Engineering Metrology
Prof. J. Ramkumar
Department of Mechanical Engineering & Design Programme
Indian Institute of Technology, Kanpur
Dr. Amandeep Singh Oberoi
Department of Industrial & Production Engineering
National Institute of Technology, Jalandhar

Lecture - 10
Linear Measurements (Part 2 of 2)

Welcome to the lecture on Linear Measurements 2.

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Last lecture we saw floating micrometer for measuring the screw threads.

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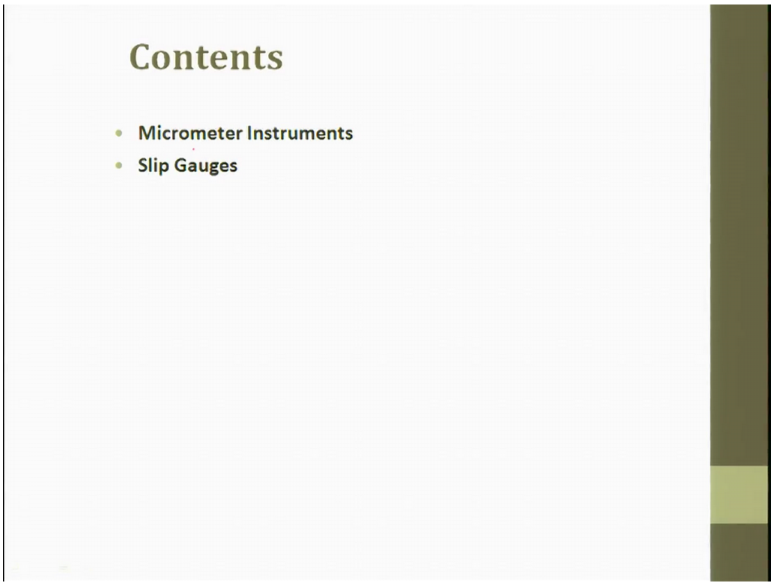

So, today we will see micrometer instruments and even see also slip gauges.

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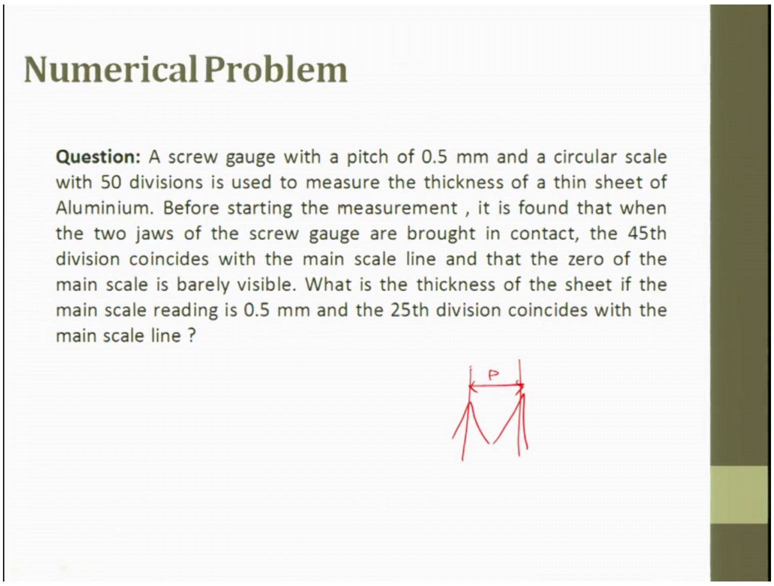

We had the basic in the last lecture. So, let us try to solve a problem. A screw gauge with a pitch of 0.5 millimeter, pitch is this is called as a pitch right 2 consecutive threads this is called pitch P right. Pitch is 0.5 millimeter and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of aluminium. Before starting the measurement it was found that when the 2 jaws of the screw gauge are brought in contact the 45th division coincides with the main scale line there is a error. And that the zero main scale division is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 millimeter and the 25th division coincides with the main scale line? So, the lesson of this problem is before trying to take any measurement using any instruments dial it to 0, see whether you get 00 in the ground state or before the start of the measurement when everything is put screw gauge, just make both the jaws comes close to each other and see whether the 0 divisions are matching.

If it is not so, there is a error. So, this error first we will try to avoid or the other way round is you try to know the error and when you get the final answer, subtract it from the final answer then you get the correct answer. So, but please try to do this 0 dialing before start measurement.

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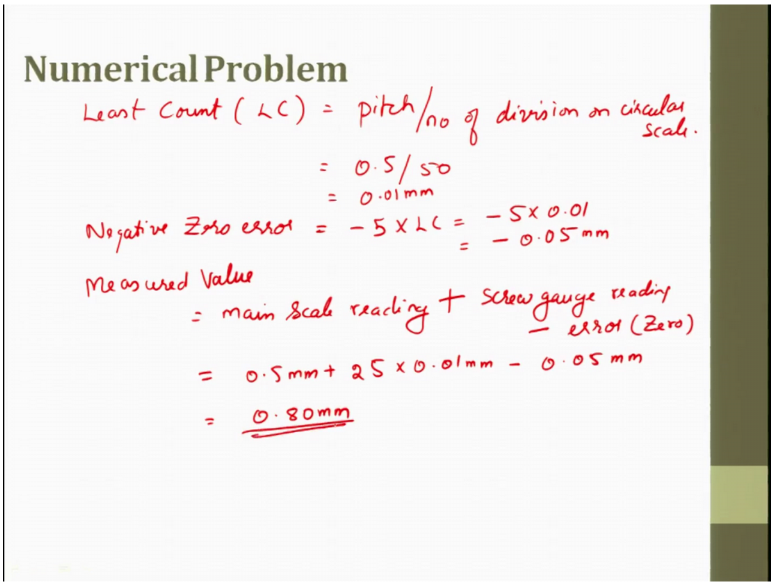

So let us call Least Count which is LC is nothing, but pitch by number of divisions on circular scale ok. So, this is nothing, but 0.5 divided by 50 so which is nothing but 0.01 millimeter. So, the negative or the error negative zero error is nothing, but minus 5 times into LC. So which is nothing, but minus 5 into 0.01 which is minus 0.05 millimeter ok. Now the measured value measured value is main scale main scale reading plus screw gauge, screw gauge reading minus the error the initial error whatever we had. So, this is or I can say if you want to be more specific we call it a 0. So, it is 0.5 millimeter plus 25 into 0.01 millimeter and this is minus 0.05 millimeter. So, the answer is going to be 0.80 millimeter this will be the thickness of the sheet let us try one more problem.

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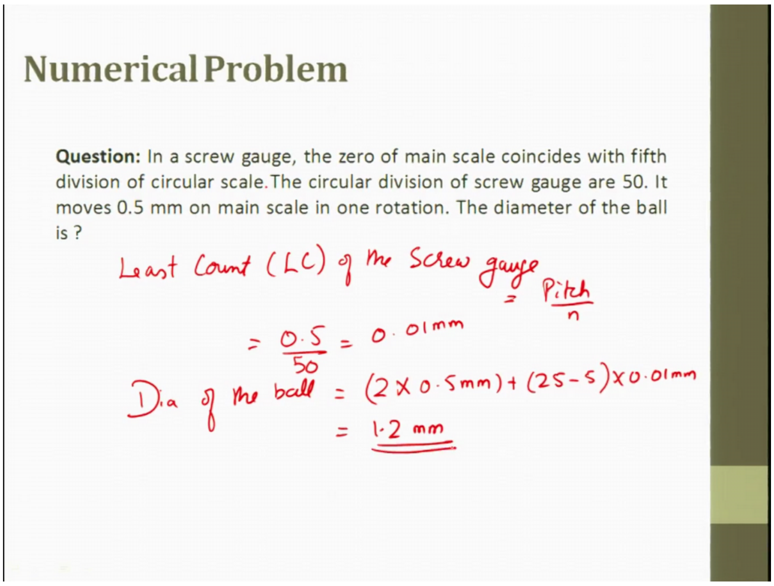

In a screw gauge the zero of a main scale coincides with the fifth division of a circular scale, the circular scale division of the screw gauge are 50. It moves 0.5 millimeter on the main scale in one rotation; the diameter of the ball is what. So, the least count LC of the screw gauge is equal to pitch by L we saw the formula.

So, this is nothing, but 0.5 divided by 50 which is nothing, but 0.01 millimeter. The dia of the ball is equal to 2 into 0.5 millimeter plus 25 minus 5 into 0.01 millimeter. So, which is nothing but 1.2 millimeter ok so, this is the diameter of the ball.

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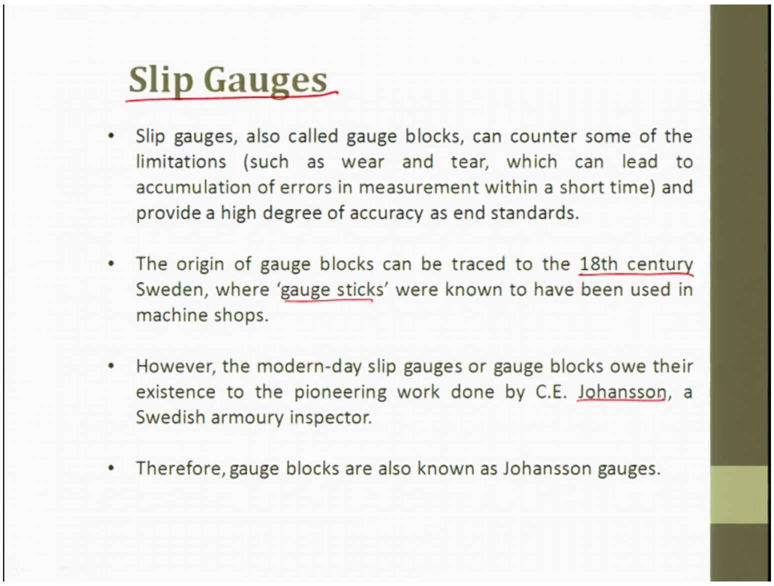

Next let us move on to slip gauges also called gauge blocks can counter some of the limitations such as wear and tear, which can lead to the accumulation of errors in measurement within a short time. Slip gauge is basically if you see it is a end measurement that than a linear measurement. The origin of gauge blocks can be traced to 18th century in Sweden where gauge sticks were found to be used in the machine shop.

However, in modern days slip gauges or gauge blocks owe their existence to the pioneering work done by Johansson a Swedish armoury inspector therefore, the gauge block is sometime called as Johanasson's gauge.

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So, this is a typical slip gauge block. So, here you see it is as I told you it is end measurement. So, you will have 16 millimeter, 30 millimeters, 20 10 and 9. So, if there is a value suppose if the value is 79.00 millimeter you have to make 79.00 millimeter then what we do is. So, that if it is to be 89 or you try to instead of 20, you try to take a 10 if it is 79 then 60 take 10 and 9. So, now, 3 blocks are taken and these 3 blocks they are attached or they are placed one above each other. When they are placed one above each other and we are looking forward for micron accuracy, then there should not be any gap between these gauge blocks ok.

So, now what you do? You make this gauge blocks pick up the values whatever you want and then you start solving it. So, you accumulated and now what have you done you have made 3 end gauges. So, if you want to take a measurement this will be perfectly measureable in terms of height. So, this is gauge 1, gauge 2 and gauge 3; 60, 10, 79 ok.

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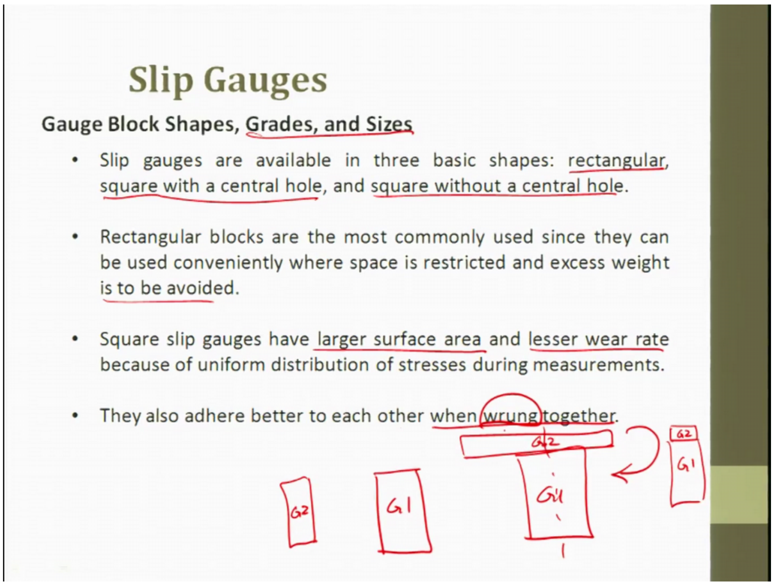

So, gauge blocks shapes grades and sizes there are several grades like the grades we had in surface plates. So, here also you will have grades and sizes the slip gauges are available in 3 basic shapes rectangle square with a central hole and square without a central hole for various application. So, what we should view as a rectangle type. Rectangle type is the most commonly used since they are more convenient where space is restricted and excess weight is to be avoided. Square slip gauge have larger surface area and lesser wear rate they are they also adhere better to each other when wrung together wrung is an operation.

So, wrung means what we do is, we try to take a block we try to take another block right this is gauge 1 or a block 1 this is block 2 then what we do is, we try to place G 1 and then we try to place G 2 on top of it and then what we do is we try to sure let at about its center line and then G 1 and G 2 are made one above each other. So, first it is allowed to slide and place and then what we do is slide and place a perpendicular. So, then G 2 is rotated in such a way G 2 and G 1 are aligned.

So, this process of sliding and rotating is called as wringing operation or wrung.

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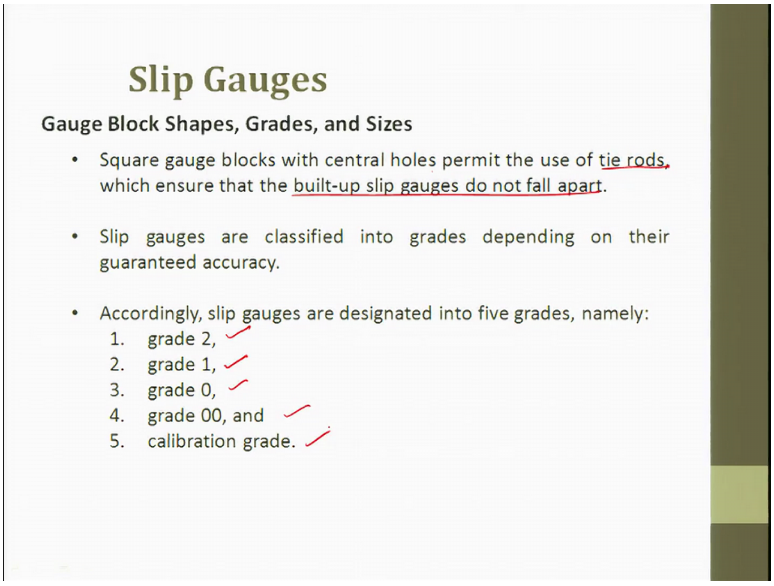

The square block with center hole permits the use of tie rods, which ensures the built up slip gauges do not fall apart. Tie rods are basically there is a rod in between and the extreme ends you have 2 nuts or 2 spaces or 2 stoppers. The slip gauges are classified into grades depending on their guaranteed accuracy grade 2 grade 1 grade 0 grade 00 and calibration grade are some of the where the 5 grade of slip gauges.

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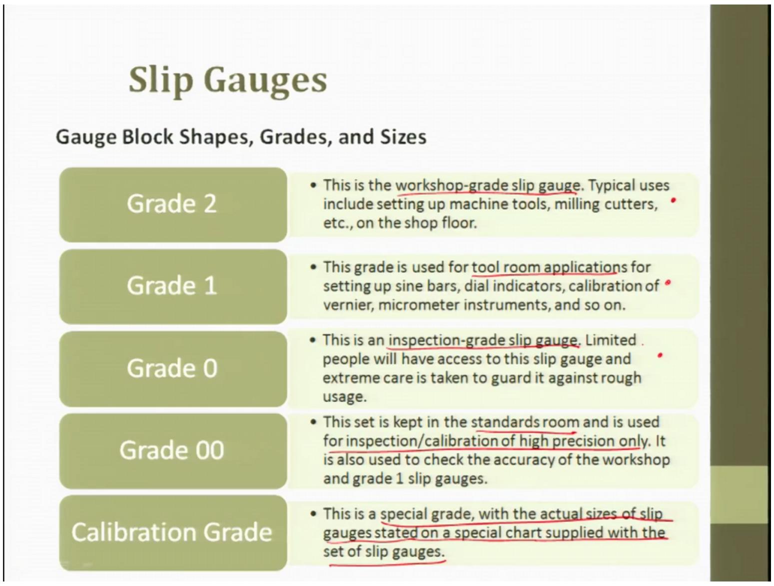

Grade 2 is generally used in the workshop, grade 1 is generally used in the tool room, grade 0 is used in inspection grade slip gauges. Grade 0 0 is kept in the standards room and is used for inspection and calibration of high precision only. Calibration grade is a special grade with the actual size of the slip gauge stated on a special chart supplied with the set of slip gauges.

So, this is at shop floor where operator works, then it is taken to a tool room then the tool room is getting calibrated at a higher end either inside the factory or in the city somewhere or in the state, then it is taken to the standard like last time we discussed I was trying to talk about tell this is district level, this is state level and this is country level and this is a special type which is used. So, these are the 5 grades gauges grades or slip gauges which are used in real time.

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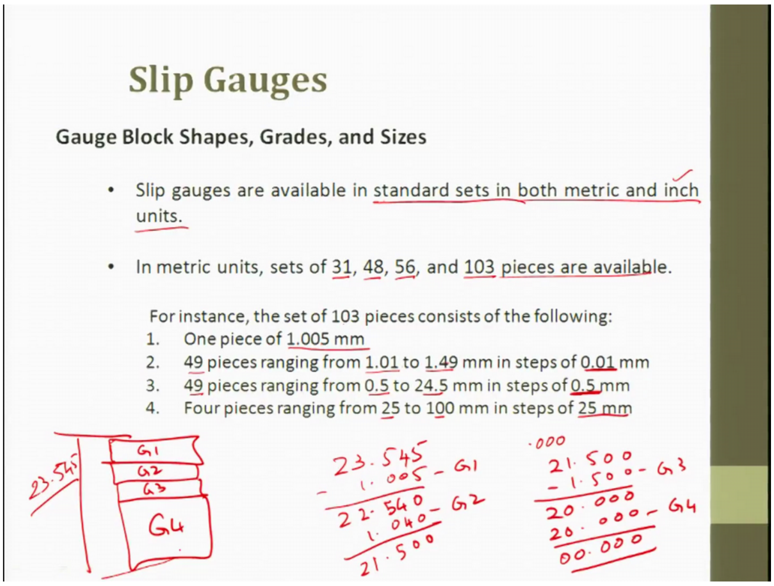

So, the gauge block shapes grades and sizes are available in a standard sets in both metric and inch units. Even today inches are used in big weight in some part of the world so, that is why we still have both metric and inches. In metric set of 31, 48, 56 and 103 pieces are available.

So, what are these pieces we are talking about? These are the pieces 1 2 3 4 5 these are the pieces. So, you can have a more of like you can have 103 pieces, 56, 48 and 31. So, when we say 103 pieces; that means, to say here you can go to the second decimal or third decimal accuracy while building these slip gauge blocks for a required height. So, for instance the set of 103 pieces consist of the following. One piece of 1.005

millimeters. So, you see to that third decimal accuracy you can build. When we talk about 49 it ranges from 1.1 to on1.49. So, it is the second decimal.

When you reduce it further down, in steps of 0.01 millimeter, when you go for 49 piece range from 0.5to 24.5 the step size is 0.5 and four pieces range from 25 to 100 is 25 millimeter. So, you can see what is not 3 if you sum it up all you will get 103 you will have one piece of accuracy 1.005; 49 piece you have at the range from this to this in step size of this 1.01. So, what you can do suppose you have 23.545 you can start building this from the block for example, 1.005. So, you say minus 1.005. So, now, it is 23.54 now this is for you for building this is gauge 1. Next what I will do is I will try to kill this so, I will try to take may be if it is 1.04. So, now, gauge 2 block is there so, I will took 23 point sorry it becomes 22 and this becomes 21.500 So, then I take 23.500 I minus it by 1.500 so, I get 20.

So, this is gauge 3 and then finally, I have a directly a block of this gauge 4. So, this is 00 0 0 0 so, this is gauge 4. So now with four gauge blocks so, gauge 4 gauge 3 gauge 2 and gauge 1 I could built a this is 23.545 millimeter. So, what is that to accuracy of micron I am able to get the slip gauges then I am able to build the height. Now with this height what I can do is I can take it to a screw gauge I can take it to a vernier I can take it to height gauge find out what is this height find out what is that height. Now I have converted an end measurement into a linear measurement or an end another end measurement. So, that now I can make sure whatever I measure in this instrument is perfect. And this is how is the calibration we try to remove or we try to work or to choose with the gauges.

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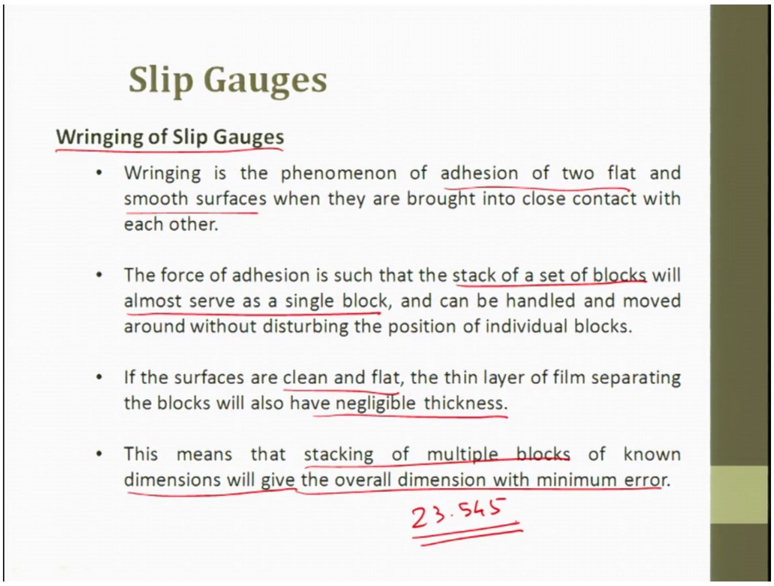

Wringing of a slip gauge; wringing is the phenomenon of adhesion of 2 flat and smooth surfaces when they are brought in close contact with each other. The force of adhesion is such that the stack of set of blocks will almost serve as a single block and interestingly said what people say after you wrung slip gauges you have to turn it upright and see whether the slip gauges fall down or not.

So, it has to be a perfect contact without any glue and can be handled and move around without disturbing the position of the individual blocks. If the surfaces are clean and flat the thin layer of film separating the block will also have negligible thickness this means that stacking of multiple blocks of known dimensions will give the overall dimension with minimum error. Because if I want 23.545 getting a block of one block of this is next to possible and second thing if I want to build several of these combinations, then it is like a modular concept which is used in building up a block. And in fact, is a model concept which is used way back in inspection itself.

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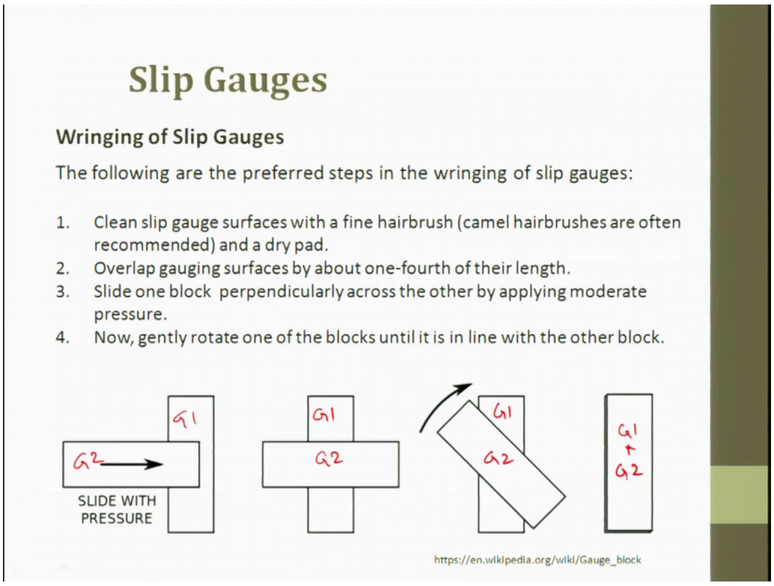

So, this is what is the wringing concept you have gauge 1 gauge 2; first we slide the applied pressure and the slides.

So, it is becoming perpendicular then we rotate it and then we put it one after it. So, this is G 2 this is G 1. So, G 2, G 1 now G 1 is inside and G 2 both are aligned. So, this we discussed there.

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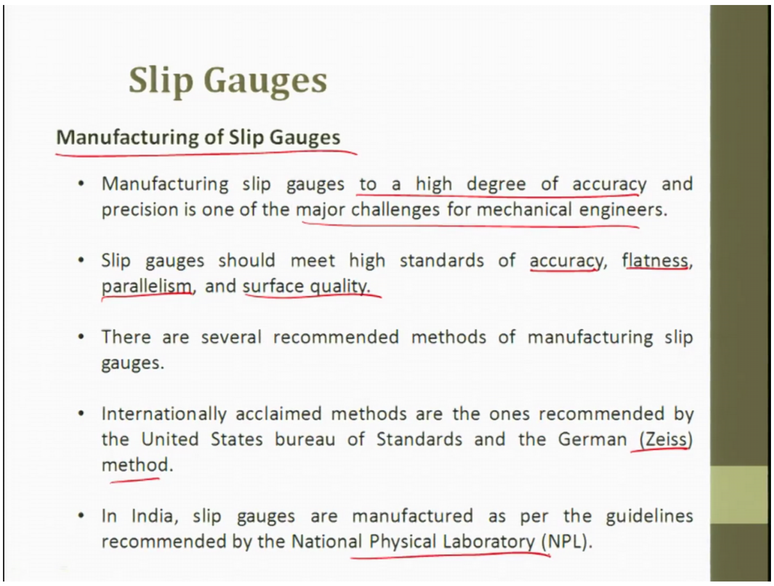

So, how are these manufacturing of slip gauges done? So, the slip gauges whatever we talk about, individual gauges should be as flat as possible it should not have any undulation on surface. First of all the roughness should be good and straightness should be good and the 2D parameter, roughness 1D where a straightness is also one d. So, then we try to talk about something called as flatness, the flatness is a 3D parameter. So, here we try to talk about 2 flat names up and down there should be as flat as possible we talk about accuracy of one micron. Manufacturing slip gauges to the highest degree of accuracy and precision is one of the major challenge for mechanical engineers; the flat accuracy flatness parallelism and surface quality has to be measure has to be maintained.

International claimed methods are the one recommended by United States Bureau of standards and the German Zeiss method in India NPL has the standard wherein which they make the slip gauges or they calibrate the slip gauges, what is manufactured and they maintained the standards in India.

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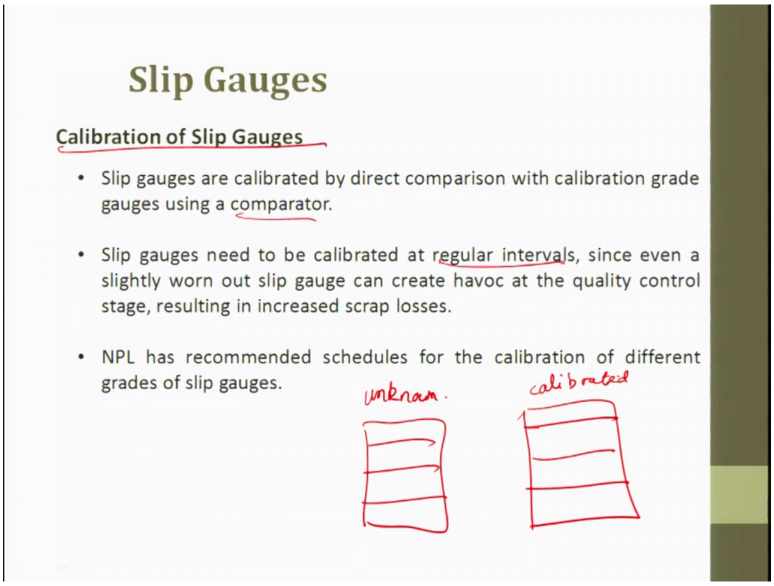

Calibration of slip gauges; slip gauges are calibrated by direct comparison with calibration gauge using a comparator. So, what is that is you have made your stack ready here, then you have made the calibrated grade and here between these you put a comparator and these comparator can be a light, anything can using comparator they check whether both the heights are ok. The slip gauge needs to be calibrated at regular intervals; that means any measuring instrument has to be calibrated at regular intervals. Since even a slighter is to own out a slip gauge to create a havoc in the quality and material. NPL has recommended schedules for calibrating the screw gauges at different level.

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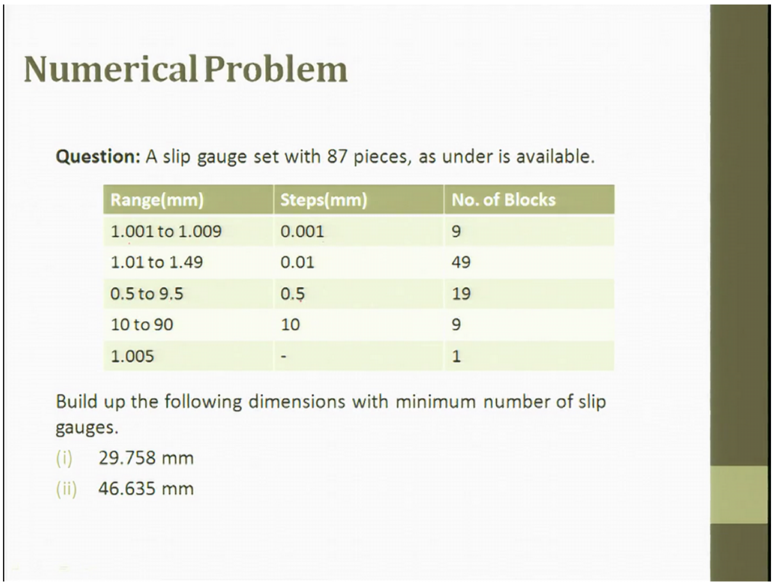

Range(mm)	Steps(mm)	No. of Blocks
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 90	10	9
1.005	-	1

A slip gauge set 87 has under this available numerical problem, which you wanted to solve.

So, here you can see there is number of blocks between this range to this range is 0.001 step you have 9 block, 1.1 to 1.49 in the step size of this you have 49 blocks, 0.5 to 9.5 you have 0.5 step size of 0.5 you have 19 blocks and then finally, you have 1. So, now, what we are trying to do is we are trying to build slip gauges for 29 point.

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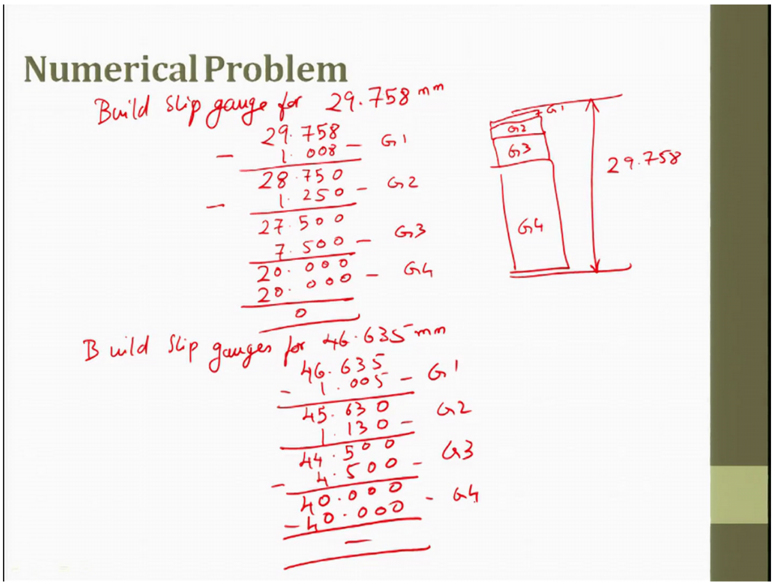

We are trying to build slip gauge for 29.758 ok. So, if you go back to the sum 0.08 you have nine blocks ok. So, what I do is I try to take. So, first I will try to take 29.578 and then I subtract 1.008. So, I get 28.750 then I try to take.

So, here if you see here I have choice of 1.25 in the next step. So, I try to take minus 1.250 next gauge. So, this is gauge 1 this is gauge 2 slip gauge 1 slip gauge2. So, then I have 27.500 right. So, then what I do is in this select. So, I have 7.5 will be the next one I subtract. So, I get 20 000 then finally, I take 20 000 and this is 0. So, I have gauge 3 and gauge 4 that means, to say I would first put 20 this is gauge 4, then I put 7.5 gauge 3 then I put 1.25 gauge 2 and I have gauge 1. So, this entire height is now 29.75 gauge, I have used wringing of the gauges to get this proper alignment to build for build gauge for next was build slip gauges for 46.635 so millimeter. So, you have to look at the box, you have to look at the steps here available and then you have to pick whatever is there in the box you just have to pick with the letters one.

So, what it will be 46.635 so, first I will put 1.005 so, I get 45.630 then I subtract 1.130 so, I get 40 four point 44 point then what I do is I subtract, 4.500. So, then I get a block of 40 then I subtract 40 I can be write down this 40 if it is available you try to do 40 directly or you can do it as 20 and 20. So, that you are based upon what is available in your box you have to pick these gauges and then start solving it. So, finally, we get 1 2.

So, 1.05 1.13 4.5 and 40 you get you try to assemble and then try to get better answer for it.

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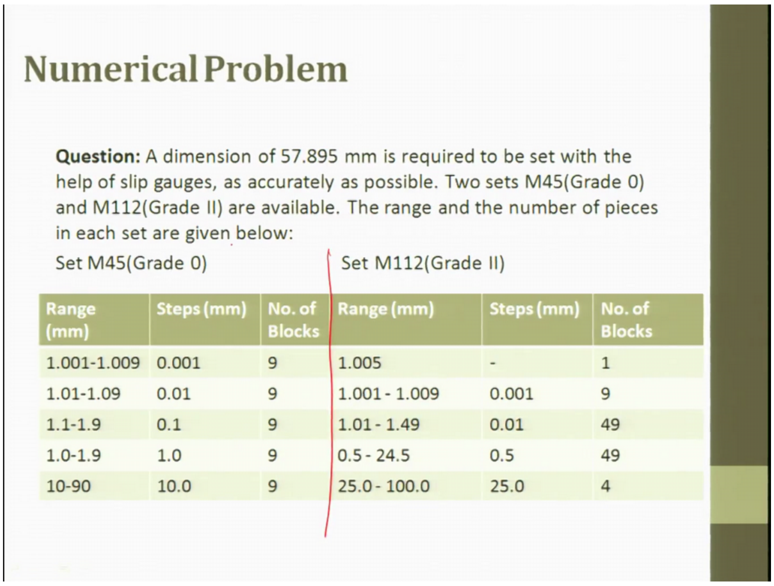

So, let us try one more sum a dimension of 57.895 millimeter is required to be a set with help of a slip gauge as accurately as possible. 2 sets of M 45 grade 0 and M 112 grade are available ok. The ranges are the ranges and the number of pieces in each set are given below. So, this is for grade 0 and this is for grade 2.

So, 2 sets are available. So, now, you have to build 57.895.

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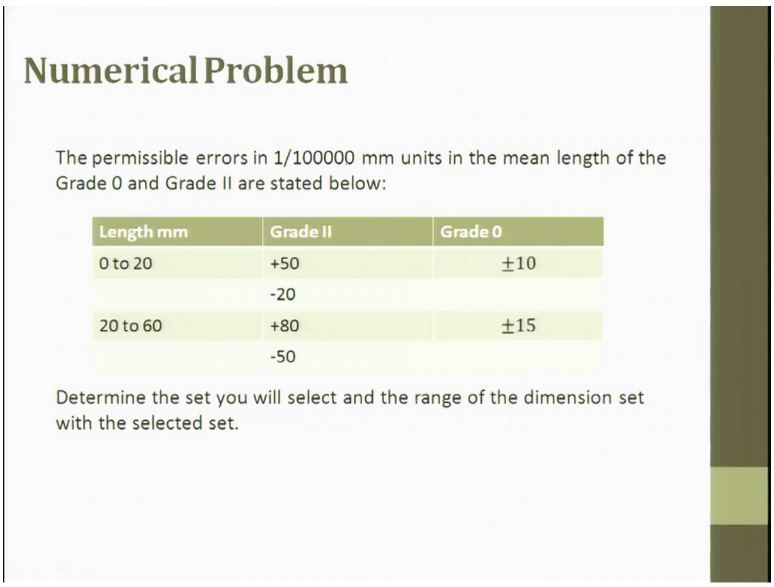

So, the permissible error is in one by this thing units in a mean length of grade 0 and grade 2 are stated, these are the grades these are the errors which are set. Determine the set you will select and the range of the dimension set with the selected set. So, here these are the lengths and here is the units which the permissible error which is given and a grade these are also given here.

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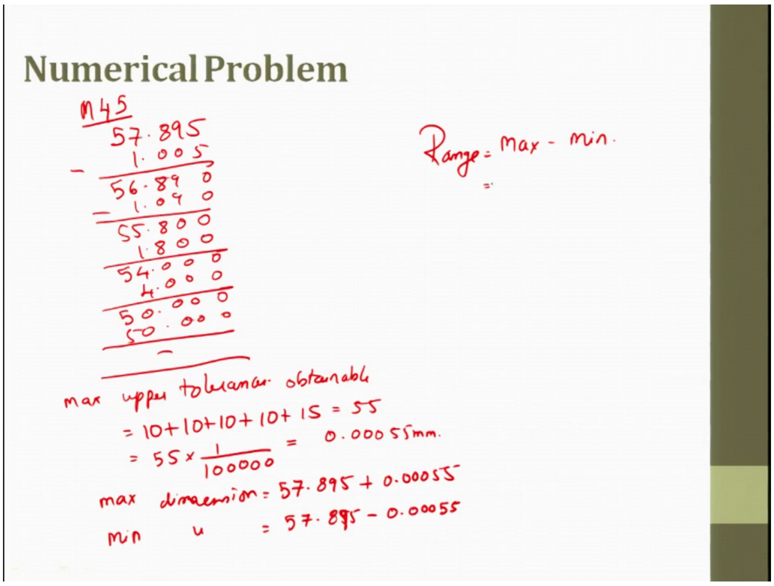

So, if we have to solve. So now M 45 so, it is 557.895. So, this can be first we take 005. So, it is 56.890 so, then it is same minus 1.09. So, it is 55.800 then it is 1.800 then it is 54 then it is 4 then it is 50 ok. So, what is the maximum permissible tolerance? Maximum upper tolerance obtainable is if you go by this.

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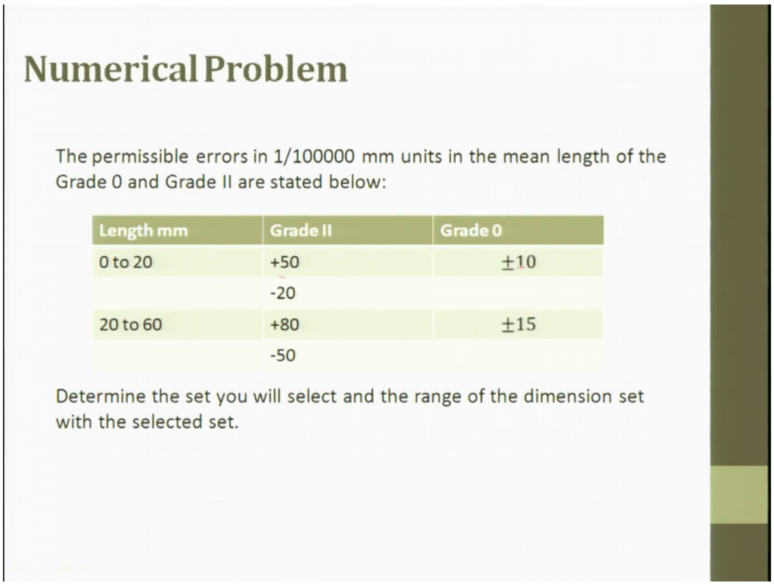

Obtainable tolerance is 10 and when it is falls between these 2 range 20 to 60 it is plus 15 ok. So, the maximum tolerance is 10 plus 10 plus 10 plus 10 plus 15 ok. So, now, it is this is equal to 55.

So, now what we have said is they said each division is 1 by 100000 so, which is nothing, but 0.00055 millimeter ok. So, the maximum dimension is going to be 57.895 plus 0.00055 and the minimum dimension is going to be 57.895 minus 0.00055 ok. So, there range what is a range we are talking about range is max minus min. So, this is nothing, but max minus min this is the range. So, using so, this is for M 45.

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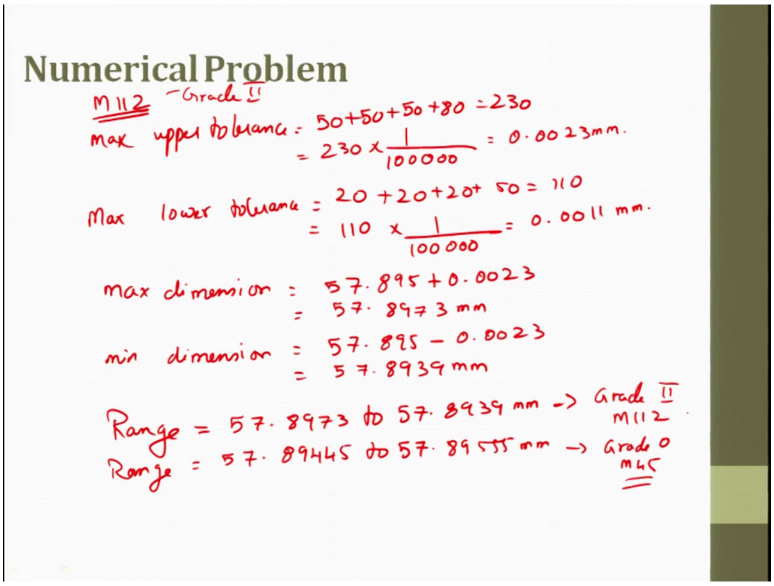

So in the same way for; M so, we have the other thong m 112 so, using the second set m 112. So, we have so, again in so, the problem will be the same which we have to solve. So, it will be 57 this will be same this will be same for both the sums so, same for M 45 as well as M 112. So, the maximum upper tolerance maximum upper tolerance will be 50 plus 50 plus 50 plus 80 which is 230 how does this 50 50 and all come? So, it is given here grade 2 the 50 50 is given for grade 2 grade 1 grade 2 grade 0 and grade 2. So, 50 50 80 has come from here this is for grade 2

So 230 so now the 230 we will multiply so, the upper tolerance. So, another is the 230 into 1 by 100000 which is 0.0023 millimeter. So, the maximum lower tolerance upper lower tolerance will be 20 plus 20 plus 20 plus 50 which is 110. So, that is 110 in to 100000 which is 0.0011 millimeter. So, the maximum dimensions in this grade M 112 will be 57.895 plus 0.0023 and which is nothing, but 578973 millimeter and the minimum dimension is going to be 57.895 minus 0.0023 which is nothing, but 57.8939 millimeter.

So, the range is going to be range is nothing, but max minus min. So, it is 57.8973 to 57.8939 millimeters ok. So, it is clear; what is clear, so, what is a range? So, you have 0.005 and then for if I want this is for grade 2 M 112 and the previous range will be range for the previous whatever you solve is 57.89445 to 57.89555 millimeter this is for grade this is for grade 0 M 45. So, now, you can say the answer so, it is clear M 45 should be selected for more accuracy as compared to grade 2 of M 112. So, like this you can expect problems in the examination

So, slip gauge is used for linear measurement this linear measurement line measurement is good, but end measurement using more accuracy. So, we are using slip gauges to build up the blocks to the required dimension and then try to find out the height measurement or the length measurement.

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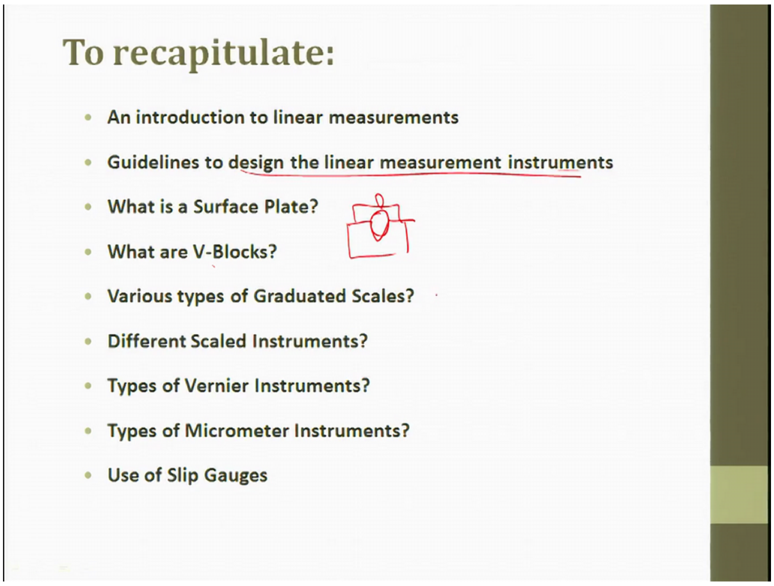

So, to recapitulate what are did we see in the linear measurement chapter first we saw the introduction, then we saw various guidelines. So, this is very important guidelines readability, reliability, repeatability, precision, accuracy all these things we saw then under coinciding the axes should coincide with the measured component then we saw about surface plate, we went for a V- block; V- block is something like this. So, we put a circular one and then you can try to measure the height. So, V- block then we saw various graduated scales and different scale instruments vernier caliper micrometer height gauge we and then finally, we saw use of slip gauges.

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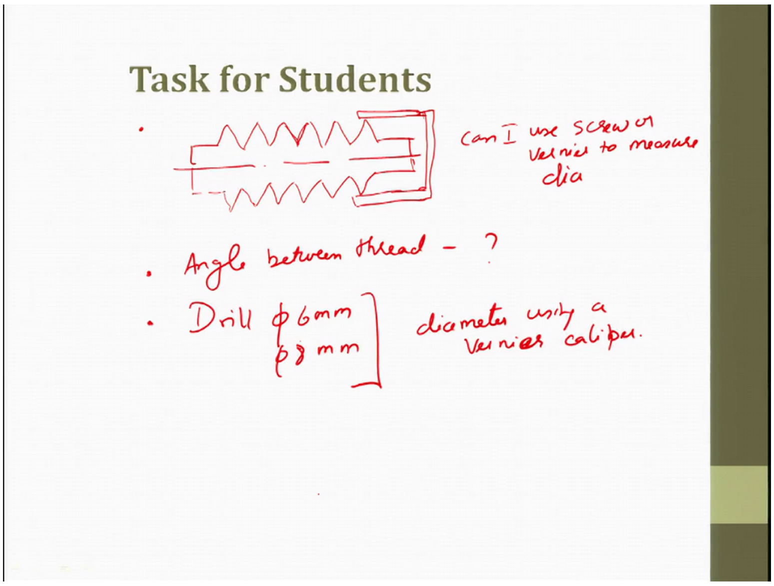

So, I would like to give a small assignment to our friends. So, let us try to take a screw ok. So, this screw we wanted to find out the dimension of a screw ok. So, you will have a counterpart also. Can I use a screw gauge or a vernier to measure diameter of the screw ok? So, this is point number 1; second thing is if I have to measure the angle say here is an angle right how do I measure this angle measure angle between threads how do I do it what should be the method? Then last one is try to take a drill of any dimension 6 millimeter 8 millimeter right any drill try to measure the diameter using a vernier caliper and see whether you get the results correct ok.

So, these 3 are assignments for you and moment you measure if you find out there is some inconsistency think what is the reason for inconsistency if you perfectly got it set with the book or the specification, which is given for that particular screw or for the drill what you have measured and what is given by them is matching.

Thank you very much.