Mechanics of Human Movement
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Lecture – 03 Part c
Levers in the Human Body

So, we all know that a lever is a simple machine. So, in this course we are trying to connect some aspects of the human body with mechanics. So, in make mechanics we encounter levers which are basically simple machines and we want to say what are the kinds of levers, that are present in the human body similar to the levers that we encounter in the mechanical world.

So, what are levers? Levers are essentially simple machines which move a load which is which we also called sometimes the resistance and you have a pivot. So, the move the load is moved around the pivot using a force which we call the effort. So, the applied force is called the effort the resistance is called the load and the purpose of levers is basically to magnify the force that. So, with a small effort you want to be able to usually lift a larger load and what happens is when you do that; so there is the cost that you pay is in terms of the distance.

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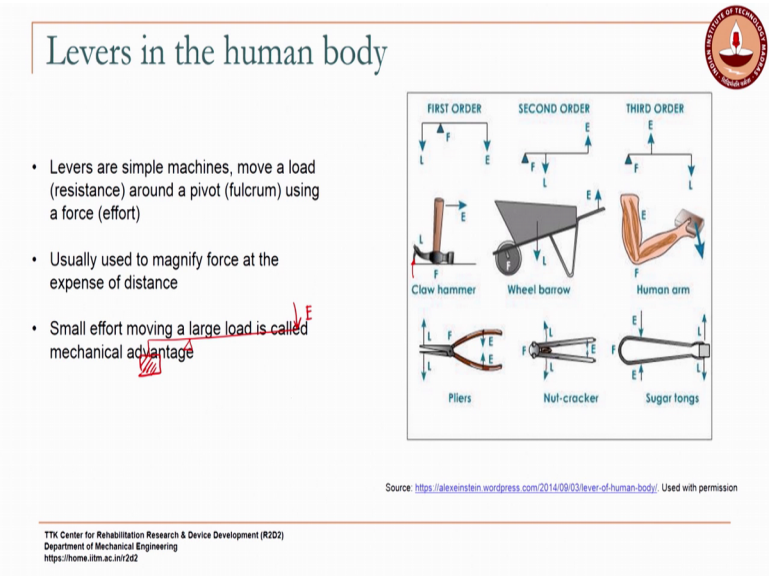

So, a typical lever is where you have a fulcrum, you have a load. So, it could be say a load that has to be lifted; let me just put it like this, say we have to lift that load and you

apply an effort in order to do so; you apply a force. And what will happen is the effort will typically have to move through a longer distance in order to lift the load through a short distance. So, you are magnifying the force at the expense of distance. So, if you see here with the hammer that is a claw hammer that is pulling out a nail, the hammer will have a long handle ok. You will apply a small effort and you are able to pull out this nail you are applying a much higher force to pull out the nail.

So, this is generally called the magnification of force; where you have a small effort moving a large load that is called a mechanical advantage and that is one of the biggest uses of levers. Now levers can be classified into three different types; so here are some examples of levers you will encounter.

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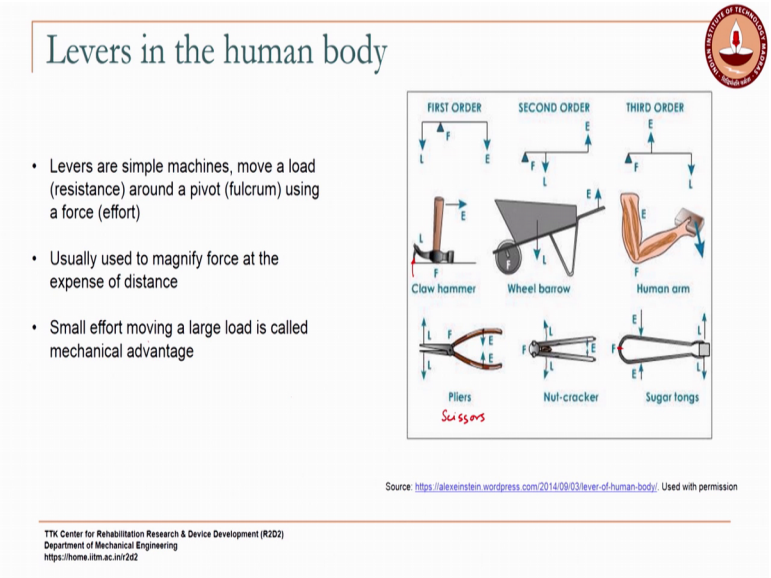

So, you have your scissors or your pliers; so, scissors are also an example of levers, then you have your nutcracker, your wheelbarrow. So, you apply an effort it will lift you can lift a load that is being carried by the barrow or when you are lifting a load with your hands; we will see that we will see the examples in the human body in a few minutes.

So, these are your tongs where you use to pick up say sugar cubes for instance. So, these are all where it is this is your fulcrum the pivot about which the effort and the load move and then you have the load and the effort.

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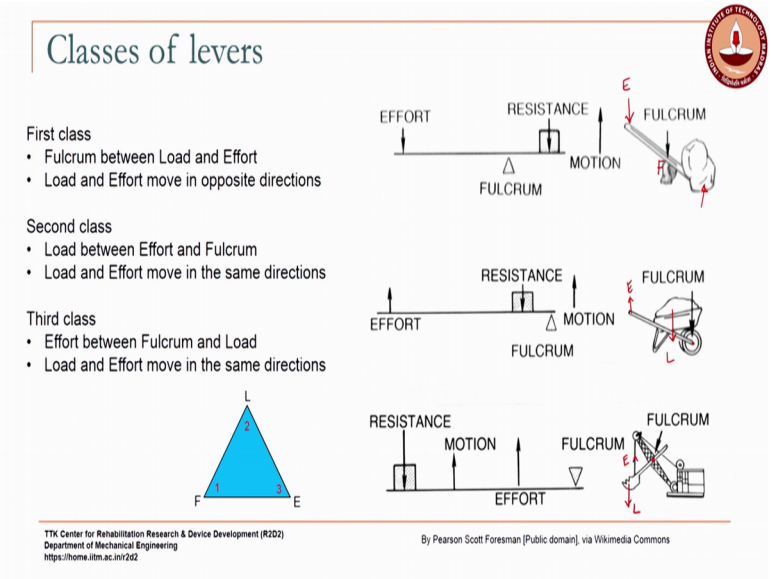

So, one way I used to remember the classes of levers is by remembering this diagram. So, if I have if I draw a triangle and I mark the vertices 1, 2, 3 and correspondingly F L E; then I can remember it is a mnemonic I used to remember which one is. So, the relative locations of the where the fulcrum is placed with respect to the load and the effort determines the class of the lever, the type of the lever.

So, levers can be classified into first, second and third class levers. So, in the first class lever as you can see from this triangle if you look at the fulcrum lies between the load and the effort; see the fulcrum here is an example you have you are applying an effort, you have a load which is your resistance. You apply an effort to lift the load, you can see here in the first class lever the motion of the effort and the motion of the load are in opposite directions. .

So, an example is you know if you want to move a large stone right you take a long bar and then you press you apply the effort here. The fulcrum is here the pivot and the load you can dislodge this large load, but the distance that the effort that the force that you are applying has to move through; you have to apply through that force through a longer distance in order to even slightly shift a larger load ok.

So, the load and the effort move in opposite directions in the case of a first class lever. Here again if you look at the triangle you can see when the load is between the fulcrum and the effort then we call that a second class lever. So in the case of the second class

lever; the effort and the resistance or the load move in the same direction; so that is the difference between the first and the second last lever.

So, again a small effort moves through a larger distance to lift a large load through a small distance ok; that is and the fulcrum is at the end. So, the load is between the effort and the fulcrum; so that is an example the wheelbarrow is an example. So, you have the fulcrum here; then you have the load here and you have the effort that is applied like that.

So, if I want to lift the wheelbarrow I pull up on the handle like that, on the lever like that which will lift this larger load and then about this pivot; so that is the second class lever. Now the third class lever is a case where the effort now is between the fulcrum and the load. So, you see here the effort lies between the fulcrum and the load.

So, the second and third class the effort and the load switch places; the fulcrum is again at one end the effort in the load switch places. And here both the load again both the load and the effort move in the same direction. So, here is an example of this you have something being lifted in this arm here which is pivoted about this point and you have the effort being applied using a rope around the pulley.

So, you have the effort applied in this manner and because the load is here the effort is being applied between the fulcrum and the load. So, this is an example of a third class lever; the in the case of the third class lever you have to apply a larger force but you will be able to move the load through a larger distance. .

So, what you gain in terms of distance; you lose in terms of the load that you can lift. So, you can move a smaller load through a larger distance by applying a large effort; in the case of a third class lever. Because you see that in the case of the third class lever the moment arm of the force that you apply or the effort that you put in is smaller than the momentum of the load. So, if you look at the moments about the fulcrum then the effort has to be larger in order to be able to balance a smaller load.

In the other two cases, the moment arms of the load are smaller typically smaller with compared to the moment arms of the effort. Of course, in the case of depending on what you do in the first class lever; they could be equal even to just balance it out. But if you want to lift a large load then you place the fulcrum closer to the load in order to be able to lift it with a smaller effort in the case of a first class lever.

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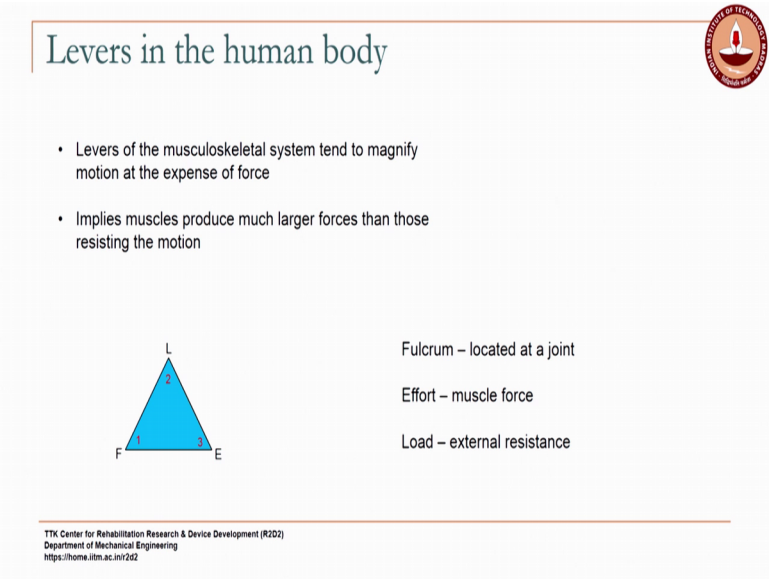

So, in the human body the musculoskeletal the; if you look at the levers of the musculoskeletal system you can kind of draw an analogy ok. So, the bones are like your levers; the bones are basically the links. The fulcrums will be located at a joint and the effort is the muscle force that you apply. So, the effort is applied by the muscles and the load is whatever external resistance.

So, you may be lifting a load or you may be that is your resistance and in the case of the musculoskeletal system typically most of the levers act to magnify motion at the expense of force. So, in many cases you have a third class lever action because the effort that the muscles apply, the forces that the muscles apply are usually much larger than the loads that you are trying to move. But what you lose in terms of the force that you are the force that you are able to lift is the fact that you can move that external load through a longer distance.

So, muscles are capable of producing when we do the static analysis and the dynamic analysis; you will see that the muscles are capable of producing much larger forces than those that are resisting the motion.

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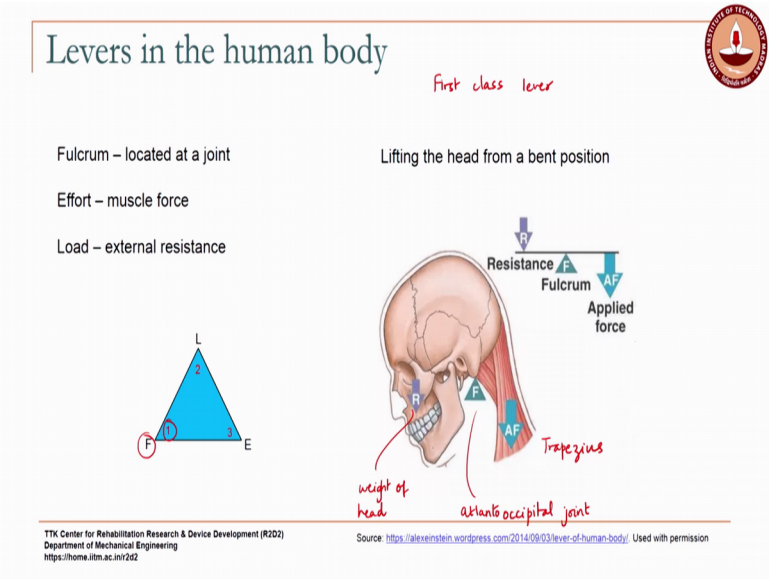

So, let us look at an example of a first class lever ok; so, this is a first class lever. So, remember in the first class lever you have the fulcrum located between the load and the effort. A good example of a first class lever is you know when you lift your head from a bent position. So, the resistance is basically the weight of the head ok; so this is the resistance is the weight of the head. Fulcrum is which joined it is the you know when you pivot your head like that; that fulcrum is the atlanto occipital joint.

So, that acts as the fulcrum for this motion and the effort is applied by the muscles at the back of the head. So, it could be like the trapezius muscle for instance; muscle at the back will apply the effort to lift the head. So, you see here that this is a very good example of a first class lever; you have the load or the resistance which is the weight of the head and you have the fulcrum in between the resistance and the applied the applied force which is the muscle force.

And you can see here that you may not really gain much of a mechanical advantage depending on the relative locations. So, because the muscles also are pretty close to the joint and the weight may also be acting close to the atlanto occipital joint here yeah so, but this is an example of a first class lever.

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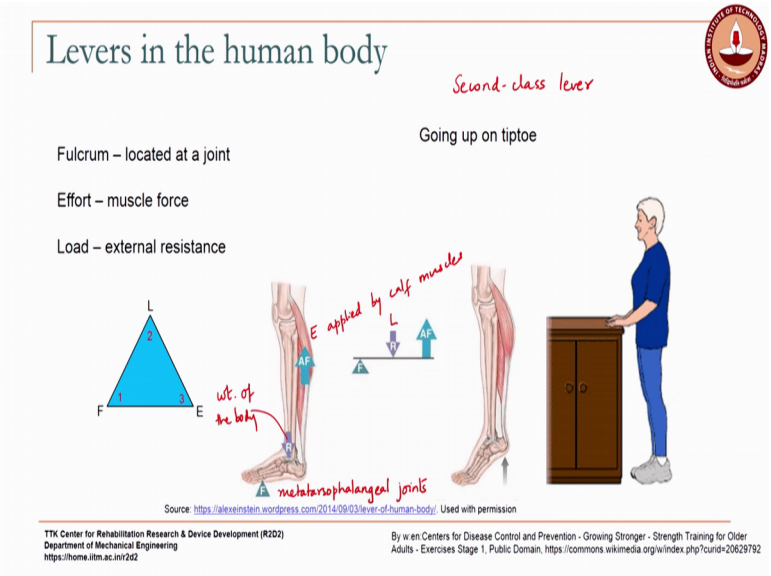

Now, let us look at the example of a second class lever; going up on tiptoe is a good example of the body acting as a second class lever or here your fulcrum is your metatarso phalangeal joints.

So, that acts as the pivot about which you are able to lift the weight of the body will be the resistance or the load. So, that is now acting between the fulcrum and the effort and the effort is applied by your calf muscles. So, the; this is the effort applied by the calf muscles and the resistance of the load is the weight of the body, which sort of act somewhere close to the somewhere between the fulcrum and the effort. .

So, the muscles through the achilles tendon; the calf muscles pull up the heel and cause this action of going upon tiptoe. So, this action is enabled by this system of the metatarsophalangeal joints acting as the fulcrum and the effort applied by the calf muscles and so it is an example of a second class lever.

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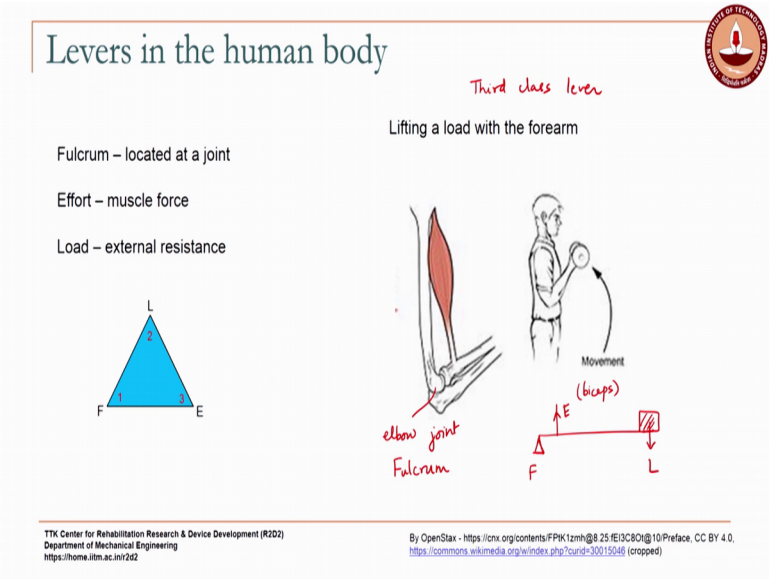

Example of a third class lever is lifting a load with your forum. So, if you look at the structure of the forum; you have the elbow joint acting as the fulcrum; you have the elbow joint acting as the fulcrum. And then you have say if I have the fulcrum, I have the effort being applied by say the biceps muscles ok.

And then I have a load that is being lifted by my hand ok; so this is the load. So, because the effort lies between the fulcrum and the load, this is an example of a third class lever. And you can see here that the muscle would have to apply because the momentum of the muscle is so small ok.

The muscles typically act pretty close to the joints about which they are causing movement and so you will find that the muscle force we will learn how to calculate that when we do the analysis later. But you will find that the muscle forces that are need to be apply that need to be applied are much larger than the loads that you are lifting ok.

But you can get a much larger movement ok; the muscle has to move or this your forearm close to the elbow is moving a much smaller distance than your hand that is lifting the load. So, these are examples of levers in the human body and in many cases because of the fact that the muscles act close to the joints, you will find that they tend to function as third class levers and have to apply much larger forces in the than the loads that they are resisting.

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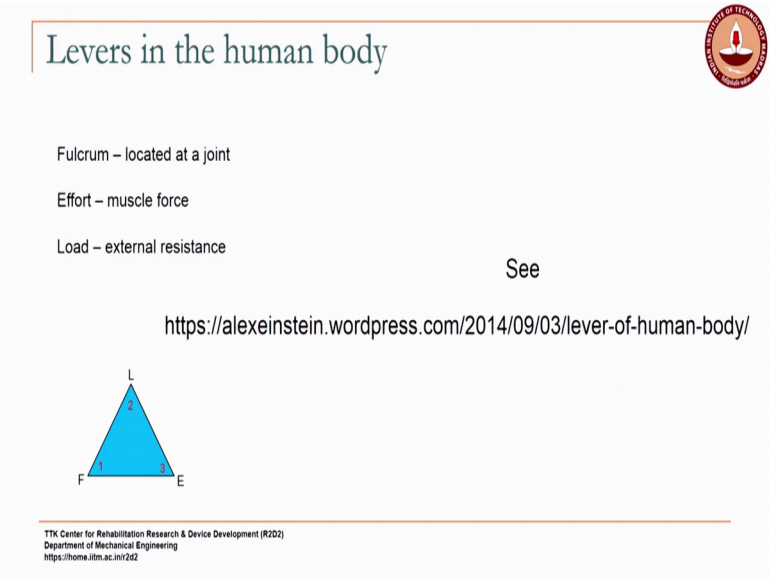

So, this is a good article with some nice figures; I would encourage you to go see this website which has some good examples of some other levers in the human body.