MECHANICS

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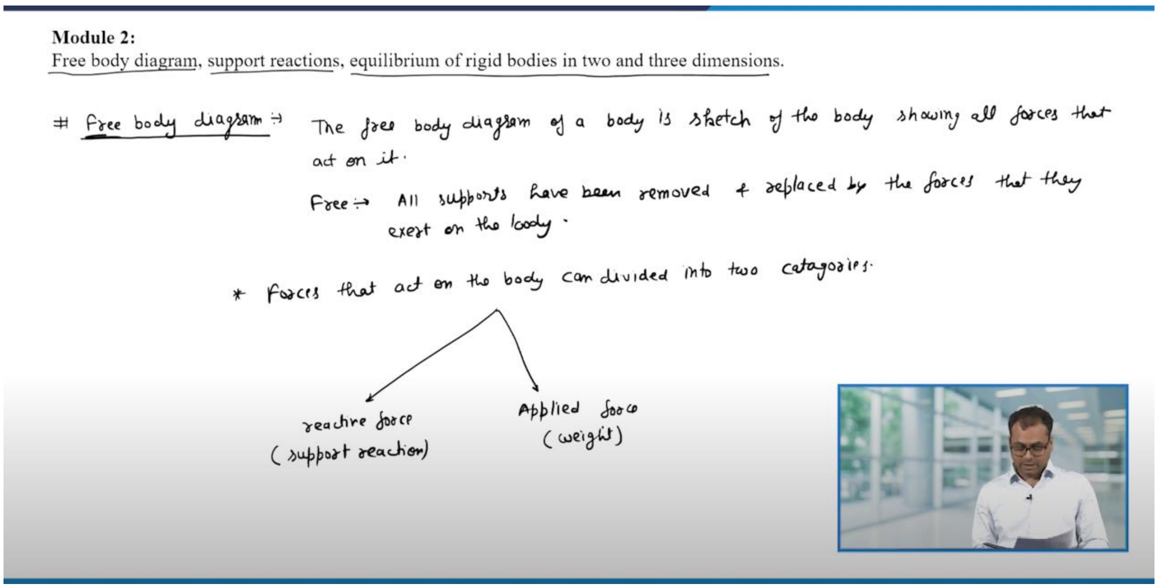
Lecture 06

Free body diagram and support reactions

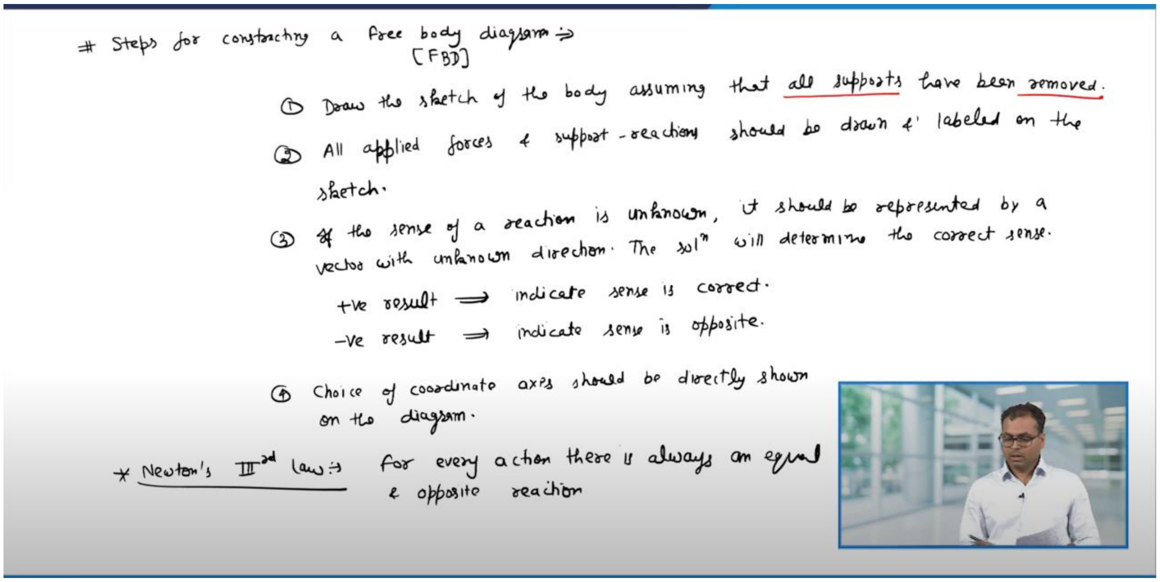
Hello everyone, welcome to the lecture again. Today, we are going to start the second module of this course.



In this module, we are going to discuss the free body diagram, the support reactions, equilibrium of rigid bodies in two and three dimensions. The first step to study the equilibrium analysis is to identify all the forces that are acting on it and for this we need the free body diagram. So, let us see what is free-body diagram.

So, let me define it the free body diagram of a body is a sketch of the body showing all forces that act on it. Now, here we have the word free. This free implies that all supports have been removed and it is replaced by the forces that they exert on the body. Now, the forces that act on the body, it can be divided into two categories.

So, we can have something called reactive force and we have applied force. So, in reactive force for example, you have support reactions and in applied force for example, the force that you are applying or let us call the weight is also the applied force.

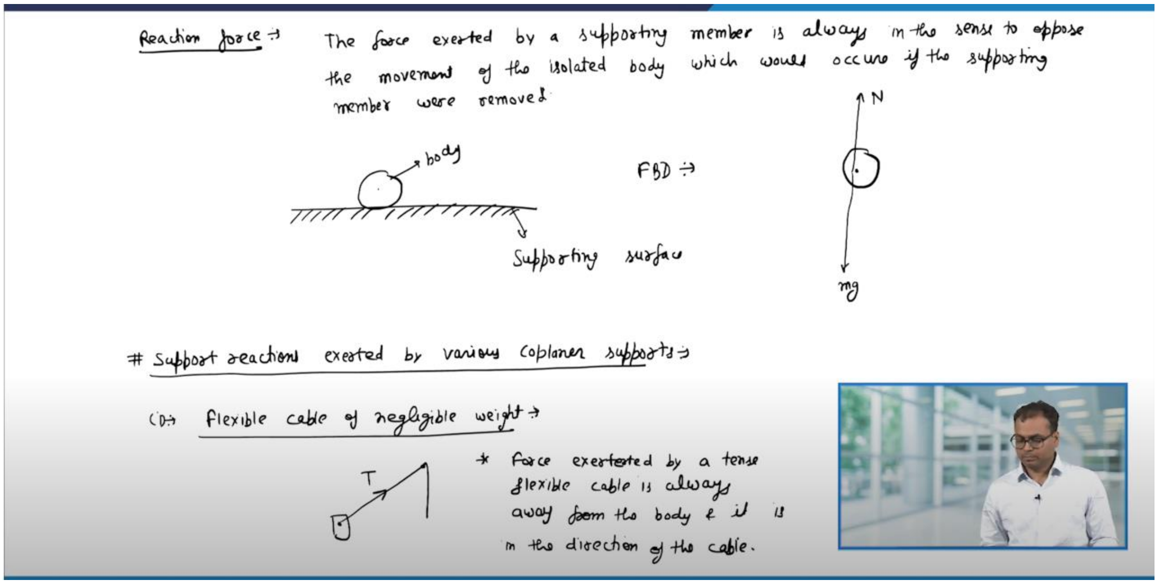


Now, let us look at the steps for constructing a free body diagram. Sometimes this free body diagram is also called FBD in sort. So, number 1, you draw the sketch of the body by assuming that all supports have been removed. Now, the second step is all applied force and the support reactions they should be drawn and labeled on the sketch. The third point is suppose we do not know that when a force is acting on the body in which direction it is going to rotate the object or in which direction it is going to apply the moment.

So, if the sense of a reaction force is unknown, then it should be represented by a vector with unknown direction. Okay. And then we will look at the solution and this solution will determine the correct sense of rotation or the correct sense of the direction. Now, if our result is positive that means

The indicated sense or the indicated direction that we have taken that is correct. And if the result is negative, that means the indicate sense is opposite and we have to change its direction. Now, another important point is the choice of the coordinate system, it should also be directly shown in the diagram. Now, to make the free body diagram, we will also use Newton's third law.

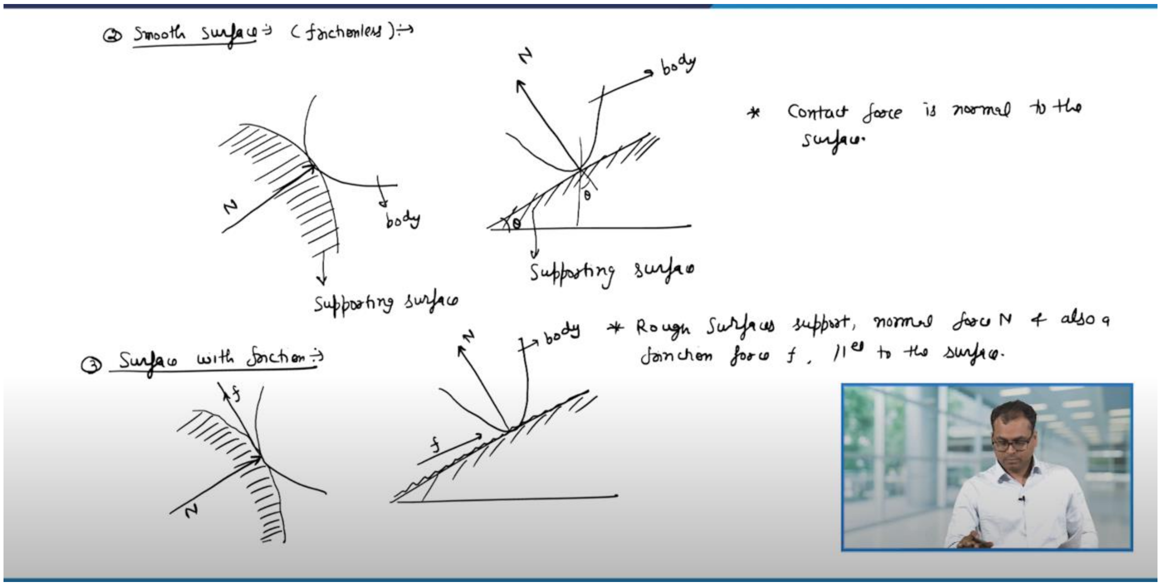
So, let me state it here and all of us know this. For every action, there is always an equal and opposite reaction.



So, with this let me briefly discuss what are the reaction forces and what is the definition of that. So, the force exerted by a supporting member is always in the sense to oppose the movement of the isolated body which would occur if the supporting members were removed. There is nothing but the Newton's third law only. So, let us look at by an example. Suppose, I have a supporting surface and on top of it, I have a body.

So, this is my supporting surface and that is the body. Now, the free body diagram of this will be you have the body, and on this body, of course, it is with mg is acting, and because of the support, you have a reaction force N. So, that is the free-body diagram of this body. Now, let us look at the support reactions exerted by various supports. So herein we can have different examples. You know the support reactions can be applied by different means.

So the first one, let us say we have a flexible cable and which has negligible weight. So let us say I have a body and this body is held by a cable. In this case, the tension will be away from the body. So, the force exerted by a tense, flexible cable is always away from the body and it is in the direction of the cable.

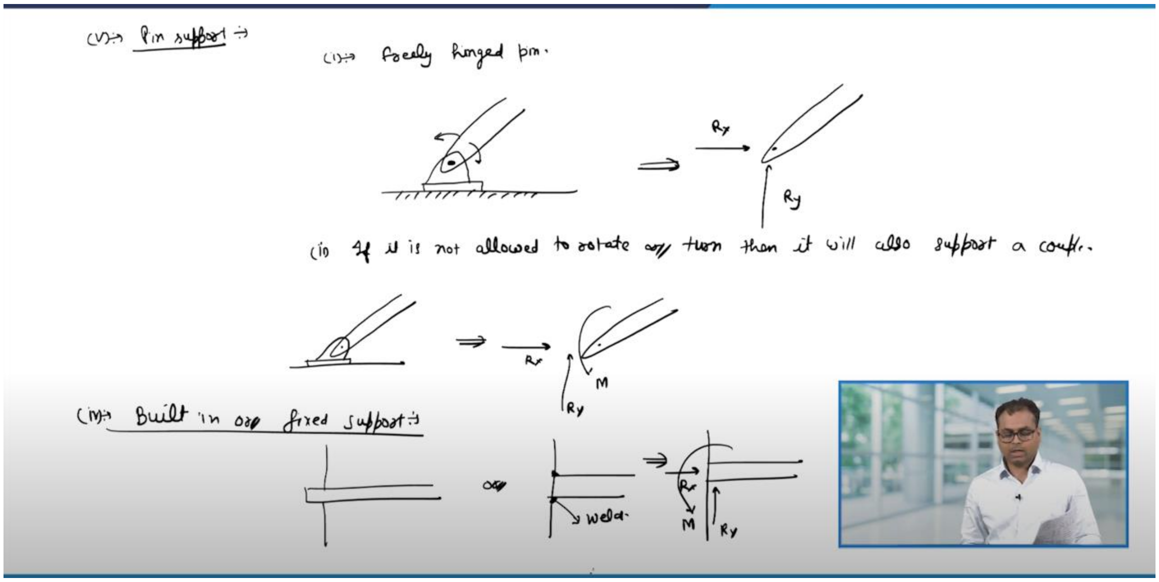


Now, let us say we have a smooth surface and this surface is smooth means it is frictionless. So, let us say I have a surface. So, this is my supporting surface and I have a body. In this case, the force will act normal to the surface. So, the support reaction will be like that.

Similarly, again let us say this is an inclined plane and on this plane I have some body. So, again this becomes the supporting surface and of course, this is the body. So, as I said the force will be perpendicular to the surface. And we can see that if this angle is theta, then this angle will also be theta. So, let me write here that the contact force is normal to the surface, the supporting surface.

Now, let us say the surface has friction. So, now we have the supporting surface and this has some friction and we have the body. So, in that case, we of course, has the same normal force, but apart from that, we will have the friction force. Let us denote it by F. We are not caring about the direction here because in whatever direction the body is moving, the friction force will be in the opposite direction.

Again, let us say we have this inclined plane, but now it has a friction. So, this is our body that is the frictional surface. In this case, we again have a normal force and we will have a frictional forces. So, the rough surface, they support normal force N and also a friction force F and this F is parallel to the surface.



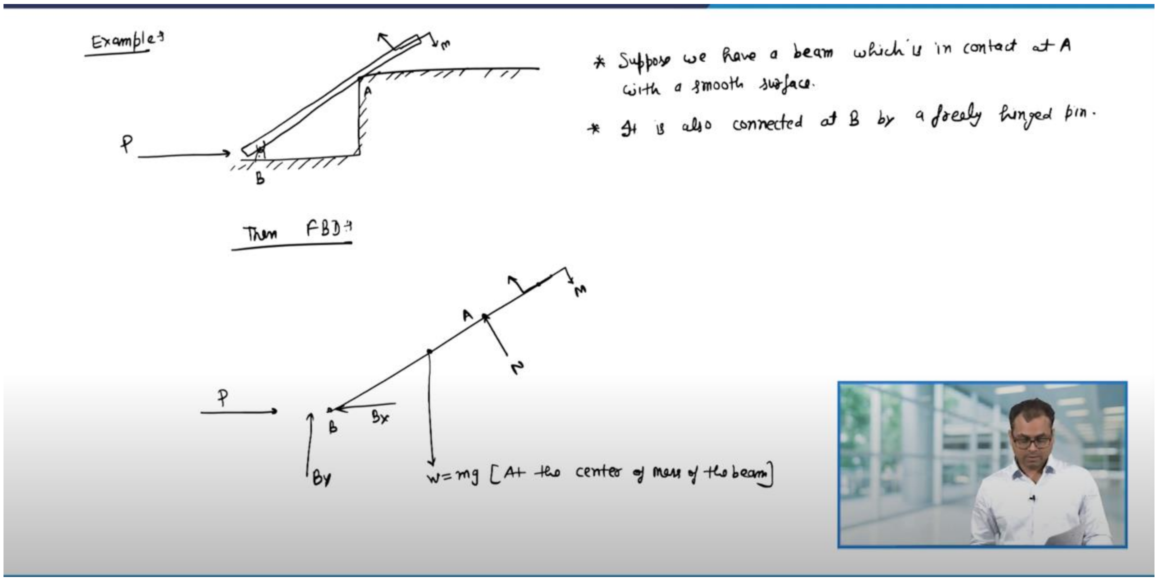
Now, let us look at other kind of support system. So, let us say we have a roller and rocker support. So suppose I have a supporting surface and on this I have some kind of roller by that a body is held or we can have this kind of configuration or we can have this kind of configuration. All of them are called the roller support and we can have this kind of configuration. This is called the rocker support.

In all these cases, the force or the reaction force will be normal to the supporting surface. So, what we have is we will have in this case, we will have a reaction force which will be normal to the surface. In this case also, we will have a force that is normal to the surface. Now, we can also have the pin support.

So, for example, Let us say we have a pin which is free to rotate. So, it is called the freely hinged pin. So, I have this surface and with this a pin is attached. And this pin can rotate in this direction as well as in that direction.

So, in this case, because the pin is free to rotate, we have two reaction forces, one in the y direction and another in the x direction. However, if it is not allowed, to rotate or turn, then it will also support a couple, okay. So, now we have this pin and this pin is not allowed to rotate, in that case we have the y reaction force, the x reaction force, and also it can support a moment.

Now, suppose we have a built-in support or a fixed support. So, let us say we have a wall, and on this wall, a beam is fixed. Or we have a wall and on this wall, the beam is weld. In both the cases, this beam is not allowed to move and not allowed to rotate. Therefore, we will have the support reactions R_y and R_x and also R_x. A couple M.



Now, let us look at the free body diagram by an example. So, let us look an example. Let us say I have a supporting surface which is like this and a beam is held like this. This is point B, this is point A and on this beam, a force P is acting like this and at this point, there is a couple which is acting. So, to write the problem, let us say we have a beam which is in contact at A with a smooth surface. So, that means the frictional force will not act and also let us say it is connected at B by a freely hinged pin. So, since this pin is free, so therefore, it will not support the moment. In this case, let us look at the free body diagram.

So, first of all, we have to remove all the support reaction. Let us say this is the beam that we have and on this beam a moment is acting. At point A, we will have a normal force and the weight of the beam, which is $W = mg$ that will act at the center of mass of the beam. At point B, we have freely hinged pin.

So, therefore, as I said, it will not support the moment, but then we have the B_y forces and B_x force that will act at B and then we have this external force B. This is the free body diagram of the given system. So, with this, let me stop here. In the next class, we will analyze various systems which will be in the equilibrium.