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Course
On
Spur and Helical gear Cutting

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Lecture 04: Helical Gear Problems

Welcome viewers to the 4th lecture of the series per and helical gear cutting.

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In the last lecture we have discussed about some of the geometrical aspects of spur gears and today we will be continuing with that, and also discussing something about helical gears, so in case of helical gears let us have a quick.

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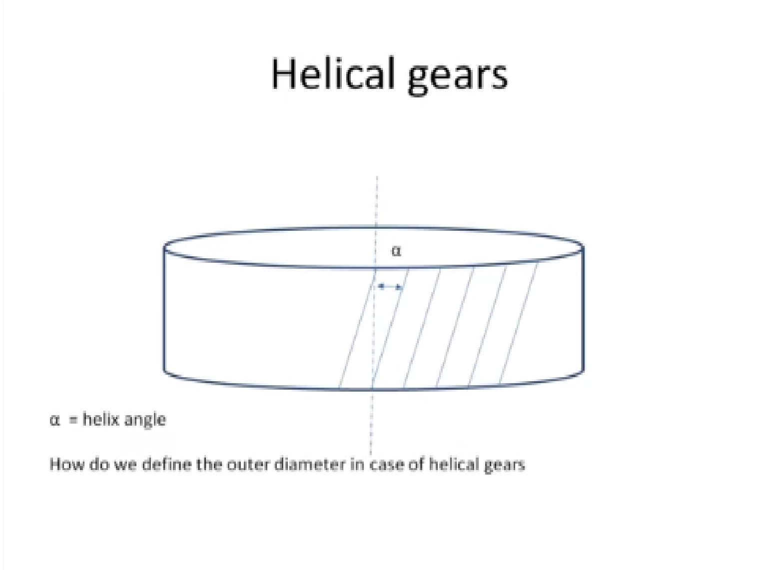

Look at the depiction the teeth are you know slightly inclined with respect to the central axis, so we have drawn the central axis as you know dot and dash line and the teeth are inclined at an angle α which we are calling as a helix angle. Now you will notice that when we are depicting the helix angle of screw threads and the helix angle of gears helical gears they are complimentary okay, so let it please be noted that this is the helix angle of helical gears, let me draw a figure and show you.

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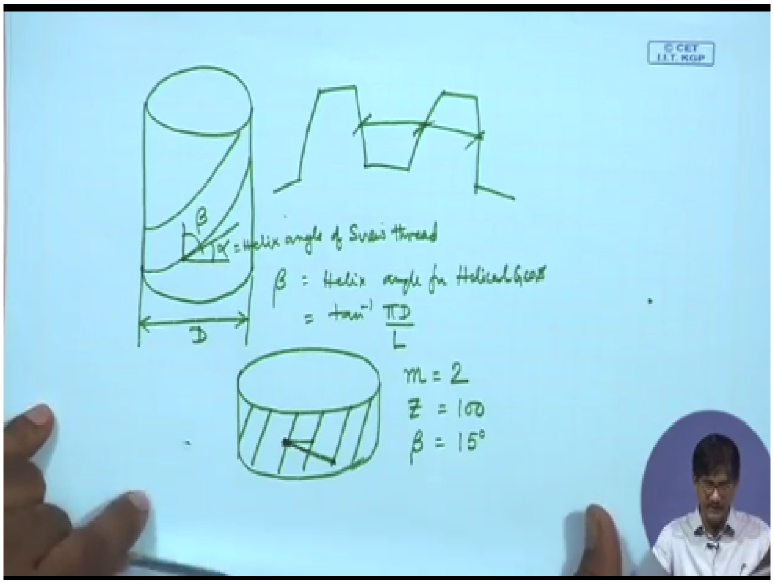

Suppose these are helix is on a screw thread in that case we will Express the helix angle as this one, you and naturally if is this if it is rising up by P okay, in that case if it is a single vertical a single start thread it will be $\alpha = \tan$ inverse of $P / \pi d$ and therefore if we take the other angle for helical gears α = 10 inverse $\pi d / P$ this diameter we are taking as D this one is P for multiple start threads P will get replaced by L lead okay, and therefore β helix angle for helical gears and this is tan inverse of πD by L okay. So coming back to our picture how is the helix angle I saw a helical gear different from the spur gear of the same specifications.

Let us take such a case say this is one helical gear it is having teeth this way, first question is what is m say m = once again say 2 what is and if you remember m defines the distance between teeth as it as we, we have seen previously this one distance this one distance is defined by m and this is equal to nothing but this whole distance is nothing but $\pi \times m$, so here also we will have the same idea. So mind you here this distance we have to define this way perpendicular to these particular gear teeth orientations.

This way this distance is defined by m, therefore this distance is larger than this particular distance which we have to note, Z = say one second 100 and say this particular helix angle that we are talking about, say helix angle is equal to β is equal to 15^0. So in that case our first question which comes with that is the outer diameter different is the pitch diameter different for that I will leave the questions to you with a hint the hint is this, suppose I take a stack of books.

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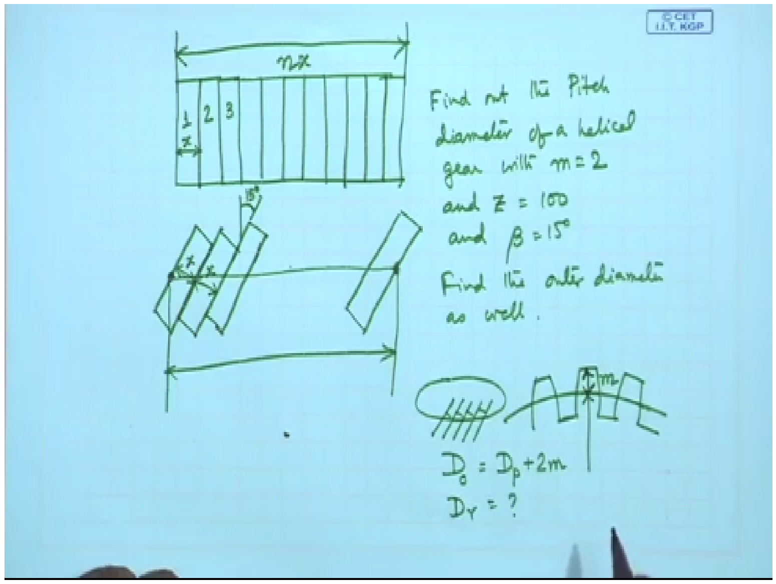

Suppose I take a stack of books some encyclopedias and I keep it in a shelf, book1, book2 book3 like that and say I filled up a particular stack this way all these books are volumes of a particular encyclopedia and they have the same width, now someone comes and disturbs this stack so that they get displaced and they are shifted what is same between these books this distance naturally remains the same say, say this is equal to x this is also equal to x what is the angle at which it has been disturbed say this angle once again.

If you remember this is the angle which is referred to in case of years 15^0 so the angle by which it has been inclined is 15^0 and x remains the same, can you find out whether from this middle point to the middle point of the last book whether the Shelf will be able to accommodate it or a larger shelf would be required middle point to middle point, once you find out the difference in this particular distance. If there are n number of books here the distance is equal to nx will this be equal to nx once again, obviously not this is x.

So it will be slightly more than x is slightly more than x and that multiplied by n will be definitely higher, the moment to find out this increase you have found out the difference in the diameters of helical gears and spur gears mind you, we are talking about pitch diameter up till now pitch diameter. So let me write down this is your assignment which we will be solving formally in later lectures, but you can have a quick look yourself find out the pitch diameter of a helical gear with m = 2 and z = I do not remember the previous one 100 and β = 15^0. Now comes the interesting part, so this is the problem that you are going to solve.

And the idea that you are going to get it is embedded here I am sure you can do it, next one is that find the outer diameter as well, now here there is a particular catch is this one going to affect any increase in distance perpendicular to the plane of the paper mind you all this is you know wrapped around a particular diameter that means we are talking about I am accommodating a certain number of teeth on a circle, I am accumulating the same number of feed but inclined where the you know normal distance between these teeth they are supposed to remain the same this is sometimes called as you know referring a referent to system normal module seem normal module.

So if this distance is supposed to remain the same we will have to accommodate these in a larger diameter, the diameter of the helical gear with the same number of teeth but the helix angle has to be higher, but this we are coming up to the pitch diameter will the outer diameter be found out just by adding one module here and one module there remember the addendum is equal to module we have moved up to the pitch diameter by this calculation. What about this part this part should be equal to module why should this part change this is in a direction perpendicular to this particular dimension.

Which has got affected if this dimensional got affected why should it affect a distance perpendicular to it, so outer diameter or outside diameters should be equal to still pitch diameter plus two module this is what we arrive at, so please find out outer diameter this way find out the pitch diameter find out the root diameter also and then we will compare our answers in the next lecture, so with this one let us take up a few problems which will introduce you to use of gear boxes etc. When we are actually discussing cutting problems.

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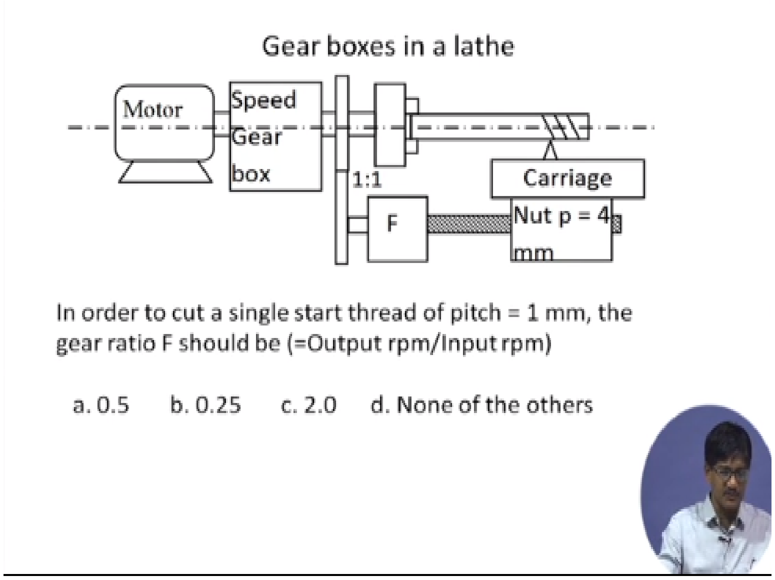

Have a look at this the actual use of gearboxes and machine tools first of all why are we studying this, we are not supposed to you know become master of gearbox calculations no but this would be required because we will be extensively using gearboxes and gearbox ratios their calculations etc. In our you know sub sequent lectures that is why one or two examples will really help what is this is the depiction of a ordinary centre lathe, there is a motor and from there we are leading on to a speed gearbox okay.

It changes the speed of the spindle so the spindle is rotating you can change the rate of rotation of the spindle by the by changing the settings of the speed gearbox and after that a tapping has been taken that means power has been taken from the main spindle by a one is to one speed ratio to our box called F, this is the feed gear box okay, so we become conversant with the idea that there are two gear boxes on the lathe and one is called the speed gear box it changes the speed of the spindle and one is called the feed gear box which changes the speed of say the feed rod.

Or the lead screw whichever might be the case, so in this case we are showing the B screw and it is connected to the half nut of pitch four millimeters, and that is connected to the carriage and it is cutting a thread the question is in order to cut a single thread single start thread of which one millimeter the gear ratio F should be give ratio F is equal to output RP by its input our name equal to 0.5 0.25 0.2 and 2 and none of the others, first of all we have taken up this question from two aspects, one is to understand the look at where the positioning of gearboxes and to understand the way its gear ratio is to be calculated please look at this drawing which I am going to do on the piece of paper.

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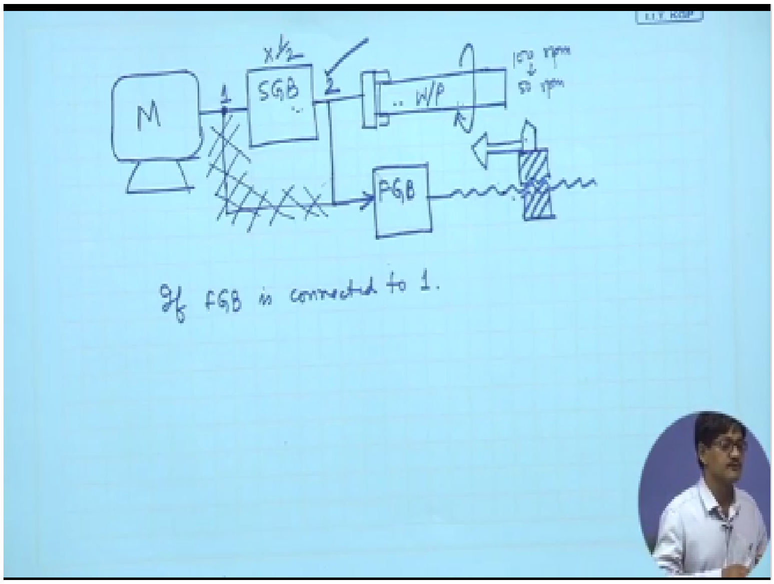

And try to answer these questions, if I have a motor and then I am claiming that yes I have a speed gearbox here from which I am you know starting the I mean rotating the work piece okay. Now you will find that in the figure we have taken a tapping from here and then I am putting average everyday works called feed gear box and then I am rotating something on that I have put a nut and moving it, now first of all I could have connected it up here let us put let us call this point 1 and let us call this point 2 you think this would have been better so let us have a look how is location of a gearbox decided on a machine tool, if I had connected it here in that case so suppose I do not connect it, so if we can write if FGB that means feed gearbox is connected to 1, then what would have happened actually it is coming to that 2 if it is connected at 1.

In that case whatever changes you make in the speed gearbox would not be registered okay, by the feed gear box. So suppose you make the speed of this one ½, 1/2 of what was previously existing so this slows down say from 100 rpm it comes down to 50 rpm, what happens to this one this rotates undeterred it is not affected by any changes because it has steering taken the tapping of power upstream of speed gearbox.

So even though speed gearboxes you know slowed down by half of its previous value this one is undeterred and rotates at whatever speed it was rotating previously and this moves at the same speed. And hence the relationship of movement gets disturbed and you will be cutting a different thread, because thread is defined by movement of this one per rotation of the work piece, work piece is moving slower now and you will cut a smaller pitch thread half the pitch will be cut now so it is a problem.

If you connect it here and if you are changing doing something with to the speed gearbox be very alert because your which you are cutting it will be changed you will say I am simply changing the speed because I want to want to cut faster no sir, if you make any changes here and you are having the tapping of the speed gearbox here you are in trouble. So by logic it has to be here because whatever changes you are making here should be shared by this line also.

Otherwise their relationship will be you know disturbed wherever you are doing something important as I were doing something where relationship relational motion is important you really cannot do this, so that is why you have to be very alert whenever you are doing something, what are you doing here you are cutting a thread how is thread pitch defined, so if it is defined by the linear motion of this one per rotation of this here is that relation that we are talking about.

So first thing we notice about location of gearboxes is this whenever you are relating some motions all these have the bifurcation of power after the gearbox which is defining the motion of the first one, so that is why we have taken the power tapping here, change the speed now this will become faster or slower this will also become correspondingly faster or slower proportionally faster or slower. So there will be no change in the relational movement which was taking place which defines pitch. So having understood the reason for putting a gearbox at a particular location we now go for the calculations, coming back to this figure let us have a look at it.

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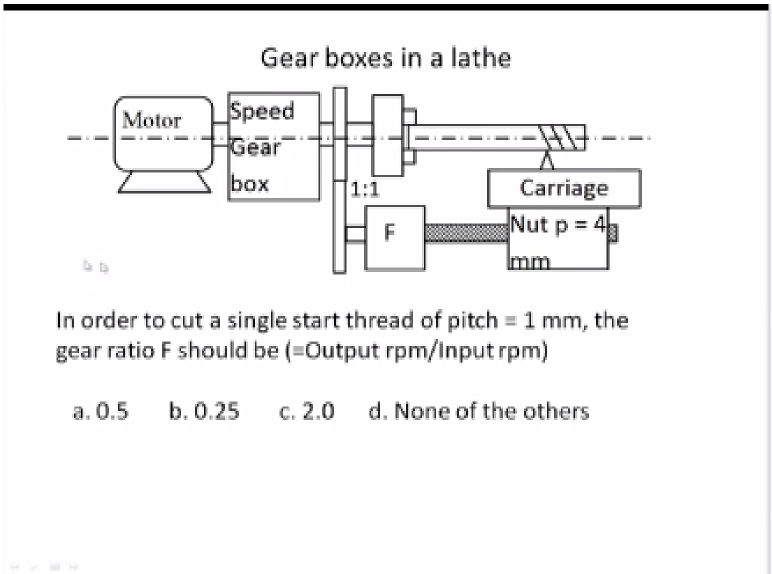

In order to cut a single start thread of pitch 1mm so by the time the spindle rotates once the carriage should be moving by one mm okay, the gear ratio F should be that is output rpm by input rpm equal to these, these, these extra, so let us have a look the nut is having four millimeters pitch, here there is 1:1 ratio so by the time the spindle rotates once this particular shaft will also rotate once.

So by the time by once it passes through F if this ratio of output rpm by input rpm be say F only so this will be 1xF as the output, 1 into F is the output, so 1xF is the rotational rate of this link screw and therefore if pitch is 4 millimeters the movement of the carriage will be 1xFx4 because one rotation four millimeters, F notations 1x F rotations, 1xFx4 millimeters of movement so we have if you come to this page.

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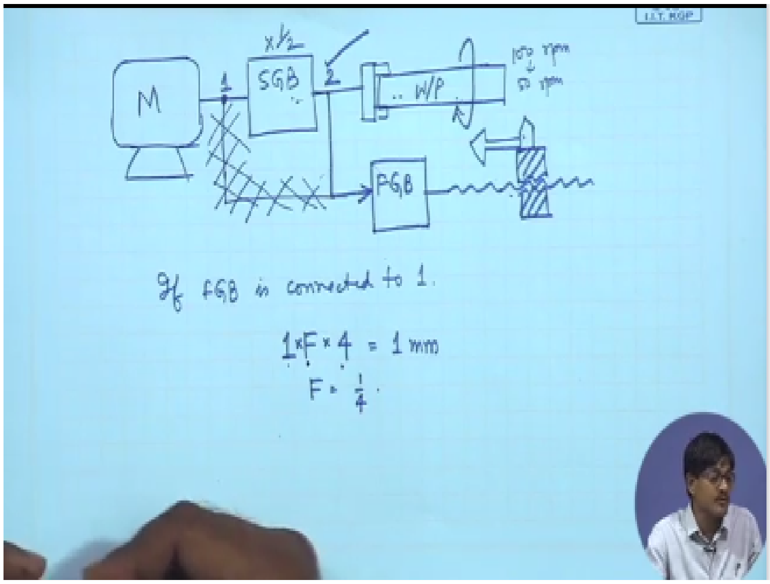

1xFx4 must be equal to 1 mm because we have started with a consideration that I am rotating that is why I have written this one every time I am rotating the spindle by one rotation 1:1 ratio makes the shaft just before the feed gear box rotate by one rotation multiplied by F which is the factor output by input rpm of the feed gear box and multiplied by 4 because 4 is the you know pitch of the nut thread this was equal to 1 mm that is the requirement. So F is nothing but $1/4^{th}$ okay, F is nothing but 1/4 let us look at the problem now.

Yes, b is the correct answer okay, so we have we will have lots of you know applications of this particular thing in our subsequent lectures that we actually discuss machining on gears this is just for practice.

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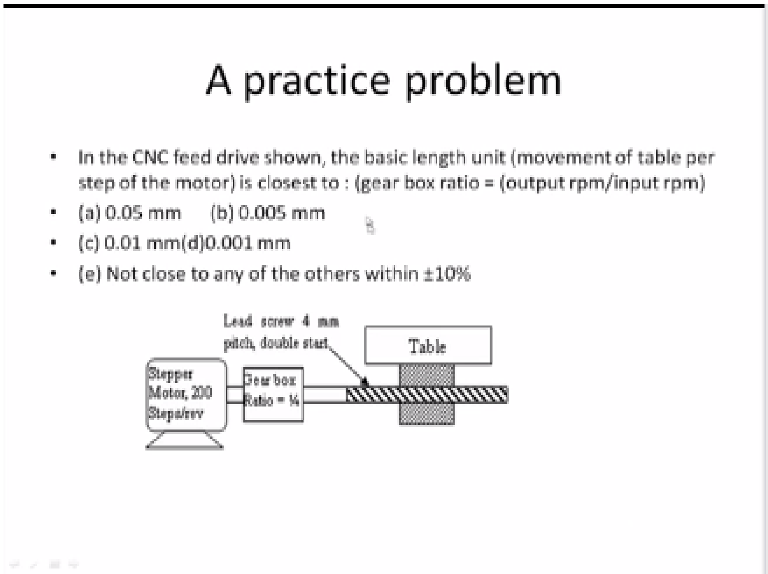

Another one slightly different configuration but this will also help you to understand the application of gearboxes later on. In the CNC feed drive shown the basic length unit that is the movement of the table per step of the motor so what do we have we have a CNC system in which there is a stepper motor which rotates in steps to cover one rotation in 200 steps.

So one rotation is 360° and 200 steps are making them that one rotation therefore first step it is moving by 1.8° so for that 1.8° movement we are asking what is the table movement, so what is given. If you notice stepper motor 200 steps per revolution is given, basic length unit is defined and given here movement of table per step of the motor.

200 steps making up 360° of movement and here box ratio which is always output rpm by input rpm that is also given $1/4^{th}$ lead screw pitch is given four millimeters, double start mind you double start we have been discussing about double start, single start, multiple start so here is an actual application little so let us calculate this and find it out.

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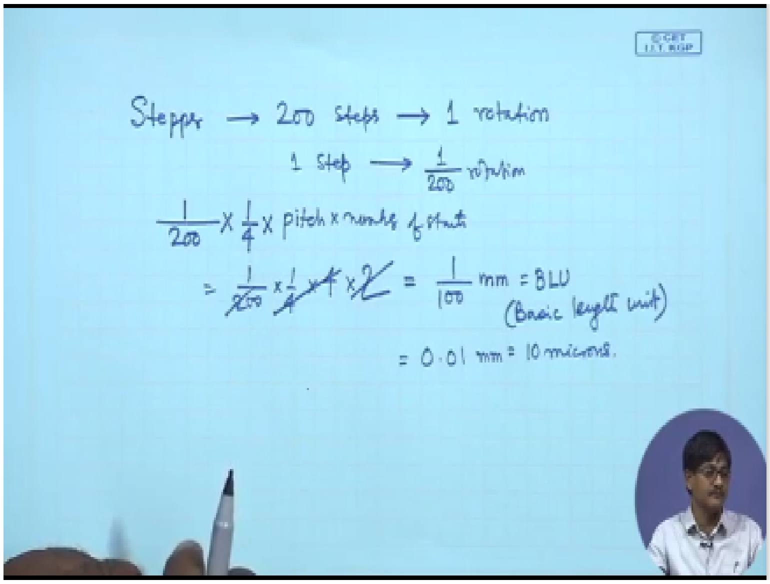

So we have stepper 200 steps one rotation, one step 1/200th of a rotation all right, therefore I start with 1/200th of a rotation multiply it by the gearbox ratio 1/4th multiply it with the lead screw lead, lead screw lead is pitch which is let me write down here pitch into number of starts equal to 1/200x1/4th into which is 4 mm and it is double start so multiplied by 2 equal to 1/100, 1/100 millimeters.

What is 1/100 millimeters the basic length unit that means the smallest distance or rather the distance moved per step of the stepper motor, okay. How much is this therefore this is equal to 0.01 mm= 10 microns okay, so this way we understand how the location of the gear box can be decided and how calculations can be done in order to find out the output which particular gear box is providing, okay if you have a look at you know, if you have a look at the typical problems that we are going to discuss.

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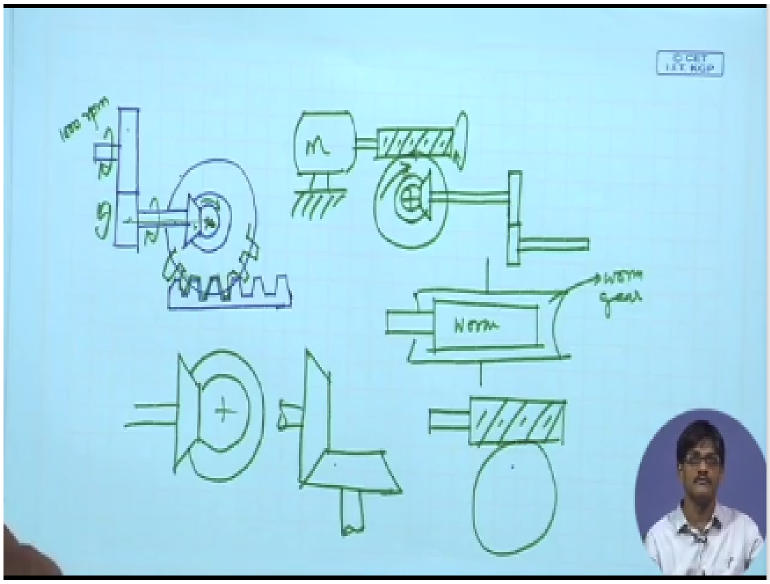

I will discuss a very short problem which you can solve your selves, so see here we are having a gear connected with another one with this, so let us see what sort of configuration that we are talking about, I might say that here I am providing you 1000 rpm okay, these are spur gears so they are rotating say this way this one is rotating that way, now this one I have just I wanted to introduce some typical figures these are two bevel gears which are connected with each other.

Bevel gears will transfer power from one axis to another axis which are generally intersecting and while transmitting power from one axis to another these might be intersecting at 90̊ degrees so that when this is rotating this way this is rotating say this way extra, and this one is having on the same shaft another gear which is in connection with a rack.

So I wanted to introduce these figures so that you are conversant with this sort of configurations there might be yet another one where I can have say a motors shaft is coming out I put a warm gear here with the warm gear I put a sorry, I put a warm here with a warm gear I put I get a configuration like this I can have bevel gears here, bevel gear this one is taken on this side, so this motor is rotating this warm gear so in this warm this warm is rotating this warm gear, this warm gear is rotating on its own shaft a bevel gear, this bevel gear is rotating this bevel gear, this one is rotating this shaft this year and together with that tag gear.

So as you can see bevel gears can be drawn this way okay, one bevel gear another bevel gear they can be drawn this way, one bevel another one warm and warm gears can be drawn this way, this is the warm, this is the warm gear they can also be drawn this way, this is the warm and this is the warm here okay, many times what happens is we include these drawings in a figure and ask a question and the student in the very beginning is that a loss to understand what has been depicted.

So in this case now after seeing these you can easily recognize yes, this is a warm and this a warm gear, this is a bevel and its pair, this is a rack and it is connecting pinion that pinion is connected to the bevel gear on the same shaft that bevel is connected to this bevel this bevel is connected to this per gear, this per gear pair and then it is ultimately getting some input of 1000 rpm. So we when we discuss for the problems we will have applications of these figures very frequently, so that this we come to the end of the fourth lecture, thank you very much.