Design of Mechatronic Systems
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Lecture 05
CD-ROM Part l

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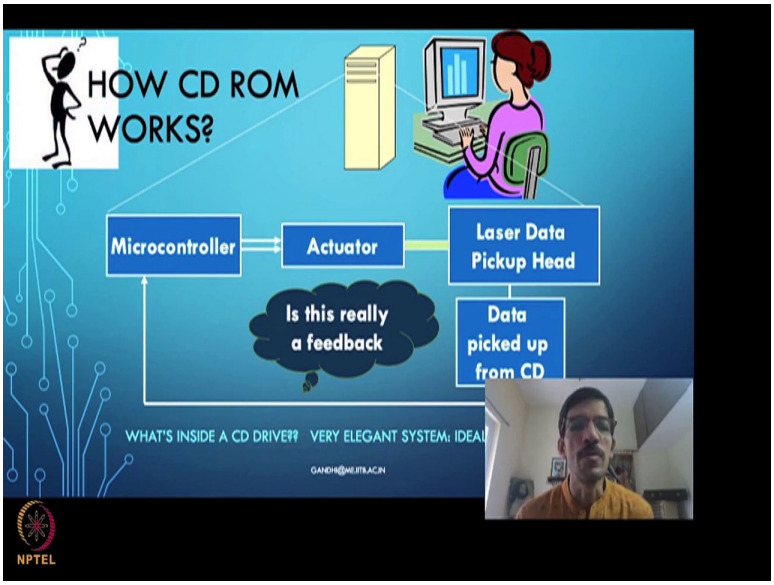

This lecture we will focus mainly, as you see the, see the little picture in the bottom, it is about how CD ROM drive works. So, we ponder over this question like you know you have been using some CD ROM or CD drives in the past, you might have I am not very sure nowadays people do not use them so much, but I am sure you might have listened to some music on CDs maybe a few years in the past maybe. So, one has to think about, like what is there inside this drive, and how the data is there stored on the surface of a CD, and how that data is read, what kind of system, mechatronic system is needed to do that job.

So, so we will start is with a, with a very different kind of approach, we will not like now do some theoretical kind of a understanding first and then like you now see okay what is there, we will actually open up the CD ROM drive and I will show you the pictures of this as we go along and start kind of discussing, so the interesting aspect that you see there. So, now while thinking about CD ROM drive we need to think about these 4 elements that are there here.

So, you can see these are the 4 elements that we are discussing, microcontroller, actuator, then you have a actually CD system, and then you will have a feedback, some kind of a feedback

from the system, you may have these sensors, the this is plant here and then there are is a sensors here. So actuator, plant, sensors and controller, these 4 elements will be indispensable for any of the mechatronics system or you may have many subsystems that will be there as a part of a big mechatronic system.

So, either way we need to look at all the subsystems we broken up into this, this components. And, then there are other aspects of the design that we will go along as we start opening up that will come up. So, maybe let us start with the discussion here on the thing to question first is, how do you think it was? So, you might have maybe looked at or like some Googled it and seen, okay oh this CD ROM has some optical way the data is written on the surface, and there is some optical pickup which picks up the data from the surface.

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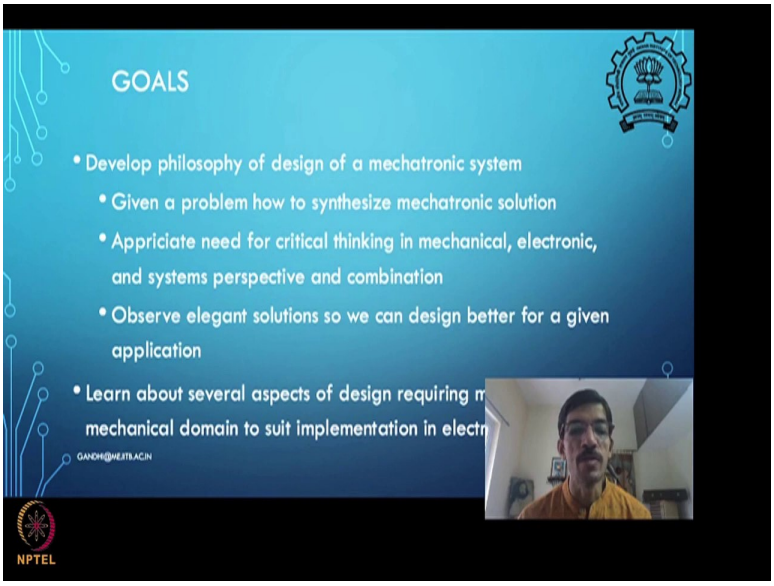

So, let us get into the more details about. So, the goal here is to kind of develop the philosophy of design of mechatronic system, not particularly this particular system, but how do you think in terms of design for such a system. So, given problem, how do you kind of synthesize a solution and then you will see the need for this critical thinking in both the domains, mechanical domain and electronic domain together to see how we come up with the requirements, how do you give the solution to the requirements of the application.

And then other aspect is to kind of look at already existing elegant solutions to these problems which are already solved and understand some of the design principles which are optimized

principles in some way that how do we make use of that in our case. And then finally, learn about several aspects of the design which requires modification in mechanical domain to suit implementation in. So, this is like integrated philosophy of thinking that we will try to learn through. So, now let us move on with the problem at hand.

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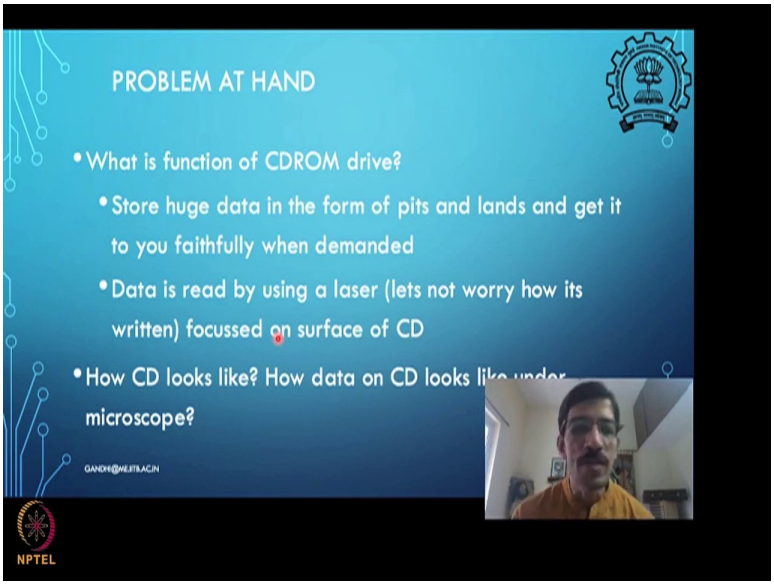

Think about what is a function of CDROM drive, as we have seen, said already, it has to store a huge amount of data, this data is stored in form of small pits and lands on the surface of CD, we do not worry about where this, how this data is written, but it is written in some kind of a form and when a user demands, that okay I want to open some file, or I want to listen to some music that is there in the CD I should be able to get it.

So, when the user clicks demands that I want to open this particular file, you have to kind of do something to go to that part portion of the CD and pick up that data from there and give it to the user, that is the kind of a problem that we are looking at it. So, now let us look at a CD and how it looks under microscope. So, this let us do that now.

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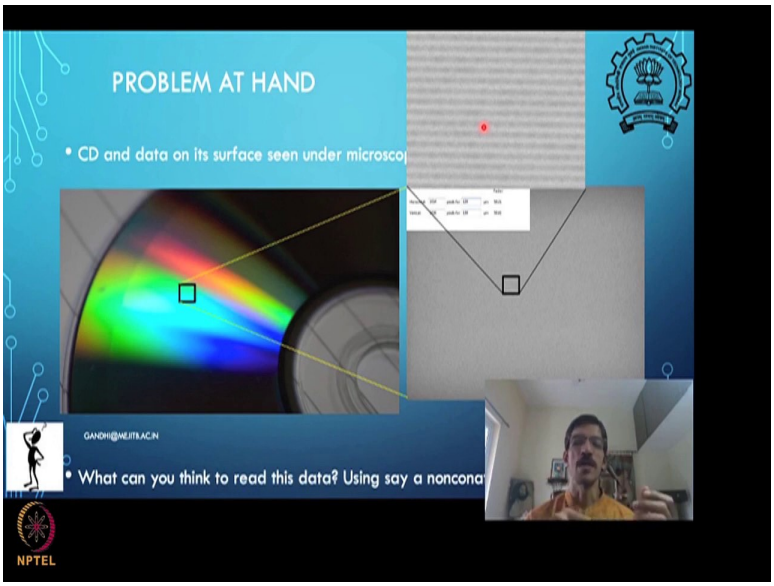

So, can you see that the CD has a surface which has this use of these different colours, can you ponder over and see why these colours have to be seen here. Think about this question, why do you see the surface of CD has this kind of a different colours coming up? So, what is a physics of light that is going on there, which gives you this different use of the colours. Now, under microscope, we will come to that question when we discuss or may answer that in the discussions.

So, if you zoom in, in the small part of that surface you will find a, there are so many dots that kind of a seen here, it is not very clear you may not very clearly see anything in microscope, but as you zoom in further you may see these kind of a tracks that are there on the surface of CD. These tracks also are not so kind of a sharp, sharply visible, because there dimensions are almost coming to the wavelength of the light.

So, light wavelength for example, in the visible range say for example this red light that will have a 630 Nano-meters kind of range and these tracks will be 1.6 microns kind of a dimension or 0.5 micron each track kind of a dimension, then they will not be visible, clearly, so to discern you need the features to be much more size than the wavelength of the light, these are more size than the wavelength of light, but they are not much more than the wavelength of light, so that is why you can see them somewhat, but you cannot see them very, very clearly. So, now the question.

So, what can you think of a system to read this data? So, I want you to kind of pause here for a while and think about, see, what can you think to kind of read this data from the surface of a actual CD. So, given that you have this data which is written in this form of small land and pits, how do you kind of design a system which will read the data?

So, let us assume that if there is some kind of read head which can read you can shine a light on the surface of the CD, and the light falls on the surface and it gets reflected from the surface bounce back and if it is falling on land it will kind of reflect like a white light, and then if it is falling in the pit then it cannot reflect.

So, that is one simple kind of way one can think about that. I am shining a light very focused, tightly focused light on the surface of a track and then the track if it has a, it has that land or data written in 0 or 1 form, then if it is aligned it is light is getting reflected or not reflected from the surface will tell me whether the data is 0 or 1, that is a simple kind of a head that that can be possible. Now, the question is, we want to make sure that this head moves on the track all the time. How would you do that? This tracks if you see they are so close to each other, so if you see that they are so close to each other, as you can see here.

So, such a closeness of the tracks, How do you kind of maintain that your focus spot remains on the surface of the on the single track and it continues to remain there as you start reading the data the CD spinning and spinning at some speed and this track is getting faster so this CD is spinning here and this track is passing under the head and you need to make sure that head is moved only such that it is kind of continuous to remain on the track.

By the way the data that is written here is in the form of a single spiral. So, the spiral start from the small end of the CD and continues to, continues in a in a way to the larger radius. So, small radius it starts and continues to the larger radius, like that a single spiral is there. So, you need to kind of make sure that the head is continuously moved on the surface in the radial direction with the precision of some something like can you guess what will be the precision, if this is say the track, between the track the distance is about 1.5 microns the precision that is needed will be what?

At least some 100s of Nano-meters, 100 or less maybe less than 100 Nano-meter kind of a precision will be needed. So, 10 percent also if you say like 10 percent of 1.6 micron is 160

Nano-meters kind of precision that will be needed there. So, we want to kind of create a system which can do this kind of a Nano-metric precision kind of a movement on the surface. How would we what thoughts come to your mind based on your knowledge so far, we have done with some microcontroller programming and things like that.

What kind of actuators can you think about what such as such a system to exist? So, let us, so you give a good thought to these before kind of proceeding from here, so wherever these questions are, I will not stop for the sake of the memory of the lecture that we are recording here.

But at every point of this, where this you see this little icon here, a person thinking, you need to be doing that job and see what kind of things come to your mind when, see because it is very important that you raise these questions in your own mind to understand what is there and open up like you know really interesting kind of a dimension, because we start thinking in whatever based on whatever knowledge that we have, and then we start putting things together at least on the paper for such a thing.

And then like we see, when actually you open up and see some stuff, it will have some different understanding that is happening and that is what is important, because that is kind of correct some of the ways you are thinking previously to you know what is your right direction to think. So, that process is very important, I am reiterating here, but please pause here, do not go through unless you have thought about this question yourself. So, the question I raised not is not just these but how do you kind of move the things on the surface of the CD? That question also so you should think about.

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Now, let us open up the, these are the questions that actually I wanted to you know you to think about and pause here. So, maybe you can list out some of your ideas and like now on the paper and start thinking about them and things like that.

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And we will proceed for actually seeing what is there inside. So, we will actually take a CD ROM drive open it up and start looking inside and observing our keen observation as I said earlier also, we is going to teach us something. So, let us start with the opening.

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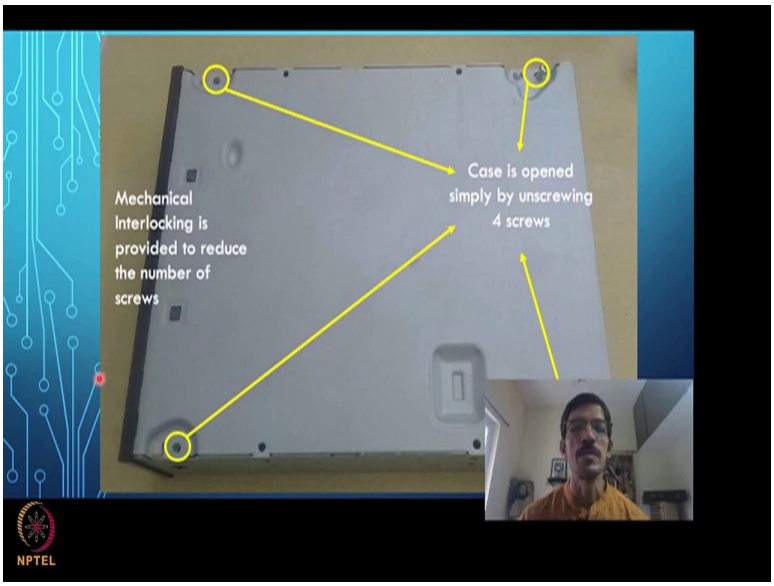

So, you have the CD ROM drive, the brand new CD ROM drive, and then you can locate there are these four screws up here, this screws you remove and then you will be able to open this top thing up. And at the, in addition you can see you can observe that there are a lot of mechanical interlocking that is provided to reduce the number of screws and things like that. As you start opening up you will find somewhere you need to move some mechanical lock and I will show some picture of some of the lock, to just kind of slide that lock and things will open up, so we will proceed now.

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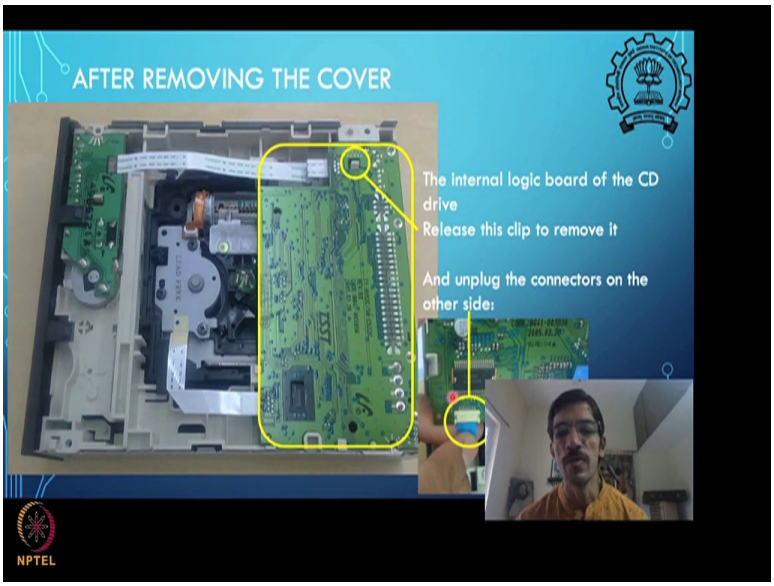

So, this is what once you open up the cover this is what you will see inside, now so we need to kind of now slowly observe things carefully and start making sense, so this electronics we may not be able to make much change because we cannot like you know we can just see the chips and maybe take their data sheets, I mean take their numbers and look at the data sheets and then we can make some make more sense of circuits.

But mechanical things certainly we will be able to do a lot of, make a lot of sense of atomic mechanical components. So, let us observe them. So, there is this one of the locks that you need to push this lock in the side in this direction and then it will open up from this it will release this PCB, so that you can leave the PCB up. And then you will find that there are these flat connectors that are used.

See there are a lot of things that you can observe, I have listed only a few of them I mean I am leaving more for you to kind of explore and observe and think about and ask questions, that is what we should, then it will be much more healthier kind of a process rather than I am pointing all the time to some kind of things in the observations. So, this is like a in some kind of a PCB which is doing the control and reading the data from the surface of the CD storing it somewhere and communicating it to your PC.

Then you we will find that these are kind of a flat cables that are used for connection. Now, one can think about why this is kind of a flat cables are used, and not normal wires. So, think about that. And then you need to remove these cables to kind of data access like better access to mechanical components.

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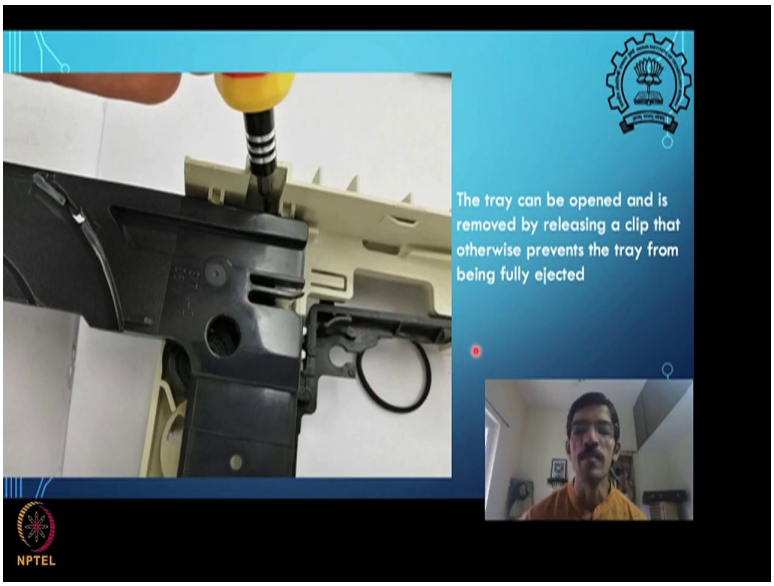

So, that is done here. So, there are a lot of like small, small aspects that will come, this tray of, this is its tray that is holding the CD, that tray needs to be coming out to come out for that tray, there are some kind of interlocks that will be provided or clips that will be provided and then you need to push something and then this tray can be pulled out, those kind of things you will need to do.

See it can be excellent if you can get some of these kind of systems like CD ROM or hard disk drive which is gone from your neighbourhood shop which is repairing shop, repair shop may like you know some people may have this thing available, they may give you some throwaway price or they may kind of just give you without any cost free of cost, anyway it is called gone not working kind of drive then you just want to kind of explore it people may be able to give you, spare it for you.

We usually doing in the normal classes in physical classes we give you actually this among these kind of systems and let you explore them. So, that opens up a lot of different kind of thinking and para demeanour in our mind, in fact everything we can talk about say for example, how do you see through for such a design of such a frame, that itself is a very interesting topic to kind of derive with, how do you kind of think for such a design and it can be manufactured what is the way this can be manufactured.

So, what kind of a die system we can have so that you can manufacture such kind of components, see because these are to be done in a masses, so then the price of such system comes down because they are fabricated in bulk, so for bulk fabrication or mass fabrication, you or mass manufacturing you need to have a systems or thought processes which are different than one off system or two of system in fabrications.

So, there are a lot of things that can be talked about. But right now our focus is only on the mechatronic part of it, we will not to get into too many details about manufacturing and materials and the gory details of even some small mechanical design such as this kind of release clips and things like that.

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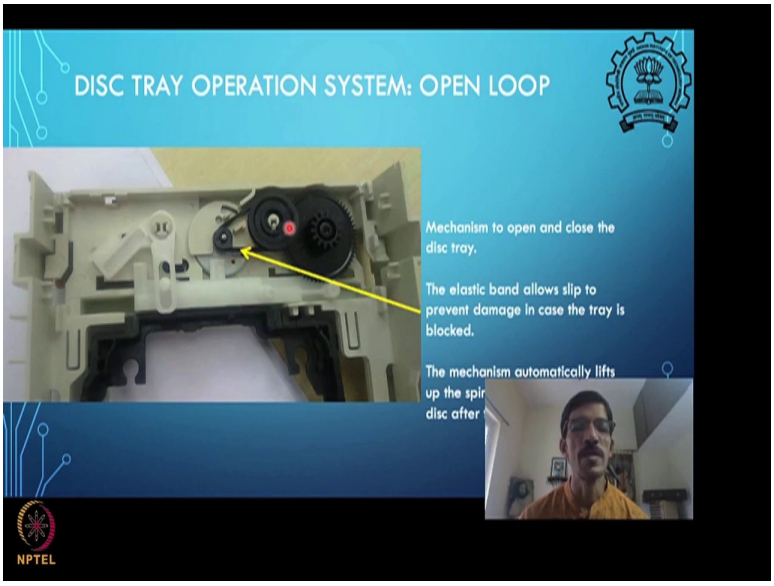

Focus, we will in case focus on the mechatronics aspect of things. So, this is one of the systems when we, when you open up like you observe this kind of a rubber or belt driven wheel and which is operating some system here with the gears and things to get it and then there is this gear which will kind of get a tray out and tray in for the CD, so CD tray is so I do not know whether if you have operated you will remember that you push some button on the CD drive and then the tray pops out actually.

So, the CD tray pops out, you put a CD there and then it is taken inside and it is set in some way somewhere. So, this is a mechanism which was the tray operation kind of mechanism. So, why this typically the belt drive is used here is used to prevent a damage in cases against a tray is

block, if the tray is block and then you still start driving the motor, see this is a motor up here, there is the motor below this, this small little wheel is driven by this motor.

And if something is locked and this wheel is not rotating then the motor still keeps on rotating and it belts start slipping. So, this argument is useful, see if imagine if instead of this belt drive with a flexible kind of a belt if you use simple gear mechanism here, then what will happen is like you know the something it gets stuck or you are holdings at that tray manually and a new motor is trying to push it, the motor is not moving, then what happens is whenever motor is not moving you are holding like motor shaft and there still power is given to the motor.

Can you imagine what is going to happen, think about you are giving a power to the motor but we are holding the motor shaft, motor is not allowed to rotate, then you are actually pushing in a good amount of current into the motor windings, will start heating and if the motor is not designed to get that kind of a heat I mean it cannot sustain this heat for a long time, I mean it may short for short durations the motor can sustain such kind of heating the temperature zone goes so high.

But if you keep on doing that for a longer duration then slowly the motor will start then the motor coils will start giving the heating so much that the enamel or the insulation on the coil burns and we will see that the motor may not function afterwards, so motor will get burned, if you do not take care of this blocking kind of issue that you know when the output is blocked motor is still allowed to rotate but with the belt will slip on the motor surface, motor shaft. So, this mechanism gets you this the tray out.

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So, we let us observe this mechanism look more closely here with this video demonstration up here, so let me see, let me run this. Maybe I have to go back to the pointer mode. So, you can see here this is the mechanism that moves, so now motor is removed from here you can see that there is no motor here the belt is removed belt is line up here, but like as this rotates there is some gear might also have been removed from the system.

So, the no, no this gear is still intact, so if this gear you see this gears rotates this when this gear rotates this will move slide here and the sliding will do some interesting thing here, if you see this sliding is pushing this small black tray up and then there is something that happens because this up and down motion that is needed is to kind of unload the CD from the CD spinner spinning motor. So, when it is you see when it is pushed on the side the CD is loaded and in some other way the CD we get in the other direction the CD will get unloaded. So, that is the system for that.

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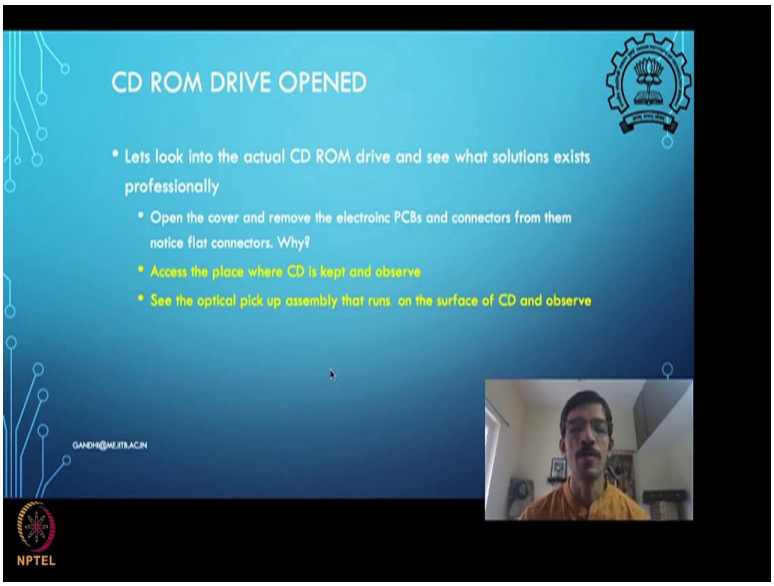

Now, let us observe some more details about where the crux of the problems, where exactly the CD is placed and how the CD optical pickup assembly actually reads from the surface of the CD.

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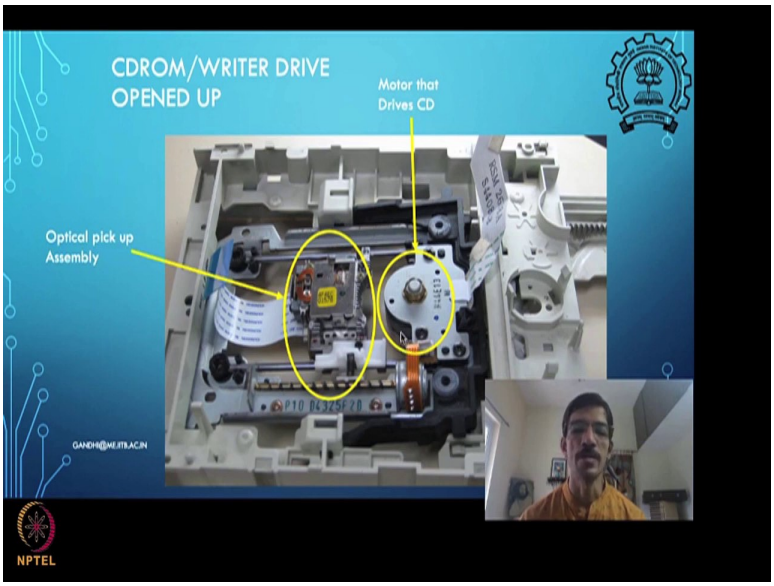

So, if you see this after removing the couple of PCBs from the surface, you will have this clear view of the mechanism here, what do you observe here is these two rods here, you see this one rod and one designer rod. And so, this was the mechanism up here for the CD tray to be popped out and all the motors and the gears, they have been removed now and this is a motor which will drive the CD.

If you see a upside down view here, the CD is kept upside down here on the other side of the motor, we are looking from the backend so to say, CD will be pulled from the backside to kind of read and then this is a head which optical pickup assembly which moves on these two rods here sidewise.

So the CD, imagine the CD has this as a axis centre of this motor as a axis of rotation and then the CD is rotating like this in a big CD is there to rotate in the on this axis and then the head is moving radially inward and outward when the CD is rotating, that is a kind of two degree of freedom motion that is required for reading x y kind of a position I mean x y place tracks lands and pits on the, on the CD tracks.

So, you need to have x y positioning system for that. One axis of rotation is CD, rotation axis and then other degrees of freedom is radial motion on the surface. So, it is not like you have fixed CD and you move the head around it, it is the CD is rotating and you just move the head radially inward and outward. So, you can have multiple ways of picking up the position date I mean pick up the data from the surface of the CD, but this is the most the way that is designed, the CD can be spun and you can have the radial motion possible for the head.

Now, let us observe little things think little more details, you can see that here there is a some kind of a screw mechanism and then there is some motor here, this motor near that you see for this coil, the other things that you may have here is think about now like these motors are for what purpose and how things are going to work in these case, so let us move on to next.

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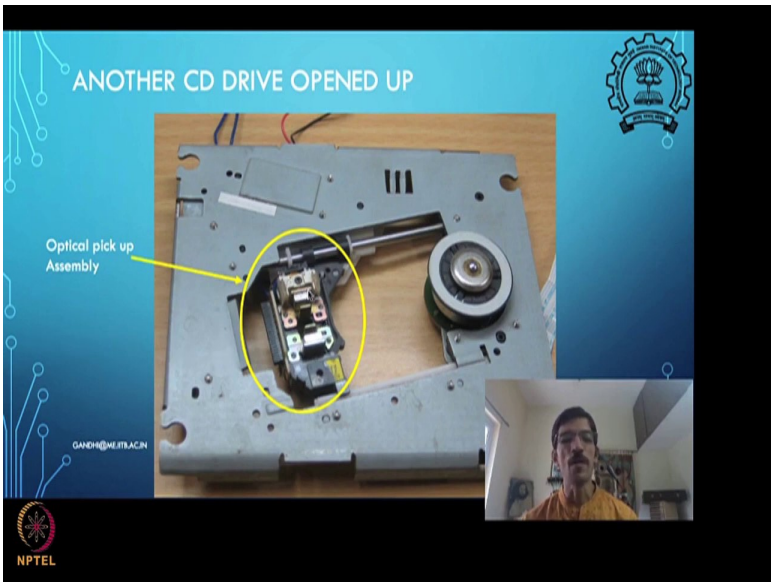

So, there is other kind of a version of same CD drive, but this is not the same company it is a different company, it has a different kind of optical pickup head you can see here. Now some of the components are here removed do not take it as it is. You can see only these are magnets here and the coils and other kind of stuff in here, from here is removed. I will show you more detail what is removed from here.

And then observe that this is a motor here, on which the CD will sit, so you have seen that CD has this small little hole in the centre that hole will match with this step up here, so where the CD is located like radially really well, so the centre of the CD and centre of this rotation of the motor is matched by using that kind of a small step there and the CD sits on the surface and then the head looks this optical pickup head lens is facing now the surface of the CD.

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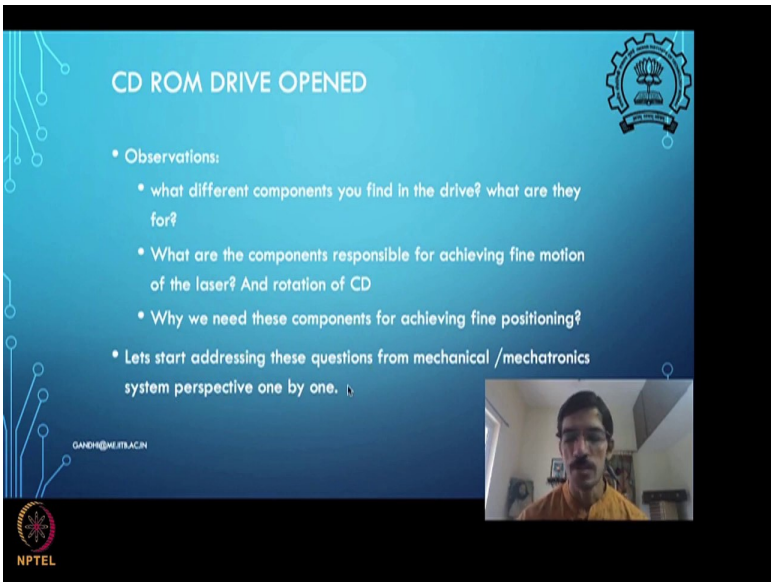

Now, some of these observations, so now you need to again ponder over these things. Let us, go back. What are the different components that you find there in the drive and what are they for? Think about that, you may observe some things which is more than what I am like making you observe in couple of slides to come or in the previous slides also, but you need to think about different kinds of components why they are there in, why they are that way only. So, that kind of a discussion or that kind of a thinking process will be very, very useful for further incorporating those kind of concepts into your own kind of a design.

Then what components in the CD can you see are responsible for achieving these kind of a for a very fine motion. So, this is very important to kind of see that, you what you saw there had some kind of a screw and some motor kind of drive, can that give you really this kind of a fine positioning is what you need to ponder over. If not, then what else is there to move?

Then why do you need these components for achieving fine positioning? So, some things you will see is for fine positioning something is there and then they need to think okay why these how they are kind of helping us to do the job. So, this slowly we will start exploring these questions as we start doing more and more keen observations.

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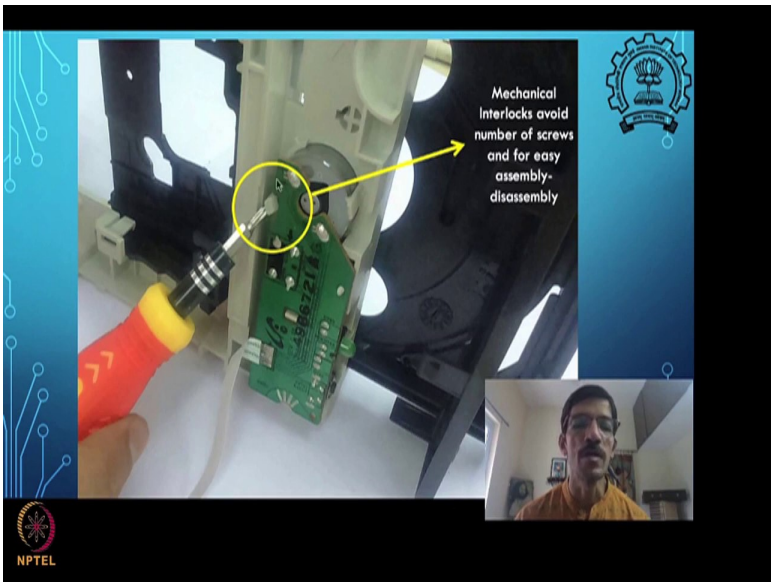

So, see, these another kind of a mechanical interlock for the PCB, as to avoid number of screws that are put in the system, so you can see that you know the this some small holes are provided and some like a pins coming out of there those holes that those plastic pins are kind of locating this PCB with respect to the motor or those kind of locations with respect to this holder of the or the tray, so that they do not move from place and then get when you assemble, disassemble they will go in exactly the same place.

So, these locations of various components is an important consideration, from the mechanical design perspective. So, we will see this how do we locate things with respect to each other, so that they are in the right place when you assemble and disassemble later, we have a class I mean we have discussions in some of the future classes about that.

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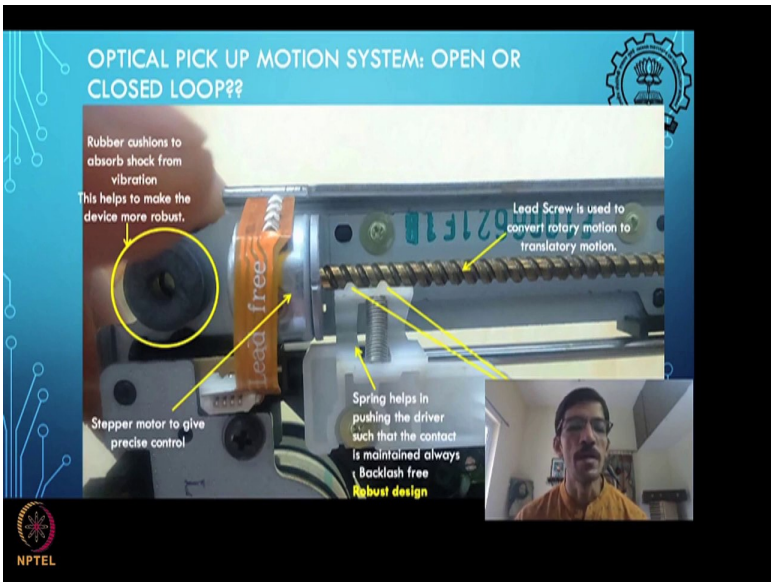

Then, you have this optical pickup system. So, it is a gross motion for that system, we can see that this is like zoomed in view of that little screw that you are seeing, so this is a screw up here and it has a motor on one end, this motor has these four terminals here, so see normally we can identify based on this terminal here what kind of motor it will be, if you have more than two terminals it is not going to be a servo motor, servo motor will have typically have two terminal plus and minus coming out, but this seems to have more number of terminals.

So, this is like a stepper motor here. Another way you will start moving the screw and you will observe that this moves in a steps, you can kind of feel that steps, that is another way to identify and this is the stepper motor really. Then there are these two stubs, which are moving on the screw, why there are two? Think about that. How are they helping, why there are two things that are required here? And why not more than two or why not less than two, why not only one?

Then what is this spring for? So, the spring is actually pushing this on these two stubs. So, and if you carefully observe this area, so one stub will be touching this side and other stub is touching this side of the screw. So, you see that for a thread that is there on the screw thread that is there on the shaft, one side is touched by one stub and other side is touched by stub.

Here what you observe is some small little rubber bush here and a hole inside, so this goes on to something and this will under rubber bush this entire thing is resting there like that rubber bushes you will see four of them at four different points are at four corners of this assembly.

And they help in doing the shock absorption, so mechanical vibrations that are coming from the mechanical vibration that means shocks that are coming from ambient they are prevented to go into the this high precision positioning system. And you can see this is a rod, which is guide rod for the for the head to move.

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So, we move further here and then observe some more things. So, if you see now this is like all the operators this screw moves this now we are doing a reverse kind of a drive here, we are actually driving the stubs and then like the motor moves actually. So, this is how typically like you know have this drive system working and see there is the other kind of corner is small little rubber bush which is used for shock absorption purposes.