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

Lecture – 23
Shoulder Problem 2: Biomechanical Analysis of Joints of Upper Limb

(Video Starts: 00:18) Welcome to this video on biomechanics, we have been looking at the shoulder joint and specifically, we were solving problems in Statics involving shoulder joint.
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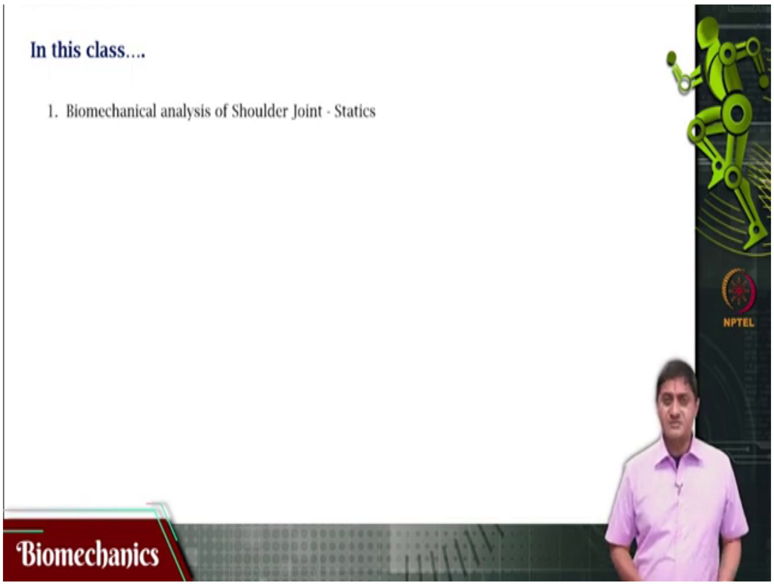

So, we will continue with one more problem on biomechanical analysis of the shoulder, joint or specifically static problem involving the shoulder joint.
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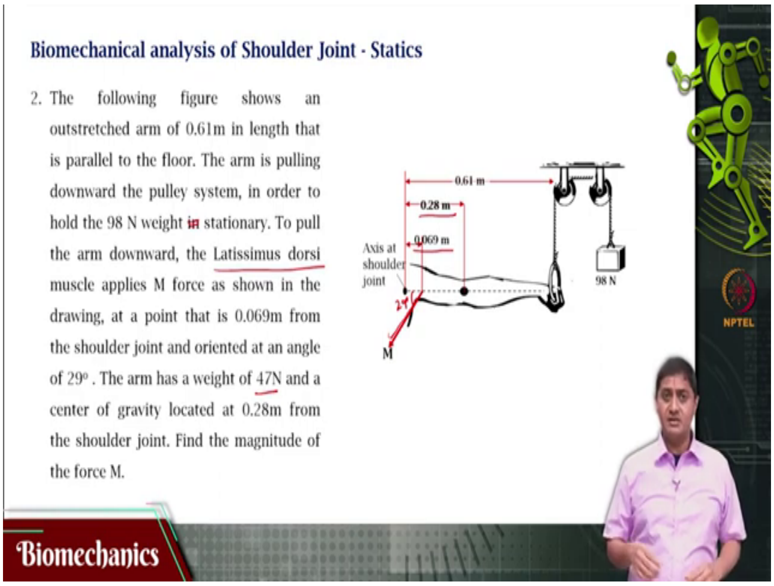

Here is the problem, the figure shows an outstretched arm of length 0.61 meters. So, the total length is 0.61 meters that is parallel to the floor. That is horizontal. The arm is pulling downward the pulley system in order to hold the 98 Newton weight in stationary position, 98 Newton weight stationary it is pulling this down. To pull the arm downward the latissimus dorsi muscle a place force, as shown in the figure.

It is applying a force like this at a point that is 0.069 meters from the shoulder joint and at an angle of 29 degrees to the horizontal. The whole arm has a weight of 47 Newtons and it is centre of gravity is at 0.28 meters from the shoulder joint question is what is the force produced by the latissimus dorsi muscle. So, this latissimus dorsi is this muscle that is on the back.

So, when people do pull-ups, when you pull up you are essentially engaging the latissimus dorsi or when you are pulling something. There is also this exercise machine called lat pull downs. So, there will be a bar which you pull down and that is actually overcoming some weight that is on the other side of the machine lat pull downs, pull-ups these are frequently used to strengthen the latissimus dorsi muscle.

It is used to pull down a weight or pull the body weight up. That is the pull up exercise against some rigid body, we do this exercise.

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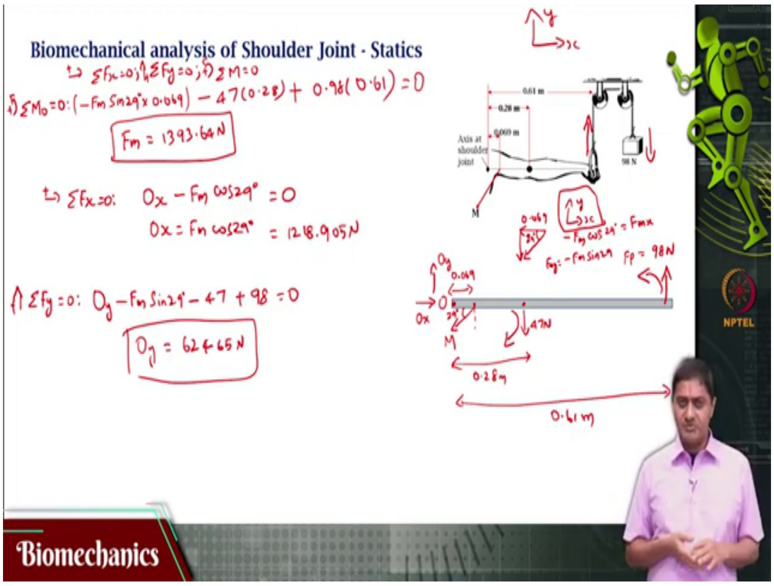

That is the situation, let us try to draw the free board diagram. This is the shoulder joint. I am going to call this point O and at a distance of I think, let us call that point is where the muscle is acting. That angle is 29 degrees, value is unknown M and that distance is 0.069 and at a distance of 0.28 meters the mass is 47 Newtons. And the external load itself is acting here at a distance of 0.61 meters, the force is 98 Newtons.

Are there any other forces or distances that we will have to mark? There are only these three. That is the mass of the entire arm that is the external load and there is the force that is produced by the muscle. These are all the forces that are there. Now because the shoulder can rotate, it will have no moment component in the reactions and because it cannot accelerate along this xy axis that we will be using.

It cannot accelerate horizontally, nor can it accelerate vertically. Because it cannot accelerate horizontally or vertically it will have reaction forces at acting at Ox and Oy. The question asks us to find only the value of the muscle force M, not the reaction forces. We will get started with that and it seems like I can solve for this muscle force, simply by writing out the moment equation. Let us, write out the equations of static equilibrium.

Those are sigma F x = 0, sigma F y = 0 and sigma M = 0. Sigma F x this is considered positive, this is positive. The moment counter clockwise is considered positive. Let us, write out the moment equation let us expand this. What are all the various forces that will cause a moment? Before that let us analyse the muscle force alone. The muscle force is the force that is inclined at some non-zero or non-90 degree angles, some inclination that is not 0 or 90.

So the distance is 0.069 this angle is a 29 degrees. So, for that x y axis, this will have negative y component and a negative x component. So that would be a so, in other words, this will be the direction of the forces that are involved but in this xy axis this will be –Fm cos 29 and –Fm sin 29. This will be the Fmx and Fmy components for this xy axis that we are looking at.

Anyhow, let us write out that equation sigma M o = 0 and expand it will find that this is –Fm sin 29 because only the vertical component of this muscle force will cause a moment not the horizontal component. Because horizontal component will act along so that will that would be this. That will cause a clockwise moment. Because of that reason it will be a negative moment because they said counter clockwise is considered positive, so – F from sine 29 times 0.069.

That is the moment that is caused by this vertical component minus anything else. Of course that is the 47 Newton – 47 times that distance is 0.28 and that will also cause a clockwise moment is it not? This will cause that kind of a moment + 0.98 times 0.61, why plus? Because this load is pulling the arm up like this. Remember because there is a pulley here is where the action of the pulley is now here is where the action of the weight is downward.

But for that person because there is a pulley and rope involved for this person, he will be feeling the load here upwards positive x axis positive y axis. So that force will cause a counter clockwise moment like this because about this pivot O, it will cause a counter clockwise moment. Alright any other forces that are there that we have to look at. There are no other forces and the whole thing is 0.

This is one equation in one variable, simplify this. If you simplify this, you find the value of Fm to be 1393.64 Newtons. Of course, you have to use your scientific calculator to do this but you find this to be a very large number. Let us look at the load that will have to be overcome that is 98 Newtons, the muscle force is about 14 times as much 1394 Newtons. So, it is a lot of Newtons.

Why is this happening? Again, the point at which the muscle force is acting is rather inconvenient and the angle at which it is acting is also inconvenient. In some cases, one of these will be inconvenient other will be okay, in some other cases like this one. Both of them are leading to a situation in which the muscle force will have to be very large and this muscle is capable of producing that much force.

Important to note that it is not that just because the muscle is producing a large amount of force that is bad. This muscle is capable of producing thousands of Newtons of force. Now, we still have to solve for sigma F x = 0. If we have to find Ox you find immediately Ox – Fm cos 29 is 0. This is the sigma F x = 0. There is no other force in the x direction, just the x component of Fm and Ox these are the only 2.

That means that Ox is Fm cos 29 and we know Fm to be 1393.64 Newtons. So, if you do that you get the value of Ox as 1218.91905 Newtons. This is the value of Ox. And then, if I am interested in finding the reaction force Oy I write out sigma F y = 0. So that would be Oy – Fm sin 29 – 47 + 98. That is the force felt at the pulley 98 the whole thing is 0. So, after because I know Fm to be 1393.64 Newtons substitute for that and simplify, you will find the value of Oy to be 624.65 Newtons.

Now, compared with the last problem, this problem appears to be slightly simple because the forces are given unlike masses and the corresponding distances at which these are acting at the centre of masses being given. Then you will have to multiply the mass by 9.81 to get the weight of the force and let it act at the corresponding centre of mass which is where this problem is slightly simpler.

The principles are still the same. So, with this we come to the end of this video on simple problems in statics analysing the shoulder joint. Thank you very much for your attention.