Mechanics Of Solids
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Lecture – 01
Course Handout

Welcome to the course, mechanics of solids. So, as I told you in the introduction, that this course is very fundamental and very conceptual and this is the basic course if you are doing civil engineering mechanical aerospace and so on. So, if you do this kind of engineering basically this course will be the bread and butter. So, everyday day to day life you have to use this course.

So, I mean for getting the idea of your actual engineering same materials or structures or whatever you are considering in your studies, basically mechanics of solid will be the backbone for that particular concept well. So, what is the objective?

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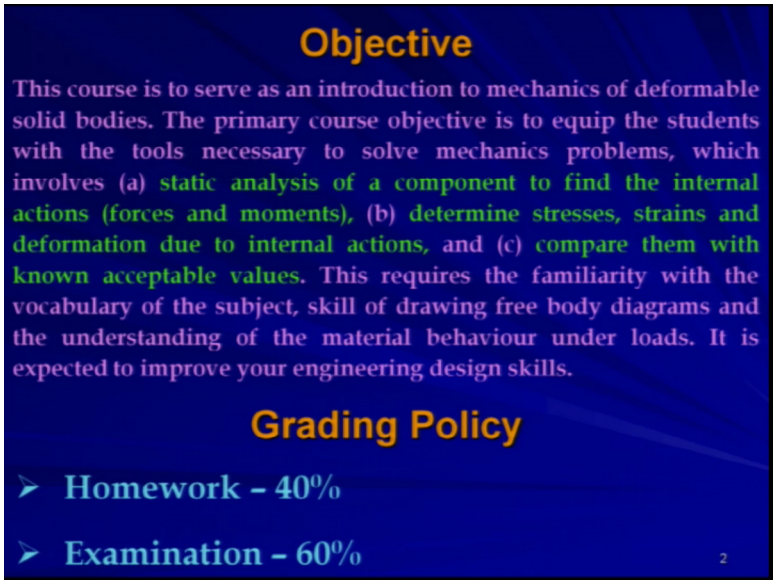

So, objective of this course is this course is to serve as an introduction to mechanics of deformable solid bodies. The primary course objective is to equip the students with the tools necessary to solve mechanics problems, which involves first static analysis of a component to find the internal actions forces and moments. Second determine stresses strains and deformation due to internal actions and third compare them with known acceptable values.

So, this requires the familiarity with the vocabulary or the subject skill of drawing free body diagrams. So, free body diagram is a very important, say concept which will be discussed later on when we will be progressing in this particular course. So, you will see that without this free body diagram concept, it is very difficult to understand the mechanical system or the mechanics of a particular body.

So, and the understanding of the material behaviour under loads, so, it is expected to improve your engineering design skills. So, this is a grading policy, as I told you in to introduction slide that is for homework 40 percent voltage is there and time to time your homework will be given homework assignment and for the final examination 60 percent voltage is there.

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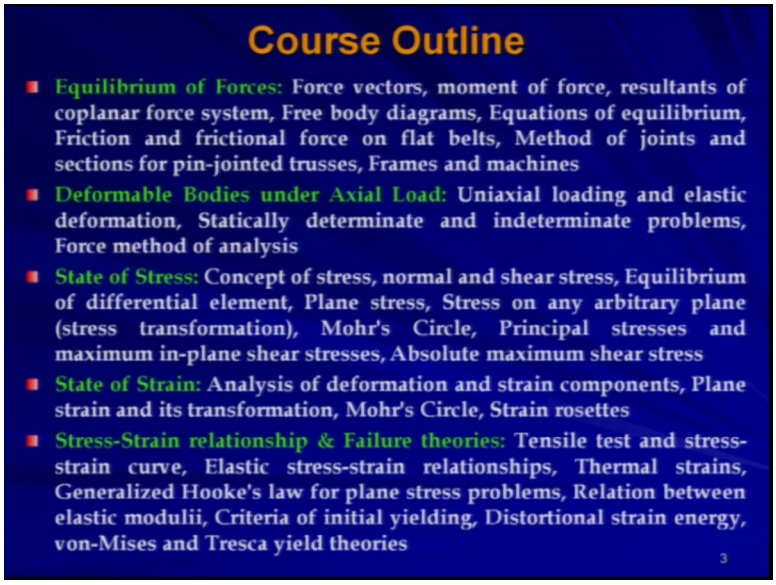

This is the brief course outline. So, we will cover this, these things in this particular course equilibrium of forces. So, it includes force vectors moment of force resultants of coplanar forces system free body diagrams equations of equilibrium friction and frictional force on flat belts, method of joints and sections for pin, jointed trusses, frames and machines.

Next is deformable bodies under axial load. It includes inertial loading and elastic deformation, statically determinate and indeterminate problems force method of analysis.

Next is state of stress. It includes concept of stress. Normal and shear stress equilibrium of differential element, plane stress on any arbitrary plane that is nothing, but the stress transformation. Mohr's circle principal stresses and maximum influence shear stresses absolute maximum shear stress.

Next is state of strain. It includes analysis of deformation and strain components plane strain. And it is transformation Mohr's circle and strain rosettes. Next is stress strain relationship and failure theories. So, it includes tensile test and stress strain, curve elastic stress strain relationships thermal strains generalized hooks law for plane stress problem, relation between elastic moduli, criteria of initial yielding, distortion of strain energy, von mises and tresca yield theories.

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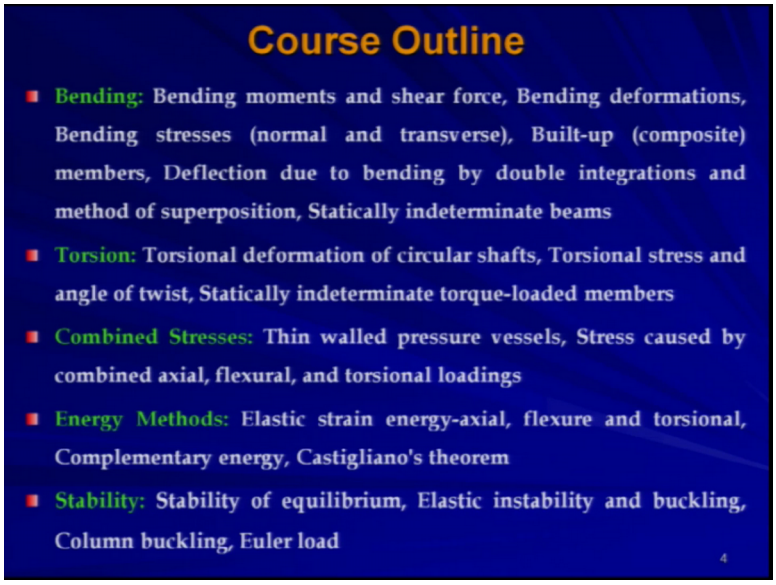

Next is bending. Say it includes bending moments and shear force. Bending deformations, bending stresses normal as well as transferous. Built up that is composite members reflection due to bending by double integrations and method of superposition statically indeterminate beams. Next is torsion. So, under this I will cover torsional deformation of circular shafts. So, we will be restricting ourselves only to the circular shafts. So, we will not be considering any rectangular or any other shape of shafts. Torsional stress and angular twist statically indeterminate torque, loaded members. Then coming to combined stresses, it includes thin walled pressures vessels stress caused by combined axial flexural and torsional loadings.

Next is energy methods, it includes elastic strain energy axial flexure and torsional, complementary energy and castiglianos theorem then finally, we will talk about stability. So, it includes stability of equilibrium, elastic instability and buckling column buckling and Euler load. So, this is the brief course outline. Now we will look at the course plan how the course will move; however, this plan is very tentative. So, we will cover all the things, but it is not necessary that we will stick to the exact course plan, because it depends on how we will cover the course in the coming weeks. So, this is a kind of tentative plan.

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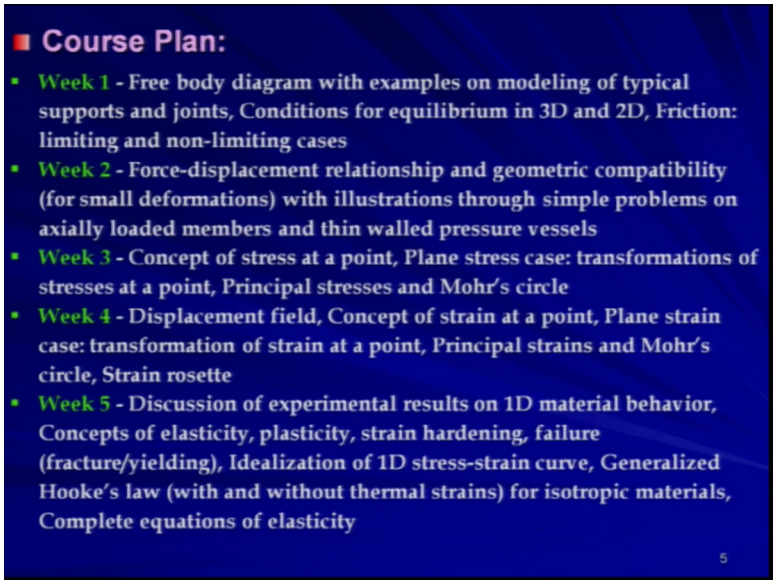

So, in first week we will covered we will try to cover free body diagram with examples on modelling of typical supports and joints conditions for equilibrium in 3D and 2D friction limiting and non limiting cases. In week 2 we will try to cover force displacement relationship and geometric compatibility for small deformations with illustrations through simple problems or axially loaded members and thin walled pressure vessels. In week 3 we will try to cover concept of stress at a point, plane stress case transformations of stresses at a point principal stresses and Mohr's circle. In week 4 displacement field concept of strain at a point, plane strain case transformation of strain at a point, principal strains and Mohr's circle and finally, strain rosette.

In week 5, we will discussion of experimental results on 1D material behaviour concepts of elasticity plasticity strain hardening failure, which will cover fracture as well as

yielding idealization of 1D stress strain curve generalized hooks law, with and without thermal strains for isotropic materials complete equations of elasticity. At though we are talking about plasticity, but plasticity will be recovered I mean nominally because we will mainly concentrate on the elastic analysis and elastic equilibrium. So, when we will be talking about the failure criterion all. So, little bit of plasticity will be required, so, that will be covered depending on the requirement.

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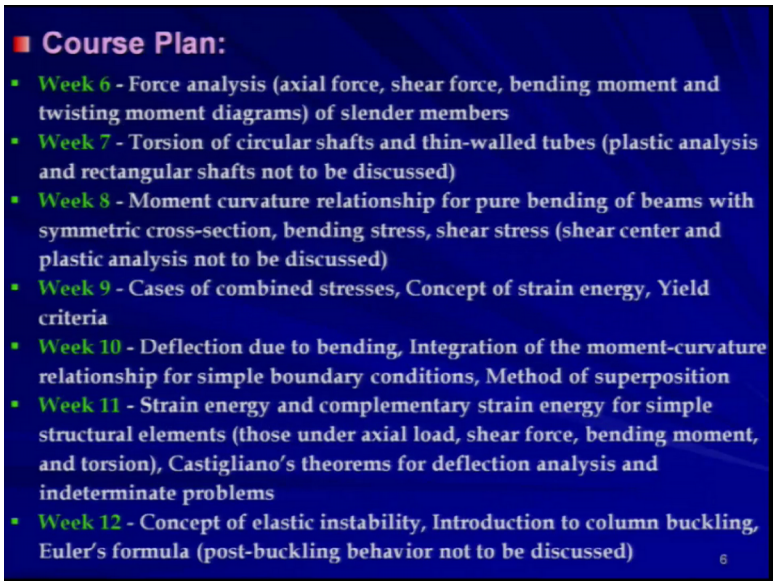

Then in week 6 we will cover force analysis. That is axial force shear force bending moment and twisting moment diagrams of slender members. Then week 7 we will try to cover torsion of circular shafts and thin walled tubes, plastic analysis and rectangular shafts not to be discussed. So, please try to understand so we will it is beyond the scope. So, we are excluding this part from the syllabus.

So, a moment in week 8, we will cover moment curvature relationship for pure bending of beams, with symmetry cross section bending stress shear stress shear center and plastic analysis not to be discussed. In week 9, we will cover cases of combined stresses concept of strain energy yield criteria. We think we will try to cover deflection due to bending integration of the moment curvature relationship for simple boundary conditions and method of superposition.

In week 11, we will look at strain energy and complementary strain energy for simple structural elements. Those under axial load shear force bending moment and torsion.

Castiglianos theorem, for deflection analysis and in turn indeterminate problems. In week 12 we will talk about concept of elastic instability, introduction to column buckling Euler's formula post buckling behaviour not to be discussed.

So, this is the brief course plan so; however, we may or may not stick to the actual course plan, because it depends how we will move in the course. So however, we will cover these things whatever we are talking about at this moment we will cover all the things, but not exactly in this sequence sometimes we will jump from one part to another part and then we will come back again something like that, but all the things will be covered in this particular course.

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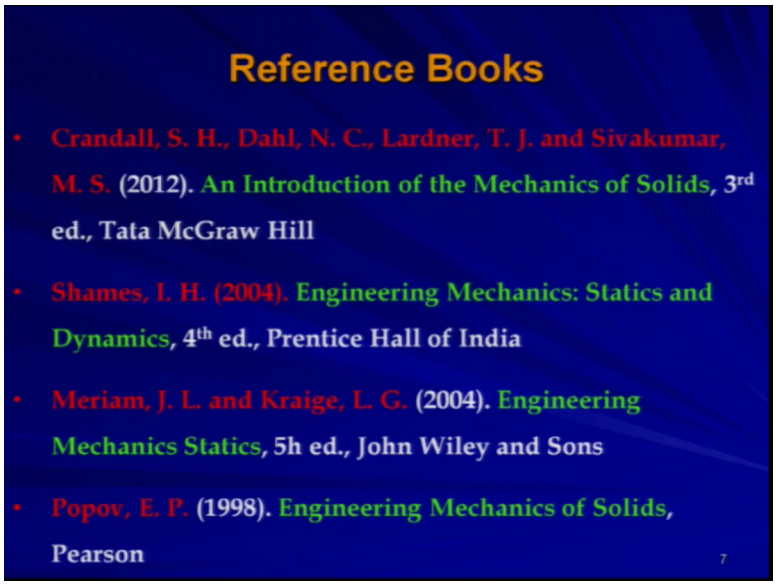

So, these are the reference books. So, we will look at different books and we will try to pick up the concept from different books. So, first one is Crandall Dahl Lardner and Siva Kumar, 2012. The name of the book is an introduction of the mechanics of solids, third edition, Tata McGraw Hill. Where the second one is shames engineering mechanics statics and dynamics, fourth edition prentice hall of India. Then Meriam and Krieg 2004 the name of the book is engineering mechanics statics, fifth edition, John Wiley and Sons, then next is Popov, 1998 the name of the book is engineering mechanics of solids Pearson.

So, these are the books, we will be covering, we will be looking at these at this different books for our course. Now there are few announcements regarding the homework.

Because the homework will be given on the regular basis, and you have to solve those homework and you have to submit the homework assignment. The homework problems will be assigned regularly to help you depend understanding of the course material covered.

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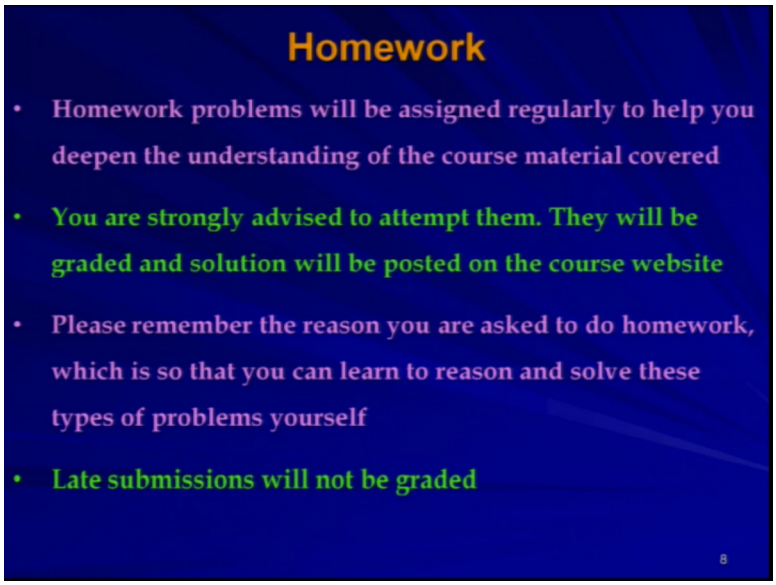

You are strongly advised to attempt them. They will be graded and solution will be posted on the course website. Please remember the reason you are asked to do homework, which is so that you can learn to reason and solve these types of problems yourself.

Let submission will not be graded well. So, with this brief introduction now we can we can exactly start our course. So, first we will talk about these things, as we have planned tentatively.

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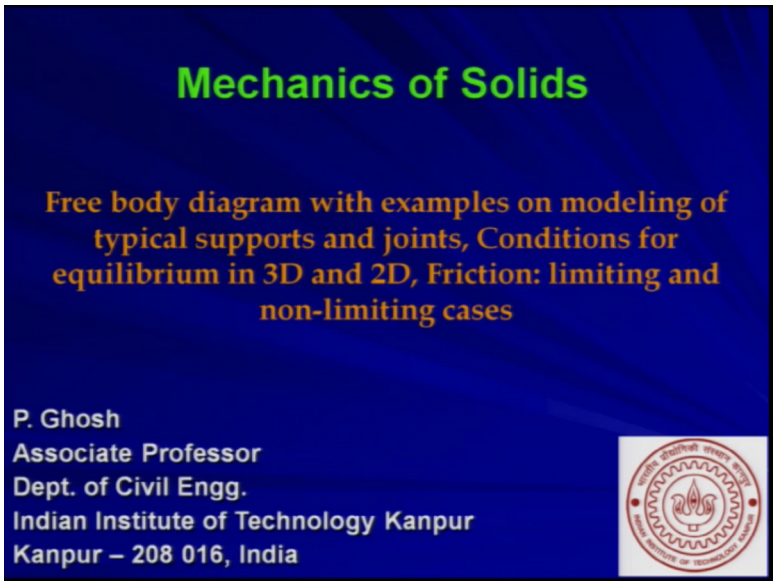

First one is free body diagram with examples on modelling of typical supports and joints, conditions for equilibrium in 3D and 2D friction limiting and non limiting cases. So, let us go to the board because this course is very fundamental. So, I prefer to do the whole course on the blackboard, so that you can also absorb as I move on.

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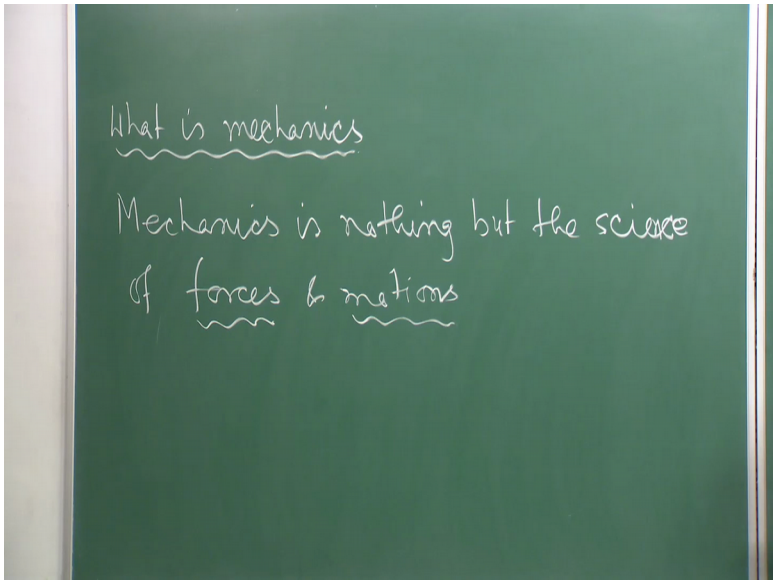

So, now what is mechanics basically we are talking about. So, much mechanics of solids mechanics, I am some time you will be coming across the mechanics of fluids and all those things what do we do you mean by mechanics right. So, mechanics is nothing, but,

but the science of forces and motions. So, mechanics is nothing, but the science of forces and motions. So, any material, any solid material you are considering in the in the universe. So, that material if you are applying, some external forces as well as moments on that particular material or the particular say body system, and if you are expecting some movements, or the motions then that physics whatever you are getting from that whole system to understand that physics basically you need to know mechanics. So, this is by enlarge is the definition of mechanics.

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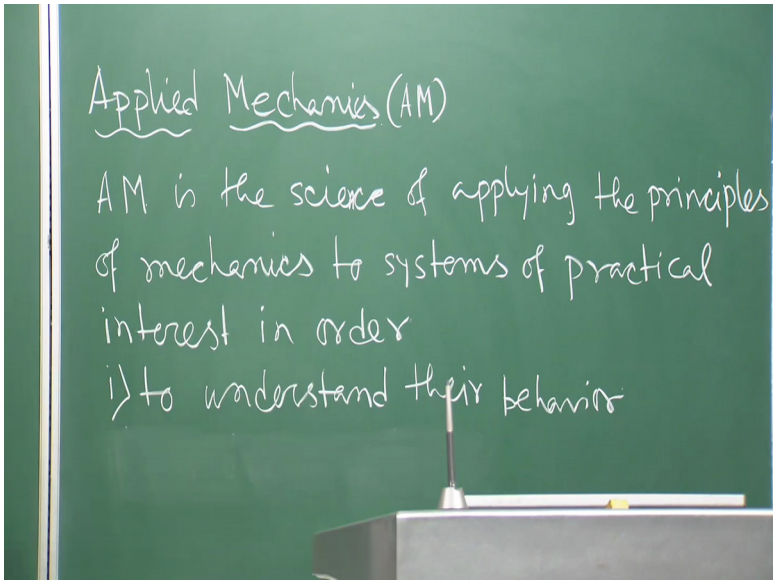

Now, what do you mean by applied mechanics. So, applied mechanics, is the science of applying the principles of mechanics to systems of practical interest in order to first understand their behaviour and second to develop rational.

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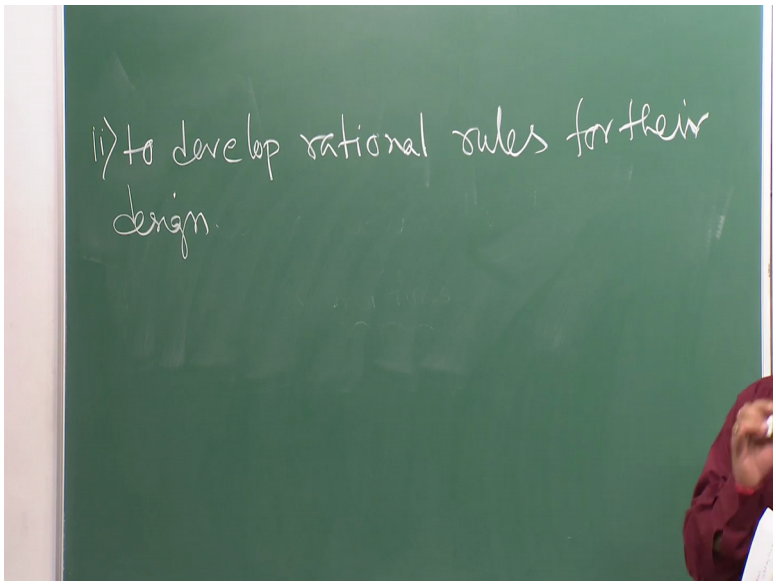

And the second is, to develop rational rules for their design. So, this is your applied mechanics. So, basically the mechanics as I told you to understand how the forces will behave and how the forces will cause some motion. So, that is nothing, but that physics is basically your mechanics, as you have seen from your 10 plus 2 also in tenth standard also. So, that is called the mechanics part of physics.

Now, what do you mean by applied mechanics. So, applied mechanics is the science of applying the principles of mechanics. So, mechanics cannot go beyond some principle. So, you have some principles some rules of the game. So, you cannot violate that. So, applied mechanics is a science of applying the principles of mechanics, to systems of practical interest, in order to understand their behaviour and the second one is to develop rational rules for their design. So, these are 2 fundamental things.

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So, now what is the principle of mechanics? Now coming to the principles of mechanics, so what are the different things we need to know to understand the mechanics of a system? First one as I told you, first one is force and the second one is motion, so force and motion, these 2 things basic I mean if you consider any system and if their system is under some force it will try to impart or try to show some motion, so these 2 things - one is your cause another one is your effect something like that.

So, these 2 things we will we will collectively talking about the mechanics of the problem. So, these are 2 things which you need to know to analyse any system any mechanical system, for which for which actually you are you want to get the solution.

So, now this motion if you talk about. So, this motion, it involves this motion involves geometry and time. So, if you talk about the motion. So, it includes 2 things. One thing is geometry and another thing is time. So, 2 different types of movements you generally expect, suppose here I am applying some force in some system I will expect 2 different types of movements. One is that the whole system is moving that is the displacement of the translation; that means overall change in the position. And another kind of movement we can expect that is the deformation; that means, the body is not moving from or it is not changing the position, rather you are getting the deformation right, to something like that if you if you talk about this paper.

So, if I want to experience some movement from this paper. So, either it can change the position from this position to this position, this is another one movement without any deformation or I can get this kind of movement that is minus; that means, deformation is happening reduction in diameter or a larger in diameter or whatever. So, these 2 things will conceal will constitute the movement. So, you can have only one; that means, the body is moving from one position to another position without any deformation. So, that thing is called a rigid body movement, there is no deformation the body is completely considered as a rigid body. Or you can have the deformation only; that means, the body is not moving. Suppose if I am putting the force here the body is not moving, but rather maybe some deformation is happening. So, that kind of movement you can have or you can have both the things together body is changing the position as well as it is expressing the deformation. So, these 2 things will constitute the movement.

Now, if you want to analyse any mechanical system. So, what are the things or what are the steps are involved in that analysis. So if you want to analyse analysis of mechanical system.

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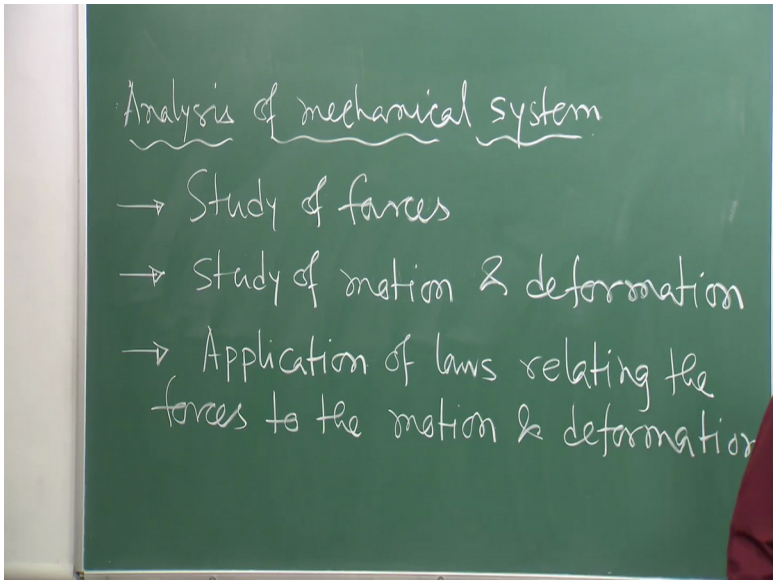

So, if you want to analyse any mechanical system. Any whatever mechanical system we are talking about or we are seeing in day to day life like your if you want to analyse, any building structure, if you want to a analyse any bridge structure, if you want to analyse any machine equipment's or any kind of machines, if you want to analyse the aircraft.

So, any mechanical system if you analyse, so this is as a whole you can analyse a particular say a particular component of the aircraft particular component on the machine. So, everything is a mechanical system.

So, if you want to analyse a mechanical system. So, basically what are the steps involved there study of forces the study of forces; that means, you want to know that what are the forces what are the externally applied forces are applied on the body on the system. So, that is very important. First you try to analyse or fight first you try to get the information about the cause; that means, what are the things are applied externally on the body.

So, that start study of forces, then next one is study of motion and deformation. So, next stage will include the study of motion and deformation. So, this is the cause because of these force you may expect some motion, as I told you may express some motion or deformation in the system. So, that you analyse and then the third one third step is application of laws relating the forces to the motion and deformation.

So, this is your third step. So, in the third step what we are looking at, we are looking at the application of laws, I told you that mechanics cannot go beyond or cannot break any laws. So, there are some laws and those laws are valid or those laws are important to analyse any system. So, application of laws relating the forces to the motion and deformation, so you study in the first step you study forces the second step you study the motion or deformation; that means, in one step you are observing where the cause, in the second step you are observing the effect, and then you try to correlate or try to get a relation between the cause and the effect right.

So, I will stop here today. So, we will continue in the next class, I mean what exactly we will try to cover in this particular course to analyse any mechanical system.

Thank you very much.