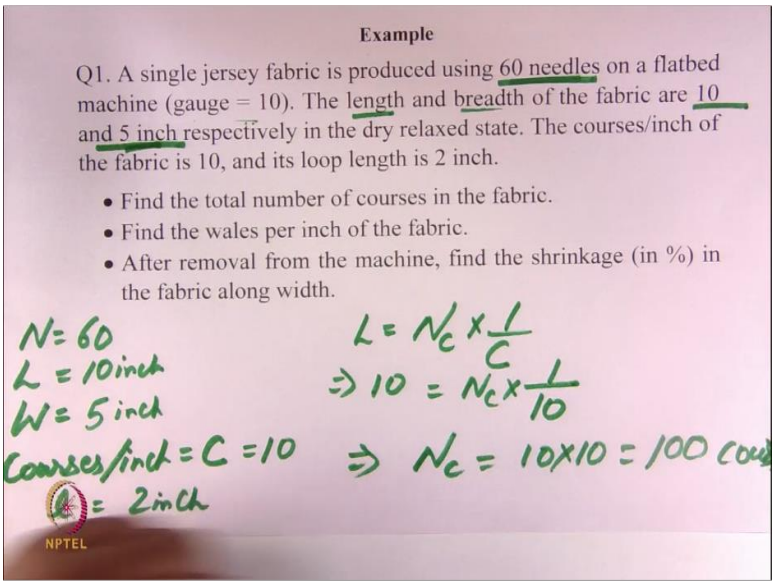
W, 20 wales per inch. And yarn count, yarn tex = 30. So, this is given to you. And we need to find out the GSM. So GSM, we already know **GSM = t*S*l/1000**. Okay. This is the formula which we need to apply. So, we have to be very careful with the unit. So, if you remember, when I was deriving this relation, the unit of t was tex which is 30. So, it is perfectly fine, 30 into; unit of s was number of loops per meter square.

So, we have to first find out the s. So, we know **S = C * W**, which is nothing but **15 * 20 loops/inch^2**. So, **15 * 20** = 300 **loops/inch^2**. So, here the unit of S is **loops/inch^2**. We need to convert this into meter^2. So, you can put the value of inch into meter. So, once you will do it, this will be **= 465000 loops/meter^2**. So, now you can use 465000 here; 5 triple zero.

Now, the unit of l was in meter, which is loop length. So, l is 1 centimeter. You can convert this into meter, 0.01 meter. So, **0.01 meter/1000**. Okay. So, you can simply then, it is a very simple arithmetic. So, that will come around **139.5 gram /meter^2**. Okay. So, I hope, you can see, once you know some of the fabric structural parameters, you can find out its weight per square meter.

So, this relationship is extremely valuable. Now, let's, another simple example, just for your clarity. Here, we will be finding out how many courses, how many wales are there in the fabric; and what is the shrinkage. So, let's see the, read, I am going to read this question.

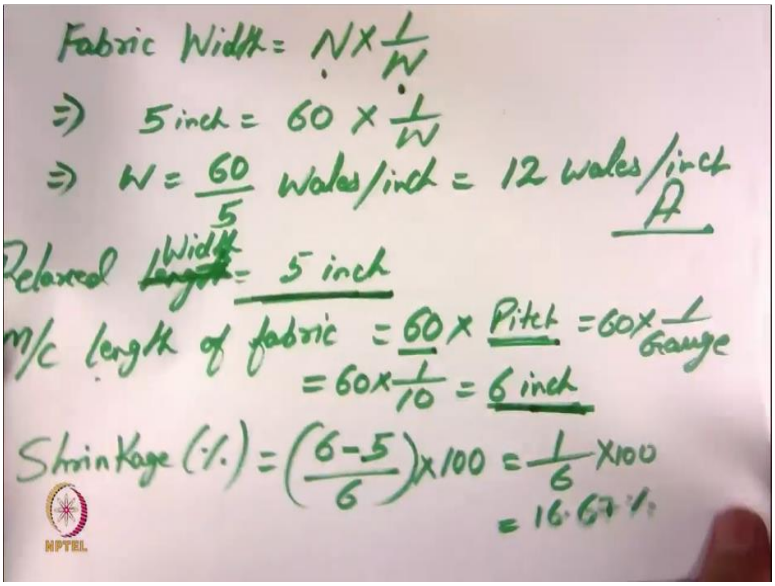
(Refer Slide Time: 22:36)



So, a single jersey fabric is produced using 60 needles. So, 60 needles; on a flatbed machine. The gauge is given 10. The length and breadth of the fabric are 10 and 5 inch respectively. So, here the length is and breath is given in dry relaxed state. The courses per inch of the fabric is 10. Okay. And it is loop length is 2 inch. So, what is given to you? Number of needles is 60; length of fabric is 10 inch; width of the fabric is 5 inch, width is 5 inch; courses per inch, which is nothing but C = 10; and loop length is 2 inch. Okay.

So, find the total number of courses in the fabric. If you see the relation, we have already defined the **fabric length = Nc*1/C**. So, fabric length is given; Nc we have to calculate; C is known to you. Okay. So, fabric length **L = number of courses*1/C**; or n is 10; N c, we have to find out; and **1/C**, C is nothing but 10 courses/inch.

So, with this, **Nc = 10*10=100** courses. Now, let's, the second part. Find the wales per inch of the fabric. So, for finding wales per inch of the fabric, we know
The fabric width=N *1/W wales/inch. So, this we have to find out.
(Refer Slide Time: 24:57)



So, **fabric width=N *1/W wales/inch**. Okay. Where N is the number of needles and W is wales per inch. So, fabric width; we have seen here, the fabric width, you do not get confused with W. So, width is 5 inch. Because, in the question, it was given 5 inch fabric width. So, this is 5 inch. And **number of needles = 60 * 1/W**. So, this implies,

W=60/5 wales per inch = 12wales/inch. Okay. Now, let's see the last part. After removal from the machine, find the shrinkage in the fabric along width direction. So, the width of the fabric which is given 5 inch is in the relaxed state. And in the previous week, I have shown you, the relationship of shrinkage. Shrinkage is nothing but, how much the fabric shrinks per unit original length.

So, when you are making the fabric on the machine, the width is more. But, once you take out the fabric from the machine, fabric will relax and the width will shrink. So, it is asking us what is the shrinkage. So, relaxed width is 5 inch. Now, we want to find out what is the width

of the fabric on the machines. So, on the machine, we know how many needles are used; and we know the gauge of the machine.

So naturally, so 60 needles has been occupied; and we can find out that 60 needles, how much distance it is occupying on the machine. So, the fabric will be there up to 60 needles. So, on the machine, machine length of fabric is 60 times the pitch. Because you are using 60 needles in making the fabric; and pitch is the distance between 2 needle. So**, 60*1/gauge**. Okay. So, 60. And what is the gauge of the machine?

This is nothing but 10; 10 needles per inch. So, **1/10**. So, this is 6 inch. So, on the machine, the fabric length, width was 6 inch; and after you take out the fabric, fabric width was 5 inch. So definitely, the fabric has shrink from 6 to 5. So, shrinkage; shrinkage percentage is original length on of the fabric on the machine, which is 6. Final length of the fabric after relaxation is 5, divided by original length into 100.

Shrinkage (%) = ((6-5)/6)*100=16.67%

So, in percentage, you can simply multiply by 100. So, once you solve this, **(1/6)*100= 16.67%.** So, you can see how these relationship are so useful in understanding not only the machine variables, but also lot of physical and structural variables. So, I hope this is clear to you. In the next class, we are again going to cover some new topic in knitting, where some relationship can be useful in defining some other fabric properties. So, let’s wait for the next class. So, thank you very much for the listening.