Biomechanics
Prof. Varadhan SKM
Department of Applied Mechanics
Indian Institute of Technology, Madras

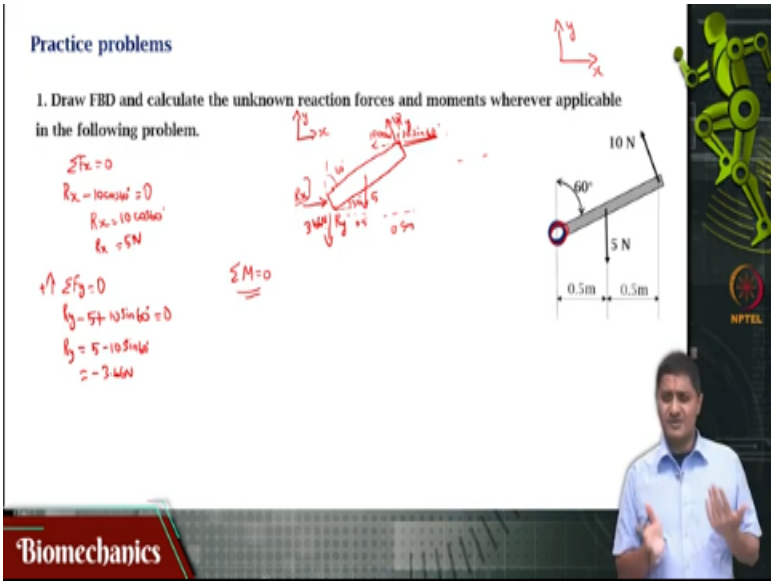
Lecture - 08
Practice Problem 1

Welcome to this video on biomechanics. We have been looking at introductory mechanics specifically introduction to Statics and Dynamics. We continue our discussion on Statics and Dynamics in this video.

(Refer Slide Time: 00:36)

So, in this video we will be looking at a couple of simple example problems in Statics that show how to draw a free body diagram, how to write out equations of equilibrium and how to solve for unknown reactions.

(Refer Slide Time: 00:54)



Consider this problem, the question is draw the free body diagram and calculate the unknown reaction forces and moments wherever applicable in the following problem. So, compute the unknowns whatever is not known compute that is what is questioned, so what is the situation? Let us try to understand the situation. Let us consider that x y axis in the negative y axis there is 5 Newton force that is acting perpendicular to this beam.

Or this bar there is a 10 Newton force that is acting that is having a component in both the x direction as well as the y direction. Y is that because the bar itself is inclined at an angle of 30 degrees to the horizontal because of this season already 60 degrees from the vertical because of this reason. The 10 Newton force that is applied on this bar will have two components, one in the x axis and one along the y axis.

Now it turns out that this bar can rotate about this point this is not given to you already it is not mentioned to you in the problem but from the way this diagram is drawn we presume that the bar can rotate about bow or here I am telling you that this bar can rotate about this axis. That means this bar will have how many degrees of freedom? It will have only two degrees of freedom, that is it cannot move in the x direction or in the y direction it cannot translate in the x direction or y direction.

So, the corresponding reaction components will be there. So, let us try to draw the free body diagram of this, so I am going to erase this and draw the free body diagram on this figure. So, how will it look like? So, there will be an Rx but actually when you are drawing you will have to remove this from the contact is it not. let us draw a free bar, there will be two components remember that will be the x y axis.

There will be a reaction component along the x axis which we are going to call as Rx there will be a reaction component along the y axis which we are going to call as Ry and these distances are given to be 0.5 meters and 0.5 meters. Is there any moment that will be there? No, because this bar can rotate about there will be no reaction moment. There will only be two forces so let us try to find out the unknown forces in the x direction a bit more complicated than the simple problem that we saw in previously but it is not too complicated.

So, let us try to write out sigma Fx is 0. What does this mean? We have said this previously this means that this object does not accelerate in the x direction, so that means that the sum of all the forces in the x direction is 0. So, I am writing out Sigma Fx equal to 0 and I am including the corresponding components of this forces in x so that would be Rx is in positive x Direction. Then will the 5 Newton force have a component in x direction, the answer is no.

Why? Because the 5 Newton force is in the negative y direction. So, this has no component in the x direction will the 10 Newton force have a component in the x direction, the answer is yes. Because this force I can resolve into two components one in the y direction and one in the x direction actually that will be a negative quantity in the x Direction. So, because the 10 Newton force is inclined like this because of that reason a little bit like this because of this it will be a longer Negative x direction.

What will that be the y component will be the vertical compound is it not that will be 10 times sine 60. The x component will be likewise 10 times cos 60. I am resolving these two force this force into two components and I am writing this. I am resolving this force into two components and writing the values of the x and y components and I am including the x component in our discussion that will be minus 10 cos 60.

Why is it minus? Because remember because the 10 Newton force is applied like this and not like this, that is a difference. If it is applied and in this way the x component will be like this. The component will be positive because it is inclined in this way as shown on the screen it will be along the negative x direction because of that reason it will be negative minus 10 cos 60, is there any other component along the x direction, the answer is no.

There is only two more forces one is Ry the other is 5 but they both are in y direction this is 0. From this I can say Rx 10 cos 60. That would be 5 Newton is it not? Because we know from high school trigonometry cos 60 is half, 1 by 2. Now I can write similarly the equation of static equilibrium in the y direction that is Sigma Fy equal to 0. What does this mean? This means because this object or this bar is not translating along the y direction.

The sum of all the forces in the y direction is 0 or rather because this object is not accelerating in the y direction the sum of all the forces is 0 because it can translate with constant velocity something to remember. Sigma Fy equal to 0 upward is considered positive I can write out as Ry because Ry is in the positive y direction as shown minus 5 Newton is in the negative y direction. So, I am simply rating minus 5.

That is it can we write equal to 0, the answer is no. Because there is 10 sine 60 in the positive y direction that would be plus 10 sine 60 is 0. So, that means I can write out Ry is then 5 minus 10 sine 60. It looks like this is not a positive number we can use a scientific calculator and check and you will find that this is actually minus 3.66 Newton. What does it mean that a force is minus 3.66 Newton? It means that the sense of the force that I have assumed is not correct.

I have assumed Ry to be vertically going up if the answer is showing that the value of Ry is negative, that means the assumed direction of Ry is wrong. The magnitude of that force is 3.66 Newton but it is in the opposite direction. It is 3.66 Newton in the negative y direction are it is minus 3.66 Newton in the positive y direction. So, from your computation it is not necessary that a reaction force always is positive.

Depending on the convention that you have taken a given reaction force may or may not be positive if it is negative that means that the assumed direction for the force is not correct the actual direction is exactly the opposite with that magnitude of force something to remember. Also you do not have to solve for all the equations of static equilibrium because we know this is a planar problem it is a 2D problem we also know that this is Sigma m is equal to 0.

So you do not have to solve for Sigma m is equal to 0, because the number of unknowns in this case with only 2 there are only two unknowns Rx and Ry are the only two unknowns and you can solve this by using two equations of equilibrium you do not have to three equations of equilibrium to solve two unknowns you need at least as many equations as the number of unknowns.

There are two unknowns and you have two equations even if they are simultaneous you can simultaneously solve them and fix them in this case they will not be simultaneous because x and y are always orthogonal and they will be simple so you do not always have to do the three equations of static equilibrium sometimes this may not be required.

(Refer Slide Time: 12:33)

With this we come to the end of this video. In which we saw a simple example problem in Statics. Thank you very much for your attention.