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Lecture – 01 Part a Basic Terminologies

Welcome to this class on the Mechanics of Human Movement. So, if you are a mechanical engineer interested in how the human body moves, how we make various movements with our limbs, or if you are a biomedical engineer or a physiotherapist or you know a clinician, you may be interested in this course because the purpose of this course is to apply the principles of mechanics to study human movement. So, to do that we have to first learn some anatomy; we have to be able to speak the same language as biologists and medical professionals.

We have to learn some of the terminology that is associated with the human body. We will learn some key anatomical structures that are responsible for movement such as mainly the musculoskeletal system. In this course, we will not be looking at the neural aspects of movement; we will only be focusing on the musculoskeletal aspects of the movement. We will learn how to apply the principles of mechanics to study you know what kind of forces are induced in the anatomical structures because of the movements that we do and what causes movement.

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So, biomechanics essentially is in this context biomechanics is a very vast field, but in this context we are going to use physics principles to quantitatively study how forces interact with the human body. And our focus will be on rigid body dynamics or actually rigid body mechanics. So, if you look at rigid body mechanics, you have both statics and dynamics; and dynamics is essentially you have kinematics and kinetics. We will not be looking at fluid dynamics in this course.

So, if you look at statics, we will be looking at the human body different postures, we are we are looking at cases of static equilibrium, where we will apply the principles of statics to study the system. When we talk about system in the context of the human body it could be the entire body in some cases or it could be specific segments or specific portions of the system that we are focusing on.

When we talk about dynamics, we can talk about kinematics which is basically just the geometry of the motion, we are looking at motion and its time derivatives without regard to how that motion is being caused; that study the study of the forces that cause the motion becomes a part of the study of kinetics. So, when we apply the principles of kinetics, then we are looking at how are what are the forces that are causing some motions to happen.

So, when I say body it could be the whole body. In biomechanics, body could refer to the whole body or any of its parts or segments under consideration. So, if you are looking at forces in the arm for instance or if you are studying the arm then if I say that you know if I talk about the body there I am only talking about the arm itself not the entire body. When we talk about positions or movements they always happen with we always talk about it in terms of it with reference to some plane of reference. You have to have something with which you are making the measurements. So, in the case of the human body, we have something called the, an anatomical reference planes.



So, movements and reference locations are expressed with respect to reference anatomical planes which are defined with respect to what is known as with respect to the anatomical position. So, this anatomical position is a specific position. So, it is your if you are standing straight with your feet you know hip width the part and you keep your arms by your sides with your palms facing forward that position is defined as the anatomical position ok.

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So, the anatomical position is like this is your anatomical position. So, you have the person standing straight palms facing forward. So, in the anatomical position, the palms are facing forward. And there are three principal are cardinal planes defined with reference to this anatomical position. So, if you look at these planes, if you imagine a plane that cuts the body into left and right halves that plane is called the sagittal plane. So, the sagittal plane bisects the body into left and right parts the frontal plane also known as the coronal plane it divides the body into front and backs halves back halves.

And then the third, so these are perpendicular planes the sagittal plane is perpendicular to the frontal plane and the third plane is your transverse plane which divides the body into top and bottom halves. Say, if you imagine the at the origin where these three planes intersect, if you imagine this, this, this, these three planes will be located, this would be the center of mass of the whole body. If you imagine that has a sphere then each of these planes divides it into two equal parts ok. So, you have the center of mass of the body located at the origin of this three reference planes now any planes that are parallel to these planes are also called like a plane parallel to a sagittal plane is also called a sagittal plane. But the principal plane is the one that will bisect the center of mass.

So, these planes are used. So, these planes move with the body. So, if I am standing like this in the anatomical position, then that defines where my sagittal plane, frontal plane and transverse plane are. And if I turn then the planes turn with me ok, so they are not they are with reference to the human body. They are not independent of the human body. Now, these planes are used to locate various parts of the body relative to one and other and also relative to these planes. So, for instance, so this we will also define the axis that are perpendicular to these planes. So, because the frontal plane divides the body into front and back parts, whatever is in front of the plane is called anterior and what is behind is posterior.

So, this axis that is perpendicular to the frontal plane is called the anterior posterior axis posterior or AP axis. So, when we talk about the AP axis, we are talking about an axis that goes from the front to the back that is the so that is the axis perpendicular to the frontal plane. Similarly, the axis perpendicular to the sagittal plane is called the mediolateral axis.

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So, the mede when we say medialm when we say something is medial so this is ML axis the mediolateral axis. When I say something is medial implies, it is closer to the midline of the body. And lateral implies that it is farther from the mid line. Now, take your eyes, your eye is medial to your ear right. Eye is closer to the midline than the ears, is or in other words I can say the ear is lateral to the eye ok. So, I can say the eye is medial to the ear or the ear is lateral to the eye that is the with reference to the midline of the body.

Then if I am talking so the third axis is what is called the, this is the axis that is perpendicular to the transverse plane and that axis is the longitudinal axis ok. So, the

longitudinal axis you have you can say something is superior or inferior ok. So, this is this direction is superior; this direction is inferior. So, when you talk about something with reference to the longitudinal axis, then you are talking about a location that is superior or inferior. So, by the same token, the eye is superior to the nose the eye is are superior to the nose. And the ears sorry the or I could say the nose is inferior to the eyes ok.

So, this is just the superior inferior here are technical terms and not used in the way its typically used in English. We need our eyes and our nose. So, just to be clear one is not superior or inferior to the other that is purely in biomechanical terms we use to describe the relative location ok.

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So, I can say my hip the hip is in if I am talking about location in the longitudinal axis, if I talk about the hip joint, the hip joint how is it located with respect to the knee, the hip would be superior to the knee because it is located higher it is located higher than the knee. So, it is superior to the knee joint. So, in addition, for the limbs, we also have another set of terms that are so for when we talk about the limbs upper and lower limbs the arms and the legs, we also talk have two more terms we use the terms proximal and distal. So, for the limbs we say when we say something is proximal, proximal means closer to its point of attachment to the body because the limbs are like.

So, if you think about this part of the body, your you know your central portion of the body the limbs are kind of attached to that. So, when we talk about the limbs, we talk about things that are proximal or distal, distal is when it is farther from the point of attachment. Again example so actually for the hip, you would say the hip is proximal to the knee ok. The hip is proximal to the knee. The knee is proximal to the ankle or you would say the ankle is distal to the knee and the knee is also distal to the hip ok.

So, now think about this for a minute in the frontal plane ok. So, now, when I talk about these planes I will start using the terms frontal, sagittal and transverse plane. In the frontal plane, how is my thumb located with respect to my little finger; my thumb how is it located with respect to my little finger. If I want to describe the location of my thumb what would I say, would I say it is medial or lateral to the little finger? I have my thumb, I have my hand here. So, would I say the thumb is medial or lateral to the little finger?

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He says that the little finger is medial to the thumb. But I was showing you like this right, here the thumb, but he is correct because you are always talking with reference to the anatomical position where your palms are facing forward. So, in the anatomical position, the little finger is medial to the thumb or the thumb base lateral to the.

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When we look at the structure of the musculoskeletal system of the musculoskeletal system as engineers we can kind of draw parallels to the structures in the human body to what we are typically used to. So, in this skeletal system, the bones are considered the structural members. So, they are assumed to be rigid, we assume that in for this particular course at least, we assume that the bones are relatively rigid because the motions that we will be studying are much larger than the deformations that happen in the bone.

So, when can you say that you can make you know you can assume something is rigid, you assume a body is rigid when the motion that it undergoes is larger typically much larger than the deformation that it undergoes ok. So, because of the forces on it; in the human body the muscles are the actuators like in a mechanical system, you may have motors or hydraulic actuators something to apply forces. In the human body the muscles are the actuators of the system. They provide they apply the internal forces in the system. You have ligaments so which basically connect with soft tissue that connects bone to bone. So, ligaments the primary purpose of ligaments.

So, where the bone where two bones meet they form a joint ok. And the motion at that joint is typically controlled partly by the structure of the joint itself, the shape of the bones that are coming together at the joint, but mainly by flexible structures around the joint called ligaments which attach the bone to bone. And their purpose is to sort of limit the motion at the joint. And then you also have tendons which connect muscle to the bone. The tendons connect muscle to bone and they function so they transmit the force from the muscle to the bone and in some cases they also have the ability to act as springs the equivalent the mechanical equivalent of tendons is springs.

So, these are the basic components of the skeletal system and that we will the musculoskeletal system, that are responsible for movement either they restrict movement or they cause movement. So, the muscle applies a force to the bones to which it is attached, and because the bones are connected by joints they have the ability to move because otherwise the bones are rigid. If there were no joints between the bones, it would essentially be a structure there would be no movement possible, but because bones are come together at places where move movement is allowed you have a very you have a system that is both rigid and flexible you and that will allow movement to happen.

So, again we have looked at the three principal planes the sagittal plane, the frontal plane and the transverse plane and correspondingly the three axis. So, the axis perpendicular to the sagittal plane is your ML axis perpendicular to your frontal plane is the AP axis. And then the axis perpendicular to the transverse plane is your longitudinal axis. Now, a lot of movements that we will be describing in the body if you can see a lot of movement that happens is kind of rotational movement and they will be described as rotations about these different axis. So, gross body movements are typically described in terms of you know whether they are predominantly in the frontal plane, the sagittal plane or the transverse plane.

For instance, if I am doing jumping jacks most of the motion that happens in the various segments can be looked, can be described in the frontal plane ok. If I am doing a cartwheel, if I am doing a somersault ok, or if I am go walking most of the movements can be seen if you see the movements at the joints the map most of the movements happen in the sagittal plane. So, some motions you would describe in the sagittal plane, but if you do a more or you know a bowling action ok, you can look at it and describe it in the sagittal plane.

Of course, most movements are combinations, they are not exclusively in one plane, but you can you talk about it predominantly in a particular plane. If I am a figure skater, and I am doing spins then that motion is happening in the transverse plane, so that is how you would describe the various movements.

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