ROBOTICS

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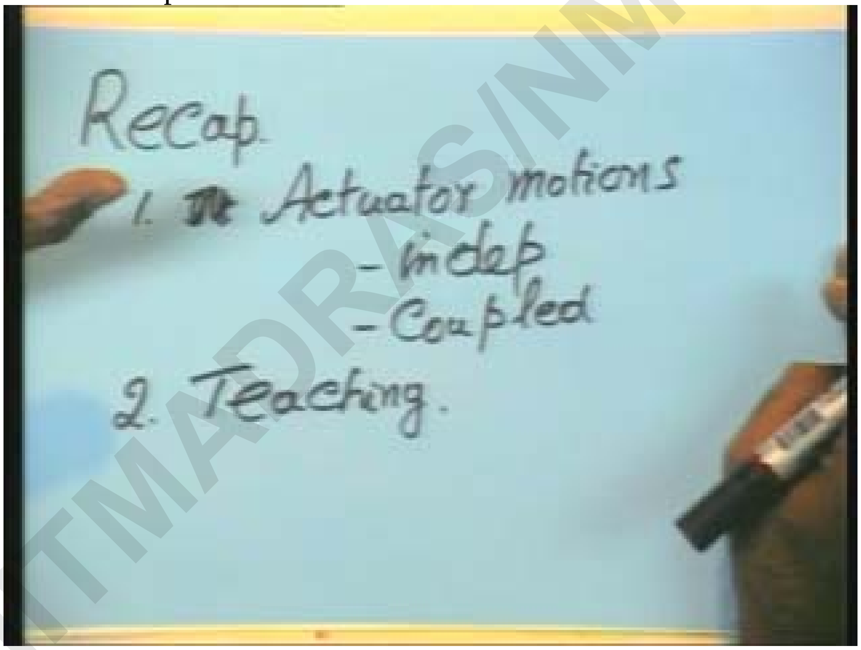
Lecture No-7

Electric Actuators

Several item like several things (refer the slide time: 02:47) like joints motion being coupled joints motions is here independent particularly when you mound some things the activator remotely away from the joints

where look at this we are also look at teaching how using the robot measuring devices is useful for teaching that is second things so joint motions are rather activator coupling motions couple where seen independent and coupled

we have look at that we have done some you know various also we look at teaching if you what we saw in the previous lecturer most of this for revote is this so staring from the



base kinematics configuration various manipulators main bodies rest than the look at the gripper you sequentially you have been starting from the base of the manipulator going upward look we have come up to the gripper than we have briefly look at teaching and activator motions independent now

i just briefly touch up on manipulator some commercial manipulator and there capability before i go and to the next topics that will be an activate electrical activated what i am going to look at subsequent topic before i go to that we will just briefly look at commercial manipulators now i have taken this you know short up on averaging look look at various manipulators some details now i am looking at manipulators particularly automotive encaptatule some details difficult future that what i would call features of industrial manipulators (Refer the slide Time: 08:52)okay

i have closer two because no end no if you go to the web you find so many company are there with deal with manipulators that enormous range of manipulators commercially available we look at the articulator arms this is widely use for wilding park wilding than for painting and we look at the scara is wildly use for assembly (d noise) now difficult reach for the articulators arms is about the "two point five " meter in the automatics industries for the scara

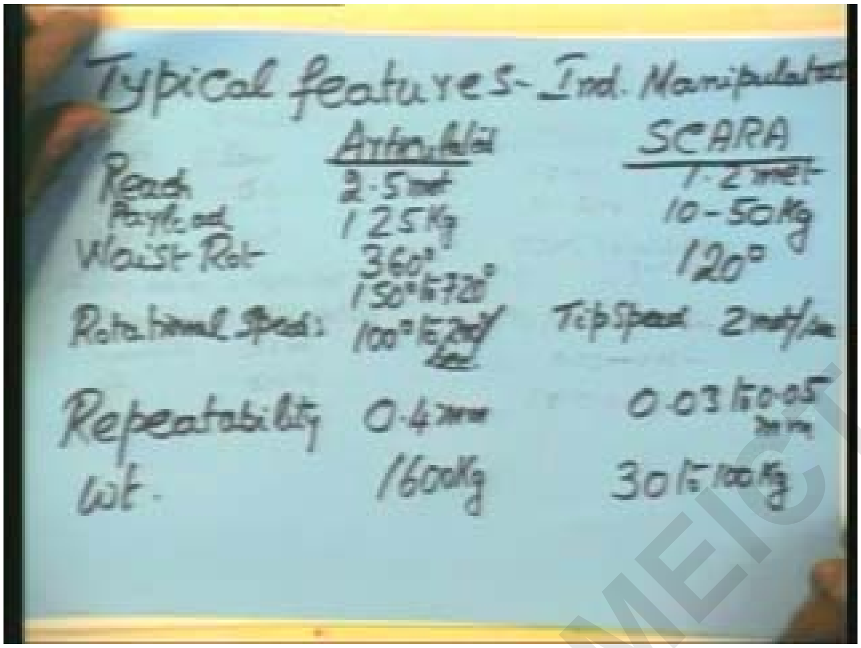
it is about the "one point two " meter okay than the payload payload of the articulator arms difficult about kalian twenty five kg kilogram for this scara arms there are those with rang from ten to fifty kilogram payload scara you knows the scara arms where the cylinder work body works space woist rotation are difficult about three sixty degrees woist rotation here it is about three sixty degrees hearing the scara obscures the woist is the main rotating joints difficult about one twenty degrees now in the articulator arms there are other what you called at joints

i means i rest there are other main body joints thee shoulder than elbow like this there are several joints they difficult rotate about hundred and fifty degrees to seven twenty particularly at rest seven twenty refer to the rest seven hundred twenty degrees rotation of this direction mind you these are not use the for doing any thing task if only to orient the object than the in the scara difficult all rotation of robot the rotations speeds of individuals joints at at individuals joints he about rotations speeds speeds (noise) hundred two hundreds degrees for seconds in the case of articulators hundred to two hundreds degrees which parley part

i think and in the case of the scare usually it is the tip speeds which is given here you will have corresponding tip speed s scara is use for assembly other about two meter for seconds assembly very fast because lot of ideal time assembly

when you quick the path to the task of you don't want loose the time repeatability in the large manipulators obviously some think tell to not need not are mush as smaller one "point four " mm in the case of the articulators in the case of the scara close down three to point not five highly accuracy because you are going to use it we have that remotes that the complaint so which is last time along with scara

if you very good capability for assembly there is positional repeatability very higher now the weight of this robot system is about sixteen hundred kilos compare with the kilos one twenty five kg multiply and here it is about thirty to hundred kilograms much like because not lifting weight in the case of the scara whole arms much like okay except end effectors there are time are not whole arms these area the difficult features of industrials manipulators if you go throw the back you will find lot more information i take it two popular manipulators which as heavily loads but okay



this is just a point piece of informatics have you look at this letter move on the various drive there are several drives manipulators hydraulics pneumatic easily servo also easily servo but for long demo common drive as the easy drive

we look at that can we briefly examine referred mini manipulators use referred particularly those handle laboratory task those do to laboratory task like you know shifting blood sample from one place to another and all now a days pleasures so many deceases you don't want to communicate with the reason many a time use they beber motor

we have look at those also begin with the DC servo because that is most common we will see how one select the DC servo that is very important point i will go along we will reading about servo control and so many other aspects so its better to have a little bit of knowledge of how one select the D C servo do you use the DC servo is the i mean one which tell you rest approach vowel tube principle are similar whether it is D C servo AC servo what are may be it okay that briefly look at the D C servo motor

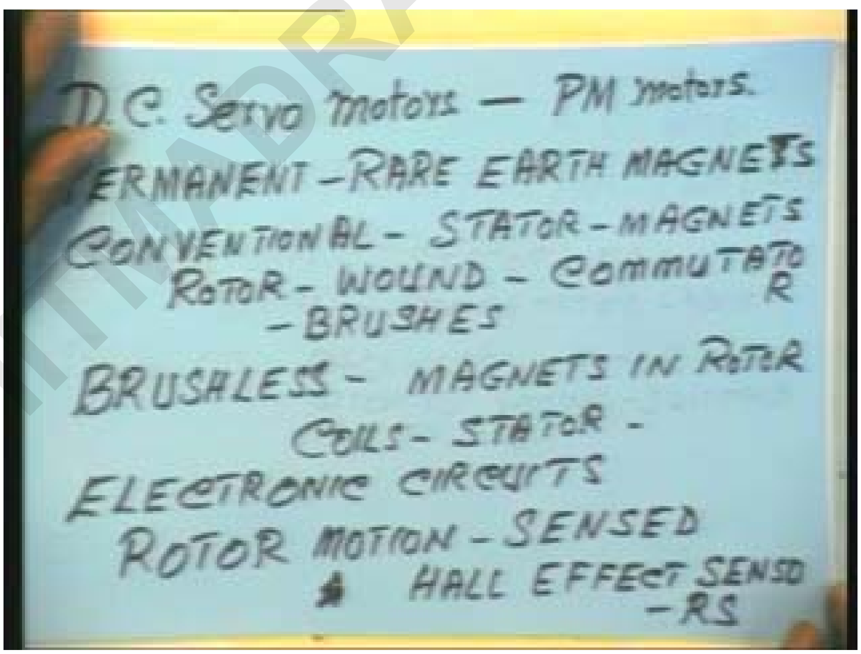
(refer the slide time: 14:57)
know one of the biggest the availability of rare at magnets have make them very compact and very light the servo motor electrics servo motor it arrival of the rare at magnets give a lot of magnate field but a small we such a small sizes we look t past twenty five years little bit most more are less half the size one stared come down

okay they use what are known as permanent magnets permanent where as magnets so usually these are called PM permanent magnets motors DC PM permanent magnet motors PM the word PM used is betted to know in the conventions DC motor you have take care a rotary called some things taker is found and rotor is also found conventions when the shifted over to many motors now take of conserving energy particularly small of motors you have permanent magnet field in the statues and rotor is the womb so as you know any DC motor you have the comminute along with rotor so you have the conventional the conventional motor as a complicate stator as the magnets the stator constrain the magnets and the rotor wound commentator now the commentator brushes there are brushes any one of those the few the open small the DC motor the commentator in the brushes

so brushes you know they there is barking its noise which dustups the electronics apart from that pixel loss of contest several problem i will where enter you have replace the brushes of the some time all this problem exit so people came out when a came out with the so called brushless here

what did what the magnets are in the rotor an the coils in the stator or the stator is the wound stator that what and commentator function now you know transfer to the stator where the electronic circuit electronic circuits cut disturb both of familiar with the electronic circuits electronic circuits switch as the magnets fields

i will rotate you appropriate switches okay this the magnets fields appropriate switches and synchronized with rotor motions throw what are know as rotor motions is sensed the motor is sensed so that you know you do the proper stitching that is sensed what are know as hall effect is the parley more involved design than the simple commutated brushes that the mechanical and electronic than by throw hall effect these are become quite popular a a promise you more reliable operations are period of pack more expensive



this is scenario as regards as regard the DC servo motor current scenario now you have AC servo motor you have day by day there are new technologies which are emerging but some of the what we i am going to discusses furthers the principle will be similar whether you are taking as DC servo and AC servo are some of the let as look at some of the performance characteristics of DC if i flat load torque

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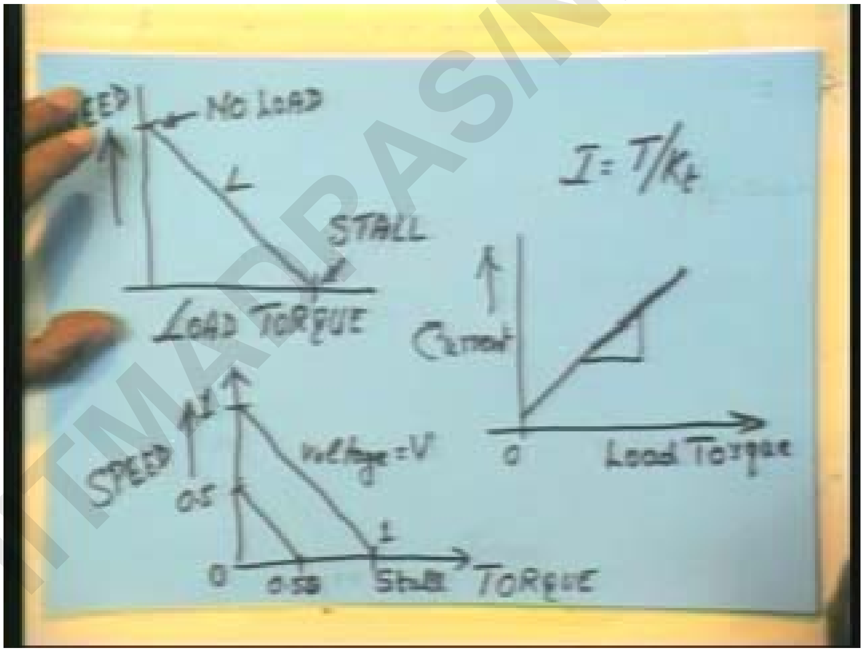
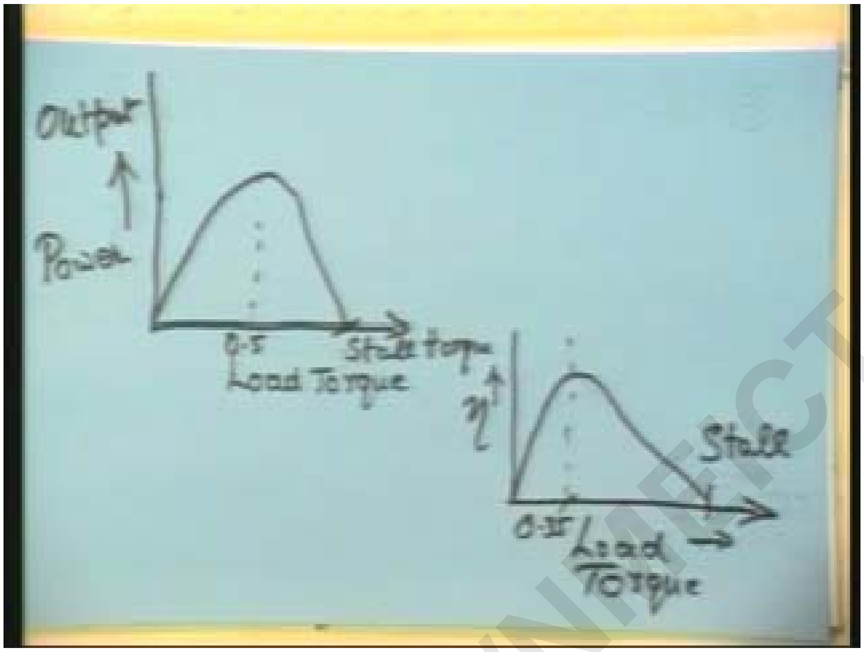
what a speed angler velocity of academy me rbm there is a no load speed from where here and there and stall star some where here this is stall this point and this is no load the no load speed and stall speed but given any voltage in specifics voltage you have applied drive the okay at links refuse heavily load the motor and some points now if you look at the current again if i have the load torque and current you have straight lines okay there is a no load current here also some current is gone he has over come the kiffsan and other law this not a zero now the current

i is equal to task divided by Kt okay the Kt the constant and Kt is given by the slob okay now this is how basics addition and so one are two more before i go to as it change the voltage this speed no torque parallel to original curve has drawn supposing a torque here and speed here now let as say one one particular torque and one particular is it stall torque for a given voltage now if i go to " point five "v i will find that okay now if i have "point five" of S as a stall torque i will "point five" if this is "point five" let say if i one this is "point five" here also this is zero and one this is "point five " length



this as the behaviors okay let means if you reduces speed the operating point here from to here and operate here like that goes on what about the power consume by the motor lets have look t at there (refer the slide time: 20:57)

if you have the load torque when the power consume this is output power output peeks at the mid point stall torque this point to stall torque the out i should say i should work the power correction because power consume defend on the here you can work out the power we look at the efficiently you will get a curve like this again load and torque stall peek in some where here point three five data called from where defense on the individual motor go upon plus and the plus



okay this is in generally behavior of the servo motor am i DC servo know let as see how could what are the applications difficult and how are you going to select motor given an applications (refer the slide time: 24:33)

one application is continues operations you driving some things some load at the particular speech over the period of time may be
after some time in order to meet your manufacturing you are not continuously what you are doing operations at a specifies speed long may be what you know as continuous operations okay now in continues operation i think all of you know how to thought of rate demo look at the no task you know the load speed task into the power do you have to check

whether motor will supply the particular task you have to check whether the amplifier are the electronics circuit will be able to carry the required current right we have to make sure that you required voltage is available in order to run the motor and last you have make surely motor doesn't heat with in particular times you have make sure the motor doesn't heat if during the particular time these are parley sight forward once motor

start running at the same speed very easy to pride how the system will behave before hand and there are several give me american formulas available from manufacturer themselves do you tell this is the way the heating will accurse if you want operator continuously they give the curve all this possible as for as continues operation is concern pearly sight forward you have if you but what we have here is what we knows as intermittent operations okay are more appropriately is called intermittent most is the more correct word intermittent so this continues operation is called continuous duty we have two things continuous duty i think adding two many things continuous duty and second one is called intermittent motion okay intermittent i show you difficult intermittent modes and cure and we will see

what i mean by intermittent mode in a robot joints you will move the arms throw may be fifty degrees weight and than again move another throw fifty degrees is one way of twenty degrees what ever may be it is right are you move throw fifty degrees weight and return okay these are the various intermittent mode you in a late lengthy late you have this various way let as look at the intermittent motion and determine how we are going to select the motor for intermittent mode
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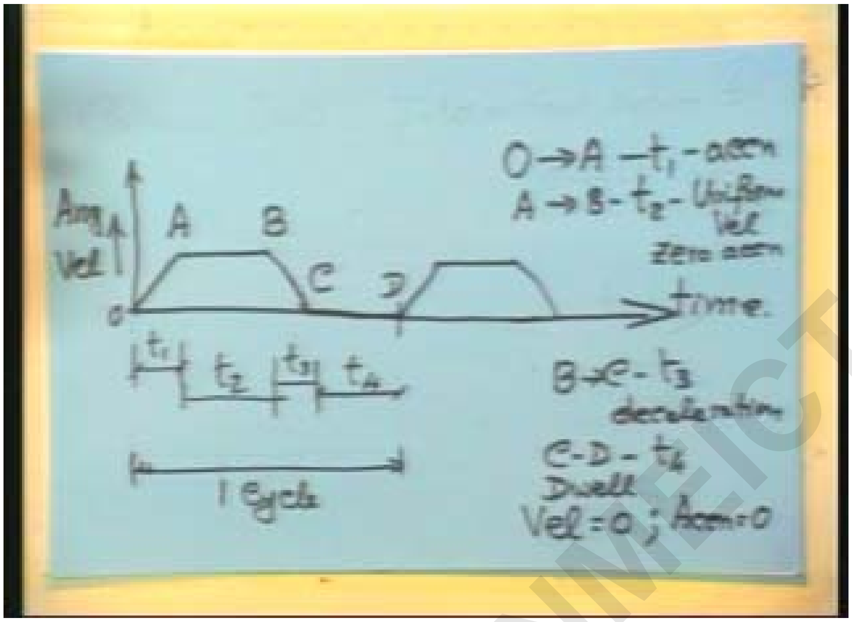
i show you difficult curve time verses angler velocity the short of motion one curve the arms is acceleration to particular velocity maintain the concept velocity

so i got it zero i got it A B C D see a particular liver as accelerated attend the specific velocity maintain the uniform velocity from A to B decelerate from B to C zero velocity and zero acceleration switch than again continue this is one cycle now cycle as given to you as one cycle as and timing are given are we have choose as a designer you choose in the time t two t three that is period of acceleration to go form zero to A is called t one the period required for the period utilize for constant velocity A to B is t two when declaration from B to C is t three and than there is the del time are past because

you know waiting for a long time difficult whole cycle may be one second are two second okay so we have zero to A acceleration the time t one acceleration you have than O to A than A to B this is time t two you have uniform velocity angular velocity okay zero acceleration obviously right uniform velocity this is zero acceleration than B to C we have time in t three declaration and C to D this is for period t four time t four period t four we have a dwell where in velocity is zero acceleration is zero now no long continues you know the operation continues duty short of the cycle



how are we going to select motor we know the motor performing characteristics and all we have to catalog how area you to cylinder now remember ever motor this is one cycle let as remember ever motor drive some load or other we will built this case difficult the first problem you encounter is you know arms is going like this some period is given okay in than going look at the motor the motor is cunning at about three of the napping there are the know

now what is the b reduce we have to use one and what should be there reduction should you today give of the motor have three hundred three thousand rpm and what (size noise) reduction of gear box ten or fifteen are today user motor of five thousand rpm to right so these are question we have to answer by this one first you have to choose the gear box because when you are driving load with a the gear box also contribute the motor load you could load

what is moment of energy of all gear box you have to choose the gear box now secondly the no divan in not being divan given at the continues operations than it is very easy for work out all whole things flexi vide velocity it change from it self it supposing you choose the gear box we will able to meet a lowest as well as the highest velocity of the these are the questions one aspect now there are know specifics answer is one to cerebrate period there are sell guidelines you have been provide both by the manufacturer as well as other engineer do have experience one choice of gear box like that
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how to choosing are any reduction of the mater gear box because you know sometime what do you to you drive like a lc machine like you drive the carriage there is the motor then there is the screw than the reduction to the screw whether the gear box any reductions i could say using gear box as any reduction are increase mostly you reduces this so what you do this you look at the maximum speed of load multiply that by two multiply that by two is first step we are going to do this things gear box maximum allowable speed of motor every motor as speed manufacturer will you tell it don't exit this speed give say and the nose of them continues operations general continues that is it

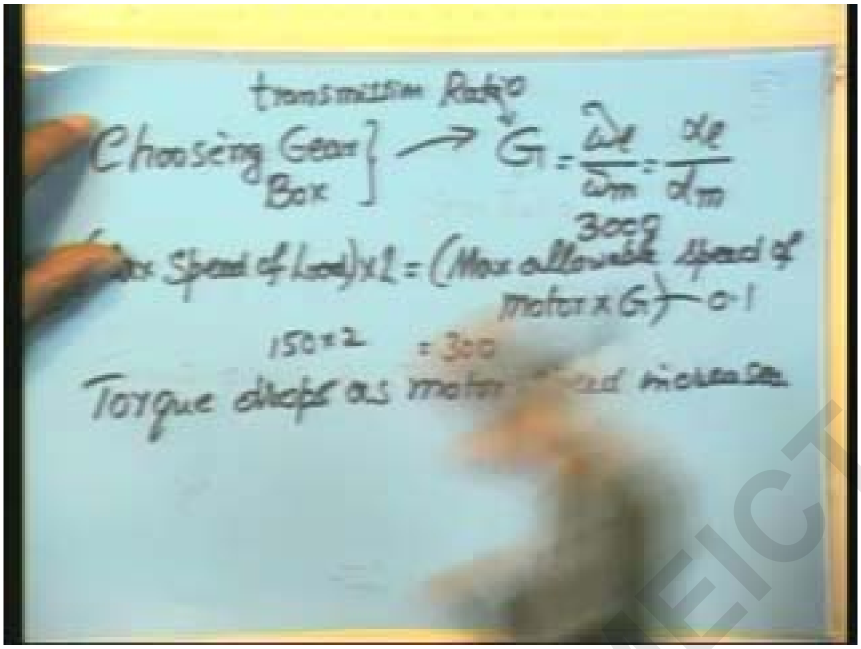
where G is reduction i call it omega load divided by omega m G is the radio okay omega load divided by omega that is the load is rotating at a lower rpm than the motor G will be less than one are if the lode is rotating lower rpm form than the motor G will be less than one notices that this is also equal to alpha L angler acceleration of the low level this is the reduction rate i not use the word gear show so i call it the reductions rate gear are i call it reduction radio transmission radio does the more correctly so this is the transmission because you know gear box you know particular insisted of the transmission rate right

so i can choose and all so what we the generally recommended is maximum speed of load into two equal to maximum allowable speed of motor into G because may be it implies let me let say the maximum allowable speed of the motor is three thousand rpm and G is selected as ten what is at i am sorry as "point one " that means reductions "point one" so your load is rotation at about three hundred rpm

you have maximum allowable speed of motor into G that say this is three thousand and this is "point one " okay maximum speed of load into two is equal to this much this comes is equal to three hundred what is the maximum of speed of load one fifty if know the maximum speed of load if the first selection of the gear box because you know the many of the time

you may go to back and revise the as at this point of time you do not know talk and all we have to now why to the torque because if you have notices performance of the motor as the speed increases this torque available to draw okay you are position is some where here some where in this side in you are taking it half this maximum allowable speed of motor essentially is equal to dividing maximum allowable speed of motor by two you position is some where for the start so this is because torque mind you this is guide line

okay you may i say i control the voltage because take into all the voltage control maximum peek voltage



will be there ever motor if can not torque there if specifics voltage you can allowable voltage manufacturing you can't say that you know i skip on pushing voltage up and attend more speed and all this is standard procedure for guide line for now you have compute the inertia you have the motor inertia

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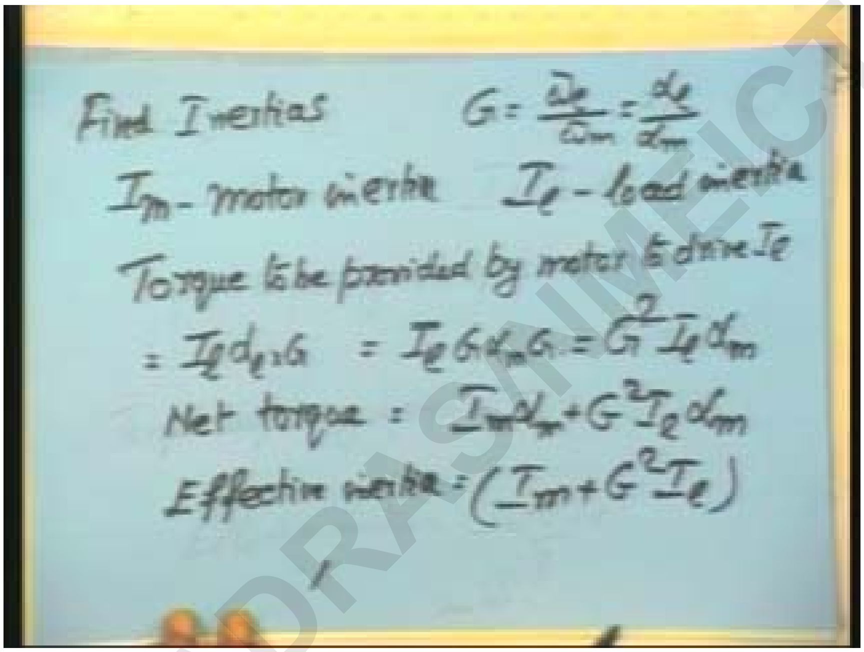
than you have IL load inertia now at this point of time do not know the motor nested you not it selected the motor we know the load inertia because you know the going to okay now what is the torque required to drive this load inertia during the acceleration space we have this torque to be provided by motor to drive IL IL into alpha L the angler acceleration multiplied by the ration multiplied by the gear ratio

okay here ration multiply that what a task you have to remember that transmission ratio as see regular remember G equal to omega L by okay now this translate into G into alpha m into g from this formula have written at the top alpha L equal to alpha m into G substation square of the ratio transmission ratio and come in order to drive both the motor and them now this is only drive to the load you have to also drive the motor i itself got it rotor so net torque that will be Im alpha m plus G squired IL okay is in a torque do you Im at the state know again

what many propose it you know Im is the state you got it you have to drive the motor also you shown rotor is the accelerate
now the effective inertia in term of to be Im plus G squired some time the divided by G squire divided by the G squired gear box divided some things we will omit it for the moment this is effective inertia one thumb rule when is locate the motor at this stage you know you know sudden things about load motor and torque and all that if you don't know i am just like you may some guide line for selecting G has keep it up half the motor kept speed similarly some guide line one guide line with use in the first incident Im is

equal to G squired let Im we equal to okay now remember why motor as to brought down the if you reduces the speed G squared keep dropping supposing you know three thousand rpm i reduce the hundred rpm what is G equal to hundred by three thousand G squared will pull down is value so the motors inertia is to larger defend heavy motor are very heavy load you can approaches be birdman but other wise divided by the square of the beat reduces the inertia is going to come down this going look large so using the right motor inertia also just know worry about this forgot about this okay got it so as a thumb rule are as a in the first this first selection first cut this Im equal to i don't want to right it because is not a formula choose i am equal to because you will go to the motor catalog



you know some of the torque required you look up there you know the speed required you look for the motor and than if you gives that see that also if you have the range of motor some of them having the motor inertia given than thump rules gives the motor in for In if closed okay so this is what we have come of this point now let go ahead now real calculation begin here now so what you have now let look at the revolve the situation

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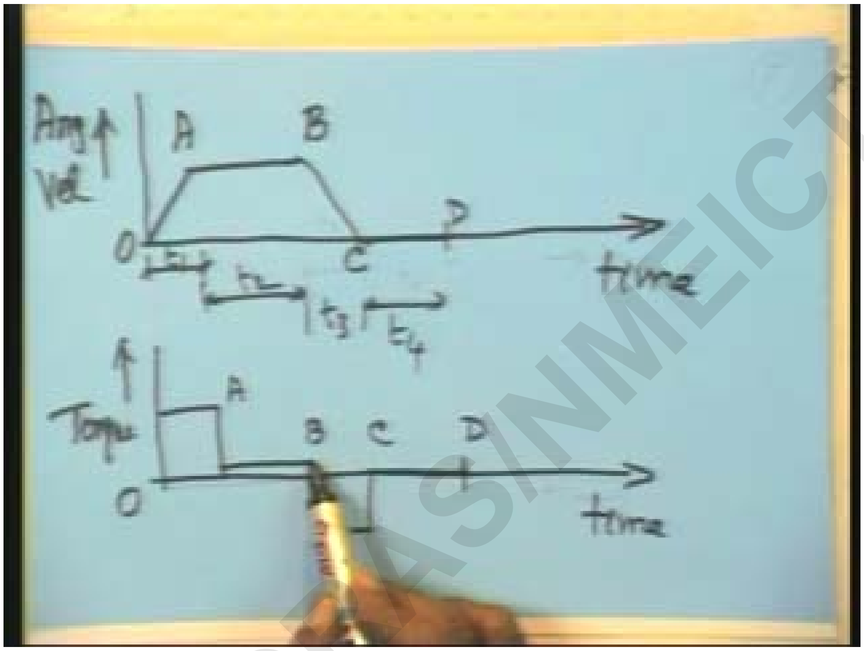
we have time we have angler velocity here and the curve know mind you have chosen this acceleration as the straight line declaration i am in the acceleration in the period the velocity change as the sight line here also constant angle acceleration need not be as you go alone you will find that several other choices for these velocity variations here i revaluate other sightline

so i that i have a constant angular this will translate if you torque a constant torque to be applied accelerate the load followed by another torque constant torque over come the pixel during this constant velocity period so many losses so that the constant than there is the for the deceleration period constant task but the negative and than no task this is D C B A if the task and timing are t one t two t three (noise) now the just the pictorial referentasation of what is will required torque two accelerate notice one things in this period the pixel torque here this torque in the some of the torque required to accelerate the mass as well as the over come the pixel okay here your only over coming pixel because the mass is moving at a particular uniform velocity here you are decelerate section is going to ed so this is okay



keep that mind in go to next step
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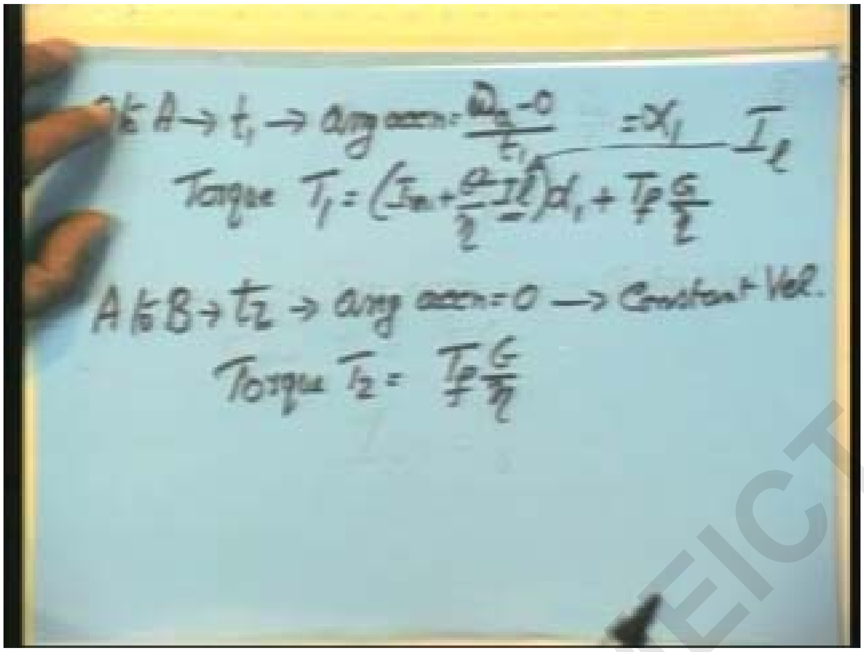
O to A the time is t one what is the angular acceleration here you have omega A as angular velocity let call that omega A and here it is zero so the angular acceleration omega A minus zero divided t one equal to call it alpha one so what is the torque required T one you will call it capital T1 torque equal to motor inertia plus G squired Il load inertia into alpha one plus pixel torque to pixel into G because

you know the load as some pixel but also has a multiple that also has multiply is it okay G squired i suffixes l sorry i wrote it as a Il suffixes l okay suffixes l i this is the torque required l now we have divided by the efficiency also this torque to the gear box it is going you will have the divided this torque also going to the gear box motor the throw the gear box motor torque the gear box okay

so this lode you have the acceleration torque the accelerated body plus what ever may be it now A to B are uniform velocity you have seen that the time is t two angler acceleration is zero because of constant velocity or uniform velocity so torque this period to be provided motor is equal to Tf friction torque okay this is during the second things



let as see what happens the third period T three during the period t three
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is it B to C period is T three angular acceleration again i know taken a very simple example omega b minus zero by t three is equal to alpha three s you know what are the angle of velocity here there is some to zero just stoke of the concept easier just for the illustration

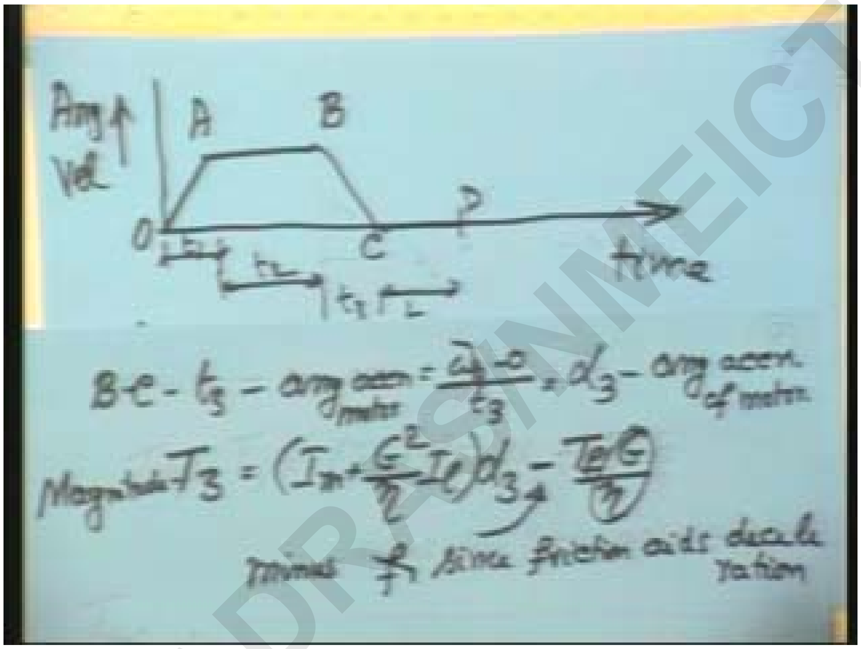
now what is the torque demanding here equal to again we can write In plus now i am incorporating the Il into alpha three minus because you have to subtract friction
for friction aids friction minus since friction aids the friction is aids declaration i have to subtraction is stopping the machine

okay you have any doubt just ask me we will be clear now i am only calculating torque i am just calculating the magnets of variations you know see your are felling up that is okay i am only calculating torque i am only calculating magnets

i could as set that this is the magnetos i am not worried about the magnets there is an acceleration or declaration forces is equal to same things i am using that because using the torque is equal to force is equal to mass into accelerating and decelerating i am only calculating magnets

i am not looking at the no no which one yah see when there is a pixel torque here the motor cc the gear the motor gear box and a load okay there is a prisons torque in to the lode there is pixel in the lode and the have the reducers what about the motor the motor as the supply less there torque right you are the load is rotating the hundred rpm and there is the pixel task see there right the gear box is reducing speed from the three hundred three thousand to hundred what is the gear reduction three thousand to hundred is thirty any torque on the output what is the torque an the input side is much less G squired coming (mu noise) yah i am looking at ever things okay this alpha three is the motors this is the motor acceleration multiplying it by the motor acceleration as seen by the motor multiplied by the motor acceleration see this is the inertia as seen by the motor alpha three is motor see okay may be this is the angler acceleration of the motor

i could write it clearly the angler acceleration not the load the angular is mode okay angler acceleration of mode yah if you have the very effusions if you have the very effusions no gear box losses i am taken care of here okay lode and the gear box losses are taken care of by this okay so acceleration of motor sorry i think i could mention this supply ever where zero to A also



remember i am not show is 0 to A also this is the angler acceleration of motion alpha one is the angler acceleration of motions okay that should be here i am very sorry i didn't mention now what we do is so for each period we have calculated torque we have the torque capital T one for period t one capital T two for period t two the torque capital T three for period t three declaration period obscures there is no torque calculate the rms TRms
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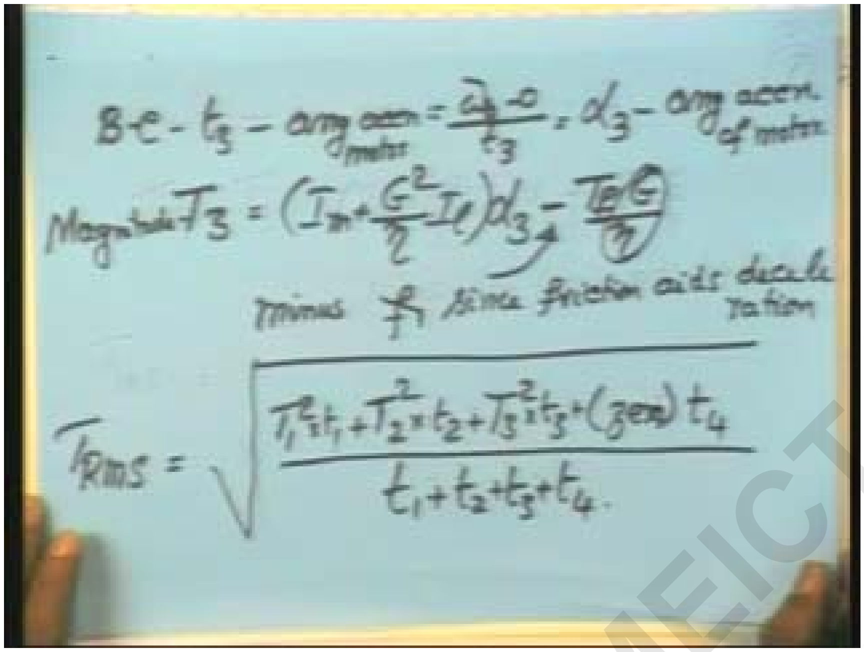
we now the calculate what is know TRms square root of T one square into the time t one all magnitude T two squared into the time t two for all magnitude okay T three squared into time t three let zero that is for the period t four into whole divided by t one plus these are the time added of cycle time it come to cycle in each of those segment calculate the torque square them multiply by the time some them up okay



so now we have got in each period torque you have got the rms torque now you have to ultimately select the motor you can now select the motor like this go to the catalog manufacturer catalog and
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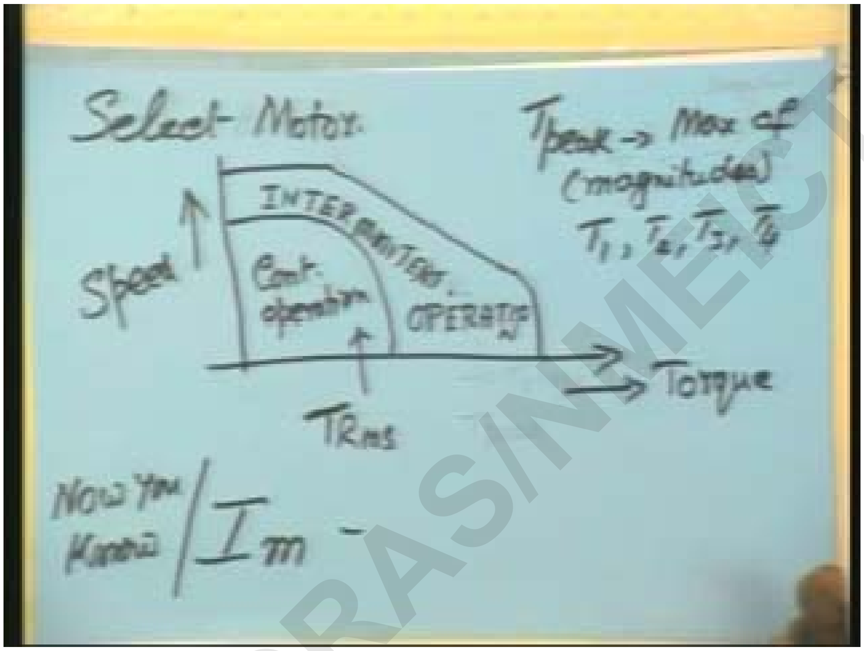
you will find in the torque speed than he will take this is the area of continues operations and we will take do not torque this boundary outer boundary do not across do not operate beyond this we will give that and this will be the this port here it be intermittent i know putting to may m and two may things them writing become please don’t worry about the spelling mistakes okay two many things am adding some time doubles here you cant see

what you are writing so when your time send to add or subtract you have this we divided which theses things go there and see let the TRms the position some where in this okay some where the continues operation okay now look at the port timings you calculate what is knows Tp maximum of i am talking of magnitudes look at this magnitude T one T two T three T four take the max of this okay that will be the tp we have four zones t four approaching zero T one T two T three right including the friction and all pick up the maximum that can line the intermittent mission okay

so any motor run continuously up to some current level motor than sustain its heat up but it can operate continuously because there are also cooling devices so equally with in reason some one in alive you can allow with the overloaded with currently being pushed up you are taking care of both okay

if you go beyond this magnet may the cashing of magnets maker or over heating of the motor all this problem are there that why they say the how you selected now once you have selected tahn you know the exactly value of i of motor go back okay you know the exactly value of the i of the motor than this time it is for away from the what you have the redo the calculations now you know Im this is design most design are always like this you start we some choices work the whole things out than you know some things okay so one of these Rms value to be here and other to like

we will also comeback here there are lot of guide line given by the motor manufactures themselves particularly with regard temperature you know the ambition temperatures maters a lot and increment motions application because you to the ambient temperature motor if its very hot ambient than the motor selection now there are elaborate rooms and



guide lines for this and they also give charge you can actually work out the temperature also close formula not close the procedure i am not telling you because you know the end at all we keep on okay now that i think you know come up the next class i go ahead in tell you how to select the various amplifiers