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NPTEL ONLINE CERTIFICATION COURSE

Course
On
Spur and Helical gear Cutting

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Lecture 01: Introduction

Good morning viewers so today we are meeting for the first time for the course open online course of ten hours lectures on foreign medical gear cutting. So basically in this course we will be learning about a little bit of about gears and their uses to us in what way we are making use of gears, what sort of gears the we are going to leave with and some basic calculations about gears and after that we will be directly going into the topic of gear cutting. So when we are talking about gear cutting gear essentially referring to those methods in which extra material is removed from a blank and ultimately our finished gear is obtained.

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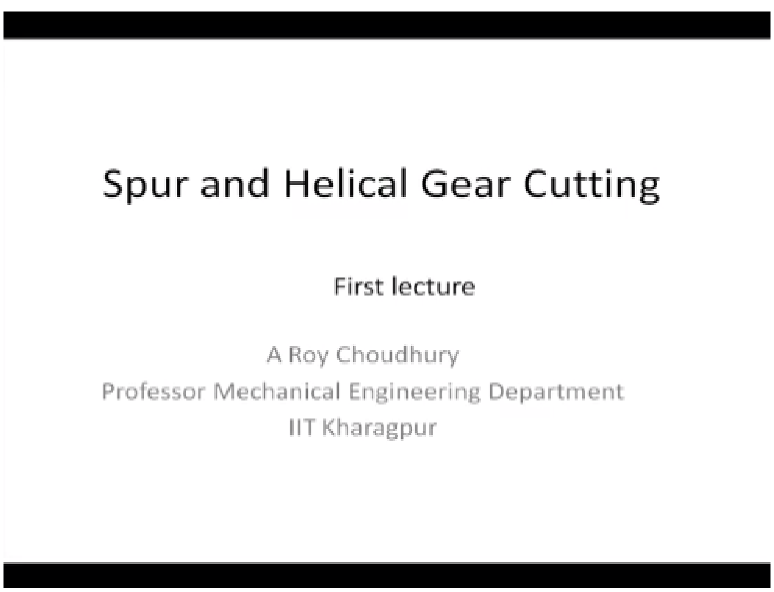

So first of all let us have a quick look what we are referring to as gears. So first lecture we start today on spur and helical gear cutting.

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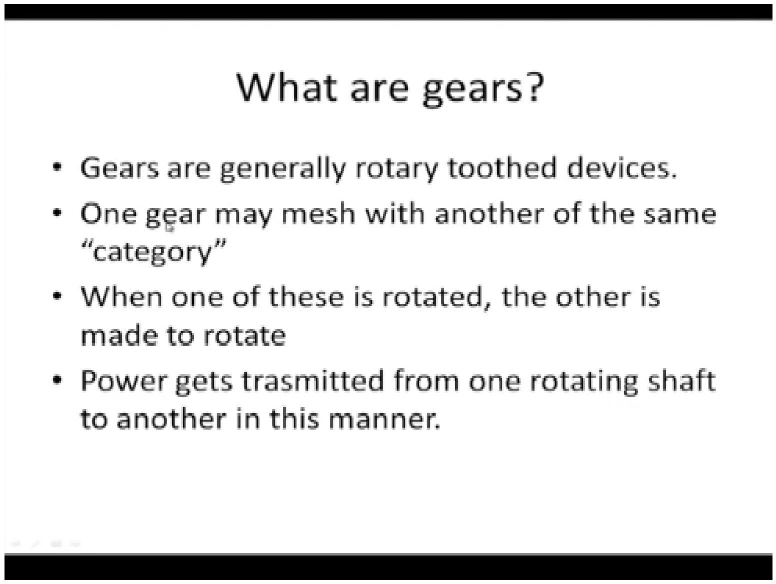

What are gears? Gears are generally you know rotary to fed devices. So they are you know in most in general cases they are rotating they have teeth on their periphery and one gear gently measures with another measures means gets connected intimately teeth too deep with another of the same category. So this word we are going to discuss later on in more detail. So for the time being let us been satisfied that, one gear of one gear may mesh with another one of the same category if we are not on the same category we cannot mesh.

And when one of these is rotated provided the other is free to rotate it will be rotating about its axis of rotation. And this way power can get transmitted from rub on rotating shaft to another okay. So let us quickly have a look at you know how we debit gears. When we are dealing with you know calculations and representation of gears, so first of all they might be having a circle, all around this circle in a gear we have teeth of this type. All around you will be seeing that I am drawing gear teeth which are all of the same size which means their height and their circumferential span.

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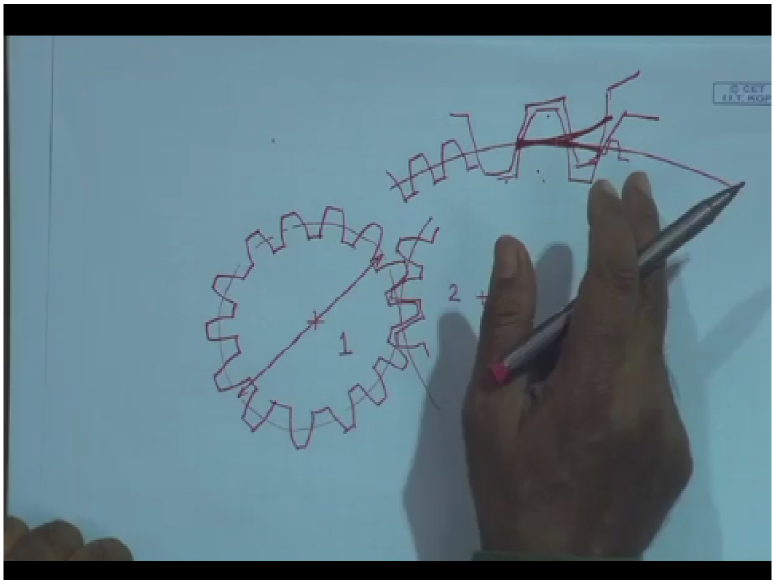

They are all the same for this here. So this way all around we have teeth. So up if the gear teeth are of the same size as we go on increasing the dimensions of a gear. That means if I increase this particular diameter this is referred to as a pitch diameter. If I increase this particular diameter I will be getting proportionately higher number of teeth now you might say that is that really necessary. That is if I have a large diameter of course I cannot draw it fully here does it mean that proportionately for if it has to mesh with this one it has to have more number of teeth yes essentially so. Then you might say that if it does not have to mesh with this one.

Does it have to have this sort of teeth no, not necessarily? It can have teeth of this type it can have teeth of this type etc., different sizes of teeth they are completely possible for you know whatever diameter you are choosing this of course some limits on the least diameter etcetera., that you can add up for a particular category of deity but on the whole if you have chosen a diameter which allows for these teeth all of them are possible.

And therefore they will result in different numbers of teeth for a particular diameter. So in that case, is there any basic relationship that we can establish for gears with which mesh with each other. So let us take a very simple example, suppose there is another gear which is meshing with this one and so let us draw these teeth and immediately we get to understand. You know as the teeth of gear one have to be accommodated by the accommodated by the toothed spaces of gear two.

Therefore, this particular circumferential distance something like this the span circumferential span of this tooth has to be accommodated by the tooth space of the corresponding gear with which it is machine. So this one has to accommodate this one likewise this one will have to be accommodated by that one. And immediately we come to a particular condition that the circumferential span of a gear tooth and it is corresponding tooth space they have to be the same for meshing gears. Basically this Plus this has to be equal to that Plus that okay. Once we have established that we come to a basic relationship between meshing gears. Let us have a quick look at that.

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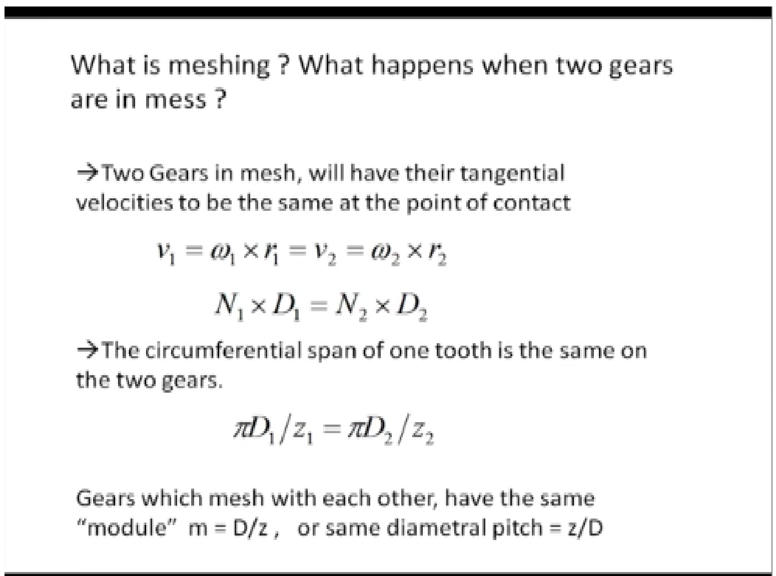

This one okay I come to these things later one everything we will be covering but first of all we have Pi D_1 which basically means the circumference. Okay what is D_1? D $_1$ is referred to as the pitch diameter of the gear pitch diameter is not the outer diameter now neither is it the root diameter but it is something in between and it has a classical definition which will come across later on. For the time being just kindly accept that.

It is somewhere in between the outer and the root diameter of the gear teeth. So pitch diameter divided by number of teeth so $Z_1$is defined as the number of teeth on gear number one must be equal to. So this is the span of the tooth circumferential span of teeth on the gear one. This is equal to circumferential span of teeth okay. One tooth on gear numbeR_2, so circumferential spans of one tooth on gear number 1 and gear number 2 they are the same if they have to mesh.

And this particular equality it is made use of to define a family of gears which have this value to be the same. And we can say that they can mesh with each other. And why keep the PI which is appearing in this equation as if it is on both sides so let's cancel it out and we have D_1 by Z_1 equal to D_2 by $Z_2$is equal to D by Z ,where D is the pitch diameter in millimeters and that is the number of teeth.

And this one if you read the last line it is mentioned that this one is called the module okay. So we say that gears which have the same module okay gears you can say your teeth which have the same module or gears which have the same module. D will mesh with each other and they form a family. So the category that we were dealing and talking about in the beginning that actually boils down to this module but mind you since it is dependent upon the type of unit you are choosing, because T is the pitch diameter in millimeters weal so have similar you know similar parameters which are defined in other systems of unit sand in a slightly different form like diametral pitch.

Diameter which is equal to Z by D basically it means the same thing Z by D less that is the number of teeth hand D is in D is the pitch diameter in inches. So first of all we establish gears which mesh with each other have same module in the metric system. And they have the same diametralpitch in the inch system. And they would be able to mesh with each other. Once this is established we can build on that further.

So let us look at the first equation that we have written down. What is meshing? Now we understand what is machine. Yes, gears which are getting interconnected so that one tooth gets into the tooth space of the corresponding are the pairing here. What happens when two gears are in mesh sorry not in this so base so what happens when two gears are in mesh this equality that the second equality can be you know said to have been satisfied.

So when two gears are in mesh we have said we have stated in the first statement that the tangential velocities have to be the same at the point of contact. Let us have a quick look at that. So if you look at this particular figure where we are basically representing the gears by circles. So this is a sort of simplification of the figures.

We are saying that if this gear is moving this way it will make the other gear move this way if it is free to rotate about its locational axis. And therefore, we say that since at this point gear number 1 is in contact with gear number 2 okay. These two are the teeth which are in contact so at this point this one and this one. They are moving together. This is not you know pushing into this.

This is not pushing into this neither is this one losing contact with this one so as they are in contact and moving with each other. The tangential velocities which they have by virtue of their rotation respective rotations. That tangential velocity must be equal. So if this tangential velocity is equal mind you here I should point out one thing that this point of contact that we have drawn here in a simplified form to be on the pitch circle.

It is not always so but for all practical purposes were for the gear cutting that we are going to deal with this sort of simplification is you know quite acceptable. If you have questions we can definitely address them later on. So if they have a common tangential velocity we can establish that if this is gear number one if this is gear number two definitely v_1 is equal to v_2. These two tangential velocities and what is $v_1$after all it is equal to you know angular velocity Omega 1 into the radius R1 so this one must be equal to Omega $_2$into R2.

That is very good but we already know that Omega is equal to 2 pi N by 60 where n is the RPM okay Rotations per Minute. So if that be so we can simply replace Omega 1 can salute to pie and 60 and we can get N_1R_1 is equal to $N_2 R_2$. So this means that N1 N2 pitch radius is equal to sorry, N_1 into pitch radius of gear 1 is equal to N_2 into pitch radius of gear 2.

What does that ultimately provide us with it gives us a relation between rotational speeds rotational rates of the two gears. You know with their respective radii but in case of gears we generally use terms like number of keep module okay terms like these generally not pitch radius or something like that. So can we relate the pitch radius that means R_1 and R_2 with other terms that we are more interested to use.

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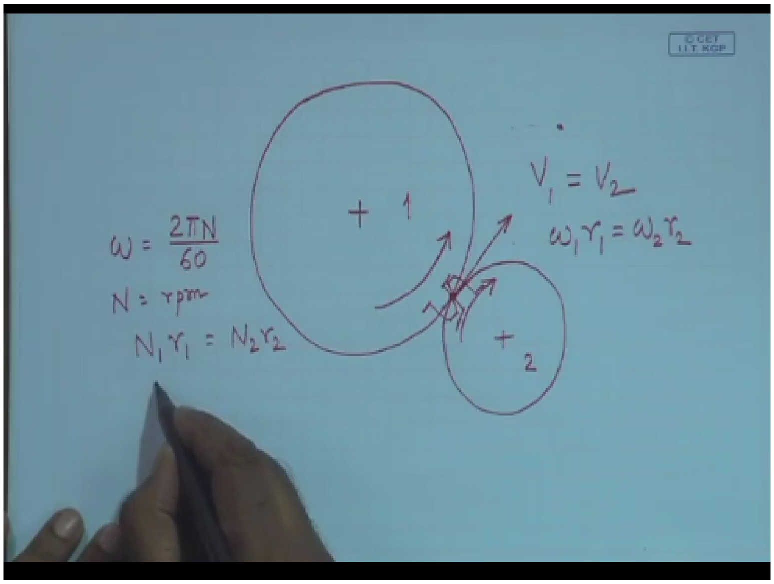

So let us have a look at that we have already established that D by Z is equal to module 4 gears which are measuring with each other. That means we can write D_1 by Z_1 is equal to D_2 by Z_2 diameter of the gear 1 divided by number of teeth of gear 1 is equal to diameter of gear 2 divided by number of teeth of gear 2 which essentially means we can also simply write R_1 by Z_1 is equal to R_2 by Z_2 which means R and that they are proportional R is equal to K into Z.

Once we have established this. We notice that here R_1 by R_2 can be placed by Z_1 by Z_2 all right. R_1 by R_2 is equal to Z 1 by Z_2 so R_1 byR_2 is equal to Z_1 by Z_2. So we finally write this one N_1Z_1 is equal to N_2 by Z_2 so that if someone asks you what's the ratio of the rotations of these two gears you can simply say it's equal to N_2 by N_1 output by input okay. Throughout these lectures we will be referring to gear ratio speed ratio Excel terms like that as output rpm by input rpm.

In many literatures you will find that it's just the opposite but to maintain you know one single definition of this particular speed ratio. We will simply take it as output rpm by input our team so N_2 by N_1 is equal to gear ratio or speed ratio equal to Z_2 by Z_1. And hence we establish the first law of you knows the first law which will be helping us to calculate speed ratios okay N_2 by N_1 is equal to sorry and extremely sorry N_2 by N_1 is equal to Z_1 by Z_2 N_2 by N_1 is equal to Z_1 by Z_2.

Please correct this so once we have established that. If we have a look at this these we have now we are we we can confidently say yes, we understand this. This comes from the constancy or equality of the tangential velocities at the point of contact and this is coming from equality of circumferential spans of the gear teeth on gear one gun one and gear two. So from these we have N_1that 1 is equal to N_2 z $_2$ so.

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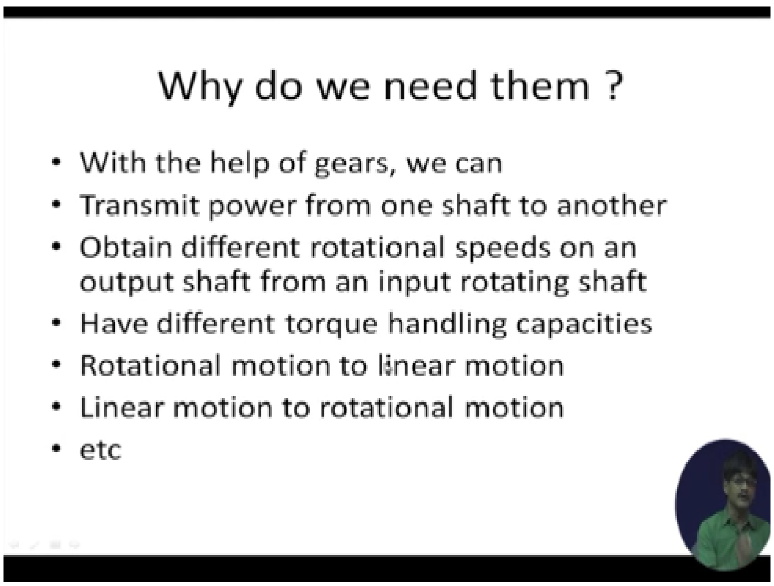

Let us first of all so before going into further calculations for the calculations are required let's finish up the introduction to gears that is okay. We understand now we have a rough idea of what our gear and how they operate etcetera etcetera. But let us in the introduction let us also established why do we need them why do we need gears? So for that we can identify with the help of gears we can transmit all from one shaft to another.

So that means if there is a question of you know some space existing between the source of power and the point of application of ultimate point of application of power. And if there is a gap you can transmit the power with the help of gears from this shaft to that’s haft and maybe there will be intermediate shafts also. Second we can obtain different rotational speeds on an output shaft from an input rotating haft.

So if there are two shafts and suppose you have thousand rpm on the input shaft. And someone asks you get input power get the input power to drive the output shaft at 500 rpm mind you from thousand rpm in on the input shaft, you have to have 500 rpm on the output shaft. So if you use gears in that is it is possible to drive the output shaft and this particular rpm. So in addition to transmission of power from one shaft to another you can also dictate the rotational speed of the output shaft.

Provided the input shaft is having a definite rpm. Have different torque and handling capacities. So on a particular shaft; you can have different torque handling capacities. That mean if the output required output torque varies okay. You can make use of gears or gearboxes to handle that torque that means that if the torque becomes very high. So that you find initially that you cannot rotate that shaft; you can have an intermediate gearbox which will allow you to to you know overcome that output required output torque.

And make the shaft rotate second I next rotational motion to linear motion. Let me give you an example, by drawing a figure okay I have rotational motion here and I have put a veer here this is rotating about this axis of rotation and I have teeth on this. So I have already put a gear on top of this rotating shaft and someone asks me to have linear motion like this. How can I do that? So for that one particular example is that I can have something called a rack a straight-sided gear.

You heard of the term rack and pinion. So we are basically discussing that particular machine element pair. The pinion is the circular gear. Pinion means a small gear in pair with a larger gear. So it can also be rack and pinion so this one we are calling the rack and this one we are calling the pinion. So if this rotates this will move towards this side alright. So with the help of this mechanism which is basically a gear pair we can have rotational motion getting converted to straight-line motion.

So naturally if you are able to convert straight-line motion actually rotational motion to straight-line motion you can also convert straight-line motion to rotational motion. This is also possible, so coming back to our discussion we we can easily identify these uses of gears and many more we have not mentioned so many other functions of gears that we might be having but these are you know quite simple examples very generic to make us realize that. Yes gears are very much essential.

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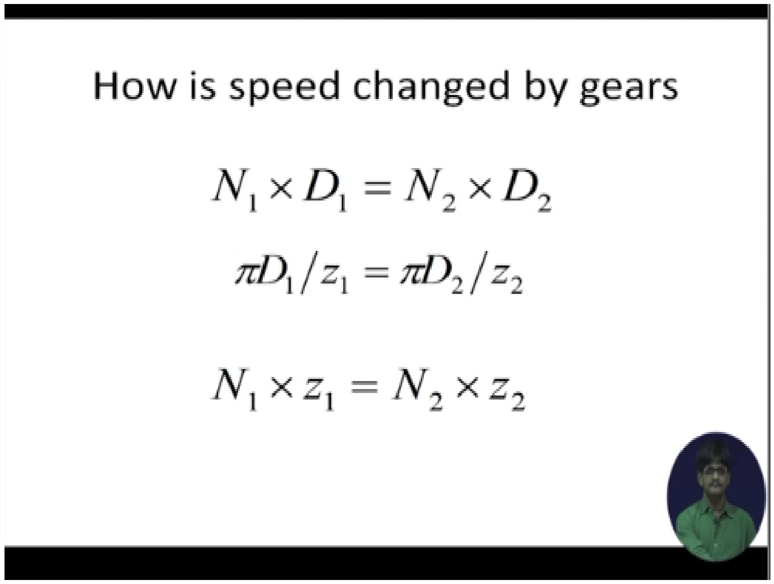

Archer this one we have already established. So let us have a quick look at some numerical problems. It will be very interesting to discuss one or two numerical problems. For example, say I have problem that we were dealing with this gear is rotating this shaft is rotating at say. Let us call it one N_1 is equal two thousand rpm and here we have another gear which is rotating at okay.

This is N_2 I don't know what N_2 is but I have been told that this has just a moment just a moment this has 100 teeth. This is 100 teeth and says this one has 50 teeth. So what is given and one is given Z_1 is given so this is Z 1 N 2 is not given and Z_2 is given. So find out N_2 so we can say the answer is N_2 by N_1being equal to Z_1 by Z_2 $N_2$is N_1into Z_1 by Z_2 equal to N_1 is thousand z_1 is 100 and Z_2 is 50 so we have a 2here therefore n 2 is equal to 2,000 rpm okay.

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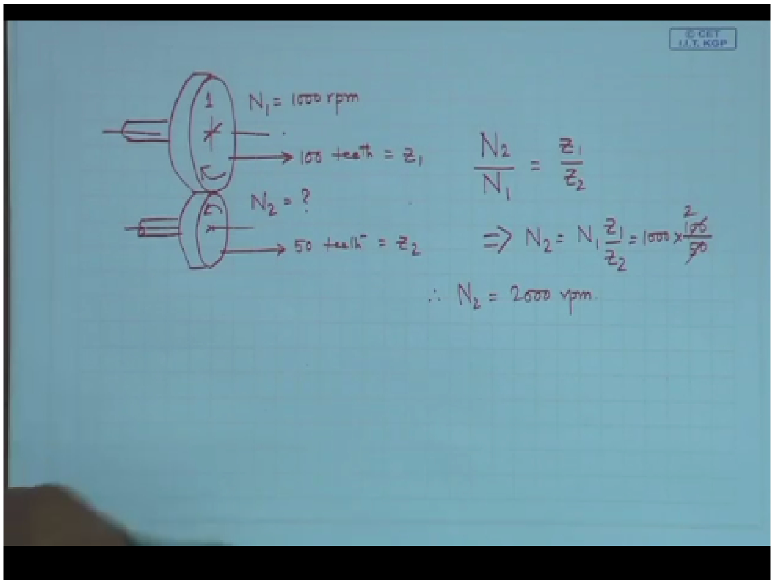

So this is quite simple to understand. If I have to give like this if I am given three values in that case I can easily solve for the last value of therefore let's have another example, sorry that is it this looks quite impressive one two three four five six seven and suppose this is the data that I am providing you. N_1 is equal to once again a thousand rpm Z_1 equal to say how many sixty-three that means the number offset on here one is sixty-three.

Z_2 is equal to 150, Z_3 is equal to 47 Z_4 equal to 50 Z_5 equal to Z $_5$ 100 Z $_6$ equal to 50 and well 7 equal to 133 find out n 7find out N_7. Now first of all we should look at the problem this way. That what are we supposed to find out this rotational speed so this rotational speed we are given N1 so this one rotates this rotates that okay rotates this rotates this etc. n_7 has to be found out so first of all what we should establish is this N_1equal to N_2. First these two rotation speeds are the same and whatever the number of teeth on one it's absolutely you know not relevant to this problem.

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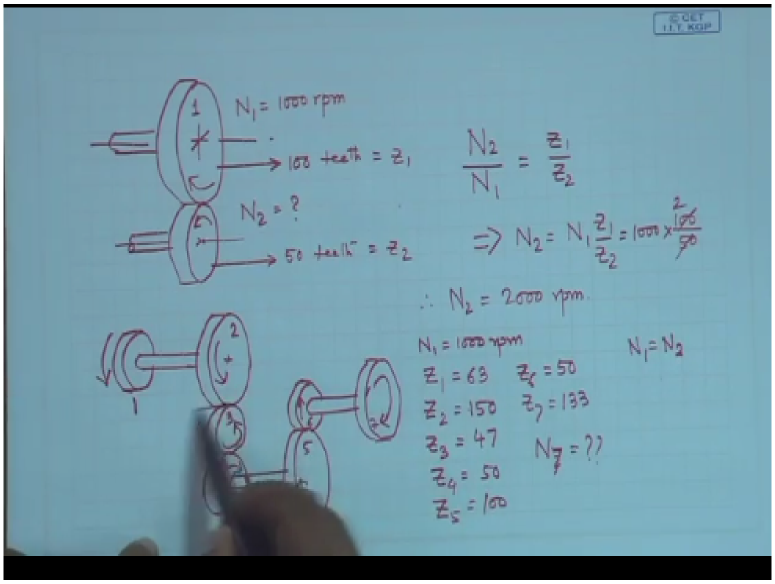

It can have any number of T so N_1 is equal to N_2 that one is not required. Next we understand that the rotational speed sorry the tangential velocity at the periphery and at the pitch circle of two. This velocity must be equal to so sorry, I I think I made a mistake here this rotates this way though this rotates this way I am sorry, so this velocity let us draw it properly this velocity and this velocity the other thing this velocity and this velocity they are the same and therefore we can totally drop this one from calculations that into a fine line to understand.

This is not required it's called I do gear what's its purpose it does have a purpose. It does not affect the rotational speed ratio but it will be affecting the direction of rotation. So if it is rotating this way this also will be rotating this way. Please understand that the rotational direction that I gave previously was wrong so this is this way this is this way and this is therefore this is rotating this way okay so since this velocity and this velocity are the same we can establish the same relation between these two.

So first of all we can write that n 2 Z_2 is equal to is 3 is 4 n 4 red 4. Next we again find out that this is since this is a rigid body with same rotational speed also so n 4 is equal to n 5 and 4 equal to n $_5$. Next if n 5 and n6 I mean if gear number 5 and gear number 6. They are connected like this we again establish n 5 and Z_5 is equal to n $_6$Z $_6$. And naturally n 6 is equal to n 7 that's it. With this sort of relational ship conditions we can find out by solving these equations.

Now is it really you know painstaking you you have to go through this one once your experience with this and once you find out that the angles a number of teeth that I have given they are very simple values you can quickly calculate as well okay. Thousand rpm you say thousand rpm okay thousand rpm thousand rpm what's the number of teeth ratio like in Z_2 and then for Z_2 and Z_4. So the number of feed is becoming triple.

So the speed must be becoming triple so thousand rpm 3000 rpm 3000 rpm 3000 rpm z_5. Z_5 is hundred and that six is 50 so again it becomes double six thousand rpm. So answer is 6,000 rpm 6000 rpm so we this we come to the end of our first lecture thank you very much.