Lecture 34
Introduction to Hot-Wire Anemometer

Hi, welcome to this particular lecture. In this lecture, we will see, Electronic Module, for Heating PT Hundred and Operating as a hot wire, anemometry to find the velocity of air. Now, what exactly anyway that is, what do we mean by animal, anemometry? And what kind of electronic module, you can design, so as to understand the operation of that particular system. First let us, understand the principle and that I'll give you an example of, how you can design a quick sensor to understand the velocity of air, if you don't have, any more, you know, meter with you. Okay? So, first let us, understand what is anemometry? And if you see the slide.

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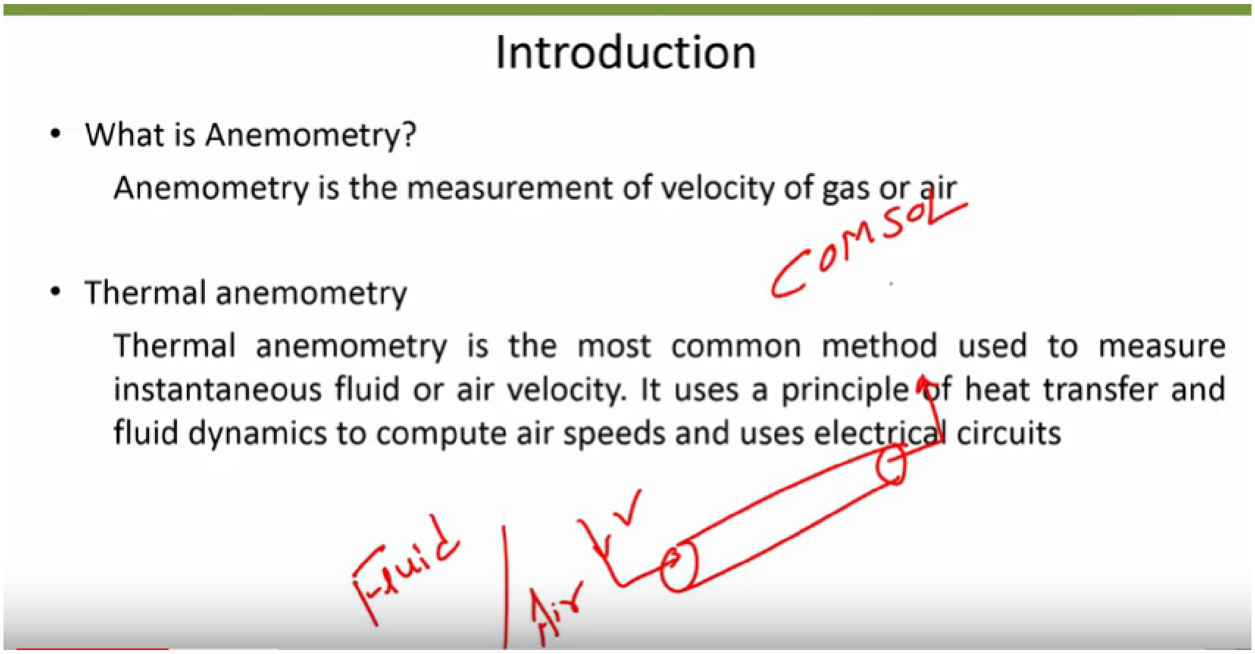

Anemometry is the measurement of velocity of gas or air. If you want to measure the velocity of air or gas, you can use the device called anemometer and when you talk about thermal anemometry, it is the most common method used to measure the instantaneous fluid or air velocity. While its principle is that, the heat transfer in the fluid dynamics to compute air speeds and uses electrical circuits. So, when there is a heat transfer, in the fluid dynamics or in the let's say, let's say, I have a cylinder, in which, I am inserting a air and the air comes out from the cylinder. Okay? I want to know, what is the velocity of this air that goes, inside the cylinder or that passes through this particular cylinder: What I can use it the anemometry? Now, the another ways that, if I am passing instead of air fluid. Then also, I can use the anemometry. And in one of the lectures, you will see, how can you design the fluid dynamics? Or how can you do the simulation for designing, such kind of fluid dynamic system, using a software called, 'COMSOL Multiphysics'. Console Multiphysics, we will see detail about simulation software, in one of the lectures. For now, let us understand that, how can you design a system, that can measure the velocity of air, in this particular cylinder and in particular, if you had, so that is a kind of sensor. Right? There is a kind of sensor or a transducer. And if I want to change the value are, the output of the sensor, to a readable format, I need to work on the signal conditioning circuit. And that is a part of this particular module.

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So, let us understand the principle of anemometry. And then we will go, to the next slide, I'll play this particular video.

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Hello, welcome to the Titus time hour podcast, I'm Jenny I'm, Misa V. Today I'm gonna answer the question, what is a hot wire anemometer? So, I was thinking about the hot wire, anemometer or the other day. Because, that's what you do and you work in HVAC or maybe it's just me, anyway I thought it'd make it this week's podcast, hot wire, anemometer used to be an option you can get on our VIP boxes, we aren't asked for them, much anymore but you will still see them, in lab equipment for measuring air flow. So, first of all what is an anemometer? An anemometer is a, device used to measure air flow. So, those spinning cups you see measuring win, are a type of anemometer. So, when the wind blows it spins, you get the point. So, our pitot tubes that you see in VAv boxes, as well as, cross flow sensors in the Titus VAv box. So, hot wire anemometry is pretty much, what it sounds like? It's a very fine wire that is heated and put in air flow. Air flowing past the wire, cools the wire down. Since, the electrical resistance of the wire, changes with temperature, you can use this change in resistance, caused by the temperature drop, to calculate the airflow across the wire. So, hot wire anemometry looks something like this, so it's usually on the end of a long probe or stick, so that you can put in the air stream. and then, there'll be a little, piece to protect the wire on the outside and then, you'll see the wire on the inside and you'll put it, so that the air flows through, the opening and over the wire, it's a pretty simple device. But, we use it every day to measure the, air flow in our lab. So, that's all a hot wire anemometry is Okay?

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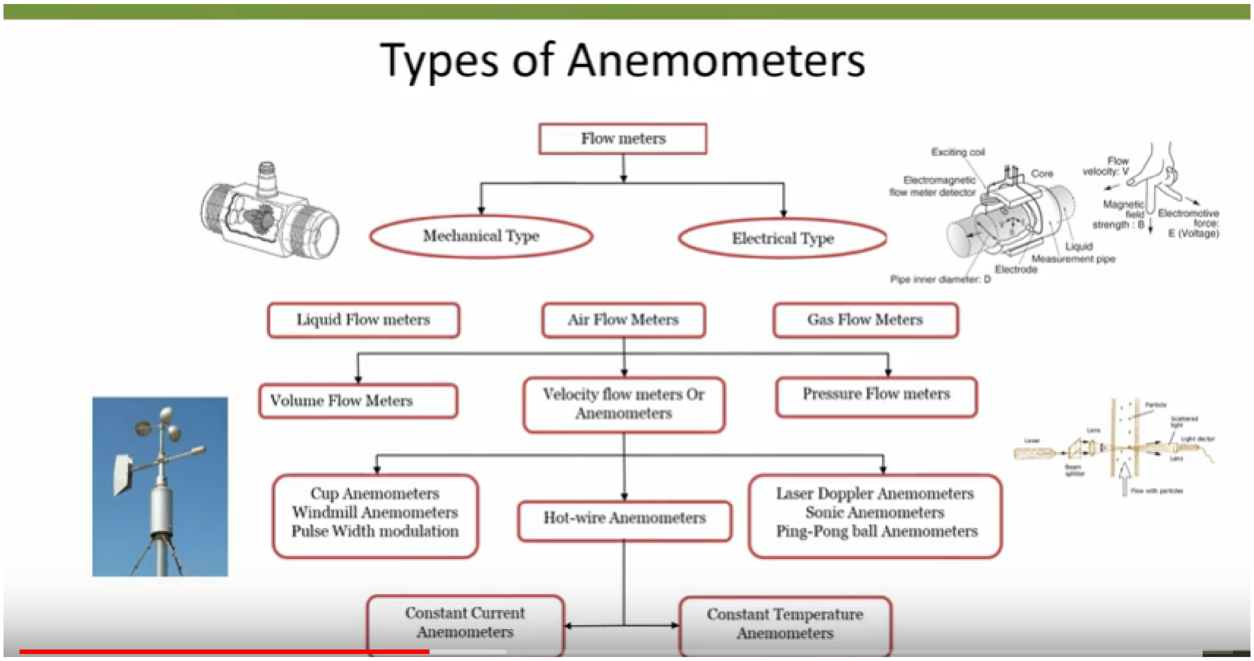

So, you have seen this particular video. Right? And what you understand is? That, what is the principle of the anemometer. Okay? Now, another point is, if I want to use anemometer, which kind of anemometer, because you see, if you have flow meters, you have mechanical type, your electrical type. Right? And then, you, if you further understand, then there are liquid flow meters, then there are air flow meters and there are gas flow meters. So, if I talk about, air flow meters in particular, because we are we are focusing on the measuring the velocity of air, then we have, our volume. So, that in the last slide, what I have shown you is, the principle behind anemometer. But, if I want to measure the flow of liquid, then also I can use the flow meters. But, but we are focusing on understanding the hot wire anemometry in particular. And that's why; we are talking about, air flow meters. So, like I said flow meters, can be divided into two types, an electrical and then further we have liquid type of flow meters, we have liquid flow meters, we have air flow meters, we have gas flow meter. And in further, air flow meters, we have pressure flow meters, we have volume flow meters and we have velocity flow meters or call, 'Anymore Meters'. Now, further you want to understand, what are the kind of anemometers, then we have, cup anemometers, windmill anemometers, pulse width modulation, based anemometers, then we have hot wire anemometers and then finally we have, a laser Doppler anemometers, we are, we can also have a sonic anemometry or we have ping-pong ball enemy a, anemometers. If you further divide hot anemometers or hot wire anemometers and we have constant current anemometers, while we also have a constant temperature anemometers .Right? So, this particular diagram is extremely important, to understand a different type of anemometers.

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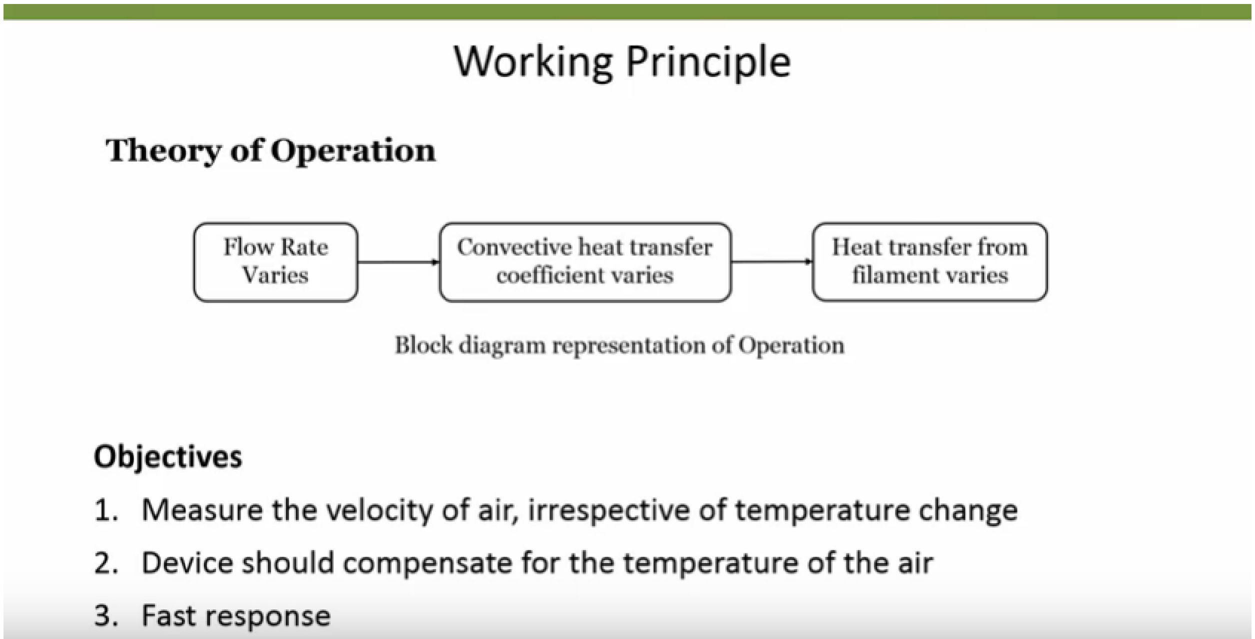

And then, we will see the working principle. As flow rate varies, the conventional heat transfer coefficient varies and that, causes the change in the, heat transfer from the filament. So what are the object is? Measure the velocity of air, irrespective of temperature change. Second one is device should compensate for the temperature of the air. And third one is the fast response. Right?

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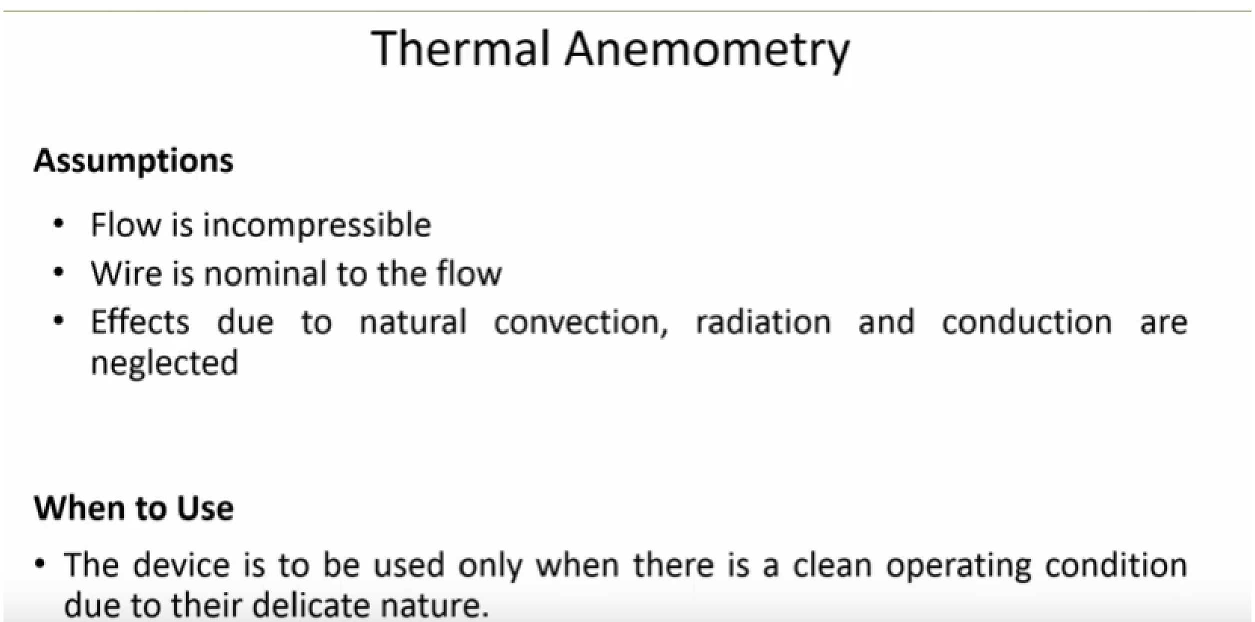

Because, we need to see that, what is a change? And when we are talking about thermal anemometry. We have few assumptions and we should know when we can use it. First is that, the assumption number one is, that flow is incompressible. Wire, second assumption is where is nominal to the flow. And third one is effect due to nature convention, radiation and conductions are neglected. These three assumptions are very important. when talk about thermal anemometry, where we when we talk about, when to use it, the device is to be used, only when there is a clean operating condition, due to their delicate nature. Right?

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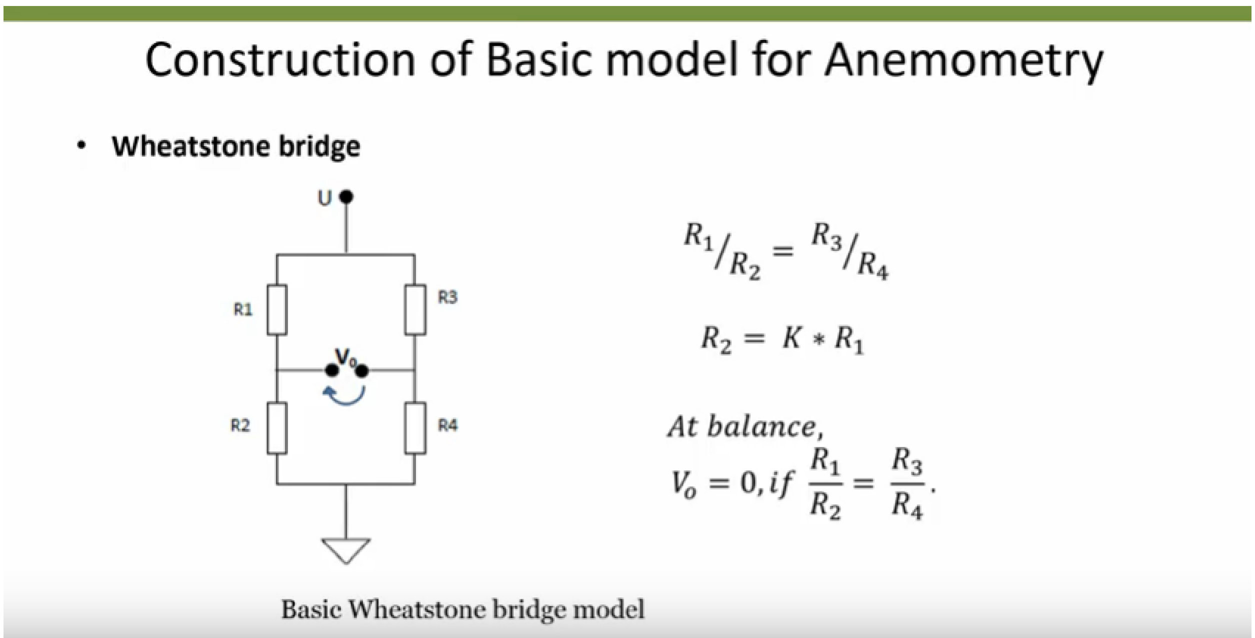

So, these are the some of the assumptions and the point. So, construction of basic model of for anemometry is with Wheatstone bridge. We will discuss about, this particular design in detail in the experimental class, where the TA will teach you, how to design the electronic module or signal conditioning circuit for, anemometry. Now, just to give you an example.

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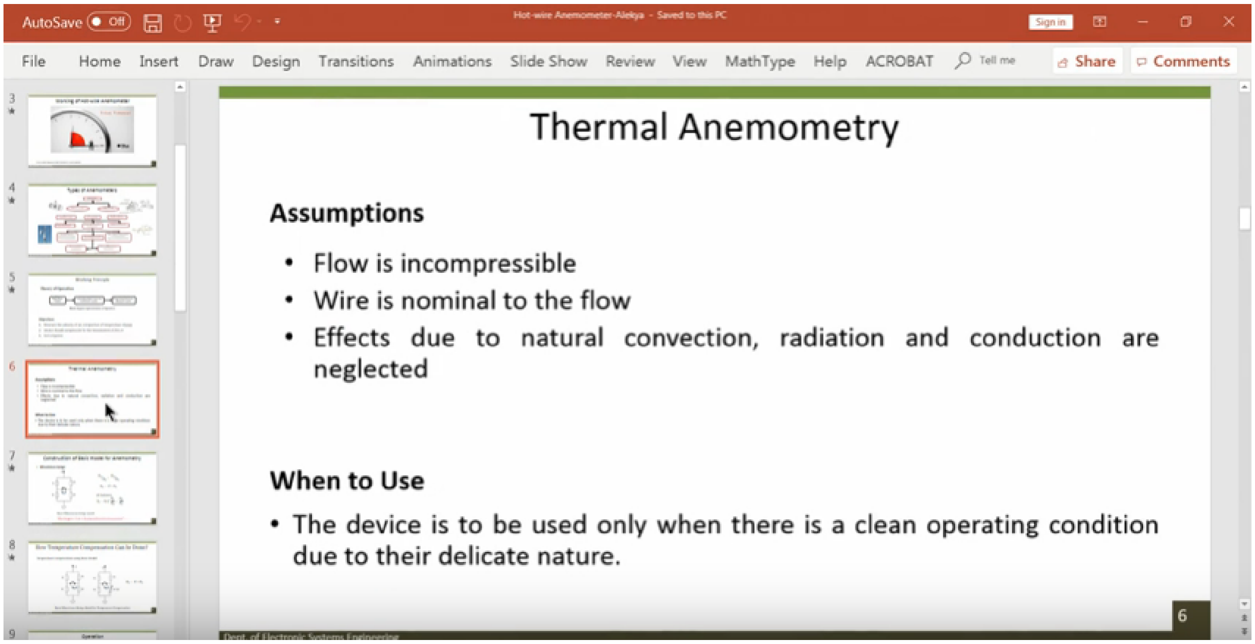

Let me just show it to you, how can you design an anemometry or a flow sensor. If you want to understand the flow of the, air in a cylinder. And assuming that is the hot air, well just air, doesn't matter hotter or colder doesn't matter.

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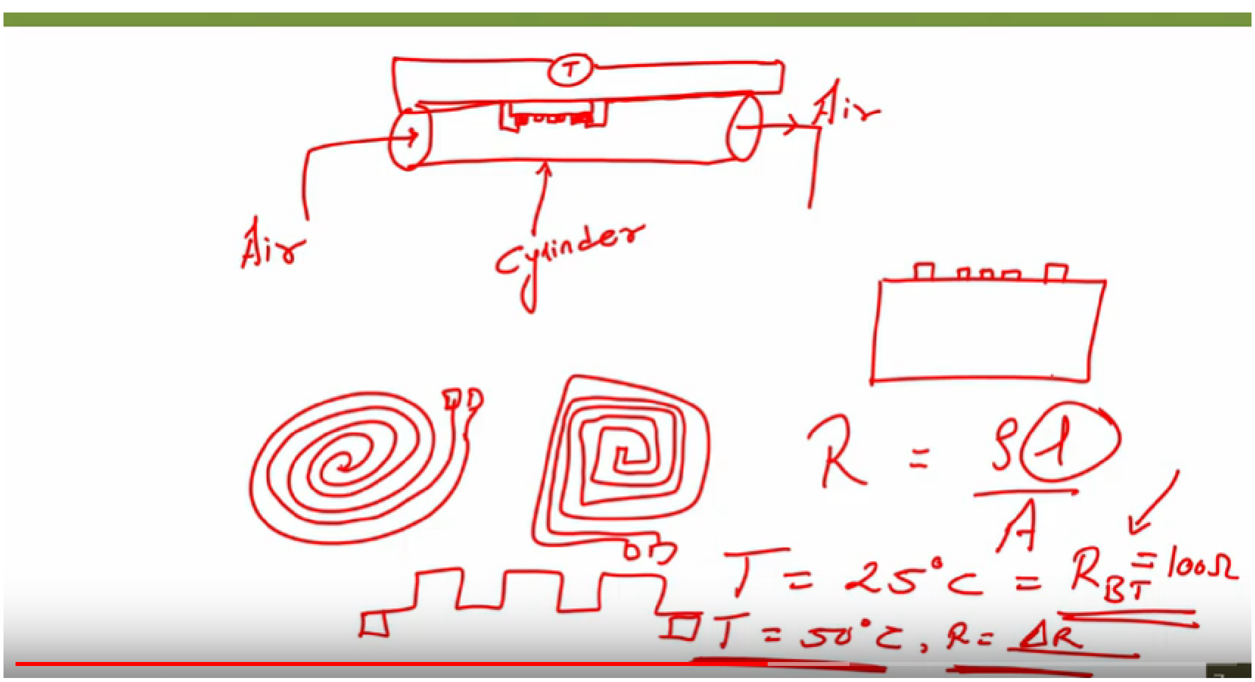

So, let me just draw a schematic. So, I can explain you, what I mean, suppose I have a cylinder and I want to design a sensor that can measure the, flow of air passing through this particular cylinder. Right? And the velocity of this air. Okay? I want to measure the velocity of the air, through the cylinder. Okay? So what can I do? The first and easiest way is, you can have, heaters or a sensor, with a heater. Right? yeah there's a contact pad and then this is a heater and if I place the heater, inside this particular cylinder, so let me just draw, so it becomes easier and I take up contact, such that, I had a contact on both the sides and the contact pads, comes on the both the sides, so here, I can measure the temperature of the heater. Okay? Now, I have a, heater in the center. And these are the contact pads, this one our contact pads to the heater and adding a contact out of, this cylinder, to measure the temperature of the heater. Now, you know that heater is nothing but, a resistor and we talked about register, resistor is nothing but, I depends on resistivity, land and area. If I increase the length, my resistance would increase, if I decrease the area, my resistance, would increase, resistivity depends on the metal that we choose. Right? So, for a particular temperature, for a particular temperature, let us say at true temperature, I would have a base resistance of the heater, to be hundred ohms. And as I heat or I just keep, I don't know where it is, hundred ohms. Right? Now, if I heat this heater, if I heat the heater, to let's say, 50 degree centigrade, I'll have a particular resistance. Right? Delta R change, to the initial value R BT correct. Now, when I flow the air, what will happen? Due to the flow of air, this temperature would decrease. Right? If my air is cooler, my temperature would decrease, that decrease in temperature will be corresponding to the decrease or increase in the resistance. Right? The decrease in temperature will correspond, to the change in the damp, in the resistance of the heater. Because, finally a heater is nothing but a resistor. Right? Either you draw the resistors in this particular format or you have, rectangular format. Right? Or you have a meander shape, sorry, just Right? Meander shape, rectangular coil or spiral coil, all the three things, what we are doing? by using the spiral coil, what we are doing, so actually it goes like this then you have to context is not sorting, this is not correct, there is a stable hand to get it done. So, you have a contact like this. Right? Similar thing goes here, you require a contact, where coming out of this. Right without touching and then you have here, two contacts. Right? same thing goes for here, you have one contact here, your second contact here, in all the cases if you have seen, what we have done is, by increasing the number of turns, we are trying to increase the length of the heater. Right? So, if you want to perform the simulation to understand, how the performance of this but three heaters, would be there, you need to work on COMSOL Multiphysics, which is the next particular, you know, next lecture in which we will teach you, this one and that is related to lot of application.

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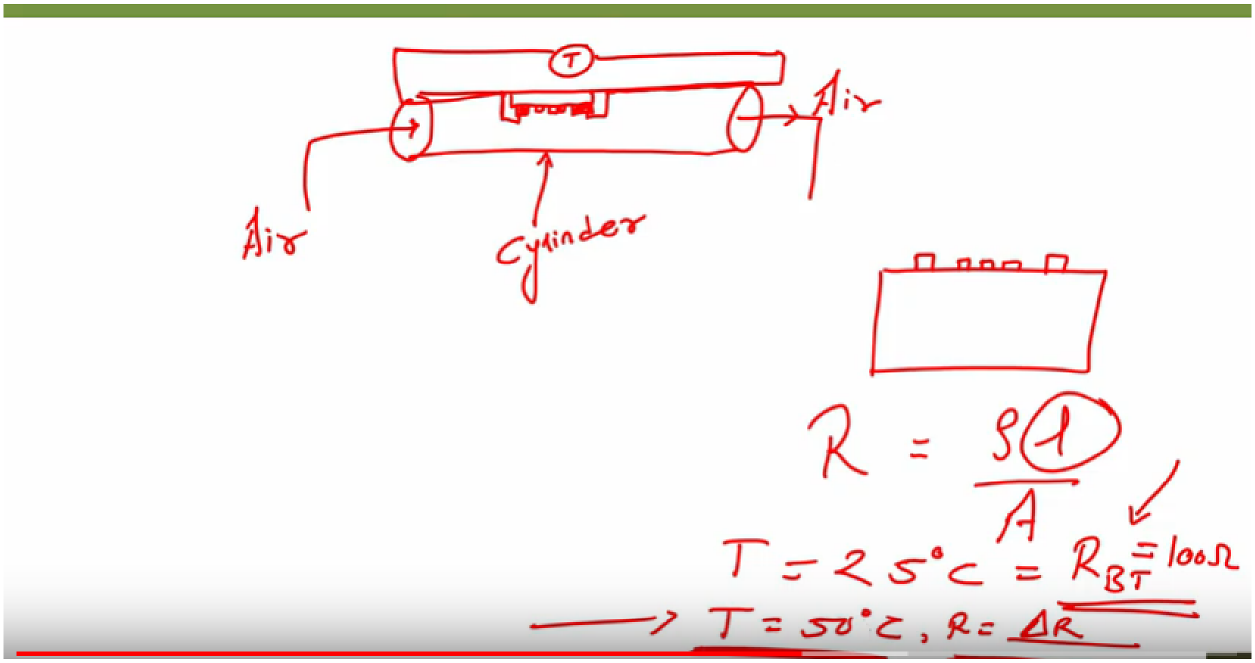

So, my example that, I was giving it to you here is, that if I have, a sensor or at the heater at 20, 50 degree centigrade. And if I flow or air, in the cylinder, what will happen? The there will be change in temperature, temperature will reduce and correspondingly, I can measure the resistance. So, the change in resistance would correspond to the chain temperature change. Thus, this heater can also work as a sensor, to understand the, velocity of your air. Right? Very easy to redesign the sensors, if you understand the basic concept. Right? Well you know, that when there is a flow of air, the temperature would change and if I have a heater, then my heater will tell, what is the velocity of there? So can I correlate that, that is the easiest way of doing it. If you want to fabricate a heater, I have taught you in my earlier classes, how to fabricate a heater. When you just quickly see, let us see, how to fabricate a heater, in the, on the screen. So, if I want to fabricate the heater that I can use to, understand the velocity of the air, it's very easy what, what we'll do?

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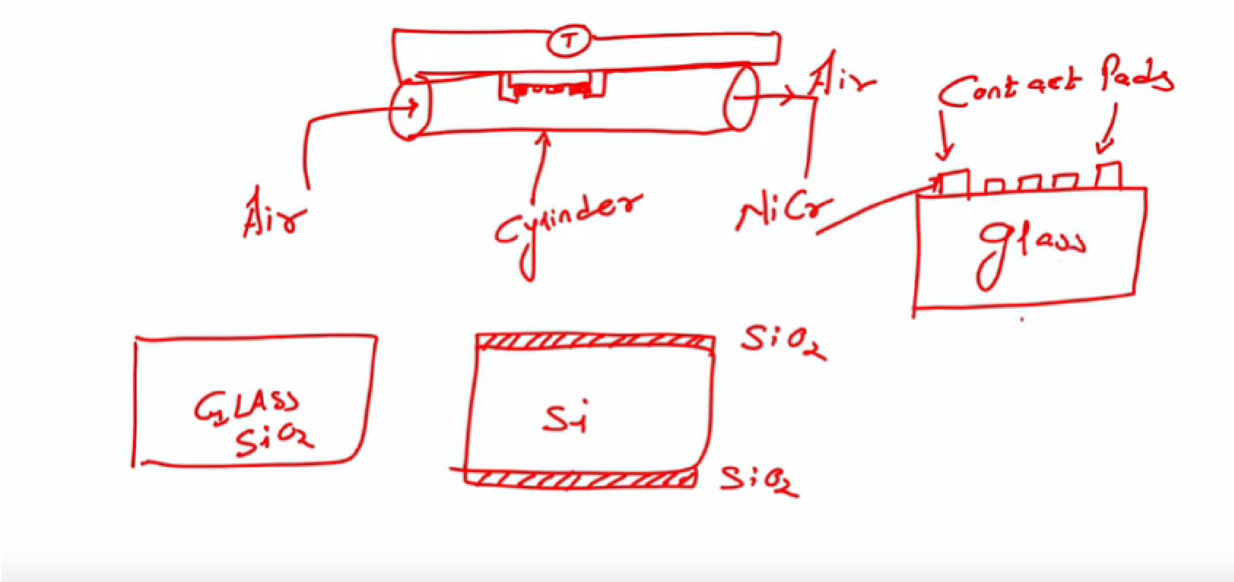

We’ll have, right’s If you don't have silicon wafer, in your, in your, in your college or university, you can take glass. Okay? Now what is the difference between silicon wafer? As a substrate and glass in silicon wafer, I cannot directly deposit metal, I have to grow, silicon dioxide .Right? I generally grow, silicon dioxide, you have seen on their lectures, in which we were using silicon dioxide or via growing silicon dioxide, on silicon wafer, in this silicon dioxide, would act as an insulating material. Right? What is glass? Glass is nothing but, silicon dioxide. So, instead of silicon if you don't have silicon, we can use silicon dioxide. there are advantages and disadvantage of using glass and silicon at some point, which falls more in the micromachining part but, right now, let us focus on, how to design a heater that you can use, inside this particular cylinder, to measure the change in the temperature and that change in temperature, will correspond to these are the correspond to the velocity of air, these are the contact pads, contact, this is C, cont act City contact pads and the material that we will be using is, chrome gold or let's use platinum, let use platinum or you can use Nichrome that's easier, micro. Right? And this one is my glass; I want to fabricate this particular heater.

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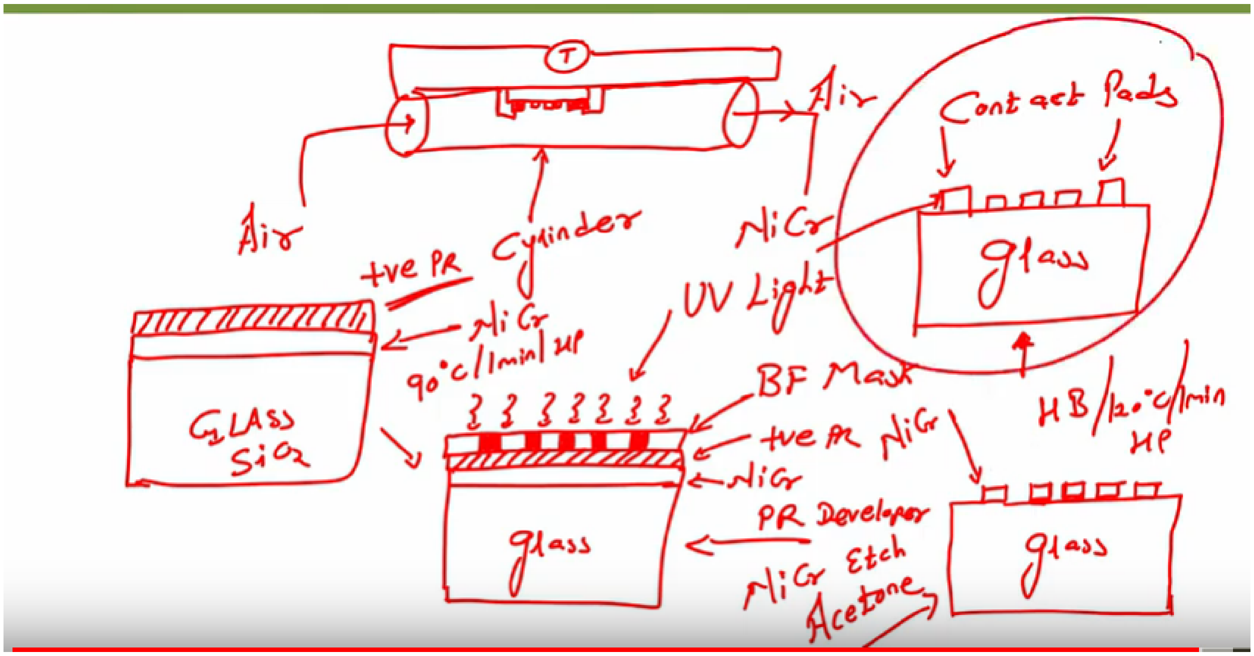

So what I am doing is? First I take glass, as a substrate and on this class, I will sputter Nichrome, what I'll do? As butter Nichrome. AlRight? Now, after sputtering Nichrome, I will perform photolithography, so first step is, we'll spin coat Photo resist, we will spin coat positive Photo resist, positive Photo resist. Next step is we lower the mask. Right? But, before loading the mask, what we have to do? We have to, we have to perform, soft bake. Right? So, after spin coating positive Photo resist here, what we'll perform? we perform soft bake at 90 degree centigrade for 1 minute, on hot plate, after this, this is what is our Nichrome? This is my positive Photo resist, I have a firm soft baking, then I load the mask. What kind of mask I can load? I load bright Feel mask, I load a bright feel mask. Bright feel mask. So, if I have a positive Photoresist and if I have a bright feel mask, then what will happen, the area which is not exposed by UV light, the area which is not exposed by UV light, will be stronger, by this point, by this time you should know this. Okay? This is what we are doing? UV exposure. Right? So, if I perform this, this is my glass. Right? Next step would be, I will dip this wafer, in Photo resist developer. If I dip this referring Photo resist developer, what will I have? I will have, I'll have my Photo resist, protected in this sections. Since, this positive Photo resist was not exposed, because of the bright feel mask. Right? What is the next step, after this, I will have Hardback, hard back at 120 degree centigrade for 1 minute on hot plate. if I perform hard backing and then the next step would be, to dip this wafer in Nichrome agent, Nichrome agent. If I did this every Nichrome agent what will happen? I will have, I will have, Nichrome only saved, where the Photo resist is there. Right? I will have Nichrome only in the area, where Photo resist is there, remaining area Nichrome will get etched. Easy, now next step is I dip this wafer, I this, this, this particular wafer, in acetone. If I dip this wafer in acetone, what will happen? It will strip off the Photo resist, it will strip off my Photo resist, if it's tip off by Photoresist what will I have? I will have Nichrome patterned in form of a heater, which is what is shown in this particular, schematic. You got it, this is how we can fabricate a heater and we can use a heater, to understand or measure the velocity of it. Now, in the experimental class, let us see, how can you use the signal conditioning circuit? For using the hot wire anemometer and then, if you have any questions, feel free to ask and will very, will be very happy to answer your questions, through the NPTEL form. Alright? Then, you take care. I'll see you in the next class. Bye.