Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Introduction to Experiments in Flight

Lecture 06
Calibration of control surface

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Hello friends I am Prasanth, I am team for this course and this course deals mainly with the experimentation which we do for air craft, determining what will be the angle of deflections of control surfaces, how to determine center of gravity, neutral point, claim rate and how to determine what will be the CD of air craft drag CD not. We have different things to experimental processes.

Today what we will be studying the calibration of control surface. Now before going deep into this topic, first let us understand what calibration mean or why we do calibration. So as you know calibration is configuring your result or output for a simple within up describe limit. For instance if I want to sample my angle or deflection in a scale of voltage from 0-5, now I have to calibrate that control surface. And why we need this sort of calibration because as you can see in an air craft as per your stick control you can maneuver your control surface whether it be ailerons or elevator.

So why do we require calibration for this control surfaces as long as we are considering mechanical systems. You can directly control it giving required input. But once your data accusation system comes into play or you go for electronic circuit, it will give you output in terms of voltage in current.

Thus, we have to calibrate your system according to what voltage your deflection has been given or you have to map what will be deflection just corresponding to your particular voltage. So that is why we need calibration control surface. So for this topic what will be the experimental setup or what will be the instruments required will be first you need a Inclinometer, second will be your Potentiometer and third will be your data accusation system and we are using an high data accusation system so NI-DAQ.

And for seeing the result you need a computer or an output device, here we are using laptop or pc and in anything you can see the result. Now these are the instruments which will require for and also software for interfacing.

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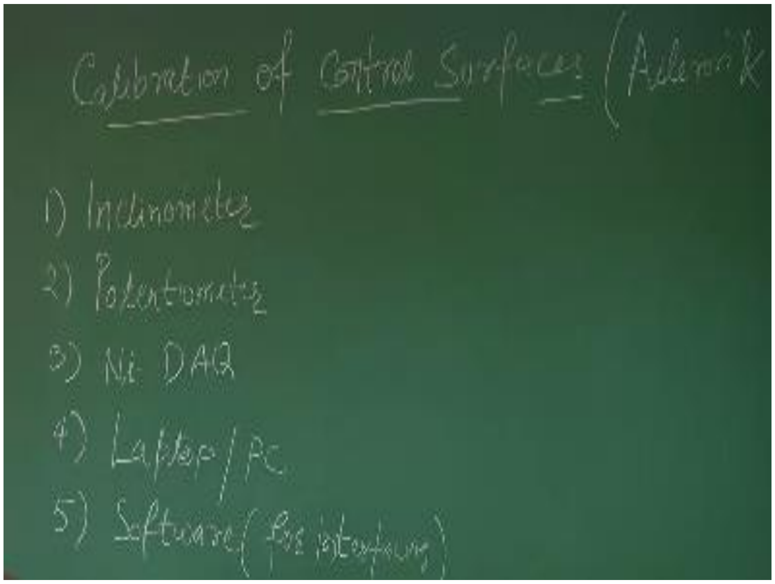

Now I will be explaining each part, what are the, what does each part measure or what does each part contribute to our experiment. Now first will be going with Inclinometer as the name suggest it has something to do with inclination. That inclinometer will give you what will be the angel tilt elevation or depression of a particular surface with a specto gravity.

So inclinometer will basically give you what will be the angel whether it is positive sorry this is a negative slop, so your angel of depression or angle of elevation or un neutral that means it does not have any slope.

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Now we in the experiment we have two different inclinometer. Now this is the digital inclinometer. As you know digital instruments have quite accurate, so the accuracy of this digital inclinometer is quite high and whereas this is your analog inclinometer. As you can see while tilting this instrument the middle indicates what particular angle it has been tilted.

This represents your inclination or positive or negative slope. Now as you know this is an analog device, so the accuracy is not as high as that of a digital inclinometer but earlier days this was used for determining your angle or slope.

Now the second instrument which we require is potentiometer. Now Potentiometer is very simple device and it is also as you can see the name suggests potentiometer, it has to do something with potential or voltage. You can imagine as you can say it is a three terminal device.

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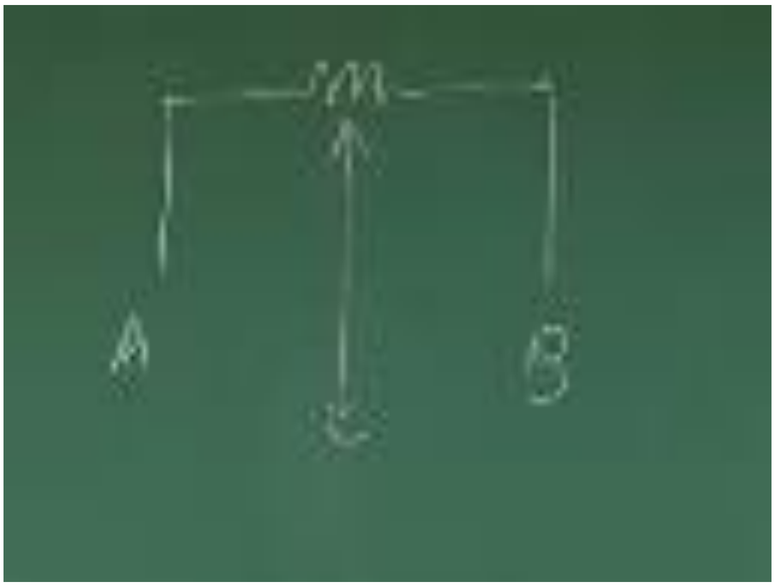

A three terminal device and it has a rotatory contact, which act as potential divided between these two terminals. These two terminals you can vary a resistance according that contacts which on your potential will vary according to that sliding mechanism. A simple circuit of potentiometer can be represented by-

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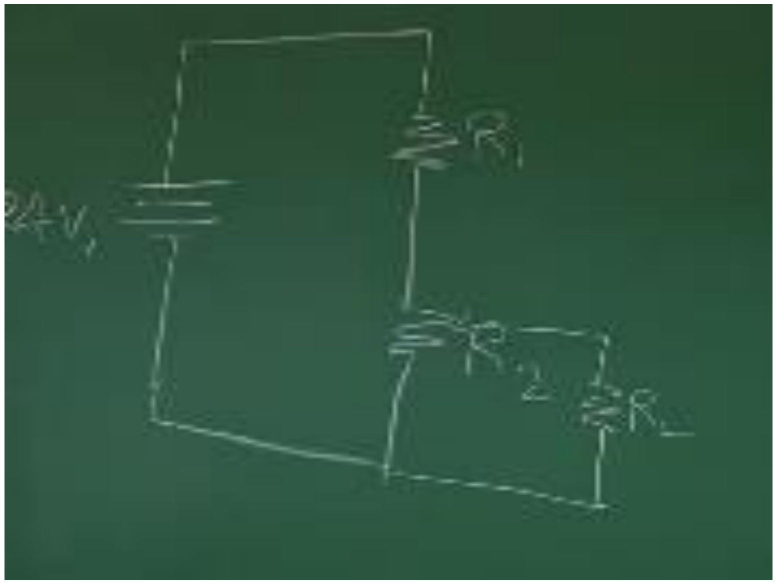

You have to determine what will be the voltage across this load resistance, which will be equal to if we further simplify this circuit.

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So the voltage across this load resistance will be the voltage across this RL which can be determiner using formula. The equivalent resistance between this two will be R equivalent = R2RL/R2+RL, now this will be modified as R1/R equivalent. So voltage across this resistance will be V equivalent = I*R equivalent, where I will be V equivalent=I*R equivalent, I=Vdc/R equivalent + R1.

Hence by VL=Vdc/R equivalent +R1*R equivalent, which is equal to Vdc/R2RL/R2+RL+R1*R2 RL/R2+RL. Further simplifying this we will get Vdc/R2 RL+R1 R2+R1 RL*R2 RL/R2+RL. So R2RL will get cancelled, so your voltage across your load resistance will be Vdc * R2 RL/R2 RL+R1 R2+ R1 RL.

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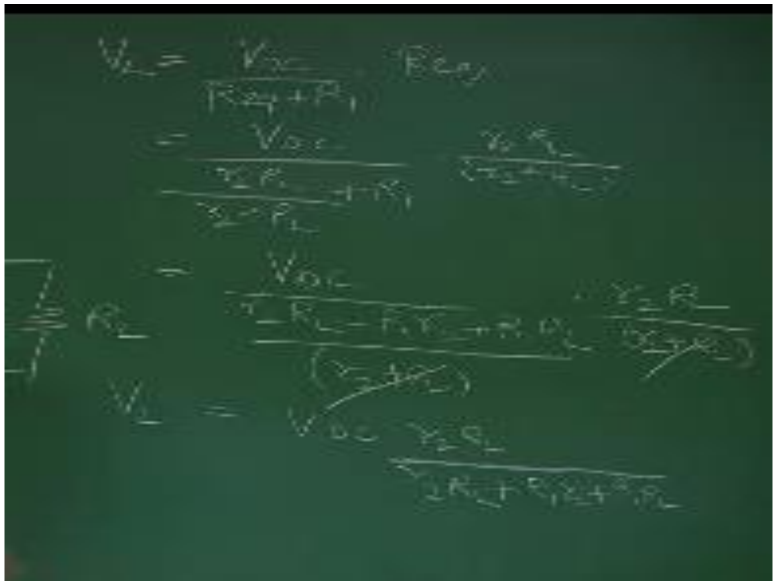

So as you can see by this particular equation, the voltage across your load resistance can be varied by varying this value of R2. If value of load resistance is very high then you can simply write this equivalent to R2/R1+R2*Vdc.

So just varying this resistance using contact switch you can directly vary the potential across your load resistance. So that principle in the potentiometer is using to determine what will be your voltage against a deflection of control surface will be coming to that when we will be discussing your experimental part. Now this two we have already discussed and I told we have to require a data accusation system.

Data Accusation System we are using is our national instrumentation and we can simplify that this system as NI module, all the sensor data's will be coming into NI module. This NI module is powered by a power supply. Now the output of this NI module, output can be seen in your laptop or pc and obviously you cannot directly access NI modules so you need your interfacing software, and here we are using Lab view.

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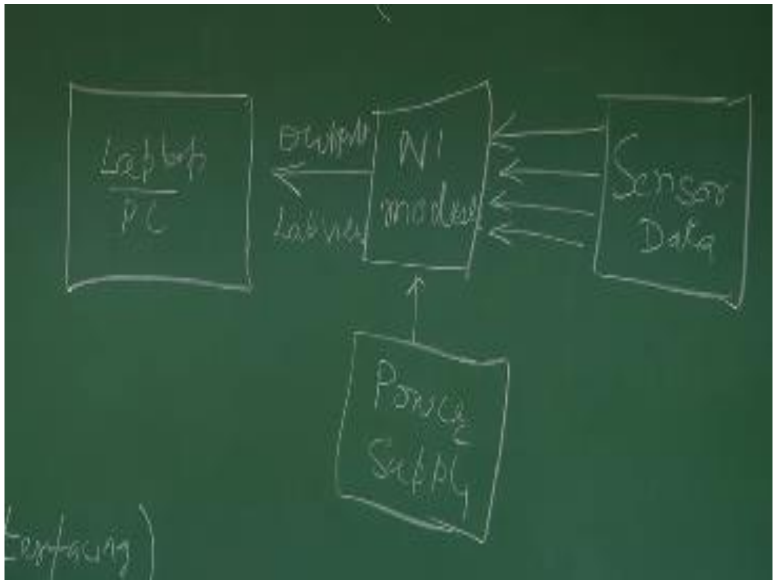

This is a basic block diagram for calibration of control surface. We have discussed about your full system what will be required for your calibration of control surface. Now what is a process for determining what calibration of your control surface? Now the procedure involves you have to first mount your inclinometer on the control surface for which we want to measure on calibrate. Once this inclinometer is mounted on that device, you have to secondly determine reference point.

Now what do you mean by reference point, suppose this is your wing, it is a 2D section of a wing and you have a control surface here. This inclinometer will be mounted on this particular control surface for which we have to do calibration. No as you can see this is not suppose this is your ground, this is not exactly parallel to ground, so by default your inclinometer will give you some reading.

Suppose for this particular instance is giving you -10 degree. So your default or reference point without any deflection this is when your control surface has not been deflected, suppose this is your wing this is your control surface. It has not been deflected that this represents your reference point. So say for this particular degree, your voltage corresponding to this is 3 volts. Now this particular reading you can we will be performing your experiments, you can see how this readings are calculated using lab view program. So this is your reference point.

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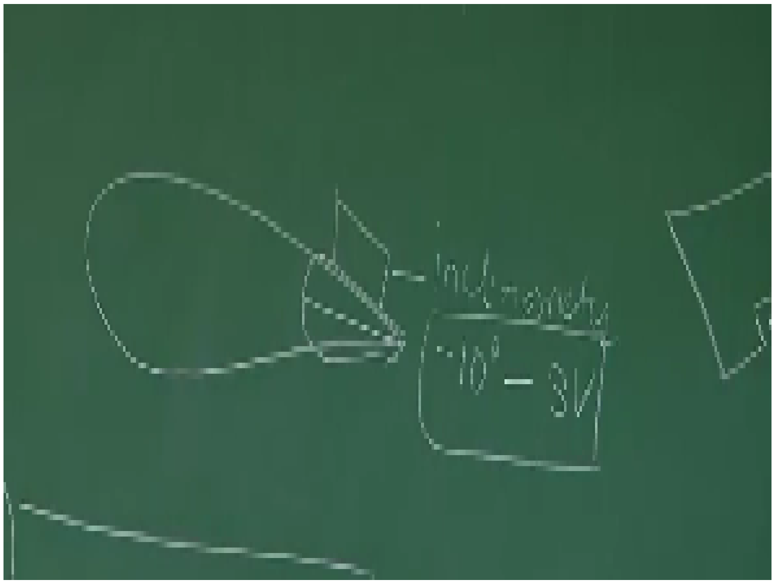

After setting reference point, third process is you have to set this reference point as 0 degree, so for 3 volts your deflection will be 0 degree. In order to calibrate your control surface, the four step involves, to deflect your control surface of the positive side and a negative side.

So if this is your zinc section, positive means you have to deflect this upwards and calculate this angle using here inclinometer. This is for positive deflection similarly for negative for negative deflection you have to calculate angle, you have to load that angle using inclinometer it will be mounted here and corresponding to that using VI program will be able to get voltages.

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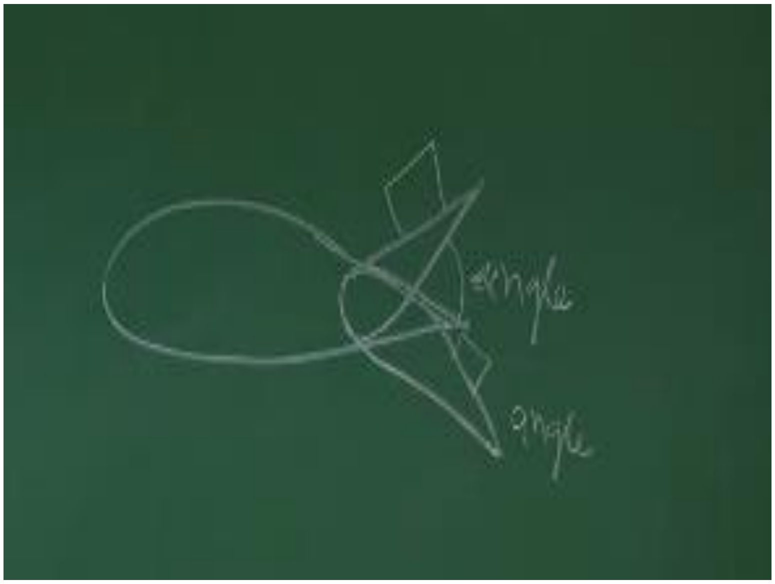

Voltages for different angles deflected on both side with some interval. That is I have already set my reference point and after that you have to deflect that in positive side and in negative side with some intervals say with 1 degree what will be corresponding voltages, we have to measure and make a note of that.

After performing this particular step you will get a chart which will be voltages and deflection. So for instance for positive deflection suppose I get a voltage of 4 volts with deflection of 10 degree. And 3.8 with deflection of 9 degree, similarly for 0 deflection I only told you it was 3 degree. Now deflecting on different side, your reading will be in for -1 if suppose your voltage is 2.8 volts and similarly -10 degree here voltage is 2 volts.

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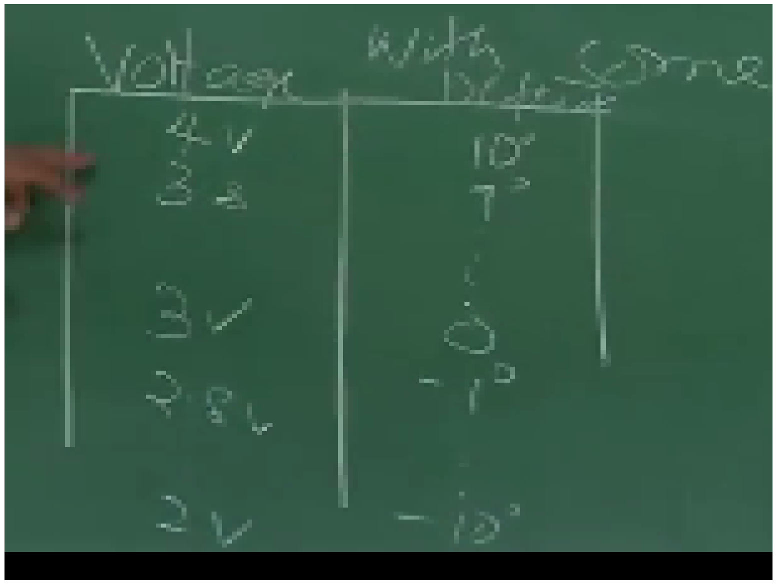

So you will get a chart with voltages and deflection of control surface. Now since we are assuming that this is a linear variation that deflection of control surface with voltage is of linear variation, so will plot a voltage vs deflection will give you positive negative. We will give you a line of sort y=mx+c.

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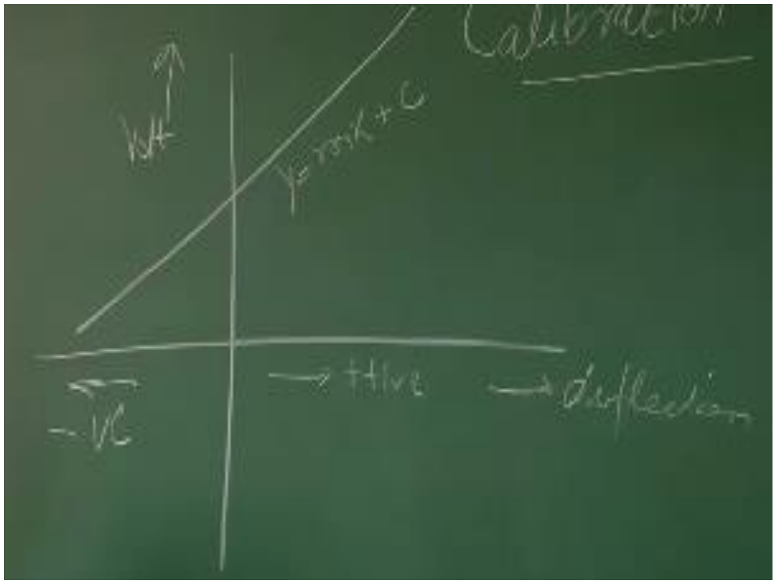

Where m is your slope, c is your intercept, y represents your voltage and x represents your deflection. So from this calculation or this particular readings you will be able to calculate what will be value of m and what will be the value of c, as you can see for x=0 deflection y will be your c and voltage will be 3 volts.

So this will be 3 volts. Similarly now giving different values of deflection, you know the value of y, you can determine m. This is one process to determine what the relation between your voltage and deflection. There is another way to determine what will be the relation of voltage and deflection of control surface?

Now suppose you do not have instruments such as digital inclinometer. In that case what can be approximate way to determine, what is a relation between voltage and your control surface deflection now we do not know what is a deflection of control surface this was the readings which we determined from using inclinometer; digital inclinometer or analog inclinometer.

Suppose you do not any of that and control surface is too small to mound that inclinometer, then in that case these approximate way to determine what will be the angle of deflection? Suppose this was your wing and you have deflected your control surface to some degree. Now you want to know what is the angle of this, since we are resuming this is a uniform control surface there is a thickness that vary.

So we measure what is a distance between, what is the width of this control surface, w is the width of this control surface. You can also calculate or you can also measure what was the distance of this particular deflection from your equilibrium point. So you know h and you know w, because this will be always constant since this is of uniform width and also this width does not vary changing your angle, so you can calculate what will be the angle of deflection using $\sin\Theta = h/w$.

Where you know w and h, so Θ will be sin inverse of h/w so you can approximate relation between voltage and deflection. Now I am saying this approximate because the result may vary, suppose for this 10 degree we are getting for volts for this you might get somewhat like 13 or 12 degree you will get 4 volts. These can vary according to that, but this is a good approximation where to calculate if you do not have such instrument or the surface is too small.

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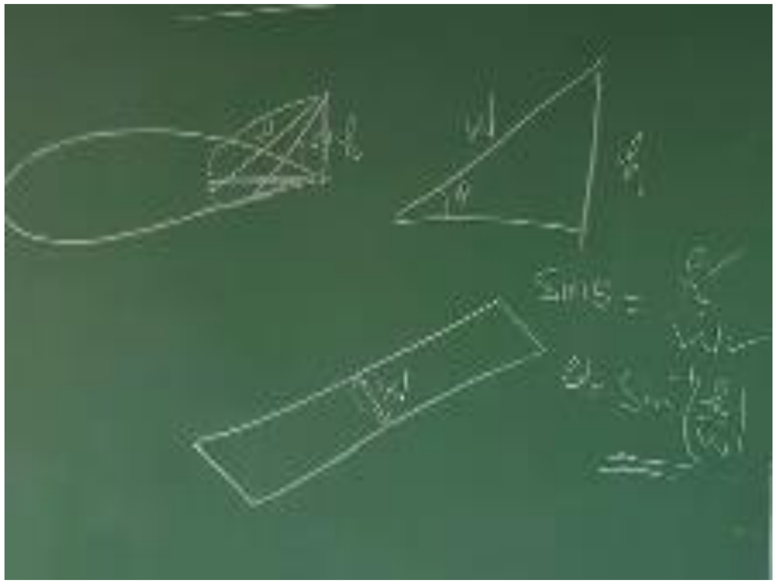

This is a good way to approximate what to be the relation between voltage and deflection. Now earlier and I discussed why did we need calibration? Once we did calibration we got voltage and deflection, so where we want to apply that so let see some application where this calibration will be needed. Now throughout this course you will be seeing various data that will be suppose what calculation of angle of attacks alpha, beta, slide slip angle as well as what will be the deflection of elevator, your ailerons and your radar.

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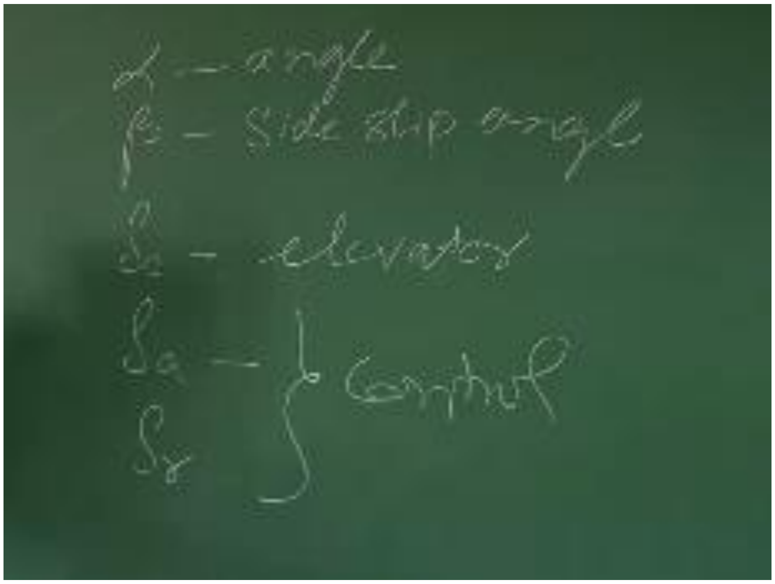

So this all are the qualities which you want to measure but I told before also that when a digital system or electronic system is involved. You can only get output in terms of either voltage or current. So that is why this voltage for determining what will be the deflection of this particular control surface or what will be angle of a side slip angle. You will need to have a relation between voltages, current this physical parameters which you want to measure.

So that is why we need calibration of control surface not only control surface different calibration, we need even for angle of attack and even for calculating side slip angle, so we will require a relationship between depth and since once calibration is done that is you have found a relation what is assuming that the control surface deflection and voltage for a linear relation.

Once this constant and this slope is determined, while taking data you will be only if interfacing a software a coding has been done. Then you will only get what will be the voltage for some deflection. That deflection you want to know because as you know in aero dynamics of an air craft in required different parameters what will be c and delta a and what will be CD delta a or CL delta e.

Hence you require a relation of delta e, so you will be getting voltages and since you know the relation what is m and what is c, you can determine what will be your deflection using this m and c value.

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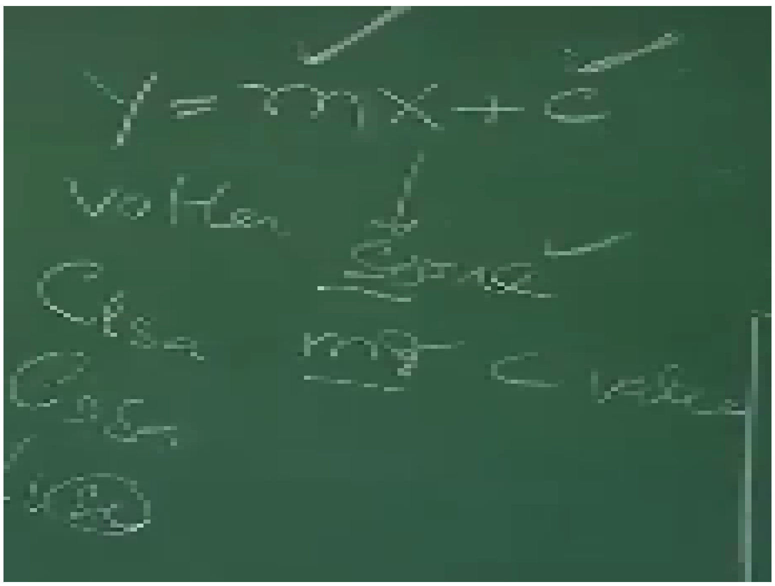

So for this experiment we have derive what is relation between voltage and deflection we will be seeing that while performing experiments like then you can see what, where the assumptions we took how to determine reference point, how to deflect surface and what voltages we are getting. Thank you

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