Strength of Materials
Prof S. K. Bhattacharya
Department of Civil Engineering
Indian Institute of Technology, Kharagpur
Lecture - 1
Introduction

Welcome to the video lecture series of the course on Strength of Materials. Well, I am S.K.Bhattacharyya from the department of civil engineering at IIT Kharagpur. If you further want to contact me on this particular e-mail address which is bsri@civil.iitkgp.ernet.in. Now, the course on Strength of Materials is designed in such a way that it covers basic aspects of the first course on the Strength of Materials. It is expected to cover the entire course in 40 lessons which is of 1-hour duration module. And it is expected that the whole course is covered in 10 modules.

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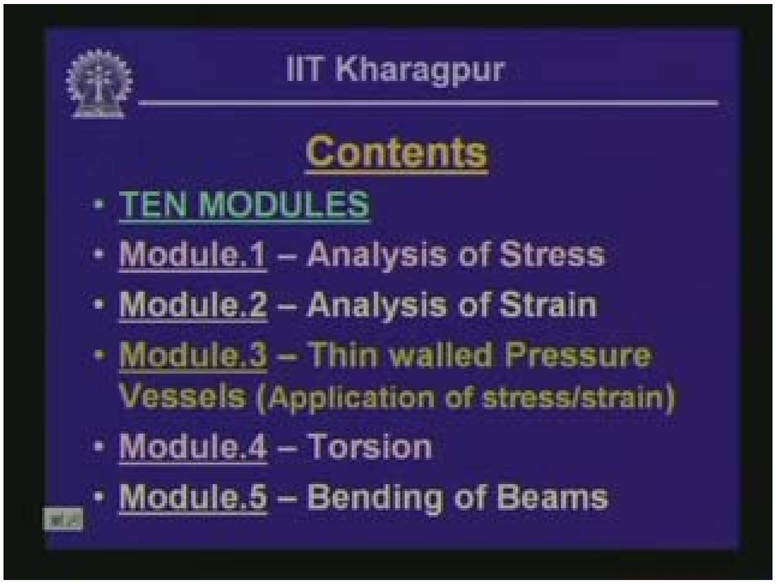

In Module 1 we expect to complete the analysis of stress and will have six lessons including the lesson which we will be discussing today where we will be introducing the concept of stress.
Module 2 will have around eight lessons, which will be on the analysis of strain.
Module 3 is the application of stress and strain, which is on thin-walled pressure vessels and will have three lessons.
Module 4 is on torsion and will have four lessons
Module 5 is on bending of beams, which will also have four lessons.

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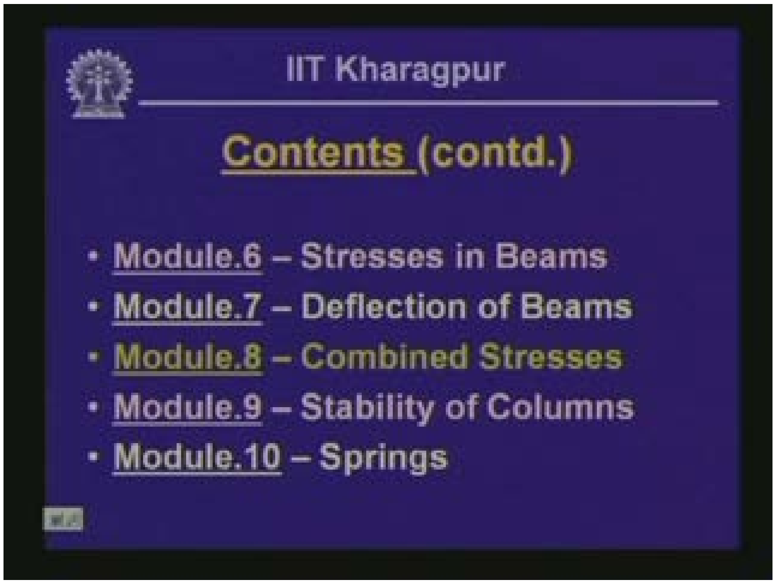

Module 6 is on stresses in beams, which will have also four lessons.
Module 7 is on deflection of beams and will have four lessons.
Module 8 is on combined stresses and will have three lessons.
Module 9 is on stability of columns and will have two lessons and
Module 10 is on springs and will have two lessons.

So thereby, in these ten modules, we expect to cover around 40 lessons in which the entire aspect or the basic aspect of strength of material is going to be covered.

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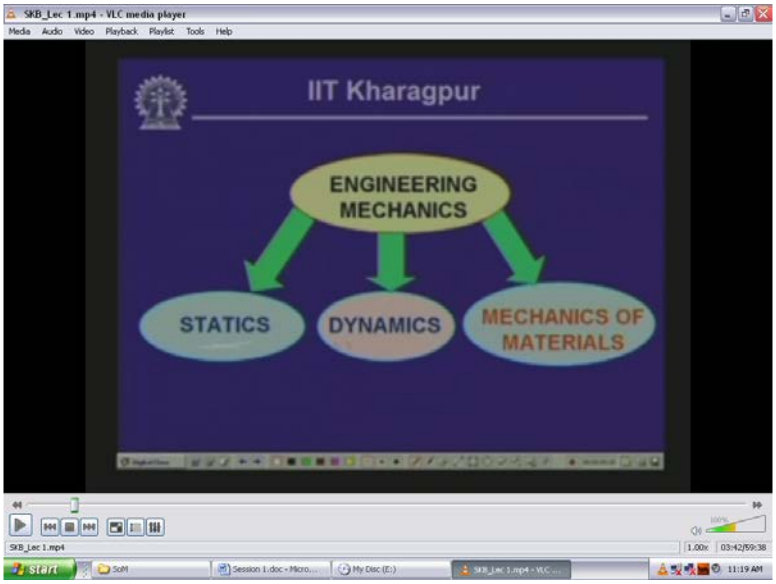

Now this particular course on the engineering mechanics, as we know, basically has three fundamental areas and they are;
The Statics
The Dynamics and
The Mechanics of material.

Now it is expected that you have already gone through aspects of statics and dynamics. You have noticed probably that statics and dynamics mainly concentrate on the study of external effects on rigid bodies. We do not worry about the deformation of the body, or deformation of the bodies is neglected. Whereas in mechanics of materials, we deal with the study of bodies, which are subjected to externally applied loads. We look into the aspects of the internal effects of the loads, which are acting externally and the deformation characteristics of the structural member. So in mechanics of materials, we are interested in these two aspects, internal effects of the externally applied load and the deformations that are caused within the body because of the externally applied load. And in fact, of these both, the aspects deformation of the load and deformation play an important role while designing a member.

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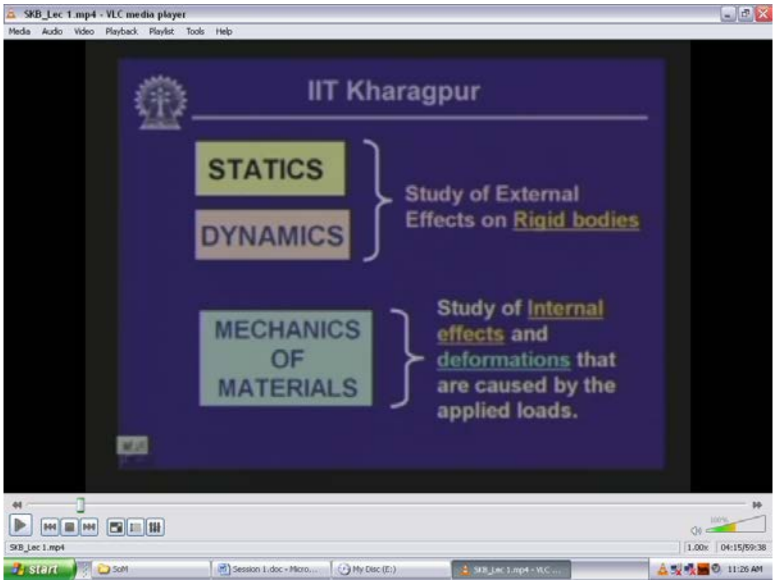

In fact we look into what we mean by design. When we try to arrive at a particular size of the member, we need to know how much it deforms and what is the effect of external load on that member internally and these aspects are dealt in the particular subject, which we call mechanics of the material.

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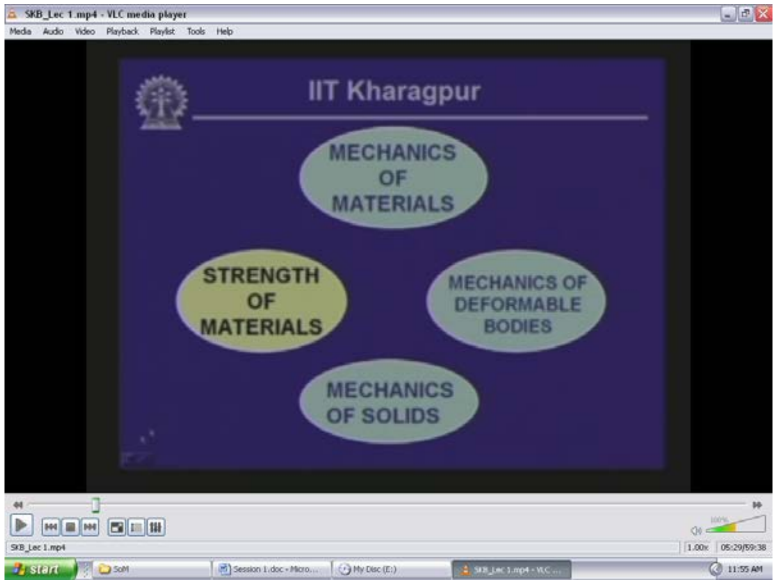

Now mechanics of material: in fact, when you look into this, you will find they are called by different names; they are called strength of materials or mechanics of deformable bodies or mechanics of solids. Now whatever the name we may call the subject as, basically, they contain the same information or they will give you similar information, whether it is mechanics of material or strength of materials or mechanics of deformable bodies or mechanics of solids; they mean the same thing. Now here we have termed it as strength of materials.

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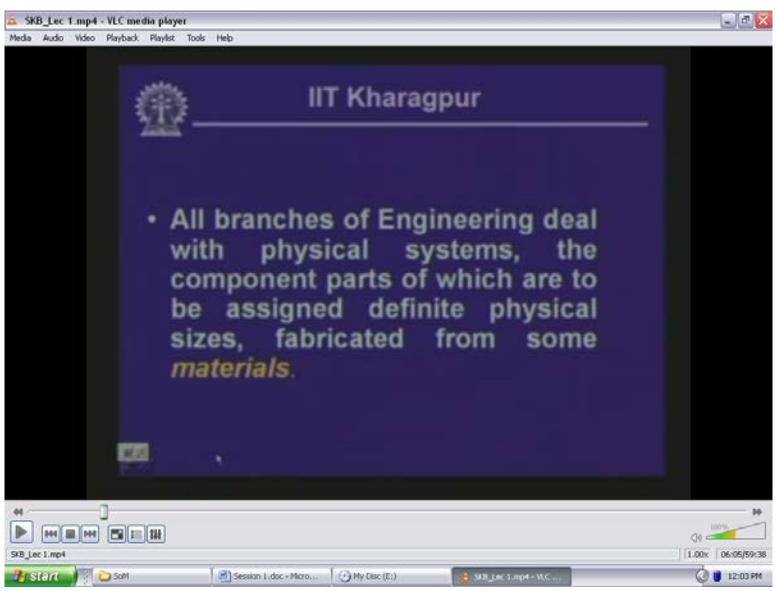

Now it is interesting that all branches of engineering deal with some kind of physical systems. And these physical systems are composed of the individual parts. When we look into different systems from different engineering disciplines, we will find that these physical systems are composed of different elements. And each individual element, when connected together, gives the whole system. Now these systems of the individual units are to be defined or assigned a definite physical size, and these elements are fabricated from some materials. And we need to know the characteristics of these materials or behavior of these materials. This helps to know the whole structure of the system or whole physical system that are made of different elements and can help us to understand whether they can stand the external load. This is the objective of this particular subject, wherein we look into what these elements are, what are the different kinds of forces they are subjected to, and what is the behavior of these elements against these external loads.

Now, if we talk about a building structure, which you must have noticed in several places this particular building structure is made of some kind of materials and also this particular building structure is made of some individual elements and all these elements, when combined together, they give this building a structural form. Now it is expected that this building structure should perform some of the functions for which it has been built or it has been designed. Now the functions this particular structure is subjected to, different kinds of loadings, and these loadings could be generated from the environmental aspect such as for the effect of wind on the structure or this particular structure may be subjected to earthquake forces. Now apart from these loadings, which are expected to come on this building from the environmental or the surrounding environment, it is also subjected to some kind of loads.

For example, its own weight of the element: there could be loads where human being will be moving around and there could be loads, which are arising because of some operation of the equipment inside the building. So these building structures as a whole and the individual components, combining which we have formed this whole structure, they are subjected to these external loads.

Now, we will have to know or we will have to find out what are the effects of these external loads on the building structure as a whole and in the individual units, in parts, what are the effects of these loads? Now it may so happen that the flow of the building on which the people are moving, if it deforms excessively then there is a possibility that it may not be in a usable form and as a result it may not be in a serviceable condition. So we will have to know whether elements within this whole structure, whether they can withstand the external load of which we just talked about, whether it can perform that it does not have excessible [excessive?] deformation, whether the whole structure is stable in its form because of such environmental loading or huge loading or wind loading or earthquake. Whether the whole structure is in a stable position or not? Now these are the answers we would like to found out. And the area which covers this is nothing but the Strength of Materials.

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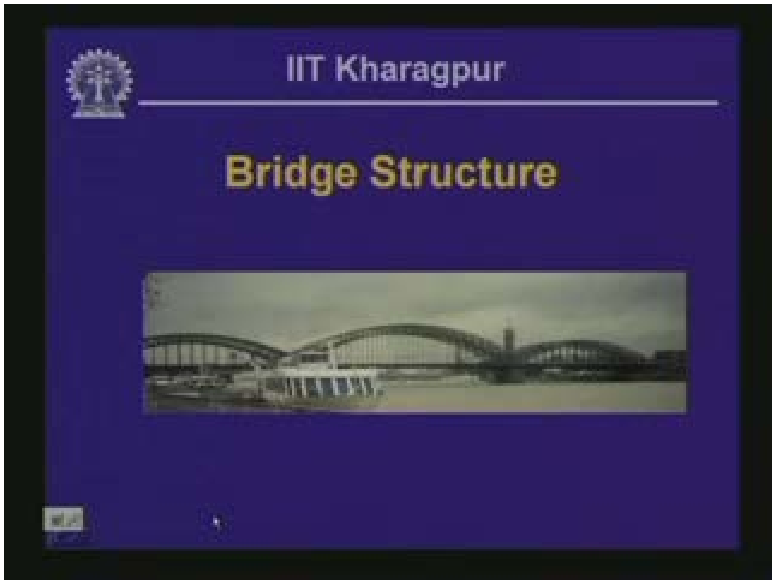

Other than the building structure, there is another interesting structure that is the bridge structure, which is bridging the gap between the two sides or two ends of the river. Now as we have seen in the case of the building structure we have loading from the environment, which we have said from the wind or the earthquake. Now this particular structure, apart from those loading, will be subjected to the loads because of the movement of the water. The supporting structure, which is holding this bridge, will have the loads because of the movement of water. So that is an additional load coming on this structure; also there will be vehicular movement on this particular supporting structure that also imparts particular load on this structural form, and as you can see the ones re-structured should withstand these loads without undergoing the excessive deformation. Or the strength of the re-structure should be such that it can withstand these external loads.

Also, as you can see, this particular structure is composed of different elements. So individually these elements should be in a position to withstand all these loads. So again what I would like to emphasize is that structures, when we consider they are fabricated or constructed out of individual elements and combined together. So each individual element will be subjected to some kind of forces which we will see as we progress in the course and those members should be in a position to withstand those forces safely without causing any failure of those elements. If any individual element fails that may lead to the failure of the whole structure.

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Now let us look into the other areas of the subject. For example, the spacecraft structure. These are also subjected to different kinds of environmental loading apart from the loading which will be generated for the movement of the spacecraft. And their structural body is made up of some material, which should withstand the forces that it is subjected to and also one of the requirements of these spacecraft is that the materials, which we use for the whole structure of the body, should be lighter in nature.

Now if we have to adhere to this particular condition, that means we need to look into the particular type of material, which can withstand safely the forces that will be generated in this particular structural form. At the same time it should not contribute too much weight to the structural form. And in one word, the whole structure should be stable; it should be strong to withstand the external forces and also it should not have excessive deformation in different positions.

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We look into this particular mechanical equipment, which is used for testing purposes. Now this mechanical equipment has several parts when the loads are applied for testing. . Now these individual parts are to be assigned size in such a way that they do not undergo excessive loading or in other words that the load distribution should be such that the parts sizes should be such that they can withstand the load which is coming when it is raised. So you can see whether building structure or bridge structure or you talk about spacecrafts or you talk about the mechanical components; even the electronic engineer when they use printed circuit boards wherein the chips are mounted. The boards are to be strong enough to withstand any environmental loading that is coming on that. It should be positioned properly, the support. It should not fail.

Therefore, you see any physical system used by any engineering discipline they are, they should be such that they can withstand the external load coming on such structural form. So our objective is to analyze these individual parts with which all these structural forms are used. Structural forms, in general, could be building structure, it could be bridge structure, it could be spacecrafts or it could be mechanical components. So any of these structures, when they are built with these individual components, now these individual components are to be analyzed and see that they satisfy the strength requirements, they satisfy the deformation requirements, and they satisfy the stability requirements. This is what we look for in this particular subject of strength of material.

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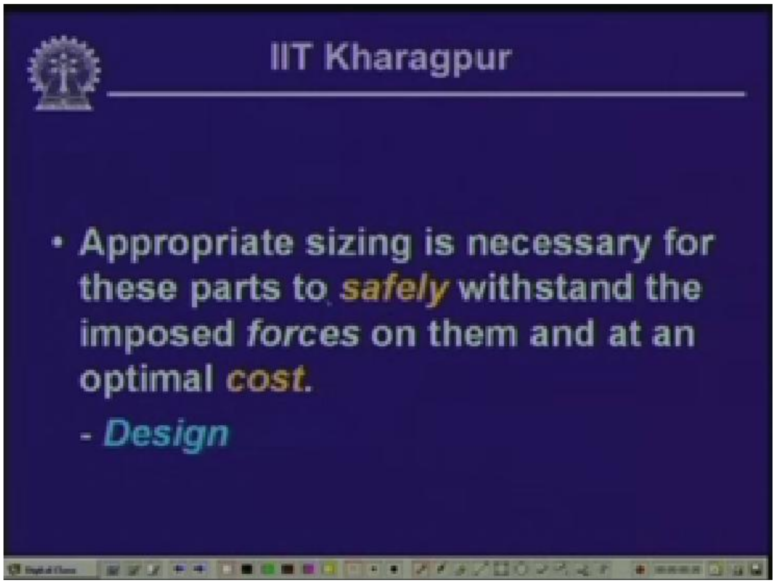

As we have discussed, appropriate sizing is necessary for these parts to safely withstand the imposed forces and at an optimal cost. Though we are not going to talk much about the cost aspect of it, but when you talk about the strong design we are concerned with both the safety and cost. When we say safety, we mean that the elements should be assigned the sizes in such a way that it can withstand any external loads. And these external loads could arise from any of such conditions as we discussed. And many a time, it so happens that we give larger size for a particular element and thereby, we satisfy the strength or the deformation of the requirement. But it may so happen that a smaller size of that could easily withstand that force without causing much of harm in terms of strength or deformation.

Naturally then, the smaller size will be more economical than the larger size, which we can go for though both are safe in terms of strength, size and deformation. Hence what we need to do is not only that we should look into these strength, stability and deformation characteristics, but we should look into the cost aspect also when we look into the proper design. That is the job of the designer. Well, for the time being, we will not look into the cost aspect of it but we will be more concerned with the aspect of strength, we will be more concerned with the aspect of deformation and the aspect with the stability. And that is what we will be looking into in this particular course.

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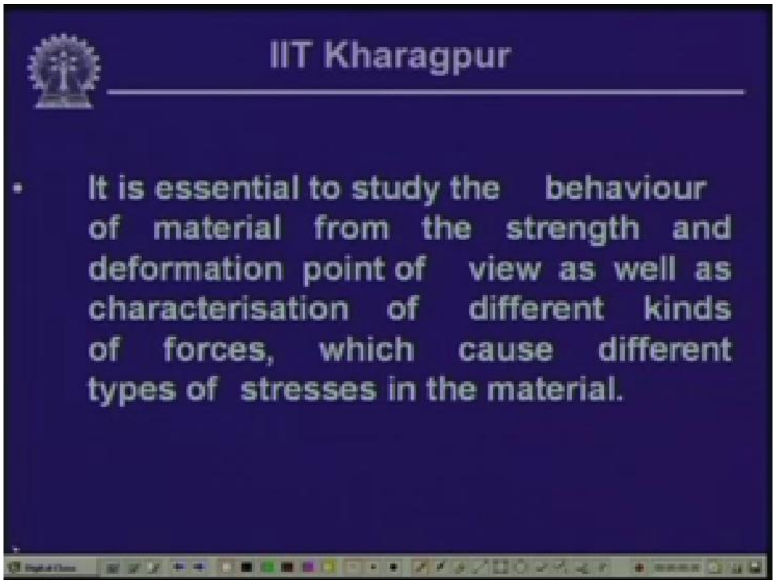

Hence, it is essential to study the behavior of material from the strength and deformation point of view, as well as the characterization of different kinds of forces, which cause different types of stresses in the material. In fact, in a few minutes, we will look into what really means by stress. So we are concerned about the strength, the deformation and of course we would like to look into the effects of different kinds of forces that this particular member will be subjected to, that can cause different kinds of stresses in the material.

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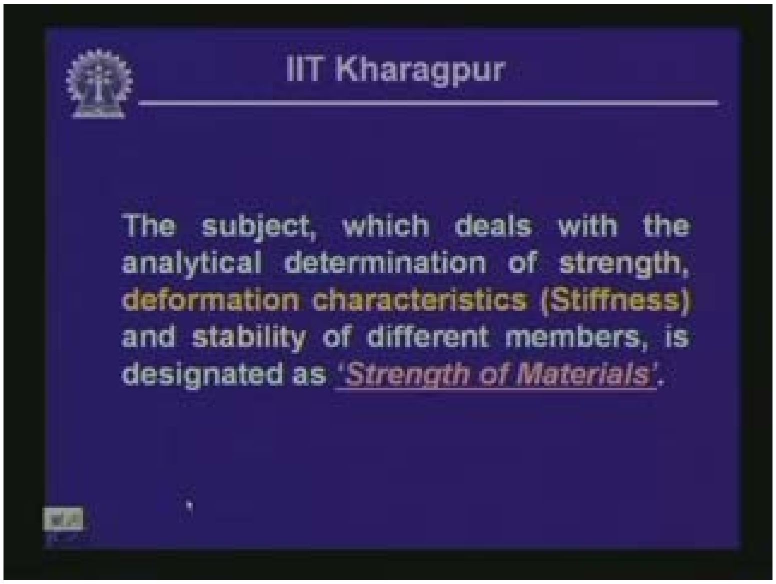

Now the subject, which deals with the analytical deformation of the strength, the deformation characteristics which you call as stiffness and stability of different members, is normally designated as the Strength of Materials. I emphasize that we like to look into these three aspects: one is strength another is stiffness, which is nothing but the deformation characteristics of the members and the stability of different elements, which we look into in this particular course and which are the combination of these three. That means characterization of the strength, the deformation, the stiffness and the stability. All we look into in this particular course, which we normally call as Strength of Materials.

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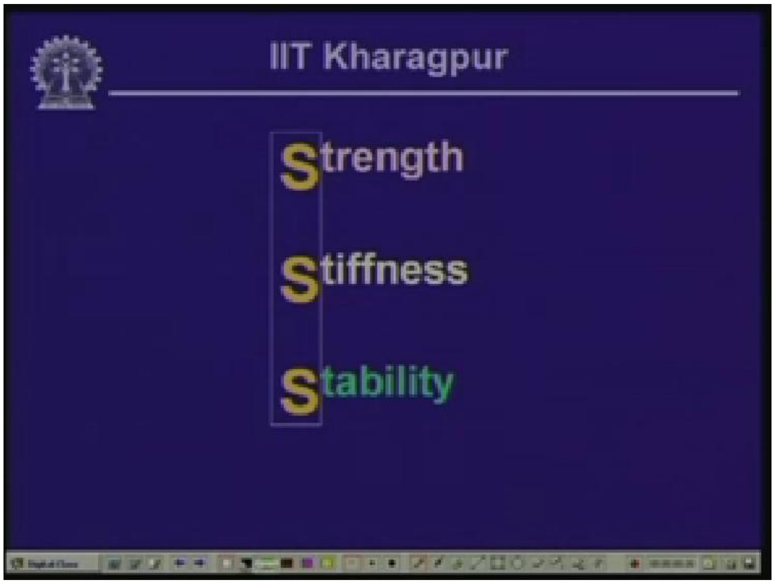

So now we are in fact in Strength of Materials, we are interested in these three characteristics: first one is strength, another is stiffness and another is stability and these are called as three Ss of strength of material. So we are concerned with the three Ss: parameter strength, stiffness and stability.

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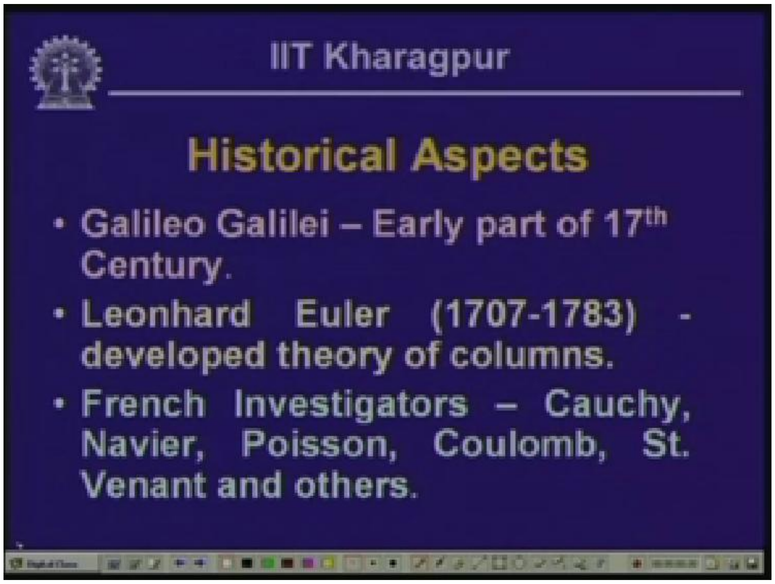

Well now, having looked into this background of strength of material, we look into the historical background of this particular course. In fact the Strength of Materials is quite an old subject. In the earlier part of the seventeenth century in fact Galileo, Leonardo-Da-Vinci tried to give rational meaning of these aspects of structural members. Prior to that, in fact, people used to use these concepts, which were based on the experience and mainly based on the rule of the thumbs. But Galileo started giving explanation in a more rational way about the different aspects of the forces in the words in terms of tension, in terms of compression, and of course they or Galileo emphasized more on the experimental side of these elemental characteristics.

In fact, Strength of Materials in that sense is a fascinating blend of both the experiment and theoretical aspects. In fact, Leonard Euler in 1744 gave his theory on the column buckling. Now he had explained how you arrive at critical buckling load for a column member. But since he didn't have any experimental evidence, in fact, it took almost 100 years to establish or reestablish this particular theory of Euler's. Still today, we talk about the Euler's column buckling aspect. In fact in the earlier stages we had lot of theoretical explanation we had experimental evidences but subsequently the French investigators like, to name a few, Cauchy, Nervier, Poisson, Coulomb, St. Venant and several others. They had devoted their attention to these areas: theoretical development of strength of material aspect or the mechanics material of the aspect, based on which, we find that this particular subject, where it stands today, is based on their research investigations. And several theories came up based on their research findings.

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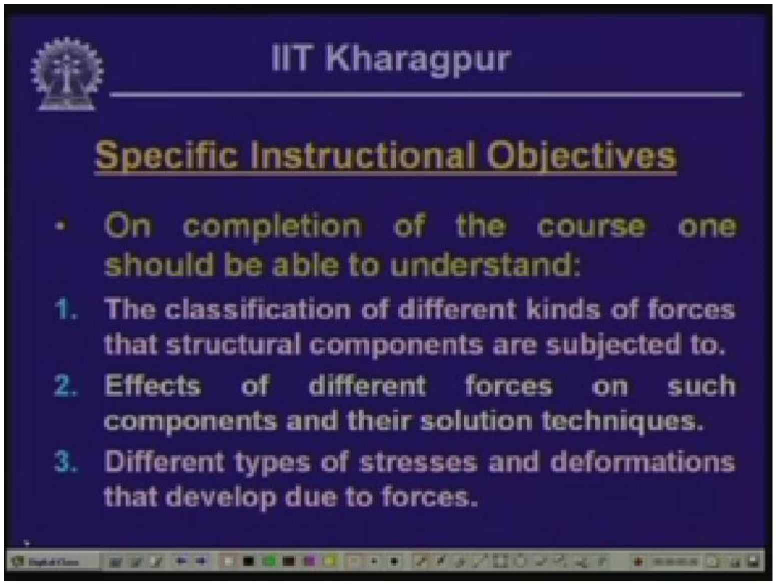

With this background what we expect from this particular course is that once this particular course is completed that means once somebody goes through all these lecture lessons of ten modules, it is expected that one should be in a position to understand the classification of different kinds of forces that structural components are subjected to. Now, when we say structural components the structural component we talk in a generalized term, it is not that of any particular structure. A structure could be building structure, it could be bridge structure or it could be structural component of any mechanical equipment or it could be part of any spacecrafts or any structural form we talk about; it is a part we could talk about, it is the part or any part of the structural system as a whole.

Any part when it is subjected to any kind of force, we should be in a position to characterize these forces, in a position to find out the effects of the forces such as structural components: the classification of different kinds of forces that structural components are subjected to and then the effects of different forces on such components and their solution techniques. This is what we will be looking into in the particular course. Subsequently, the stresses of these forces on the members and the deformations these members will be subjected to will be analyzed systematically.

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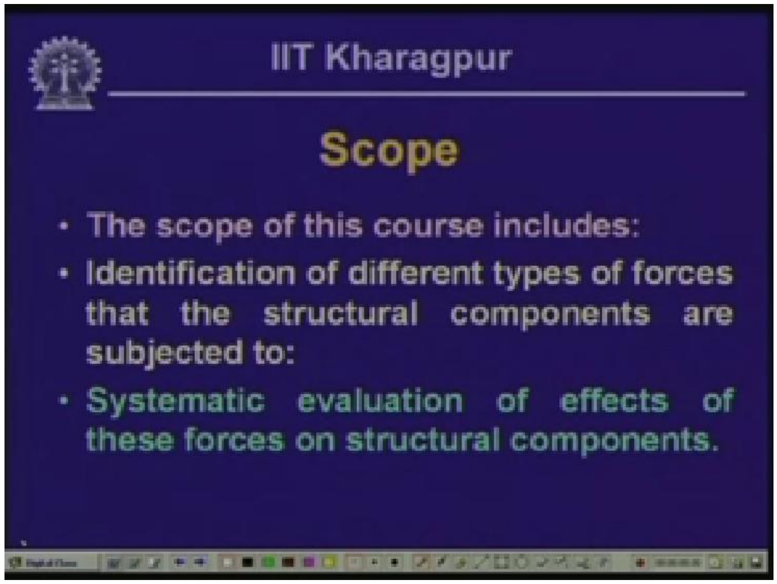

Hence the scope of this particular course includes the identification of different types of forces that the structural components will be subjected to and as we will go along in this particular course, you will find that in different modules that we have looked into, the different types of forces the structural components are subjected to and how to analyze those forces or the components of the forces that the members will be subjected to and how to compute the stresses in the members based on the forces. Also, we will look into the systematic evaluation of the effects of these forces on such structural components.

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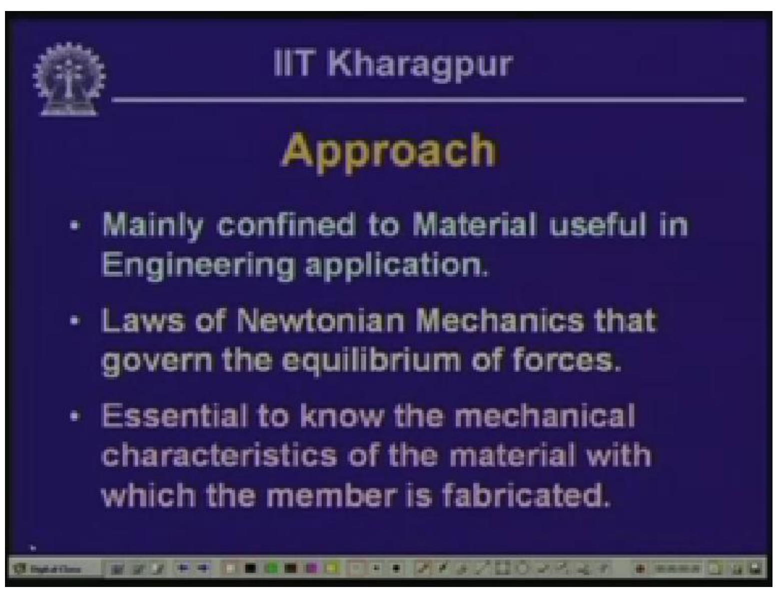

We will be confining ourselves to the materials, which are useful for engineering applications. This is important because, we are not going to cover the whole lot of materials because when you talk about the materials it is quite general in nature, it covers many aspects, different kinds of materials, but here we will be restricting ourselves to the materials, which are useful for engineering applications and that is what we should keep in mind. Also, the structural members which we talk about, they do follow the laws of Newtonian mechanics and thereby the equilibrium of forces governed by the mechanics law will be enforced. Also, it will be essential to know the mechanical characteristics of the materials with which the member will be fabricated.

So you see here that when we talk about these aspects, here we will be dealing with one that is the theoretical aspect, where we will be looking into the equilibrium of forces which are acting on the body and we try to analyze the internal forces so governing the Newton's laws of mechanics adopted and subsequently we will have to use the mechanical behavior of the material with which these structural elements will be fabricated. Now to characterize this behavior of this material or the mechanics of that material we need to adopt some kind of experimental investigation. So this part will have some out put from the test results in the laboratory. So you see that it will be combination of the theoretical aspect along with the experimental investigation. The Strength of Materials is a blend of these two. That is, theoretical aspects on which we apply the laws of Newtonian mechanics and we try to characterize using the behavior of the material based on certain experimental evidence. The combinations of these two will lead us to different theories and will lead us to the different classification of the stresses due to the externally applied load on structural members.

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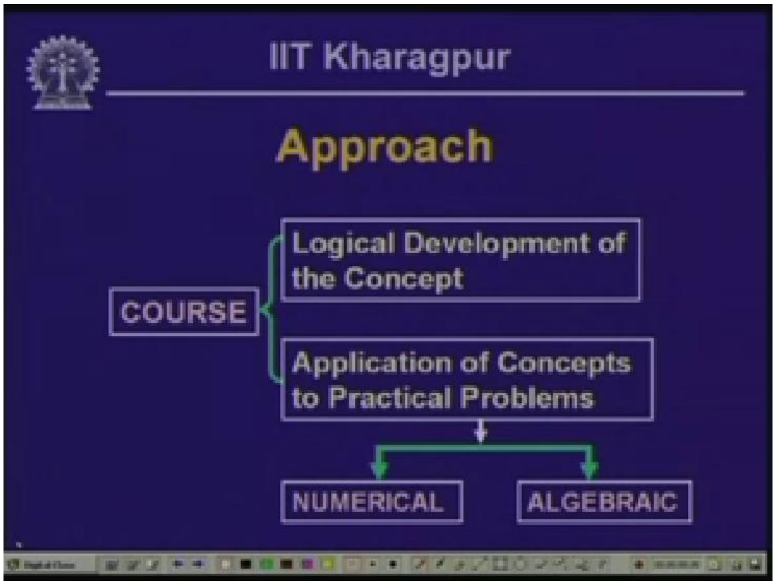

As we go along, we will find that the whole course will be divided broadly into two parts: one is the logical development of the concept and another one is the application of these concepts to the practical problems. When we talk about the logical development of the concepts, basically based on these concepts we will try to derive the formulae that are necessary for arriving at different kinds of stresses in the members for the external loads. That is what we will be looking into and the first part will be devoted for that. For any reason the initial part will be devoted to the derivations of the theoretical background or the concept and based on those concepts and formulae that we arrive at, we will be looking into some application problem areas or example problems and in those application concepts we find, we classify into two groups, one we call the numerical problem and other the algebraic problem.

When you talk about the numerical problems, we will be dealing with some example problems in which we will be assigning some specific values, whereas in the case of algebraic problems, we will try to arrive at some expressions which are very general in nature. Now both are having its merits. When we talk about the numerical examples, at each type of these examples, we will be evaluating it. We can visualize it: based on the values of the parameters we will be arriving at, we can get a feel of those parameters, physically what they represent and what they should be and what actually we are getting.

Now when we talk about algebraic problems, there we would be discussing about the problems which could be general in nature and thereby we will arrive at certain expressions and these expressions can be used for solving specific problems where we will have specific numerical value or some parameter. This is how we classify the two groups of problems. This is what is indicated over here that the application concept which we derived in the initial stage, these concepts when they are applied to practical problems, they could be applied to the numerical problem or the algebraic problem and as we go along in the course in the different modules, we have taken different examples and different areas, which satisfy the requirements of different engineering disciplines. Those structural components can be used for characterizing the behavior of those individual elements. So they can be used according to the need of any structural system.

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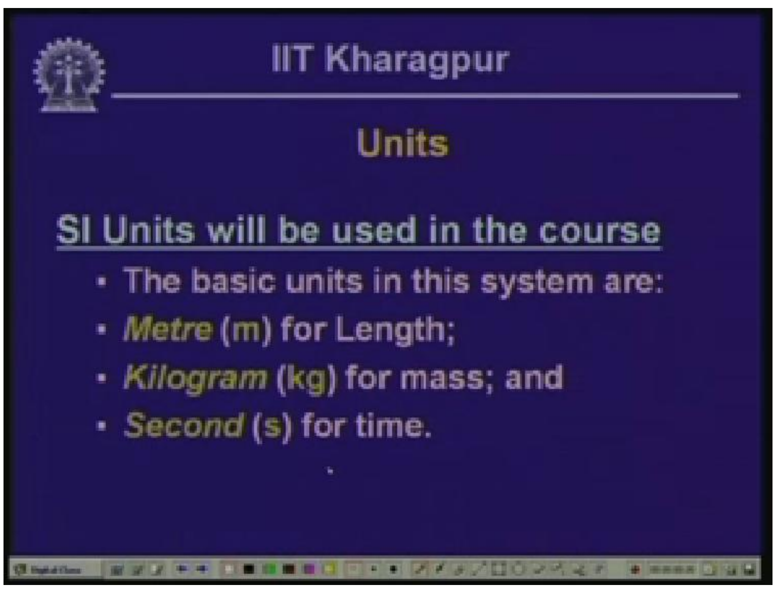

When we talk about the numerical problems or the algebraic problems, we talk about the units and the basic units which are used. We use the international system of units in this particular course. And the basic units for these in the international system are

Metre is for length. Let us call this length as L. Kilogram the abbreviated form is kg that is for mass M and Time we use second abbreviated form as s for time, which we can call this time as T. Based on these basic units L, M and T, we arrive at certain derived units.

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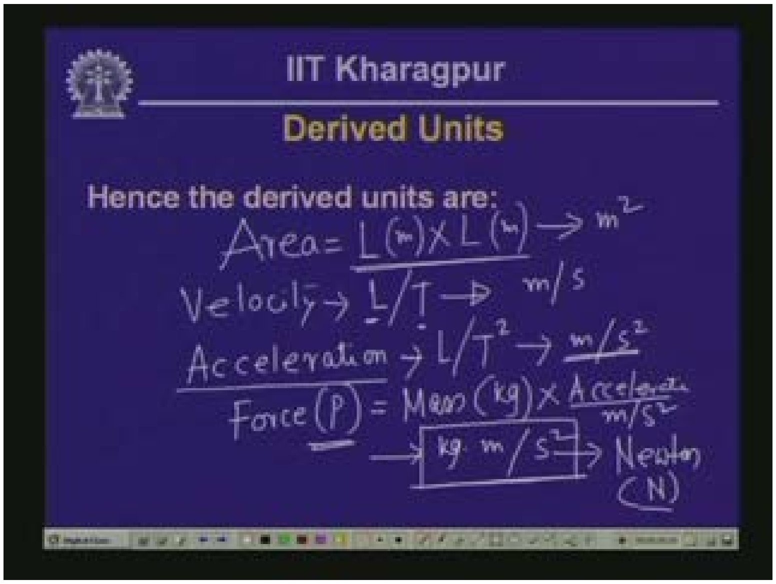

Now when you talk about the units for the area; Area as we know is the product of two linear parameters. So let us call L, which is in meters, multiplied by L is in meter and there by we will get the unit of area m square. Now when we talk about the unit for velocity, which is distance by time so L by T and if we substitute the units for these basic parameters we get m by s. Now if we talk about the units for acceleration, which is rate of change of velocity, it is L by T square and thereby gives the unit as m by s square.

Now once you know the acceleration, then based on Force P this is equal to Mass, the basic unit of which is kg times the acceleration, as you have seen in the units, which is m by s square. So this gives us the unit kg m by s square. This unit kg m by s square we normally designate as Newton(N). And the abbreviated form of the Newton is N. So when you talk about the unit of force, it is N. Now for higher values we use kilo Newton, which is 10 to the power 3 Newton, we define in mega Newton, which is 10 to the power 6 Newton.

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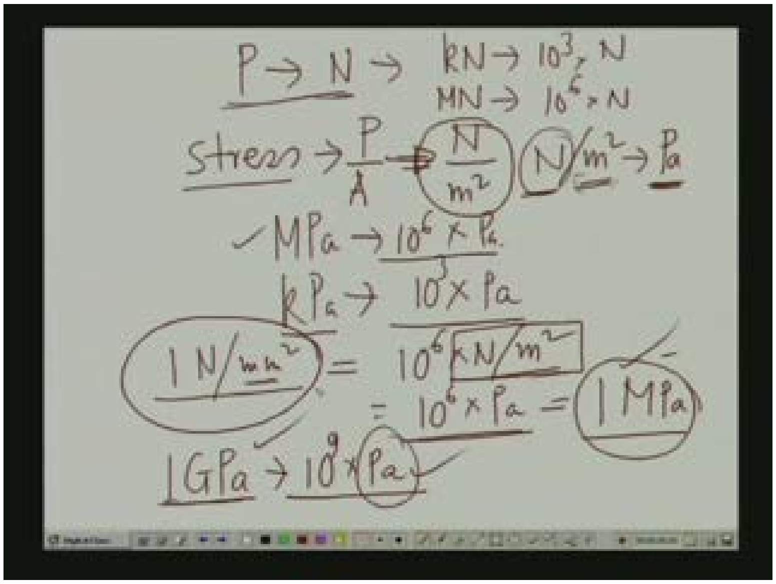

Also many a time, we use parameters as we have seen Force, which we define in Newton, it could be in kilo Newton or mega Newton, which is 10 to the power 3 Newton or 10 to the power 6 Newton. And we define another parameter, which we call as stress in few minutes. This unit for stress or the stress we define as the force per unit area. So as we have defined, the unit of force is Newton and area is m square. So the unit for stress we call N by m square and this is called as Pascal, Pa.

When one Newton of force is acting on one square meter of area, in fact this amount comes small, where Newton load is very small when compared to meter square area is very large, many a times this stress we represent in terms of mega Pascal or kilo Pascals. Now when we talk of kilo Pascals, we have designated as kilo Newton, the kilo Pascal is 10 to the power 3Pa and mega Pascal is 10 to the power 6Pa. Many a time, instead of defining area in meters, we define in terms of millimeters (mm), the stress in N by mm square, and this equals 10 to the power 6 Newton per meter square(10 to the power 6). As we have seen Newton per meter square is Pascal. So this is 10 to the power 6Pa. Now 10 to the power 6Pa is nothing but one mega Pascal. So we can say that one mega Pascal is equal to one Newton per millimeter square. Also many a time we use the unit Gigapascal it is 10 to the power 9. So 10 to the power 9 into N by mm square. So the stresses can be represented as either Pascals or kilo Pascals or mega Pascals or Gigapascal.

As you can see, based on these units that we use in international system that your length in meter, the mass in kg and the time in second and based on those basic units, we can arrive at the derived units and we look into these in this particular course. We will be more concerned with the units of the stresses, which is Pascal, and thereby at many a place you will come across kilo Pascal, mega Pascal or the Gigapascal for the units of the stresses.

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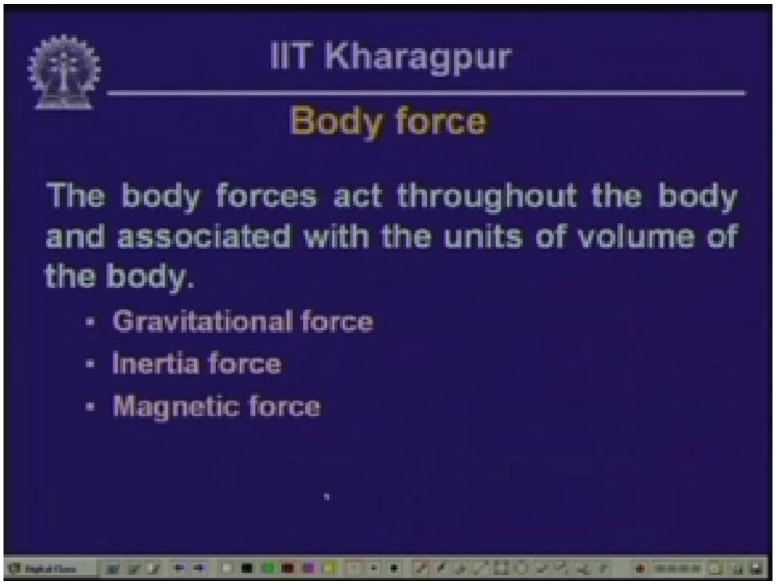

Having known the units, let us look into the aspects of the forces that the body or the member is subjected to. Now we come across a term which is called a body force; now the body force is basically associated with the units, the volume of the body, and thereby it is basically a distributed system, that is, the force which is distributed over the entire volume of the body. Or in that sense the gravitational force or the inertial force or the magnetic force – these are the forces which we term as body forces. Now, though it is distributed over the volume, when we try to analyze the forcing system, the body force we apply assuming that it is at the centre of the gravity of the body. So when we analyze a particular structural component, the body force we apply at the centre of the gravity of the body. Basically these are the forces: the gravitational force, the inertia force or the magnetic force are generally termed as body force.

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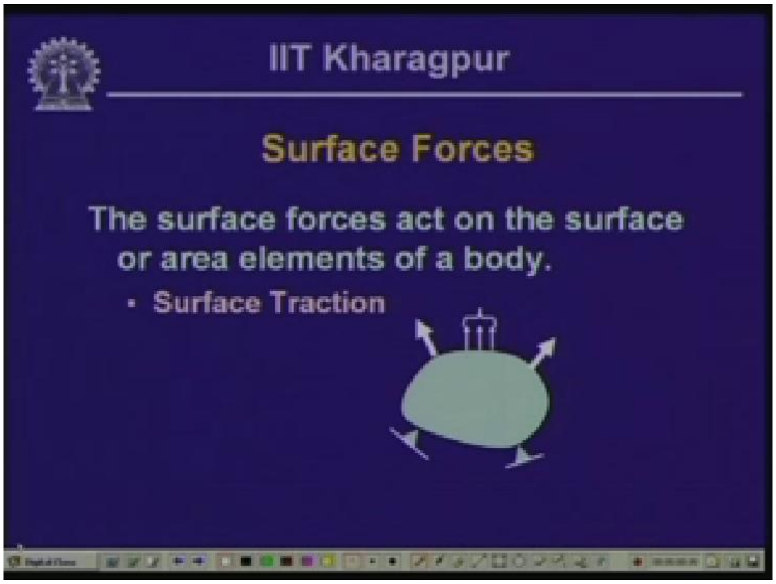

Now, having known the body force, we are interested to know the kind of surface forces. This is another kind of force which acts on the body, that is, the surface force. From the name itself you can make out these forces act on the surface of the body. We call these the area elements of the body. Now these forces on the surface, supposing this is the structural body, we have two kinds of support. The body is supported at these points and subjected to the forces at these points. Now these forces, which we call as concentrated load at these points, act on these particular surfaces of the body; this particular force is acting and it is over a small area and thereby the force concentration at that particular point. That particular force we call as concentrated force. It could be distributed over like in some area, in this particular case if you look into that, it is distributed and this we call as distributed force system. The body on the surface could be subjected to either a concentrated force or a distributed force. Now when these surface forces act on the boundary, we call that as surface traction. So please keep in mind the surface forces could be a concentrated force or a distributed force. When this forcing system acts on the boundary, we call that as surface traction.

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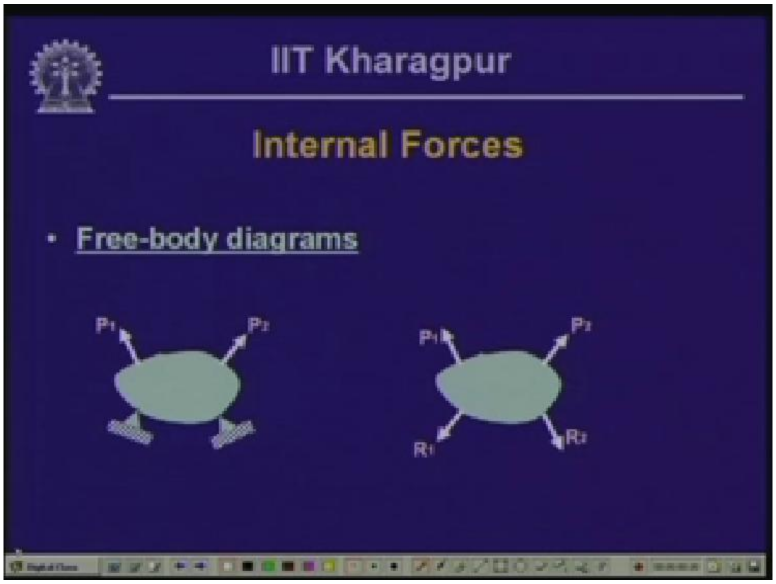

Now, having known the body force and the surface force, another aspect that we would be dealing with quite frequently would be the internal force. Now to know the internal force, we will have to look into one aspect, which we call as a free body diagram. Now let us consider a body which is supported at these two points, and subjected to these loads P_1 and P_2. And these we call as external loads. So the external loads are acting on this particular body. Now since this particular body is in equilibrium, under the actions of these external loads, there will be some amount of reactive forces generated at these support points.

So, if we remove these supports from this body, and represent the body in this form where P_1 and P_2 are the forces acting on the body, which we call as active force and because of these active forces on the body there are reactive forces, which are R_1 and R_2. Now these active forces of P_1 and P_2 and reactive forces of R_1 and R_2 are keeping this body in equilibrium. Hence when we consider or represent body with the external loads, in fact these reactive forces are also external loads, but when we represent the whole body, when we free or we make them free from these supports, and represent them using the active force and the reactive force, this particular diagram we call as free body diagram. So this is the free body diagram of the structure as a whole. That means, we have freed this structure from its supporting constraints and applied the reactive forces over there. Now if I like to cut this particular body through a line and divide and break it into two halves, then if this particular structure is cut through the line divided into two halves, then what do you get?

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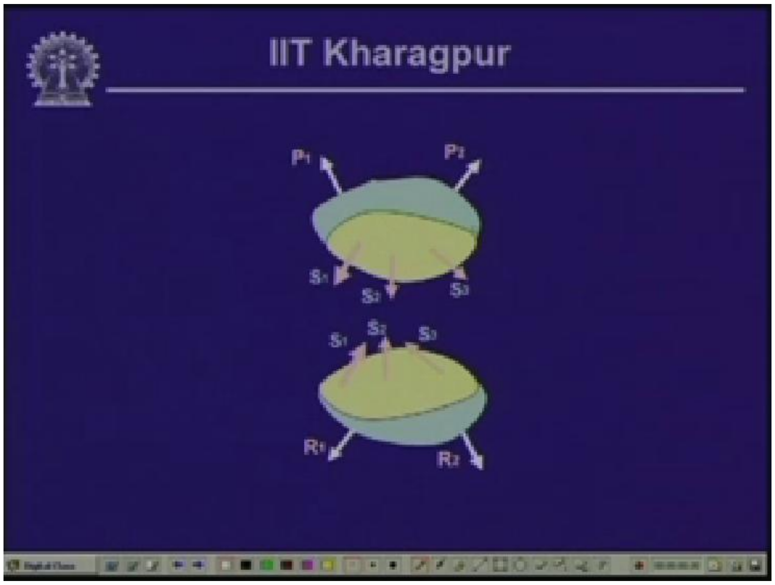

Then we get a form, something like this, wherein you see this particular half of the body is subjected to these external loads, P_1 and P_2. Since the whole body is in equilibrium, the parts of the body should also be in equilibrium. So when we make a cut in the body and separate it out into two halves, as you can see internally there are forces which will be generated, which are called S_1, S_2 and S_3. And the other half will also have the reactive forces, and these forces will be equal and opposite in nature because in static form they are in equilibrium condition.

Now these forces, which are generated internally to equilibrium these loads, we call these forces as internal forces. And these diagrams also are called as free body diagrams. So as you can see free that to obtain a free body diagram, we can remove the reactive constraints and make the body from the support and thereby we draw all the external loads acting on that. That is also a free body diagram or we cut the body and make different parts and on that we show the external force and the internal force and that is also a free body diagram. Now this free body diagram gives us the idea of the internal forces.

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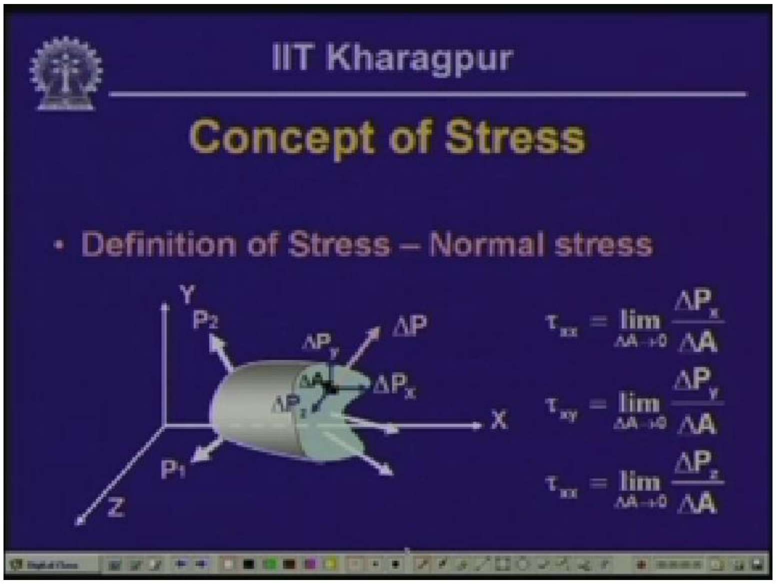

Now in mechanics of materials or Strength of Materials, what we are concerned with is this internal forces or the intensity of the forces that are acting. Now as you have seen these internal forces equilibrate the external forces and keep the body in equilibrium. Hence what we are interested to find out is the intensity of these forces and how they keep the body in equilibrium and thereby reduce the deformation of the whole structure. Now if we look into this particular body, wherein we have taken a cut and this cut, if you take the normal to this cut, this directs along the x axis.

On these we have a small force ΔP acting on a small area, which is ΔA. Now it is customary to decompose this force into two directions: one is perpendicular to the direction and another one is along the plane of the cross section. Now if we do that, if we decompose this load perpendicular section, which is ΔP_x because it is the direction of x and further in the plane the load in the section can be decomposed into two directions, one is ΔP_y and another is ΔP_z. Now since we are interested in the intensity of the force over this area, so ΔP and ΔA give us the intensity and that we call as stress. So stress basically equals $\frac{\Delta P}{\Delta A}$. Now we have taken the components along x, y and z directions, and mind that we have taken a cut, the perpendicular to that is matching with the x direction. Now this – $\frac{\Delta P_x}{\Delta A}$ – we call this as the stress in the x direction τ_x, $\frac{\Delta P_y}{\Delta A}$ is the stress in the y direction and the $\frac{\Delta P_z}{\Delta A}$ in the z direction. Now on a limiting scale, when we talk about the stress, at a point when this ΔA tends to zero this τ_x, τ_y and τ_z give us the stress at a particular point.

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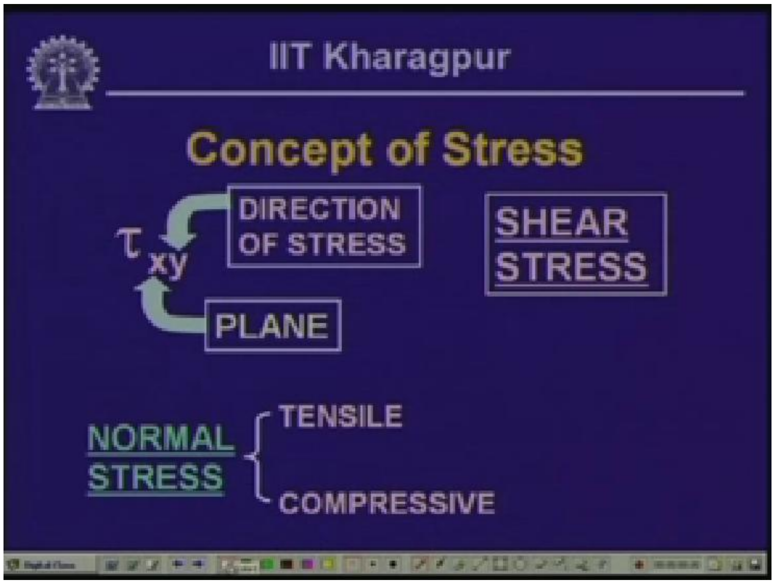

Now the way we have given these designations, if you look into τ it is the term of stress, the first subscript defines the plane, as I said, for a body we have taken a cut, the normal drawn to the plane, directs towards the axis x. This we call as x plane. This particular we call it as stress. Now τ_{xx} indicates that it is the stress in x plane and directed towards x and τ_{xy} indicates that the stress in x plane is directed towards y, and τ_{xz} indicates the τ in x plane directed towards the z.

Now, when we have the plane and direction coinciding or if this is the direction of the normal to the plane and this is also directed towards this, this we call as the normal stress. We denote this generally with σ_x. Sigma x defines that this particular stress is normal to the plane and this normal stress could be tensile or compressive in nature. When the pull, when this particular force is perpendicular to the plane and it tries to pull the body, we call that as tensile and when it pushes the body we call that as a compressive stress. We will look into more aspects in later lessons. Also the stresses, which are acting in the plane of the act, we call that as shear stress.

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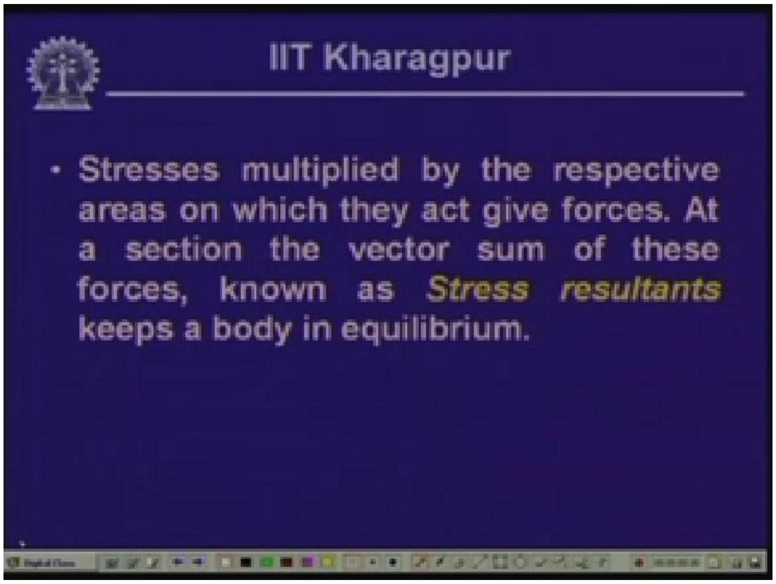

So stresses, multiplied by the respective areas, on which they act, give us the forces and at section, the vector sum of these forces is known as the stress resultant. Basically, in the problem of Strength of Materials, we are interested to evaluate this stress resultant and from those stress resultants, we compute the values of the stresses of a body, which are subjected to different kinds of loads.

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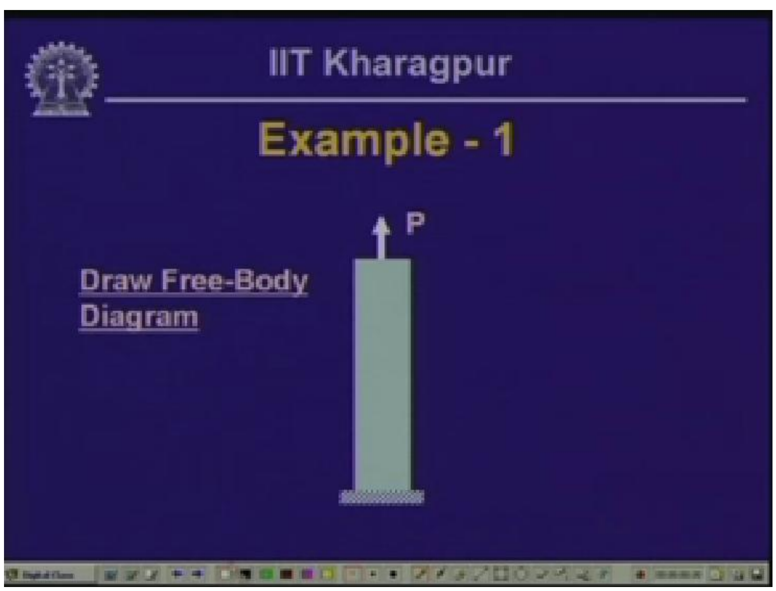

Now in this example we are interested to draw the free body diagram for this. Now this is the part which is subjected to a tensile pull. Now if you would like to draw the free body diagram of the whole part then, the free body diagram will be like this: that it is acting on by this force which is passing through the centre of gravity of this member, so the reactive force will also be P. Or if we take a cut somewhere, it will be a small part of the body and that also will be in equilibrium under action of these loads. This is free body of α the part of the structural form.

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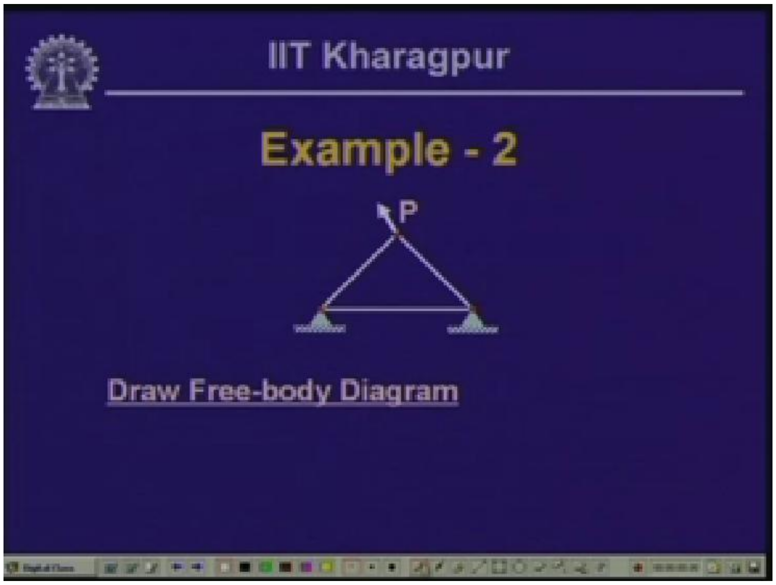

Also, if you like to draw the free body diagram for this structural form, which are bars subjected to this load P, now as we have done, make these structures free from the support and thereby get the reactive forces, they could be in this form or we can take a cut in this particular structural form and thereby you get the reactive forces, the active forces and the member forces. This is the free body diagram of this particular part. And this is how we make the elements free and take a cut, which give us the free body diagram of the structure.

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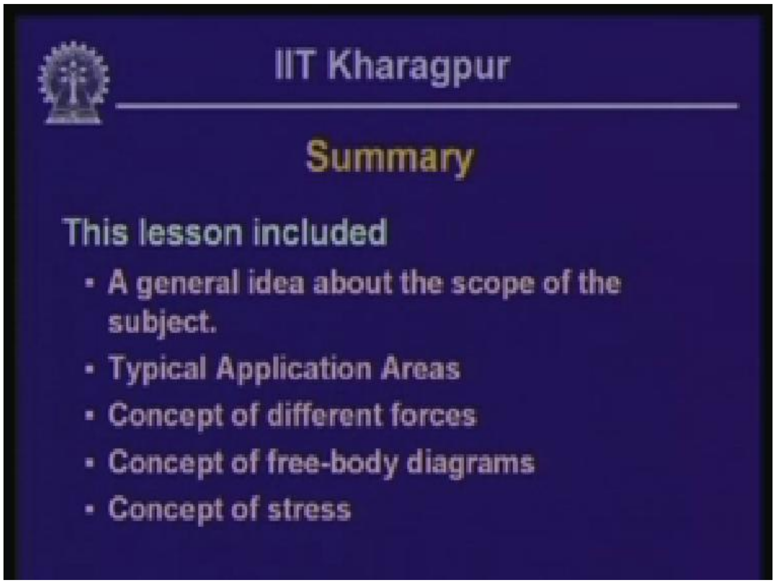

Hence to summarize in this particular lesson, we have included the general idea about the scope of the subject, we have discussed the typical application areas where strength of material can be applied. What is the scope of this particular subject? What are the disciplines where we come across the different problems based on the strength of the material formulae, where based on what we can get the solutions for such problems? Then concept of different forces also we have looked into: the concept of free body diagram and thereby the concept of stress.

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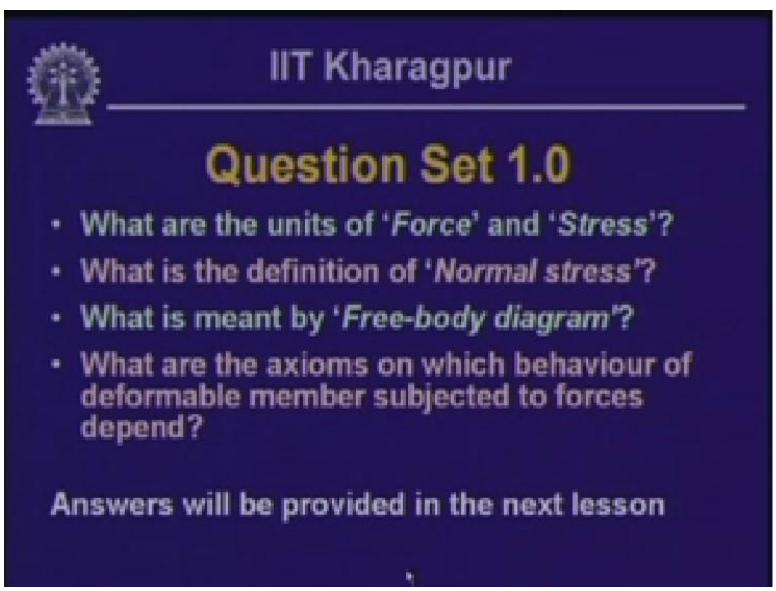

These are the questions for you.
What are the units of the Force and Stress?

What is the definition of normal stress?
What is meant by free body diagram?
What are the axioms on which the behavior of the deformable member subjected to forces depend?

Now look into these questions. If you go through this lesson, you should be in a position to answer these questions. We will be discussing about the answers of these questions in the next session.