Engineering Mechanics
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Module 1
Lecture No 01
Introduction to vectors

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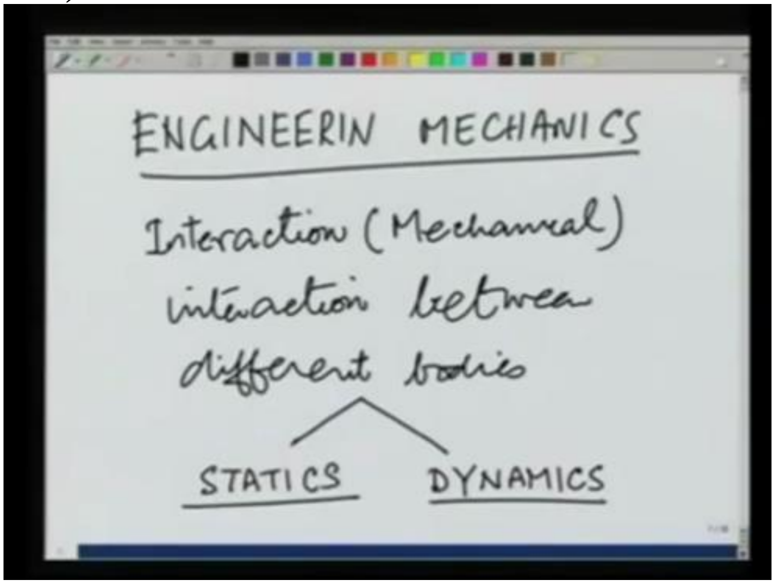

This is a course on engineering mechanics in which we would be studying interaction or let me be more precise, mechanical interaction between different bodies when they interact through the forces applied on each other. This would consist of 2 parts, statics and dynamics. In statics, we would mainly be concerned with equilibrium between different bodies. I would specify later what we mean by equilibrium.

And in dynamics, we would be concerned with how different bodies move under the influence of different forces they apply on each other or when the force is applied from outside. In the 1st part, we are going to focus on statics, which is the study of equilibrium between different bodies.

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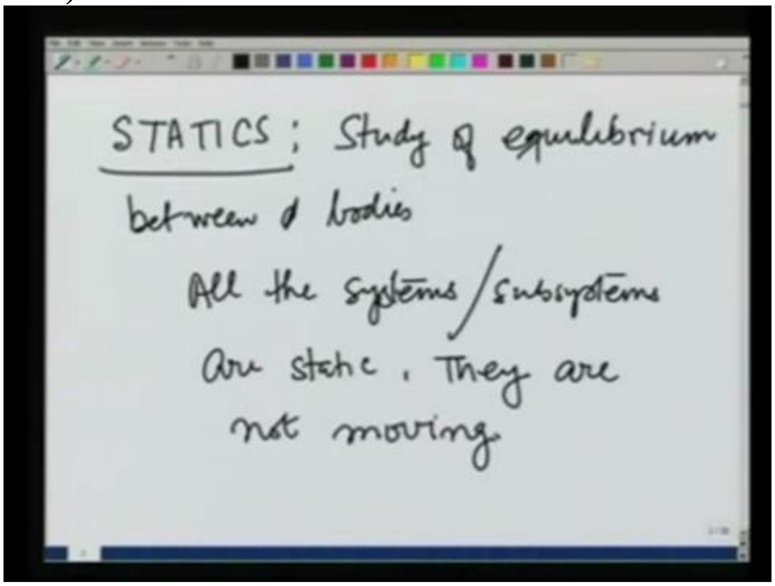

So…of equilibrium between bodies. When we say equilibrium, in general it means that there is no acceleration on any part of the system. In statics, specifically we are concerned with when all the subsystems, all the systems or subsystems are not only not exhilarating but are static. That is they are not moving. The study of statics or dynamics is based on Newton's 3 laws of motion.

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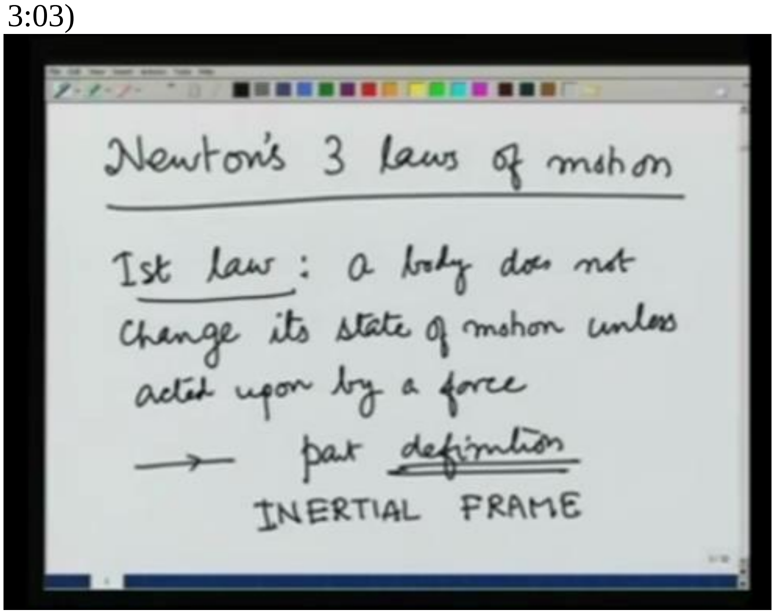

So let us start by the discussion. The 1st law states that a body does not change its state of motion. So if a bodies moving in a straight line, it will keep moving in that state line until a forces applied. Similarly if a body is static and sitting somewhere, unless a force is applied, it will not start moving spontaneously. The 1st law is a part observe it is based on observation and it is part definition. You may ask, definition of what?

It gives you the definition of an inertial frame and we do most of our calculation in an inertial frame. And inertial frame by definition then is the one in which the body does not change its state of motion unless a force is applied. For example, in this room, for all practical purposes, this room is a good inertial frame because if I see somebody or some body somewhere, it is not going to change its state of motion without a force being applied.

On the other hand, suppose I am on a train. It suddenly starts moving. As soon as it starts moving, you see objects outside which are accelerating in the opposite direction by the same acceleration. So, without any apparent force. So that accelerating train is not a good inertial frame. It is not an inertial frame at all.

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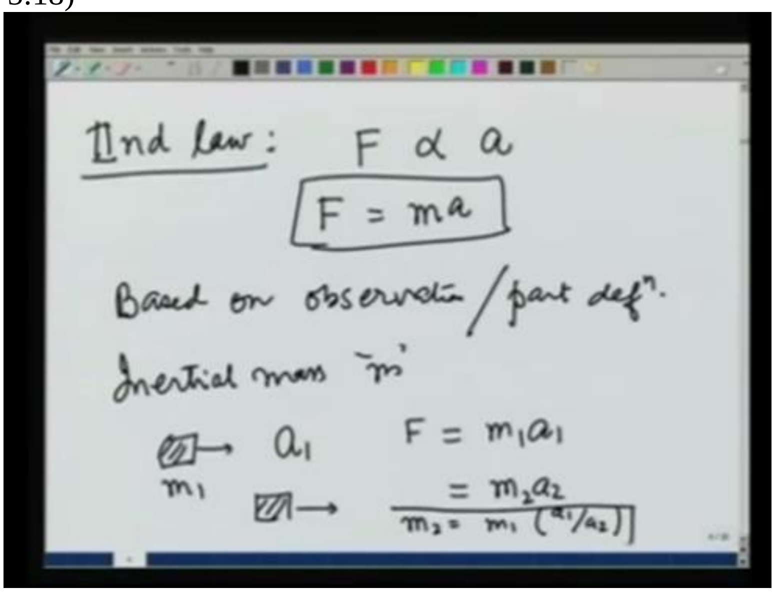

Then the 2nd law states that the force applied on a body is proportional to the acceleration that it produces. Then we write F equals MA which defines for us the mass as well as the force. So this is also based on observation. And part definition, it defines for us something called as inertial mass. Suppose I take a standard body, apply a force on it and produce an isolation, A1 so that F equals M1A1.

And I take another body, apply the same force on it, maybe by a spring, maybe by hitting it from something and find that acceleration is A2. Then the mass of the 2nd body is going to be M1 times A1 over A2. This becomes the operational definition of inertial mass. So this is part definition.

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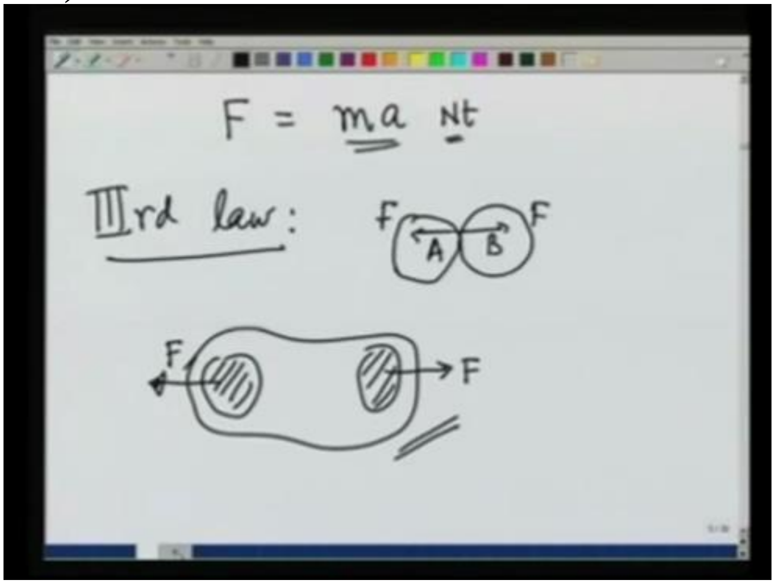

Then it also tells us, given a mass, I can also measure the force in Newtons as M times A. Mind you, this is operational definition. I cannot always use it though. Because suppose I am pushing a wall, the wall does not accelerate. So I cannot really determine its mass by measuring the acceleration when I am pushing it.

Then there is Newton's 3rd law that states that for an action, there is always a reaction. That means if there is a body A, it is pushing another body B by a force F, then there is going to be a reaction on A by B in the opposite direction. A very confusing situation arises in this. Most of the students ask, if the forces are in opposite direction, why do not they cancel each other?

They do not because you see, force A is applying a force on B. It produces something on B. On the other hand, A is being pushed by a force by B in the opposite direction. So it is acting on a different body. Therefore they both cancel. However, if I take the entire system as one then they being internal forces, they do cancel. But be very careful when applying it.

Having given this preliminary discussion of Newton's laws of which we will mostly be using the 3rd law in statics part and we will be using the 2nd and 3rd law in the dynamics part, let us now start with a review of vectors.

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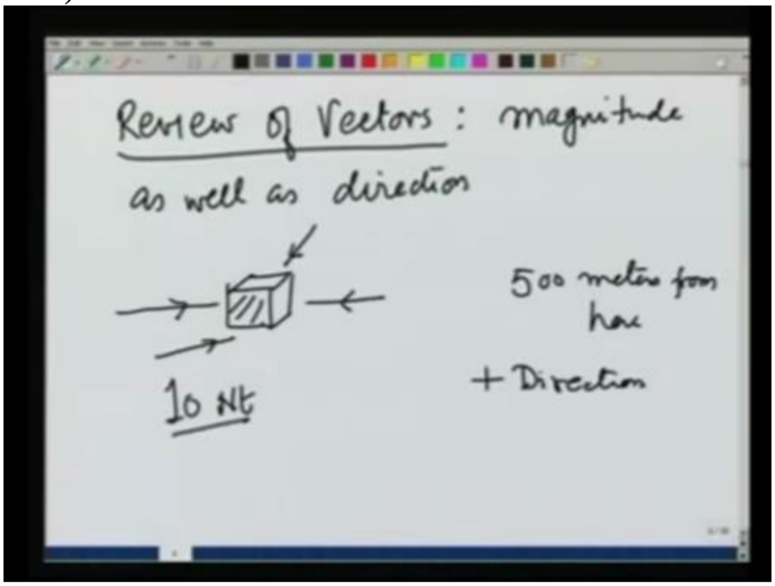

Because we will be using vectors extensively to represent forces, velocities and things like those. So it is a good way to start this course by reviewing what we know about vectors. I am sure most of you have learnt about it in the 12th grade but we now make it slightly more sophisticated. Why do we need vectors? It is because there are certain quantities which have magnitude as well as direction.

For example, if somebody tells you that I am pushing a box by a force of 10 Newton, does not convey the full meaning until I say that I am pushing it to the right to the left, in this direction or in this direction. Until the direction is specified, the complete description is not there. To specify a force, I need both, it is magnitude as well as its direction. Similarly, suppose somebody comes and asks you, where is your friend's house? And you say, it is 500 m from here.

Again, it will be a meaningless statement unless you tell him that it is 500 m to the east, to the west, to the north, to the south, south east. So + a direction is also needed. So there are certain quantities for which you need the magnitude as well as the direction and these quantities we call vectors. Having defined vectors, how do we represent them? Let us ask that question.

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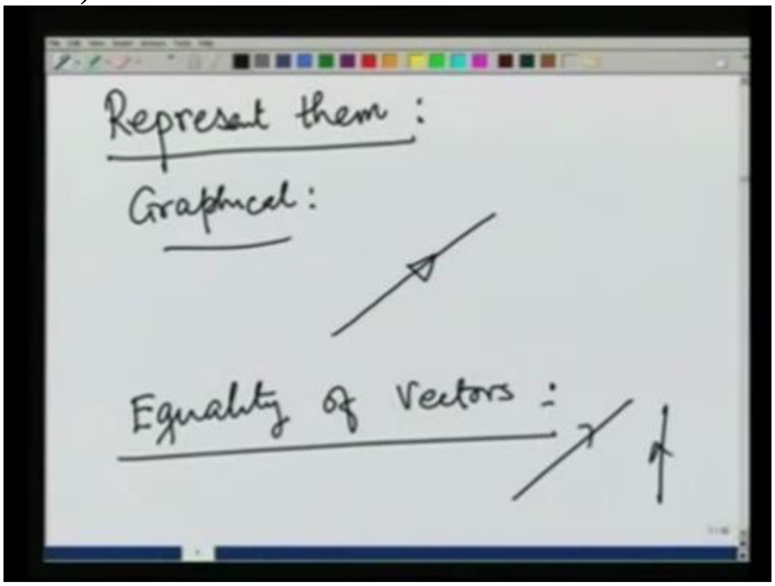

There are 2 ways, one is graphical and one is algebraic. We will 1st do graphical method and see that it is, gets little complicated when we go into many many vectors and do many operations. Then we will do a a algebraic way of writing vectors. So graphical method of representing a vector is that you make an arrow with the arrow showing the direction and the length of the arrow showing the magnitude of the vector.

In this manner, if we now have 2 vectors, how do we decide whether the 2 vectors are equal or not.

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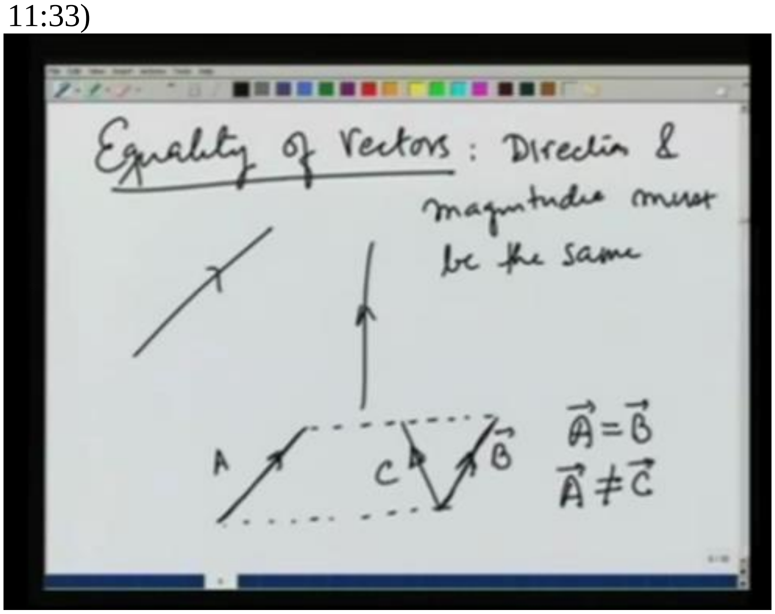

If there are 2 vectors given, they will be equal if they produce the same effect. So their direction and magnitude must be the same. Graphically, that means that if there is a vector A, another vector which is parallel to it and has the same magnitude, B is equal to A. I can have a vector parallely shifted compared to A but still it can be equal to A. So in this case, A is equal to B because both of them have the same direction and the same magnitude.

On the other hand, if I make a vector here, C, it is magnitude may be the same as A but it is not, it does not have the same direction as A. Therefore A is not equal to C.

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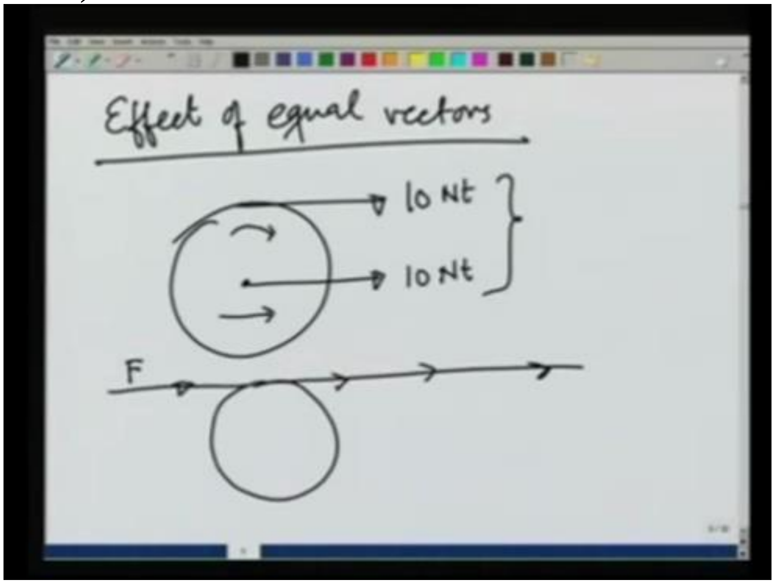

One has to be very careful in the effect of equal vectors. Two vectors being equal does not mean that their effect will always be the same. For example, if I take a wheel, I apply a force on its top, say 10 Newtons. If I apply the same force on the axle in the same direction, although the 2 vectors are equal, their effect would not be the same. In the 1st case, the wheel will start rolling. In the 2nd case, it will just move forward without rolling.

So although the factors are equal, their effect is not the same. On the other hand, think of the same wheel. If a rope is pulling it which is tied to its end. Whether I apply a force here, here or here along the line of action, its effect would be the same. I can also hit the disc from this side by the same force and that would also produce the same effect. So, equality of vector has to be further specified by something else.

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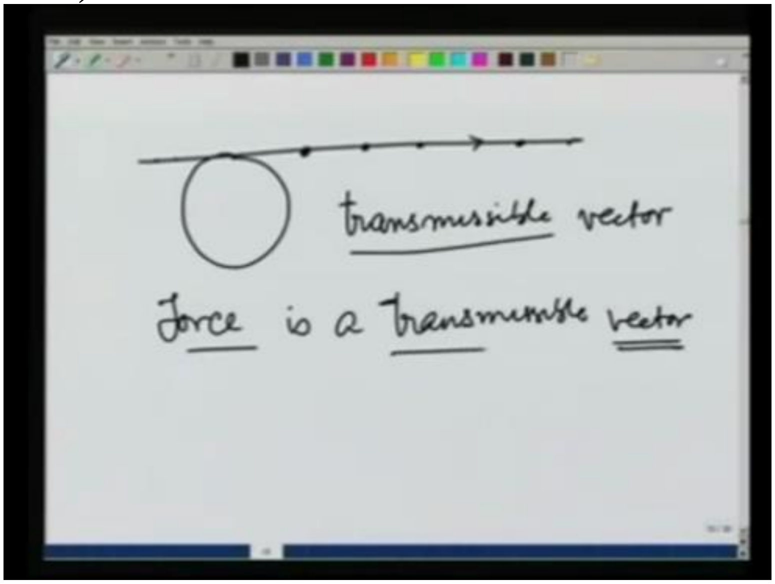

And that is if there is a vector and no matter where I apply it along the line of its application, if the effect is the same, then it is known as transmissible vector. So not only equal but if I can apply it at any point along the line of its action and it produces the same effect, then it is plausible vector. For example, force is a transmissible vector. So force has this quality called the transmissibility