**Indian Institute of Technology Kanpur**

**National Programme on Technology Enhanced Learning(NPTEL)**

**Course Title**
**Introduction to Experiments in Flight**

**Lecture – 07**

**Calibration of Control Surface (Experiment)**

**by**
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In your lectures you have seen how we developed a relationship between your in voltages and deflection of control surface. Now we will verify experimentally, whether the data we are getting is a linear sort or non-linear sort.

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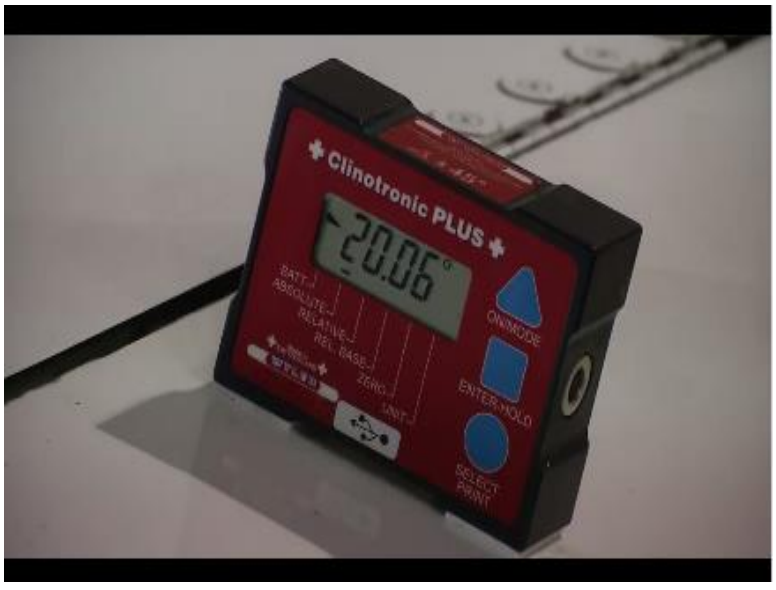

As I have already told you in my lectures, this is a digital inclinometer and is currently showing -20.07degree , to check whether this is -ve or +ve you can see a small symbol here indicating a negative slope, which I have already mentioned in my lectures, now while deflecting this control surface you can see, the angle is changing whereas, the slope remains the same that means this is a negative slope ,now while it is deflected it in opposite direction, slope is still negative but the angle value has changed , further deflecting,

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It in opposite direction you can see at this particular deflection the slope angle has changed and now the angle which it is showing is 1.93 ,now while in my lectures I have already explained how to determine your reference point ,now this wing is at some angle with respect to your ground that is why if you want to take a reference when you say if this is your neutral position or your control surface deflection is 0 here , your getting a default angle of -12.09degree , as seen you can verify with your inclinometer that is analog inclinometer its showing some where close to 12degrees ,now while performing experiment.

Your deflection will be controlled through your control stick in aircraft and this angles will be determined in both opposite and negative direction. So first let us set our reference point. Now as I told you in my lectures that with this deflection of the surface you will be getting a respective voltage with that deflection ,now how this voltage was calculated we showed that during setup of the experiment , a inclinometer , a potentiometer ,laptop ,interfacing software and a data cohesion system that is an we are using . Now this is a small potentiometer not using this particular application but as I told it had three-terminals, these are the three terminals,

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This is a rotating contact switch on wearing this you can vary the voltage between, This particular two pins and while doing same principle you can apply to while calculating your voltage for deflection of this control surface as you will deflect this it will act as a rotating switch and corresponding to that rotating switch a voltage will be shown in your lab view software on that particular angle and that particular value of voltage you can calibrate or map that on your linear scale, so we will be showing you how that experiment is performed.

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Now I mentioned you how to use this potentiometer to determine what will be the deflection of your control surface the phenomenon was same but for this aircraft this is your potentiometer. As you can see a string attached to your control surface now as my colleague is deflecting control surface the tension in the string varies and according to this potential or voltage corresponding to a particular deflection in control surface is seen in lab view , it works on the same principle but instead of this manual rotation of this contact switch here a string is attached that is wearing a resistor and according to that your voltage for different deflection for this control surface the voltage varies according to deflection.

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Now in performing this experiment while drawing the block diagram we showed that we need a interfacing software to determine at what particular deflection what will be the voltage of that deflection now you can see as, This is a lab view program which we use for determining voltage against deflection of control surface. The interface consist of an output channels which determines which particular control surface of parameter you want to select, Now I have already told you in this we determine 16 different parameters for this aircraft for which the channel for all around deflection we are doing the experiment to determine what is the relationship between voltage.

And deflection of all around, will be on channel 13, for my colleague has selected channel 13 as to display what will be the output corresponding to that and as you can see that voltage part as I will be deflecting this control surface you can see the voltage is varying according to deflection. Now we have to map this voltage as per deflection of my control surface. Now first point while performing this experiment was to determine my reference point that is when my elevator or my alarm is with zero deflection.

Now while setting reference that is when my deflection of alarm is zero my angle which inclinometer showing is -12.12 and corresponding to that the voltage which I am getting is.2.4volts now my colleague will set this as zero angles that mean the alarm deflection is zero. Now my colleague will deflect this control surface both in positive direction and negative direction with respect to your reference point.

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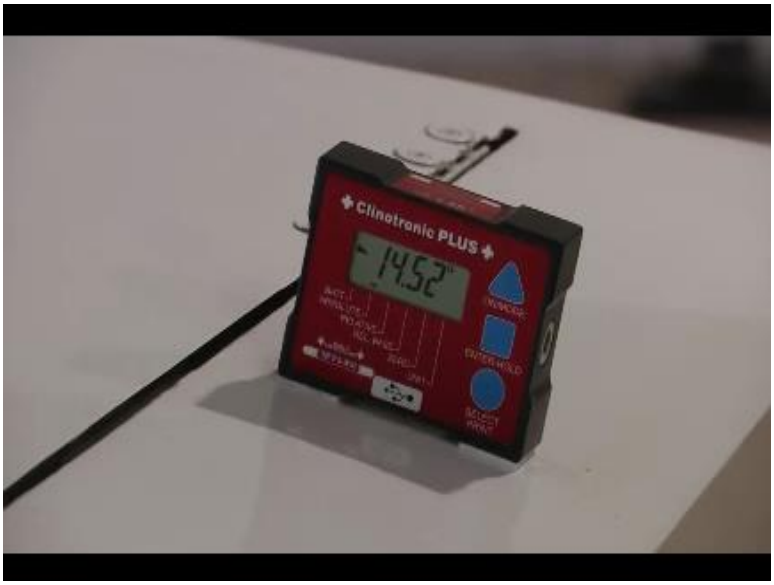


Now this was my reference point, my colleague will be deflecting this control surface in both directions with regular interval. So first deflecting it in downward direction, as this control surface is deflected in downward direction with respect to reference point your angle is changing. Now deflecting it in opposite direction , angle was changing and corresponding to that you will be getting different voltages, So while wearing your control stick you can determine what voltage you have to give to your control stick or what with particular deflection what voltage your getting in your lab you can determine using lab view software .

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Now after setting the reference point the next step was to your lab view programme and deflect your control surface in both directions downwards and upwards with respect to your reference point. So earlier I told you my reference point was -12.05degrees or somewhere close to that, now while performing experiment as you knows the first step was to determine your reference point, that is when deflection of control surface was zero. For our aircraft that zero deflection point is -12degrees .in corresponding to that my colleague will set angle as zero.

The voltage which I am getting will be recorded in your lab view. Further to continue calibrate your control surface you have to deflect your control surface in either direction with reference to your initial point. That is -12degree you have to move within either direction. So I am deflecting it by 1 degree in negative direction. That is -13 degree, and corresponding to that the voltage my colleague will record in lab view code, that will be recorded as -1 degree.

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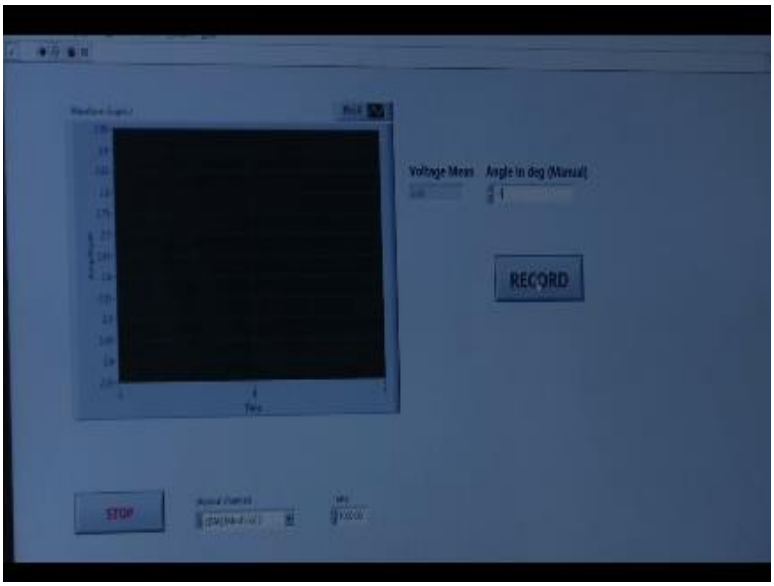


Further I will shift it downwards to -2 degree, That is -14degrees, and that will be recorded in lab view as -2 degree and corresponding voltage will be recorded in your lab view code. Now further shifting it to -3 degree that is -15degree and corresponding voltage will be recorded in your lab view. Now similarly you have to take 10-15 readings in particular direction so you get a good accuracy of voltage verses your deflection of your control surface. Now I am shifting it in +ve direction, as you know my reference point or initial point was set at -12degree that is zero deflection of control surface.

Now in upward direction with 1 degree that is -11 degree the corresponding voltage will be saved in lab view code as voltage corresponding to 1 degree deflection. Further now shifting it to 2 degrees that is -10 degree and corresponding voltage will be recorded as 2 degree. Further shifting it upwards to 3 degree, that is -9 degrees in our inclinometer and corresponding voltage will be saved as 3 degrees in our lab view code. Similarly you have to take 10 to 15 readings in either direction to get good results for your calibration of performing this experiment.

We will be seeing how the data are accumulated and will be plotting a relationship between your control surface deflection and voltages. Every time you perform this experiment the data file will be saved in your laptop or PC whatever your using, That is inbuilt lab view programme, After the data is recorded you can analyze what is the relationship between control surface deflection verses voltage which as I told you during file data recorder for distal circuits you require, The output will be in terms of voltage or current.

There you require this voltage reading so that you can determine what my deflection of control surface was. So we will be showing you the data which we recorded while performing this experiment. The experiment is lengthy since it requires 15 to 20 readings in either directions, Will be showing you what readings we got and we will be plotting what was the value of M and what was the value of C, That is intercept and slope and how using that you can determine what was the control surface deflection if particular voltage was given to you.

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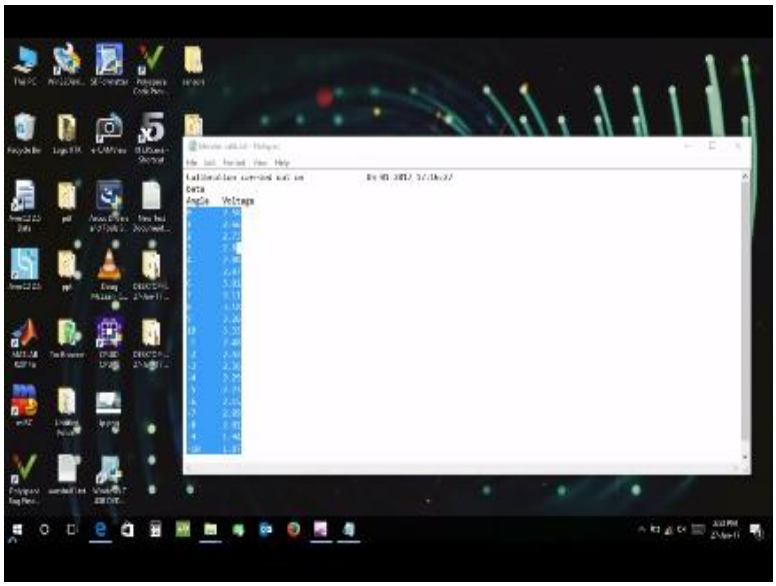

While you are doing this experiment calibration of control surface, we told you that we have to first set our reference point and after that we have reflect your control surface in either direction and take as readings say 10 to 15 readings in either direction, So that you will get a exact relationship between control surface deflection and respective .So we perform the experiments and. These are the reading for definite control surface. Now for elevator these are the readings obtained while we deflected control surface in either direction, we took 10 readings in different direction.

Now in order to establish the relationship between control surface deflection and you are have to find relationship between these and what is the value of slope and intercept easy way to do this is you can take this in a direction X and Y. And using a co-fitting tool you can directly access what are the value of slope and intercept, so this finds intercepts and slope for this voltage and angular deflection you contain for the elevated direction.

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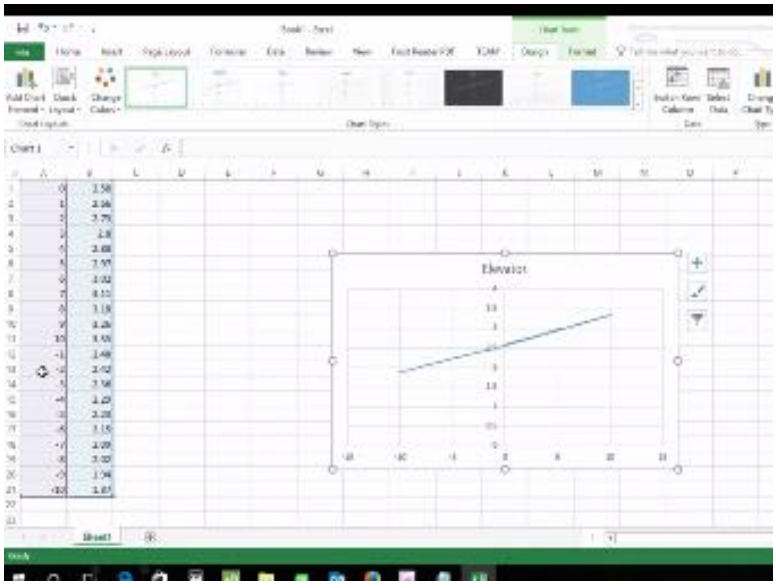


Now in order to plot a graph between these two data points all you have to do is go to insert and select scatter plot and select data hence and add since this is for elevator calculation Il gets series of minus. Now your X data will be angle and Y data will be

corresponding to the .Now as you can see this, This is a straight line but you can see here the line is little bit outward , This is because this data is not arranged in a ascending order or descending order,

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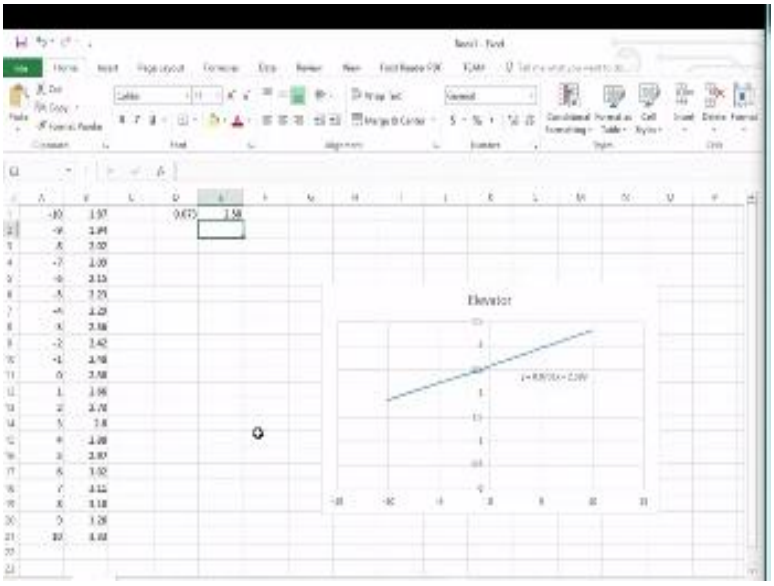

All you have to do is Select these two data and click sort and filter. And arrange from smallest to largest or largest to smallest Now you can see this as scale. Now to get what is the value of slope and intercept we have to go to design, add chart element and trendline, click on more trendline options, since you have selected across fitting linear sorts. That is we will be leaving a to see what is the equation of that line you have to click display equation of chart.

So this is equation of a line which will offer eliminate a deflection with respect to voltage Now we have derived from excel what if we do not have this excel or if we want to do it manually. Let's see what is the slope angle which we get data point lie on a straight line so as we know the slope is y2-y1 upon x2-x1.so we can know slope using this formula This is your slope y2 minus y1 this is your y1 divided by x2 this is your x2 slide minus x1. This is the slope we are getting and which is very close to while getting co-fitting.

Now as you know intercept will be the point at which your angle will be zero so you can see from these greater headings its 2.58. So these are the values time which we have got for slope and intercept using analytical method not getting in line .Now in a similar fashion you can do for different control surfaces.

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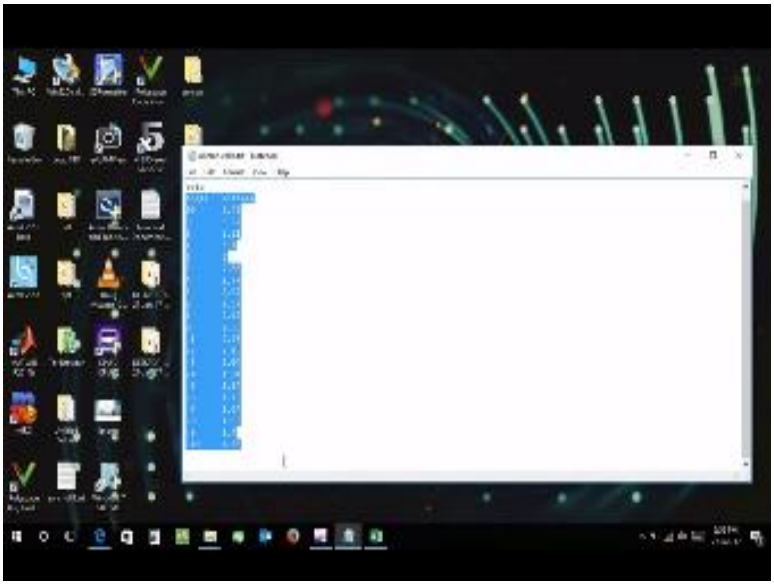

While performing experiments took data for all the reflections and these are the readings we obtain, let us find out what are the values of slope and intercepts same way we will copy this data into excel file paste.

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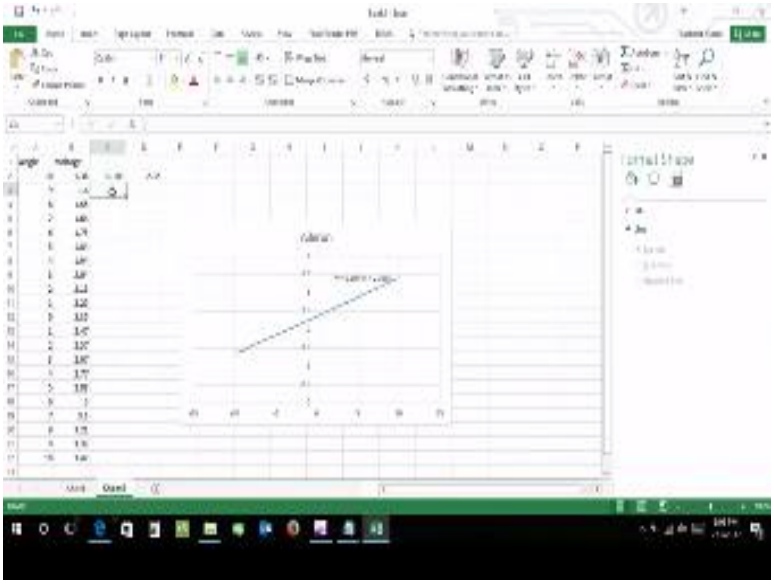

Again this is used for sorting and filters for increasing time ascending order or descending order. Now again go to insert select scatter part open scatter part and select data and this is for aileron so enter aileron and your X data will be deflections and your Y data will be corresponding voltages. And as you can see this is the straight line slide which you got for voltage vs. Angle deflected for aileron. Now the same way in order to get equation of straight line go to add chart element, Trendline , More trendline options and select display equation of chart , So this is your slope and this is your intercept.

And same way we can verify using analytical method since you can see for zero reading X 2.35 so this will be your intercept and your slope will be Y2-Y1, X2-X1, 0.103 and here we are getting 0.155.so its quite accurate as we take using analytical method. So this all regarding to how to calibrate your control surface. In the coming lessons we will see how to analyze the data that we collect from appear.

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