Electronics Enclosures Thermal Issues
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Lecture – 31
Round Up

This is an introduction to the course which we talked about saying electronic enclosures and thermal issues in the electronic enclosures and the context of the courses if you can follow my presentation on this site, can you please show me this sir.

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This monitor you see here we have pigeonhole here, something very posture about pigeonhole is every we have pigeon has a place to rest and whatever it is and then this look a little like the white pigeons, but extreme left top you will notice two pigeons are trying to get into a one opening you have seen.

This is exactly what happens in the case of most real life products.

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One of the first thing is what has been shown there as pigeonholing is not valid; we end up in what is called the over the world design. So, somebody make something he makes electronics and then afterwards you know I am sorry one group makes electronics and afterwards, it is passed on to another group to sort out the issues that may have cropped up.

So, the thing what has been done here is to sensitize a core functional engineer of whatever know, now the word domain knowledge is used what I will call it whichever functional knowledge he has in one area with other areas it is electronics people will be able to understand what is the mechanical and especially thermal issues regarding the physical products that come into being.

Similarly, if you have manufacturing people, they should also know what and what should not be compromised when a drawing is present to them. So, that is where you know we have this reality of having to work with several other groups. So, I am showing for convenience sake you know, this we have a behave there all of the people know seem to work for a common good of the whole thing. So, it is just allegorical representation nothing to do that there know bees and all that.

The other thing is in case you fail the sometimes the consequences are disastrous. At least here you see here we have a harnessed nest. So, this harnessed nest if somebody comes in tries to attack; what will happen like this. So, these are all part of it.

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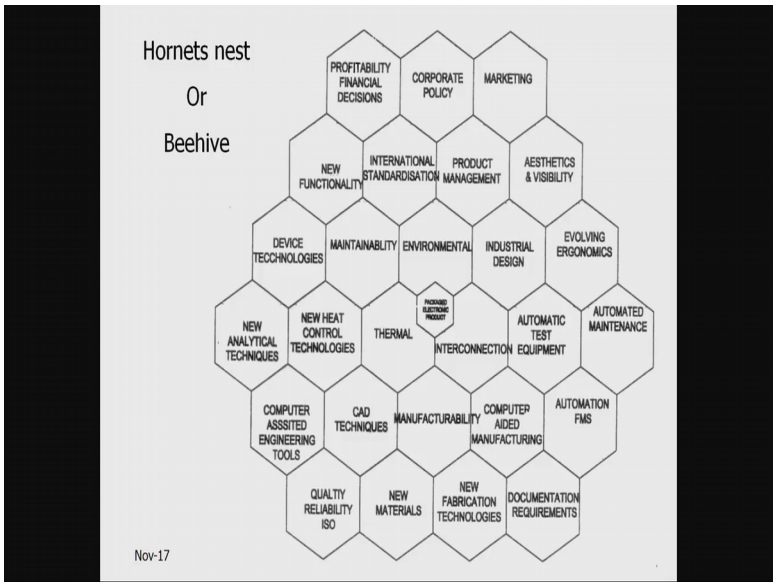

So, we see that the product real life product know is in the context of so many other things like this ok. In the earlier chapter I will talked about environmental industrial little bit of ergonomics and then product positioning and profitability accessibility industrial design, ergonomics and so on.

Now, as we come to the core part of it, one of the first thing you will notice is.

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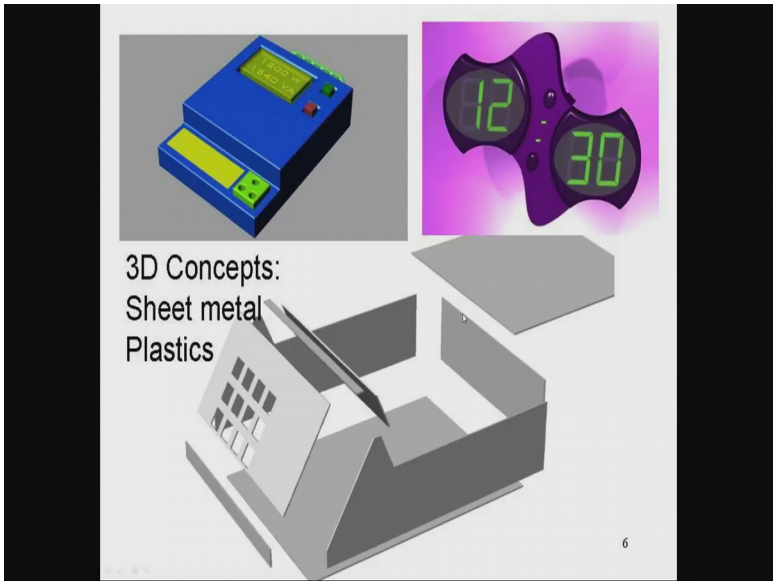

Real life products like this have so many other issues. One of the is manufacturing another is you see here it looks a whimsical design, but if you have to go into the market

and imagine this product, which is looking neat and clean and you are looking for a wall clock. I am sure this makes more sense in the in a modern decor I am sure you will like it. And some other things have been built into it is one of my students (Refer Time: 04:20) is one of them is mine.

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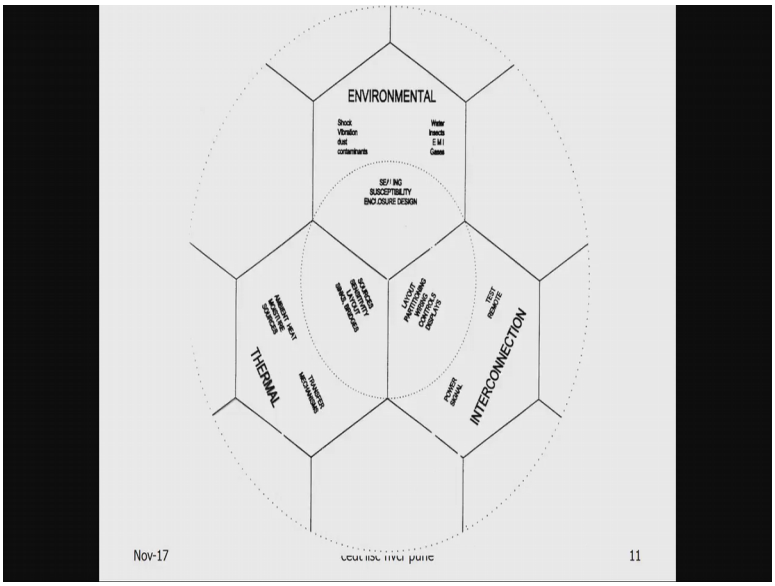

So, you will notice here that the important aspect of one of the important aspects of product design is, how to make an inclusion here and very much related to this enclosure is thermal. If you seal the box you can take the heat out at least intuitively it feels like that you will see the box you can take the heat or do you need to permit a few openings and if you provide a few openings all the stuff from outside gets inside.

Now, you may be wondering how do all the things work. Anything like a conventional thing like you are any of the domestic things inside your home if you have to have a washing machine. You see that that point which handles the liquid or the cleaning device is very separate from the electrical and other things usually display panel is on top, which is reasonably protected. Then you know various drum have a top loader or a front loader then you have several types of electronics and plumbing they are all identified and generally they are reasonable isolated can be dealt simply, but then as you keep progressing into more and more complicated things, design across this seems to be not as easy as it looks like you are seen here.

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I think this may be giving you a reasonably good idea of what it is I to have no clue what it is it you look like it may be a gaming PC and you say C 905 something and all and you will notice that cooling is not easy and some other beauty also one of the beauty is you will notice is it has several unconventional or at least know what attracts your attention you see here we have a very unconditional heat pipe, which is going about its work there.

Now, if my what do you call if you can kindly show me this sir I will try to view with the.

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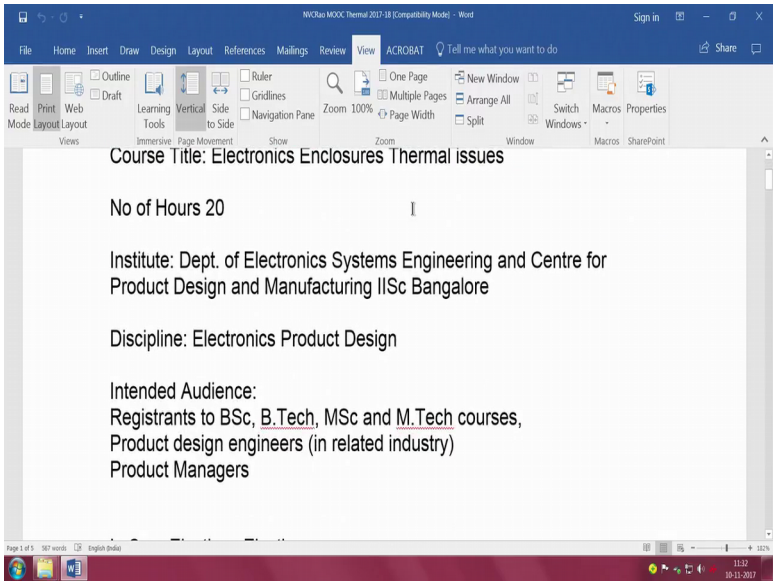

Page width electronics I belong to this place from IISC and down if you go most important is we have thermal design text books.

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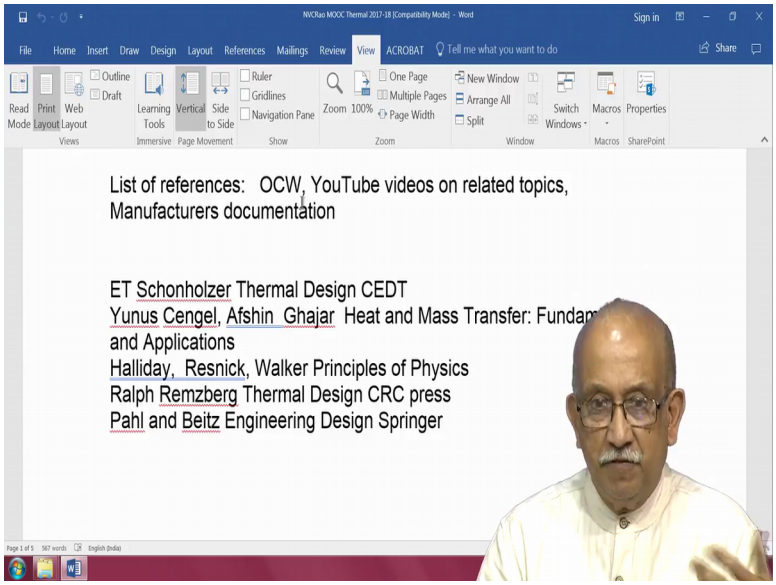

This is where the little problem will I want call it a problem its an opportunity for you, you can learn the fundamentals here you understand know. So, you have heat and mass transfer fundamental and applications and then the good old physics, then you have one more recently have found a good book which deals things reasonably well and something else saying engineering design. This is books are what you call sort of the core of it.

Now, you will see here list of references I have also provided something which is relatively open source. So, just like that I used a what do you call a (Refer Time: 07:39) OCW then you have YouTube videos and topics and then very important is manufacturers documentation. So, frequently I will be referring to the manufacturers documentation I think here we have product heat sinks blowers coolers mounting hardware and so on.

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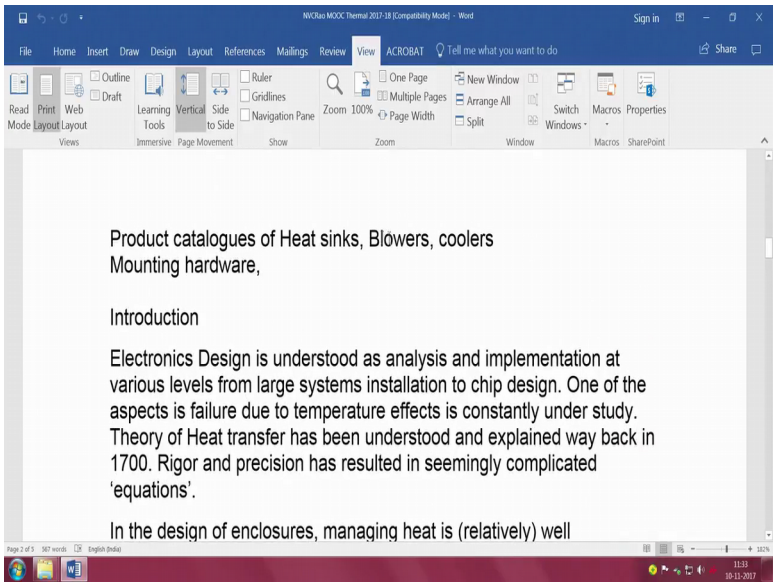

Read it along with me which we will be force to do. Theory if we heat transfer has been understood and explained way back in 1700 rigor and precision has resulted in seemingly complicated equations.

So, this is where the crux of the matter lies there is a lot of industry practice by I cannot saw what it is, they have been try to make things a little bit of understood a little bit of experimentation little bit of trial and error. And if somebody tells you especially one of the teachers tells you that he has invented the equations respect him ok. If you do not like your teacher shall end up being one of them and like me.

The thing is delta part of it has been then, but the basic things has been around for a very short time. ore over 300 years back anything you wanted to know has been simplified and presented like the saying. In case there is a temperature difference, they will be more he transfer in case there is more area of something else will be there, and this is the physics of reality then somebody has model them and made them equations. So, equations are valid with all the things that they have given.

So, I will now close this and try to now go back to a beautiful book here, which I suggest you people know should be able to probably see it on the internet and if you have access because this being an open source thing I read it for yourself you cannot copy it and you cannot this thing; however, you see here if you go for.

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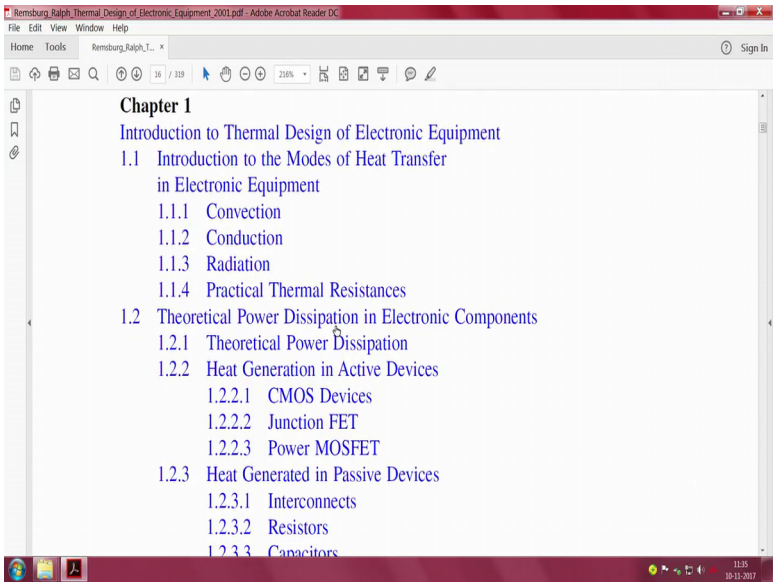

What do you call practical thermal resistances all these, somebody has already worked on it including a large number of heat generation in active devices what is it that causes this heat generation.

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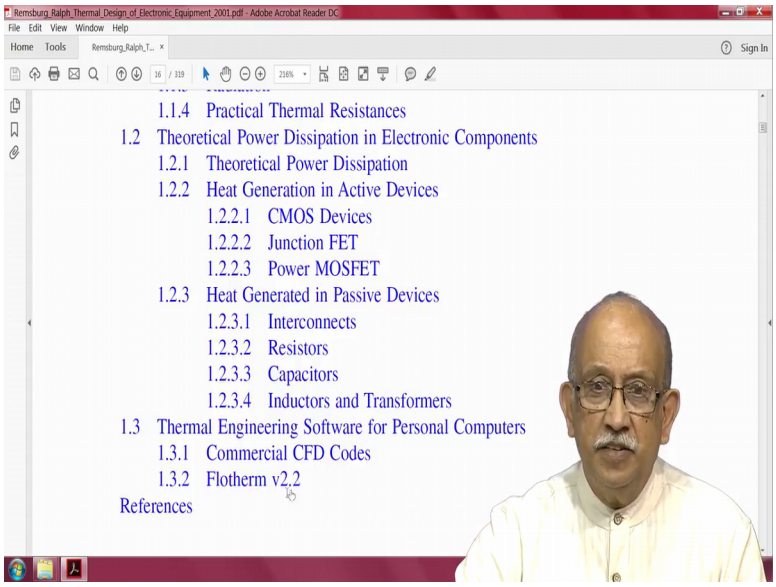

And little bit of I think several of us know or probably know the what do you call there is a patent not patent I am sorry there is a [laugher] what you call CRC press has released all this long long ago. So, I have not taken you knows any special what you call this

thing about it, but then permission from a this standard thing, which you will find everywhere.

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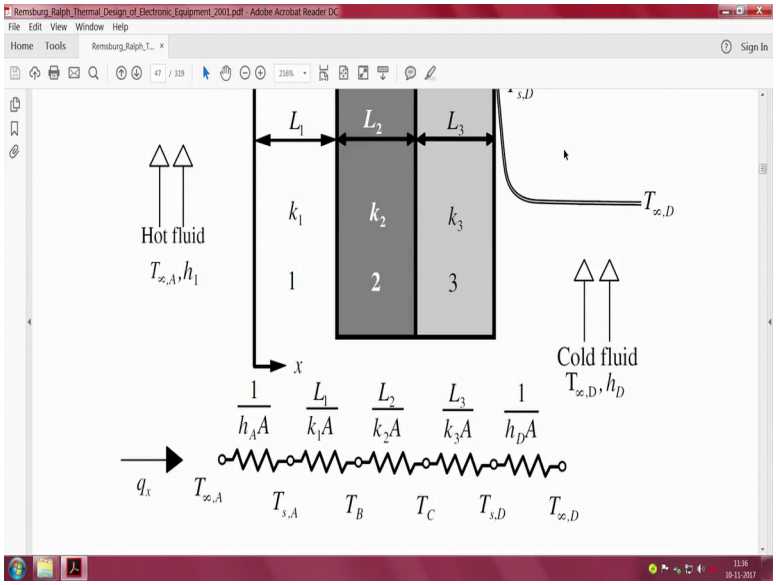

noise] I suggest you read the original or by any other text book and since you are taking it on one of our courses there is no exam you need to pulse and nobody is going to give you are not going to be graded you understand know. I cannot be judgmental about you I may be opiniated, but cannot be judgmental about you.

The only thing would finally, makes an impact is probably you have this beautiful phone you will seen that know by itself. It is a stupid clone do not say sorry for my words again being unnecessary.

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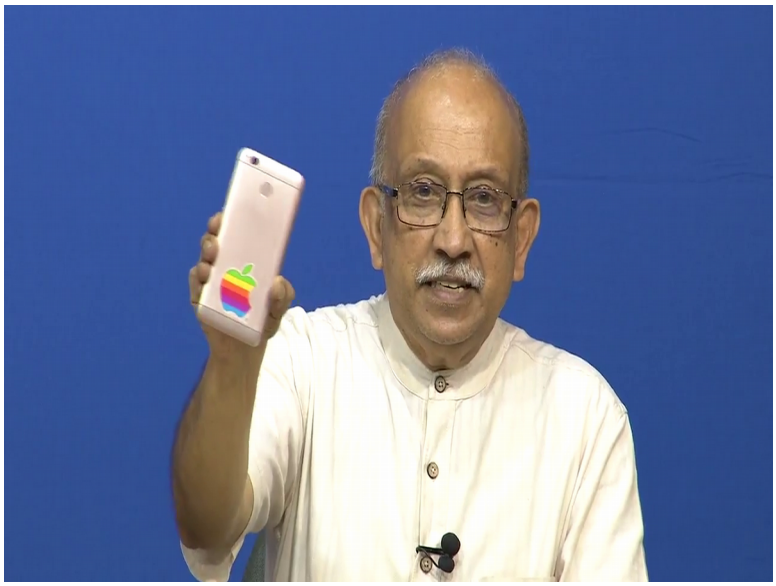

A colorful picture at the back does not make it anywhere near the origin, but I can copy a little about how it looks I can even copy; I can even copy and the various types of tiles and all that. So, you know what the user interfaces and you know you are all familiar with this sticker, but you know very well this is not the original you will notice, that somebody has spent huge amounts of time and money to optimize every aspect of this device including we have now suddenly a fingerprint sensor, and then I have a box and then I have something here in all that same it is with our case.

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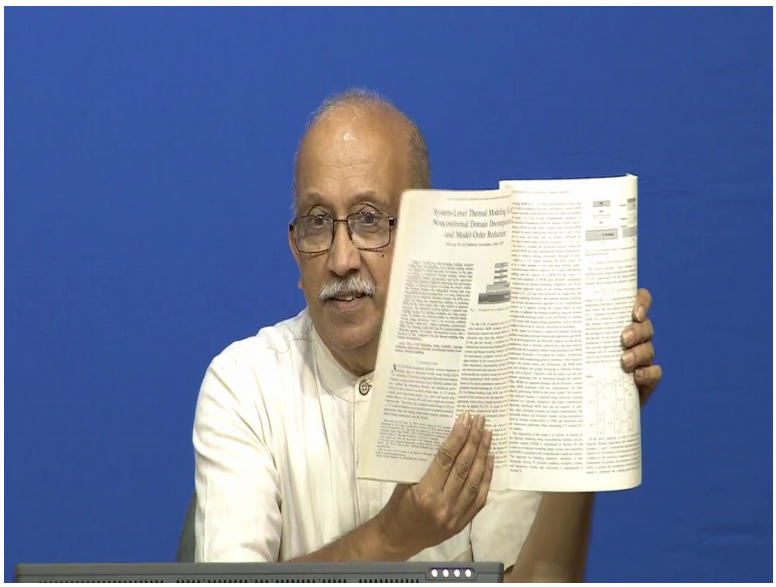

And then in this case you see here we here we have we continue to have journals like this, this general journal now is a recent thing it was made in probably 2014 I triplet transactions and components packaging and manufacturing technology. Even today, if you go around and if you subscribe and if you belong to academic place like ours; so we access to these things.

In between the pages lot of things are packed you have seen this some of them are real. Real means if you conduct the experiment the way there that has been done here it will work very well. And secondly, somebody has already done a lot of work on how to carry out an experiment including you have fantastic things like saying system level system on package l band antenna and so on. So, in these cases you have huge amounts of information which is thermal modeling seen this its real thermal modeling all this has been done and academic somebody has done at all the trails for you.

Now, when you come to a practical device this is what I keep.

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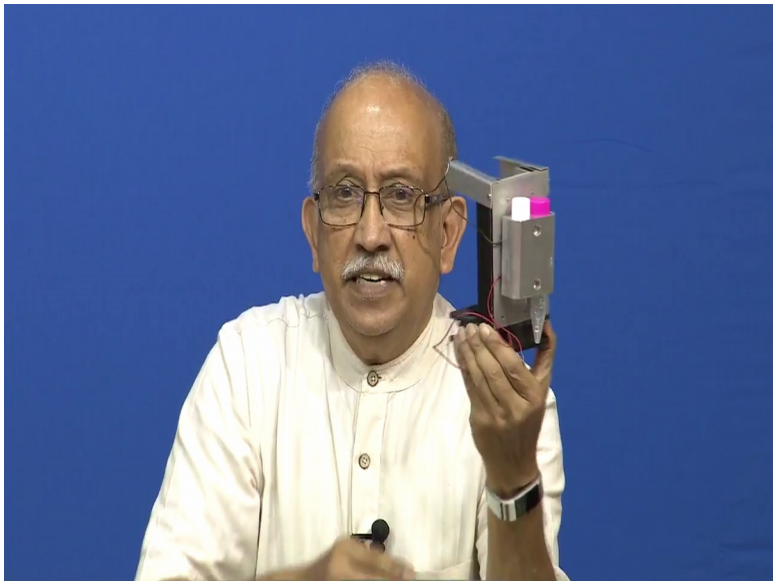

Trying to show in my lectures you need to use your own creativity and try to see how best you can solve the problem. If you have found out a way of conveying this device, then you can analyze it before that I do not know whether anything can be analyzed.

One of the peculiar question says you see this black stuff here and you see there is something here the beautiful colorful thing ok. Maybe it looks a little like a some device

which can make ice candy and I am sure several of you have seen this is where the thing about conventional and nonconventional cooling comes.

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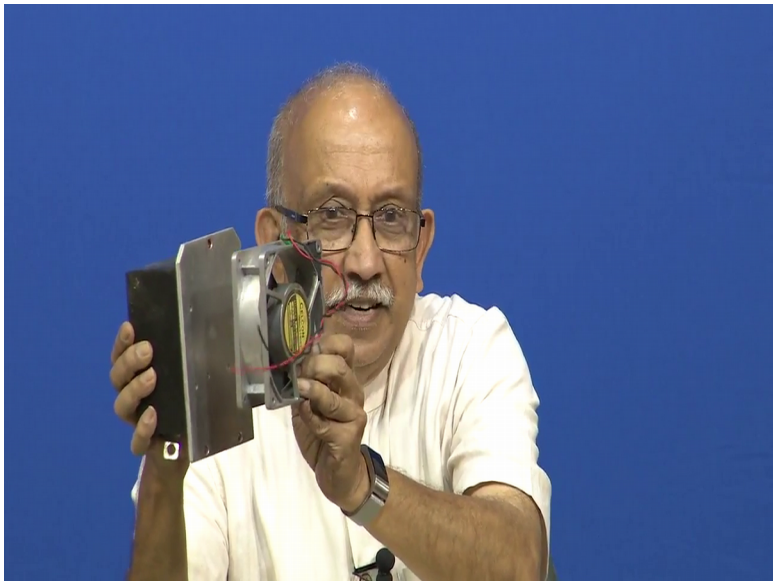

Its looks like a little bit of what you call I want call it a surplus yard, this is the reality of electronics packaging see this beauty this beauty is a device, which supposed to work with 180 amps speak and 36 volts nominal dc drive. The beauty of it is its nice compact and they have given a beautiful surface here.

So, something is written here. So, if you I mean just like that it if you multiply say approximately 150 into this 36 volts it comes to 5 kilowatts that is a lot of lot of power is it not. Now comes the comes the thing does it really the load is 5 kilowatts in the peak average when things run know it may be bearly about 2 or 3 2 kilowatts maximum or approximately 1 kilowatt.

Now the things come about where the mechanical engineer should appreciate the electronic saying usually if you are working and part lord conditions even with switching devices chances are you may end up with losses and any loss ends up is heat. So, if you have to take a one kilowatt device and 90 percent efficiency still you have 100 volts of loss there is no way simple plate like this can loose that heat now we end up with the manufacture know usually two ways they do, they will give you with fine print all over things are valid provided this surface is kept at 50 degree centigrade now how do you keep it 50 degree centigrade these are our problem comes.

Obviously are very simple way one of the simplest way is attach a heat spreader to it, and put a fan looks good enough is not it small heat spreader and a fan alternatively if you suspect the fan itself is going to take I have put this monstrous thing on its you have seen it know oh I am sorry I put this monstrous thing on its.

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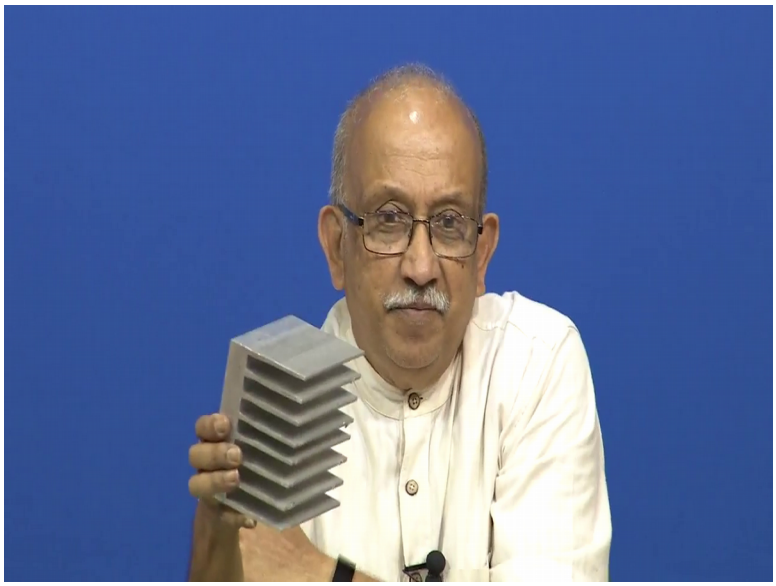

So, we call this. loosely it is called a heat sink the word sink know also I mean there is a semantics about it saying heat somehow keeps going of into it. It is true probably for this part of it you understand know it is true for this part of the device; massive, a massive then afterwards you have this fins this fins need to exchange the heat to the ambient.

Now, we come to the other important aspects of it. It is very heavy you will get a muzzle building thing. Instead of now putting some monster like that there, can we do something about it can we use something which is slightly better and this is where it will come to the original packaging thing.

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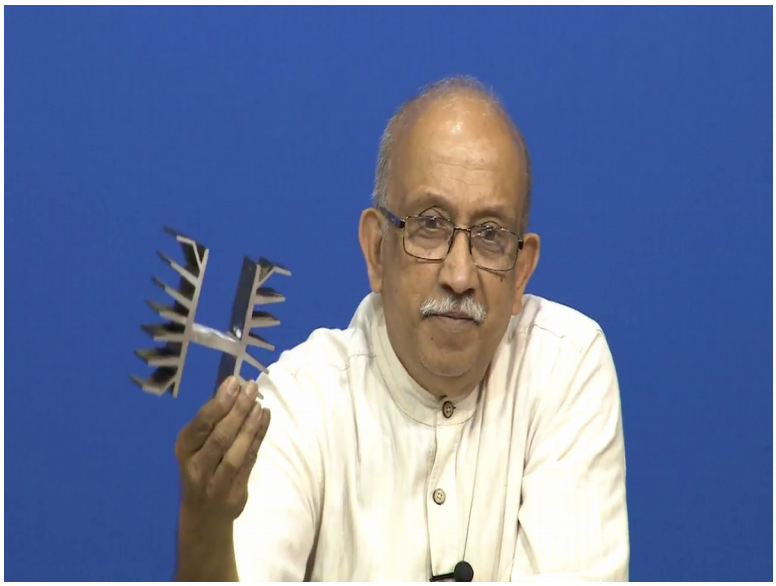

This is nice neat sealed equipment by default probably it is an ip 55 or ip what you call 56 a type of equipment. So, it is splash proof and accidently even if water falls into it nothing is likely to happen.

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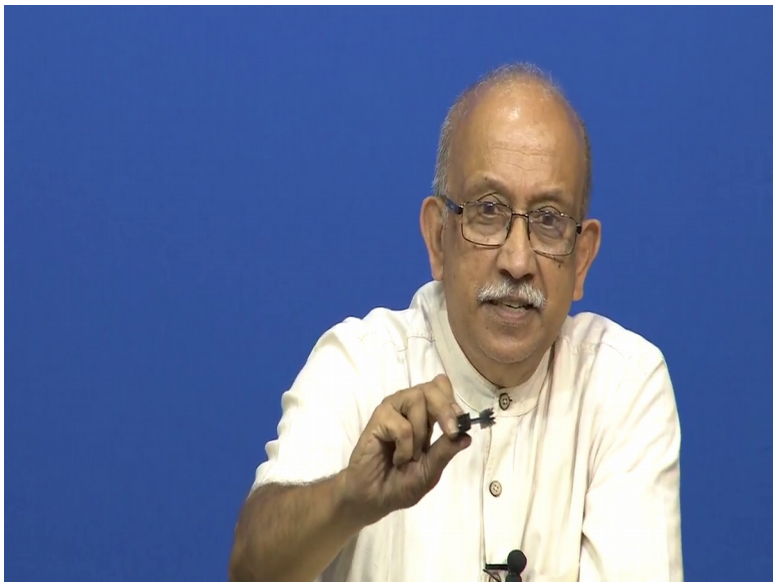

Next what do we do about the small what you call small thing which we will like which we end up mounting at all I think my shirt will show you this or you can see here, know what do we do about all these things these are all this small heat spreads, which use all the places and not as if we have stopped it here, you have seen this we have another.

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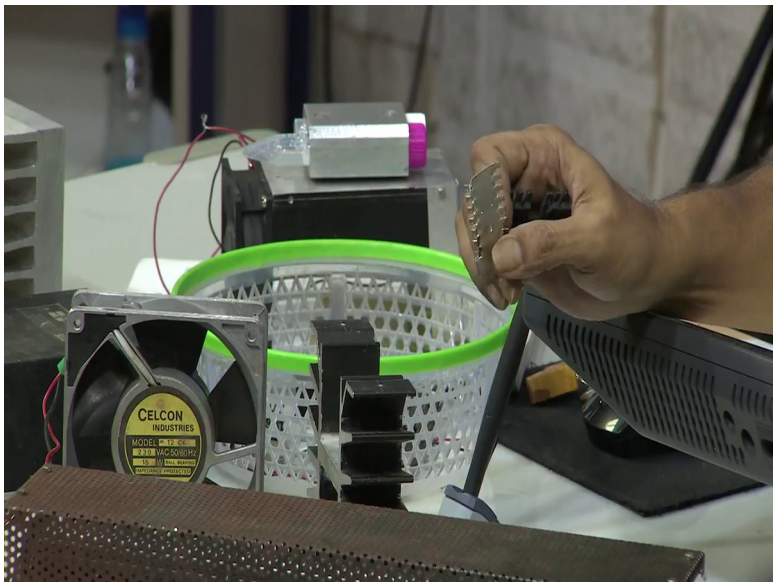

Very cute this thing now a shining heat spreader and for good effect somebody has made it black.

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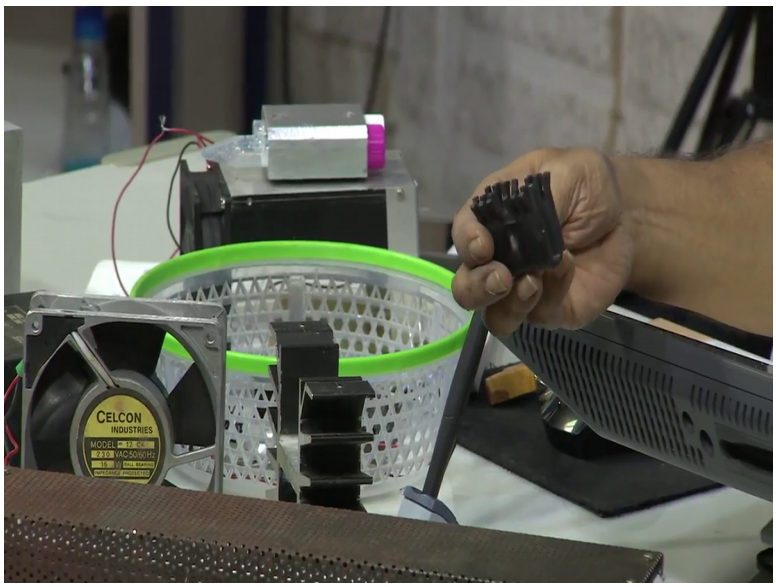

So, this lecture tries to explain to you a little more and then as I have explained to earlier there are no automatic what you call questions and answers for these things.

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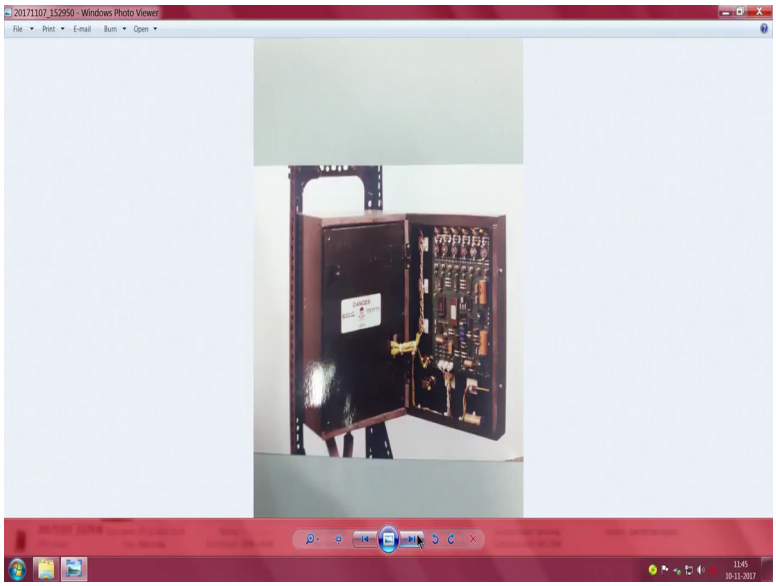

It is for you to see towards the end I have shown these pictures there is a drive, and when you open it these all things look like.

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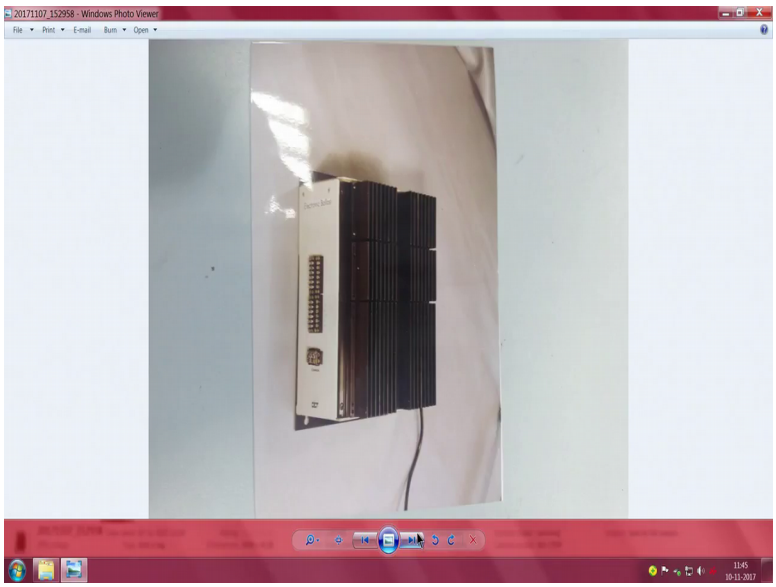

And this again one more thing about the orientation how do you keep it and all that, these are little practical things which we have been implementing in are research lab for a long time.

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Again this where I have explained in one of my lecture saying in the academic, we have a such once you define a problem which one would which problem I would like to study in detail. So, that you can improve things in it what do we do? First of all we will look for all the existing publications in these are best called literature survey understand know? We carry out a literature survey to see, what are all the publications that are existing, equivalent to that in our product design is prior art.

Whatever you do can be if it is not already open source and if you can justify of you have done it you have to make sure it is already not patented by somebody else. So, one is patent search another is prior art. However, is the other people solving the similar problems; so in the case of our product design, now if we come back to my monitor here.

One of the first things are we need to check know. However, people making these things here.

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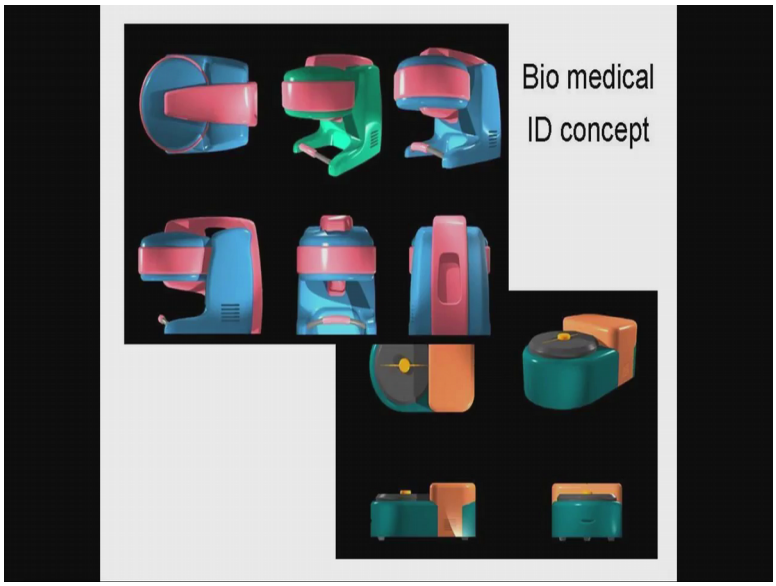

There is something about IP classes and you will see we have beautiful I do not know some nice a colorful equipment is there, what exactly is the equipment I to have interest I means sorry though I have done it I have to Know firsthand knowledge.

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You will see here are electronics invariably ends up with being out in the open and instantly open source, I think you know if you identify all the components you will know what it could be this one is a drive for a electric vehicle.

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Now when you see if you have a drive for the electric vehicle, top you see here this one is the raw electronics circuit which he one group has developed like that afterwards you know we took a look at it again and then we try to package it ended up with some things like this which are somewhat commonly used in the industry.

(Refer Time: 21:58) the issue is they are commonly used in the industry. There are somewhere the moment you have pins like this it means power is taken from a source, and then you have output this is circuits. So, power is given to the other thing. So, they are all color coded and various things you know which he are attached to this, I thought I will just take you here and stop it here. I will given a escape and then I will go back to the main monitor here. We have this data acquisition system which was made for a solar tiny power plant.

Elsewhere I have already one of the lectures if you follow know, we have I have shown you an actual installation where huge recommended equipment there.

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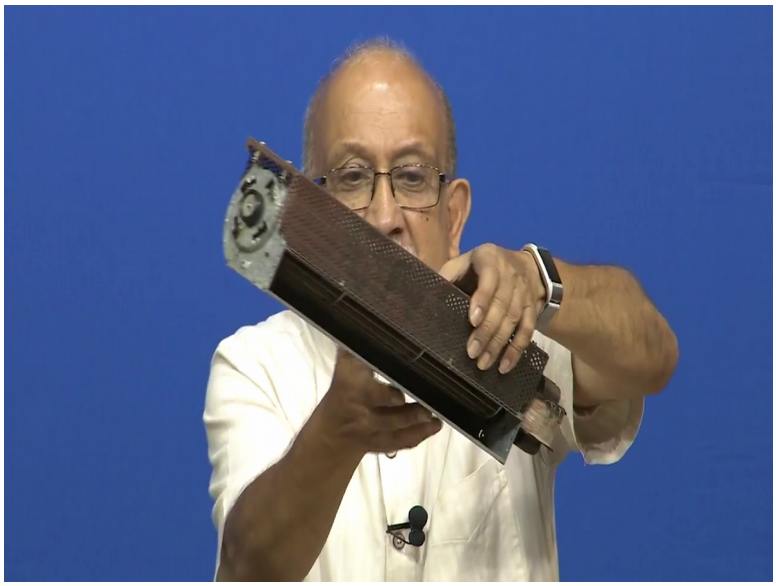

A have a look at this, this will looks a little like your what you find usually as you enter into a room now.

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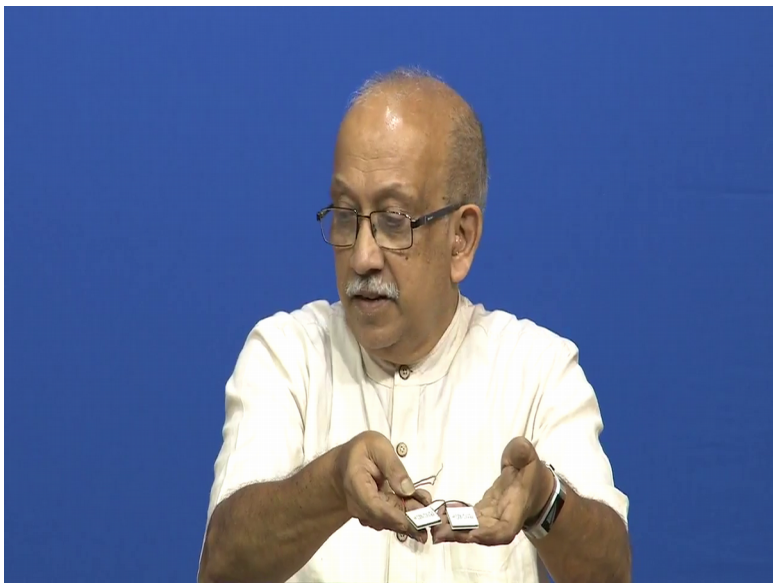

It looks a little like your air cut in fan in fact, you can this is small air cut in fan now where do you such things. So, if you have to have rows of heat sinks probably you can use it for lifting the air.

So, samples of I know place where a solar installation is there, how air is I mean cooling air is handle including for a large place meaning you have something of the size of a

huge building. And all the way to tiny things like how would you cool this device while in principle it looks very nice we have a nice simple thing, all you have to do is if you put two of them we have two of them parallel ; obviously, more area is available and then you can also cascade them. If you cascade them, you can get better I mean whatever temperature differential.

But only if you consult the manufacturers catalog, they will tell you under what conditions it can maintain this various parameters which have been taken away. If you keep it in the air like this and show you and if you put a small what you call thermometer in show, its not a where a reliable way you cannot you cannot go ahead and design equipment like this. In contrast the same device is sitting here seen this know in between it is sitting here, and one side the heat is being generated other side we have provided a thermal mass for something, these are biomedical equipment.

. So, we have something one sample is kept here it is heated and cooled and this has been taken from this whole thing is insulated, and what looks like a candies, but this is the probably a [laugher] urinary sample, which we need to collect it quickly freeze it I am sorry not freeze keep it a lower temperature such that activity has stopped, then we have two things one is a control is a control and this one is a the actual test.

So, this is kept inside and this is kept inside some various reagents are added typically antibiotics in the end, depending on your BMI depending on the reagent and you are what you call already resistance can quickly identify, which medicine works on your particularly on the target thing.

And the beauty of it is things like this are not very how do you say not good I am I am not so much convinced about it. But still they have a use for it where you have to raise temperature to beyond the above the ambient similarly, quickly at a given rate you have to cool it to at different temperature. So, this is typically a peltier thermoelectric cooler device like this. So, this lecturer has to do a little wire like this thing saying how do we go around trying to know understand things which are there and so on.

Now, go up again and then see ok. Now kindly if you look at my the other monitor, you will notice that using an available commercial software I would like to see whether we can create things like a I have a heat sink there seen it there.

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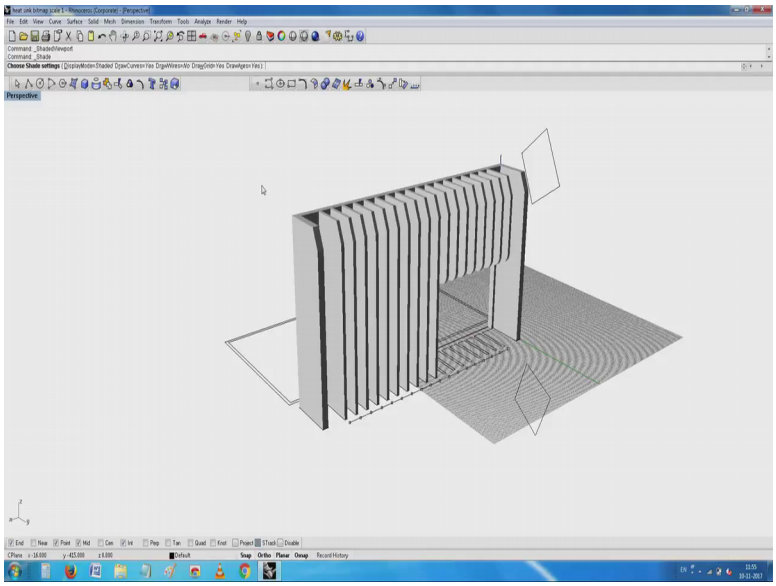

I will started with something which is directly available on the what I call the it is available on the proportions for this have been taken from here seen this here.

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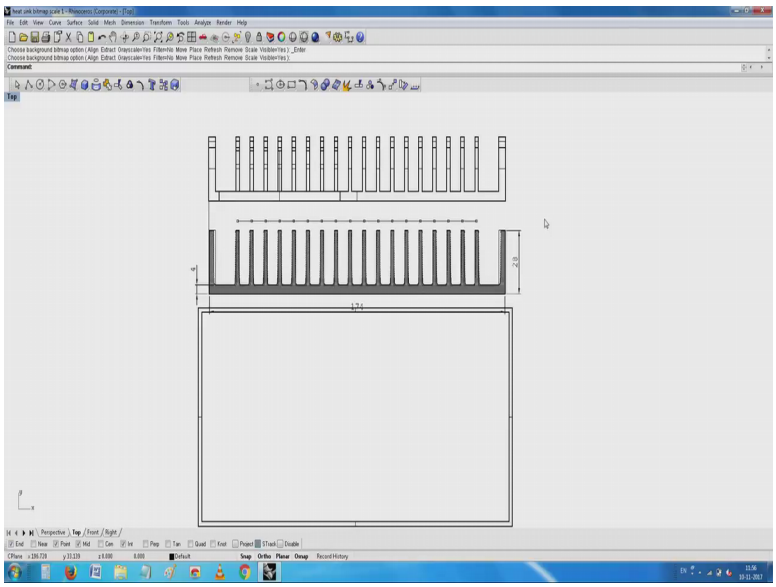

See the back see at the back that is a commercial what you call heat sink which is available, see there the dark one is the heat sink that has been taken directly from the manufacturers catalog.

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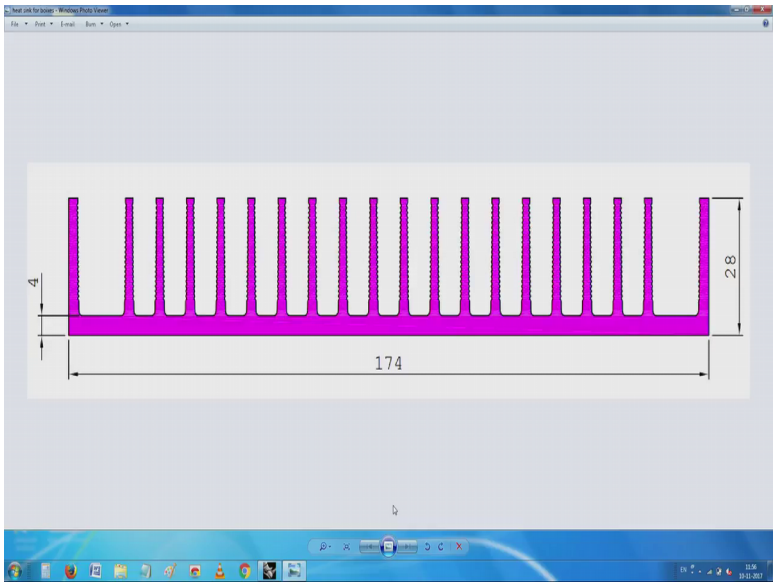

When we work in real life products we do not every time go about reinventing the basic things like devices like this the heat sinks, and then devices like this fans and so on similarly most other things are taken are adapted from plain old of the shelf items commonly available of the shelf items.

Advantage being everything has a an alternate source and only when things are in very large numbers are they are very what you call very specific as in let us say if you need to send out a satellite, only one satellite it will be finally, launched, but when we start know I think ten of them are made anywhere even they there is nothing like one unique thing everything is a minimum batches there. Such conditions it is worthwhile reinventing everything, but even there if you see inside the reference design for everything is already been tried and then incremental things are done on how to packages and so on.

. So, part of this course has been what you call as exposed rather I enjoy people being exposed to trade catalogs and then available things, and remember by just copying something from the catalog its unlikely you will come into any useful result. However, if you can source them and negotiate them and try to use commercially available things, you are much better off that is what I was trying to say all along in this.

Now, I will check whether where I am in this and keep looking at it meanwhile I will come here and say.

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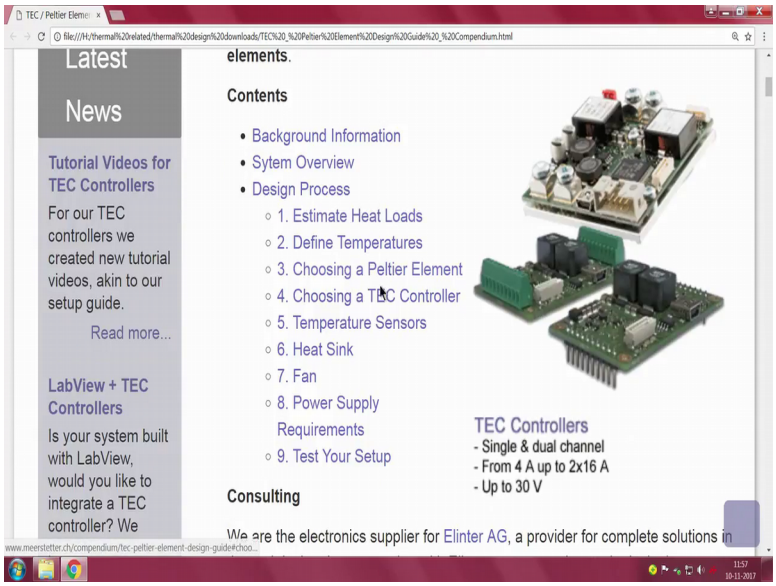

If you could see here they are beautiful companies, which he specifically for the components that they make they have gone out of the way and try to create things, which are seen here know saying tremendous amount of material is there on the system overview design process and important is how to choose a Peltier element ha choosing a TEC controller.

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As I said since we have this there all the time, it is much much easier for you to examine these things and try to use them as you are like. Unless you are a completely what do you

call somebody who is very much you know what you call you have a little problem with these things, starting with.

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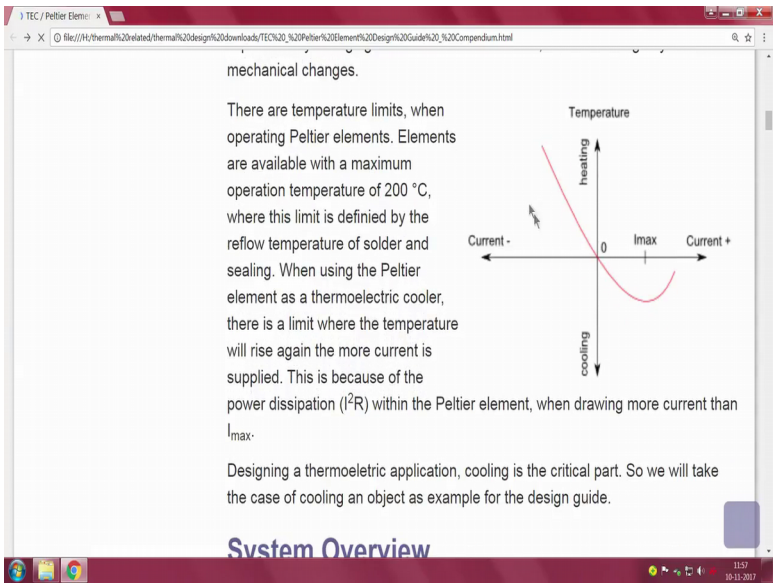

Very important things of what is the maximum temperature, what is the maximum current, and then how does this system things work what is the design process everything is very very clearly mentioned here.

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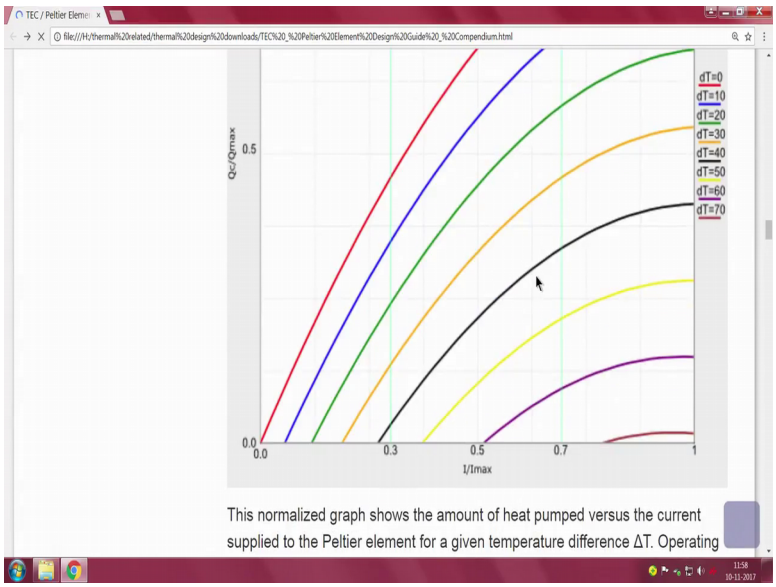

You can always this being video thing you can always try to go back and then check saying which is the maximum efficiency point.

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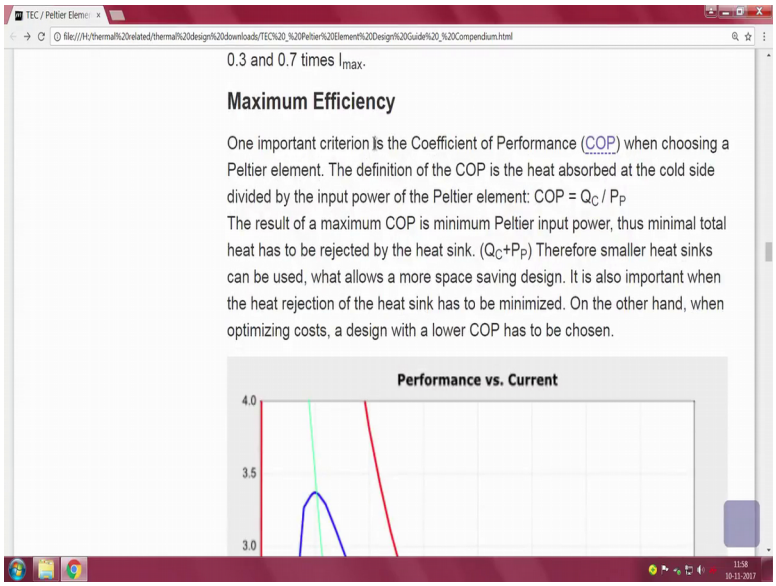

Coefficient of performance when choosing a peltier the definition is be it absorbed and so on and so know.

. So, the thing is these green lines know you.

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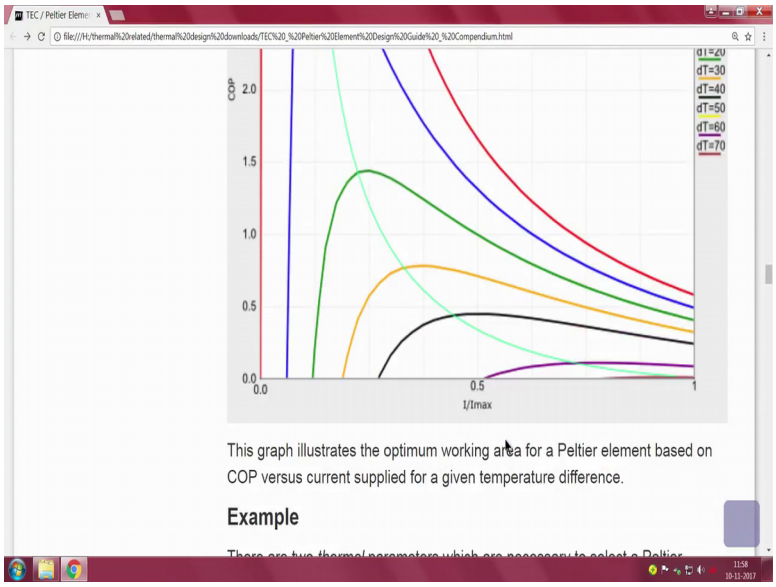

Will give you what is the q max and then which is the device you need to choose what is the temperature and so on know.

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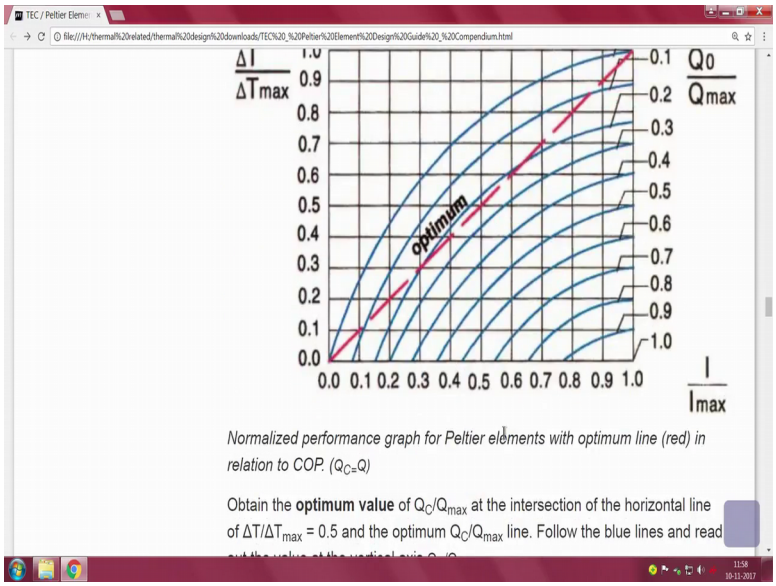

I think one needs to consult these catalogs, because for every device that is this much more than one manufacturer and they are contracted specifications are very very useful. So, practicing engineers will benefit probably by looking to all the items in the course, and one more time with both apologies in the reality is, they had no equations which will solve the problem. But tests which is see whether we have a understood as concept probably you know question and multiple answers choice are useful like that.

In reality you only have products which work under given atmospheric conditions and after its fully packaged and put to test you will know if the design is correct. So, we have failures occasionally and in the case of your what you call commercial items like I am carrying audio or rf audio transmitter, which is hook there.

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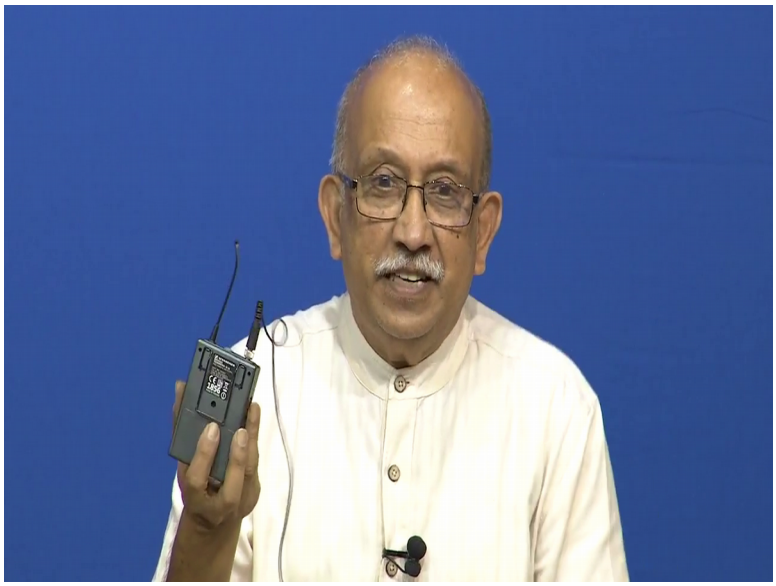

You know very well it has to work and in this particular case now it has rechargeable batteries then it has a charger and so on and so on.

Now, you know that it has taken a long time for them to come. This one factor I thing it know well and all of you people know about it has been in this business forever. So, has a serious researcher you can in case there is a problem in there is no one small problem you can improve same thing it is with several things I wear a in they can all hearing it cause a lot of money this cause huge amount of money. I do not know when your, I have paid 50000 Indian rupees for it; so it is money. So, if it takes something as a what you call a dollar equivalent to 100 rupees probably it is 500 us dollars and then in the US you may be spending a 1000 dollars to have it in your ear.

The thing is everything including the power supply including the audio and then it has it has a four channel dynamic compender type things you know, which are built into it and then it is programmable I have a switch I can choose between four programs for channels and so on other all very complicated miniaturized things. The same heat transfer devices which you have there are also used here and mind you it is it has two what you call microphones and it has built a noise canceling and it has you know and both the ears face control is there like this is the growth of electronics, and probably all the electronics which is inside here now including some equivalent to a Bluetooth is also built into it all

of them in two small chips and it has a tiny battery it is my life saving what you call devices I thought I will just explain to you a little about.

How do we go around you see here, this whole thing has been built on that same.

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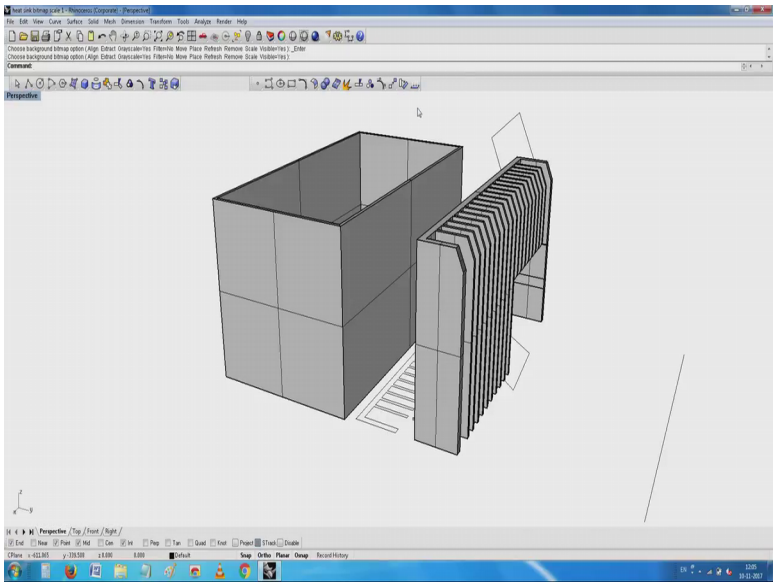

In the case of a practical device, how do you start with a enclosure like this and try to build beautiful equipment. So, the people from the academic community can benefit by a just following all the references and see how best you can make use of the information that I have presented here.

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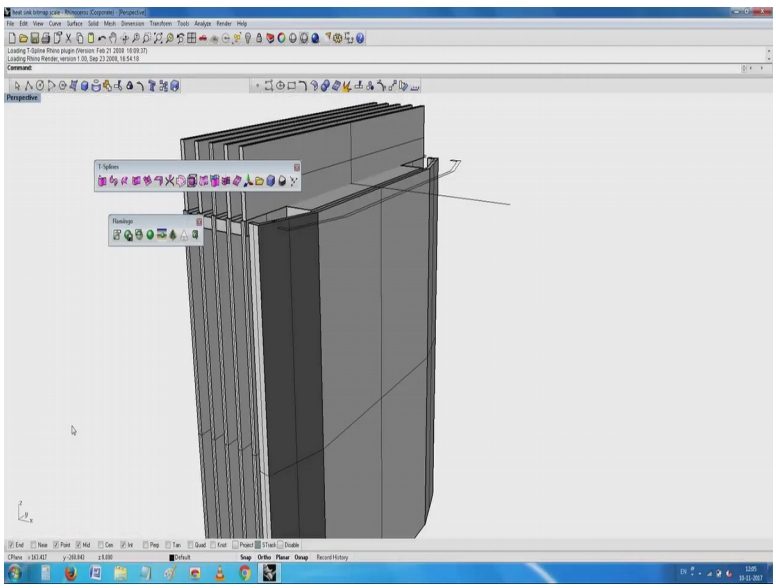

You see here at this point I have used the commercial heat sink and try to build an equipment in the last lecture, how well can I make an equipment which looks like this. This is about the concept design and secondly, most manufacturers catalog is will give you given length what should be the thermal resistance of the device. Further if you want basic equations everything I have been explained in the earlier chapters and then I suggest you refer to the original text books and we also have along the way we had one professor Schonholzer who worked with us and made all these notes thermal design of electronic equipment.

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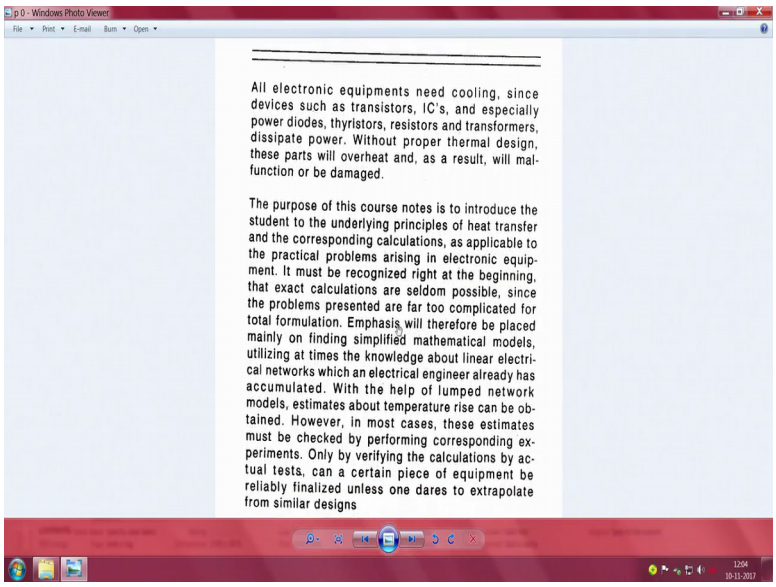

So, maybe you should understand just reading it a little more recognize right at the beginning the exact calculations are not possible shown also there has been around practically forever. Since the problem presented are too complicated for total formulation. There ore we placed and finding simplifies models times the knowledge about simple electrical circuits. So, if you go further down in the end of these notes, small worked examples and all are here.

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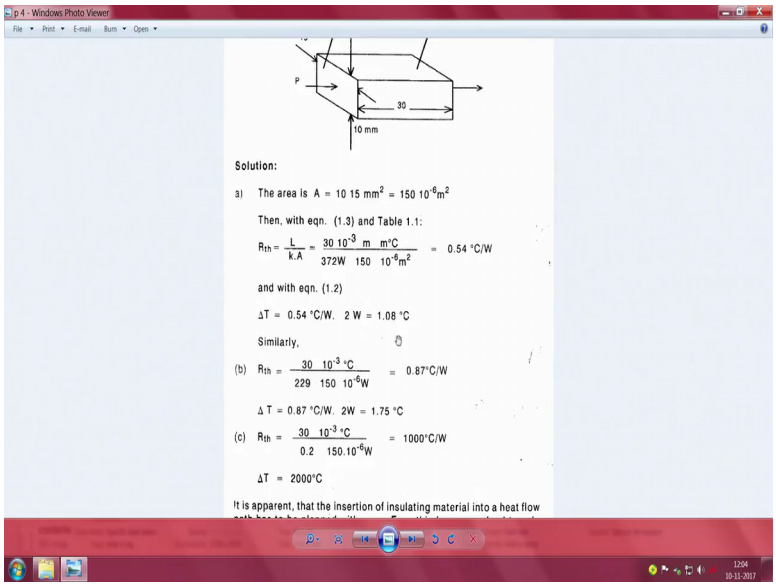

But then you will notice it that when you work with the small things like this you know, while the equations are about the same for both this an the monster the actual conditions are not that easily available. You see here I have to heat dissipaters something fully black on both sides, and something which has a cute area which is cleaned. So, does it have any effect? Does this what you call surface finish has some issue with it or what is it.

This things you know my repeating will only take us somewhere, I think you should face the thing automatically and you will learn nothings like this. So, a lot about there is a little.

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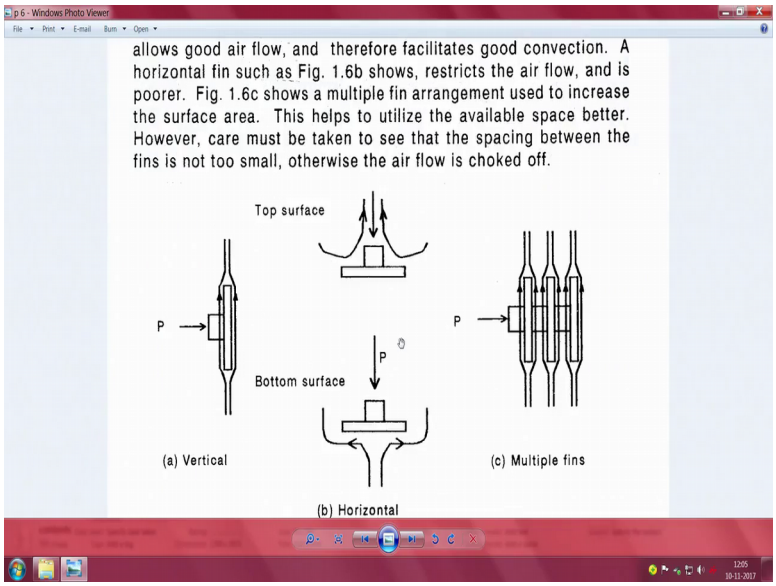

Controversial thing also between two of my lectures, you may find the little controversy saying how does the bottom surface of a flat plate work how does the top surface work, and then in case both sides are free and then in case they are what you call stuck together there are various things which are mentioned here.

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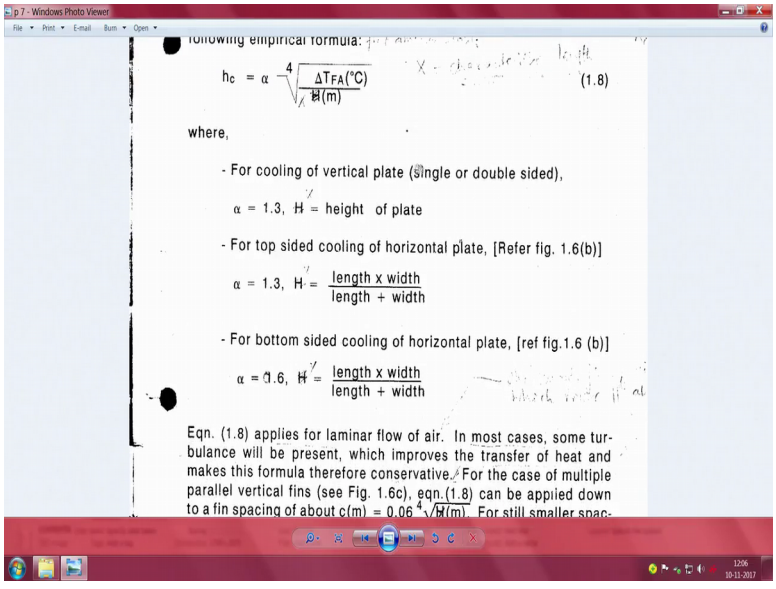

Most important is can you see here? This heat transfer coefficient in convection lot of it depends on figures like this, which are gathered empirically saying for bottom sided it is 1.6 and it is for you to verify these things in your specific condition.

Towards the end expect that you will be able to try and make equipment, and I can just say welcome to the course I want say welcome to the jungle or anything professionals will benefit by trying to go back to theory which is already presented, and also a few sources are available for the various components which we have mentioned and engineering students or any physics students. And all can understand saying where they have started 300 years back and I mean come here.

. So, thank you I can say welcome to the course this is again part of a large series one of the first thing is about the basic concepts relation of the product, second part is again the little focus on how do you provide a cooling solution and then I have try to show you very big things like a huge solar installation, which is put by our government in a place which you will see the pictures if you follow the whole course.

And then finally, very very tiny thing saying how do you cool a small area using a peltier and other nonconventional things there is only a passing mention of heat pipes that not very common. Same thing it is even a very very what you call transient mention vapor chambers, but they are very real and nobody should try to construct a vapor chamber it its not easy similarly you have called what you call jet impingement cooling and so on and so, on know all of them have their own application, which is not a very general nature.

. So, basically something how to use simple forced cooling, something about how to use peltier there is probably the most common that is used and then occasionally you have the things like if you see a so, called main processor cooler, you can see to improve the fin effectiveness what has been done. How the core has been what you call something has been removed something has been put. So, that over the end why this particular thing has a very peculiar shape here why is this thick and then as it comes here.

So, I will stop here, what you call invite you to go through these things and continue with your area of research or construction or anything and the only what do you call the answer to most of the mails, that you need to try and the closer you are it is the better.

Thank you let us stop here.