Biomechanics
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Lecture – 27
Elbow problem 3

Welcome to this video on biomechanics. We have been looking at biomechanical analysis of the joints of the Upper Limb specifically we have been solving some simple problems in the static equilibrium of elbow joint.

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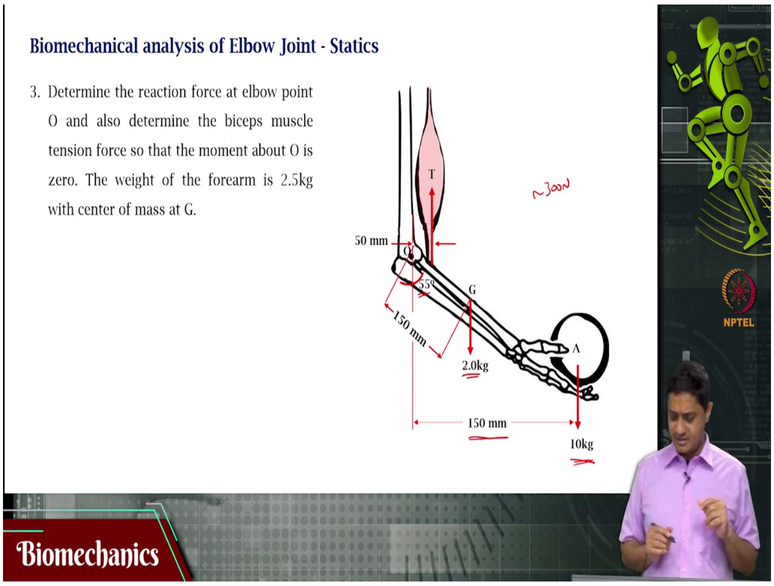

So, in this video we will be looking at biomechanical analysis of elbow joint ah problem in static equilibrium. It is a simple problem a person is holding a ball or some weight that is 10 kg and is holding it at some angle such that this angle yes 55 degrees. He is not holding it at you know the forearm parallel to the floor but rather like this at some angle it is an angle of 55 degrees. The mass of the forearm is given to be two kilograms that is acting at a distance of 150 mm from the axis of rotation O along the forearm.

Now the question is determine the reaction force at the elbow joint the reaction forces here and the tension in the biceps muscle so that the moment about O is zero that means that the whole joint is in static equilibrium find the tension T in the muscle. Also what is given is my own writing what is given is that the perpendicular distance between the line of action of force for the muscle and the joint is 50 mm this is what is given.

Now as usual let us try to analyze this using our back of the envelope approach remember that this time I may not be very accurate and I know that I may not be very accurate. Why do I know this? How do I know this? Because in earlier problems the angles they are simpler and rather easy for me to make assumptions in this, this angle is 55 degrees and I do not know I do not seem to have a very clear intuitive understanding of what this could do that is ok.

I have always told that the idea of this back of the envelope approach is not to give you an accurate answer. The idea is to give you an idea the idea is to give you some sense of the scale in which the answer is going to be. Is it going to be hundreds of Newton's or is it going to be thousands of Newton's or is it going to be tens of Newton's this is where the idea is. So, let us try ah this. um The muscle is attaching at 50 mm and the perpendicular distance between the load and the joint is 150 mm.

Note that this is the distance that matters the perpendicular distance between the line of action of force and the joint axis of rotation is what matters. So, that is about 150 mm. So, this is 10 kg let us say this is 100 Newton's. So, I am going to have about 300 Newton's in the vicinity of that somewhere but somehow I am not comfortable with that but I do know that it is going to be in hundreds of Newton's range that I am somewhat confident about because you know because there is there are 350s in 150.

I am not even counting this 2 kg load I must count for this right. So, I know that at least the answer is anywhere in the hundreds of Newton range with that in mind let us try to proceed with the problem.

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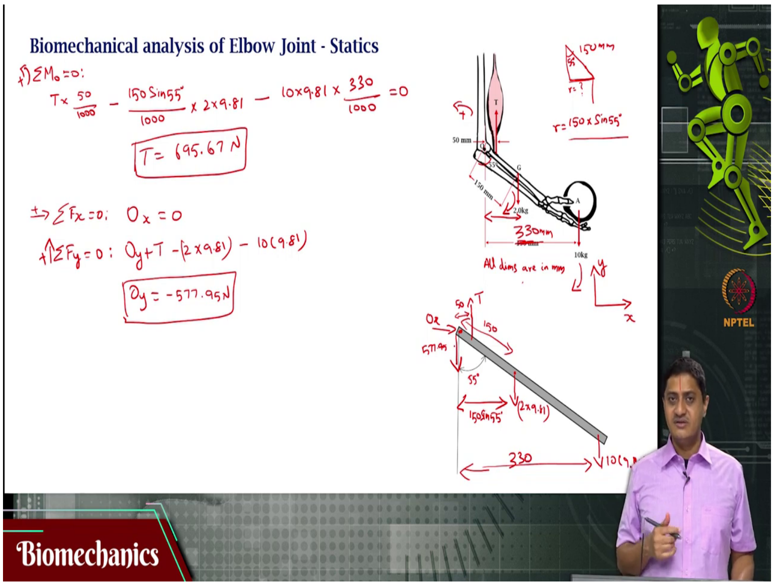

This is a rough free body diagram of the situation. So, the forearm free board diagram is given this angle is given to be 55 degrees um this is the joint O and a known muscle tension T is acting here I do not know the value of this force but what I do know is that this distance is 50 mm all the dimensions are in mm when I am drawing all the dimensions are in mm. This is 50 mm what I also know is at a distance of 150 mm along the forearm not in the XY axis.

This is the XY axis I am going to assume at a distance of 150 mm along the forearm at that distance the mass of the forearm is acting and that is having the weight 2.9.84 sorry 2 times 9.84. Now and 10 times 9.818 is acting at a perpendicular distance of 150 mm whereas here this distance is 150 mm. So, it is a slight difference it is realized that this distance cannot be 150 mm because if the distance along the forearm is 150 mm for the perpendicular distance to also be for 150 mm you know you need to have a different angle.

I just rechecked this is not 150 mm but rather 330 mm please note this change the perpendicular distance between the external load and the joint of rotation is 330 mm. So, this is this distance is 330 mm remember this. Now what is asked what is asked is the unknown tension in the muscle and the joint reactions of the elbow. So, I have to do Sigma f x 0 Sigma f y 0 Sigma m is equal to 0.

But I would start as usual with the moment equation because it is likely that I will have only single equation in single unknown. So, I can solve for the tangent T straight away. However before we proceed um I thought um somehow this distance 150 mm is along the distance where the mass of the forearm is acting is along the forearm but uh I am interested in finding that distance that is perpendicular to the line of action of force.

The line of action of force is acting here like this the perpendicular distance is that not that is the perpendicular distance. So, I want to know what is this? This is the momentum of interest for me well the momentum is also a vector I can resolve for this that is actually then using principles of you know trigonometry I could simply write this out as R is equal to 150 times sine 55. Now I can write out the equation remember when you are writing out the momentum you will have to write it out as 150 times sine 55.

You could of course solve this by resolving the force along the bar but then that is a slightly confusing for beginners. So, let us resolve the momentum along the X axis ok because ah the distance that we know is inclined to both x and y axis and I am interested in finding the distance along the X axis why is that because the mass of the forearm is acting along the negative y axis. So, I am interested in finding the perpendicular distance which is the distance along the X axis.

So, I am interested in finding this R and that R is 150 times sine 55. Now I can write the moment equation as Sigma m equal to 0 counter clockwise considered positive that is the equation I can write this as I start with the tension T the tension T if a positive moment because it is going to cause a counter clockwise moment and it is having the perpendicular distance. In this case the perpendicular distance itself is given.

So, that is actually 50 mm 50 by 1000 or 0.05 minus because this 2 kg is going to cause huh clockwise moment which is a negative moment minus 150 sine 55 divided by 1000 remember this 150 sine 55 is the perpendicular distance this distance that distance this is 150 sign 55. that is the distance times the force did not 2 into 9.81. Let us not forget the 9.81 minus because the 10 kg is also going to cause a clockwise moment.

So, its minus 10 into 9.81 into 330 by 1000 in this case the distance is perpendicular so that is fine. Only for the case of the mass of the forearm the distance is given along the forearm then you will have to resolve it along the X axis because this weight is acting along the y axis and you are interested in finding the perpendicular distance. Remember this perpendicular distance is always dropped. So, this is the perpendicular that is dropped on the line of action of force and the joint axis.

Line of action of force is where the perpendicular acts. ah Any other force that is there answer is no. So, I am writing this as equal to zero. So, after all this analysis I find the answer as so, this is one equation in single variable after some algebra or my request is for you to try and simplify this you will find the value of t as 695.67. Essentially take all the terms that does not have T to the right hand side and then take the 50 by 1000 to the right hand side.

Then you will essentially get this answer 695.67. Our back of the envelope calculation gave me an answer in the hundreds of Newton's range I said 300 Newton but I was also quite uh you know uncomfortable with that answer I said no that is not exactly likely to be true but I am somewhat confident that the answer is going to be in the vicinity of hundreds of Newton’s somewhere in the hundreds of Newton's range it is not going to be one thousands of Newton’s and it is not going to be tens of Newton’s.

It is going to be in the hundreds. So, that way I at least have some this is not the way to verify this solution I am aware of that but many times I see students who write the answer as 69 Newton’s or 6000 Newton’s somewhere along the way there is a simple numerical mistake and because you will use this T to find the reaction force and the reaction force will then be wrong and I cannot give points for that.

This is I mean something that I have picked up by looking at students answer sheets over the last 10 years of teaching engineering mechanics. So, you need to have an intuitive sense of where your answer is I mean that is something that no one can give you that is something that only you can develop yourself you can learn yourself. So, you need to work on this and build this intuitive understanding of this solution.

This is something that is not given to you no course can teach you this a lot of practice can teach you this. Then we are interested in finding these the reaction forces OX and OY I am interested in finding ox Sigma f x equal to zero right side going is considered positive but uh there are no forces that are acting along the x axis all forces are acting along the y axis. So, that means that the reaction force y axis zero there is no reaction force along the x axis.

Then what about oy that we can find by saying Sigma f y equal to 0. So, away is along the positive y axis T is along the positive y axis and then you have minus 2 times 9.81 along the negative y axis minus 10 times 9.81. So, then go away is you know take all the uh all these terms to the right hand side and use your scientific calculator to simplify this. You will find the value of y as minus 577.95 Newton's.

What does this mean a reaction force is negative in the direction shown that means that reaction force is actually positive in the opposite direction that means that it is 577.95 Newton's in that direction that is going down along the negative y axis. Along the negative y axis the magnitude is 577.95 Newton's along the positive y axis the magnitude is minus 577.95 Newton's or this force is acting along the negative y axis that is what we learned from this.

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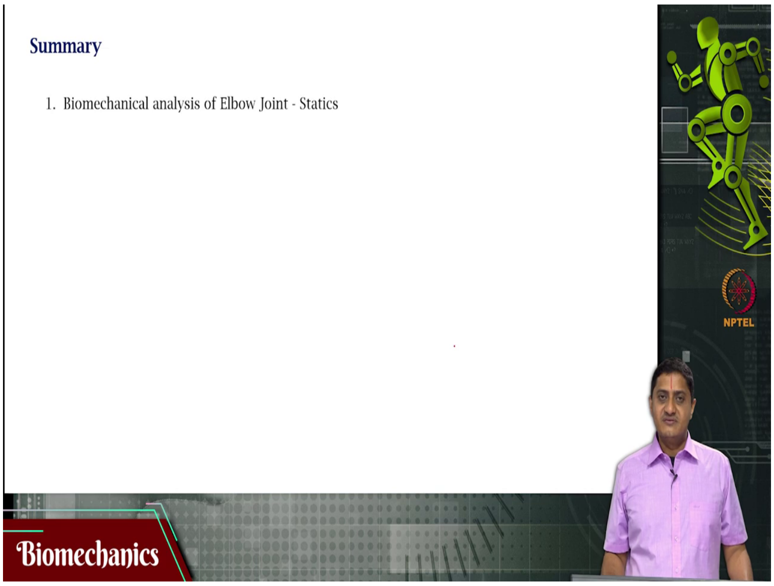

So, with this we come to the end of this video on solving some simple problems in statics of the elbow joint. Thank you very much for your attention.