Experimental Physics I
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Lecture - 20
Determination of Young's modulus

So, today we will start experiments in laboratory we will demonstrate different experiments we performed in our during our undergraduate course. So, basically if first year laboratory, second year laboratory, third year laboratory, right. So, in different years we have different laboratories and we designed the experiment in such a way whatever in theory class students learn different topics. So, on those topics we arrange experiments in the laboratory.

So, before going to lab to do experiment students should know learn about some basic things that is what so far I have discussed different basic things what are the basic tools or operators in the laboratory we very frequently we use. So, like multi meter, volt meter, galvanometer and then slide calipers, screw gauge, then meter scale, magnifying glass, screw, nut, bolt, right. So, basic tools basic operators one should know so that hopefully already you know now because I have discussed all of them I have showed you also ok.

So, then also one should learn about the basic analysis in the laboratory. So, that also I have discussed how to collect data, how to calibrate the instrument and how to draw graphs and how to calculate the error. So, when we are discussing how to calculate the error so also we through this error analysis I mentioned how we have to perform experiment very carefully so that you can minimize the error means your experiment will be more precise, your results will be more accurate. So, what is the accuracy, what is the precisions, so, all those things I have discussed. So, now, hopefully we are ready to perform experiment in the laboratory.

So, let us first so, again when you are going to perform a particular experiment, so first you should know about that about the theory of the experiment means, what experiment you are going to perform. So, when you are performing experiment means you are going to measure some physical parameters right. So, how these physical parameters is related with the measured parameters and what are the measured parameters and for measuring

them what are the instruments you require ok. And then how what is the procedure of the experiment how we will follow the procedure of the experiment ok.

So, that is what one should know before starting the experiment. So, and then you perform the experiment and then next step will be the analysis of data and report the result with errors. So, basically for performing an experiment in the laboratory I can make in three section, three division; one is theoretical part, theoretical knowledge about the about the topics which we are going to basically study through the experiment. So, you should have knowledge about the topics of that experiment and how to perform the experiment, what is the procedure, what are the instruments required. So, before just performing experiment we have to be ready with this ok.

So, then you perform the experiment this is second division second section and then after performing experiments you will have data with you. Now, third and last section is basically analyzed then and report the result, ok. So, here basically first I will discuss this first section where I will discuss theory about these topics of the experiment and procedure as well as the requirement instrument ok.

And then I will go to lab and there I will give you light demonstration of the experiment I will perform the experiment. Basically I will not take data there because it will take long time. So, I will just show or using the instrument different steps of measuring the parameters ok. Then again I will come back here with those data and I will analyze and how to find out the final result with error so that I will discuss in three steps we will complete an experiment.

So, let us take an experiment. So, how to measure how to measure or determination of Young's modulus of a material.

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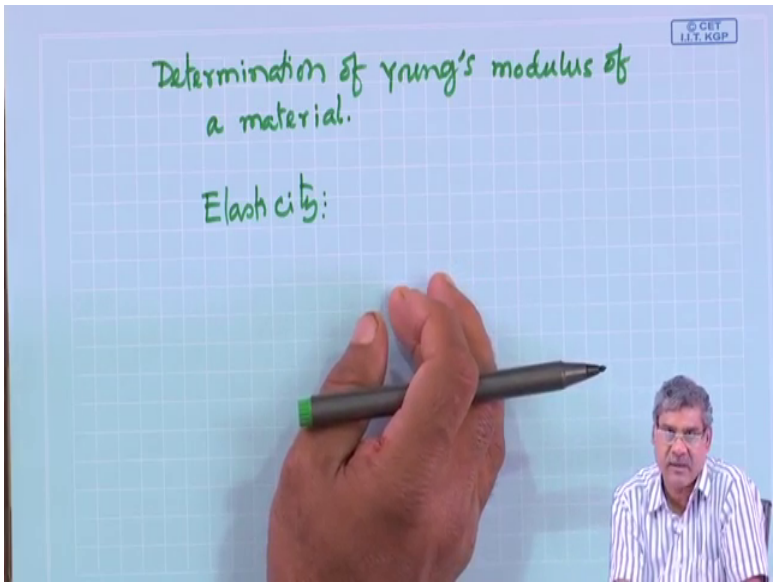

So, that is what the our topics today ok. So, we would like to measure Young's modulus of a material right. So, this is the obviously, this is the subject of elasticity subject of elasticity ok. So, basically that is the elastic property of the elastic property of the materials. So, we should have basic knowledge about the subject matter; what is the elasticity or elastic property of the material right.

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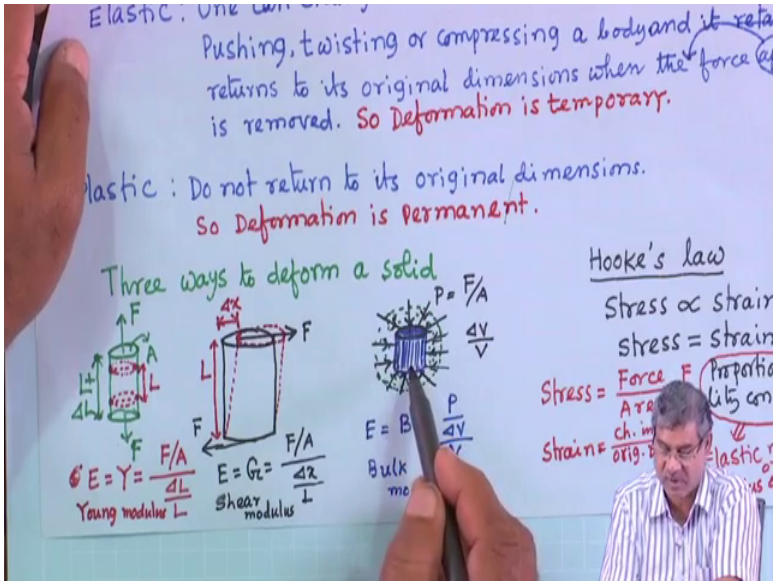

So, elasticity elastic when we tell elastic right. So, there is another term plastic right. So, what is elasticity or elastic and plastic? So, elastic is basically one can change

dimensions slightly or largely by pulling or pushing or twisting or compressing a body and it returns to its original dimensions when the applied force is removed when the applied force is removed.

So, deformation is temporary. If so, then we tell this is the elastic material and if it do not it does not return to its original dimensions after releasing removing the applied force then we tell this deformation is permanent and that is what is plastic ok.

So, anyway we are not interest about the plastic we are interested about the elastic in this subject in this class. So, there are three ways to deform a solid. This is the basic things you know just I am we I am repeating the same things. It is always better to repeat the things when we are going to perform the experiment. So, you should know from the basic.

So, there are three ways to deform a solid; so, one if you take a cylindrical form of a material. So, if you apply perpendicular force along the length then there will be elongation along the length. So, original length is if it is L and then after applying this force if the length is L plus del L ok.

So, then this is the elongation of the rod and if you its air condition is if release this applied force F then it will come back to its original length L. So, it is assumed that this force is applied in such a way that after reviewing the force it will come back to its original form. So, sometimes elastic material, but it does not come back to its original position. So, then we tell this is this force limits the across the limits ok. So, there is a limit of this applied force.

So, that I think I will tell you. So, another type of deformation can be like this. If you apply tangential force F like if you ap. So, this is the elongated and this other one just your applying force tangentially on the surface like this ok.

So, then its just it just deforms its tilted this side. So, it makes angle; it makes angle; so, this type of yes. So, this is another type of deformation. So, then third type of deformation may occur with this uniform force is applied from all directions. So, just if its just like pressure if you put something in a liquid. So, liquid and then if compress the liquid then this force will act on the body emerged into the liquid. So, (Refer Time:

13:46) in from all directions. So, this three kind so, then this one will be default. So, its so, let me just tell that.

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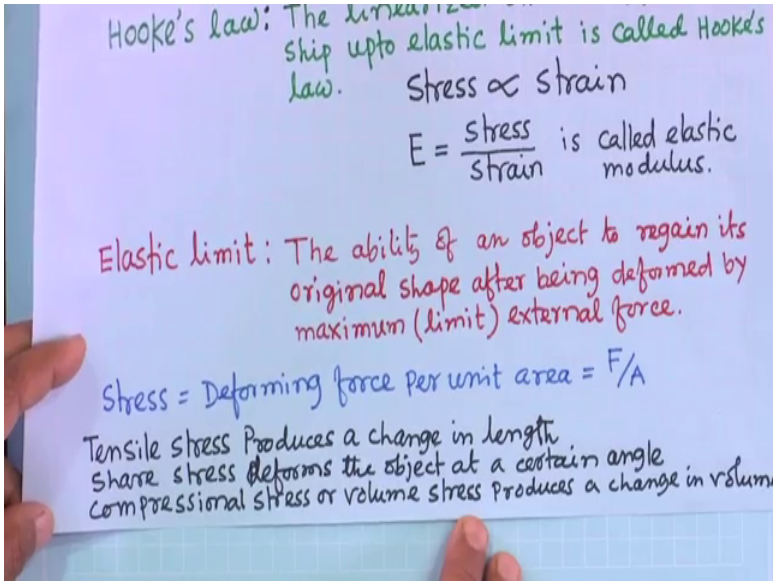

This elasticity it is based in basically Hooke's law. So, what is Hooke's law? Hooke's law is basically linearized stress strain relation shift up to elastic limit as I told some limit is there elastic limit is basically Hooke's law.

So, according to Hooke's law this linear relation between stress and strains means stress is proportional to strain. So, stress by strain is a constant, proportionality constant. So, this constant is called basically elastic modulus and elastic limit, the basically the ability of an object to regain to return its original shape after being deformed by maximum external force, ok. If you apply beyond this force then it will not come back or regain its original shape. So, then Hooke's law is not valid. So, that is why this hooks law is valid means basically up to elastic limit means, it will come back the maximum force is permitted up to that force that body will come back to its original shape when you will remove this force right.

So, now here stress and strain stress is defined by force per unit area F by A. So, now, thick so, I told these three ways we can deform the solid. So, basically that is and the force is applied in three ways basically. So, those force are basically called tensile stress, now this force is in terms of stress. So, we tell this tensile stress, one case is tensile stress

that produce a change in length; another case share stress deforms the object at a certain angle that is as I told the just it tilted this body tilted I showed you.

So, share stress deforms the object at a certain angle and compressional stress or volume stress that basically produces a change in volume ok. So, that example I showed you this if body is put in a liquid so that this type of force basically that is pressure basically force per unit area it is again its called pressure so, in case of bulk stress. So, that is that we can consider it as a pressure. So, when an object is subjected to a stress whether tensile stress or share stress or compression or stress so, there will be so, it will suffers it will so, its suffers a strain ok.

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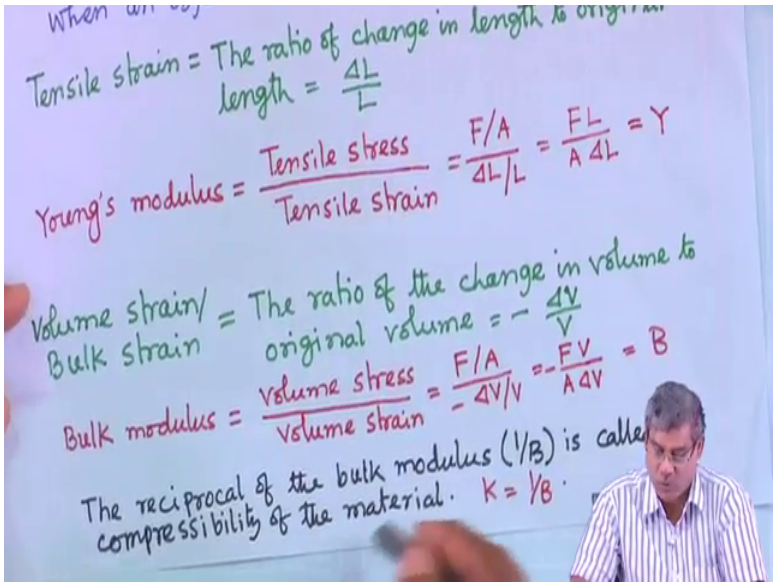

So, it will be deform and that then that is basically we express in terms of strain. So, what is strain? So, again strain also in three types. So, when we apply tensile stress, so, then there will be tensile strain and tensile strain is basically the ratio of change in length to original length ok. So, this is del L by L if this along change of length is del L and the original length is L. So, del L by L that is the tensile strain.

So, this according to Hooke's law this stress by strain that is the elastic modulus. So, in case of tensile strain and stress so, this ratio of tensile stress and tensile strain, so that is the give elastic modulus that elastic modulus is called Young's modulus. So, for Young's modulus this stress is F by A and delta L by L equal to of course. So, that elastic modulus

that Young's modulus in this case and we express generally in terms of by this Y capital Y.

So, other strain this volume strain and bulk volume strain. So, that is the basically ratio of the change in volume to original volume. So, from there people can find out the bulk modulus. So, bulk modulus is equal to volume stress by volume strain ok. Similarly, for share strain and share stress, so that is that elastic modulus we tell that is the share modulus anyway. So, now, our topic is basically to determine the Young modulus of a material.

So, here what is Young modulus just I refresh it just I repeat it; you know, but still the parameter we are going to measure from basic concept how it has come. So, here just I mentioned. So that means, for doing experiment here it is clear that for doing experiment we have to apply stress, tensile stress or force over a area. And then stress will be force per unit area and then we have to there will be strain tensile strain and that strain we have to basically measure ok.

So, for Young modulus I need for I need to apply force then I need to measure the original length, then I need to measure the area over which this force is applied and then I need to measure the elongation delta L ok. So, we have to design experiment this formula will take different form depending on the design of the experiment. So, basically in laboratory there are two methods generally we follows to measure the Young modulus of a material.

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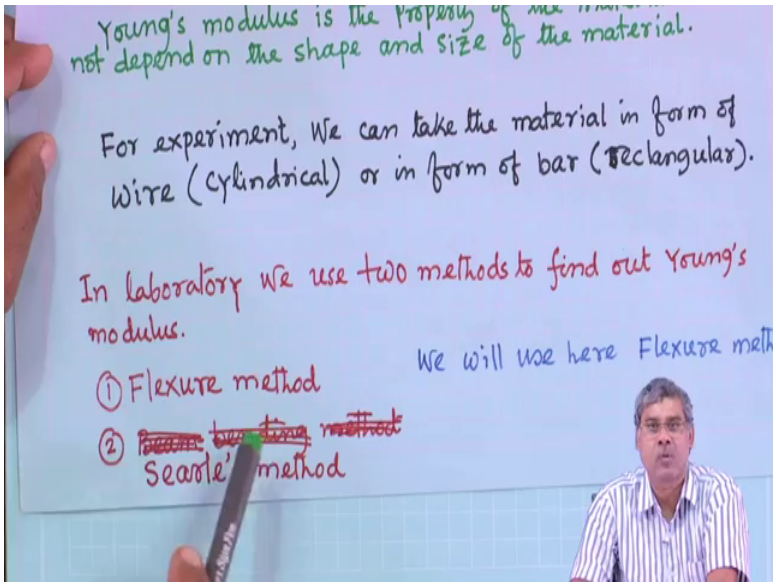

So, this two method is basically is called Flexure method and another method called Searle's method ok. So, in flexure method we take the material in a rectangular form in a rectangular form in a bar form or we tell beam ok. So, that will I will define and then Seale's method we take the material in form of wire ok. Now in this method we are measuring the Young modulus of a beam or bar or cantilever we tell cantilever also cantilever beam and in this method we are measuring the Young modulus of wire.

So, now question is now question is whether we are measuring. So, this if both wire and this bar is made of same material say steel or copper whether the Young modulus will be different or same? Does it depend on the does it depend on the shape of the material? So, Young modulus is basically the property of the material. If does not depend on the shape and size of the material.

So, for experiment we can take the material in form of wire that is basically cylindrical form or in form of bar that is the rectangular form. So, since in our laboratory we are going to measure the Young modulus of some material I think material is steel using this flexure method. So, I will discuss here now this method about this method before going to the laboratory. So, let us see what is flexure method.

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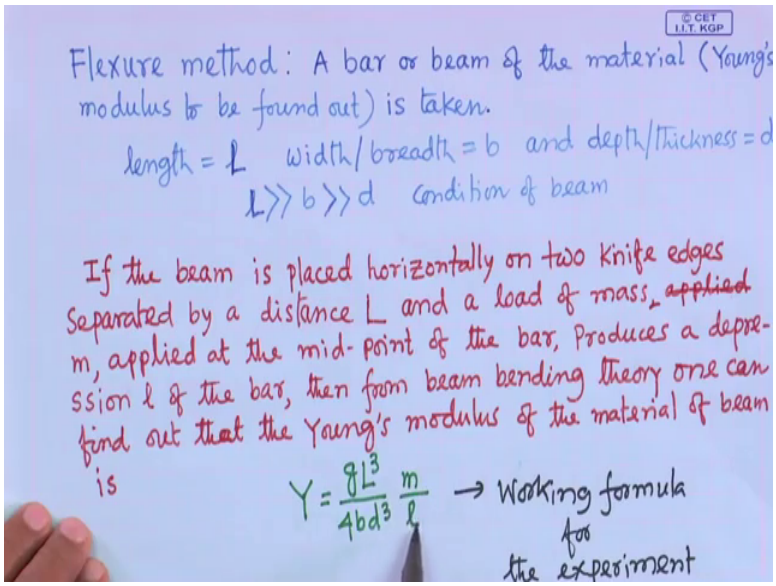

So, as I told that in flexure method if bar or beam of the material is taken ok. So, the materials Young modulus to be find out for this material is taken in form of beam or bar. So, if bar have length say capital L, it has width or depth that is b and depth or thickness that is d ok. So, it will be bar this condition of beam or bar basically L length it has to be very greater than breadth and breadth has to be very grater than thickness ok.

So, then we tell this shape we tell that is the beam. So, this type of beam one has to take which is having length L capital L breadth b and depth d. So, now for this experiment there is geometry of the experiment is basically this beam we placed on a two sharp knife edge on a two support on a two support that support is basically its a very sharp edge knife edge. So, on this sharp knife edge we will place the we will place the bar we will place the bar.

Now, then so, then this effective length of this bar is basically between distance between this two sharp edge right. So, that one has to measure this length. So, this length typical length generally we take between 80 to 100 centimeter. So, we will use for this which instrument we will use this the meter? Scale meter scale we will use to measure this one and meter scale what is the least count of the meter scale? Generally it is 1 millimeter fine.

So, then next what we will do? We will apply we will apply. So, we need also then length I need that is fine we may need breadth and thickness breadth and width also breadth or

width thickness or depth that also may we need. So, what we need?. So, experiment is that this we will place the bar on two sharp edge. Now, in middle exactly in middle we will put weight means we will put weight. So, due to this weight so, there will be force gravitational force right. So, this beam will bend. So, this beam will bend basically this beam will bend.

So, this beam will bend like this beam will bend like this ok. So, I think we will see so, beam will bend. So, now, that what is the original position? Now it will bend. So that means, this middle point will depressed will go down is depressed basically. So, how much it is depressed that we will that we will measure. So, anyway so, this is the geometry. So, we will put weight and there will be depression so, that depression how much depression that we have to experimentally measure. But what the what are the parameters we have to measure?

So, for that we need the final formula for this geometry of the experiment we have to find out the working formula we have to find out the working formula from the theory. So, here this it is a calculation for this theory it is slightly longer. So, I will not calculate that one. I will give basically this calculation as a supplementary material. So, just what is the final result from that calculation here I have shown here I have shown.

So, that Y equal to g L cube capital L cube that is the length of the bar that is the effective length of the bar that L cube by divide by 4 b that is breadth and d cube that is the depth of the bar and this m by l what is m that load mass at the middle point we are putting the mass ok. So, that is the m and what is the small l? That is the basically for each mass what is the depression of the cantilever of the middle point of the cantilever so, that is the small l.

So, this is we tell this the working formula for the experiment ok. So, now we have to look at this working formula what are the measured parameter that I have that we have to decide and then for that you need the need arrangement for the tools. So, then you have to perform the experiment you have to measure the parameters one by one. So, here clearly one parameter is length, effective length. So, we will use meter scale this breadth is the b. So, we will use the slide calipers for this and d this is the depth you can use slide calipers, but here we will prefer to use screw gauge.

Now question is why? Because in error analysis you have seen that this error over d will come. That will be three times of the last count of this instrument. So, if we use the slight calipers so, what will be the error over d if we use the screw gauge then error will be much smaller. So, to reduce the error so, you should depending on the power of the parameters you should choose. You should choose the precise tools. Now then this other part we have to apply the load and measure the detection.

So, for measuring detection we will show our arrangement there you will see we are we will use travelling microscope and this I will show the travelling microscope and describe what it is and how it is used. So, I think this the cleannery preparation for before starting the experiment. Now, let us go to the laboratory and perform the experiment that I will show you in next class.

So, thank you for your attention.