Mechanics of Human Movement
Prof. Sujatha Srinivasan
Department of Mechanical Engineering
Indian Institute of Technology, Madras

Lecture - 10 Part a
Static Analysis of Shoulder- Part I

Good morning, the elbow joint and what kind of load the biceps muscle produces in the case of this particular analysis. The next thing we started looking at is what if there is more than one muscle acting at the elbow joint; we know that typically so, the first assumption that we made that only one muscle is acting was a simplification because we know that we have only 3 equations.

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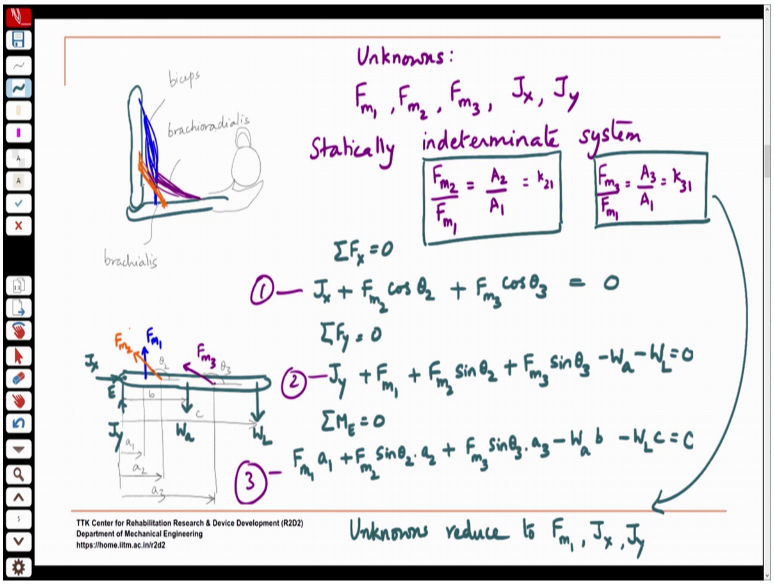

When you do a planar analysis and you have 3 and to make it 3 unknowns; the 2 joint reactions and the muscle force we assumed only one muscle was acting.

So, when you have more than one muscle acting it becomes a statically indeterminate system. So, you have more unknowns than equations and so you need to put some other conditions, relate some of the unknowns in such a way that you can solve this system. And one of the ways to do that is to assume that the muscle force produced by a muscle is proportional to its cross sectional area.

So, if I say that F m 2 by F m 1 is equal to a 2 by a 1; it is proportional to their cross sectional areas and I call that constant k 2 1; then I can express F m 2 in terms of F m 1. Similarly F m 3 into F m 1; so my unknowns 3 F m 1, J X; J Y which I can now solve; so they and then find F m 2 and F m 3 in one; it is a fairly straightforward way to do that.

So, instead of using the cross sectional areas I could also see maybe look at EMG activity to see which muscles are active at the c signals to the forces produced in the individual muscles. So, that is one way I could relate the various muscle forces that are acting at that particular instant.

Student: (Refer Time: 02:48).

So, the third method is to use; so this is.

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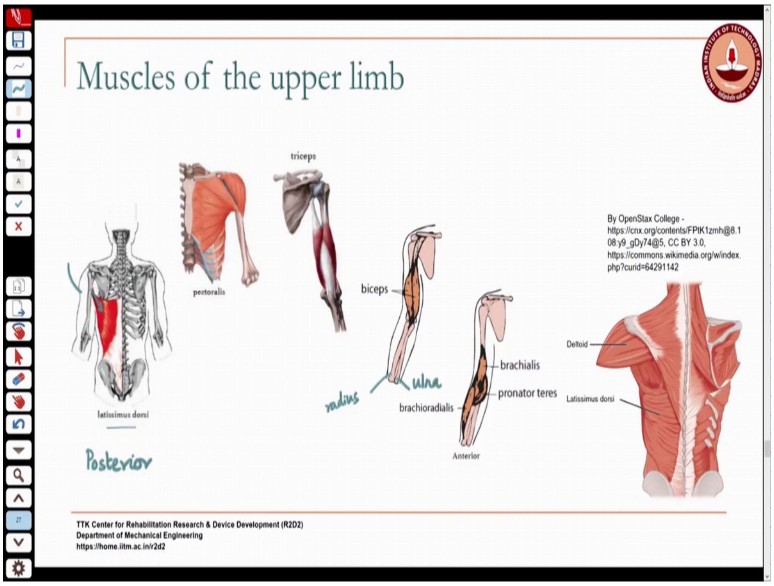

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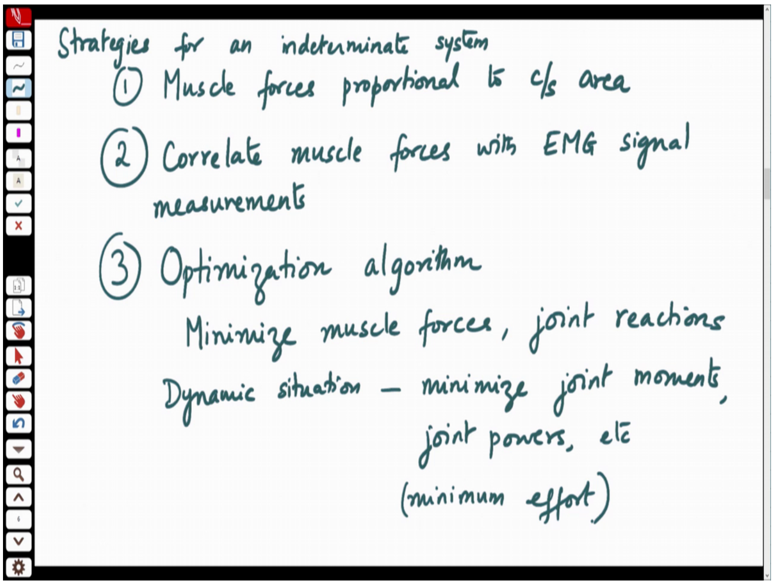

So, one is forces muscle forces proportional to cross sectional area that is one strategy.

So, strategies for an indeterminate system; correlate muscle forces; EMG signal measurements EMG basically measures the electrical activity of the muscle diseases that are in the muscle, but you can tell which muscle started acting been for how long it after that such. So, and the third method is to use some kind of and optimization of the an optimization algorithm for this.

So, you could for instance say minimize the muscle forces; what is the combination of mass a certain level or minimize the joint reactions; what combination of these muscle forces will produce the minimal joint reactions. You could use one or a combination of objective functions. The more of these you combine the more complex your problem is; here we are only talking statics, but in a dynamic situation you could try to minimize the muscle powers over the cycle ok.

So because that in a sense relates to the metabolic cost of a particular activity; so, powers etcetera because this implies that you are using minimum effort to perform the task. So, some kind of a combination of this can be used for a dynamic situation. So, optimization is very commonly used if you look at complex models which model various muscles way; so the complexity of the model may mean that you are modeling closer to the actual system, but it also means that you are making other assumptions.

So, it is not necessary that because whatever assumptions you make is going to determine how accurate. So, for our purpose we will generally stick to their objective is just to look at how these various parts of the body, how various activities can be modeled and what would be the effect on the internal forces; yes.

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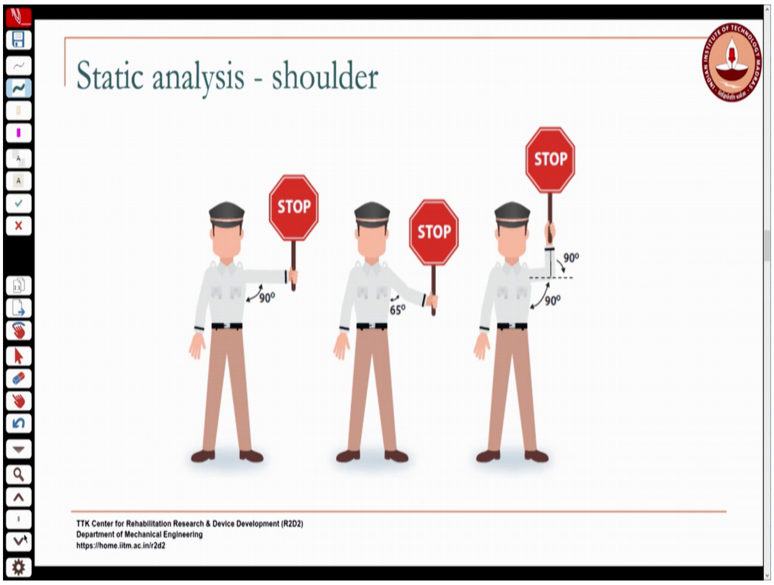

Student: Can I voluntarily flex my muscle were doing work such that the 3 muscles exert the desired amount of force that have somewhere around that?

So, that is a good question; there is some you know you are in many cases your body performs the work and the objective appears to be based on various studies; like for if you take walking for instance; most of us walk at a specific speed which we are comfortable with. Now that comfort comes from the fact it; it has been shown that that comfort correlates to a minimal metabolic cost.

So, our body is programmed to accomplish tasks such that you are consuming minimum energy. Whether you can voluntarily you know groups of muscles that that may be something that falls under the purview of the neural system you may have to look at; the neuro mechanics to say can I voluntarily exert forces in only these 2 muscles to perform a particular task, I do not know the direct answer to that question, but it may be something that has probably been looked into in research.

And if you are interested you can go look up some papers ok. So, we looked at the forearm; the next portion that we will look at is we will look at a static analysis at the shoulder joint. So, a lot of activities that we do involves you know holding our arms at specific positions and perhaps carrying a load in that. Even if you are not carrying a load I could just have my arm outstretched like this and that would still be acting on my arm right.

So, you have this policeman holding a stop sign at an intersection; we have lots of places where the signals do not work right. And so this guy has gotten the job today of holding up this stop sign; now there are various set up fairly high; so it is seen from. So, you know he cannot just hold it like this tries to change gesture so, that he can still hold that sign and see and what we are going to do is compare these 3 situations.

What does it do to the loading and the shoulder? So, that is the next exercise we are going to look at. So, we are looking at the static analysis; again if you think about the shoulder you are looking at this deltoid muscle. So, if you had to pick one muscle right which we are which is what we are trying to do which would be responsible for this action; what is what is this action at the shoulder?

Student: (Refer Time: 10:34).

Abduction; so, I am abducting and what plane am I looking at?

Student: (Refer Time: 10:39).

I am looking at the frontal plane. So, shoulder abduction in the frontal plane is what accomplishes that task. So, I would be interested in looking at the middle deltoid muscle which is going to which I am going to assume is the only muscle acting for this particular purpose ok. So, I have this and let us say because the angle is changing; let me call this angle theta. The theta is fill which the angle of shoulder abduction; the angle which the arm makes with the vertical I will take that as thither.

So, we know that the shoulder is a ball and socket joint and there is actually you have various movements that are all places, we are going to look at abduction in the frontal plane.

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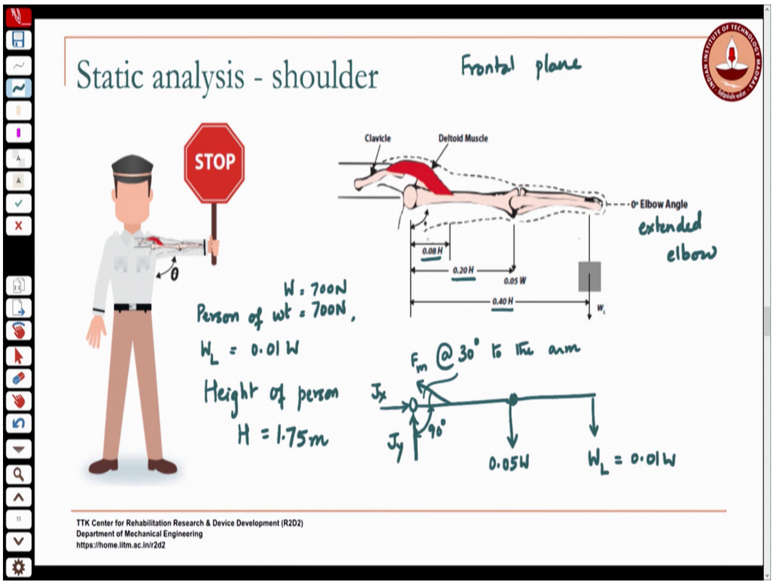

So, if you look at this case let me spell out the; so, let us say this persons weight person of weight equal to 700 Newton; I am assuming about 70 kgs an average man about 70 kgs is holding up the stop sign the weight of the stop sign the weight of the load let me say it is 0.01 times the weight of the person, W is 700; and 7 Newton meaning it is about 700 grams.

The stop sign is about 700 grams ok; so it is not a very heavy load, but we will see what kind of loads it is what kind of loads it generates. And so you and let us say that the elbow is extended. So, we are not looking at the elbow joint now; so we are considering this entire system; the entire arm as the system of interest because we are now interested in what is happening at the shoulder joint ok.

So, we are assuming that the elbow is extended; so, this is an extended and what other information do I need? So, I am again performing a planar analysis the shuttle plane ok.

Student: (Refer Time: 13:38).

I know this is 0.01 sorry this is 0.5; so I am given I draw the freebody diagram if I isolate this. So, in the frontal plane essentially the shoulder is a hinge joint I am assuming this is; so, I will not even consider this joint here because it is kept extended and those are all internal forces that are keeping it extended. So, I am not concerned about them in this. So, I have the weight of the load let us say it is acting at the middle at this distance 0.2.

So, this person the height of the person equal to 1.75 meters and let us say the arm is 0.05 times the body weight of the person this entire arm ok. And initially the person I have the muscle and let us say that the muscle insertion angle ok; muscle force is acting at an angle of 30 degrees to the arm ok. So, the insertion angle the angle and the line of pull is at 30 degrees to the arm that angle is 30 degrees what other forces do I have I have?

Student: Reactions.

I have joint reaction; so I have a J X and a J Y acting at this joint. So, this is the simplest model one muscle force; I am assuming this is like a hinge; so those are the assumptions I am making and I am also giving you these distances. So, the muscle insertion point; the load is acting at a distance.

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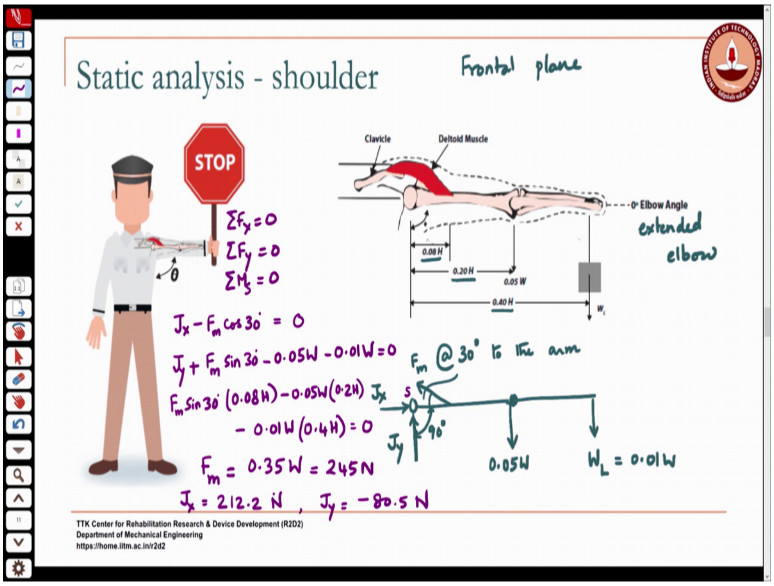

Now I want you to calculate it is ok; you should have done this before write down the equations and calculate the unknowns.

F m, J X and J Y; my equations are sigma F X equal to 0 sigma F Y is equal to 0 and sigma M about the shoulder equal to 0 because then I can eliminate J X and J Y. So, if I do that J X minus F m sorry cos 30 equal to 0; there are no other forces in the x direction. I have J Y plus F m sin 30 minus 0.05 W minus 0.01 W equal to 0 and the third equation is the horizontal component of the muscle force does not contribute.

I only have F m sin 30 into 0.08 H minus 0.05 W into point 2 H minus point o; anybody?

Student: (Refer Time: 18:55).

In terms of W.

Student: (Refer Time: 19:01).

Fine you can give me.

Student: 245 Newtons ok; so, I get F m equals 35 percent of W which is 245; I generally substitute only at the end. So, because it is easier to them compare and then J X.

Student: 212.

212.2 Newtons and J Y is.

Student: Minus 18 (Refer Time: 19:35).

Minus 18 point?

Student: 80; 80.5.

Straightforward; now so this the muscle is exerting a force that is about 35 of the person’s body weight; which is fairly high force, the muscle is exerting. And after a while; the person finds it hard to keep it in this extended position. And slowly the arm kind of sags then person brings that load closer to the midline of the body.