Biomechanics
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Lecture - 09
Practice Problem 2

Welcome to this video on biomechanics, we have been looking at interactive mechanics with an introduction to statics and dynamics. We were looking at some simple problems in mechanics we saw one problem in the previous class.

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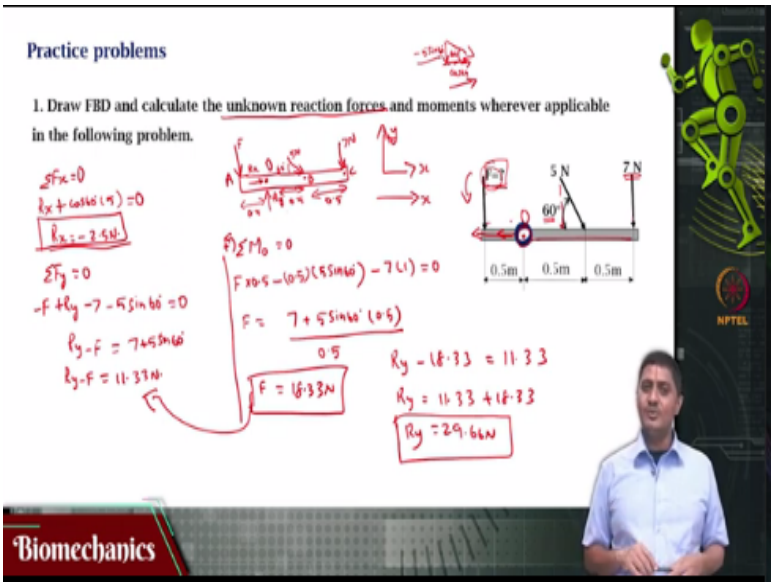

In this class we will see one more problem. Here is a problem in Statics the question is draw the free body diagram and calculate the unknown reaction forces and moments wherever applicable in the following situation. This is the situation, there is a force that is applied here which I do not know and there is a known 5 Newton force that is applied at an inclination of 60 degrees to the horizontal in this way.

And there is a 7 Newton force that is applied perpendicular to the bar these are all separated by 0.5 meters. How many unknowns will be there, in this case and it turns out that there is a connection there is a joint that is a hinge sort of thing here, there is a pin sort of thing that is there. So, there will be reactions here how many reactions will be there, because this bar can

rotate like this, this I am holding it is like my left hand like this I am holding like that and I am applying a force.

So, it can rotate like that means it is moment will not be there. But it is preventing moment in our acceleration in this direction are in that direction that is being prevented. That means that there will be two reactions also in addition there will be one more unknown force. So, there are two reaction forces R x and R y that will be there and one unknown force that will be that. So, let us draw the free body diagram.

These are the distances there will be an R x and there will be an R y, I am going to call this point as O and at that end point A, that point I am going to call as A. There is an unknown force that is acting which I do not know and at point B here is a force of 5 Newton acting at 60 degrees to the horizontal as shown and at point C there which is at that other end there is a 7 Newton force that is acting.

Now I can try to write out the equations of static equilibrium for this case let us write let us assume that xy axis and I can write sigma F x = 0. Because this object does not accelerate in the x direction the sum of all the forces in that x direction will be 0. What are the forces in the x direction, will F be in the x direction? The answer is no, because it is obviously in the negative y direction for the direction shown and 7 Newton is in the negative y direction. Will R x be in x direction?

Yes, because that is R x that is the reaction force in x direction. So, that is R x and that is in the positive x direction R y obviously is R y it will not have an x component. Will 5 Newton have an x component? The answer is yes, 5 Newton has an x component and will it be positive the answer is yes, because I have to resolve this, this force if a result that will be like this and you know like this I said not.

If I resolve; it will have a negative y component and a positive x component. So, I will write this as R x - 5 times cos 60 is it not this angle is 60 degrees then not so this distance then is cosine of 60 cos 60 times 5. But will it be negative no right it will be positive because this is in the positive

x direction, it will be R x + 5 times cos 60 is 0, anything else I have missed answer is no. So, this is 0 this will straight away give me R x to be - 2.5 Newtons.

What does this mean minus 2.5 Newtons? That means this force is going in opposite direction, is it? Yes, it is not that this force is being applied here like in this direction with positive magnitude but rather with positive magnitude at this point there is a pull that is happening towards a negative x direction in this direction for the same magnitude. So, R x is minus 2.5 Newtons for that positive x axis did not.

Now I can write the next equation of static equilibrium, now sigma F y = 0, because this object does not accelerate in the y direction. The sum of all the forces in the y direction will be 0 what are the forces in the y direction that would be minus F, why minus F? Because F is in the negative y direction because this is positive y, F is in the negative y direction. So, minus F + R y, R y is in the positive direction, because it is given, I have assumed R y to be in the positive y direction you always assume the unknowns to be in the positive direction.

Anything else? Minus 7 Newtons, minus 7 because that is acting at C, anything else because this 5 Newton will have a negative y component that is minus 5 times sin 60 is it not, we saw. That will be - sin 60 times 5. The whole thing is 0 this problem does not seem like so simple. Why? Because there are two unknowns and only one equation how do we solve this. Let us first write out this equation let us write out this equation properly that is R y - F is 7 + 5 sin 60.

I can actually compute 5 sin 60 using the scientific calculator and summit so I can find this as R y - F is some 11.3 Newtons are we done the answer is, no because I have to find the R y and F, I do not know how to find it. Because I have found the previous equation is in R x that is not very helpful for me, because there is no R x term in this. So, that means that I have to write out the third equation of equilibrium which is sigma M about o is 0.

This whole thing can rotate and I am taking moment about this point O that is counter clockwise considered positive. If I consider then that would be this F will be causing a moment F times 0.5 in the counter clockwise direction that would be F into 0.5. This minus 5 sin 60 this vertical

component will be causing a moment in the clockwise direction with the; what momentum, with the momentum of 0.5 is it not.

And that will be in the clockwise direction. So, that will be - 0.5 times 5 sin 60. And the 7 Newton will be causing a moment in the clockwise direction with a momentum of 1 meter and that will be a clockwise moment. So, that will be - 7 times 1 anything else there any other force. The 5 Newton force in the x direction and R x will not cause the moment, so I am writing this as 0. Now it seems to me like this equation has only one variable is it not which is F.

I can simply solve for F using this, how? F is 7 + 5 sin 60 times 0.5 the whole thing divided by 0.5 is it not. You can compute this using a calculator and you realize F is actually 18.33 Newtons. Now substitute this F in this equation which is R y - 18.33 is 11.33, so R y is 11.33 + 18.33 that would be 29.66 Newtons this is our way. What is the question? Calculate all the unknown reaction forces or all the unknown forces reaction forces all the unknown forces.

In this case we have found that as R x is - 2.5 Newtons R y is 29.66 Newtons and F is 18.33 Newtons. The question is why did I choose to find moment about O why not any other point. Because if you choose to find moment about any other point it turns out that R y will also cause a moment R x may also cause a moment, if you are taking it about the width of the bar. In this case let us assume that the width is 0.

Other unknown forces may also cause a moment then it will become 2 equations in two variables it will be a slightly more tedious. So, for the sake of convenience if I choose a point at which these two reaction forces have zero momentum then what happens all these two moments disappear. And I have one equation in one variable which I can quickly solve and get the value of F which I can then plug in into the previous equation and find the value of R y.

So, it is a matter of convenience. So, how do you know before you solve the problem. There to choose your point, how do you know? You actually do not know when you start but after you observe you realize or after you write out the free body diagram you realize. If you choose a

point at which there are many unknowns acting it is convenient to choose that point to take the moment about, you can technically take the moment about any point.

But it is convenient to choose a point at which many unknown forces are acting. Of course, this is only a rule of thumb. This insight on where to choose this point about which you take the moment will come only when you solve a lot of problems. This is a simple problem practice many more problems and you will get that insight as to where do you choose.

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So, with this we come to the end of this video. Thank you very much for your attention.